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Small Waste Tank Sampling And Retrieval System

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ABSTRACT

At the Test Reactor Area of the Idaho National Engineering and Environmental Laboratory (INEEL), four 1500-gal catch tanks were found to contain RCRA-hazardous waste. A system was needed to obtain a representative sample of the liquid, as well as the hard-packed heels, and to ultimately homogenize and remove the tank contents for disposal. After surveying the available technologies, the AEA Fluidic Pulse Mixing and Retrieval System was chosen for a technology demonstration. A demonstration, conducted with nonhazardous surrogate material, proved that the system was capable of loosening the hard-packed heel, homogenizing the entire tank contents, and collecting a representative sample.

Based on the success of the demonstration, a detailed evaluation was done to determine the applicability of the system to other tanks. The evaluation included the sorting of data on more than 700 tanks to select candidates for further deployment of the system. A detailed study was also done to determine if the purchase of a second system would be cost effective.

The results of the evaluation indicated that a total of thirteen tanks at the INEEL are amenable to sampling and/or remediation using the AEA Fluidic Pulse Mixing and Retrieval System. Although the currently-owned system appears sufficient for the needs of one INEEL program, it is insufficient to meet the combined needs at the INEEL. The INEEL will commence operation of the system on the TRA-730 Catch Tank System in June 2002.

I. INTRODUCTION

In June 2000, the Idaho National Engineering and Environmental Laboratory (INEEL) and the Idaho Department of Environmental Quality (IDEQ) entered into a Voluntary Consent Order (VCO)[1] to address potential compliance issues with the Idaho Hazardous Waste Management Act (HWMA)/Resource Conservation and Recovery Act (RCRA). One of the issues covered by this consent order is a group of over 700 tanks across the INEEL that require further characterization. The INEEL must determine whether each of these tanks is empty, or whether the contents are RCRA hazardous. For tanks found to contain hazardous waste, the next actions (e.g., RCRA closure) will be negotiated under the consent order. Obtaining a representative sample for the RCRA hazardous waste determination for some of these tanks is troublesome. The VCO tanks range in size from a few gallons to 30,000 gallons, with the majority in the 5,000 gallon or less size range. Because of the relatively small size of these tanks, and associated access issues, technologies designed for the larger high-level waste (HLW) tanks cannot be used on these tanks.

The TRA-730 Catch Tank System (CTS) at the INEEL Test Reactor Area (TRA) contains hazardous waste and is managed under the VCO as a separate action plan. The CTS contains four catch tanks. Each tank is a 1,500-gallon horizontal, cylindrical tank, that contains multiple phases (i.e., liquid, soft sludge, flocculent solids, and hard-packed tank bottoms/heels) of high-activity, low-level waste. Liquid-phase samples were obtained, but conventional methods were inadequate to obtain samples of the hard-packed heels; complete characterization requires an alternate sampling approach In addition, a method for removal of the hard-packed tank bottoms/heels is necessary to complete HWMA/RCRA closure of this tank system.

The objective of this paper is to describe the results of two work activities: (1) the selection and nonradioactive testing of the sampling and retrieval system for this tank system, and (2) the evaluation of this system for use on other tanks at the INEEL.

II. WORK DESCRIPTION—TECHNOLOGY SELECTION AND DEMONSTRATION FOR TRA-730 CTS

To complete the TRA-730 CTS characterization and to proceed with the RCRA closure, the INEEL needed a representative sample of the hard-packed heels and a method to remove those heels from three of the four tanks. The fourth tank does not contain hard-packed heels. Therefore, the TRA Engineering Support and Project Management personnel surveyed the available technologies for tank cleaning and sampling. Video inspection clearly revealed the existence of multiple phases. Simple recirculation and sampling of the tank contents was not an option because the hard-packed heels could not be resuspended and because the recirculation equipment did not meet interim status permit (double containment) requirements. Several other sampling methods were attempted. First, a suction device was developed that was based upon the principles of a Consolidated Liquid Waste Sampler. Although the sampler was successfully demonstrated on a water and sand mixture, it was only effective in obtaining water and flocculent samples from the actual tank; the device was unable to extract the hard-packed heels. Attempts were made to loosen the hard-packed heels with the sampler but to no avail.

