

## **Commercial Submersible Mixing Pump for SRS Tank Waste Removal - 15223**

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### **ABSTRACT**

The Savannah River Site Tank Farms have 45 active underground waste tanks used to store and process nuclear waste materials. There are 4 different tank types, ranging in capacity from 2839 m<sup>3</sup> to 4921m<sup>3</sup> (750,000 to 1,300,000 gallons). Eighteen of the tanks are older style and do not meet all current federal standards for secondary containment. The older style tanks are the initial focus of waste removal efforts for tank closure and are referred to as closure tanks. Of the original 51 underground waste tanks, six of the original 24 older style tanks have completed waste removal and are filled with grout.

The insoluble waste fraction that resides within most waste tanks at SRS requires vigorous agitation to suspend the solids within the waste liquid in order to transfer this material for eventual processing into glass filled canisters at the Defense Waste Processing Facility (DWPF). SRS suspends the solid waste by use of recirculating mixing pumps. Older style tanks generally have limited riser openings which will not support larger mixing pumps, since the riser access is typically 58.4 cm (23 inches) in diameter. Agitation for these tanks has been provided by four long shafted standard slurry pumps (SLP) powered by an above tank 112KW (150 HP) electric motor. The pump shaft is lubricated and cooled in a pressurized water column that is sealed from the surrounding waste in the tank. Closure of four waste tanks has been accomplished utilizing long shafted pump technology combined with heel removal using multiple technologies.

Newer style waste tanks at SRS have larger riser openings, allowing the processing of waste solids to be accomplished with four large diameter SLPs equipped with 224KW (300 HP) motors. These tanks are used to process the waste from closure tanks for DWPF.

In addition to the SLPs, a 224KW (300 HP) submersible mixer pump (SMP) has also been developed and deployed within older style tanks. The SMPs are product cooled and product lubricated canned motor pumps designed to fit within available risers and have significant agitation capabilities to suspend waste solids. Waste removal and closure of two tanks has been accomplished with agitation provided by 3 SMPs installed within the tanks.

In 2012, a team was assembled to investigate alternative solids removal technologies to support waste removal for closing tanks. The goal of the team was to find a more cost effective approach that could be used to replace the current mixing pump technology. This team was unable to identify an alternative technology outside of mixing pumps to support waste agitation and removal from SRS waste tanks. However, the team did identify a potentially lower cost mixing pump compared to the baseline SLPs and SMPs. Rather than using the traditional procurement using an engineering specification, the team proposed to seek commercially available submersible mixer pumps (CSMP) as alternatives to SLPs and SMPs. SLPs and SMPs have a high procurement cost and the actual cost of moving pumps between tanks has shown to be significantly higher than the original estimates that justified the reuse of SMPs and SLPs. The

team recommended procurement of “off-the-shelf” industry pumps which may be available for significant savings, but at an increased risk of failure and reduced operating life in the waste tank. The goal of the CSMP program is to obtain mixing pumps that could mix from bulk waste removal through tank closure and then be abandoned in place as part of tank closure.

This paper will present the development, progress and relative advantages of the CSMP.

## INTRODUCTION/BACKGROUND



Fig. 1. SLP



Fig. 2. SMP



Fig. 3. CSMP

SLPs and SMPs have been developed, matured, and successfully used to perform waste removal within the Savannah River Site Tank Farms. As early as 2010, these pumps were the baseline for tank waste suspension and mixing for closure activities at SRS. SLPs have proven reliability and have the process flexibility to support most tank closure requirements. SMPs are higher capacity pumps which provide an adequate cleaning radius that requires the use of only 3 per tank versus 4 SLPs. The SMP's hydraulic design and operational requirements typically increases the tank liquid level needed for long duration mixing campaigns and are not designed to operate for long periods of time in oxalic acid or in water which has been used in some tank closure campaigns as a means of final tank cleaning. Table 1 below provides specific pump details for the SLP and SMPs.

