At Savannah River Remediation (SRR), robots are used in gigantic high-level waste storage tanks because they go where no human can for the following four reasons:

- To inspect the integrity of the waste tanks’ systems;
- To remove waste from the tanks;
- To clean up contaminated tank surfaces and equipment; and
- To retrieve samples of the residuals that cannot be removed from the tanks.

Savannah River Site (SRS), owned by U.S. Department of Energy, has 51 underground carbon-steel waste storage tanks, located in two tank farm facilities. These tanks are built to hold liquid radioactive waste from nuclear weapons production, and range in size from 750,000 to 1,200,000 gallons. Today, about 37 million gallons of highly radioactive liquid waste remain in 45 waste tanks. There are no plans to build additional tanks, so it is essential to continue to validate the integrity of existing tanks and transfer systems. Service life management of these tanks includes an on-going surveillance program where the primary and secondary tank walls and bottom areas in the annulus space are viewed with a manually manipulated camera. Select areas receive additional visuals (high resolution digital photography) and ultrasonic inspections. The cameras and sensors for these inspections are deployed on ‘wall crawler’ robots.

SRR became the Liquid Waste Operations contractor on July 1, 2009, and is tasked with the safe disposition of this waste and operational closure of the tanks in order to reduce the environmental risk to the surrounding communities and residents.

Both chemical and mechanical techniques are used to remove the waste to the lowest levels practical. These removal techniques have been further improved by SRR’s use of robots inside of the waste tanks. Several different robots have been used to achieve further removal of waste material, cleanup of contaminated tank surfaces, and retrieval of samples of the waste for laboratory evaluation.
Waste removal in these tanks is completed in a series of steps. The first step removes the bulk, or most significant volume of waste, and leaves behind a much smaller waste heel. Mechanical and chemical techniques are used in the second waste removal step to take out more of the hard-to-reach waste, leaving behind an even smaller amount of residual waste material. Additional steps, depending on the physical characteristics of each tank, may include cooling coil flushing or annulus cleaning.

After all of the applicable waste removal steps are completed, the samples of the residual waste material are retrieved and submitted for laboratory evaluation. Those results are analyzed to ensure the tank is ready to be operationally closed and filled with a cement-like substance. Only a small percentage of these residuals may be hazardous. Additionally, the tanks are remotely inspected and results are documented in a report to ensure that the chemical cleaning process has not impacted the structural integrity and waste confinement capability of the waste tanks.

These robots are equipped with cameras and controlled remotely by engineers. Engineers are selected for maneuvering the robots due in part to their technological and physical skills developed by playing video games. Their video game experience helps them know how to navigate the crawlers through the maze of cooling coils and in places otherwise inaccessible.

The Robots

The **Small Roving Annulus Inspection Vehicle (SRAIV)** is a modified, commercially available wall crawler designed to supplement the In-Service Inspection (ISI) of waste tanks. The SRAIV provides an improved capability to achieve a more complete inspection of the tank walls than existing methods. The SRAIV is deployed through annulus risers in the tank to gain access to tank walls requiring inspection. The SRAIV is deployed using a manually operated deployment pole and is coupled to the wall using permanent magnet wheels. Navigation is performed from the remote console where pictorial views can be displayed from the on-board cameras. The unit incorporates multiple ultrasonic inspection (JUT) transducers for traditional weld examination. These visual surveillances are performed on all accessible surfaces in the annulus in a systematic manner. Remotely controlled magnetic wall crawlers equipped with cameras and ultrasonic transducers integrated with commercially available “P-scan” data analysis equipment have been used to visually and ultrasonically inspect tank walls, weld areas, and leak sites.

The **Sand Mantis** has been used for reducing residuals using a patented water-jet system that transfers the material to a mill for grinding into smaller particles that can be more easily removed from the waste tanks. It sprays highly-pressurized water from a tiny opening made of gems, including sapphires – specially selected material that can stand up to the water’s pressure over time. The complete robot is 8 feet long and weighs approximately 800 pounds. The Sand Mantis’ cross-shaped body can be collapsed into a straight line for insertion through the small openings in the top of a tank. Once inside, the robot unfolds and is guided by remote control.
Tizzy is a tank-cleaning robot that functions much like a swimming pool cleaner. It will crawl along the floor of waste tanks and vacuum up residual material, which is then transferred to other tanks. Tizzy, designed and built by SRR, has yet to be used in the tanks and is still under development, but will accelerate the ability to cost effectively close some tanks and enhance the safety of workers.

Frankie, a commercially available robot, was modified by SRR and moves across the tank floor on treads that closely resemble the treads on a military tank. Frankie’s primary function is to scoop thin layers of residual material left behind from prior heel removal and cleaning processes. Frankie replaces a custom-built vial that was scraped along the tank floor; Frankie does a better job and with less risk to workers.

New innovations have led to the creation of **G.I. Joe**, SRR’s latest sampling robot. An enhancement of Frankie, G.I. Joe was also a commercially available design and was modified by SRR in order to obtain better samples of residual waste. The arm grips a scoop that is dragged along the tank floor. Once the scoop is filled with material, an engineer uses cameras and remote controls to maneuver the robot to another area within the tank where the scoop is placed into a basket. The basket is then lifted out of the tank and sent to the laboratory for analysis of the sample.

**PackBot and Brokk 400** are both remote controlled robots whose primary functions are to perform cleanup and inspection work. Both were purchased from suppliers and modified by SRR.

**PackBot**, about the size of a foot stool, performs remote cleanup activities in the Defense Waste Processing Facility (DWPF) Melt Cell, where hazardous waste is mixed with molten glass and poured into stainless steel canisters. The robot’s versatile design navigates various terrains of rubble, narrow passages and steep grades. Cameras on PackBot take real-time images that are displayed in 3D on control units, which allow for precise positioning to improve inspection of the DWPF sand filter structure.

**Brokk 400**, about the size of a golf cart, is used at DWPF to reduce waste volume. The robot cuts waste curved transfer piping, called jumpers, into straight lines so that they may be easily loaded into containers for disposal. This function has helped reduce the total number of storage containers, saving both money and environmental space and, additionally, reducing radioactive exposure to workers.

August 2013
Sample Crawler Versatrax 450
Manufactured By
Inuktun USA
- First used to sample Tanks 5 & 6
- Due to radiological concerns left in tank after use.

- Designed for pipe inspections
- 20" L x 15" W x 13" H
  (20" w/camera Raised)
- Weight - 100lbs
- Material – Aluminum
- 2 cameras / lights (3 sets)
- Manipulator – 4 function arm

Skids added by SRR
Gripper
Camera

Modification made by SRR base on lessons learned

- Skids (assist in transiting coils)
- Lifting bail – allows deployment in tank
- Replaced arm fasteners with hardened bolts
- Added undercarriage cage
- Replaced aluminum tracks with stainless steel
- Added splash guard for camera

SRR-LWE-2014-00144
Sept. 15th, 2014
Tank Characterization Sampling Overview

Challenges
- Limited Access
- Internal Obstruction

First Time Operations (Tank 12)
- Multiple Crawler Operation
- Tank 12 Two crawler sample hand off
- Wet Sampling

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Tank 5 Crawler insertion
Tank 5 Cooling coils before sampling/grouting
Tank 12 Sampling through water