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Saltstone Enhancements and Performance during 1st year of Salt Waste Processing Facility Operations - 22388

Andrew Jezewski
Savannah River Remediation, Aiken, SC

ABSTRACT

The Savannah River Site (SRS) Saltstone Production Facility (SPF) processes low-activity liquid waste and immobilizes the decontaminated salt solution (DSS) into a non-hazardous cementitious waste form (saltstone) suitable for safe disposal in a Saltstone Disposal Unit (SDU). These SDUs are suitable for long-term storage and disposal of the solidified saltstone. Radioactive startup of the SPF was authorized in 1990 by the Department of Energy (DOE). Since 2015, however, the SPF has processed 23.5 million liters (6.22 million gallons) of DSS into multiple different SDUs. The current SDU design differs from the previous five in that this "Mega SDU" can hold a volume of up to 125 million liters (33 million gallons) of saltstone, versus the 21.2 million liters (5.6 million gallons) – 75.7 million liters (20 million gallons) for the existing SDUs. All future SDUs are planned to have similar volumes as this SDU configuration (namely referred to as "SDU-6 type SDUs"); the seventh SDU was recently commissioned into service in 2021, and an estimated five more are remaining to be built.

The SPF has an essential role in SRS safely processing DSS, with an annual throughput of salt solution increasing from approximately 2.8 million liters (0.74 million gallons) on average per year to up to greater than 45.4 million liters (12 million gallons) per year in the future due to the increased throughput from the Salt Waste Processing Facility (SWPF). For FY21 approximately 11.35 million liters (3 million gallons) of DSS was processed.

With the markedly increased throughput needed to support SWPF, continuous improvements to the safety, reliability, and efficiency of the SPF are necessary to support the Liquid Waste Organization (LWO). Some of these initiatives include the enhanced low activity waste disposition (ELAWD) initiative, along with cement-free processing. These initiatives have positioned the SPF to handle the increased throughput of DSS, supporting dispositioning activities. The ELAWD initiative has been an ongoing effort since 2012, with the most recent phases of implementation occurring in 2021. The ELAWD initiative enhanced the capabilities of the bulk material handling (BMH) system and the process room system to allow for easier transporting of dry materials needed for saltstone processing (namely cement, fly-ash, and slag) and modifications to components such as the Saltstone Hopper Overflow Container (SHOC) (a catch-all container in the case of an upset condition in the process room).

Cement-free material processing, which uses two dry feed materials instead of three requires only two of the four silos for SPF processing. This new modification allows for flexibility in processing: for example, two silos can be used for processing while maintenance activities occur on the other two, or two silos can be filled with the same dry material, which may allow for longer continuous processing times. Also, fewer different types of dry material delivery trucks are needed to refill the silos.

In support of the increased throughput in the first year of SWPF, many SPF processing parameters have changed to accommodate SWPF operations. The most notable is the increased level in the Salt Solution Receipt Tanks, which increased from ~57,000 liters (15,000 gallons) per tank to ~227,000 liters (60,000 gallons). This increase in level was made possible because of the lower activity of the DSS entering SPF (from ~77.7 million Bq/L [0.008 Ci/gal] of β/γ to ~24.42 million Bq/L [0.0025 Ci/gal] of β/γ).

These enhancements to the SPF are important to the overall LWO mission of waste disposition. By implementing these changes, SPF processing capabilities have increased drastically, so much so that

record volumes of waste have been processed all within the last fiscal year, with new milestones being set each processing window.

INTRODUCTION

The SRS SPF processes low-activity liquid waste primarily from the Effluent Treatment Project (ETP) and SWPF and immobilizes the DSS into a non-hazardous cementitious waste form called saltstone. The SPF processing systems include dry BMH and storage, salt solution storage and processing, Saltstone Mixing and Transfer (SSMT), and SDU filling. Previously cement, slag, and flyash were unloaded from trucks, now just slag and flyash, and pneumatically conveyed to storage silos. The dry feeds are discharged from the silos, weighed, and blended to produce a premix. Salt solution is received from outside areas through the inter-area transfer system and stored in a feed tank. The premix and salt solution are fed to a continuous mixer to produce grout. The grout is pumped to an SDU, where it hardens to form saltstone. The saltstone is a leach resistant solid that is non-hazardous as defined by regulations. The saltstone waste form and the SDU limits migration of the chemical and radioactive constituents such that the groundwater at the disposal site boundary will meet drinking water standards. Radioactive startup of the SPF was authorized in 1990 by the Department of Energy (DOE), with first disposal into a SDU occurring shortly thereafter. Since startup SPF has processed a total of approximately 76.47 million liters (20.2 million gallons) of DSS through FY21. Since 2015, however, the SPF has processed 23.5 million liters (6.22 million gallons) of DSS into multiple different SDUs.

