Evaluating Liquid Waste Transfers and their Impacts to the SRS Tank Farm to Support Operations and Closure

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ABSTRACT

The Liquid Waste (LW) contractor at the Savannah River Site, Savannah River Mission Completion (SRMC), supports the storage, processing, and safe disposition of legacy, radioactive liquid waste. The LW Tank Farms contain approximately 127 million liters (33.5 million gallons) of liquid waste within 43 active, underground waste tanks. To meet mission critical milestones for the closure of waste tanks and processing of 34 million liters (9 million gallons) of salt waste per year by the LW Salt Waste Processing Facility (SWPF), an increase in Tank Farm operations, including waste tank transfers, is required. Waste is compiled in salt and sludge batches in the Tank Farms and transferred to SWPF and the Defense Waste Processing Facility (DWPF) for treatment.

All waste tank transfers, such as waste removal and batch compilation transfers, must be pre-evaluated to ensure Documented Safety Analysis (DSA) requirements are met via Evaluated Transfer Approval Forms (ETAFs). Facility conditions and configurations may change as a result of a waste transfer. These changes must be reflected in the Tank Farms Emergency Response Datasheet (ERD), which contains data utilized for operation and emergency situations.

With the start-up of hot operations at SWPF in October of 2020, the number of transfers and, consequentially, ETAFs and ERDs has significantly increased to support its operation. ETAFs are completed within an online application called the Waste Characterization System (WCS) Online. WCS Online contains current tank chemistries and configurations. The ETAF specifies initial and final conditions of the transfer tank and receipt tank, required compensatory measures and controls, and recommendations prior to, during, and following waste tank to waste tank transfers. If a DSA requirement is not met in the evaluation, WCS Online flags it and requires an outside evaluation to be performed. ETAFs and outside evaluations analyze regulatory conditions such as flammability, corrosion, sludge carryover minimization (SCOM), facility waste acceptance criteria (WAC), and transfer controls. If a non-conservative change to the facility is identified in the ETAF, the ERD is updated with the most conservative conditions prior to transfer initiation.

In addition to an increase in transfers needed to support tank closures and SWPF, more flexibility in the ETAF evaluations and ERD must be considered as the conditions of the facility fluctuate frequently. Facility adjustments and the timing of transfers may change due to the weather, transfer or mixing equipment challenges, procedure development, or outside facility needs. Evaluating the waste tanks over a wide range of conditions and ensuring the most conservative outputs are incorporated in the ETAF and ERD allows the facility to adjust accordingly and continue operating. Flexibility may be provided by permitting simultaneous transfers into or out of the tanks, multiple uses of ETAFs, and raising or lowering of transfer devices, mixing devices, and high liquid level conductivity probes (HLLCP).

This paper describes the development of ETAFs and ERDs to ensure DSA requirements are met, facility conditions are properly recorded, and flexibility is provided to the Tank Farms to remain fluid and prevent operational delays. Effective operation of the Tank Farms allows waste tanks to be closed sooner and

provides sufficient material for the increasing processing rates at SWPF and DWPF. ETAFs and ERDs used to support operation of the Tank Farms are key factors for SRMC mission completion.

INTRODUCTION

Since 1954, the Tank Farms have safely stored nuclear waste generated at SRS from the processing of nuclear materials for national defense, research, medical programs, and outer space missions. The Tank Farms is made up of two areas, H and F Tank Farm, containing a total of 51 waste tanks, with 8 operationally closed and grouted. The waste tanks are characterized into four groups by their design: Type I, Type II, Type III/IIIA, and Type IV. Type I and II waste tanks have a partial secondary containment, Type III/IIIA have a full height secondary containment, and Type IV does not have a secondary containment. Of the Type I and II tanks, some have known leak sites and have leaked a small volume of material into their containment. Of the active waste tanks, no Type III/IIIA or IV waste tanks have leaked [1,2].

