A Mobile, Teleoperated, Tool Platform for use in Waste Tank Remediation Efforts

Thomas A. Nance and Robert F. Fogle
Westinghouse Savannah River Company, Savannah River Site
Aiken, SC 29808

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-96SR18500 with the U. S. Department of Energy.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE Contractors from the Office of Scientific and Technical Information, P. O. Box 62 Oak Ridge, TN 37831; prices available from (423) 576-8401. Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

Abstract

For several decades at the Department of Energy's Savannah River Site, large underground storage tanks have been used to contain highly radioactive waste. This waste must now be transported out of the tanks to be processed into a more suitable long-term storage medium. In addition, the emptied tanks must be cleaned in adherence to both state and federal requirements before being permanently closed. Unfortunately, transfer of the waste by pump leaves behind several types of waste forms away from pump suction: highly alkaline and radioactive sludge, rock-like solid masses called clinkers, or large, solidified salt formations known as tank heels. These waste forms must be dissolved and moved on the tank bottom to pump locations prior to being removed from the tank.

A low cost crawler is being developed to carry a range of tools to dissolve or breakup the residual heel and clinkers left in these large storage tanks and move the waste so that it can be easily pumped out of the waste tanks. The remotely operated tool platform being developed will carry a water cannon and other water conveyance devices and will be able to access the tanks through available small access ports. This paper will discuss the cleaning challenge, possible solutions and their evaluation and selection, design, development, and mockup testing results of a low cost, mobile, teleoperated, tool platform for breaking up large waste deposits remaining in underground waste storage tanks.

Background

General Tank Information

The majority of waste tanks at SRS are categorized by four types. Type I tanks contain interior columns as well as cooling coils. Type II and III tanks both contain an interior center column and cooling coils. Type IV tanks contain no columns or cooling coils. The tanks also contain other interior obstructions such as pumps and thermocouple well pipes from other ports. In addition, the tanks contain other interior interferences in the form of general debris.

Target Tank Selection and Details

The underground storage tanks to be cleaned and closed are approximately the same size but internally have differences. The target tank for this project is a Type IV tank with no internal obstructions such as columns or cooling coils. This would allow the mobile platform to enter the tank with a tether from the platform to the command center above the riser with little chance of becoming entangled during movement around the tank bottom. This tank is 85 feet in internal diameter and 34 feet in internal height. This tank contains no internal columns or cooling coils to interfere with the platform's movement. The access to this tank is through a 22" diameter riser several feet in length. The riser is located near the edge of the tank with the space above the riser open for use by a crane.

General Description of Tank Waste

The waste material in the tanks varies for each tank. The material location in each tank is determined by the type of waste material, the action of slurry pumps, additions to the tank, subtractions from the tank, and the locations of pipes, columns, and debris in the tank. The location of a riser port above the waste is desired but not always available. The smaller ports are easier to access due to the reduced size and weight of the riser plug to be removed. Smaller openings also decrease the radiation exposure of the operating crew.

Target Tank Waste Description

The target tank for this project will have several inches of liquid on the tank floor after pump-out and additional liquid level is anticipated with any sluicing during use of the platform. The tank contains material that is radioactive and alkaline and also contains general debris. This tank contains a waste heel in the form of a mound of waste located in a band the width of the tank. The mound rises to a height of four feet in the center and is expected to breakup upon blasting with a focused water stream.

Past Tank Cleaning Methods

Several cleaning methods have been utilized previously by tank farm operations. Water cannons (sluicing monitors) have been lowered through the tank risers and utilized near the tank ceiling. The water nozzles did result in some breaking up of the waste mound but left a significant amount of amassed waste due to the distance from the nozzle to the waste material on the tank floor.

Sewer-cleaning rigs have also been used. These rigs consist of a water nozzle on the end of a hose, which sprays a cutting spray ahead, and several driving spray streams to the rear for propulsion forward. This tool worked well removing waste but was difficult to steer and direct at the remaining waste accumulation.

Ducted turbine pumps have also been tested to mix solid/sludge waste into solution. These mixers were deployed through riser ports into the tanks and used to produce currents in the supernate. These pumps have been successful but waste material remains after the pumps have been removed and the supernate has been pumped out.
Selection of Solution

From past experience removing solid waste material from tanks, the waste can either be returned to solution for pump-out by breaking the material up and mixing with liquid, or the waste can be gathered and moved to a mixing chamber where it can be mixed with liquid for pump-out. These methods of removing the waste from the tank are basically: mix and pump, or scoop/dredge and move then mix and pump. These solid/sluide waste removal methods can be accomplished by movement of current sluicing devices using a transport platform.