As the SPF is the sole processing facility for DSS, the processing quantity is not only dependent on the facilities capability to process, but the available quantity of DSS to process. With the recent commissioning of the SWPF, a new facility for the processing of radioactive salt waste, the SPF was expected to support a markedly increased production of DSS with an annual throughput of salt solution increasing from approximately 2.8 million liters (0.74 million gallons) on average per year to up to greater than 45.4 million liters (12 million gallons) per year in the future due to the increased throughput from SWPF. For FY21 approximately 11.35 million liters (3 million gallons) of DSS was processed.

DISCUSSION

With the marked increase in expected throughput for SPF to support SWPF production, continuous improvements to the safety, reliability, and efficiency of the SPF were necessary to ensure the LWO mission of waste disposal was successful. Some of these initiatives include the enhanced low activity waste disposition (ELAWD) initiative, the "Mega SDU" initiative, cement-free processing, and other adjustments to processing parameters. These initiatives have effectively positioned the SPF to handle the increased throughput of DSS from SWPF.

Enhanced Low Activity Waste Disposition

The ELAWD initiative has been an ongoing effort since 2012, with the most recent phases of implementation occurring in 2021. ELAWD was broken into multiple portions to be effectively implemented in a phased approach to maintain facility processing capabilities as much as possible throughout the span of the initiative.

The first phase of the ELAWD initiative consisted of modifications to the SSMT system. The SSMT system needed significant improvements in order to satisfy the expected increased production rates and minimize process interruptions. The SSMT system consists of the necessary components for mixing and transfer of the grout from the SPF process room to the SDUs. As a result, redesigns of the Mixer, Grout Hopper, Process Piping, Pulsation Dampeners, and SHOC (components of the SSMT system) ensued.

The SPF mixer, which is the initial component in the flow of the SSMT system [Fig 1], was replaced with a new model consisting of a two-piece barrel design with split wet and dry end mechanical seals for increased operating durations and ease of installation. Additional mixer paddle assembly design iterations have been made to minimize the amount of wear experienced on the mixing paddles during processing. Mixer paddle changes have included a base material change to Astralloy V compound, for its material hardness properties and resistance to wear, as well a change to the paddle assembly configuration.

Following the proper mixing of premix dry feeds and DSS, the grout is gravity-fed to the grout hopper located beneath the saltstone mixer. This grout hopper was replaced as part of the ELAWD initiative to include a larger working volume and better access for maintenance. Additionally, the hopper was affixed with nozzles to allow spraying of the hopper interior for post processing cleaning. The new hopper is a 1700-liter (450-gallon) capacity stainless steel 2-piece vessel with an agitator and cone bottom discharge outlet to minimize grout buildup while maximizing accessibility in the case of any upset conditions. The level in the grout hopper is monitored and controlled by the Distributed Control System (DCS) by varying the speed of the grout pump.

The grout pump, provided to transfer grout to the SDUs, is a dual head positive displacement peristaltic type pump. To ensure a flooded suction to the grout pump and prevent pumping of a grout-air mixture that could disturb process instrumentation, the grout hopper is used to provide a surge capacity for the grout pump and dampen process control oscillations. The ELAWD initiative ensured the piping installations in association with the grout pump and SSMT system had no low points between the grout hopper and pump, and all process piping connections were converted to true “Y-connections” to ensure better flow characteristics of grout. The outlets of the grout pump were equipped with dual pulsation dampeners to minimize vibrations of the process piping downstream.