TABLE I. Performance characteristics comparison

	SLP (Reference)	SMP (Reference)	Comment
Flow Rate	4.5 m <sup>3</sup> /min (1200 gpm)	28.8 m <sup>3</sup> /min (7600 gpm)	
Flow Speed	73.3 – 188.5 rad/sec (700 – 1800 rpm)	41.9 – 146.6 rad/sec (400-1400 rpm)	
Motor	112KW (150 HP)	227 KW (305 HP)	SMP product cooled and lubricated
Weight	6305kg (13,900 lbs)	4917kg (10,840 lbs)	
Length	14.3 m (47 Ft)	15.5 m (51 Ft)	
ECR (Effective Cleaning Radius)	7.3 m (24 Ft)	15.8 m (52 Ft)	
Min liquid level at startup	53.3 cm (21 in)	114.3 cm (45 in)	
Estimated Operating Life	8,000 hrs	10,000 hrs	
Support Systems	Bearing Water	Flush Water, Radiation Monitoring	SMP flush water and column design Safety Significant due to potential waste path
Bearing Design	Tilt pad bearing	Silicon carbide, product lubricated	Design change to SMP bearings recommended to allow for dry bearing start and lower viscous fluid ranges (water & oxalic acid)

Waste removal and system planning as of 2010/2011 was focused on Tank Closure activities. This plan was to close 22 tanks within the company’s potential 8 year contract period. The waste removal equipment required to meet this plan called for the procurement of up to 21 new mixing pumps. Even with procurement of 21 additional pumps, closure of the tanks would still require multiple pump moves between tanks.

To support the projected mixing pump requirements, specifications were written for a new multi-purpose pump (MPP). The plan for the MPP was to provide tank mixing pumps that provided a larger cleaning radius than available in 112KW (150 HP) SLPs and/or address lessons learned/improvements for the SMPs. The specification called for a larger cleaning radius than the SLPs in order to improve waste removal from SRS Type I tanks which are 22.9 meters (75 feet) in diameter with many cooling coils and columns which interfere with mixing. The larger Effective Cleaning Radius (ECR) would also be applicable to support removal from the remaining tanks that are 25.9 meters (85 feet) in diameter.

In order to evaluate and select the preferred MPP option, two specifications were written. One specification was written for a SLP style design with an increase in the power and flow to obtain a greater cleaning radius. The second specification was for a SMP style design which did not

require as large of a cleaning radius as provided by the SMP, but improved features of the pump by avoiding safety significant qualification and having operational characteristics that supports a broader range of waste removal applications. Both specifications continued to require anticipated long operational life and reliability, with expectations to move the pumps between tanks as waste removal is completed. During the bid review process, a technical evaluation would be performed on the responses to determine the best design to proceed with for the MPP. It is during this review in 2011, that external process and funding restrictions indicated that waste removal and tank closure accelerated schedule and funding would decrease. This funding reduction removed the funding available for development of the MPPs. However, the relative procurement cost for the MPPs was found to be the same as the baseline SLP and SMPs.

## **ALTERNATIVE WASTE REMOVAL TECHNOLOGY**

In 2012, SRR initiated a number of review teams to investigate alternative solutions to Tank Closure technology. These teams were challenged to investigate alternate solutions to Tank Closure activities to continue to make closure progress despite funding limitations. One team was initiated to review alternatives to waste removal mixing technology. As discussed above, the baseline technology for waste suspension and waste removal is mixing tanks with SLPs or SMPs. The team was made up of representatives from Construction, Engineering, Operations, Rad Con, and Design organizations. To perform this review, the team brainstormed new ideas for waste suspension and removal along with reviewed previous System Engineering Evaluations from the site and available DOE complex alternatives. As part of the evaluation, each alternative was weighed against four critical factors:

1. Must fit within 57.2 cm (22.5 inch) wide riser
2. Must demonstrate significant cost savings
3. Must employ technically mature technology
4. Must demonstrate effectiveness of mixing/suspension over a broad spectrum of hydraulic conditions

The team performed a qualitative review of the options raised and did not identify a new or different technology to perform waste removal from SRS closure tanks. As part of the review, one option was identified was that mixing and waste removal lifecycle costs could be significantly reduced if commercially available pumps were found to slurry the tank waste. Several vendors were identified as commercial manufacturers of short shaft mixing pumps that with modest modifications to the pump volute and motor would be capable of waste suspension in SRS tanks. The team stipulated in the requirements that the mixing capability should at a minimum meet the cleaning radius provisions provided by the existing 112KW (150 HP) SLPs. The team identified this option as the Commercial Submersible Mixer Pump (CSMP). The recommendation from the team was to procure an established commercial pump in lieu of an Engineered Equipment Procurement. In order to attract potential bidders, the requirements for pump run life were shortened and the Engineering and Quality Assurance requirements were tailored to a leaner set of “must have” criteria. The revised service life was based upon historical averages that showed a 3000 hour expected service life would be adequate for the pumps to suspend and remove solids from a single SRS waste tank to a point suitable to continue with the tank closure process. Then, these pumps could be left within the tank for closure avoiding

expensive relocation and storage costs. This idea is similar to the transfer pump life and procurement scheme already being used for closure tanks e.g. a commercially available, disposable, inexpensive pump. Transfer pumps are procured by data sheet procurements with minor modifications provided to improve pump life within the nuclear waste environment.

