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Overview of the Closure Approach for the Hanford Site Single-Shell Tank Farm

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse
Hanford Company Richland, Washington

Hanford Operations and Engineering Contractor for the
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ABSTRACT

The disposal of chemical and radioactive waste stored within the single-shell tanks (SST) represents one of the most significant waste management problems at the Hanford Site. A comprehensive program has been established to obtain analytical data regarding the chemical and radiological constituents within these tanks. This information will be used to support the development of a supplemental environmental impact statement (SEIS) and ultimately to aid in the selection of a final disposal option.

This paper discusses some of the technical options and major regulatory issues associated with SST waste retrieval and in situ waste treatment and disposal. Certain closure options and treatment technologies will require further development before they can be implemented or accepted as being useful. In addition, continued negotiations with the regulatory authorities will be required to determine the preferred closure option and the regulatory pathway to accommodate such closure.

SINGLE-SHELL TANK SYSTEM BACKGROUND

Between 1943 and 1964, 149 SSTs were built at the Hanford Site for the storage of high-level radioactive waste. The SSTs are located in 12 tank farms consisting of 4 to 18 tanks each. These tank farms are located in the 200 West and 200 East Areas of the Hanford Site. The volumes of the SSTs vary from 208,197 L to 3,785,400 L as follows: 208,197 L (16 tanks), 1,892,700 L (60 tanks), 2,893,050 L (48 tanks), and 3,785,400 L (25 tanks).

The SSTs are constructed of carbon steel, American Society for Testing and Materials (ASTM) A283 Grade C or ASTM A201 Grade C (241-AX Tank Farm), that lines the bottom and sides of a reinforced concrete shell. The bottoms of most of the tanks are slightly concave. The tanks are below grade with at least 1.8 m of soil cover, which minimizes radiation exposure to operating personnel. Inlet and overflow lines are located near the top of the liner. Most of the 1,892,700-L and 2,839,050-L tanks were built in "cascades" of three or four tanks. Waste was transferred to the first tank of the cascade and allowed to overflow into successive tanks through piping in the side walls. Access to the tanks is provided by risers that penetrate the dome of the tanks.

The carbon-steel liners in the SSTs were not stress-relieved after fabrication. As a result, hot alkaline radioactive-waste mixtures of liquid and sludge have induced stress-corrosion cracking of the steel and over the years leakage to the environment has been suspected or confirmed in 67 SSTs.

Over the years, waste has been retrieved from the SSTs to recover specific radionuclides and later to reduce the volume of free liquids within the tanks. During the 1950's, SST waste was retrieved from certain tanks for extraction of uranium; during the 1960's and 1970's, SST waste was retrieved for extraction of cesium and strontium fission products. During the 1970's, the volume of liquid wastes stored in the SSTs was reduced by evaporating the liquids, leaving moist sludge and salt cake. The evaporation efforts also served to reduce the environmental impact of potential releases from the tanks by minimizing the volume of drainable liquids available to contaminate surrounding soils. The SSTs now contain approximately 37 Mgal of salt cake, sludge, interstitial, and nonpumpable supernatant liquids, based upon the "Tank Farm Waste Surveillance Report for March 1989" (1).

Interim management activities for the SSTs will continue until a decision is made on final closure and corrective action. These interim activities include the following:

1. Stabilization, via saltwell pumping of interstitial liquids
2. Surveillance for tank integrity (to detect leaks, liquid intrusion, and changes in the radiological status of the contaminated soil)
3. Heat management to prevent excessive tank temperatures
4. Tank isolation (i.e., sealing the tank piping and openings) to deter liquid intrusion
5. Groundwater monitoring.

HANFORD FEDERAL FACILITY AGREEMENT AND CONSENT ORDER

The "Hanford Federal Facility Agreement and Consent Order" (Tri-Party Agreement) was signed into effect in 1989 (2). This agreement establishes a mechanism for bringing existing treatment, storage, and disposal (TSD) facilities into compliance with the provisions of the Resource Conservation and Recovery Act of 1976 (RCRA) and the Washington (State) Administrative Code (WAC) 173-303 or conducting closure in accordance with these regulations (3,4).

