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DWPF Process Improvements and Performance During the First Year of SWPF Operations – 22467

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ABSTRACT

Successful treatment and disposal of salt waste is integral to effectively reducing potential long-term environmental risk at the Savannah River Site (SRS). The Salt Waste Processing Facility (SWPF) performs a key role in the SRS Liquid Waste system by treating the salt waste removed from SRS liquid waste storage tanks. SWPF receives raw salt solution from the waste tanks, separates strontium and actinides from the salt feed by Monosodium Titanate adsorption and filtration, and removes the cesium-137 by solvent extraction. Resulting SWPF waste streams include concentrated cesium-137 Strip Effluent (SE) and Monosodium Titanate/Sludge Solids (MST/SS), which will be disposed through vitrification at the Defense Waste Processing Facility (DWPF).

As production at SWPF increases, DWPF will be required to process an increased volume of MST/SS and SE. The SWPF throughput of up to 34.1 million liters (9 million gallons) of salt feed results in waste stream volumes that far exceed those processed at DWPF thus far. Modeling was used to determine the volume of MST/SS and SE that DWPF will need to process to support SWPF capacity. While the throughput of DWPF is sufficient to meet SWPF requirements, DWPF is not robust to upset conditions. Any processing delays (e.g., equipment failure) will extend DWPF cycle time and jeopardize the ability of DWPF to meet SWPF production goals. To meet the increased processing demand and to increase flexibility to allow for inevitable process delays, a thorough assessment of opportunities to maximize the efficiency of the Chemical Process Cell (CPC) operations was undertaken. The CPC was chosen as the focus of this effort as it has the longest cycle time in DWPF.

First a process study was performed to determine the constraints associated with SE and MST/SS additions in DWPF. Potential opportunities for removing and relaxing constraints were identified where applicable. Then each CPC process step was analyzed for potential cycle time improvements and an extensive list of options to improve processing efficiency was generated. Each item was assessed to determine known constraints, such as potential risks, additional processing requirements, and increased workload and to determine benefits, such as cost-saving measures, process flexibility, and cycle time reduction. By weighing the constraints and the benefits of each option, those items deemed pursuable were further prioritized according to greatest impacts with the fewest known constraints.

Several of the process improvements identified by the processes above have since been implemented in DWPF. Most of the improvements identified under the category of standard practices have been implemented through weekly production outlook meetings. These items include performing transfer preparations before a transfer is needed, sampling tanks as soon as they are available, and coordinating process additions to minimize processing downtime. Some longer-term improvements have also been implemented. These include the implementation of a new antifoam, an increase in steam flowrates, and increased flexibility in engineering calculations for varying processing needs.

This paper compares proposed and implemented process improvements with DWPF processing data during SWPF first year of operations. DWPF CPC cycle time was reduced and process flexibility increased from implemented process improvements. Additional increases in processing capacity and flexibility are expected from items yet to be implemented, such as the glycolic acid flowsheet and the Strip Effluent Feed Tank (SEFT) to Slurry Mix Evaporator (SME) project.

INTRODUCTION

The DWPF processes three high level waste streams. These waste streams are sludge, MST/SS, and SE are adjusted and concentrated in the DWPF CPC. Sludge and MST/SS are added to the Sludge Receipt and Adjustment Tank (SRAT). A sample is pulled to determine the volume of acid to add to the vessel. Following acid additions, steam is added to strip mercury and the slurry is concentrated. During this processing step, conflux, SE is added to the vessel. A sample is pulled and the SRAT contents are transferred to the SME. Frit is added to the SME, the resulting slurry is concentrated to approximately forty weight percent solids, and a final product sample is pulled to ensure glass quality constraints are met. Following conformation of an acceptable melter feed, the SME contents are transferred to the Melter Feed Tank. Throughout SRAT and SME processing, foaming of the waste is expected due to gas generation during boiling and chemical reactions. Antifoam is added to prevent foam carryovers into the condensate.

Previous DWPF processing campaigns have focused primarily on the processing and immobilization of sludge. The salt waste streams, MST/SS and SE, were processed when available, and sludge only CPC batches were processed otherwise. The SRS Liquid Waste System Plan recognized the requirement for increased salt production as current glass quality models are not applicable to salt only cans. The remaining waste volume in the Tank Farms is 8.5% sludge, 46% supernate, and 45.5% salt cake. Due to the volumes of sludge and salt remaining and several extended processing outages, production at DWPF has slowed awaiting increased salt production. Since the commencement of SWPF operations, significantly more salt has been added in each batch than during previous processing campaigns.

