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STATUS OF MECHANICAL SLUDGE REMOVAL AND COOLING COIL CLOSURE AT THE SAVANNAH RIVER SITE – F TANK FARM CLOSURE PROJECT- 9225

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F-Tank Farm Closure Project

ABSTRACT

The Savannah River Site F-Tank Farm Closure project has successfully performed Mechanical Sludge Removal using the Waste on Wheels (WOW) system within two of its storage tanks. The Waste on Wheels (WOW) system is designed to be relatively mobile with the ability for many components to be redeployed to multiple tanks. It is primarily comprised of Submersible Mixer Pumps (SMPs), Submersible Transfer Pumps (STPs), and a mobile control room with a control panel and variable speed drives. These tanks, designated as Tank 6 and Tank 5 respectively, are Type I waste tanks located in F-Tank Farm (FTF) with a capacity of 2839 cubic meters (750,000 gallons) each. In addition, Type I tanks have 34 vertically oriented cooling coils and two horizontal cooling coil circuits along the tank floor.

DOE intends to remove from service and operationally close Tank 5 and Tank 6 and other HLW tanks that do not meet current containment standards. After obtaining regulatory approval, the tanks and cooling coils will be isolated and filled with grout for long term stabilization.

Mechanical Sludge Removal of the remaining sludge waste within Tank 6 removed ~ 75% of the original 25,000 gallons in August 2007. Utilizing lessons learned from Tank 6, Tank 5 Mechanical Sludge Removal completed removal of ~ 90% of the original 125 cubic meters (33,000 gallons) of sludge material in May 2008. The successful removal of sludge material meets the requirement of approximately 19 to 28 cubic meters (5,000 to 7,500 gallons) remaining prior to the Chemical Cleaning process.

The Chemical Cleaning Process will utilize 8 wt% oxalic acid to dissolve the remaining sludge heel. The flow sheet for Chemical Cleaning planned a 20:1 volume ratio of acid to sludge for the first strike with mixing provided by the submersible mixer pumps. The subsequent strikes will utilize a 13:1 volume ratio of acid to sludge with no mixing. The results of the Chemical Cleaning Process are detailed in the “Status of Chemical Cleaning of Waste Tanks at the Savannah River Site – F Tank Farm Closure Project – Abstract 9114”.

To support Tank 5 and Tank 6 cooling coil closure, cooling coil isolation and full scale cooling coil grout testing was completed to develop a strategy for grouting the horizontal and vertical cooling coils.

This paper describes in detail the performance of the Mechanical Sludge Removal activities and SMP operational strategies within Tank 5. In addition, it will discuss the current status of Tank 5 & 6 cooling coil isolation activities and the results from the cooling coil grout fill tests.

INTRODUCTION

SRS, one of the facilities in the DOE complex, was constructed during the early 1950s to produce nuclear materials. The site covers approximately 800 square kilometers (310 square miles) in South Carolina and borders the Savannah River. The tank farms were constructed to receive High Level Waste generated by various SRS production, processing, and laboratory facilities. The use of the tank farms isolates these wastes from the environment, SRS workers, and the public. In addition, the tank farms enable radioactive decay by aging the waste, clarification of waste by gravity settling and removal of soluble salts from waste by evaporation. The tank farms also pretreat the accumulated sludge and salt solutions (supernate) to enable the management of these wastes at other SRS facilities (i.e., Defense Waste Processing Facility (DWPF) and Saltstone Disposal Facility (SDF)). These treatment facilities convert the sludge and supernate to more stable forms suitable for permanent disposal. The F-Tank Farm (FTF) is a 90,000 square meter (22-acre) site consisting of 22 waste tanks, 2 evaporator systems, transfer pipelines, 6 diversion boxes, and 3 pump pits. Tanks 5 and 6 are located in FTF. The Federal Facility Agreement (FFA) between the SCDHEC, the DOE, and EPA was issued to “govern the corrective/remedial action process for site investigation through site remediation and describe procedures for the process.” The FFA establishes the regulatory framework for the operation, new construction, and eventual closure of the liquid waste tank systems. [Reference 1]

The FFA results in enforceable timetables for the closure of tanks as well as provisions for new construction and prevention and mitigation of releases or potential releases from the tank systems. SRS tanks such as Tanks 5 and 6 that do not meet secondary containment standards, as established in the FFA, must be removed from service per the FFA schedule. There are a total of 24 tanks at SRS that do not meet the secondary containment standards and are scheduled for closure by 2022. Twelve of these non-compliant tanks are in F Tank Farm. Two F Tank Farm tanks, Tank 17 and Tank 20 have been previously closed, and Tanks 5 and 6 in addition to Tanks 18 and 19 are the next tanks scheduled for closure.

Tanks 5 and 6 are two of eight Type I tanks in the FTF. A typical Type I tank is shown in Figure 1. These waste tanks have a nominal operating capacity of 2,840 cubic meters (750,000 gallons).

