STATUS AND DIRECTION OF THE BULK VITRIFICATION PROGRAM FOR THE SUPPLEMENTAL TREATMENT OF LOW ACTIVITY TANK WASTE AT HANFORD

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ABSTRACT

The DOE Office of River Protection (ORP) is managing a program at the Hanford site that will retrieve and treat more than 200 million liters (53 million gal.) of radioactive waste stored in underground storage tanks. The waste was generated over the past 50 years as part of the nation's defense programs.

The project baseline calls for the waste to be retrieved from the tanks and partitioned to separate the highly radioactive constituents from the large volumes of chemical waste. These highly radioactive components will be vitrified into glass logs in the Waste Treatment Plant (WTP), temporarily stored on the Hanford Site, and ultimately disposed of as high-level waste in the offsite national repository.

The less radioactive chemical waste, referred to as low-activity waste (LAW), is also planned to be vitrified by the WTP, and then disposed of in approved onsite trenches. However, additional treatment capacity is required in order to complete the pretreatment and immobilization of the tank waste by 2028, which represents a Tri-Party Agreement milestone.

To help ensure that the treatment milestones will be met, the Supplemental Treatment Program was undertaken. The program, managed by CH2M HILL Hanford Group, Inc., involves several sub-projects each intended to supplement part of the treatment of waste being designed into the WTP. This includes the testing, evaluation, design, and deployment of supplemental LAW treatment and immobilization technologies, retrieval and treatment of mixed TRU waste stored in the Hanford Tanks, and supplemental pre-treatment. Applying one or more supplemental treatment technologies to the LAW has several advantages, including providing additional processing capacity, reducing the planned loading on the WTP, and reducing the need for double-shell tank space for interim storage of LAW.

In fiscal year 2003, three potential supplemental treatment technologies were evaluated including grout, steam reforming and bulk vitrification using AMEC's In-Container Vitrification™ process. As an outcome of this work, the bulk vitrification process was recommended for further evaluation. In fiscal year 2004, a follow-on bulk vitrification project was initiated to design, procure, assemble and operate a full-scale bulk vitrification pilot-plant to treat low activity tank waste from Hanford tank 241-S-109 under a Research, Development and Demonstration permit. That project is referred to as the Demonstration Bulk Vitrification System (or DBVS). The DBVS project will provide a full-scale bulk vitrification demonstration facility that can be used to assess the effectiveness of the bulk vitrification process under actual operating conditions. The pilot-plant is scheduled to commence operations in late 2005.

The Supplemental Treatment Program represents a major element of the ORP's strategy to complete the pretreatment and immobilization of tank wastes by 2028. This paper will provide an overview of the bulk vitrification process and the progress in establishing the pilot-plant.

INTRODUCTION

As discussed in the previous papers, in order to meet the requirement to treat all Hanford Tank Waste by

2008, it will be necessary to supplement the low-activity waste (LAW) treatment capacity of the Waste Treatment and Immobilization Plant (WTP). This supplement treatment, at a facility currently referred to as the Supplemental Treatment Plant (STP), must meet several mission requirements:

- Treat approximately 47% of the LAW sodium
- Provide pretreatment capability for low curie feed (pre-treated in 1970's and 1980's) and if needed, medium curie waste.
- Produce 31 MT of LAW glass/day (or equivalent if a non-glass technology is chosen)
- Start production concurrent with startup of the WTP in 2011.

In this paper we discuss the current status and direction of the Supplemental Treatment Program at Hanford. The current research and demonstration effort is centered on the Bulk Vitrification technology, but it is not certain that this technology will be the one selected to fulfill the mission needs.

Following a selection process in 2002 and 2003 (see references below for previous Waste Management papers describing this process) two request for proposals were issued in 2003. As a result of the reviews of the proposals in 2004, a decision was made and a contract signed in June 2004 to build and operate a demonstration Supplemental Immobilized Low-Activity Waste (ILAW) Treatment system using in-container vitrification (ICV[1]) technology. This facility has been given the name: Demonstration Bulk Vitrification System – DBVS. The DBVS is intended to provide pilot plant operating information to assist in a decision in 2006 on which technology will be chosen for the Supplemental Treatment Plant at Hanford.