Waste tanks in the Tank Farms contain radioactive waste in the form of supernate, sludge, saltcake, or a combination of these forms. Supernate and saltcake make up approximately 91 percent of the volume of waste remaining in the Tank Farms, but only around half of the curie content. Sludge makes up approximately 9 percent of the volume of waste and the remaining half of the curie content [3].

A focus of SRMC is the closure of Tank Farm tanks in the water table, Type I and Type II tanks, that are a higher risk to the community and the environment. To remove waste for waste tank closure, sludge must be slurried and saltcake must be dissolved into a salt solution. Slurrying of sludge and dissolution of salt is generally accomplished by mechanical operation of a mixing device and addition of mixing media. Water is commonly used as the mixing media to increase salt dissolution and sludge slurrying effectiveness. Following mixing, the salt solution or sludge slurry is transferred out to another waste tank. Solids soundings, camera inspections, or both are performed to determine the extent of removal of this material. If further saltcake dissolution or sludge slurrying is required, mixing media must be added and the process is repeated. Salt solution is transferred out to a salt solution hub tank or a salt solution blend tank. This material will then be utilized for compilation of salt batches and transferred to SWPF for treatment. Sludge slurry material is transferred to a sludge hub tank or a sludge feed preparation tank. This material will then be utilized for compilation of sludge batches and transferred to DWPF for treatment [4].

For any type of waste tank to waste tank transfer, an ETAF must be completed. ETAFs are developed using WCS Online, an application containing the current conditions of all Tank Farm waste tanks and associated DSA requirements. These conditions include the chemical and radiological composition, solids levels, HLLCP set points, and safety analysis values for hydrogen concentrations and waste temperatures. These conditions are either directly compared to DSA requirements or are compared following background calculations performed using DSA methodology in the application. For ETAFs, the program is able to quickly and accurately analyze waste tank conditions prior to, during, and following a transfer. Using this information, it provides regulatory requirements, compensatory measures, and recommendations for the transfer. In the event a transfer results in a non-conservative change to a waste tanks conditions or the facility, the ERD is required to be updated with this information prior to the initiation of the transfer [5].

The original development of the ERD was to contain a snap-shot of the current conditions of the Tank Farm facilities for use in emergency situations. Today, the ERD still serves this role, but includes additional information to support day to day operations. Emergency information includes waste stream dose concentrations in the event of a leak, waste tank flammability emergency response priority, and fill limits. Operational information includes conditions needed to support salt dissolution, sludge removal, evaporator operation, such as temperatures, number of days before mixing devices need to be operated to release flammable gas from sludge solids, and sample frequency [6]. The ERD contains conservative information to ensure the safe operation of the facility. Information in the ERD is updated via WCS Online or from information in external evaluations. When an ERD change is made, the facility uses an implementation procedure to ensure all effected roundsheets and procedures are updated and any necessary actions are taken [7].

To achieve SRMC milestones for closure of higher risk waste tanks and a processing rate of 34 million liters (9 million gallons) at SWPF, the frequency to complete ETAFs and ERD revisions has increased. Innovative thinking can be used to challenge the standard approach to ETAFs and ERDs development while still remaining within the safety envelope of the DSA. Inputs to ETAFs may be adjusted or evaluated over a range to provide flexibility to operations. Assumptions may be made on the front end and confirmed prior to approval of an activity to avoid delayed start of the ETAF. ERD changes for multiple upcoming activities may be incorporated in as few ERD revisions as possible to avoid delays to processing. These innovations are key to achieving SRMC milestones.

DISCUSSION

With the increased need for material to feed SWPF and DWPF, as well as the need to meet tank closure milestones, the frequency and amount of Tank Farm activities will inherently continue to increase. For SWPF to process 34 million liters a year (9 million gallons), a salt batch must be compiled and qualified in 45 days. Historically, each salt batch has received material from three to five salt solution hub tanks or source tanks, with the majority of salt batches receiving transfers from four different waste tanks [8]. As material is used to compile salt or sludge batches, it must be replenished. The waste removed from tanks being closed is a main source of material for salt and sludge batches.

