Underground Radioactive Waste Tank
Remote Inspection and Sampling*

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UNDERGROUND RADIOACTIVE WASTE TANK REMOTE INSPECTION AND SAMPLING*

Abstract

Characterization is a critical step in the remediation of contaminated materials and facilities. Severe physical- and radiological-access restrictions made the task of characterizing the World War II-era underground radioactive storage tanks at the Oak Ridge National Laboratory (ORNL) particularly challenging. The innovative and inexpensive tank characterization system (TCS) developed to meet this challenge at ORNL is worthy of consideration for use in similar remediation projects.

The TCS is a floating system that uses the existing water in the tank as a platform that supports instruments and samplers mounted on a floating boom. TCS operators feed the unit into an existing port of the tank to be characterized. Once inserted, the system’s position is controlled by rotation and by insertion and withdrawal of the boom. The major components of the TCS system include the following:

- boom support system that consists of a boom support structure and a floating boom,
- video camera and lights,
- sludge grab sampler,
- wall chip sampler, and
- sonar depth finder.

This simple design allows access to all parts of a tank. Moreover, the use of off-the-shelf components keeps the system inexpensive and minimizes maintenance costs.

The TCS proved invaluable in negotiating the hazards of ORNL’s Gunite and Associated Tanks, which typically contain a layer of radioactive sludge, have only one to three access ports that are usually only 12- or 24-in. in diameter, and range from 12 to 50 ft in diameter. This paper reviews both the successes and the difficulties encountered in using the TCS for treatability studies at ORNL and discusses the prospects for its wider application in remediation activities.

Introduction

As the contractor for the Oak Ridge National Laboratory’s (ORNL’s) Remedial Investigation/Feasibility Study (RI/FS), Bechtel is responsible for developing plans and procedures, conducting field investigations, and reporting characterization results. The 8,800 acres of the ORNL reservation have been divided into 20 Waste Area Groupings (WAGs) with approximately 250 known Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-contaminated sites and RCRA solid waste management units. In one of these WAGs, Bechtel developed and deployed a new robotic system to characterize underground radioactive waste storage tanks. These underground storage tanks were built in the 1940s of Gunite, a sprayed-on concrete frequently used for in-ground swimming pools. Detailed characterization of these tanks was required to provide information to an ongoing Treatability Study.

The tanks contain sludges and liquids. They have been used to collect, neutralize, store, and transfer radioactive and/or hazardous chemical wastes since the beginning of ORNL operations in 1943. A significant portion of the sludge in this tank farm was recovered during a sludge mobilization campaign in 1983. That sludge removal project was stopped before the tanks were completely cleaned; the present work is to characterize the remaining contents. These tanks are either 25 or 50 feet in diameter and have dome-shaped roofs up to 18 feet high. They are buried under approximately 6 feet of soil. There are between one and three available entry risers for each tank, with internal diameters of either 12 or 24 inches.

The needs of the ongoing Treatability Study program were as follows:

1. selectively retrieve samples of sludge and objects (from areas throughout the tanks) to determine waste properties for remediation system designs;
2. measure the depth of the sludge to refine volume estimates for waste management planning; and
3. videotape the inside of the tanks for waste management and remediation engineering planning.
To perform these studies, we designed and fabricated a number of unique tools and a deployment system to pass through 24-inch, and in some cases 12-inch, manholes and enter the tank. Seven Gunite tanks were characterized using the newly developed ORNL Tank Characterization System (TCS). The ORNL TCS uses simple principles and off-the-shelf technology to solve difficult problems. It includes four major subsystems: the floating boom and support system, the video camera and lights, samplers including a grab sampler and a concrete chip sampler, and a sonar depth finder. These systems aided in determining the locations, quantities, and compositions of materials in the tanks as the basis for remediation planning. With the TCS, we were able to inspect the tank above and below the water, map the sediments in the bottom of the tanks, take samples of the sediments or debris, and take small samples of the Gunite walls of the tanks. The TCS tools reach up to 50 feet horizontally away from the manhole.

**Floating Boom and Support System**

This is the structural portion of the TCS and consists of a flexible floating boom and boom support (Figure 1). It is used to transport tools and characterization instruments to any lateral location in the tank.

The boom support is fabricated from aluminum and consists of a base, a “lazy Susan,” and support channels that extend down into the tank through the riser. The boom support can be installed by two men in less than 30 minutes at the manhole. In our application, the base was simply clamped to the riser flange at the tank manway. The support channels can be lowered at least 25 feet into the manhole, and the “lazy Susan” can be rotated 360 degrees.