In addition, the grout hopper and grout pump were fitted with overflow/vents to drain to the SHOC, which provides material containment in the event of an upset condition in the grout production process. Due to the increased size of the grout hopper the SHOC was retrofitted with a capacity of approximately 1700 liters (450 gallons) at overflow and is located in the regulated process room area. The SHOC, the grout hopper via the overflow line to the SHOC, and the grout pump via the pump head vent lines to the SHOC are vented to the Facility Process Vessel Vents (PVVs). The SHOC has a bubbler level indicator which has high-level alarms to alert the operator to potential upset conditions. The SHOC overflows to the process room floor drain which is routed to the Saltstone Feed Tank (SFT). The SHOC is designed to be removed following an upset condition by the process room overhead crane.

The latest phase of the ELAWD initiative included what are called the SHOC Recovery Modifications. These modifications included the addition of a SHOC recovery pump to the SSMT system and additional instrumentation to prevent a SHOC overflow into the process room trench during an upset condition.

The new SHOC recovery pump, a single head positive displacement pump, allows the SPF to pump the contaminants of the SHOC during an upset condition. Due to the nature of the contaminants in the grout, overflow of the SHOC into the process room trench is a very labor-intensive process to remove and the new SHOC recovery pump prevents the SHOC overflow. Other enhancements in association with the SHOC recovery modifications include conductivity probes in the grout pump vent lines to warn of process upsets, and associated flush water piping and valves to accommodate process water flushing following use of the pump.

The second phase of ELAWD effectively enhanced the capabilities of the BMH system. The BMH system consists of the bulk material unloading and conveying system, premix blending and conveying system, and the premix feeder system. To allow for a greater throughput of DSS, the BMH system needed to be capable of supporting a greater dry material throughput. As a result, the BMH was equipped with an additional dust collector, additional slide gate valves between the silos and batch weigh hopper, improved process air compressors, additional silo bin aeration, and pre-mix screw-feeder replacement. These enhancements to the

BMH system, completed in 2020, have allowed for easier and more consistent transporting of dry materials during saltstone processing.

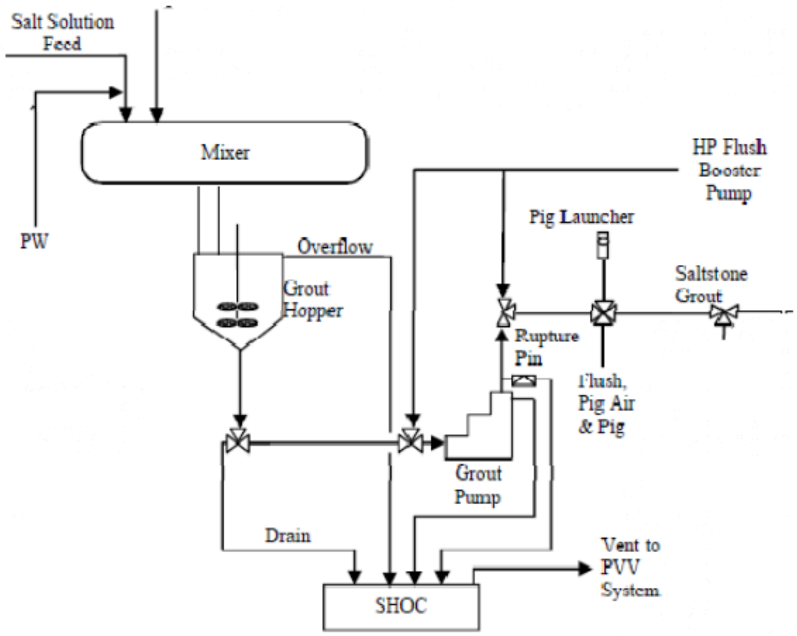

Fig. 1. SSMT System.

Mega Saltstone Disposal Units

In support of the increased processing throughout the years and the expected markedly increased throughput from the operation of SWPF, a change in SDU design was necessary. The current SDU design differs from the previous five in that this "Mega SDU" can hold a volume of up to 125 million liters (33 million gallons) of saltstone, versus the 21.2 million liters (5.6 million gallons) – 75.7 million liters (20 million gallons) for the existing SDUs. All future SDUs are planned to have similar volumes as this SDU (namely referred to as "SDU-6 type SDUs"); the seventh SDU was recently placed into service in 2021, and an estimated five more are remaining to be built.

