WSRC-MS-2000-00520

New Equipment and Techniques for Remote Sampling of Stored Radioactive Waste

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

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Abstract

Radioactive waste is stored at the Savannah River Site (SRS), part of the Department of Energy (DOE) complex. This radioactive waste is stored in buried tanks and management of the waste requires several processes, including material addition, heating, cooling, mixing, and transfer from tank to tank. During waste processing, it is necessary to know the chemical components and their characteristics to determine the steps necessary to maintain the waste form or to manipulate the waste into the form desired. Waste characterization begins by obtaining a sample for analysis. High level radioactive waste sampling is routinely done with simple, standard samplers such as a dip sample. Other sampling is non-routine or specialized, with unique, special requirements, such as sampling remote areas that are difficult to reach. Other specialized sampling includes sampling materials with unknown characteristics or material that must be gathered to obtain an adequate sample or materials that must be broken up to sample or forcibly separated from the tank.

The samplers described in this paper are specialized samplers. These samplers include the Dip Filter Sampler, Soft Core Sampler, Hard Core Sampler, Circle Scrape Sampler, Small Scrape Sampler, Suction and Strain Sampler, and Vial Snapper Sampler. The Dip Filter Sampler is used to sample floating particulate matter or floating organic matter. The Soft Core Sampler and Hard Core Sampler are used to obtain samples of solids from the tank floor. The Soft Core

Sampler is used on soft solids such as sludge and saltcake and the Hard Core Sampler on hardened solid deposits. The Circle Scrape Sampler is used to obtain solid samples through a small entry riser and out from under the riser. The Small Scrape Sampler enters a small entry riser and is used to scrape a sample from the tank wall. The Suction and Strain Sampler is used to gather a remote submerged sample or filter a solid sample from supernate. The Vial Snapper Grab Sampler is used to sample a wide variety of materials from the tank floor, submerged under supernate, or from the supernate at variable depths.

Sampler development must take into account several design considerations, including safety and minimal personnel exposure, and criticality and hazardous energy concerns. Ease of operation is desired with quick, efficient sample handling on the tank top and in the lab . The sample size needed for analysis, the transport container size, and the need for camera support are additional considerations. Other criteria used in Sampler design include minimizing services required for operation of the sampler, minimizing the sampler cost and the cost to dispose of the sampler .

This paper describes the tank environment to be sampled, design criteria used in sampler development, and the specialized samplers developed. The samplers will be defined by their function, components, and capacity. The sampler selection process and the deployment of these devices will also be described.

Background

SRS has waste tanks of various sizes and shapes with approximately 50 High Level Waste (HLW) tanks, five evaporator tanks and 20 solvent tanks. The HLW tanks hold over a million gallons of waste material and have a vertical cylinder shape. These HLW tanks are approximately 85’ across and 35’ from the inner tank floor to the center of a domed ceiling. The tanks are accessed through risers on top of the tanks positioned above the center of the tank and around its perimeter. Due to the thickness of the tank top, the distance from the top of the riser to the tank floor is approximately 42’. The risers average 23" in diameter and are sealed with large plugs with smaller access risers built into the plugs. These smaller access riser openings are typically 8" or less in diameter. Many of the risers are dedicated to equipment that requires insertion into the tank and are thus not available for sampling.

Evaporator tanks are much smaller tanks with a cylindrical section mounted over a conical section. The evaporator tanks are 10-15’ in diameter and slightly taller. The tanks have 3" diameter access risers on top and can be accessed using temporary platforms above the tank and riser. These risers also are dedicated to piping jumper connections that must be removed to provide an entry point for sampling. These tanks are made from stainless steel and contain warming coils directly below the access riser.

The solvent tanks are horizontally arranged cylinders that average 25’ in length, 10’ in diameter, and buried 10’ deep. The solvent tanks have vertical access pipes that begin above ground and travel down to the two opposite ends of the tanks. These risers are 2-3" in diameter and often contain objects interfering with sampler access.

These different tank types often have objects within the tanks under the access riser that are permanent objects or are deposited objects, through movement of the waste material or riser disposal. Explosive gas concerns, criticality concerns, transport size issues, and gas generation issues are some of the many challenges of obtaining a sample from these tanks.

Sampling Device Criteria

The design of the samplers is subject to numerous criteria. Safety of the operator is the most important criteria in the development of the sampling device. The exposure of the operator to radioactive sources must be minimized by designing the sampler to be quick and easy to operate. Explosive, criticality, electrical and material reaction possibilities must be taken into account. The sample must be large enough to perform analysis on. The sample must be retained after obtaining in the field and easily and safely transferred to a shipping container. Finally the sample

container should not alter the sample and the container should be easily unloaded in the laboratory remotely.

Other factors assist in determining the sampling equipment design. These factors are the cost of the sampler, the scheduled date the sampler is required, whether camera support is needed, the likely disposal of the sampling device after usage and contamination, and the need to minimize services required to sample (air, water, electrical, etc).

Sampling Devices

Dip Filter Sampler

The Dip Filter Sampler filters the top layer of liquid, or supernate, within a tank to obtain a sample of any existing floating organics on a special filter media. Floating solid material is also collected within the sampler. This sampler is based on the Floating Waste Sampling Device developed at SRS and provides an increased and omni-directional sampling area, increased volume to the filter media, improved solids retention, a method to eliminate retained liquid, and improved operation.

The Dip Filter Sampler, shown in Figure 1, is composed of a reservoir, sample vial, filter media, and a check valve. The reservoir holds the liquid to be filtered by the filter media. The sample vial is connected below the reservoir with the filter placed inside, and the vial is attached to a check valve containing a floating ball.