While sampling was being attempted, engineers were also evaluating techniques for removal of the hard-packed heels. Access restrictions complicated the selection. Most tank cleaning devices, such as robotic cleaners or rotary ball washing devices require a relatively large access hole to be cut into the tanks to deploy the device or its support equipment. High radiation fields, ranging from 200 to 300 mR/hr, complicated direct access to the tanks; this presented a repeated and unacceptable radiation exposure. In addition to the tank radiation hazards, the tank vault is a confined space, thus posing significant physical hazards to personnel making a vault entry.

Further evaluation of the available technologies found common deficiencies and limitations. For example, cutting large access holes for deployment of equipment into a small tank did not appear cost-effective or protective of human health or the environment. Robotic collection systems for sampling did not resolve the difficulties regarding the collection of samples from the hard-packed heels. Additionally, the troublesome issue of obtaining representative samples of the highly heterogeneous tank contents remained. However, one system, the AEA Fluidic Pulse Mixing and Retrieval System (FPM&RS), stood out as a viable technology that could resolve the aforementioned problems. Therefore the INEEL chose the FPM&RS as a solution to the TRA-730 CTS problem.

The system uses compressed air to drive a combination of jet pumps that extract liquid from a tank and reinject it into the tank under high pressure. The reinjected liquid loosens and homogenizes the sludge in the tank. Once the sludge is fully homogenized, a portion can be extracted for sampling. In addition, the homogenized sludge can be removed and discharged to waste containers for off-site disposition.

The system mixes the sludge and supernatant via a three-phase mixing process: a suction phase, a drive phase, and a vent phase. During the suction phase, conceptually shown in Figure 1, the jet pump creates a partial vacuum in the charge vessel, which in turn draws liquid up from the storage tank into the charge vessel (AEA Technology 2000)[2].

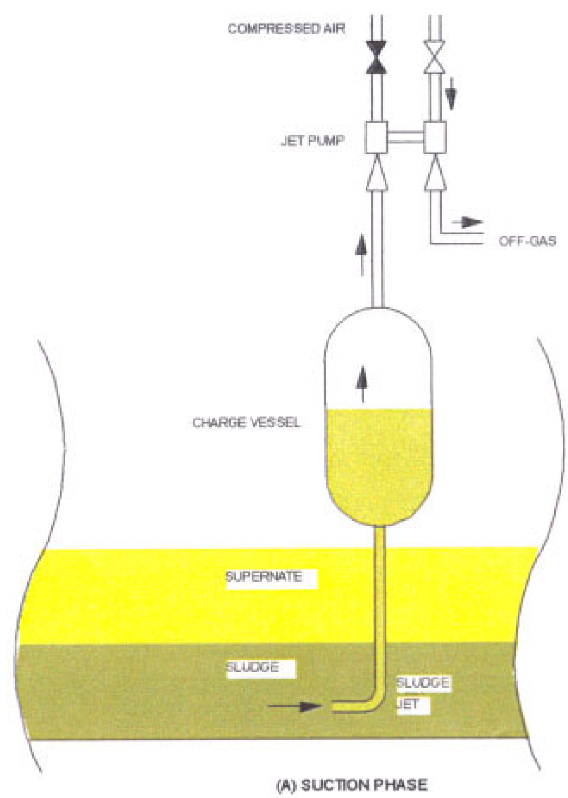

Figure 1. Suction Phase.

Once the charge vessel is filled with liquid, a realignment of the valves pressurizes the charge vessel. The high-pressure air drives the liquid back into the storage tank, agitating the contents of the tank and resuspending solid particulates into the supernatant. This is known as the drive phase (see Figure 2).