As noted above, the CSMP concept is the utilization of a short shaft commercial submersible pump in order to mix and suspend waste. These pumps would be suspended within the tank with a mast provided separately. This mast would interface to the tank top riser gear assembly for mounting and rotation of the pump.

Provided below is a summary of the benefits and risks the team identified for the CSMP alternative:

- Similar or greater mixing capabilities to SLP baseline
- Reduced or no support systems (flush water, bearing water, radiation monitors)
- Interchangeable column to satisfy specific tank application vs one size fits all
- Reductions to pump weight, resulting in increased potential for direct tank top mounting vs use of new structural steel
- Reduced site testing since pump is “component” tested by vendor
- Data sheet (model no) procurement streamlines procurement process and duration but allows for vendor performance testing, vibration testing, and hydrostatic testing of each pump
- Reduced disposal costs
- Potential for reduced pump life – Mitigated by use in one tank
- Potential for increased minimum motor submergence (cooled by submergence)
- No previous nuclear application - Mitigated by N Class motor windings and High rad power cable

## **CSMP COST COMPARISON**

SLP, SMP and the proposed MPP’s have relative high procurement costs due to the original site specification driven by their complexity, reliability and effectiveness. Baseline expectations for these pumps are to support 8,000 to 10,000 hours of operations with years of service within waste tanks. The high cost and procurement lead time drives the current mixing pumps to be moved between waste tanks and reused. The baseline for the CSMP is a one-time use to be disposed in place, eliminating relocation cost and exposure. Essentially the SLP/SMP/MPP is a high dollar and high radiation exposure pump compared to the CSMP, a disposable pump at a fraction of the cost.

CSMP Procurement was awarded for 6 CSMPs. The costs included prototype testing, design and vendor factory acceptance testing. Final procurement costs for the pumps were significantly less than the baseline mixing pumps. Also, the CSMP is now a catalog vendor item allowing for direct procurement of the pump versus repeat development and issuance of custom Engineering Specifications.

## OTHER GENERAL COST CONSIDERATIONS

### Pump Relocation

Baseline planning includes relocation of mixing pumps from tank to tank as waste removal progresses through the tank farms. To date, this has only been successful between adjacent tanks where cranes can move the pumps between tanks in one lift, at a cost of \$1.18M.[1] Both SLPs and SMPs have been successfully moved in one pick between adjacent tanks. General requirements include huts on each tank and pump sleeves for contamination control with critical crane lifts for pump relocation. For movement of pumps between tanks that are not adjacent, the scope and contamination controls are much greater. In addition to containment huts and pump sleeves, containment and transportation boxes are required. A second crane is also required to support pumps as they are placed on ground supports. A recent estimate to move one SLP between tank farms estimates the cost at \$1.45M. For SMPs, the pump must be transported at a 5 degree slope after contamination since the vendor provided impeller locking device cannot be installed on a contaminated pump. Provided below is a summary of the scope required to relocate pumps by transportation.



Fig. 4. Tank top hut, containment box, main and tailing crane.



Fig. 5. Sleeving of pumps for contamination control



Fig. 6. Pump sleeved and clear of riser



Fig. 7. SMP Pump Transport Container

### Pump Storage

Another relocation consideration is long term storage outside of waste tanks which include storage duration, risk of plastic containment cover degradation, storage location/shielding, and freeze protection for SMPs. Provided below is a picture of one of two stored SMPs that were used to close Tanks 5 and 6. Future tank application and installation are not funded or scheduled

for another 6 years at a minimum, but these pumps required removal to provide tank access during the grouting phase. To date, no SLP has been required to be stored outside of a waste tank after use. However, contamination and shielding controls would be similar. Also, long shafted pumps require routine shaft rotation not available within storage containers.