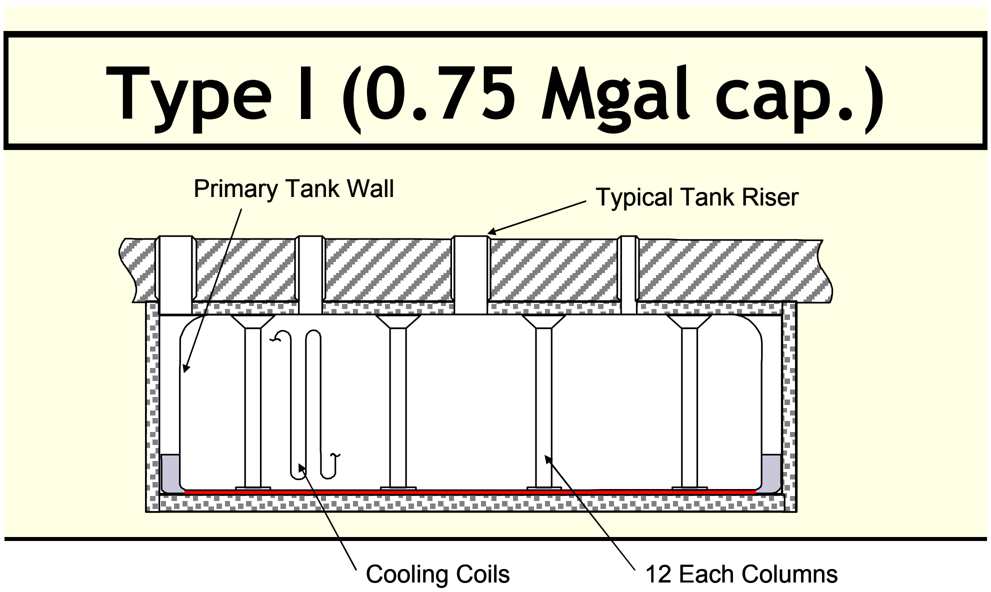


Figure 1 – SRS Type I Underground Tank

The primary liner for Type I tanks are cylinders made of 12.7 mm (½ inch) ASTM A285-50T carbon steel. The inner radius of the primary container is 11.4 meters (37.5 feet), and the inner height is 7.5 meters (24.5 feet). The walls of the primary container are welded to the top and bottom of the waste tank by a 12.7 mm (0.5 inch) thick, curved knuckle plate. An 24.4 meter (80 foot) inner diameter vault surrounds the Type I tank primary container, creating a .8 meter (2.5 foot) wide annulus (the upper portion is formed by the concrete vault while the bottom is formed by the 1.6 meter (5 foot) carbon steel shell). The vault is formed by a reinforced concrete roof and walls that surround the primary container and connect to the base slab. A layer of backfill covers the top of the waste tank. Twelve concrete and steel columns support the roof of a Type I tank. These columns were made from steel pipes welded to a steel bottom plate. The pipes are 12.7 mm (½ inch) thick carbon steel with a .6 meter (2 foot) outside diameter, and are filled with concrete. The columns have flared capitals at the top filled with concrete. The bottom of the columns is cylindrical and has eight 25 mm (one inch) thick stiffeners on each column. The columns are welded to the top and bottom of the primary container.

The Type I tanks are equipped with a cooling system. The tanks have 34 vertical cooling coils that are supported by hanger and guide rods that are welded to the primary liner. Two horizontal cooling coils extend across the bottom of the tanks and are supported by guide rods welded to the bottom of the primary liner. The cooling coils are 5.1 cm (2-inch) diameter schedule 40 carbon steel seamless pipe.

HLW PROCESSING SUMMARY

Tank 5 began receiving high heat waste in March 1959 and became filled by May 1960. Tank 6 began receiving high heat waste in November 1964 and became filled by October 1966. The liquid waste levels in both tanks fluctuated over the following decades as supernate was periodically decanted to feed the 1F evaporator system, and fresh waste was periodically added.

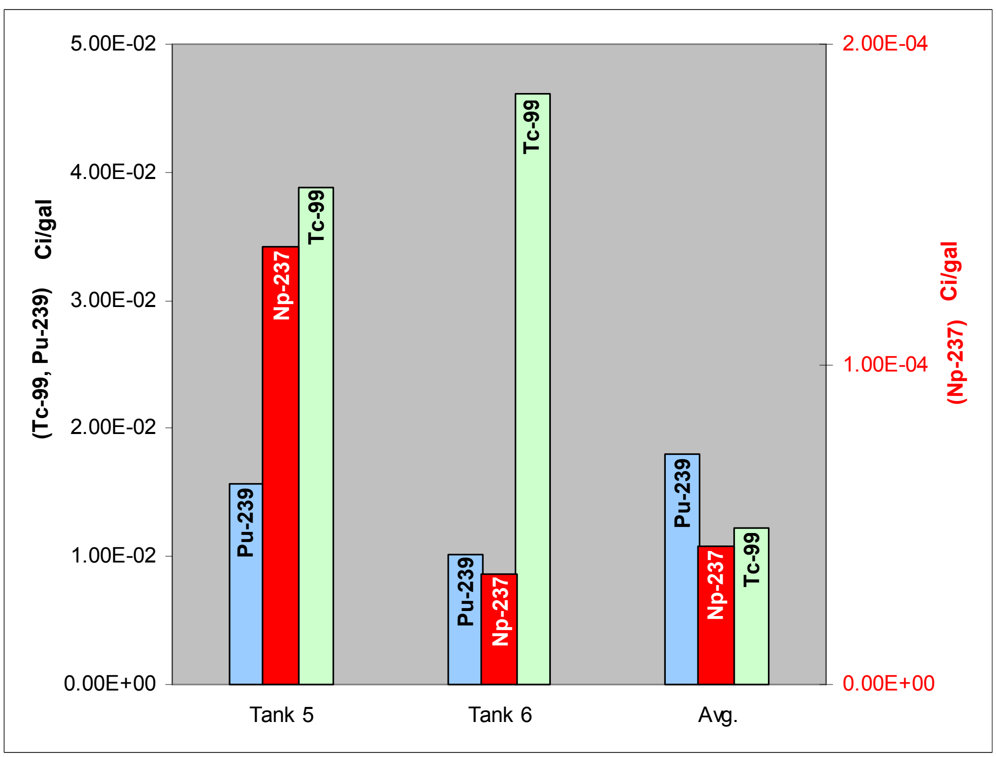
The waste stored in waste tanks generally fall into two categories: high heat waste (HHW) which contains the majority of the fission products; and low heat waste (LHW) which results from purification processes and from dissolving aluminum cladding from reactor fuels. Tanks 5 and 6 received mostly HHW and therefore contain sludge with some of the highest radionuclide concentrations in FTF.