Throughout the first year of SWPF operations, DWPF cycle time and processing downtime has not resulted in a loss of production at SWPF. However, it is recognized that increased future production rates at SWPF will challenge DWPF operations. Cycle time improvement is required to keep up with expected production rates. Additionally, as the DWPF continues to age, process flexibility will be necessary as equipment repairs will be required.

To support cycle time reduction and increased flexibility, a review of processing data and previous modeling efforts (CORESIM) was completed. These efforts have shown the CPC to be the longest cycle time evolution in DWPF. A Lean event was initiated to determine future process improvements to reduce cycle time and increase flexibility.

DISCUSSION

First Year Performance

During the first year of SWPF Operations, DWPF has processed 264,950 liters of sludge, 643,450 liters of SE, 113,550 liters of MST/SS, and poured 59 canisters. During 2010, a similar volume of MST/SS was processed at DWPF from interim salt processing facilities. Throughout that fiscal year, DWPF processed 813,775 liters of sludge, 113,550 liters of SE, 113,550 liters of MST/SS, and 196 canisters. This is a 1,100% increase in salt added to canisters.

Although DWPF did not stop SWPF production, several areas for improvement were recognized. Cycle times for each processing step have increased since previous processing campaigns. Equipment failure and resulting processing downtime has increased as the facility has aged. Cycle time trending was completed to determine processing improvements that could be made.

The SRAT cycle time was determined to be the longest of the CPC cycle times. Figure 1 shows cycle times for SRAT batches processed since SWPF operations began. Processing times analyzed include: the time required to mix the Tank Farm waste tank and transfer to the SRAT, sludge transfer, the time required to add MST/SS and concentrate prior to sampling, MST/SS addition and caustic boiling, the time required to analyze a sample and add acid, SRAT receipt sample and acid addition, the time required to transfer SE and boil to the final concentration endpoint, SE addition and concentration, and the time required to pull a sample and transfer the SRAT to the SME, SRAT product sample and transfer. Processing downtime was evaluated to determine if DWPF processing was on hold due to a lack of salt waste to process, waiting on MST/SS or SE, or because of equipment failure and downtime.