Selection of a Transport Platform

The transport platform could travel on the tank walls or tank ceiling, in the air space above the supernate, or on the tank floor. A transport platform could travel on the walls and ceiling using magnetic forces in carbon steel tanks but would be difficult to develop to resist the large reaction forces of the sluicing payload. The wall crawler would also not be useful in tanks with non-magnetic walls and ceilings or with paint, corrosion, or residues on the walls and ceilings, which would interfere with its magnetic engagement. Limiting the crawler to the walls and ceiling would also position the sluicing payload far from any waste accumulation in the center of the tank floor.

A transport package operating in the air space above the supernate would be required to handle the reaction forces of the sluicing device payload. This could be accomplished with a cable system extending to several risers. The cable transport system would consist of a cleaning device attached to multiple cables with each cable extended from a different riser around the tank perimeter. By varying the relative lengths of each cable in the tank the device can be moved to virtually every location on the tank bottom. This transport package would not deliver the sluicing payload over every position on the tank floor and would also require usage of multiple access ports. Horizontal movement of the waste material across the tank floor would also be difficult to control using water streams from above the waste as opposed to a stream aimed horizontally at the waste.

A transport package on the tank floor would use friction with the floor to counteract the reaction force from a sluicing payload. The bottom crawler could be used in tanks made of magnetic or non-magnetic materials. The crawler could also enter through any riser and travel to any location on the tank floor. This crawler would also direct the stream from its sluicing payload horizontally across to the movement of the waste across the tank floor. The bottom travelling crawler would offer the most stable platform with the ability to travel to any location in the tank with the lowest amount of development required.

A transport platform travelling on the tank floor would require traction and tight turning capabilities, which could be provided by tracked systems. Therefore a tracked, submersible, remotely operated platform to carry a sluicing payload could be used to clean and close the tanks. This crawler would also need to easily to decontaminate to allow removal from the tank for crawler servicing or for deployment in other tanks. The crawler also needs to be low in cost to make disposal a viable option after the crawler's life has been shortened due to in-tank work.

Evaluation of Commercially Available Crawlers

Numerous remote operated robotic platforms are available that could be used in the cleaning and closure of radioactive waste underground storage tanks. These crawlers are represented across a range of sizes, capabilities, and costs. Numerous robotic crawlers can pass through the available riser to access the tank but can not carry the required payload while dragging its tether and the payload's tether. Other crawlers can carry the required load and drag load and are submersible but are costly and cannot pass through the access riser. Therefore, development of a robotic platform is required to provide the capability of accessing the small riser with a submersible mobile platform able to carry a payload and pull tethers across the tank at a low cost.

Design Criteria

Numerous criteria must be met to provide a crawler with the capabilities to perform the desired task. The crawler must be able to pass through a 22" diameter access port. The crawler must be remotely operated from outside the tank. The crawler must be submersible to a depth of two feet. The crawler must be operated by electrical, water or air driven motive force. Hydraulic motive force is not desired due to the risk of creating mixed waste by possible leakage of hydraulic fluid. The crawler must be capable of carrying a sluicing device payload and provide a stable platform to withstand the reaction forces associated with its actuation. The crawler must be able to carry the payload with positive engagement of the payload to the crawler. The positive engagement will ensure that the payload will not be lost in the tank. Safety cables should also be attached to the crawler and to the payload devices for further removal assistance if needed in the case of loss of motive force. The crawler should be designed to accept several types of payload devices with no modifications or adjustments made to the crawler. The crawler mounting plate should be able to have the payload devices inserted into the tank and remotely loaded onto and unloaded from the crawler. The crawler must be able to be inserted into the tank and also retrieved from the tank.

The crawler should be able to travel 80 feet across the tank bottom from a starting point of under the access riser. The crawler must be able to carry the payload device and pull its retrieval cable and any other umbilical tether across the tank floor. The crawler must be able to maneuver on the tank floor in sludge material up to six inches in depth. The crawler should be able to turn in a full circle to return to its place of origin under the access riser. The ability to maneuver will provide the operator with assistance in payload removal and mounting and also in positioning the payload devices to optimize their cleaning abilities. The crawler must be able to crawl over ½ inch thick plates and general debris such as steel measuring tapes.

