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Saltstone Disposal Units Project Progress and Design/Construction Approach– 23269

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ABSTRACT

The Savannah River Site (SRS) Saltstone Production Facility (SPF) processes low-activity liquid waste and immobilizes the decontaminated salt solution (DSS) into a non-hazardous cementitious waste form (saltstone) suitable for safe disposal in a Saltstone Disposal Unit (SDU). These SDUs located in the Saltstone Disposal Facility (SDF) are suitable for long-term storage and disposal of the solidified saltstone. Radioactive startup of the SPF was authorized in 1990 by the Department of Energy (DOE). Since 2015, however, the SPF has processed more than 39.6 million liters (10.46 million gallons) of DSS into multiple different SDUs. Beginning with SDU 6, the SDUs are based on a design that will safely contain more than 121.1 million liters (32 million gallons) of saltstone grout each. SDUs 6 and 7 are in operation. SDUs 8 and 9 are under construction with plans to turnover SDU 8 to Operations in the second quarter of the 2023 calendar year. Another project authorizes construction of SDUs 10, 11, and 12 and site preparation is in progress to support SDUs 10, 11, and 12 construction.

Building the SDUs consists of a design/construction approach that can be refined to seven sections:
1) Site Preparation (Subcontracted) - getting the location ready for construction
2) Mud mat installation (Savannah River Mission Completion [SRMC] Construction) – laying the foundation for the SDU
3) Cell Construction (Subcontracted) – building the SDU that includes the floor, walls, and roof
4) Liner Installation (Subcontracted) – prepping the interior of the cell and applying a protective liner
5) Balance of Plant (Site Construction) – the installation of all systems that make an SDU operable; ventilation, grout transfer, grout monitoring, electrical, drainwater collection and return, and public address
6) Leak Testing (SRMC Testing) – filling the SDU with water and a phosphorescent dye to perform hydraulic leak tightness test and spot any leaks with a black light
7) Balance of Plant Testing (SRMC Testing) – testing the operation of the systems that will make the SDU functional

With the annual throughput of salt solution increasing per year due to the increased throughput from the Salt Waste Processing Facility (SWPF), continuous improvements to the safety, reliability, and efficiency of the SDUs is necessary to continue to support the Liquid Waste Organization (LWO) mission. Lessons learned from building SDU 6, the first "mega-SDU", led to changes in how all future SDUs are designed and constructed. These changes include:

- The floor slab thickness.
- The Type V concrete mix modification.
- The floor slab construction improvements.
- Tapered wall thickness change.
- Additional post-tensioning rods in the walls and increased circumferential cabling.

Along with the above changes, following a value of continuous improvement, additional changes have been evaluated and determined to be technically acceptable for SDUs 10, 11 and 12. These changes will reduce project costs as SDUs construction continue to move forward. These changes include:

- Hybrid Coating/Liner installation.
- Reduced number of grout pour locations from nine to five.
- Deleting Distributed Control System (DCS) controlled actuators from grout valves.
- Reducing shotcrete cover coat from 5.08 cm (2 inch) thick to 3.81 cm (1.5 inch) thick.

Implementing these changes will place the SDF in a position to process an increased throughput as well as ensuring the continued success of the overall LWO mission for waste disposition. Each project maintains a lessons learned program to ensure continuous improvement while ensuring sure that the project's functional requirements are met in a safe, reliable and efficient storage of solidified saltstone.

INTRODUCTION

At SRS, the liquid waste mission is accelerating at a faster pace than ever before. This is primarily due to the SWPF coming online and integrating into the liquid waste mission. In 2022, the SPF processed over 7.57 million liters (2 million gallons) of DSS in under six months, setting a record pace for the treatment of DSS. With the accelerated throughput for the liquid waste mission, it was necessary to design, develop and construct mega-SDUs for the SDF that supports this operation.

