Progress of the High Level Waste Program at the Defense Waste Processing Facility - 13178

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ABSTRACT

The Defense Waste Processing Facility at the Savannah River Site treats and immobilizes High Level Waste into a durable borosilicate glass for safe, permanent storage. The High Level Waste program significantly reduces environmental risks associated with the storage of radioactive waste from legacy efforts to separate fissionable nuclear material from irradiated targets and fuels. In an effort to support the disposition of radioactive waste and accelerate tank closure at the Savannah River Site, the Defense Waste Processing Facility recently implemented facility and flowsheet modifications to improve production by 25%. These improvements, while low in cost, translated to record facility production in fiscal years 2011 and 2012. In addition, significant progress has been accomplished on longer term projects aimed at simplifying and expanding the flexibility of the existing flowsheet in order to accommodate future processing needs and goals.

INTRODUCTION

Liquid Waste Operations at the Savannah River Site

Since becoming operational in 1951, the Savannah River Site has produced nuclear material supporting a number of national interests including defense, research, medical, and space programs. These activities resulted in the generation of large quantities of radioactive waste that are currently stored in large underground waste storage tanks. Continued long-term storage of these radioactive wastes poses a potential environmental risk. Thus, the focus of the Liquid Waste Organization of the Savannah River Site is to safely store, remove, treat, and disposition legacy radioactive waste in an effort to significantly reduce this environmental risk.

The waste inventory currently stored at the Savannah River Site is a complex mixture of insoluble metal hydroxide solids and soluble salt supernate. The insoluble solids component of the radioactive waste represents a small portion of the overall volume of radioactive waste on site (approximately 8%), but represents almost 50% of the total curies [1]. By contrast, the soluble salt supernate (present in the form of salt supernate and concentrated crystalline saltcake) represents an overwhelmingly large portion of the overall volume of radioactive waste on site (approximately 92%), and an equal portion of the total curies [1]. The insoluble solids are treated at the Defense Waste Processing Facility via vitrification, stabilizing the High Level Waste in a final borosilicate glass waste form. The soluble salt waste is treated to remove the radionuclides from the non-radioactive salts in the waste and then sent to the Saltstone Facility, which disposes of the Low Level Waste in a cementitious waste form. The High and Low Level Waste programs are not mutually exclusive, but require careful integration and planning to successfully achieve tank closure. Thus, the success of both the High Level Waste and Low Level Waste programs at the Savannah River Site are critical to reducing environmental risk at the Savannah River Site. An overview of the Liquid Waste Operations is provided in Figure 1.