Fig. 8. SMP in long term cold weather storage

### **Flush Water**

SMPs require  $0.38\text{m}^3/\text{min}$  (100 gpm) of flush water to support bearing flushing before and after pump operation. The use of Flush water is also required to prime the pump during low tank level startup with existing SMPs. Required flushing during low level startup drives a safety control to restrict pump speed to avoid a waste transfer into the flush system.

### **Bearing Water**

As mentioned previously, SLPs provide cooling and lubrication for the shaft inside a pressurized pump column which is sealed at the top and bottom with a mechanical seal. During normal operation, each pump column consumes small quantities of water through evaporation or seal leakage into the waste tank (less than 5 ml per hour). Despite the use of permanent heat tracing and insulation, this type of system is challenging to maintain if ambient temperatures drop below  $-6.7^\circ\text{C}$  ( $20^\circ\text{F}$ ) for more than a few consecutive days. If the pump shaft develops an out of balance condition due to excessive wear on the shaft or bearings, this could translate to excessive vibration at the lower column mechanical seal, resulting in seal failure. Continued operation of a SLP is possible under these conditions, however the consumption of seal water has in such a case approached 0.13 - 0.19 liters/second (2 - 3 GPM) per pump of continuous operation.[2] In most cases, the downstream impacts of excessive seal water leakage dictates that the pump to be removed and replaced.

### **SMP Column and Motor Boundary Safety Significant**

The SMP column design creates a potential path of waste to flow through the column to the tank top. Accident analysis for the column design and potential flow path drives the SMP to be Safety Significant (SS) for the related column and motor pressure boundaries. Another safety control for this accident is a requirement to provide SS radiation monitors at each SMP to detect



the presence of waste in the column above the tank top as well as requiring a SS power supply disconnect.

### **Site Testing**

SMPs and SLPs are large complex pumps which drive site testing of the pump at the site's TNX facility due to the unavailability of vendor facilities and/or as appropriate after receipt. The CSMP, by its smaller size, allows for testing at the factory and can support limited run-in/bump testing outside of large TNX efforts. Factory testing allows for another area of cost savings as it eliminates large amounts of support and equipment needed for the site's TNX testing facility. As an example, a new SMP is run through a 3 day run in test at TNX to ensure its performance before field installation. Including set up and breakdown this test usually requires 5 days, two cranes, and numerous personnel.

As a part of the CSMP implementation plan, the first CSMP received on site was tested at the TNX facility to baseline operational. At this time, no other CSMPs are planned to be tested at TNX.

### **CSMP PROCUREMENT STRATEGY**

A team was assembled as part of the Tank 33 Bulk Waste Removal project with cradle to grave responsibility for the administration of the CSMP procurement contract including testing and delivery. This sub group also had direct functional ties the larger Integrated Project team tasked with design and implementation of field modifications associated with deployment of the CSMP (Project Manager, Design, Procurement and Quality) as part of the overall bulk waste removal program. This team determined that a direct "off-the-shelf" pump was not available. Differences from available pumps included the number of nozzles, N-Class windings, and pump motor size restriction. The team determined to procure the CSMPs through an Engineering Specification. While the procurement of the pump was being performed through an Engineering Specification, the goal remained to obtain a pump built by an established vendor to their existing processes.

The procurement specification provided prospective bidders detailed information relative to the type of pump to be manufactured, critical dimensions, materials of construction and minimum hydraulic performance requirements. The specification for the CSMP was issued to the pump performance and effective cleaning radius similar to the MPP. This specification was considered aggressive in particular in maintaining motor sizing within the riser allowance. The award was based upon a best value approach under a competitive bidding process. The ultimate goal at the end of contract is to not only take delivery of the pumps specific for this project, but for the vendor to have developed a pump as a commercial item in their company inventory. This will facilitate future orders for these pumps using a commercial datasheet as opposed to developing a job specific specification as was required for the initial procurement contract.

The quantity of pumps purchased in the initial order (6) was deemed to be a sufficient number to support initial deployment for one bulk waste removal campaign, with the expectation that initial per unit pumps costs will be higher due to need for the vendor to design and qualify the final



product. Six pumps also provided several spare pumps in case of premature failure prior to completion of waste removal.

The procurement contract did require the vendor to possess an in-house quality program with a specific focus on demonstrating compliance specific to the following areas: design and document control, material identification and control, test control including management of measuring test equipment, and handling storage and shipping of subcomponents and finished materials.