The DBVS project has two major activities: 1) Tank Waste Retrieval and Feed to ICV process, and 2) the DBVS facility where the In-Container Vitrification will be performed.

[1] In-Container Vitrification™ (ICV) is a trademark of AMEC Inc.

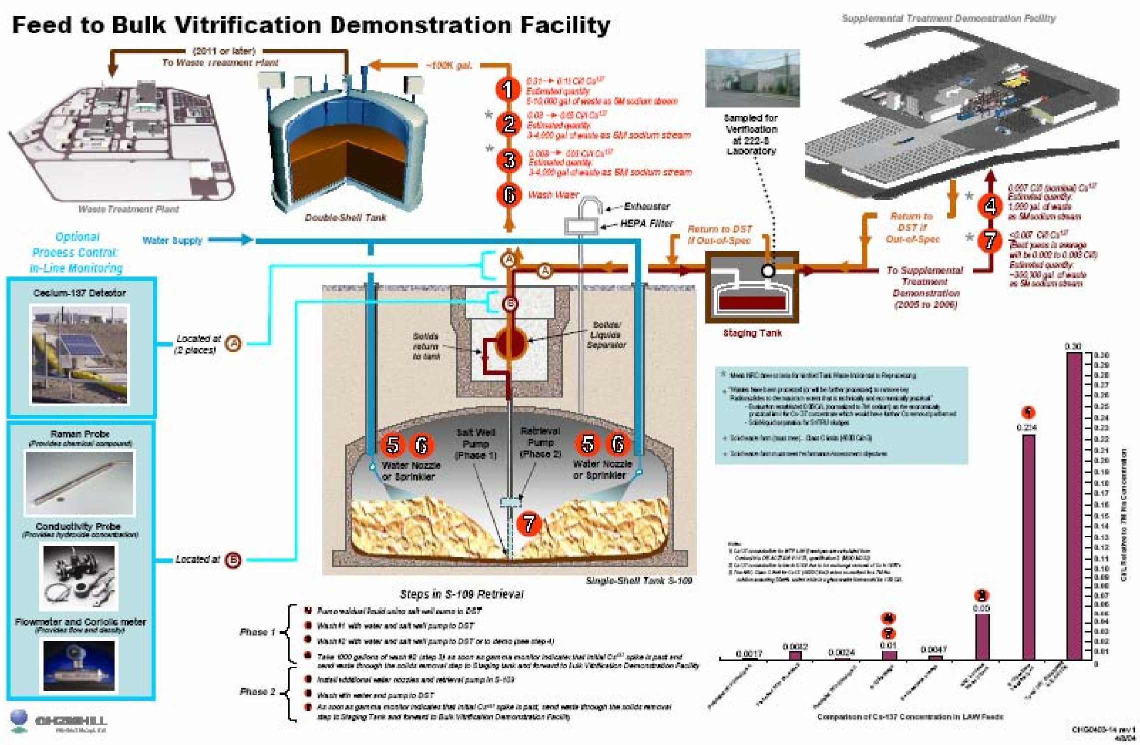

Fig. 1. Waste feed to DBVS

Waste Retrieval and Feed to DBVS

Figure 1 provides a simplified flow diagram for the waste feed to the DBVS. There are four major parts for appropriate waste feed to DBVS:

1. Selection of Tank: Tank 241-S-109 chosen as feed tank for DBVS for three basic reasons:
   - Salt Cake Waste: Tank S-109 contains a total of 2,070,000 L (546,000 gallons) of waste, 2,020,000 l (533,000 gallons) of which is saltcake.
   - Low Cesium Content: The waste in Tank S-109 is residual waste from the cesium separations process used in the 1970's at Hanford which produced cesium capsules. As a result, the waste in S-109 has a lower average Cs concentration than waste stored in the Double Shell Tanks at Hanford. Samples taken from Tank S-109 show an average cesium concentration in the tank of 0.01 Ci/L [2]. The saltcake average (the feed material for DBVS) is even less at 0.0044 Ci/L [1]. This compares to 0.30 Ci/L [1] for a typical DST such as AN-101.
   - Efficiency in use of retrieval systems: Neighboring Tanks S-112 and S-102 are currently being retrieved using similar retrieval methods. Choosing a neighboring tank allows for more efficient usage of retrieval equipment and training.
2. Additional pretreatment of the waste from Tank S-109 will be performed in order to assess its effectiveness. This includes:

[2] These concentrations are reported relative to a 7M Sodium solution for consistency with the agreement for Cs concentration between DOE and the NRC. Current plans are for STP feed material to be at 5M.

- Selective Dissolution: The waste from Tank S-109 will be selectively dissolved in order to further reduce the dissolved cesium sent to DBVS for vitrification. The cesium, which is much more soluble than sodium nitrate or sodium nitrite (predominant chemical species in the saltcake), will be washed off the saltcake and transferred to the Double-Shell Tank (DST) system for future processing in WTP. Gamma detectors will be used to monitor the cesium in the transfer piping to the DSTs. Current predictions based on gamma monitoring of Tank S112 retrieval, predicts that 80% or more of the cesium will transfer out of Tank S-109 while 20% or less of the sodium is retrieved. After cesium concentrations have dropped, subsequent retrieval will be directed to the DBVS.
- Solid/Liquids Separation: A centrifugal separator (hydro-cyclone) will be used to meet the requirement for less than 3% solids carry-over into DBVS. Solids carry-over is important to minimize the TRU content of the waste to meet agreed criteria for management of this waste. This will be monitored using a flow meter and a Coriolis meter, and verified by sampling.
- Feed Material Monitoring: One of the primary requirements of the DBVS project is to provide an acceptable waste product for ultimate disposal. A significant part of meeting this goal is feed material characterization. For DBVS, this is done by collecting the feed material in a feed tank which is then sampled and a certified laboratory waste analysis will be used for this purpose. In order to avoid system delays due to analysis cycle times three feed tanks are provided: One receiving waste, one that has been sampled and is awaiting sample report, and one actively feeding the vitrification melt. Another goal of the DBVS project is to provide data to support real time process monitoring as the basis for waste product quality control for the production STP. For this purpose, a cesium detector, conductivity probe (to measure hydroxide concentration) a Raman Probe (chemical compounds) and flow meter and Coriolis meter (used to measure specific gravity) are part of the data collection system for waste feed to DBVS.

3. Current plans are to feed tank waste to the DBVS in two phases: Phase 1 will use an intermediary staging tank to limit waste feed to less than 3,780 L (1,000 gallons). Waste will be staged in this tank, sampled, verified to be within specifications. A unique jumper will then be moved from connection to S-109 and positioned to provide feed to DBVS. This provides separation and isolation from any potential mis-routing from S-109 to DBVS. Current plans are to use the staging tank up to 3 times prior to proceeding to phase 2.
4. In phase 2 we will feed waste directly to one of the feed tanks at the DBVS facility and by-pass the staging tank. This is the same feed arrangement as is intended for the STP. This phased approach has operational and safety advantages because it allows a staged increase, from none, to minimal, to eventually full chemical and radiological hazard in the DBVS facility. The strategy is to take small steps and learn from them before introducing the more hazardous material into the facility.