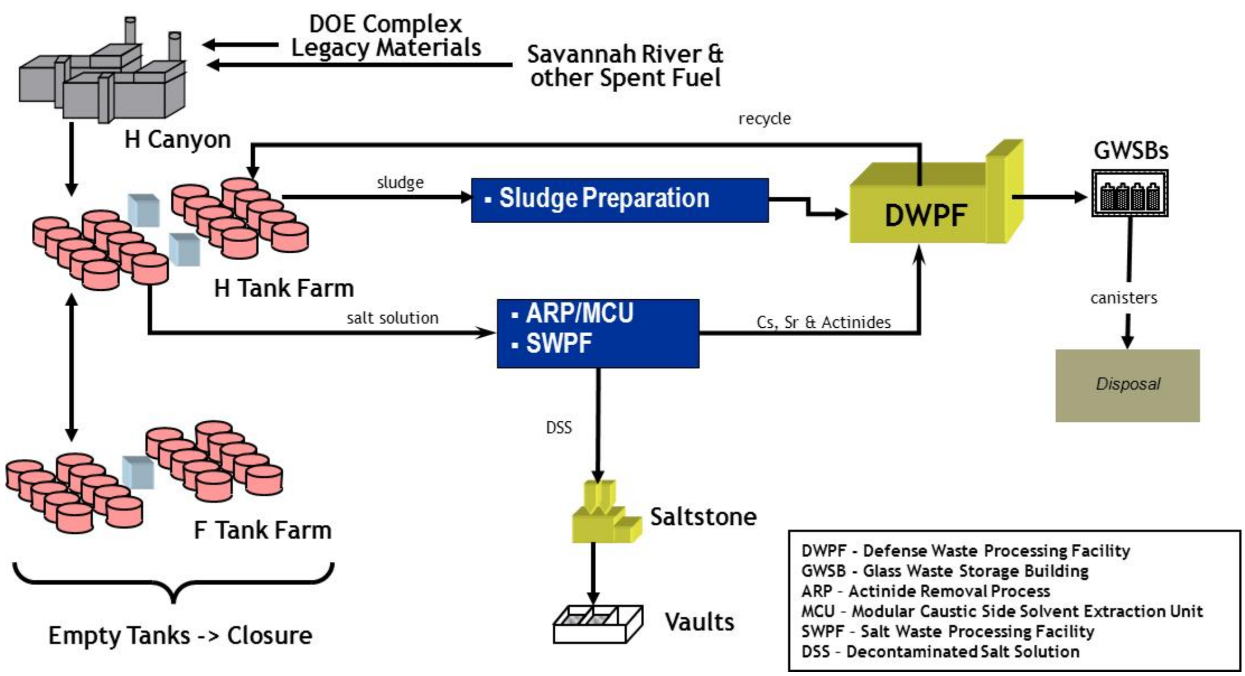

Fig. 1. Overview encompassing the High and Low Level Waste programs of the Liquid Waste Organization at the Savannah River Site.

High Level Waste Program

Final processing of High Level Waste generated from the production of nuclear material at the Savannah River Site since the 1950s (approximately 136 million liters) occurs at the Defense Waste Processing Facility by first treating the waste via a complex sequence of controlled chemical reactions, followed by blending the treated waste with glass formers. The blended waste is then vitrified into a borosilicate glass form, and the resulting molten glass poured into stainless steel canisters.

Nominally, 22,500 liters of sludge is received on a batch basis in the Sludge Receipt and Adjustment Tank from a 3.7 million liter feed tank. The sludge is chemically adjusted in the Sludge Receipt and Adjustment Tank via addition of concentrated nitric and formic acids. The purpose of the chemical adjustment is to acidify the incoming sludge to adjust the rheological properties to improve processing, remove mercury from the sludge feed, and to prepare the sludge feed for melter operation by controlling the reduction/oxidation state of the glass. The Sludge Receipt and Adjustment Tank also receives and processes by-products from salt processing, namely an actinide-rich stream containing primarily monosodium titanate solids as well as a cesium-rich dilute nitric stream (see Figure 1). Following chemical adjustment and concentration in the Sludge Receipt and Adjustment Tank, the sludge material is transferred to the Slurry Mix Evaporator where the material is blended with frit (glass former). The Slurry Mix Evaporator represents a hold point in the process to ensure the contents will produce acceptable glass (based on statistical process control rather than statistical quality control). Upon confirmation that the blended Slurry Mix Evaporator material is acceptable, the material is transferred to the Melter Feed Tank, which represents a transition in the process from a batch to continuous process, as the Melter Feed Tank continuously feeds the melter. During normal operation, the melter constantly receives a small stream of slurry from the MFT (nominally 3.8 liters per minute) and melts the feed through the use of an electric current which is passed through the melt pool by two sets of electrodes, resulting in heat-up of the melter feed (i.e. Joule heating). Molten glass from the melt pool is then transferred into stainless steel canisters for permanent immobilization. An overview of the Defense Waste Processing Facility is provided in Figure 2.