At the end of the manufacturing period, the vendor performed factory acceptance testing of each unit to demonstrate compliance with the contract requirements relative to hydraulic performance, electrical integrity of the stator, mechanical integrity of critical pressure boundaries and vibration curves/data. All acceptance testing was witnessed by SRR personnel.

External to the contract, SRR took the first CSMP that was delivered and outfitted it to a test mast to undergo endurance testing in water. The results of this effort are discussed in the Site Testing section.

## **DESIGN DEVELOPMENT**

At the end of the bidding process, two companies responded to our request for proposals; however both prospective bidders took exception to our performance requirements with particular concerns for a motor that would fit within the constraint of a maximum diameter of 58.4 cm (23 in). Based upon this feedback, the requirements and expected motor horsepower were reduced and the two companies were asked to provide a best and final offer. In late June of 2013, the contract to build the CSMPs was awarded to GPM Inc. of Duluth MN.

As anticipated, the vendor chose to perform a rework of one of their existing slurry transfer pumps, with the actual details of the impeller and volute design to be confirmed through a performance test with a prototype.

A major step in this process was the vendor's ability to partner with their sub tier suppliers in the design and construction of the electric motor. In addition, the vendor collaborated with SRR on several concepts for providing a robust mechanical connection between the pump motor and mast, and early on into motor development came to SRR with a proposal to upgrade the HP rating closer to our original request of 149 KW (200 HP). SRR was able to negotiate a fair price for the horsepower increase which provides additional operation flexibility when handling waste slurries with high salt and solids content. Concurrent with this, the vendor proceeded with development and demonstration of a 112 KW (150 HP) prototype to validate the hydraulic design.

## **VENDOR ACCEPTANCE TESTING**

Acceptance testing and delivery of the six finished CSMPs was completed in two phases. In order to meet SRR scheduling requirements, a single pump shipment was completed in late June of 2014, followed by the remaining five pumps ten weeks later.

Initial hydraulic performance of the first mixer pump suggested that there existed excessive clearance between the impeller and the volute casing. A teardown of the pump did confirm small variations in impeller clearance due to normal variations in the casting dimensions. The clearance was tightened and after careful machining of the volute casing and the pump retested. All hydraulic performance requirements were met once these design changes were implemented.

During phase II acceptance testing the second motor associated in this batch of pumps did exhibit a vibration, albeit within the acceptance criteria of the contract, which was higher at all pump speeds compared to the two previous units. The vibrational signature was indicative of an out of balance condition with the motors' rotor. While acceptance testing proceeded with the remaining three mixer pumps, a teardown of the unit confirmed the out of balance rotor. The out of balance condition was able to be corrected and the motor reassembled at the vendor's shop.

Hydraulic performance testing of all pumps confirmed flow rates and pressures for the CSMPs. Flow rates were confirmed at 1950 gpm at full speed and required head pressure. This flowrate and nozzle design demonstrates that the CSMP can meet and exceed the SLP for an estimated cleaning radius of 8.84 meters (29 feet) vs the 7.32 meters (24 feet) for the SLP. The vendor also demonstrated in house capabilities to performed acceptance testing allowing the Site to avoid on-site factory acceptance testing. Since factory testing included testing the pump dry (outside of test tank), this confirms the additional ability to perform brief bump testing at tank top for important pump rational confirmation prior to final installations.

## **SITE TESTING**

Testing of the first CSMP received was performed at the site's TNX large tank testing facility in July/Aug of 2014 as a part of our implementation plan. The purpose of the test was to baseline CSMP operational data by detailed monitoring of the pump during 240 hours of operation. Specific objectives of the test are listed below:

1. Confirm connectivity and assembly between mast and CSMP
2. Confirm pump and test mast crane lifting techniques
3. Perform a mock insertion through a 58.4 cm (23 in) diameter tank riser
4. Perform a functional run-in of pump and mast assembly
5. Obtain run data/trends
6. Determine a minimum operational submergence



Fig. 9. CSMP installed in the TNX test tank

An example operational data graph and table below shows the run data during a ramp up/down, integral speed step, and continuous run in water over 9+ hours. Useful trends that can be pulled from these graphs are:

- Run data under no load, in case of screen pluggage
- Inrush current expectations
- Expected current/voltage readings (SG = 1.0 at TNX) at various speeds and levels
- Expected fluctuation in current/voltage/power at various speeds and levels
- Temperature increases with time at various speeds and levels
- Vibration monitoring to identify critical speeds and tank levels