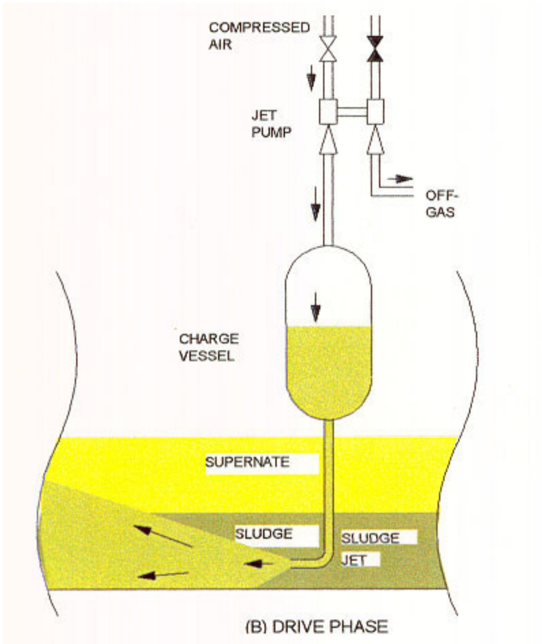

Figure 2. Drive Phase.

When the liquid level reaches the bottom of the charge vessel, another realignment of the valves terminates the drive phase and vents the charge vessel through the jet pump. (see Figure 3). The vented off-gas discharges to the atmosphere via a high-efficiency particulate air (HEPA) filter. The cycle is repeated until the sludge and the supernatant are homogenized.

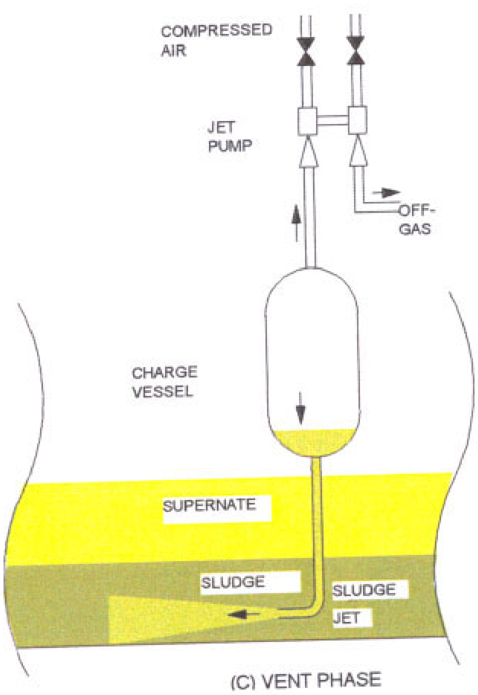

Figure 3. Vent Phase.

Through alternate valve alignment, a portion of the charge vessel contents can be suctioned off into a variety of sample containers. Alternatively, the liquid can be easily suctioned into the charge vessel and then discharged to other waste containers for off-site treatment or disposition. This is known as the transfer operation (see Figure 4).

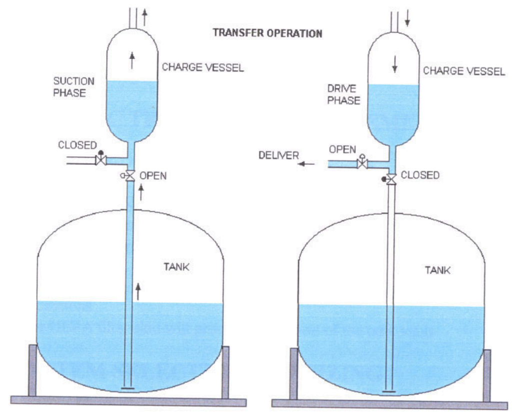

Figure 4. Transfer System Operation.