Since commencing operations in 1996, the Defense Waste Processing Facility has processed approximately 15 million liters of radioactive sludge slurry over the course of eight campaigns. In addition, the Defense Waste Processing Facility has successfully accommodated receipt of by-products from salt waste processing since 2007. This paper will provide a brief summary of progress made to date with respect to the processing of High Level Waste at the Defense Waste Processing Facility. The summary will include challenges introduced in an effort to support the acceleration of tank closure at the Savannah River Site by providing an overview of recent facility and flowsheet modifications implemented to improve overall throughput by 25%. In addition, this paper will summarize progress on long-term projects aimed at simplifying and expanding the flexibility of the existing flowsheet to accommodate future processing needs and goals.

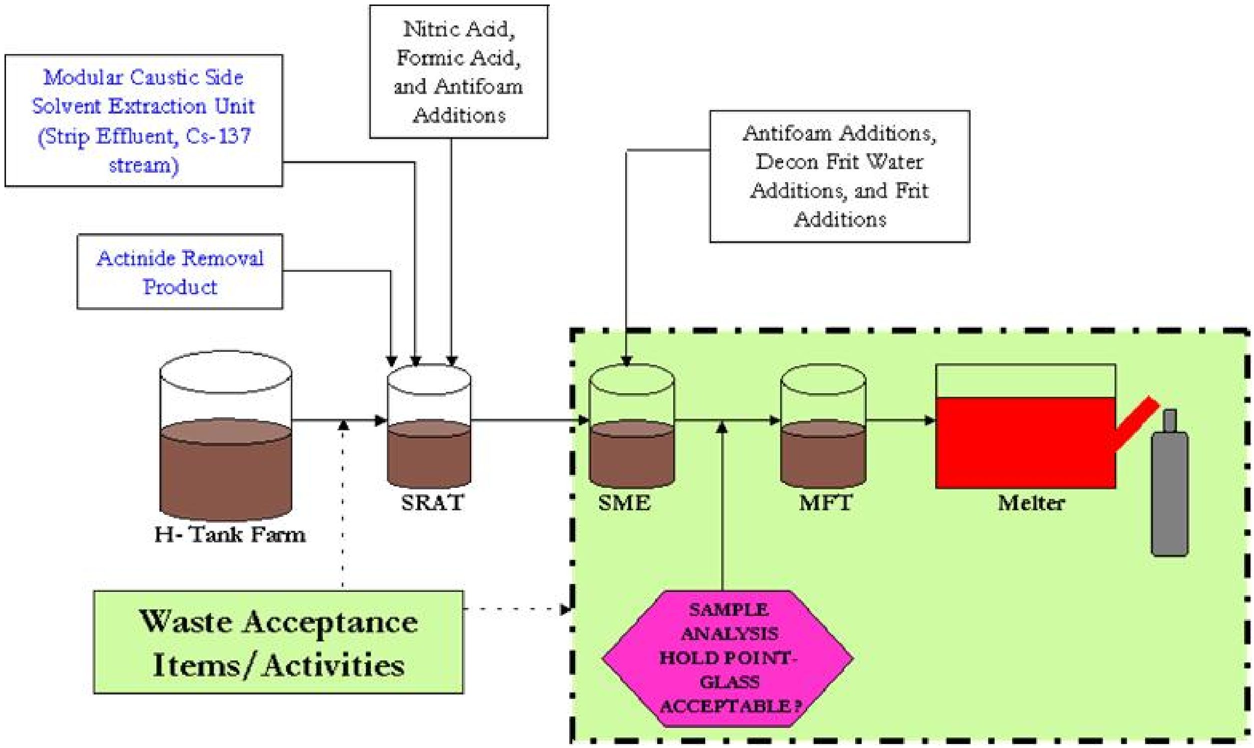

Fig. 2. Schematic providing an overview of the current Defense Waste Processing Facility flowsheet.