The concentrations of radiological constituents in the sludge in Tanks 5 and 6 (decayed to 2005) are estimated using data from the SRS Waste Characterization System and calculations (Table 1) [Reference 2]. The concentrations of some radionuclides expected to be important to the performance assessment in Tanks 5 and 6 sludges are compared to the average concentrations of the other tanks in F Tank Farm in Figure 2.

Table 1 – Tanks 5 and 6 Sludge Radiological Concentrations for Selected Constituents

	Sr-90 (Ci/gal)	Tc-99 (Ci/gal)	Cs-137 (Ci/gal)	U-232 (Ci/gal)	U-235 (Ci/gal)	U-238 (Ci/gal)	Np-237 (Ci/gal)	Pu-239 (Ci/gal)	Pu-240 (Ci/gal)	Pu-241 (Ci/gal)	Pu-242 (Ci/gal)
Tank 5	8.41E+01	3.88E-02	5.94E+00	1.76E-06	3.42E-06	8.10E-05	1.37E-04	1.57E-02	3.76E-03	2.51E-02	1.11E-06
Tank 6	1.10E+02	4.62E-02	7.71E+00	2.15E-06	2.67E-06	9.97E-05	3.46E-05	1.02E-02	3.55E-03	3.97E-02	6.98E-06

Figure 2 – Comparison of Tanks 5 and 6 Sludge Concentrations to the Average Concentrations of Other FTF Tanks (Curies/Gallon)



The typical closure process steps for the F-Tank Farm Type I tanks are:

1.) Bulk Waste Removal
2.) Mechanical Sludge Removal
3.) Chemical Cleaning Process – utilizing 8 wt% Oxalic Acid
4.) Characterization and DOE/Regulatory Reviews
5.) Tank Grouting

The SRS F-Tank Closure Project has successfully completed Mechanical Sludge Removal in Tank 5 and Tank 6 utilizing the Waste-on–Wheels (WOW) system. The chemical cleaning process has been initiated in Tank 5 and Tank 6 utilizing 8 wt % oxalic acid at a 20:1 volume ratio of acid to sludge for the initial strike. The subsequent strikes will utilize a 13:1 volume ratio of acid to sludge. The results of the chemical cleaning process are detailed in the "Status of Chemical Cleaning of Waste Tanks at the Savannah River Site –
F Tank Farm Closure Project – Abstract 9114."

After cessation of all planned waste removal activities within Tank 5 and Tank 6, the residual material in the tank will be characterized. Following characterization of the residual material in both tanks, the following determinations will be justified and documented in a Waste Determination Evaluation.

- Determination that waste removal goals have been met and actual results are consistent with tests results.
- Determination that residual radionuclides (including uncertainties) will be consistent or less than source term used in the performance assessment.
- Determination that the costs and risks of continuing removal operations do not warrant the potential benefits (reduction of dose to the public).

Mechanical Sludge Removal Process

The first step in each mechanical sludge removal phase is to transfer supernate (liquid waste) into the waste tank to a level of approximately 3 meters (120 inches). Supernate is used as the slurry media to minimize the amount of water added to the tank farm. Adding additional water will impact storage space. The liquid level is raised to 3 meters (120 inches) to cover the SMP weep holes so that the cooling/lubricating liquid is not discharged into the tank vapor space. Experience has shown that the HEPA filters in the tank ventilation system became moisture-loaded when the liquid is discharged from the weep holes into the tank vapor space. The second step in the cleaning phase is to operate the SMPs to mix the tank contents. The SMPs are operated in either index mode or oscillation mode. The purpose of the indexing mode is to aim the stationary SMP discharge jets at the mounds of sludge for the purpose of eroding and moving the sludge solids. The purpose of the oscillating mode is to put the solids in suspension to create a slurry for eventual transfer out of the tank.