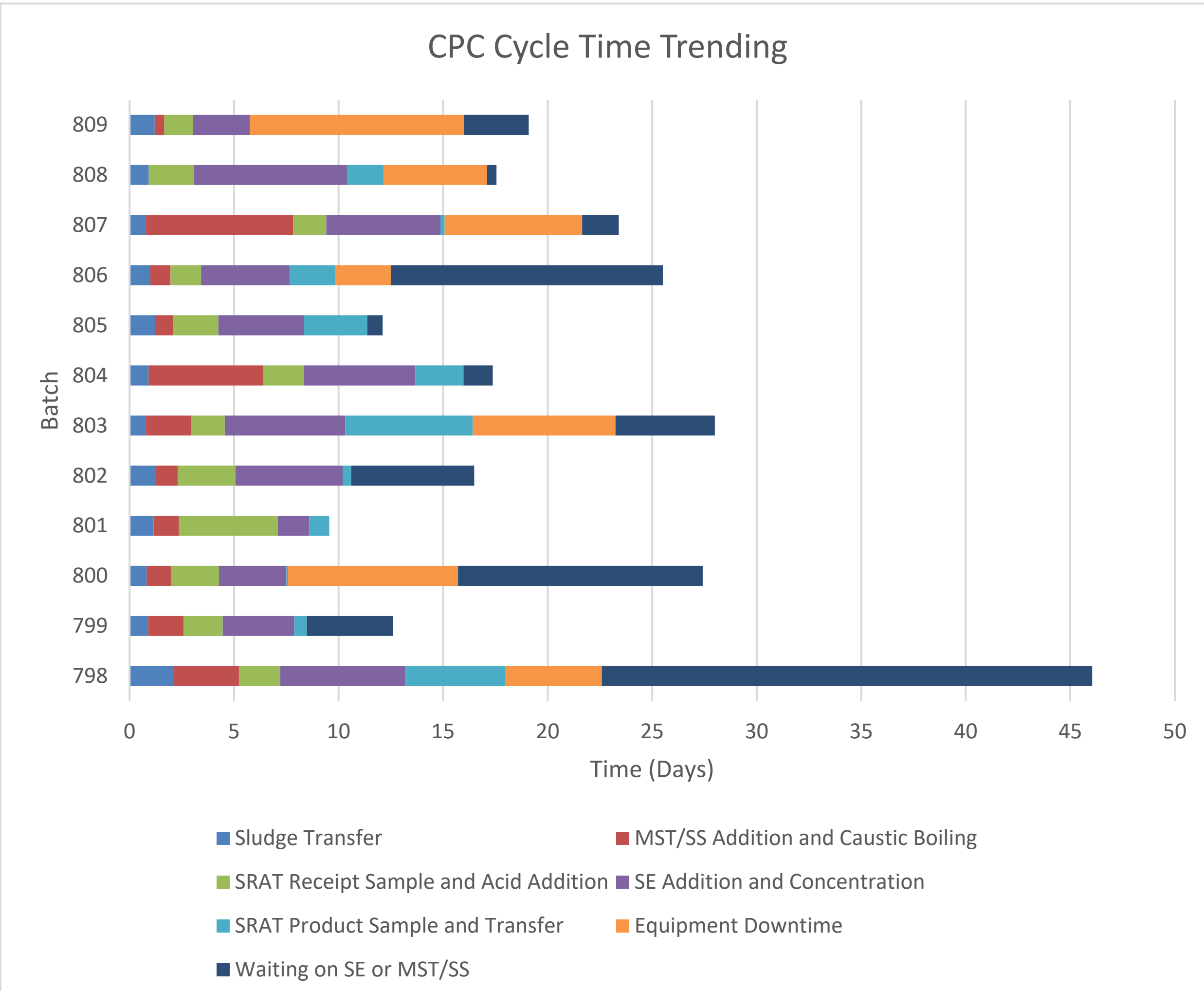

Fig. 1 CPC Cycle Time Trending

CPC Cycle Time Reduction Lean Event

Following a review of the CPC cycle time trending, a Lean event was organized to decrease cycle downtime and increase process flexibility. Lean is a systematic approach to continuous improvement that aims to make processes more efficient and effective by eliminating waste. Waste can be characterized as any activity that consumes resources but does not create value for the customer. Through Lean, performance is improved by identifying solutions to eliminate non-value-added activities.

Each step involved with CPC processing was analyzed for potential cycle time improvements (Figure 2). As a result of the process mapping exercise more than 90 opportunities were initially identified as gaps or areas to improve. The team then used a systematic approach to pare down and group opportunities based on ease of implementation, cost, process risk, or redundancy. The outcome of this effort resulted in; 18 opportunities with low effort and low cost, categorized as “Just Do Its” or “Best Practices”; 10 opportunities with high cost or high effort, yielding high impact to cycle time or process flexibility, categorized as projects to further research; 5 opportunities within SWPF scope but out of Savannah River Remediation Liquid Waste Organization scope. Some of the opportunities with large cycle time reductions or process flexibility increases are discussed below.