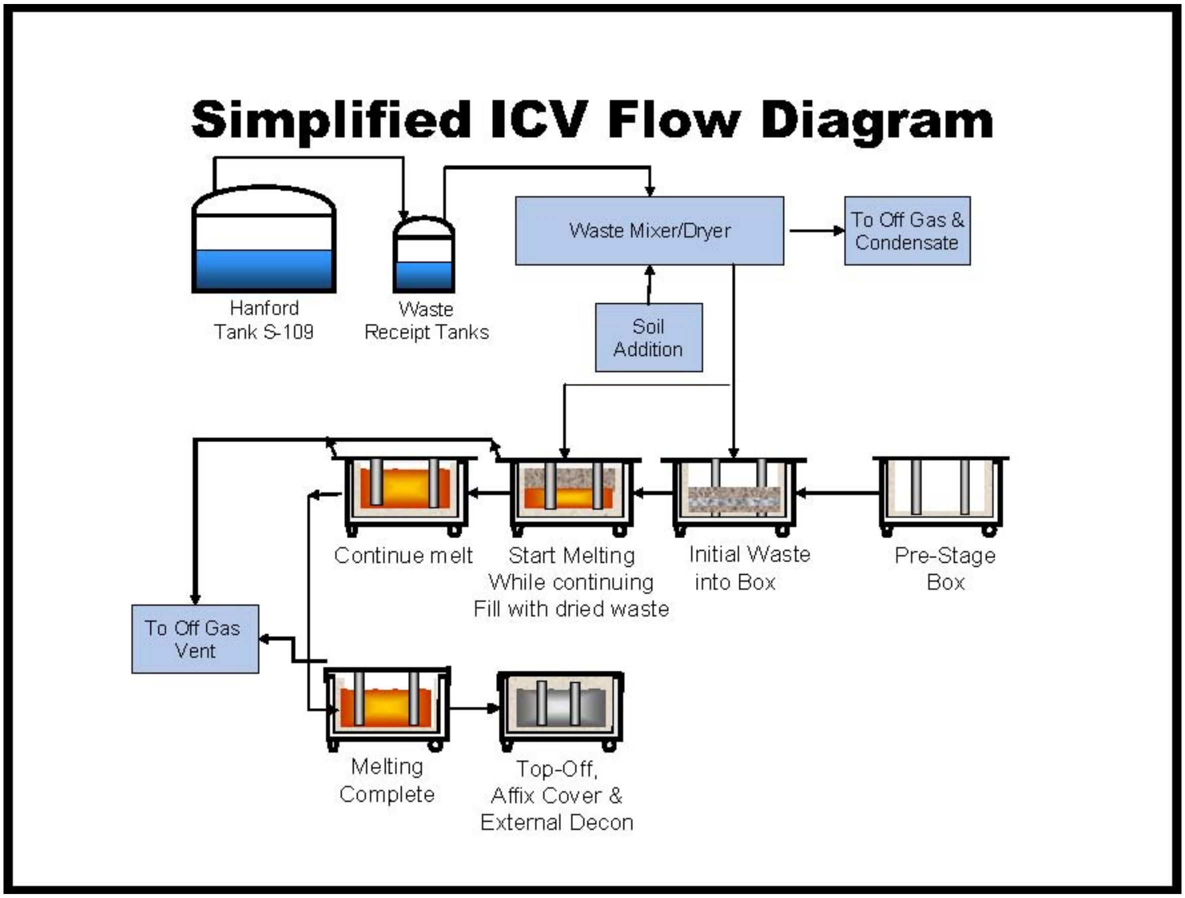

Fig. 2. Simplified in-Container vitrification flow diagram

In-Container Vitrification

Figure 2 provides a simplified flow diagram for the vitrification process planned for DBVS. The disposable melter box (ICV^2), which is also the disposed package, is prepared off-site and then connected to electrical power and to waste and soil feed hoppers at the melt station. About 49,200 L (13,000 gallons) of waste (5M basis) is fed from one of the three receipt tanks in batches to a 10,000 L mixer-dryer. In the mixer-dryer waste is mixed with about 38MT of soil and dried to about 2% moisture. If operated in batch mode, 8 batches will be needed to empty one waste receipt tank.

Electrical power (about 650 KW) is applied while the waste is fed into the ICV^2. The melt occurs at about 1300C for about 140 hours, which includes a cold (non-radioactive) soil melt at the top. After cooling, additional clean (non-radioactive, native) soil is added. The resulting product box contains 43.8 MT glass with 7.7 MT of waste sodium oxide (there is about 2% non-waste Na in typical native Hanford soil).