The SPF is the facility that treats and immobilizes DSS, which is a low-level radioactive waste (LLW) that is received from the SWPF and Tank Farms. The LLW is treated by mixing a cementious material blend and DSS in the saltstone mixing process. Once the two inputs are mixed, it becomes what is known as saltstone or saltstone grout which has a DSS to saltstone grout volume factor of approximately 1.6. The saltstone grout is pumped at a steady rate of approximately 530 liters per minute (140 gallons per minute) during SPF production runs into the aligned SDU. The saltstone grout will then be monitored there for years to come by SPF Operations personnel and will remain there for safe, permanent storage [1]. SDF's mission is to provide safe and permanent storage of saltstone grout, which requires constructing SDUs for operation and then filling them with saltstone for safe disposal. Figure 1 displays a final rendering of the SDF after completion of the mega-SDUs. For SDF to support the throughput of 34.07 ML of DSS annually, it was necessary to change the design of the SDUs. The previous SDUs were 11.35 ML (3 Mgal) tanks. Under this design, approximately 82 tanks would have been needed to complete the liquid waste mission. The new mega-SDU design is a modified American Water Works (AWWA) D 110 Type I (cast-in-place) water tank design. With their 124.9 ML (33 Mgal) capacity, only 7 tanks are needed to complete the mission. There was an estimated cost savings of \$0.59/L (\$2.25/gal) difference between the previous SDU and the new mega-SDU design. Therefore, the decision was made to proceed with the mega-SDU design.

SDU 6 was the first mega-SDU constructed at SRS. It was turned over to Operations in 2018 for use in production and safe disposal of saltstone grout. Over the course of its construction, there were many lessons learned, improvements recommended, and changes made for SDU 7 and beyond. Some of the major changes include:

- The floor slab thickness.
- The Type V concrete mix modification.
- The floor slab construction improvements.
- Tapered wall thickness change.
- Additional post-tensioning rods in the walls and increased circumferential cabling

Additionally, in the last four years, there have been continuous improvement items that have been evaluated for potential use in SDUs 10, 11 and 12. SPF Operations personnel's input from SDU 6 operation has driven improvements such as deleting the DCS remote controlled actuators and installing manual valves on top of the SDU. However, most of the improvements are cost and schedule driven items that will help expedite mega-SDU construction while reducing costs for the customer.

Fig. 1. SDF End State Rendering.

DISCUSSION

A mega-SDU's construction cycle takes approximately 4-5 years and construction activities can be broken down into seven sections. First, the SDU's site must be prepared. This includes clearing and grading the SDU site area which takes approximately 8 months. The site of the SDU is predicated on an Engineering Evaluation Study (EES) that considers the Performance Assessment requirements [1]. It also evaluates the geotechnical conditions of each site and includes underground drainage to prescribed outfalls. This site preparation lays the foundation for the SDU's mud mats to be installed which takes approximately 3 months. The SDU is constructed on a lower and upper mud mat. In between the mud mats, a geosynthetic clay liner (GCL) and high-density polyethylene (HDPE) membrane are installed. The leak detection system includes 4 sumps located on the outside of the SDU which allows for samples to be taken for analysis if needed. From there, the cell construction begins, which includes the walls, roof, floor, and columns which are constructed on top of the upper mud mat. This takes the most time of the seven sections with an estimated 20 months for completion. The cell is constructed per a modified AWWA Type I design. The construction includes the placement of a 61 cm (24") foundation, 208 columns that are 61 cm (24") in diameter, and 25 tapered walls that are prestressed with approximately 547.2 km (340 mi) of cable. After the SDU cell is constructed, the liner is installed on the inside of the SDU, and balance of plant (BOP) equipment is installed. The cell's liner is constructed from a bromobutyl liner system and completely covers the floor and walls of the entire SDU and takes 7 months to complete. The cell's bromobutyl liner's purpose is to achieve leak tightness for the SDU in the event of cracking on the floors or wall. BOP equipment includes all the equipment that is needed to fill an SDU by SPF Operations such as piping, flammability monitoring stations, ventilation systems, motor control centers, temperature monitoring systems, and closed-circuit television systems. It takes approximately 7 months to install all the BOP equipment. After all the equipment is installed and construction is completed, testing is performed to ensure that the SDU meets all its design and functional requirements prior to turning it over to SPF Operations. Testing takes approximately 5 months. It is important to note that a lot of these sections partially overlap and are worked concurrently to one another when the design allows. This streamlines the SDU construction process.