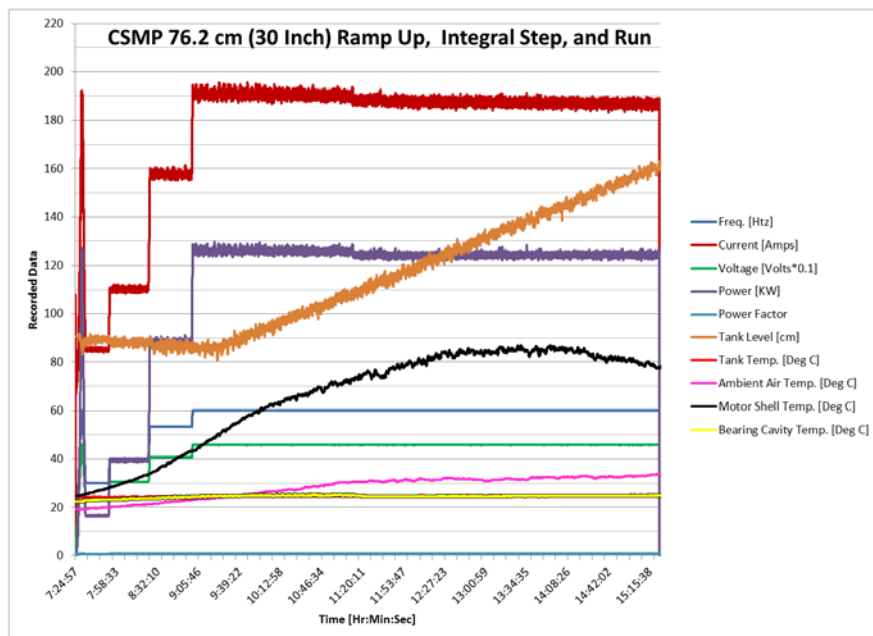


Fig. 10. Graphed Data recorded during TNX Testing

TABLE II. Tabled Data recorded during TNX Testing

76.2 cm (30 in) Submergence at 188.5 rad/sec (1800 RPM)								
	Current [Amps]	Voltage [Volts]	Power [KW]	Power Factor	Tank Level [cm]	Tank Temp. [Deg C]	Motor Shell Temp [Deg C]	Bearing Cavity Temp [Deg C]
average	190.98	459.25	126.06	0.83	85.78	76.09	47.21	24.47
1st quartile	189.90	459.00	125.40	0.82	85.14	76.00	45.10	24.30
3rd quartile	191.90	459.50	126.70	0.83	86.66	76.10	49.00	24.60
q1 to q3 range	2.00	0.50	1.30	0.01	1.52	0.10	3.90	0.30
min	187.40	458.00	123.70	0.82	80.70	76.00	43.20	24.10
max	195.70	460.80	129.60	0.84	89.38	76.20	51.60	24.80
min to max range	8.30	2.80	5.90	0.02	8.69	0.20	8.40	0.70

The testing allowed attention to be given to some focus areas that drive the operational ability of the CSMP, most notably; overheating, vortexing, rooster tailing, and vibration. Overheating of the pump has two areas of concern; the bearing lubricant in the oil reservoir, which spans from 55.9 to 76.2 cm (22 to 30 inches) from the pump bottom, has a flash point of 140°C, and the stator, which spans from 86.4 to 198.1 cm (34 to 78 inches), has built in thermistors that limit their temperature to 200°C. For testing, two thermocouples were placed on the outside of the CSMP; one at 185.4 cm (73 in) and another at 66.0 cm (26 in). Testing revealed that submergence levels at or above the stator could sustain continuous operation with no threat to overheating. The rate of rise of the stator temperature did increase as the level lowered. However, the CSMP was able to operate as low as 43.2 cm (17 inches) for approximately 3 hours and the thermocouple at 185.4 cm (73 in) recorded less than 70°C. As for the oil reservoir, the thermocouple at 66.0 cm (26 in) never recorded a temperature higher than 43 °C while the CSMP was operating in water at any level.

Vortexing was witnessed during testing at lower levels and higher speeds; however, no direct relation to vibration readings indicates that significant cavitation is not prevalent with vortexing.