Three separate skids contain the equipment: a charge vessel skid, a control system skid, and a HEPA filter skid. The system also requires an industrial air compressor.

The FPM&RS has numerous advantages for sampling and remediation of the TRA-730 CTS. Most importantly, the system will allow the tank heels to be completely mobilized, remotely sampled, and remotely extracted from the tanks and repackaged without additional manned vault entries. Additional advantages include:

- The system enables the separation of the liquid phase waste from the tank heels. This enables more effective mixed-waste minimization and cost effective treatment and disposal.
- The equipment is easily decontaminated, enabling reuse on other tanks and easy disposal at the end of its life cycle. Major components do not become contaminated and therefore allow reuse on other tank projects.
- Although the system is large, it is skid-mounted, relatively portable, and easy to assemble, thus enabling prompt deployment to other tanks.
- The nozzle deployed into the tank can be left in place following sludge homogenization to act as a readily installed port for the subsequent injection of flowable fill or grout for tank remediation.
- The system can be installed through an existing tank penetration, removing the need to prepare new penetrations in a tank.

The FPM&RS has the distinct advantage of being able to be installed in tanks with limited access and the ability to be operated remotely. This system is expected to enable remote cleaning of the TRA-730 CTS to meet performance-based RCRA closure standards. Furthermore, the ability to remotely collect a single, homogeneous, and representative sample from tanks, which sometimes have internal obstructions that prevent conventional sampling efforts, could result in significant savings in analytical laboratory expenses for RCRA analysis of highly radioactive samples. Normally, sampling and analysis protocols require multiple samples for a heterogeneous sludge/solid in order to demonstrate that the analytical results are statistically representative of the waste as a whole. Analysis of a single homogeneous sample eliminates the need for analysis of multiple highly radioactive samples and the associated costs for analysis of more than one sample.

In 2001, the INEEL placed a contract with AEA Technologies for the design, fabrication, testing, and deployment of a FPM&RS for the sampling and remediation of the TRA-730 CTS at the INEEL Test Reactor Area.

III. RESULTS—TECHNOLOGY DEMONSTRATION

AEA Technologies conducted a nonradioactive demonstration at their facilities in Moorseville, North Carolina in the spring of 2001. The demonstration used kaolin clay and sand as a surrogate material to simulate the hard-packed heels present in the actual TRA-730 CTS. Kaolin clay was chosen based upon previous experience at other DOE sites with radioactive waste tanks that had similar hard-packed heels. The demonstration clearly showed that the technology was capable of loosening hard-packed heels, homogenizing the entire tank contents, and collecting a representative sample. The system was also able to remove and segregate various sizes of lead pellets, which were used to simulate nuclear fuel fragments that are believed to exist in the CTS. However, the suction nozzle had to be in very close proximity to the pellets.

On the basis of the successful nonradioactive demonstration, the VCO Program elected to deploy the FPM&RS on the TRA-730 CTS. The three skids were transported to the INEEL in the fall of 2001 and assembled adjacent to the TRA-730 CTS. Due to inclement weather, actual use of the system was deferred until the spring of 2002.

Figure 5 show the unit as installed at the INEEL TRA. The skid on the left is the HEPA filtration skid, which is approximately 5 ft wide by 19 ft long. The charge vessel and major piping and major valves, are mounted on the skid shown in the center of the photo; the charge vessel skid is approximately 10 ft square. The control skid, which is not shown in the photograph, is approximately 12.5 ft wide, by 8 ft long and 8.5 ft high and is located near the charge vessel skid.

Figure 5. FPM&RS as installed at TRA

As of May 2002, efforts are underway to commence operations of the FPM&RS on the TRA-730 CTS tanks. TRA Operations personnel experienced problems with rubber gaskets that were over-torqued during installation. Those gaskets were replaced with a Durlon fiber gasket; however the harsh winter weather caused many of those gaskets to dry out and split. The gaskets are being replaced with Gylon 3500 gaskets that are more flexible, presumably more weather resistant, and are commonly used in nuclear reactors. Deployment of an alternate waste drum filling technique caused some additional delays. Operation of the FPM&RS to remove the liquid phase mixed wastes from the CTS will commence in June 2002.

