MARS, the Robot Arm Cleaning up Radioactive Waste

The Department of Energy has now spent more than two decades trying to clean up the Hanford site in Washington state, formerly one of the biggest plutonium-producing areas in the country. Now, the newest tool—a robotic arm that can blast compacted radioactive waste from Hanford's old holding tanks—is operational and speeding up the cleanup there.

BY TIM NEWCOMBPUBLISHED: NOV 7, 2011

You can't exactly drop somebody into an underground tank filled with thousands of gallons of radioactive sludge and have them wipe it clean. But at the largest nuclear waste cleanup project in U.S. history, a smart machine is on the job. The Mobile Arm Retrieval System (MARS) is a robotic arm that officials hope will speed up the process and dramatically cut down the costs of radioactive waste cleanup.

Lead Nuclear Chemical Operator Dave Krug operates the controls of the Mobile Arm Retrieval System now removing waste from Hanford's single-shell Tank C-107. It is the largest robotic arm ever placed inside a Hanford tank to remove waste.

The site of this high-tech cleanup is the Department of Energy's 586-square-mile Hanford site, located in the desert of southeastern Washington state. The site, established in 1943 as a plutonium-

producing hub for the Manhattan Project, houses nine former nuclear reactors and their associated processing facilities used during World War II and throughout the Cold War to build America's nuclear arsenal. That process produced billions of gallons of liquid waste and millions of tons of solid waste, which the DOE has been cleaning up since 1989.

There are 149 underground single-shell tanks at Hanford housing radioactive sludge, according to Kent Smith, the single-shell retrieval and closure manager for DOE contractor Washington River Protection Solutions. Since 1999, crews have used the "modified sluicing" technique that pumps in liquefied waste to push the sludge toward the center of the tanks, where a central pump sucks it up and transfers it to a double-shell tank for safer storage. However, the sluicing machine hasn't budged the toughest of the sludge, often leaving more than 10 percent of the radioactive goop inside the tanks.

But MARS, a fully maneuverable robotic arm that Smith says began working on Sept. 29, can reach nearly 40 feet into a tank and sluice 90 gallons a minute at 100 psi. That's its normal speed; at high pressure, MARS can fire 20 gallons a minute at up to 5000 psi, attacking the gunk that traditional sluicing leaves behind.

The Mobile Arm Retrieval System, the largest robotic arm ever inserted into a Department of Energy waste storage tank, is at work at Hanford removing 253,000 gallons of waste from single-shell Tank C-107.

Smith says the articulating knuckle on MARS has a telescoping ability that lets the unit reach every portion of the tank, top to bottom, to clean out the 253,000 gallons of waste left inside. "Telescoping 37 feet out to the edge of the tank, the arm can move up and down off a pivot point," Smith says. "At the end effecter, a nozzle system can rotate in all directions. There is a lot of flexibility to get to the waste itself, something lacking in the current system." The operating head has multiple low- and high-pressure spray nozzles that hydraulically "rake" waste to a central pump. And by blasting liquid waste already retrieved from Hanford's tanks, MARS can loosen the compacted sludge without contaminating more water.

So far, one of the biggest challenges in using MARS has been just getting the 20,000-pound steel and hose contraption into the tank—the hatch was too small. Crews remotely cut a 172-inch-circumference hole in the concrete, using a pressurized mix to methodically etch away the 15- to 20-inch-thick concrete and rebar. The slow and steady stream ensured the debris remained miniscule and easily removable by MARS.

The robotic arm is made primarily of steel hydraulic hoses and EPDM (ethylene, propylene, diene, and polymethylene) hose. All the movement is driven by a hydraulic power unit weighing 96,000 pounds and located on the top of the tank system, which also ensures a constant tension on the hosing system to keep tangles out of the C-107 process. One person operates the arm from a trailer over 50 yards away in an upwind, uncontaminated area; another monitors the flow rates; a third watches the hydraulics powering MARS and a fourth checks the flow into the retrieval tank.

By about three weeks into the MARS project, crews had cleared 27 percent of the waste out of C-107, the first tank in which it has been used. It's already exceeded the performance of ordinary sluicing and eliminated the need for multiple cleaning methods for each tank, cutting millions of dollars and months of time from the process. The first-ever Hanford C-farm tank cleaned—C-106—cost $100 million as crews figured out the process. Now costs range between $6 million and $9 million a tank for the sluicing method. The C-107 tank will cost about $15 million to Mars, Smith says, but the equipment is reusable at least two more times. And as crews get better with the system, the cost for the next two tanks could drop to $5 million each.

MARS has proved so popular that its creators are designing a second generation bot, one that replaces the sluicing of liquid with a vacuum system. That could come in handy at Hanford: Of the 149 tanks, 67 are known or suspected leakers, and regulators have said the leaky tanks can't handle the thousands of gallons of liquid required to loosen the sludge, for fear that MARS' power would blast radioactive contamination through the leaks. The new system is undergoing final testing in preparation to deploy into tank C-105 late in 2012.

Of course, once the MARS robots collect all this radioactive sludge, it has to go somewhere. The DOE aims to turn Hanford's 56 million gallons of liquid waste into vitrified glass, through a process that heats and blends the waste with molten glass, then pours the mixture into stainless steel canisters for storage. The DOE is building four major concrete facilities—a pretreatment center, low-activity waste vitrification site, a high-level waste vitrification site, and an analytical laboratory—and about 20 support facilities that include operations and maintenance buildings, utilities, and office space.

"The vit plant will be largely self contained, functioning like a small city," says Gary Olsen, DOE area project manager. The project kicked off in 2001 and is nearing its final design deadline of 2013. Construction will wrap in 2016, and the plant will be operational by 2019. By then, the MARS project should be even more refined, and ready to take on the huge task of cleaning up the remaining tanks—there are 136 still not full clean, Smith says. "I think MARS would be used at the majority of the tanks," he says. "We are pretty excited about this. We think it's a new day for retrieval."

Nancy Uziemblo from Washington state's Department of Ecology agrees. "It has been a long process to achieve one of the state's highest priorities—removing waste from single-shell tanks to protect our environment. We are counting on the MARS to jumpstart single-shell tank retrievals."