The box is then contact handled (90 mR/hr center point on top 42 mR/hr center point on long side) and held for sampling at the DBVS site. For DBVS, the product is scheduled for core sampling as part of the waste farm qualification program. Such sampling is not planned for the production STP.

Off Gas Treatment

For the DBVS, the majority of system hardware and cost and most of the facility hazards are in the off-gas system. The contents of the off-gas material from the DBVS are similar for all vitrification processes and include gases (primarily NOx , but includes CO and CO2) and volatile metals (such as Tc and Cs). The off-gas system includes:

- The hood on the ICV[2] box. Current design is for the hood to also be disposed as part of the disposal package. Significant testing has gone into the design of the hood due to the potential for condensation of volatile gasses on the hood during and after the melting process. Observations have shown that off-gassing and condensation happens whenever there is liquid glass.
- A sintered metal filter which provides for a solid recycle of 99.97% of condensable materials in the off-gas system. The temperature of the off-gas stream is dropped just upstream of this filter to allow for this re-cycle process.
- Water and caustic scrubbing
- NOx abatement is performed using Selective Catalytic Reactors (SCRs). In case of SCR failure during a melt a temporary backup NOx abatement system has also been designed into the system. This is a Tri-Mer ™3 submerged bed scrubber.
- HEPA filtration and
- Stack release and monitoring.

Package Sample Holding Area

The DBVS includes provision for sampling and hold for re-sample (if necessary) of up to the full permit limit of 50 boxes. This sampling system then allows the product to be verified as part of the waste form qualification program. This information will also be used to provide a request for Determination of Equivalent Treatment which is needed for a production facility to treat some of the listed components in the waste in some of the tanks.

Research, Development and Demonstration Permit (RD&D)

DBVS will be operated under an RD&D permit (issued 12/12/2004). This permit allows up to 50 ICV[2] boxes to be produced and sampled. It allows no more than 400 operating days and limits treatment to no more than 300,000 gallons from S-109. The DBVS facility will be a new Class 2 nuclear facility in the DOE system and will be operated under a modification to the Tank Farms Documented Safety Analysis (DSA). The primary hazard in the facility is the NOx is the off-gas system.

[3] Tri-Mer™ is a trademark of Tri-Mer Corporation.