The Tri-Party Agreement divides the Hanford Site into operable units and identifies subunits within each operable unit. The SST system has been divided into six operable units:

1. 200-BP-7
   241-B Farm (16 tanks)
   241-BX Farm (12 tanks)
   241-BY Farm (12 tanks)
2. 200-PO-3
   241-A Farm (6 tanks)
   241-AX Farm (4 tanks)
   241-C Farm (16 tanks)
3. 200-RO-4
   241-S Farm (12 tanks)
   241-SX Farm (15 tanks)
4. 200-TP-5
   241-TX Farm (18 tanks)
   241-TY Farm (6 tanks)
5. 200-TP-6
   241-T Farm (16 tanks)
6. 200-UP-3
   241-U Farm (16 tanks).

These six operable units include the SSTs, diversion boxes, catch tanks, contaminated soil from spills and discharges, cribs, valve pits, vaults, and septic tanks.

The current approach for closure of the SSTs is to close all ancillary equipment (i.e, diversion boxes, catch tanks, piping and contaminated soil) under the provisions of Section 3004(u) of the RCRA, which addresses remediation of past practice units. The SSTs, themselves, will be closed as RCRA TSD units in accordance with the RCRA and the WAC 173-303-610, "Closure and Post-Closure" (4). In addition, the Tri-Party Agreement establishes a schedule for closure of the SSTs. Some of the major milestones associated with this task include the following:

1. Complete SST interim stabilization by September 1995, interim stabilization removes pumpable interstitial liquids from SSTs

2. Complete preparation of the SEIS and issue a draft for public review by June 2002

3. Submit closure plan to the Washington State Department of Ecology (Ecology) for approval by December 2003

4. Complete closure of all 149 SSTs by June 2018

5. Complete closure of all six SST operable units by September 2018.

WASTE RETRIEVAL TECHNOLOGIES

Waste retrieval is intended to include the recovery of salt cake, sludge, slurries, and liquid wastes from the SSTs and the associated transfer of these wastes to an onsite pretreatment facility. Methods for removal of SST waste require special attention because the integrity of some of the tanks is questionable. In fact, 67 of the 149 SSTs are presumed to have released a portion of their contents to the environment. Because adding liquids to remove solids could potentially increase the risk of releasing waste to the environment, a mechanical waste retrieval method has been recommended.

At this time, three waste retrieval techniques have been examined. All three methods are scheduled to be reviewed by independent review panels, such as the National Academy of Sciences. The three techniques, discussed in the following paragraphs, are dry mechanical, hydraulic, and pneumatic retrieval.

Dry Mechanical Retrieval

Dry mechanical retrieval reduces the potential for additional releases from the SSTs due to hydraulic retrieval operations. Preliminary design studies for mechanical retrieval have been completed. Waste tank contents would be excavated with the aid of an articulated mechanical arm, placed in an elevator clamshell bucket, and brought to a platform. The platform would be carried by independently powered tracked transporters spaced beyond the diameter of the tanks. Straddling the tanks in this manner would minimize the loads applied through the ground to the tank structure. The retrieved waste would be unloaded from the elevator bucket to a shielded shipping container. This retrieval system would require only minimal alterations to tank farm structures and would be designed to avoid direct loads on the dome.

Hydraulic Retrieval

A hydraulic retrieval system would use a liquid-slurry transfer system to retrieve the waste. The equipment used would include a high-pressure, high-volume water jet with associated pumping and supply systems as well as accumulation tanks and recirculation systems. The waste would be dislodged by water jet impact, dissolved or broken down, and washed into the vicinity of a slurry pump where it would be pumped to the surface.

Leakage barriers, if required, would be provided to control leakage from the tanks during hydraulic retrieval operations. The leakage barrier would be a freeze barrier, grout barrier, or other water-impervious type of installation under and around the SSTs. The barriers would provide external containment during the hydraulic retrieval operation and would have a release detection and recovery system to recover waste if a major tank release occurred.

Pneumatic Retrieval

Pneumatic retrieval is a system that uses air conveyance to perform waste retrieval operations. Pneumatic retrieval uses a maneuvering and control system similar to the one for dry mechanical retrieval. The air conveyance system uses a positive displacement blower to produce high-velocity air for entraining the waste.

The key elements of the air conveyance system are the cyclone separator and positive displacement blower. The cyclone separator is used to remove particulate materials from the airstream. A positive displacement blower would create a high-air velocity in a suction hose. The system operating velocity would suspend material in the airstream to allow transfer of the material. The material can be transported any distance that the velocity can be maintained. All equipment in this system except the suction hose is outside the tank. This would reduce maneuvering system loads and improve reliability. The system would be able to move anything that can be suspended in the airstream. Air or water jets, or mechanical means may be used at the end effectors of the arm to break up the waste for transfer.