After mixing the contents of the tank, the slurry is transferred out of the tank using the STP. During the transfer, the SMPs continue to operate as long as possible to keep as many solids suspended in the slurry. The SMP speed is reduced when the liquid level is approximately 1.2 meters (4 feet), and they are stopped when the liquid level is approximately .9 meters (3 feet) prior to nozzle exposure to prevent waste aerosolization. The STP is operated at maximum speed until a tank level of approximately 10.2 cm (4 inches) when the speed is reduced to prevent cavitation. The transfer is continued until the STP loses prime at approximately 7.6 cm (3 inches).

The configuration of the residual sludge following each cleaning phase is used to trend sludge removal progress. A process called sludge mapping is performed with a team of F Tank Farm (FTF) Closure Engineering, Operations personnel and the FTF facility camera crew. Sludge mapping typically begins at a liquid level of approximately 71 cm (28 inches). Camera inspections to support sludge mapping are conducted from the center riser and risers 2, 5, 7. As the slurry is transferred out of the tank, exposed solids are mapped corresponding to the liquid level by a radar level transmitter (sludge mapping consist of hand-drawing a field sketch contour map of the exposed solids). The field sketch is then converted to a computer program grid topography map. Each grid square of the computer program topography map corresponds to .1 square meter (one square foot) of tank floor area. The summation of the heights of sludge in each grid is used to calculate the volume of sludge remaining after each cleaning cycle. The configuration of the remaining sludge is evaluated to determine the mixer operational strategy for the next cleaning phase. After the material is transferred to the hub tank, the solids are allowed to settle in the receipt tank and then supernate is transferred from the receipt tank back into Tank 5 and Tank 6 to be reused as the slurry media for the next cleaning phase.

WASTE-ON-WHEELS (WOW) System

The Waste-On-Wheels (WOW) concept is to reduce waste processing cost by developing mobile and reusable equipment that can be utilized for processing multiple waste tanks simultaneously. This approach saved the cost of updating or refurbishing installed equipment on tanks that were scheduled to be decommissioned. The WOW system consists of a Mobile Substation (25kVA) that provides power and a Mobile Waste Removal Control Center (MWRCC) that provides local control and monitoring capabilities during Mechanical Sludge Removal. These mobile units can be co-located near any tank or tanks scheduled for processing. Figure 3 shows the outline of the WOW major components.

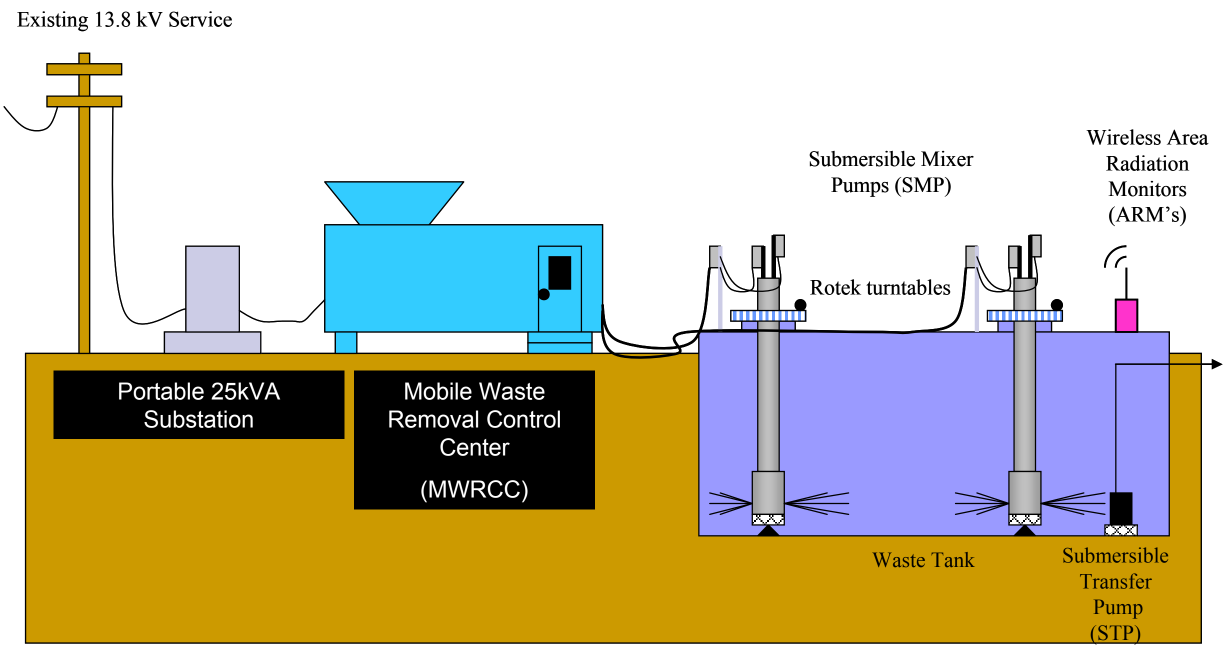


Figure 3 – WOW Major Components

In addition, the WOW system consist of re-useable Submersible Mixer Pumps (SMPs) for suspending sludge and Submersible Transfer Pumps (STPs) that are used for final sludge removal. Once a tank or tanks are processed, the mobile units and SMPs can be relocated to another set of tanks or another tank farm for reuse. The submersible transfer pump (STP) is not being reused due to the inexpensive material design and motor windings and wiring being susceptible to failure when exposed to an intense radiation field.