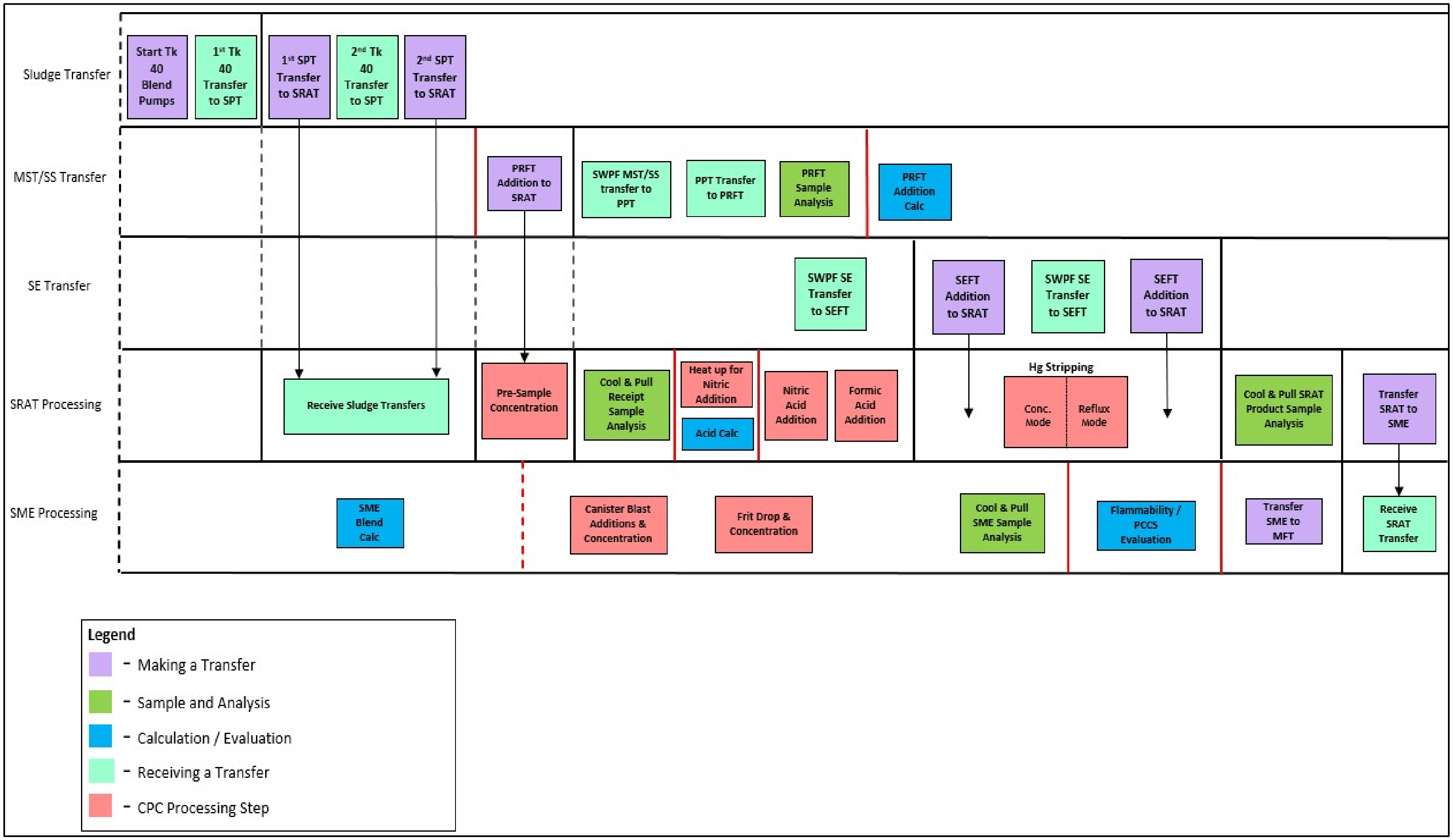

Fig. 2 CPC Process Steps

Best Practices

The Tank 40 mixing pumps are required to run for 12 hours before transferring sludge to DWPF to ensure the material is well mixed. The best practice is to notify Tank Farm Operations of anticipated sludge transfers at least 12 hours prior to completion of a SRAT batch. This ensures mixing is complete and the sludge transfer from the Tank Farms to DWPF can be started immediately upon completion of a SRAT batch.

Before adding MST/SS material to the SRAT, engineering performs a calculation based on sample results to specify the maximum volume allowed. The sample takes about 24 hours to receive full results due to the analysis time of the high temperature calcine method. However, the inputs needed for the MST/SS calculation are a subset of the sample that can be obtained in 12 hours. Laboratory Information Management System (LIMS) is currently being modified so that a partial sample report can be provided with the analytes needed for the calculation. Because the sample will take 12 hours to provide the results needed for the calculation, the best practice is that the MST/SS be sampled immediately upon receipt from SWPF. This will ensure that, whenever possible, the calculation is completed prior to the facility being ready to add MST/SS to the SRAT.

Frit is added to the SME in two ways: large batches of process frit and small additions of frit used to decontaminate canisters or can blasts. Each can blast typically adds a volume of 4,550 liters to the SME. With a typical SME heel of 4,550 liters, there is enough room to blast one can to the heel and then receive the full SRAT batch without reaching high level alarms in the SME. Therefore, the best practice is to blast one can into the SME heel when the SME batch has finished before the SRAT batch is ready to transfer.