IN SITU TREATMENT TECHNOLOGIES UNDER DEVELOPMENT

If it is not practical to remove SST waste, several in situ treatment technologies are currently under consideration. The decision to leave or retrieve waste will be based, in part, upon the results of a performance assessment that evaluates the total risk associated with each closure option. At this time, three in situ treatment technologies (in situ drying, in situ chemical stabilization, in situ vitrification) are being evaluated for use in conjunction with the SSTs closure. These options are discussed in the following paragraphs.

In Situ Drying

In situ drying uses radio-frequency drying to remove free liquids from the SST. The heating would drive the liquid into the vapor phase where it would diffuse through the salt cake and be removed in the off-gas system. After liquid removal has been completed, the remaining void space within the tank would be filled with basalt gravel. Then, a final engineered intrusion and infiltration barrier would be installed that meets all regulatory requirements.

Microwave or radio-frequency heating is the most effective way to introduce energy into the waste. Early developments using microwave frequencies indicate that dry salt cake attenuated 50 percent of the microwave energy within a few centimeters. Preliminary data indicate that in the radio-frequency ban dried salt cake would be transparent to radio-frequency energy. This would allow the radio-frequency energy to be transmitted throughout the dried upper layer of waste with low attenuation down to the lower wet layers.

In situ drying would not change the dangerous waste designation of SST waste. However, the final waste form would be free of liquids, thus eliminating the driving force for contaminant migration. This waste treatment and closure option would have the greatest dependence on engineered barriers and monitoring programs to ensure that dangerous waste does not migrate from the disposal zone after closure.

In Situ Chemical Stabilization

In situ chemical stabilization combines SST waste with a grout mixture to provide a stable, leach-resistant matrix. This in situ option uses augers to mechanically combine the SST waste with the grout mixture. It is expected that the grout would reduce the mobility of the waste and combine with nitrates and nitrites to reduce the reactivity of the waste. All mixing equipment would be located within a given SST, and the grout and chemical additives would be mixed in surface facilities. The off-gas generated from exhaust mixing operations would pass through prefilters before being discharged to high-efficiency particulate air filters and subsequently to an emissions stack.

In Situ Vitrification

In situ vitrification uses joule heating to melt the waste and associated tank in situ. The resulting vitrified mass provides a stable matrix for the long-term disposal of SST waste. The high temperatures from vitrification are expected to cause the decomposition of a majority of the wastes (nitrates, nitrites, and organic wastes) leaving oxides of nonvolatile constituents in the matrix. While certain wastes would be destroyed with this technology, the waste may continue to be subject to regulation under Washington State "Dangerous Waste Regulations" imposed by Ecology and/or due to the presence of listed waste constituents.

For this technology to be applicable to the SSTs, a melt depth of 20 m would be required. The current full-scale design with fixed electrodes has reached depths of 6 m. Technologists have proposed two new design concepts (moving and hot-tipped electrodes) to obtain the necessary depth. Moving electrodes eliminates expensive stationery electrodes that would require placement to a specified depth before melting begins. Hot-tipped electrodes concentrate power at the bottom of the melt, which improves melt efficiency.

REGULATORY STATUS OF SST WASTE

Federal and State regulations have been developed since the SST waste was generated and placed in storage within the SSTs that establish specific requirements for the management of hazardous waste. The overall intent of these regulations is to protect human health and the environment from hazards associated with hazardous waste. The number of regulations applicable to SST waste and the fact that the SSTs are regulated under the RCRA yet located within a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 unit may lead to complicated and potentially conflicting regulations (5).

The SST waste is a complex mixture of chemical and radioactive constituents. On May 1, 1987, the U.S. Department of Energy (DOE) published its final byproduct rule (6), which stipulates "that only the actual radionuclides in DOE waste steams will be considered byproduct material." The effect of this interpretative rule is that the chemical waste constituents contained within DOE waste streams are subject to regulation under the RCRA and by authorized states. The radionuclides, however, remain subject to regulation in accordance with the Atomic Energy Act of 1954 (AEA) (7). Thus, radioactive mixed waste (i.e, waste containing both radioactive constituents regulated under the AEA and chemical constituents regulated under the RCRA) is subject to dual regulation by the DOE and the U.S. Environmental Protection Agency (EPA).