The floating boom is constructed from commercially available plastic chain. The chain is rigid laterally and is built to roll in only one direction. Foam is added for flotation, and the boom is deployed by sliding the chain down the support channels to the water surface. By rotating and inserting or withdrawing the plastic boom, any part of the tank can be reached. By measuring the length of boom inserted and the angle of deployment, the operator can pinpoint the location of the tool at the end of the floating boom.

*Place Fig. 1 here*

**Video Camera System**

The TCS includes a custom-mounted video camera that can inspect either above or below the waterline. All camera system functions are controlled from a control box outside of the immediate work area. The camera system consists of the following sub-systems: camera with built-in pan-and-tilt, waterproof housing, and lights (Figure 2).

The video camera is a standard resolution color camera with 8 times zoom, manual focus, 1 lux light rating, and auto iris. The pan-and-tilt unit is an integral part of the camera with 180 degrees pan and 180 degrees tilt envelope. This is an inexpensive off-the-shelf unit that was modified for remote operation and placed in a specially fabricated waterproof housing.

The waterproof housing was fabricated from PVC. It is designed to be rugged, lightweight, and able to float without the use of any additional flotation material. It houses the camera, pan and tilt unit, and an electrical connector for the camera control cable. The face of the housing is a clear plastic dome that allows the camera to operate through its full pan-and-tilt range. The camera system can be removed for maintenance or adjustments by sliding the top cover out of the housing. The housing system also includes a pneumatic actuator that tilts the whole housing up to 90 degrees so that the camera’s 180 degree tilt can cover floor-to-ceiling or front-to-back underwater.

The basic lighting system consists of a 50 watt quartz halogen light lamp. The bulb was placed inside the metal housing, which serves as a heat dispenser and allows it to operate both in and out of water. The unit is then placed in a waterproof PVC housing. The light is also designed to be self-floating. An electronic transformer in the control box is used to supply 12 volt AC to a dimmer that controls the brightness. Additional lights can be mounted on the floating boom or camera housing, and drop lights suspended from the boom to just a few inches above the sediments were also successfully tested.

*Place Fig. 2 here*
Remotely Activated Samplers

The ORNL TCS includes two remotely activated samplers, a clamshell grapple for taking samples of bottom sediments and debris, and a concrete wall chip sampler. The clamshell grapple system is designed to retrieve sludge and debris samples and small objects from tanks with limited access. The grapple system consists of two sub-systems: grapple and winch.

The grapple is a double-jaw sampler operated pneumatically from a remote location (control box). It can be open or closed as often as required without the need for manual reset. Force at the jaws can be adjusted anywhere from 0-60 pounds on the current design, and more with minor modifications (Figure 3). All parts are waterproof and fully submergible. The body is fabricated from PVC, which was selected for its light weight, low cost, and ease of cutting and machining.

The winch system is an electric driven winch floating on the water directly above the grapple. It will lower and raise the grapple to and from the bottom of the tank remotely. Deployment depth is determined by monitoring lowering and raising times, by an electronic pulse read at the control box, and/or by direct observation with a video camera. A worm drive gear reducer can stop and hold the grapple at any depth and at any distance from the winch system to facilitate the entry and exit from the tank manhole.

Place Figure 3 here

The concrete wall chip sampler consists of a small pneumatic die grinder that is mounted on a float at the end of the floating boom. The grinder is maneuvered to the desired sample location and the bit is placed in contact with the wall. A small venturi is used to create suction and collect the grindings in a sample bottle. By grinding the wall, small samples of concrete are collected for radiological analysis. These data will be used to model dose rates and residual contamination levels.

Sonar Sludge Mapper

An off-the-shelf sonar depth finder was mounted on the TCS floating boom to map the depth of sludge in the tanks. By varying the sensitivity of the sonar, the operator can distinguish the sludge surface (high sensitivity) and the concrete floor of the tank (low sensitivity). This technique allowed us to refine sludge volume estimates in any tank with at least 2 feet of water. Figure 4 shows examples of the sludge maps generated from TCS data.

Place Figure 4 here

Conclusion

The ORNL TCS demonstrates that innovative use of off-the-shelf technology, combined with remote operations know-how, can solve difficult problems at low cost. This system was used to characterize seven highly radioactive underground storage tanks at ORNL. Data collected included sonar depth information, sediment samples, debris samples, concrete samples, and video observations. The TCS concept can be easily modified to accept a variety of samplers and sensors. For example, addition of radiation detectors would be a simple matter as would collection of liquid samples, if these data were required by a project. Data from the characterization campaign in now being used in planning and executing the treatability study that will lead to final remediation of these tanks. The floating boom concept is ideal for characterization of large underground tanks, aboveground tanks, waste basins, and ponds.