Antifoam

Throughout SRAT and SME processing, foaming of the waste is expected due to gas generation during boiling and chemical reactions. Antifoam is added to prevent foam carryovers into the condensate. Until June 2021, Antifoam 747 was used in DWPF. Antifoam 747 had several disadvantages: it created flammable byproducts, it was not stable throughout most of CPC processing, and it was not very effective. To avoid carryover events, the SRAT and SME typically operate at a steam rate of 1,360 kilograms per hour, or 1,130 liters boiloff per hour. This is significantly less than the design basis steam rate of 2,270 kilograms per hour, or about 1,890 liters of boiloff per hour. Increased steam flowrates are directly proportional with a reduced concentration time; twice the steam flowrate means half the concentration time.

To increase steam flowrates and decrease cycle time, the Savannah River National Laboratory (SRNL) researched and tested a new antifoam for processing in DWPF. The new antifoam, Momentive Y-17112, does not generate flammable byproducts and is stable and effective throughout CPC processing. Momentive Y-17112 was implemented in June 2021. SRAT processing with Antifoam 747 and Momentive Y-17112 is compared in Figures 3 and 4.

In Figure 3, Antifoam 747 Additions During SRAT Processing, SRAT pressure steadily increases after each antifoam addition as foam increases in the vessel. Over a 10-hour processing period, 6 antifoam additions (denoted by red vertical lines) are made to decrease foam in the SRAT. Despite the frequency of the additions, a carryover occurred between the second and third additions. This can be seen in Figure 3 when the SRAT pressure decreases approximately 3 hours after the first antifoam addition. Steam was secured to prevent a larger carryover event.

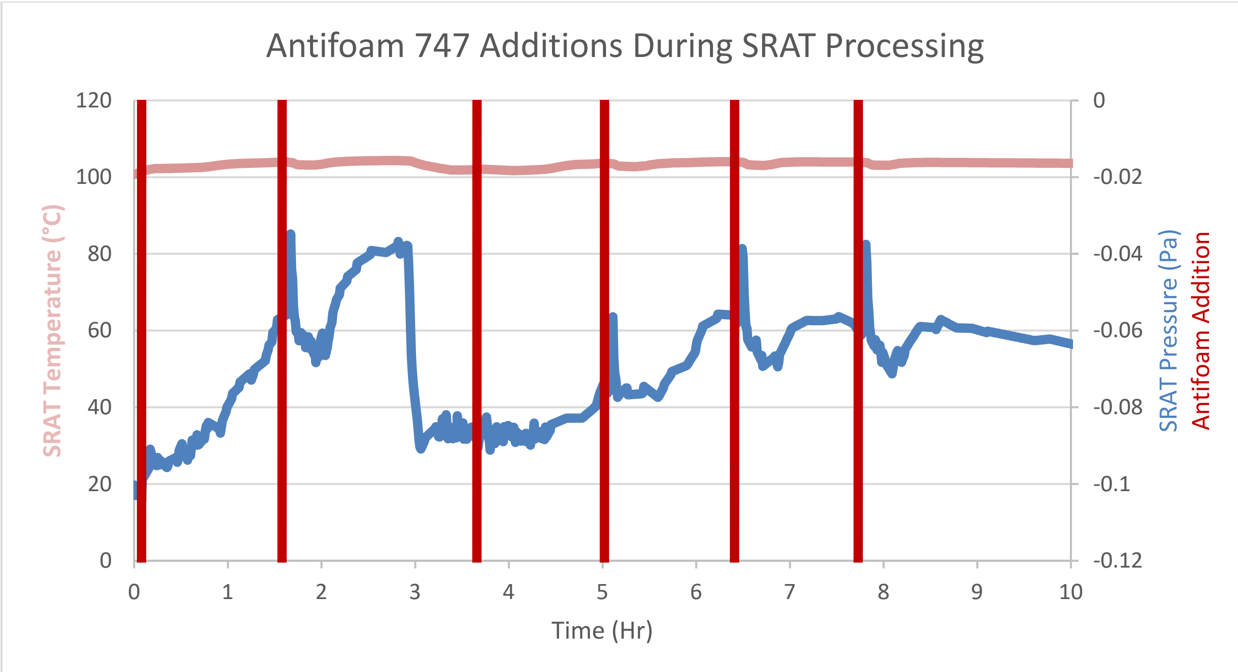

Fig. 3. Antifoam 747 Additions During SRAT Processing

In Figure 4, Momentive Y-17112 Additions During SRAT Processing, SRAT pressure remains stable after each antifoam addition indicating a lack of foam. Over a 140-hour processing period, 55 hours at boiling, only 3 antifoam additions (denoted by red vertical lines) were made. There are no indications of any carryover events during this time.