Section 70.105.050 of the State of Washington Hazardous Waste Management Act of 1976, in the Revised Code of Washington, was revised on July 26, 1987, to give Ecology the authority to regulate hazardous waste that also contains radioactive constituents (8). On November 23, 1987, Ecology received final authorization from the EPA to implement the amendment and to regulate the hazardous constituents of mixed wastes. Washington State implements the federal RCRA program through the WAC 173-303. Wastes regulated under WAC 173-303 are identified as dangerous wastes, rather than hazardous wastes as identified under the RCRA.

In response to this State action, the DOE Field Office, Richland submitted a Part A permit application for the SSTs to Ecology on March 1, 1988. Thus, the SSTs have been identified as interim status RCRA treatment and storage tanks. The DOE does not intend to pursue final operating status for the SSTs. Therefore, the SSTs will undergo closure during interim status and a Part B permit application will not be submitted.

REGULATIONS APPLICABLE TO CLOSURE OF THE SSTs

Closure as a Treatment and Storage Tank

As discussed previously, the SSTs are regulated under the provisions of the RCRA and WAC 173-303 as treatment and storage tanks (3,4). The closure requirements for dangerous waste tanks are identified in WAC 173-303-640(8). This section of the WAC 173-303 regulations indicates that upon closure the owner or operator shall "Remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), contaminated soils, and structures and equipment contaminated with waste, and manage them as dangerous waste" (4).

This section of the WAC 173-303 regulations further states that if the owner or operator can demonstrate that all contaminated soils cannot be practicably removed or decontaminated, then the owner or operator must close the tank system and perform postclosure monitoring in accordance with the requirements for landfills. Note, the landfill closure option assumes that a dangerous waste tank can be removed or decontaminated and that only contaminated soils will remain in place, if a landfill closure is pursued.

If the DOE determines that the preferred alternative includes leaving some SST waste in place, the remove-or-decontaminate standard would be applicable to the tanks and tank waste. According to the State dangerous waste regulations, the remove-or-decontaminate standard will be met only when listed and characteristic waste constituents or residues do not exceed background environmental limits. In addition, waste constituents or residues must be removed or decontaminated to at least designation limits for State-only dangerous wastes (i.e., those wastes regulated due to toxicity, persistence, or carcinogenicity).

Closure as a Landfill (Disposal Tank)

Although Washington State dangerous waste regulations do not allow closure of a treatment and storage tank as a landfill, the EPA has determined that under limited circumstances, a treatment and storage tank may require closure as a landfill. The EPA provided a clarification to the definition of a landfill in the December 10, 1987, "Federal Register" (9). This "Federal Register" states:

> "Landfill" will cover tanks or vaults used for disposal of hazardous waste. Subpart J of Part 264 only regulated storage and treatment in tanks and the Agency to date has not developed specific standards for disposal of hazardous waste in tanks. However, under limited circumstances, the Subpart J standards do allow treatment or storage tanks that cannot remove all contamination at closure to close and to perform post-closure requirements for landfills. Disposal in tanks will be regulated under the Subpart N standards for landfills because "landfills" and the disposal of hazardous waste in tanks raises similar human health and environmental concerns and because tanks are similarly placed on or in the land."

As discussed previously, the EPA interpretation establishes a mechanism that allows closure of the SSTs with waste and tank structures remaining in place. To demonstrate the need to pursue this closure option, a performance assessment that evaluates the risk to human health and the environment associated with SST closure options is being developed. In addition, closure options may be limited based upon available technology. To address this issue, waste retrieval and treatment technologies are being evaluated for technical feasibility and cost, among other things. If it is not feasible to meet the removal-or-decontamination standard of WAC 173-303-610, the DOE may be forced to pursue a landfill closure, which will involve revisions to the existing Part A permit and submittal of a closure plan that addresses closure of the SSTs as a landfill. In addition, a postclosure permit application will require development and approval by Ecology.

Atomic Energy Act of 1954

The AEA establishes the authority of the Government via the Atomic Energy Commission (later the U.S. Nuclear Regulatory Commission and the DOE) to regulate the production and use of source, special nuclear, and byproduct material. The DOE implements the requirements of the AEA through DOE orders, which establish the requirements for management of radioactive waste. One of the major provisions of the AEA is to maintain personnel exposure to radiation sources as low as reasonably achievable. The SSTs must undergo closure in accordance with the provisions of the AEA.