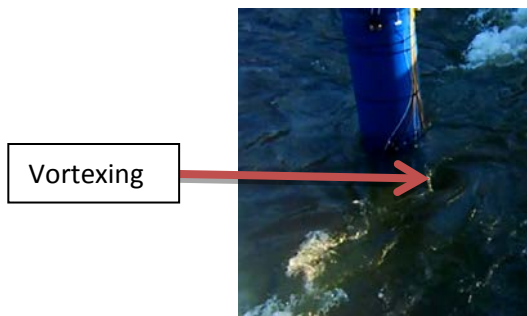


Fig. 11. Vortexing during the TNX testing

The operation of a mixing pump in a manner that results in “rooster tailing” is not allowed per the current SRS Tank Farm Documented Safety Analysis (DSA). This is to eliminate the potential to aerosolize waste during mixing in a waste tank. An evaluation was conducted to determine the levels and speeds the CSMP can run at without rooster tailing, the photo below is an example of the CSMP rooster tailing. The evaluation determined that the CSMP can run as low as 76.2 cm (30 inches) of submergence at full speed, at lower levels it should be run at 157.1 rad/sec (1500 RPM) or less, and the CSMP should not be run at all below 61.0 cm (24 inches) of submergence.



Fig. 12. Rooster Tailing during Testing at TNX

Vibration of the CSMP was monitored using 11 probes mounted in strategic locations along the CSMP and mast during the entire 240 hour test. The evaluation was conducted to identify critical speeds, resonance frequencies, or cavitation in the CSMP. During the testing the vibration probes did not identify any issues.

A concern that arose during testing was the inefficiency of the CSMP, as current readings were as high as 190 Amps. With the full load current (FLC) at 214 Amps and a higher specific gravity supernate in the waste tanks, this could limit the mixing potential of the CSMP. Possible responses to this are to; use the pump as is and thin the supernate during mixing, reevaluate the name plate to raise the FLC, and/or redesign the wet end.

The major differences between testing at TNX and GPM are: TNX testing is conducted with a full size mock tank and riser while test facilities at GPM Inc. employ a closed piping system in a relatively small tank. Also, testing at GPM is conducted with flanges on the discharge nozzles, this allows for flowmeters to be attached, while the nozzles have been trimmed to allow for installation in a 58.4 cm (23 in) riser at TNX.

Site testing was able to prove the ability of the CSMP to operate in a waste tank. The CSMP met all testing requirements, proving its ability to run at a range of speeds and levels in the test tank. The testing was able to prove the functionality of mating the CSMP to the SRR mast, and lifting and installing the CSMP into a mock riser. Run data from submergence depths ranging from 0.43 meters (17 inches) to 2.26 meters (89 inches) and varying speeds were obtained and analyzed. In addition, input for operational submergence was gathered based off of the limiting conditions of overheating, vibration, vortexing and rooster tailing. Testing at GPM Inc. and at the TNX facility demonstrated that the CSMP can meet all design criteria during operation. Overall, the testing proved the CSMP is capable of use as a mixing pump in a waste tank.

## **CSMP HAZARDS ANALYSIS**

As a new mixing pump to be used in the SRS Liquid Waste Facility, a hazard analysis has been performed on the pump and its application. The analysis has not identified any new or additional controls required for its use in the Tank Farms. As with SLPs, the CSMPs are functionally classified as Production Support and do not require SS controls required by the SMPs.

## **CONCLUSION**

Based on increased emphasis on waste removal to support closing waste tanks, additional mixing pumps were identified. In an effort to reduce costs, commercially available pumping technologies were pursued. The CSMP was selected and tested at GPM Inc. and at TNX with positive results. The initial procurement and receipt of the new CSMP was of typical duration for a new product due to the vendor design and prototype required for new pump. However, the CSMP is now available as a vendor catalog number (model SBMX2S200-4T4-15.0 part number G24722 ) which will significantly streamline future procurement and receipt durations. Cost of the CSMP has already been found to be a significant direct saving.

The CSMP acceptance testing demonstrated the necessary capability to achieve an effective cleaning radius that exceeds the baseline SLP. No significant performance issues were identified during testing to include a 10 day run-in test. Support systems such as flush and bearing water and Safety Significant control equipment are also avoided.

SRS has designed a mast to interface with the CSMP to support the pump within a waste tank, and is scheduled for deployment in the field by fiscal year 2015.

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