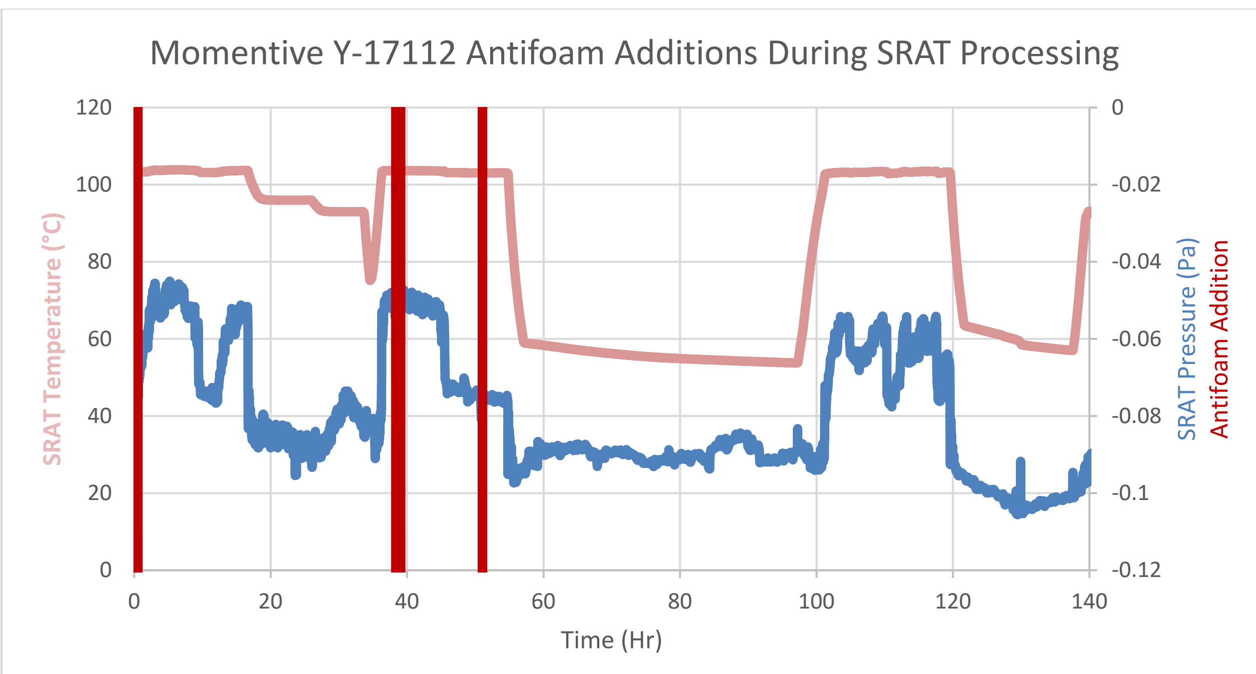

Fig. 4 Momentive Y-17112 Additions During SRAT Processing

Since implementation of the new antifoam, steam flowrates in the SRAT and SME have been increased from 1,360 kilograms per hour to 1,590 kilograms per hour, saving approximately 20 hours of cycle time per batch. At 1,590 kilograms per hour steam, pressure in the vessels remains consistent, indicating a lack of foaming. In early 2022, steam flowrates will be increased to 1,815 kilograms per hour. If pressures remain steady, further increases in steam flowrates will be evaluated.

Material Tracking Program

The Material Tracking Program (MTP) verifies that the final SRAT composition, and the composition of downstream vessels, is within the limits of the Safety Basis. The SRAT serves as the point of compliance for radiolytic hydrogen generation rates, inhalation dose potential, canister heat generation, and salt solubility in glass. The MTP specifies the maximum volume of sludge, MST/SS and SE material that may be added to a single SRAT batch. The calculation assumes bounding conditions for each of the inputs. Using actual sample results and transfer volumes for an individual SRAT batch results in greater allowable addition volumes. Performing individual MTP calculations for each SRAT batch therefore enables increased processing flexibility and decreased overall cycle time.

Throughout the first year of SWPF operations, several individual SRAT batch calculations were performed. These calculations allowed for an increase in the volume of SE added to the SRAT. The increase in SE volume accommodated equipment repairs in DWPF without delaying SWPF production. However, due to the length of the calculation, engineering requires a week to perform a new calculation. Therefore, it would be too burdensome to perform an individual calculation for every SRAT batch.