Most regulatory requirements verified in the ETAF fall under the flammability, corrosion, SCOM, WAC, and transfer control programs. The flammability program evaluates the generation and release of hydrogen gas based on the conditions of the tank during scenarios such as mixing of sludge, salt dissolution, seismic events, and loss of ventilation. The program ensures activities that may cause a flammable condition do not occur [9]. The corrosion control program protects the waste tanks and equipment from corrosion, such as stress and pitting, to ensure the integrity is maintained for their intended service life [10]. The SCOM program defines criteria for designation of transfer type, supernate or sludge slurry, and methods for determining the volume of sludge transferred during sludge slurry transfers [11]. The facility WACs provides information on the controls for transfers between facilities and ensures the transfers are compatible with the facility specific DSA requirements [12]. The transfer control program provides information on controls for the transfer of material in the Tank Farms, such as transfer flushing requirements, siphon potentials, and inhalation dose potential (IDP) [13].

If the ETAF determines a DSA requirement is not met, an external evaluation performed outside of WCS Online may be required or changes to the activity must be made. WCS Online has certain analysis limitations, such as the inability to model salt dissolution or calculate the inhalation dose potential (IDP) of a sludge slurry transfer. These types of calculations require external evaluations be performed. Identification of the need for an external evaluation is important to reduce delays to the approval of an ETAF, and therefore the transfer.

WCS Online has an environment where scenarios can be evaluated without impacting the live application, called ‘Sandbox’. When possible, ‘Sandboxes’ are performed to become informed of any changes that may need to be made to meet DSA requirements or external evaluations that must be performed prior to a transfer. Early identification of changes or external evaluations needed for an ETAF that impact the ERD facilitate better management of ERD revisions with fewer impacts to facility activities.

When an ERD impact is identified, the ERD is required to be updated with changes from the ETAF or from an external evaluation prior to the activity. This is so necessary changes are implemented in the facility in preparation for the activity and emergency conditions are correct. With increased processing in the Tank Farms, multiple activities being evaluated may have ERD impacts that must be implemented prior to their initiation. An ERD must be fully implemented before implementation of the next ERD revision is started. This may cause conflict and delay to activities. For example, when an HLLCP is moved, the ERD must be updated to reflect the new level and any associated impacts. The facility cannot implement the ERD until the physical work has been completed. If a transfer in a different tank is planned to occur at a similar time and has ERD impacts, it may not be possible to generate and implement these two ERDs without delaying an activity.

To avoid conflicts like this, ERD management has significantly increased with the increase in facility activities. All expected ERD changes are identified as early as possible and combined into the fewest amount of ERD revisions. For a situation with an HLLCP move and a transfer with similar timing, planning ahead and capturing both activity changes in one ERD is done when possible. This has been accomplished by increasing communication between operations, engineering, and project teams to establish clear priorities and explanation of limitations for ERD implementation, as well as early identification of activity impacts via ‘Sandbox’ and implementation of a weekly ERD planning meeting.

Prior to a waste transfer, additional information may be needed to meet DSA requirements. Project teams may also request additional information be obtained to increase the extent of a waste removal effort. The level of solids and the transfer device suction setpoint in a waste tank are two key parameters that may be needed for these reasons. A turbidity meter is a tool used to determine the level at which solids are present in a waste tank. The meter is equipped with a light and photoresistor. The resistance measured is based on the amount of light detected by the photoresistor. When a turbidity meter is lowered into a waste tank, the solids level is determined at the point when a significant resistance change is measured, indicating the presence of solids blocking the light [14].

If mixing of sludge, salt dissolution, or a sludge slurry transfer occurs, a turbidity may be used to reestablish the solids level or the volume of solids within the tank [11,14]. The solids level and transfer device suction level establish the type of transfer, supernate or sludge slurry, based on SCOM program guidelines. The level and volume of solids serve as inputs to WCS Online and external evaluations that affect operational abilities to dissolve saltcake or mix sludge. Project teams seeking to increase their operational ability for waste removal by decreasing flammability evaluation constraints imposed by the level of solids may request additional settling time or multiple readings to establish lower solids level. As an input to evaluations, paperwork can only be started once this information is known. In specific situations, a turbidity measurement may be foregone and conservative assumptions may be used to support a waste tank transfer. An example of this is not re-establishing a new solids level in a waste tank that received a sludge slurry transfer and assuming the maximum amount of sludge from the transfer tank was carried over. This allows activities to occur quicker but may reduce waste removal operational abilities.