National Environmental Policy Act (NEPA)

Any closure and/or remedial action associated with the SSTs must satisfy NEPA requirements (10). The DOE has committed to provide NEPA documentation in the form of a SEIS to address SST waste disposal. In summary, the NEPA process analyzes reasonable alternatives, including a no-action alternative, in comparative form associated with a proposed Federal action. Information on environmental consequences and a description of the affected environment for each alternative is presented. Site characterization information is needed (1) to understand the nature to appropriately discuss in the SEIS and extent of contamination associated with the SSTs and (2) to appropriately discuss in the SEIS the levels of required actions. Finally, a record of decision (ROD) is issued that will select a preferred alternative for SST waste disposal. In the case of the SSTs, the ROD for the SEIS will establish DOE's position on SST waste retrieval, in-place disposal, or some combination of the retrieve and in-place alternative.

Final disposal options for the SSTs and associated ancillary equipment were initially addressed in the DOE's "Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington" (HDW-EIS) (11). The ROD for the HDW-EIS indicates that the DOE decided to undertake additional development and evaluation activities before a final decision on the SSTs would be made (12). As contained in the HDW-EIS ROD, these additional development and evaluation activities include the following:

- Characterize radioactive and hazardous waste constituents
- Demonstrate barrier performance by instrumented field tests, natural analog studies, and modeling
- Determine the need and methods for improving the stability of the waste form
- Determine the need and methods for destruction and stabilization of hazardous waste constituents
- Develop and evaluate a method for retrieving, processing, and disposing of the wastes.

The HDW-EIS final ROD commits to the preparation of a SEIS for SST waste. A major milestone has been added to the Tri-Party Agreement, milestone M-09-01, which indicates that a draft SEIS will be prepared and issued for public review by the year 2002. A review of the closure schedule established in the Tri-Party Agreement indicates that acceleration of the SEIS may be necessary to accomplish closure by the year 2018.

One of the problems with accelerating the SEIS is that significant waste characterization information from all of the SSTs may not be available to support the ROD. To resolve this issue, the SSTs have been categorized into groups of tanks or tank farms that have received similar types of waste from specific chemical separation facilities. Based on existing process knowledge, the analysis from a given tank within a specified grouping is expected to be representative of the other tanks in that group. A statistical analysis will be performed to verify this assumption. If this is a correct assumption, analytical data regarding the chemical and radiological constituents contained within the SST waste will be available to support acceleration of the SEIS. The other development and evaluation activities will be ongoing throughout the development of the SEIS.

U.S. Nuclear Regulatory Commission Requirements for Disposal of High-Level Waste (HLW)

The U.S. Nuclear Regulatory Commission has established specific requirements in Title 10 "Code of Federal Regulations" Part 60 for the disposal of HLW in geologic repositories (13). While the DOE must ensure that HLW will be disposed of in a geologic repository, these regulations would not be applicable to SST waste that is treated and disposed in place. However, the U.S. Nuclear Regulatory Commission does have licensing authority for the shallow land burial of HLW. If SST waste is determined by the U.S. Nuclear Regulatory Commission to be HLW and such waste is treated and disposed in situ, a license from the U.S. Nuclear Regulatory Commission will be required. At this time, the U.S. Nuclear Regulatory Commission has not issued licenses for the shallow land burial of HLW so the licensing requirements are not clear.

CONCLUSION

As discussed previously, SST closure options under evaluation include those that would require waste retrieval and in situ treatment and disposal. The risks associated with these closure options are being evaluated through development of a performance assessment. The performance assessment uses modeling techniques to evaluate the risk and performance associated with each closure option. The final disposal method must prevent significant impacts to human health and the environment, as envisioned by the EPA, while also keeping radiation exposure to workers in a manner consistent with the as low as reasonably achievable principle. The results of this analysis along with the conclusions reached in the SEIS will identify a preferred method of closure for the SSTs.

At this time, investigations and development of prototype retrieval equipment and technologies required for certain in situ closure options are in the initial phases of development. Milestones have been added to the Tri-Party Agreement to ensure (1) that these development activities are done and (2) that the 149 SSTs will be closed by the year 2018.

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