To gain the process flexibility of performing a MTP calculation with each SRAT batch, a software program is being developed. The software program will allow for sample results and transfer volumes to be used without significant engineering effort for each calculation. The design of the software is currently in progress and the implementation is expected in the summer of 2022.

SEFT to SME

SE is transferred from SWPF to the SEFT. To meet flammability requirements, SE is transferred to the SRAT at a low flowrate while the SRAT is boiling. This step requires the greatest cycle time in SRAT processing. An average addition of 56,775 liters of SE, when added at a nominal 30 liters per minute, takes over 30 hours to complete. Because the SME cycle time is significantly less than that of the SRAT, there is a project underway to implement SE additions to the SME. This will bring significant cycle time reductions and process flexibility to CPC processing. Additionally, this project will create significant process flexibility. SE is only added to the process following acid additions in the SRAT. SEFT to SME additions could take place while the SRAT is not in the conflux processing step.

In addition to increasing process flexibility and decreasing cycle time by transferring SE to the SME, the project also aims to increase the flowrate of SE and MST/SS to the SRAT. The Safety Basis currently limits the addition of SE and MST/SS to 38 liters per minute. An orifice ensures the Safety Basis limit is not exceeded. Design of the orifice results in an actual flowrate of SE and MST/SS of 23-30 liters per minute. The Safety Basis revision and subsequent design change will increase the flowrate to 53 liters per minute.

Flowsheet studies conducted by SRNL and a review of past DWPF processing have been completed. Design and physical modifications within the facility are ongoing. The Safety Basis revision allowing the new SE transfer route is underway. Submittal of the Safety Basis change is expected in the summer of 2022, with implementation expected late 2022.

Glycolic Acid Flowsheet

The implementation of the glycolic acid flowsheet has several benefits. Addition of the current reductant, formic acid, results in the production of catalytic hydrogen. The large volumes of hydrogen produced necessitate high purge flowrates to the CPC vessels. Implementation of the glycolic acid flowsheet will allow for a significant reduction in the purges. Reduction in the purge flowrate will allow for increased steam flowrates, as it is not expected that the new antifoam will allow for processing at design basis steam flowrates. Additionally, implementation of the glycolic acid flowsheet allows for the potential for increased acid addition flowrates. The glycolic acid flowsheet is also more stable which lends itself to increased process flexibility due to a lower chance of carryover, more stable pH, and more consistent melter feed.

Implementation of the glycolic acid flowsheet is expected to start in early 2022. It is expected the full implementation of the flowsheet will occur in late 2022. Benefits of the flowsheet are expected to be achieved in late 2022 or early 2023.

Improvement Impacts

Several of the opportunities identified in the CPC Cycle Time Lean event have since been implemented. These opportunities resulted in a decrease in cycle time and an increase in process flexibility. These initiatives were critical in ensuring DWPF downtimes did not result in SWPF processing delays. Several more opportunities are in the process of being implemented. Implementation of the opportunities will ensure DWPF can continue to support SWPF operations and maximize throughput of the liquid waste system.

Figure 5 and Figure 6 capture the status of the opportunities from the Lean event. Figure 5 reports the status based on number of opportunities and Figure 6 reports the status based on potential cycle time savings.