Submersible Mixing Pumps (SMPs)

The Submersible Mixer Pumps (SMPs) are new designed pumps that were utilized by F Tank Farm Closure Projects to complete Mechanical Sludge Removal in Tank 6. The pumps are Curtiss-Wright, variable speed, single stage centrifugal, 440 VAC, 3 phase power, and rated at 305 HP at 1400 RPM. The pumps have two 180 degree discharge 10.2 cm (4 inch) diameter nozzles that provide approximately 29,000 liters/minute (7600 GPM) flow rate at 1400 RPM. The SMPs utilize the product to cool the motor and lubricate the upper and lower bearings. The two discharge nozzles give the SMPs the capability to produce an effective cleaning radius (ECR) of approximately 15.2 meters (50 feet). The pump column is a 46 cm (18 inch) diameter, 10.4 meter (34 feet) long stainless steel pipe that is welded to a motor/pump assembly transition piece on one end and the top support connection flange on the other. Pump configuration is shown in Figure 4. To achieve the most effective mixing, the SMPs are rotated utilizing a turn table assembly. The turn table provides the motive force for oscillating mode and in addition provides repositioning capabilities for stationary indexing operation. The turntables are rotated by a reversible, single speed, 1 horsepower motor. The reversible motor allows directional change to facilitate oscillations of the SMP for mixing operations. The reversible motor is directly coupled to a Boston 600-to-1 gear reducer. The gear reducer turns a drive gear that meshes with a ring gear attached to the perimeter of the SMP bearing plate.

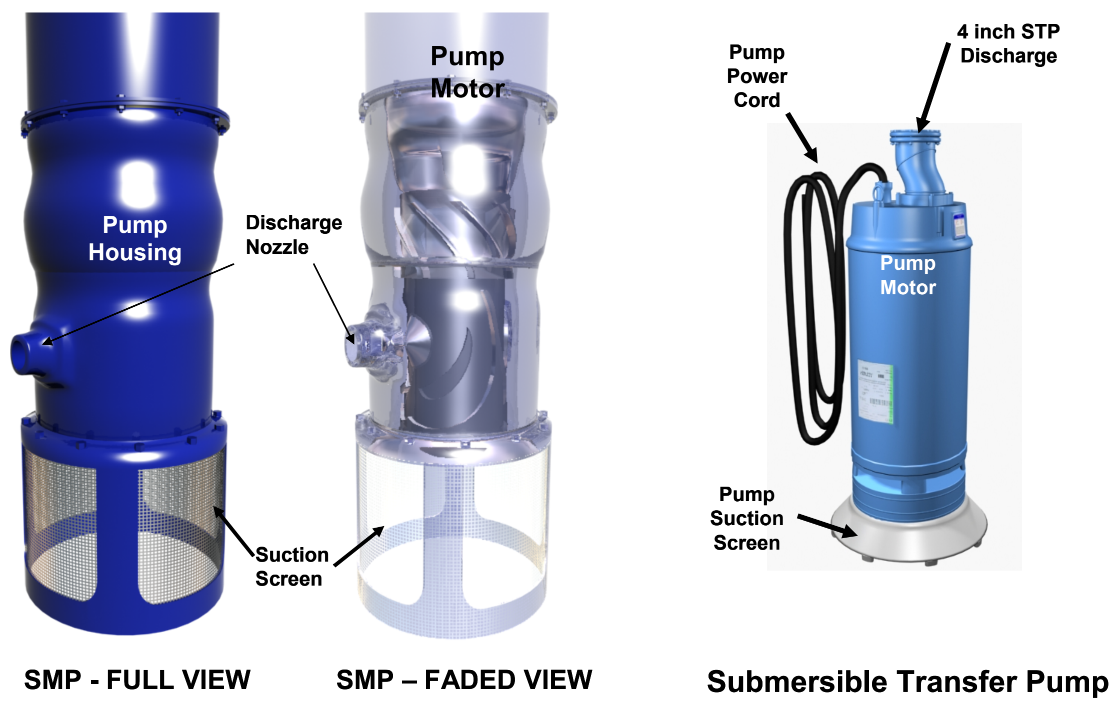


Figure 4 - Submersible Mixing Pump Full View

Submersible Transfer Pump (STP)

Transfer capabilities during Tank 5 and Tank 6 Mechanical Sludge Removal were achieved by utilizing a Submersible Transfer Pump (STP) [Figure 4]. The submersible pump is a 15 HP, 460VAC, 3450 RPM, 950 liters/minute (250 gpm), Tsurumi single-stage, centrifugal pump that has the capability of being located at any elevation within the primary tank. The Tank 5 and Tank 6 STP during MSR was placed as close to the Waste Tank Floor as possible to achieve a liquid level after transfer of < 7.6 cm (3 inches). The pump suction is screened to filter large sludge particles that could cause clogging within the cooling channel for the motor. The pump discharges into a pipe-inside-a-pipe assembly. The pump is connected to a 10.2 cm (4 inch) discharge pipe that overlaps a 7.6 cm (3 inch) pipe connected to a stationary discharge valve manifold in the riser. In addition, the submersible transfer pump is located inside a 56 cm (22 inch) diameter sleeve pipe (Caisson) that has been inserted into the tank and rests on the tank floor. The 56 cm (22 inch) diameter caisson was required to protect the STP from direct discharge from the SMP or falling debris created by impact of the SMP on other equipment. The caisson rests on three spacer legs [19 cm (7.5 inch) clearance] that are designed to allow the caisson to straddle interferences on the tank bottom while still resting on the bottom of the tank.