Once the solids height is established, the transfer device may need to be adjusted to meet SCOM requirements or to achieve a desired salt dissolution or sludge removal goal. A transfer device adjustment may require manual handwheel turns, a crane to be moved, and shims to be added to achieve the target level. The time to complete a transfer device adjustment will depend on how large of an adjustment is needed, personnel availability, and equipment availability.

To prevent a delay from being unable to start an ETAF without the exact transfer device location, the specific scenario and conditions of the waste tank are evaluated to determine if an alternative approach exists. If the transfer device suction level is being used to meet SCOM separation criteria requirements for a supernate only transfer or if only a certain volume of sludge is allowed to be transferred, the exact transfer device level must be specified on the ETAF. To avoid delays to key transfers and to make effective use of time while a transfer device is being adjusted, an ETAF may be started in advance of the physical transfer device adjustment with an assumed level. The ETAF is then held for approval until the transfer device adjustment is complete and the position is verified. If the position does not match the evaluated ETAF level, the ETAF may require re-evaluation.

To meet closure requirements, efforts are made to remove as much waste as possible. This goal can be achieved by placing transfer devices as low as possible in the waste tank. Multiple attempts of physically lowering the transfer device may be required and involve adjusting or removing equipment in the waste tank, on top of the waste tank, or extension pieces on the transfer device to ensure the lowest level is achieved. This work delays the transfer and the expected transfer device level may not be known until the work is complete. With the expectation the transfer device will be as low as possible in the waste tank and if the tank contains sludge, it is conservative to assume the transfer will be a sludge slurry and all the sludge is transferred to the receipt tank. A range of transfer device suction levels may be provided on the ETAF. Making these conservative assumptions prevents delays from waiting for physical work to be completed before the ETAF is approved and avoids re-work of the ETAF if the exact, targeted level is not achieved.

Mixing devices are used for waste removal and require a minimum liquid coverage be maintained while running to prevent waste aerosolization (e.g., rooster tailing) [15]. It has been observed that as saltcake or sludge is removed from waste tanks, the lower layers of this material are more difficult to dissolve or remove. Due to this, mixing device liquid coverage requirements, and the use of water as mixing media, multiple batches of dilute material may be generated. Dilute material may cause an environment favorable for corrosion.

As a result of scenarios like this occurring, Tank 35 has received multiple transfers of dilute material that have resulted in the chemistry not meeting corrosion compliance. Tank 35 is a Type IIIA waste tank and serves as a salt solution and sludge hub tank [3]. Because of this, it is a highly utilized waste tank for waste removal material to be transferred to and is expected to remain as a hub tank for the long-term future [4]. It is crucial the conditions of the tank be closely monitored to ensure longevity of the tank, while also remaining available to support various projects at the same time.

The effects of being out of corrosion compliance can result in limitations to processing. When a Type III/IIIA waste tank is non-corrosion compliant, remediation and sampling to confirm corrosion compliance are required within a set period of time. To remediate a tank, a transfer must be made in with material to bring the chemistry back into compliance. If no material from other waste tanks is available to reestablish corrosion compliance, corrosion inhibitors such as sodium hydroxide or sodium nitrite must be added. Addition of chemicals reduces the space in Tank 35 available for other waste tank material. The time it takes for chemicals to be ordered and added can cause delays to processing. Lead time for requisition of chemicals takes an average of two to four weeks. Additionally, only a certain number of tanker trucks can be unloaded in a workday and tankers only arrive on weekdays. To reduce the volume of chemicals added, highly concentrated chemicals are used. Upon addition of these chemicals, the tank must be mixed if the density of the chemicals is significant different than the material in the tank [10]. This ensures the chemicals do not sink to the bottom, with the surface chemistry remaining non-compliant. Due to the nature of dilute chemistry causing corrosion non-compliance, mixing is common during remediation.