The crawler will be partially submerged in supernate liquid in the tank. The crawler must be resistant to the supernate, which has a pH of 7 to 12 to provide a life span of three months. The crawler must be intrinsically safe to operate in the environment of the tank bottom. The crawler should be capable of being washed down before being pulled from the tank riser. The crawler is likely to carry sludge waste material on the outside of its body during removal from the tank. Washing down the crawler will remove the waste from the crawler and eliminate possible contamination of the tank top and exposure of the operators to the radioactive waste material.

Design Development

A tracked platform has been evaluated to be the best method for transporting tools within a tank with a limited opening and containing a layer of sludge/liquid only a few inches in depth. The tracked vehicle will need to be submersible due to the liquid content of the tank and the use of several tools within the tank that would discharge water/liquid. Special tracks will need to be used to provide traction in the liquid/sludge contents of the tank. The tracked vehicle will need to be powered remotely using an umbilical to provide electrical power to allow the vehicle to be utilized for several months without the difficulties of battery replacement. The electrical umbilical will also provide control signals to control the vehicle without the difficulties of radio transmission within the tanks.

The vehicle will require at least two tracks to provide the ability to turn on the floor of the tank. The width between the tracks will be the same or wider than the platform to provide stability for the mounted tools. The framework joining the left and right tracks will be made to fold for entry and removal of the vehicle through the tank riser. The tools will cause reactive forces and moments to act on the platform and tracks and will require the length of the tracks to be at least as long as the width the tracks are spaced from each other. Due to the length of the commercial tracks that will be used, two tracks will be used to provide the desired track length on each side of the crawler.

The platform will need to be compatible with the various tool payloads to be transported within the tank. The platform will need to access the riser while providing the largest area possible for mounting tools. The platform will need to allow remote loading and unloading of the tools while providing a secure base for their operation. Dowels will be provided on the framework of the crawler to allow mounting/removal of tools remotely from above while also allowing the tool platform to fold to pass through the tank riser.

Procedure for Field Use

The process of using the crawler is described in the following. The crawler would be suspended by two safety cables attached to the two rear lifting points on the track plates. These two lifting points would be at the end of two rods allowed to swivel towards the rear of the crawler. This would cause the crawler to fold for entry into the access riser. The center rear riser would be hooked to a separate hook and cable with slack provided. The crawler would then be lowered in its folded configuration into the access port. Once the crawler has emerged from the access riser into the tank and has cleared the inside ceiling of the tank interior, the crawler can be unfolded. The crawler is unfolded by holding the rear center cable while paying out the two cables to the two track plates. This lowers the track plates around the center support until the side linkages become perpendicular to the track plates. The side linkages would then be locked out using a spring-loaded locking bar mounted on the center support. The crawler is then lowered to the tank bottom with the tracks actuated in forward. The
forward movement of the tracks assists in the crawler landing in an upright position. The crane hook is then detached from the rear center bail.

The crawler is ready to be mated with a payload device. The crawler is maneuvered under the riser to wait for the payload device. The payload device is lowered through the access riser while being guided down the two safety cables. The payload device mounting plate mates with the crawler to provide a stable platform to resist the reaction forces of the payload device during its usage. The crawler then is driven to the location of desired payload usage while paying out its electrical tether, the safety cables and the payload tether. At completion of the tasks for the payload, the crawler is positioned underneath the riser with slack in the tethers and cables taken in. The payload is lifted from the crawler, washed for decontamination purposes, and removed through the riser. The crawler is ready for mounting another payload. If the crawler is to remain in the tank for an extended period without a payload, the crawler can be lifted by the rear center bail to suspend it inside of the tank. This allows the crawler to be washed by spraying down from the access riser. Suspending the crawler also removes it from contact with the corrosive waste material and supernate on the tank floor.

The crawler is removed by attaching a crane hook to the front center bail and lifting the crawler. The front center bail is connected to the spring-loaded center bar mounted on the center support. Lifting by the center bail pulls on the bar and releases the side linkages, allowing the track plates to rotate down around the center plate. This provides the crawler with a small profile to allow it to be removed through the riser. The crawler is washed prior to removal from the riser for decontamination and is retrieved through the access riser.

Conclusion

A prototype of the crawler has been built. The crawler has been tested for its load capability and its maneuverability. Further testing of deployment, payload mating, stability during payload usage, ability to climb over debris and objects, and cable management have to be conducted. This mobile tool platform will be a useful tool in the tank closure arena.

Click here for Figure 1
Click here for Figure 2
Click here for Figure 3
Click here for Figure 4
Click here for Figure 5