Tank 5 Mechanical Sludge Removal Summary

Campaign 1 and Campaign 2 of the Tank 5 Mechanical Sludge Removal (MSR) process was completed in November 2005 and December 2005 respectively, with two SMPs located in Riser 1 and Riser 3. During these campaigns, the SMPs were operated for approximately 5 days for campaign 1 and 10 days for campaign 2 and removed a total volume of 24,000 gallons of sludge. After the completion of Campaign 2, the two SMPs were removed and installed in Tank 6 and utilized to complete the Tank 6 MSR process. Lessons learned from the eleven campaigns performed on Tank 6 showed the Sludge Heel Curve flattening over the last five cleaning cycles, which indicated that benefits from further cleaning activities would be marginal with the two SMP configuration. Utilizing this information, the F-Tank Farm Closure Project Team installed three SMPs inside Tank 5 to continue sludge removal on the remaining 18,000 gallons of sludge.

Campaign three was initiated on February 20, 2008. The SMPs in riser 1 and 3 were started; however, the SMP installed in Riser 8 could not be started due to a faulty relay inside the WOW skid control panel. The faulty relay was replaced and riser 8 SMP was started on February 21, 2008. In addition, the FTF West Pump House Cooling Tower, due to a failed domestic water line, was taken offline prior to SMP start up. Without the cooling tower in operation, the liquid slurry temperature rose above 50° C requiring the SMPs operating speed to be reduced from 45 Hz to 43 Hz.. On February 23, 2008, the riser 3 SMP was shut down due to the Variable Frequency Drive's (VFD) temperature sensor reaching a high temperature from inadequate cooling from the WOW skid air conditioning unit. The liquid slurry temperature continued to rise which caused the Tank 5 to Tank 7 transfer to be initiated earlier than the planned pump run strategy. The two remaining SMPs were stopped by operations when the Tank 5 liquid temperature reached 60° C. These two SMPs were only in operation for the first sixteen hours of the transfer. The transfer was completed on February 25, 2008.

Camera inspections show that the three SMP operational strategy was able to successfully mobilize the large sludge mound that was previously underneath the tank cooling coil valve house. Due to the early shut down of the riser 3 SMP, the sludge mound settled on the opposite side of the tank. After campaign three (3), it was estimated that approximately 2,000 gallons of waste was transferred out of Tank 5 which left 14,000 gallons of sludge.

Campaign four (4) was initiated on March 13, 2008. The SMPs in riser 1, 3 and 8 were started to transfer the suspended slurry back to Tank 7. During the morning of March 15th, a tornado watch was declared and operations personnel secured the facility. Emergency procedures required shutdown of the Tank 5 to Tank 7 transfer and SMP operations on Saturday March 15th. Due to the lengthy SMP shutdown, F Tank Farm Closure engineering determined that at a liquid level of 51.2", it would not be possible to run the SMPs at the speeds necessary to re-suspend the sludge into the supernate. F Tank Farm Closure management decided to end the fourth campaign and restart mixing activities when supernate material can be transferred back from Tank 7 to Tank 5. There were no sludge mound mapping activities performed due to the supernate level.

Campaign five (5) was initiated on April 9, 2008. The SMPs in risers 1, 3 and 8 were started and operated. The SMPs were operated approximately 63 hours before the Tank 5 to Tank 7 transfer was completed. A post mapping camera inspection was conducted on April 14, 2008 to confirm that a significant amount of material, approximately 9000 gallons, was transferred out of Tank 5 to Tank 7. After Campaign 5, F Tank Farm Closure Engineering estimated that approximately 4,800 gallons of waste remained in Tank 5.

Campaign six (6) was initiated on April 22, 2008. The SMPs located in risers 3 and 8 were indexed during this campaign for a 12 hour period toward the sludge mound located near riser 5 and 6, followed by 58 hours of oscillation time for the remainder of the pump run strategy. Riser 1 was operated in the oscillation mode the entire campaign for a total run time of 67 hours. The SMPs operated and were shut down April 24th in riser 1 and April 25th in riser 3 and 8. As a result, two mounds remained unchanged from the previous MSR campaign. The sludge mound trail located beneath riser 1 was determined to be too low to be influenced by the flow of the SMP in Riser 1 as that SMP was suspended 13 inches from the tank floor due to horizontal cooling coils. The remaining sludge mound, located between risers 5 and 6, was nested between a fence of horizontal return coils. This coil protected the main body of the mound during the sixth campaign which made the retrieval of the sludge more difficult than the previous SMP run strategies. However, the overall volume of the mound changed somewhat from campaign 5, with most of the 700 gallon reduction coming from the area above and outside of the coil. The remaining material estimated by F Tank Farm Closure engineering, after campaign six, was ~ 3,500 gallons.