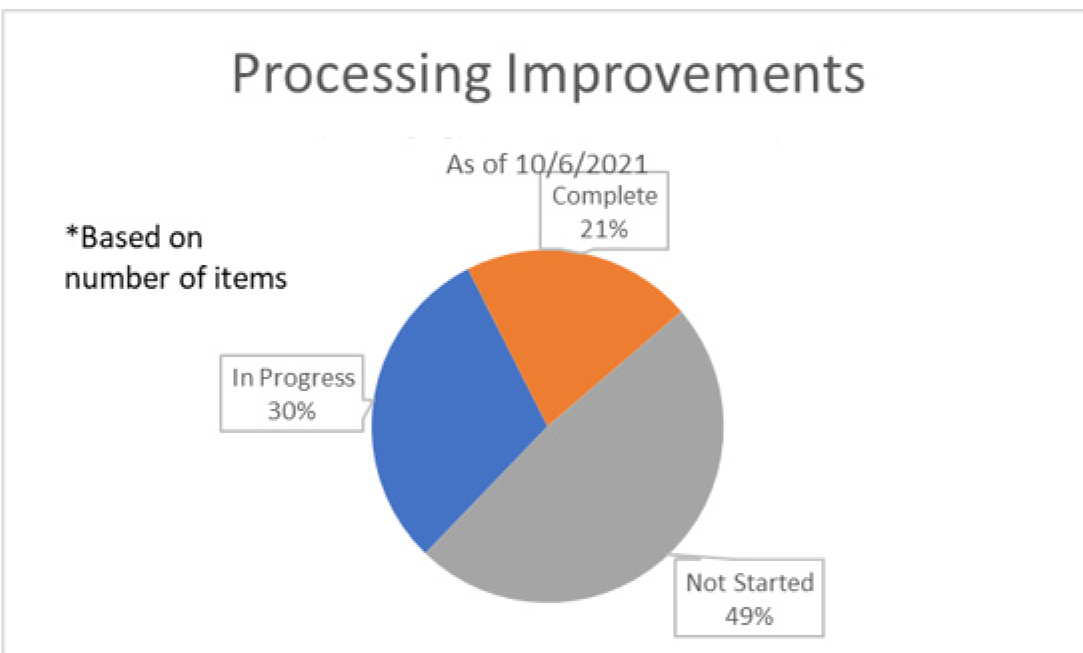

Fig. 5 Status of Processing Improvements

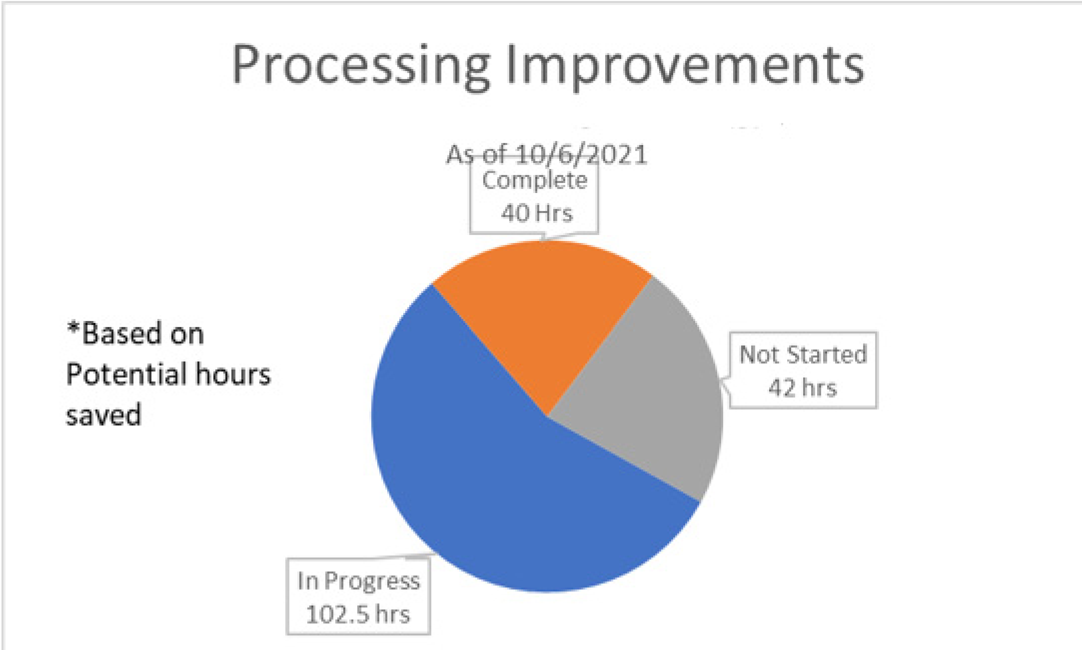

Fig. 6 Potential hours Saved by Processing Improvements

CONCLUSIONS

In comparison to 2010, 1,100% more salt was processed through DWPF during the first year of SWPF operations. Throughout this first year, DWPF cycle time and processing downtime did not result in a loss of production at SWPF. However, several areas for improvement were recognized. Cycle times for each processing step have increased since previous processing campaigns. Equipment failure and resulting processing downtime has increased as the facility has aged. Cycle time trending was completed to determine processing improvements that could be made and a Lean event was organized to decrease cycle downtime and increase process flexibility. The Lean event identified a number of opportunities, some of which have already been implemented. Implementing the remainder of the opportunities identified will ensure DWPF can continue to support SWPF operations and maximize throughput of the liquid waste system.