Hanford Technology Development (Tank Farms) – 12509

Thomas Fletcher, Stacy Charboneau, Erik Olds
US DOE
thomas_w_fletcher@orp.doe.gov, Stacy_L_Charboneau@orp.doe.gov,
Theodore_E_Erik_Olds@orp.doe.gov

The mission of the Department of Energy's Office of River Protection (ORP) is to safely retrieve and treat the 56 million gallons of Hanford's tank waste and close the Tank Farms to protect the Columbia River. The millions of gallons of tank waste are a by-product of decades of plutonium production. After irradiated fuel rods were taken from the nuclear reactors to the processing facilities at Hanford they were exposed to a series of chemicals designed to dissolve away the rod, which enabled workers to retrieve the plutonium. Once those chemicals were exposed to the fuel rods they became radioactive and extremely hot. They also couldn't be used in this process more than once. Because the chemicals are caustic and extremely hazardous to humans and the environment, underground storage tanks were built to hold these chemicals until a more permanent solution could be found.

One key part of the ongoing work at Hanford is retrieving waste from the single-shell tanks, some of which have leaked in the past, and transferring that waste to the double-shell tanks – none of which have ever leaked. The 56 million gallons of radioactive tank waste is stored in 177 underground tanks, 149 of which are single-shell tanks built between 1943 and 1964. The tanks sit approximately 250 feet above the water table. Hanford's single-shell tanks are decades past their 20-year design life. In the past, up to 67 of the single-shell tanks are known or suspected to have leaked as much as one million gallons of waste to the surrounding soil.

Starting in the late 1950s, waste leaks from dozens of the single-shell tanks were detected or suspected. Most of the waste is in the soil around the tanks, but some of this waste is thought to have reached groundwater. The Vadose Zone Project was established to understand the radioactive and chemical contamination in the soil beneath the tanks as the result of leaks and discharges from past plutonium-production operations. The vadose zone is the area of soil between the ground surface and the water table 200-to-300 feet below. The project tracks and monitors contamination in the soil. Technologies are being developed and deployed to detect and monitor contaminants. Interim surface barriers, which are barriers put over the single-shell tanks, prevent rain and snow from soaking into the ground and spreading contamination. The impermeable barrier placed over T Farm, which was the site of the largest tank waste leak in Hanford's history, is 60,000 square feet and sloped to drain moisture outside the tank farm. The barrier over TY Farm is constructed of asphalt and drains moisture to a nearby evaporation basin.

Our discussion of technology will address the incredible challenge of removing waste from Hanford's single-shell tanks. Under the terms of the Tri-Party Agreement, ORP is required to remove 99 percent of the tank waste, or until the limits of technology have been reached. All pumpable liquids have been removed from the single-shell tanks, and work now focuses on removing the non-pumpable liquids. Waste retrieval was completed from the first single-shell tank in late 2003. Since then, another six single-shell tanks have been retrieved to regulatory standards.

The high-level radioactive waste is complex and takes many forms, from hard saltcake, soft sludges and, in some tanks, a bottom layer of hard, insoluble material. Access to the tanks is limited to small pipes, called risers, which extend from the inside of the tanks to above ground. The tanks themselves are covered with 10 feet of soil. All work conducted inside the tanks must be done remotely. Tanks can also have obstructions inside, such as old equipment or instrumentation. Due to these challenges, several methods have been utilized to address this unique challenge.

To remove the waste from the tanks, several technologies and techniques have been utilized to break up the waste and mix it into a slurry that can be pumped. Below are just some of those technologies:

- Saltcake dissolution: sprays water or liquid waste from above the waste to dissolve and mobilize the solid material so it can be pumped.
- Acid dissolution: uses oxalic acid to dissolve the hardened material at the bottom of the tank.
- Modified sluicing: uses less water and lower pressure than traditional sluicing methods.
- High pressure mixer: inserts a high pressure jet of water directly into the waste to thin it, making it easier to pump. The mixer is directional allowing jets of water to also be used to clear the intake of the pump and prevent clogging.
- Remote water lance: uses high pressure water at very low volume to break up hardened material on the bottom of the tank.
- FOLD TRACK: track-mounted device with a blade on the front that stretches out to be lowered into the tank, then reconfigures to push waste to the pump.
- Vacuum retrieval: injects low volumes of water at high pressure to mobilize the waste and vacuums it out almost as fast as it was introduced. It is ideal for tanks that are known to have leaked because it uses low volumes of water to break up the waste and removes the water quickly.
- Selective dissolution: removes certain isotopes, such as Cesium 137, with minimal dissolution of the saltcake waste.