DISCUSSION

Short-term Facility Improvements and Accomplishments

Throughput of High Level Waste at the Defense Waste Processing Facility is critical to support the timely closure of underground waste tanks and to accommodate Low Level Waste initiatives. To support an increase in throughput of High Level Waste, modifications were made in September 2010 to retrofit the Melter with a bubbler system to promote higher glass production rates by decreasing temperature gradients within the melt pool. Typically, Melter performance has been the rate limiting factor for the throughput of High Level Waste at the Defense Waste Processing Facility. However installation of the bubbler system removed the Melter as the rate limiting step and refocused efforts to the Melter feed preparation. Whereas improvements to Melter throughput were achieved through an optimized alteration of the technical baseline of the facility, changes to Melter feed preparation (encompassing chemical adjustment and blending with glass formers) were achieved through process optimization, requiring minimal cost and risk to the facility. Improvements to Melter feed preparation included the reduction of analytical cycle time as well as a reduction in the impact of the analytical cycle time on the process. For example, new samplers were installed in the analytical cells which reduced downtime related to equipment failures and decreased sample turn-around time. In addition, certain analyses are now performed in parallel with processing (i.e. "sample-and-send"), significantly improving cycle time while adding no new risk to the facility. Though these efforts improve the overall cycle time of the Melter and Melter feed preparation, throughput was also increased by performing a cost/benefit analysis of the sludge transfer evolution from the Tank Farm to the Defense Waste Processing Facility, resulting in more mass of insoluble solids treated on a per batch basis.

Combined efforts to reduce the overall cycle time required to produce Melter feed and increase throughput through the Defense Waste Processing Facility successfully improved facility production by approximately 25%. Figure 3 shows the number discrete canisters poured in each of the last five years of production. Since the installation of Melter bubblers and associated optimization of the Melter feed preparation in 2010, a record number of canisters have been produced in each of the last two years. Prior to 2010, no single month of production resulted in more than 30 canisters produced. Since implementation of facility improvements, the Defense Waste Processing Facility has achieved monthly canister production numbers in excess of 30 canisters in 8 of the last 24 months, including a record of 37 canisters produced in the month of December 2011. In addition, the facility demonstrated the capability (based upon an instantaneous twelve month rolling total) to produce up to 337 canisters in a given year, which is the highest rolling twelve month total observed since commencement of operation in 1996. This increase in production has been achieved in conjunction with an increase in waste loading (defined by the mass of calcined waste per mass of glass produced), resulting in more overall throughput in the Defense Waste Processing Facility, which is critical to the mission of the Liquid Waste Organization.

Status on Long-term Projects for Facility Improvement

Though throughput has achieved an all-time high at the Defense Waste Processing Facility with implementation of Melter bubblers and optimization of the existing flowsheet, current work aims to further improve production in order to reduce environmental risk by accelerating tank closure. Current work focuses on longer term projects which focus on simplifying and expanding the flexibility of the process, specifically addressing the Melter feed preparation. Among the most promising of these projects is the Alternate Reductant Project, which was initiated by Savannah River Remediation to explore options for the improving the current nitric-formic flowsheet used for preparation of Melter feed at the Defense Waste Processing Facility. The goals of the Alternate Reductant Project are to reduce cycle time of Melter feed preparation, increase mass throughput of the facility, provide operational flexibility, and reduce operational hazards.