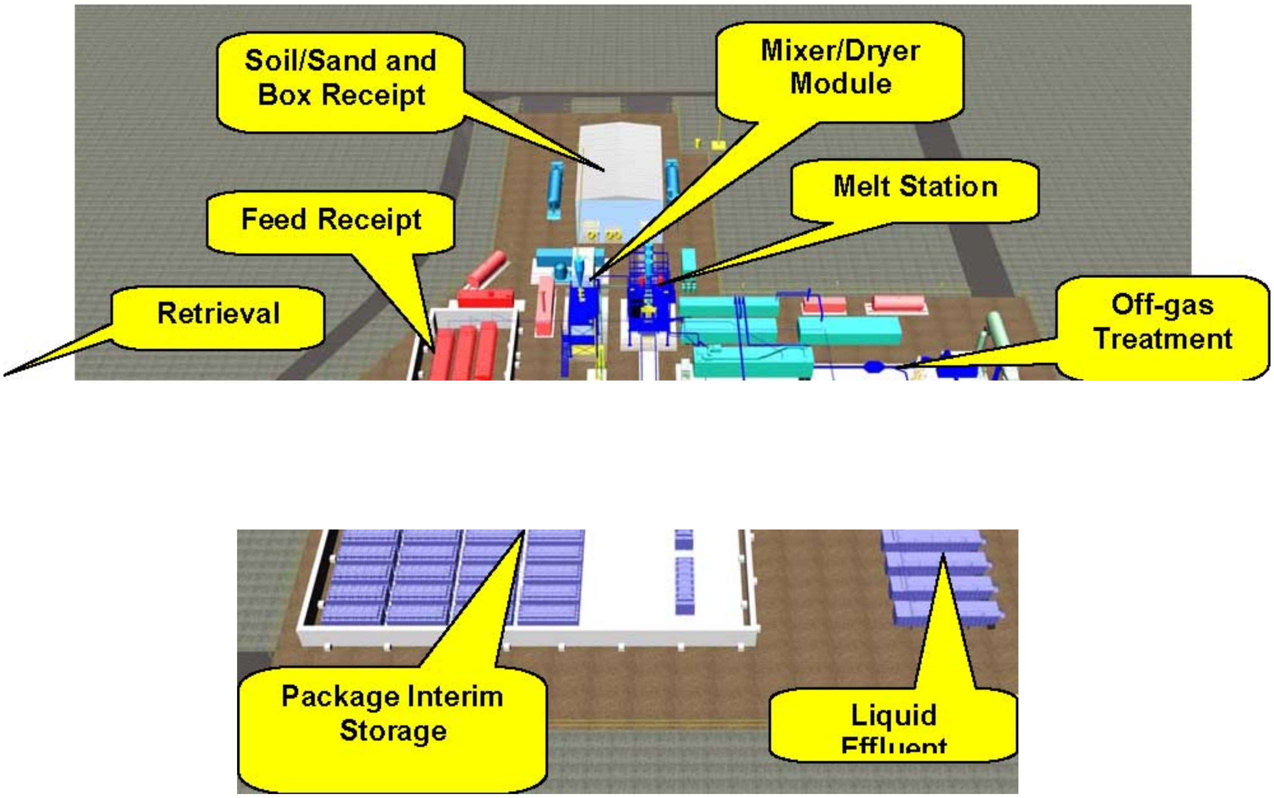

Fig. 3. Facility layout

Facility Layout

Figure 3 provides the general facility layout which shows the Feed Receipt tanks, Mixer/Dryer module, the melt station, off-gas treatment components, Package interim storage, and liquid effluent storage tanks. The facility is located west of S Tank Farm in the 200 West area of the Hanford Site.

Fig. 4. Engineering scale test in progress

Testing in Support of DBVS

Figure 4 shows a picture of an engineering scale test in progress. In Calendar Year 2004, 15 engineering scale (1/6 scale in all dimensions) tests were performed. They have resulted in:

- Improvements in process including feed while melting and reduced Rhenium salts in the package
- Qualification of the use of castable refractory instead of sand immediately next to the glass melt
- Actual tank waste used in engineering scale melt
- Improved feed methods

Supplemental Treatment Program Status and Schedule

The DBVS plant design is currently nearing the 90% completion level. The design is scheduled to be completed in the Spring of 2005 with construction scheduled to start shortly thereafter. Construction and commissioning of the plant will occur through the fall of 2005.

A series of tests with simulants will then follow to confirm that the operator training, operating procedures and equipment are operating properly before conducting tests with actual LAW. The first radioactive test(s) will begin in Winter 2005-2006 and will involve approximately 1,000 gallons of actual waste combined with approximately 12,000 gallons of simulated waste (Phase 1 operations).

Phase 2 operations with full concentration waste from Tank S-109, spiked with various chemicals to test performance with potentially different waste streams will begin in winter 2006.

Information from this testing and waste form qualification will then be incorporated into a decision process as dictated by the Hanford Facility Consent Order (Tri-Party Agreement) in June 2006 (TPA M62-08. Following this the technology for the Supplemental Treatment Plant will be chosen and a baseline established by November 2006 in accordance with TPA M62-11.

The STP is then scheduled for production in 2011, concurrent with WTP production. As currently sized, it must produce 31 MT LAW glass/day with 8 process lines and operate from 1/2011 – 12/2028

ACKNOWLEDGEMENT

CH2M HILL Hanford Group, Inc. acknowledges the DOE Office of River Protection for the programmatic direction and funding provided to carryout the work.

CH2M HILL Hanford Group, Inc. acknowledges AMEC Earth and Environmental for the performance of design, construction, and operation of the In-Container Vitrification™ facility which is an integral part of the DBVS.

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