To date, over 10 technologies have been developed or used at Hanford for the retrieval of single-shell tanks. The testing of many of these technologies and training of tank farm operators takes place at Hanford's Cold Test Facility (CTF) – a clean non-radioactive, full-sized mock tank where simulated tank waste is used to test retrieval tools. Constructed to replicate the majority of the older single-shell tanks, CTF is 75 feet in diameter, 27 feet tall and can hold approximately 660,000 gallons of material. The floor of the tank can be partitioned into segments, which allows equipment to be tested on the full range of liquids, sludges and hard saltcakes found in the actual tanks. Steel superstructures above the mock tank simulate ground level above different types of tanks and contain vertical risers like those found in Hanford's tanks.

Of the most promising new tools for tank waste retrieval is the new generation of robotic arms called the Mobile Arm Retrieval System, or MARS. This system is capable of rotating 360 degrees, moving up and down and telescoping to reach all parts of the inside of a tank. The MARS has high-and-low pressure water nozzles on its end to clean the sides of a tank and break up waste solids. The arm extends from a central mast that hangs from the top of the tank. A pump moves the waste up the mast and outside the tank. MARS is controlled remotely by an operator using joysticks, switches and push-button controls. In-tank video cameras guide the operators. Unlike earlier retrieval systems that were lowered into tanks through existing risers, the MARS is mounted on a concrete platform placed on top of the tank. This required excavating the soil covering the tank, and cutting a 55-inch hole in the steel reinforced concrete tank dome. The MARS was extensively tested and then installed into single-shell tank C-107 at Hanford, with retrieval operations now underway.

The MARS robotic arm is made primarily of steel hydraulic hoses and EPDM (ethylene, propylene, diene and polymethylene) hose. The movement is driven by a hydraulic power unit that is located on the top of the tank. This placement guarantees constant tension in the hoses to keep tangles from occurring. Unlike earlier sluicing methods, the MARS system is capable of outputting 100 gallons a minute at just 100 psi at normal pressure. The sluicing water is also recycled for reuse. These lower levels are needed in older tanks that may not be able to handle the stress of higher pressures, nor have the extra space for storing sluicing water contaminated through the process. However, when needed, the MARS system can output 20 gallons a minute at 5,000 psi.

Development work is continuing on retrieval tools that can be attached to the end of the MARS arm. Also, a second generation MARS system is currently being developed that replaces sluicing with a vacuum system. The vacuum MARS is expected to deploy into tank C-105 in late 2012. Like other vacuum retrieval methods, this technology is expected to be beneficial in retrieving waste in tanks suspected of leaking in the past.

Additional treatment technologies are being developed that can be directly deployed in the tank farms. A mobile wiped-film evaporator system is being developed to reduce the volume of tank waste by removing excess water from the tanks. A commercial system that has been adapted to use in the tank farms is being readied for testing.

Portable pretreatment technologies are also being evaluated. Rotary microfilter technology will be tested with Hanford high-level tank waste to segregate the low-activity liquid waste from the solid high-level waste. Small scale cesium-strontium ion exchange is being tested for removing soluble high-level waste from the liquid waste stream.

The Waste Treatment Plant (WTP), as currently being built, will not have the capacity to vitrify all the low-activity waste in Hanford's tanks. A second Low-Activity Waste Vitrification Facility is planned adjacent to the WTP. However, the consent decree between DOE and Washington state requires DOE to evaluate bulk vitrification and other alternatives for treating up to half of the low-activity tank waste.

Technologies are being evaluated on their ability to create a waste form as good as, or better than, vitrified glass; the ability to contain mobile radioactive contaminants; technical maturity; cost effectiveness and life-cycle costs, ability to scale up to treat up to half the low-activity tank waste and ease of operation and maintainability within the defined schedule.

Some of the potential supplemental treatment options include:

- Steam reforming: uses superheated steam and a reactant to convert low-activity waste into a dry mineral product.
- Bulk vitrification: places the waste and glass formers within a large open box and uses electrodes inserted into the mixture to heat and glassify the waste.
- Cast stone: low-activity waste is mixed with cement and fly ash to produce a hard stone-like waste product.

All of the supplemental treatment options require an in-tank pretreatment system to separate low-activity waste from the high-level radioactive tank waste. Pretreatment options that are being considered are ion-exchange technology to remove soluble radioactive cesium from liquid low-activity waste by binding it to a specially designed resin, and rotary microfiltration to remove suspended solid high-level waste.

One of the toughest challenges facing the Tank Operations Contractor (TOC) is consistently and reliably feeding the WTP 150,000 gallon batches of high-level tank waste that meet strict regulatory and operating requirements. Waste must be retrieved from underground tanks and transferred to 15 double-shell tanks that will be used to feed waste to the Pretreatment Facility at the WTP. Demonstration projects will test the effectiveness of the baseline plan to use two 300-horsepower mixing pumps in the feed tanks to break up the waste sludge, suspend the solid particles, and keep the waste mixed while it is transferred to the WTP.