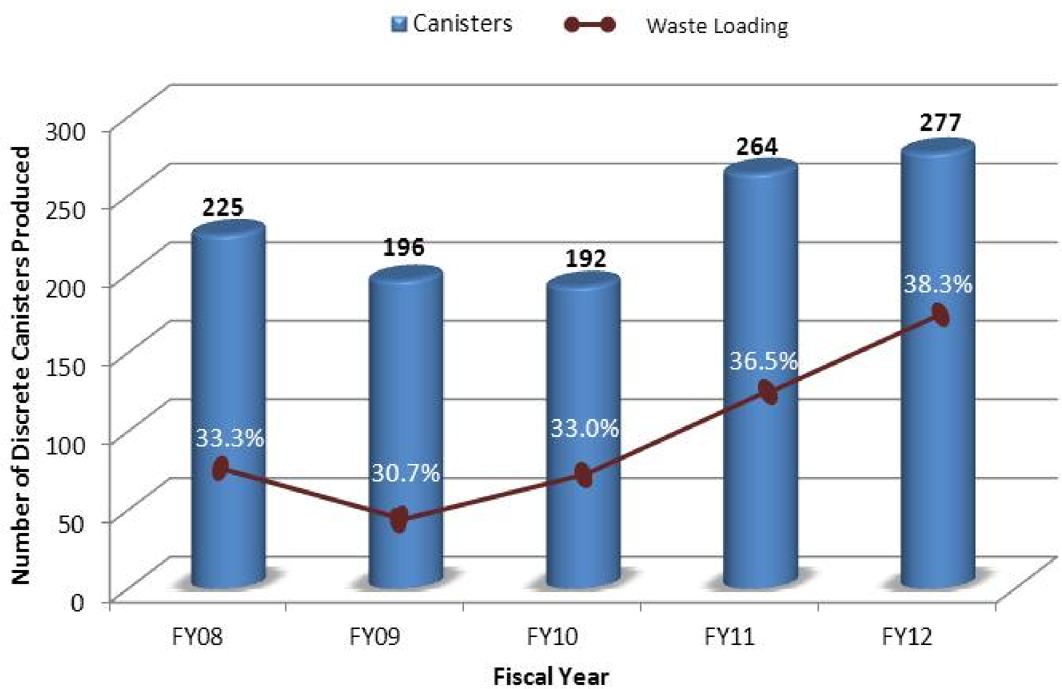

Fig. 3. Number of discrete canisters poured and their associated averaged waste loadings (defined as the mass of calcined waste per mass of glass produced) for the last five years of production at the Defense Waste Processing Facility.

As of July 2011, the Savannah River National Laboratory and Energy Solutions/Vitreous State Laboratory completed initial flowsheet development work for two potential alternatives to the current nitric-formic flowsheet. Based upon this work, a Systems Engineering Evaluation was initiated to down-select an alternate reductant flowsheet for further development. A nitric-glycolic flowsheet which minimizes or replaces formic acid with glycolic acid was ultimately selected for further development. This decision was made on the basis of a number of process and business impacts in conjunction with results from the initial development work performed by the two laboratories [2].

In 2012, significant developmental advances were made via testing with a nitric-glycolic acid flowsheet [3,4]. During the developmental testing, a number of potential improvements were noted that relate directly to further improving facility production. For example, minimal catalytic hydrogen was detected in the Sludge Receipt Adjustment Tank and Slurry Mix Evaporator. Hydrogen, produced as a by-product of the current flowsheet, is a potentially flammable gas which has to be diluted with a large air purge to prevent a flammable mixture from forming. The hydrogen produced during Melter feed preparation is currently measured by Safety Significant gas chromatographs in the facility. Based on the reduction in catalytic hydrogen observed during testing at the Savannah River National Laboratory, the gas chromatographs may be downgraded to Production Support, and lower air purges may be achievable for the Sludge Receipt and Adjustment Tank and Slurry mix Evaporator process vessels. The reduction in air purges would improve the operating efficiency of the Defense Waste Processing Facility Process Vessel Vent System. In addition to lower hydrogen production, lower CO_2 and N_2O production has also been observed. This may reduce the frequency of potential carryover events in the process vessels. Lower overall off gassing could translate into higher operating levels and boil up rates for the process vessels, translating to reduced cycle times and increased mass throughput. In addition, the replacement of formic acid with glycolic acid also eliminates the large pH increase (8 to 10) as observed during Melter feed preparation for the baseline nitric-formic acid flowsheet. As the pH rises, the rheological properties tend to deteriorate resulting in the facility targeting lower weight percent total solids to overcome rheological issues. This impacts the total mass per unit volume processed resulting in fewer canisters per given batch of feed processed. The resulting melter feed from the glycolic flowsheet has lower rheological properties which should make viscous sludges easier to process and allow further concentration of the melter feed compared to the baseline flowsheet.