Campaign seven (7) was the last campaign performed on Tank 5 which was initiated May 6, 2008. The SMPs located in Risers 3 and 8 were started in the indexing mode specifically to attack the sludge mound near Risers 5 and 6, followed by oscillation of all three pumps for the remainder of the run. The SMP operation had no operational issues during the campaign. The tank 5 to tank 7 transfer began on May 7, 2008 and ended on May, 9, 2008. The two mounds remained unchanged which suggested that the effectiveness of additional pump runs would be minimal.

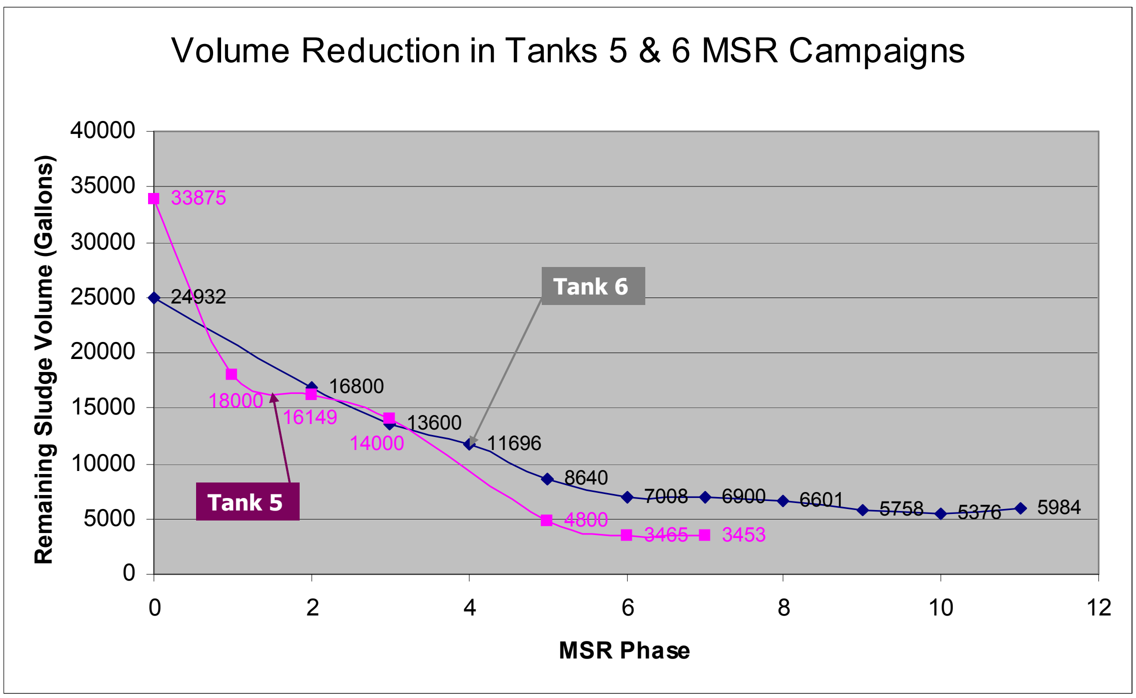


Figure 5 – Remaining Sludge Volumes

Assessment of Remaining Sludge Heel

Examining the sludge removal curve for Tank 5 in Figure 5 it was determined that consistent progress was made in removing the sludge during cleaning campaigns 1-6. Very little progress was made during campaign 7, as the sludge heel curve flattens due to the diminishing return of the SMPs Effective Cleaning Radius. To try and improve on the sludge removal efficiency, the SMP operation strategy was altered to operate in the indexing mode toward the southeast mound of the tank in order to clean as much as possible before chemical cleaning. However, due to a cooling coil fence in front of the remaining sludge mound, the altered cleaning strategy was ineffective.

Sludge mapping was used to estimate the remaining sludge heel volume in the waste tank after completion of each campaign. Camera inspections were utilized in conjunction with radar level instrumentation and known tank dimensional landmarks. With this process development, the sludge mapping method described above was adequate to develop interim sludge maps and estimated volumes to support mechanical and chemical cleaning process decisions. The estimated sludge heel after campaign 7 is ~ 3500 gallons. This value was used as the starting point for chemical cleaning.

Impact to Chemical Cleaning

Sludge dissolution using 8 wt % oxalic acid with an initial sludge heel of 5000 gallons is the planning basis of the chemical cleaning process flow sheet. The first batch of dissolution employs a 20: 1 volume ratio of acid to sludge while the subsequent batches employ a 13:1 volume ratio. Well water will be added to raise the level in the tank to a 45 inch elevation which is the minimum level required for SMP operation.

The development of the Documented Safety Analysis for chemical cleaning has used a 10,000 gallon sludge heel as the bounding case for determining accident progressions and consequences. The initial sludge heel of 3500 gallons for Tank 5 is well under the DSA bounding case. Therefore, there are no safety basis impacts resulting from starting Chemical Cleaning Process with the sludge volume of ~3500 gallons in Tank 5.

Lesson Learned

During the Tank 6 Mechanical Sludge Removal Campaign, 2 SMPs were utilized to remove approximately 75% of the original 25,000 gallons. Removal of the last 25% of the sludge was exponentially more difficult, as less sludge was available to mobilize and the lighter sludge particles were likely removed during the early mixing campaigns. Mechanical Sludge Removal activities using 2 SMPs caused the sludge to migrate to areas of the tank that were outside of the SMPs Effective Cleaning Radius (ECR). Lessons learned from Tank 6 were applied to Tank 5 by installing and operating 3 SMPs to perform Mechanical Sludge Removal. As a result, Tank 5 MSR completed removal of ~90% of the original 33,000 gallons of sludge material. Lessons learned from Tank 5 MSR clearly showed evidence that 3 SMPs are more efficient at suspending and removing sludge material during waste removal activities.