Tank 35 contains a small portion of sludge solids and mixing disturbs them. Once the tank is mixed, a transfer out from the waste tank must be considered a sludge slurry transfer unless a turbidity measurement or an engineering evaluation is performed and SCOM separation criteria is met. Sludge slurry transfers from Tank 35 to the salt solution blend tanks are to be avoided. This is to prevent restricting the capability of compiling salt batches in the blend tanks due to flammability evaluation constraints imposed by the addition of sludge solids. Furthermore, sludge slurry transfers from salt blend tanks to the salt feed tank are prohibited [15]. Transfers out of Tank 35 to a salt solution blend tank are frequent and are expected to increase in frequency as SWPF processing rates increase. At the current conditions of Tank 35, it has been observed that seven to ten days of solids settling is required to obtain a turbidity measurement to meet SCOM separation criteria [16].

To reduce delays to waste removal projects and salt or sludge batch compilation due to corrosion control constraints, remediation methods have been improved. Although space is a constraint, excess chemicals may be ordered to preemptively treat the tank to remain corrosion compliant for expected transfers in. Transfers in may be permitted during the time waiting for chemicals to arrive or simultaneously with the chemical additions. The volume of chemicals ordered and added must account for this additional material. Simultaneous transfers are a new approach to reduce processing delays and requires adjustments to the standard ETAF methodology. As such, the ETAF must evaluate any chemicals that are being added during the duration of a transfer and the transfer and receipt tank levels and transfer volumes must be adjusted accordingly.

CONCLUSION

As processing continues to increase, efforts must be made to ensure the Tank Farm is prepared to meet mission critical milestones. All facets of the process are examined for improvements to their effectiveness and efficiency while remaining in DSA compliance. Many steps are involved for compilation of salt and sludge batches and waste removal for tank closure. Development of the ETAF and ERD play a major role in our ability to accomplish milestones and ways to improve upon our standard approach continue to be investigated.

Delays are expected to occur by the nature of work at SRMC. Equipment failures, replacements, and adjustments take time away from being able to process material. Additional delays can occur due to weather, procedure development, or outside facility changes. These delays may be unpredictable, while some can be expected. The need for external evaluations, solids level measurements, transfer device adjustments, and development of an ETAF and ERD can be expected. Innovative approaches can be made for expected and unexpected conditions to support flexibility in processing.

Utilization of 'Sandbox' in WCS Online to evaluate activities in advance helps determine if any changes are identified for the ERD and if external evaluations are required. Additionally, open communication with the facility about upcoming activities and an understanding of ERD implementation limitations are used to combine ERD impacts from multiple activities into as few ERD revisions as possible. These methods reduce delays to activities requiring ERD changes.

Early initiation and completion of ETAFs allows for increased processing of material in the Tank Farms. Conservative assumptions may be made to avoid the need for turbidity measurements and setbacks to ETAF initiation. If transfer device adjustments are needed, the ETAF can be initiated with the assumed level prior to the physical work being completed. If difficulties occur while adjusting equipment, in certain cases, a range of levels may be provided to avoid delay and re-work of the ETAF.

If waste removal efforts result in corrosion non-compliance, efforts can be made to reduce delays associated with remediation. Using highly concentrated chemicals, addition of excess chemicals, and allowing transfers in while awaiting chemicals or during chemical additions are examples of approaches being taken.

These approaches are important to ensure mission critical milestones, such as waste tank closures and an increased SWPF processing rate, are achieved in a timely manner. Improvements to our process allow crucial operational tanks, like Tank 35, and tanks undergoing waste removal for tank closure to have more flexibility and less delays to processing. This is done through an understanding of hold points in the process, DSA requirements, and necessary communication within and across facilities.

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