Development work has thus far shown significant potential in terms of improving production at the Defense Waste Processing Facility. However, a significant amount of work remains to support implementation of the new flowsheet. To this end, Savannah River Remediation has issued a detailed description of the project risks and the testing required to close these risks [5]. Figure 4 shows a high level summary of the progression of the planned work scope related to the Alternate Reductant Project. Phase I testing was completed in 2012 and Phase II testing, which optimizes the flowsheet closes any remaining project risks is fully funded for 2013. Phase III of the project deals solely with facility implementation.

Other long-term initiatives aimed at improving High Level Waste processing include developing strategies for accessing higher waste loadings, resulting in less canisters produced per unit mass of insoluble solids received from the Tank Farm. This initiative has the potential to significantly reduce the footprint of the final waste form and reduce costs associated with canister procurement and storage. Multiple initiatives are also on-going which address a reduction in the amount of recycle water generated by the facility and sent back the Tank Farm for processing. A reduction in the amount of water added to the facility via various unit operations has the potential to significantly reduce cycle time of the Defense Waste Processing Facility while reducing the burden on the Tank Farm evaporators. Lastly, the facility is working a number of initiatives in anticipation of accommodating by-products from increased salt waste throughput. The desire is to create flexibility within the facility to be able to integrate with ongoing initiatives to increase salt waste processing.

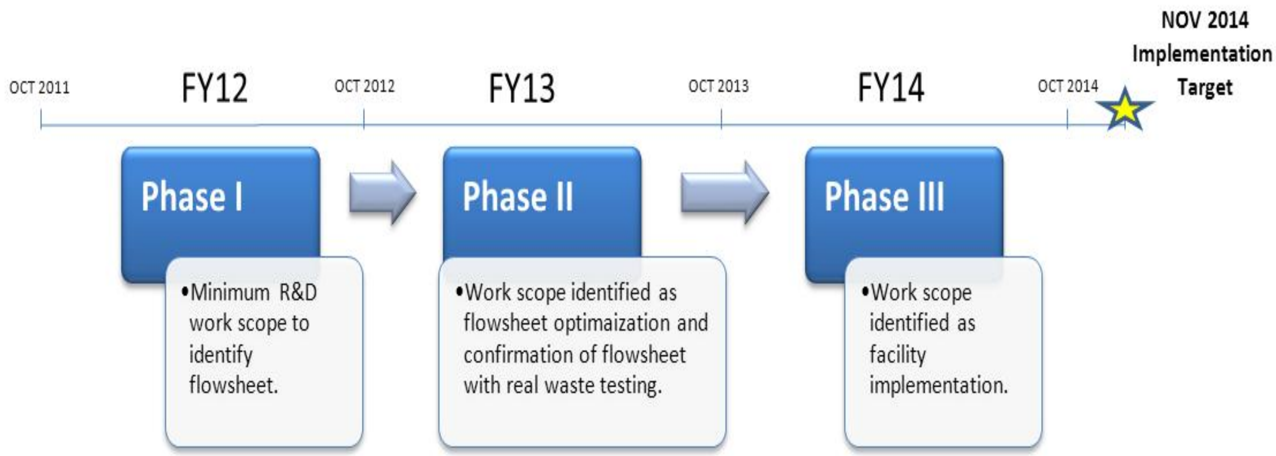

Fig. 4. High level summary of the planned work scope related to the Alternate Reductant Project for the Defense Waste Processing Facility.

CONCLUSIONS

The High Level Waste program at the Savannah River Site significantly reduces environmental risks associated with the storage of radioactive waste from legacy efforts to separate fissionable nuclear material from irradiated targets and fuels. In an effort to support the disposition of radioactive waste and accelerate tank closure at the Savannah River Site, the Defense Waste Processing Facility recently implemented facility and flowsheet modifications to improve production by 25%. These improvements translated to record facility production in fiscal years 2011 and 2012. In addition, significant progress has been accomplished on longer term projects aimed at simplifying and expanding the flexibility of the existing flowsheet in order to accommodate future processing needs and goals.

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