Cooling Coil Isolation

After the completion of Mechanical Sludge Removal within Tank 5, tank cooling coil isolation commenced by physically isolating the vertical and horizontal cooling coil loops from the main chromate water system. Currently Tank 5 is complete with Tank 6 isolation work in progress. The cooling coils consist of carbon steel piping rigidly attached inside the tanks. The piping is nominal 2 inch pipe (2.375 inches actual outside diameter). For Tanks 5 & 6 type I tanks, the cooling coils consist of 2 horizontal bottom coils (upper and lower) and a number of vertical coils. Table 3 summarizes the cooling coil dimensions and compares them to the tank dimensions for Tanks 5 & 6.

Table 3: Type I Tank Cooling Coil Dimensions

Total length of cooling coils	22,800 feet	6949 meters
Volume of cooling coils	5,240 gallons	19.8 cubic meters
Ratio of cooling coil volume to tank volume	0.70%	0.70%
Surface area of cooling coils (up to overflow limit)	14,100 ft^2	1309 square meters
Ratio of cooling coil surface area to tank/column surface area (up to overflow limit)	120%	120%

During isolation activities, the bulk of the chromate water was removed from the cooling coils and what water remains will be flushed out into the primary tank vessel of Tank 5 with F- Tank Farm facility well water. For breached cooling coils that have the potential to contain waste on the interior, the coils will be flushed before they are closed. All coils (leaking & non-leaking) require cleaning to remove chromate and waste, if applicable.

Breached cooling coils can be divided into three types:

1) Broken cooling coils—broken cooling coils will be flushed from inlet and outlet, prior to the final oxalic acid strike.
2) Leaking cooling coils—cooling coils that have leaks, such as pinholes, will be flushed to clean out any contamination prior to the final mechanical cleaning cycle.
3) Broken, separated cooling coils – broken cooling coil sections that are disconnected from the cooling coil system will be left in the tank for closure. It is assumed that a very small quantity of broken, separated cooling coils will be left in each tank.

The flushing process for cooling coils is expected to be required only once due to the amount of contamination re-entering breached cooling coils during the final oxalic acid cycle and/or final mechanical cleaning cycle is assumed to be very low. The flushing activity will be deemed successful when it has achieved three coil volumes throughout each coil. This requirement is outlined in the performance assessment modeling input for facility transfer line cleaning; therefore, three volume flushing is assumed sufficient for cooling coil cleaning.

Cooling Coil Grout Testing

To complete cooling coil closure after flushing, F-Tank Farm Closure Project plans to pump grout into the cooling coils to prevent pathways for infiltrating water after tank closure. F-Tank Farm Closure Project and the Savannah River National Laboratory worked in conjunction to design a grout formulation that was used to perform a full scale test to assess the grouting performance in a simulated field condition.
The full scale test consisted of a vertical and horizontal cooling coil and the equipment used to prepare and transport the grout to the coils. The grout formulation that was recommended for the full scale test was composed by mass of 90% Masterflow (MF) 816 (a commercially available cable grout) and 10% blast furnace slag, with a water to cementitious material (MF816 + slag) ratio of .33. A ChemGrout™ GC500-DH grout mixer/pumping unit was used for mixing and transporting the grout. The operating conditions for the two different assemblies were different due to the lessons learned gained after the successful filling of the vertical cooling coil, which in turn was changed for the horizontal coil testing. During the vertical coil grout testing, the equipment used to mix and transport the grout had many paths for air entrainment. To reduce air entrainment for the horizontal cooling assembly test, multiple grout batches were placed into a single mixing tank to make a single large batch and the suction to the pump was enclosed. Process flow and pressure measurements were obtained during the filling of both cooling coil assemblies. In the vertical assembly, in-situ temperature measurements were also electronically recorded for un-insulated and insulated piping. Samples from both the vertical and horizontal cooling coil assemblies were obtained and analyzed for weight percent water content and density. Overall the full scale test was a success with some recommendations needing further review. The F-Tank Farm Closure Project is currently planning the integration of the grouting system into the Tank 5 & 6 closure plan.

CONCLUSIONS

The FTF Closure Projects has successfully performed Mechanical Sludge Removal using the Waste on Wheels (WOW) system to complete the initial step of the tank closure process for Tank 5 and Tank 6. Sludge removal during the latter phases became exponentially more difficult as less and less sludge was available to mobilize and cooling coils and column supports presented obstructions. To compensate for the waste migration and loss of ECR efficiency, SMP operations were modified to perform more Indexing operations to provide a more dislodging effect during the later mixing campaigns.

Cooling Coil obstruction lessons learned were successfully applied by designing, constructing and utilizing a cooling coil cutter to assist with SMP installation. The lessons learned from Tank 6 were applied to the Tank 5 Mechanical Sludge Removal process which showed a significant improvement of sludge removal during SMP operations.

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