IV. WORK DESCRIPTION—EVALUATION FOR APPLICABILITY ON OTHER TANKS

The apparent success of the nonradioactive demonstration lead the VCO Program to consider its use on other VCO tanks. Therefore, the VCO Program conducted a detailed study[3] to determine if the Program should purchase a second FPM&RS or if the currently-owned unit would be sufficient to meet program needs.

The VCO Program used data-mining techniques to cull through the data from the 700-plus tanks. Many of the tanks are small, open-top sumps, empty, or potentially containing other products that are not conducive to sampling or remediation with the FPM&RS. After initial culling, a subset of approximately 200 tanks remained. The data on these tanks were examined in more detailed culling steps that resulted in many more tanks being eliminated from consideration because their size was too small, they were likely empty, or process knowledge indicated that the tank was not RCRA hazardous. After several iterative evaluations, six candidate tanks appeared to be amenable for deployment of the AEA technology. Those tanks include:

- Two 360,000-gal wastewater compartmented retention basins and one associated 18,000-gal sump at TRA
- A 100,000-gal Hot Waste Storage Tank at TRA
- Two 20,000-gal sumps at Test Area North.

In addition to the VCO tanks, the VCO Program evaluated the FPM&RS for use on seven other tanks at the INEEL. Those tanks include:

- A 25,000-gallon slurry storage tank that was used to treat fuel storage pool water[4]
- Three 10,000-gallon and one 400-gallon liquid mixed-waste collection tanks that were solidified with diatomaceous earth
- Two 50,000-gallon liquid mixed-waste collection tanks that were also solidified with diatomaceous earth.

The cost for deploying the FPM&RS on one of the VCO tanks was compared to the cost for using traditional methods. Several schedule scenarios were developed to determine if the VCO Program could meet enforceable milestones with the use of a single FPM&RS, or if a second unit would be needed to operate in parallel. The scheduling scenarios also considered use of the FPM&RS on non-VCO tanks.

V. RESULTS OF EVALUATION FOR APPLICABILITY ON OTHER VCO TANKS

The evaluation of VCO-managed tanks indicates that six VCO tanks and seven other INEEL waste tanks appear to be candidates for deployment of the FPM&RS. The costs for deploying the FPM&RS appear similar to the costs for traditional sampling and remediation methods. The currently-owned unit being used for the TRA-730 CTS appears to be of sufficient size to accommodate the VCO tanks. Preliminary schedule evaluations show that VCO milestones could be met with the current system. However, combining the schedule for the non-VCO tanks with the VCO schedule identified conflicts indicating that the currently-owned unit could not fulfill all potential needs at the INEEL. In addition, the size of the currently-owned unit may not be optimal for use on larger non-VCO tanks. It is apparent that a single unit is insufficient to accommodate all of the INEEL needs.

VI. CONCLUSIONS

At the INEEL, over 700 tanks must be characterized under the VCO to overcome potential RCRA issues with waste characterization. These tanks are relatively small in comparison to the HLW tanks for which much of the technology development has taken place, and have unique issues such as access limitations.

The INEEL is deploying the Fluidic Pulse Mixing and Retrieval System on the TRA-730 CTS. The nonradioactive demonstration on tanks with hard-packed, simulated radioactive sludge was successful; the system was able to homogenize, sample, and remove the simulated sludge with little effort.

Six other VCO tanks and seven other INEEL tanks appear amenable for deployment of this technology. Additional detailed engineering evaluation is needed to confirm the applicability of the technology for those tanks and to integrate the design requirements so that an optimal unit can be fabricated to accommodate the wide variety of tanks anticipated.

ACKNOWLEDGEMENTS

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