During the first mega-SDU's construction, there were a few issues identified and recommendations incorporated prior to the construction of SDU 7. The floor slab design was changed significantly for SDU 7. SDU 6's floor slab has a sloped floor of 1.5% radially from the center, down to the inside wall. SDU 6's roof columns are supported by 0.465 square meters by 0.457 meters thick (5 square feet by 1.5 feet) footing on top of the 0.3-meter (1-foot) slab. Whereas SDU 7's floor slab is level, and the roof columns are supported directly onto the 0.61-meter thick (2-feet) floor slab. The elimination of the sloped floor slab and column footings increased the saltstone grout storage capacity by over 2,839,000 liters (750,000 gallons). SDU 6's floor slab utilized a checkerboard placement whereas SDU 7's utilized a linear placement. The floor slab sections are cured with water for a minimum of 12 days and placements are restricted to 14 days. The purpose of the limit between placements is to reduce the potential for cracking. Another area that was improved upon was the SDU wall thickness. SDU 6 was designed with a 25.4 cm (10 in) thickness at the top of the wall. For SDU 7, it was designed with 30.48 cm (12 in) at the top of the wall and includes one additional vertical-post tensioning rod in each wall section as well as 80.5 km (50 mi) of additional circumferential prestressing cables. This change was to account for the temperature differences for heat of hydration in the saltstone grout. Additionally, SDU 7 utilized a modified Type V concrete mix. The modified Type V concrete mix was tested to ensure its compressive strength was 41.4 MPa (6,000 psi), shrinkage was below 0.02% and its transport properties were within the Performance Assessment requirements.

Following the lessons learned from SDU 6 and incorporating them into the design for SDU 7, 8 and 9, other continuous improvement items that are being evaluated for potential use to help reduce costs and construction duration for SDUs 10, 11 and 12. For SDU 6, in response to the initial imperfections in the SDU 6 floor slab during construction, a full bromobutyl liner system was used as a conservative approach to achieve leak tightness. Subsequent modifications that were made to SDU 7 and beyond for the floor slab design and installation processes have produced promising results, this has allowed SRMC project engineering to explore the potential use of a hybrid liner system. The hybrid liner system would cover the floors and halfway up the walls of the SDU, where the SDU is most likely to leak, and would apply a coating on the remainder of the wall of the SDU. This proposed change has an estimated cost savings of $2M [3]. An evaluation was also performed on reducing the number of grout pour locations from nine to five. During long-radius flow testing for the mega-SDU design, it was observed that there was an estimated minimum 25 meter (82 feet) pour radius. Therefore, it was determined to utilize nine pour ports for mega-SDUs to achieve an even coverage across the 114 meter (375 ft) inner diameter tank. However, given operational data from SDU 6 and 7, grout flow has been observed to have a grout flow radius of 57.3 meters (188 feet). This conservatively exceeds the minimum grout flow radius of 41.1 meters (135 ft) required for five pour ports. By eliminating 4 pour ports and the associated piping for each, the change has an associated cost savings up to $100k per mega-SDU. Another improvement item for SDUs 10, 11 and 12 is to remove the DCS controlled remote actuator valves from the top of the SDU and install manual valves. To date, SPF Operations have only utilized the center pour port and due to lower radiological dose rates, it was deemed not necessary to have remote controlled valves for pour port alignment. This presents a costs savings of up to $750k per SDU. Another potential item to be utilized for future SDUs is reducing the SDUs outer shotcrete coating from 5 cm to 3.8 cm (2 in to 1.5 in) thick. By reducing the thickness, it minimizes potential drying shrinkage cracking and delamination of the shotcrete layer. This is due to the additional layers of shotcrete needed to meet the 5 cm (2 in) requirement. This presents a potential costs savings up to $50k per SDU. These improvements have been implemented in the projects Technical Requirements and Criteria (TR&C) documents and are being implemented starting with the shotcrete thickness reduction for SDU 9. The other improvement items will be implemented for SDUs 10, 11 and 12.

Fig. 2. Mega-SDU in Construction.

CONCLUSION

The mega-SDUs being constructed at the SDF continue to progress towards operational status. The mega-SDU design and construction approach with the seven major sections has been tried and proven with SDUs 6 and 7 now operational. These seven sections will continue to be the footprint for SDU 8 through 12. The SDU projects' lessons learned program and operational data from SDU 6 and 7 has allowed the SDU project team to implement many continuous improvement items that will be a better fit for the SPF and SDF to support the liquid waste mission at SRS for years to come.

REFERENCES

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