Cement-Free Processing

An additional initiative to improve the SPF processing capabilities includes cement-free material processing. Legacy SPF processing consisted of a 45/45/10 weight percent blend of the dry feed materials used in SPF processing (45 wt% blast furnace slag (BFS), 45 wt% class f fly ash (FA), and 10 wt% ordinary Portland cement (OPS)). Prior to processing, these dry feed materials are stored in four silos outside of the SPF. Each independent dry feed material has a dedicated silo, with an additional fourth silo acting as a spare, as seen in Figure 2.

The change to cement-free processing consists of altering the dry feed material weight percent blend to 60/40 BFS/FA. This two-component formulation simplifies the procurement, transportation, off-loading, and storage of the dry feed materials, compared to the three-component, and increases the storage capacity for the individual components (i.e., two silos each dedicated to BFS and FA). This results in longer continuous processing times due to the increased quantity of available dry feed material.

Cement-free processing has also resulted in minor but beneficial changes in process parameters. Due to the nature of the cement-free formulation, the grout produced has a lower viscosity, lower yield stress, and lower density. The fresh densities of the cement-free and standard formulations are not significantly different with the cement-free grout being around 1.69 g/cm^3, as compared to 1.743 g/cm^3 previously. These lower coefficients allow the slurry to be easier mixed and pumped throughout the system.

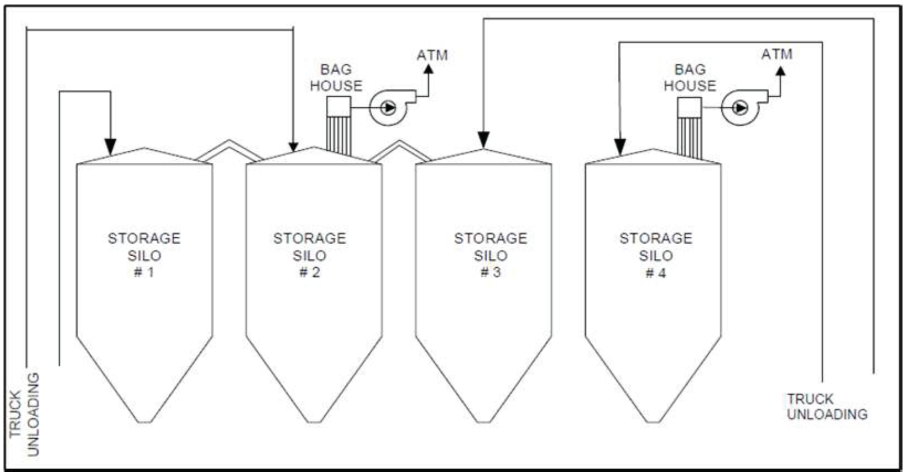

Fig. 2. Silo Storage.

Processing Parameters

In support of the increased throughput in the first year of SWPF, many SPF processing parameters have changed to accommodate SWPF operations. The most notable is the increased level in the Salt Solution Receipt Tanks, which increased from ~57,000 liters (15,000 gallons) per tank to ~227,000 liters (60,000 gallons). This increase in level was made possible because of the lower activity content of the DSS entering SPF (from ~77.7 million Bq/L [0.008 Ci/gal] of β/γ to ~24.42 million Bq/L [0.0025 Ci/gal] of β/γ) and associated fire safety standards.

Other processing parameters that are being adjusted to support increased processing include grout line pressure, grout pump current, mixer current, and grout pump vibrations. Each of these parameters are instrumental in the effort to increase processing times from the current 8-9 hours per run to 10 hours to the eventual goal of 24-hour continuous processing.

CONCLUSION

These enhancements to the SPF have been instrumental to the overall LWO mission of waste disposal. By implementing these changes, SPF processing capabilities have increased dramatically, so much so that record volumes of waste have been processed in the last fiscal year. The SPF has processed 14 million liters (3.7 million gallons) during the first year of SWPF operation (since October 6, 2020) with most recently 14 days straight processing a total of nearly 1.89 million liters (500,000 gallons) of DSS.

Process improvements are instrumental to the entire DOE complex, not only for purposes of progression over time but also as a proactive measure of risk assessment and implementation of engineered controls. Not only has the SPF continuously improved upon it's process to support the DOE complex, but we continue to evaluate and explore more processing parameters to ensure these enhancements are performing as expected.

REFERENCES

[1] G-SD-Z-00003, SALTSTONE FACILITY - SYSTEM DESIGN DESCRIPTION (U) SALTSTONE PROCESS