The sample device is lowered into the liquid supernate with the floating ball sealing the check valve, the sample vial, and the reservoir. The sample device is lowered further until the reservoir is submerged just below the surface of the supernate. The surface layer of the supernate pours into the top opening of the reservoir. The device is lifted from the liquid prior to complete filling of the reservoir to prevent overflow of the desired organic layer and any floating solids. Upon complete removal of the sampling device from the supernate, the floating ball falls inside of the valve, opening the check valve and allowing the liquid in the reservoir to filter through the sample vial and drain through the check valve. The desired organic layer will contact the filter media providing the sample of the organics. Larger floating waste material collected by the sampler may require straining of excessive retained supernate through a screen located in the top of the reservoir. This retention screen also provides a visual indicator to assist the operator in determining the maximum volume of liquid within the sample reservoir prior to sampler removal from the tank supernate. After removal from the tank, the sample vial is removed from below the reservoir. The check valve is removed from the vial and the vial is capped on both ends and placed in a "doorstop" shipping package for transport to the lab.

Figure 1. Dip filter Sampler

Soft Core Sampler

The Soft Core Sampler uses a mast assembly of extension pipes to push a core sample cup into soft solid waste material to be sampled below the access riser. The core sample cup allows solids and liquids to enter the cup and retains the solid material upon removal of the sampler from the material. This sampler is based upon the Sludge/Solids Sampling Device developed at SRS and provides improved quantity feedback as well as sample cups for several different material types.

The Soft Core Sampler, shown in Figure 2, is composed of a sample cup, quantity indicator section, pipe mast of numerous pipe sealed sections, a riser mounting plate, spray ring, and impact cap. The mast is made of aluminum to lighten the sampler weight, and the sample cup and quantity indicator section are made from stainless steel to obtain a sample without reacting to the high pH of the waste material. The sample cups used are the standard sample cup with basket retainer, the compression sample cup, and both cup designs with teeth.

The standard sample cup has a basket retainer that allows solids to enter the cup but not to leave the cup. The standard cup also contains a piston that moves upwards as sample material fills the cup during sampling. The quantity indicator section attaches to the standard sample cup and contains rods and a movable indicator inside. As the sample is taken, the piston moves upward in the sample cup pushing on the rod from the quantity indicator showing the relative volume of the sample. This external indication allows the operator to know the content volume inside of the sample cup prior to retrieving the sample mast from the tank.

Another sample cup that has been developed is the compression cup. The compression cup is slitted on two sides which causes the two halves to be spread apart when sampling but push together upon removal from the waste material. This principle aids the sample cup in retaining a sample. Hand rotation of the sampling mast has been shown to increase the sample cup penetration into sludge/salt simulant. Hand rotation has also been shown to be very effective with teeth cut into the sampling cup leading edge.

Figure 2. Soft Core Sampler

Hard Core Sampler

The Hard Core Sampler uses a remote, pneumatic actuated slide hammer with electromagnet release to drive a sample cup into dry, hardened sludge to obtain a core sample. The sampler, shown in Figure 3, is composed of a long sample

cup, quantity indicator section, drop hammer section, air cylinder with electromagnet, extension mast, riser plate, and electromagnet power supply. The long sample cup contains a basket retainer for sample retention and is connected to the quantity indicator section by a hidden pin coupling. The coupling provides easy disassembly by rotation of a protecting collar and removal of the pin. The coupling also provides a smooth outer surface to the sampling cup and quantity indicator to eliminate any interference with penetrating the waste surface. The quantity indicator functions as described in the previous section on the Soft Core Sampler. The drop hammer section consists of a drop weight, an impact anvil, and a guide pipe. The pipe mast assembly is similar to that described also in the previous section on the Soft Core Sampler.

The sampling mast is lowered into a tank until the sample cup contacts the waste material to be sampled. The crane hook is detached from the sampler mast and the magnet engaged to the hammer weight. The air cylinder is then used to lift the weight four feet upon which the electromagnet is de-energized causing the weight to fall and impact directly above the sampling cup. The impact drives the core sample cup into the hard waste material and the impact process is continued until the sample cup is fully driven into the waste surface and a full sample is obtained. Upon completion of the sample, the mast is removed from the tank through the access riser and the sample cup removed for shipment. An empty sample cup can then be mounted to the sampling mast, the sampling mast lowered into the tank, and the second sample cup lowered into the hole left by the first sampling cup. Using this method, an extended core can be taken and shipped in several segments due to the limitations of transport package size.

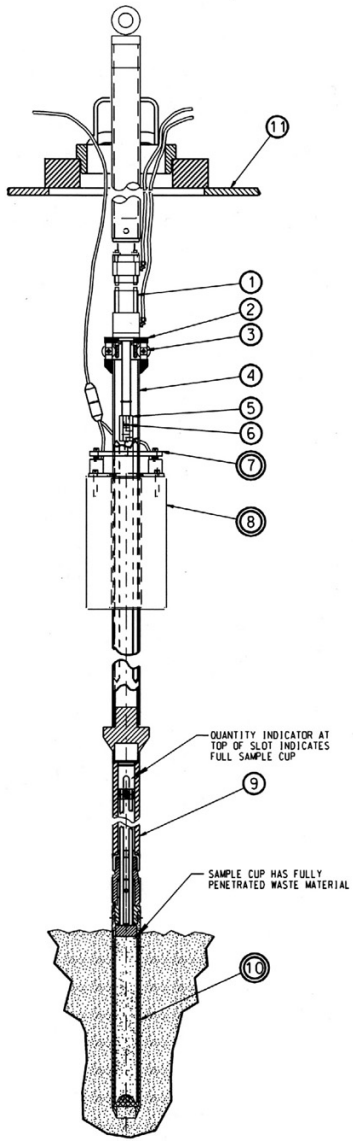

Figure 3. Hard Core Sampler

Suction and Strain Sampler

The suction and strain sampler, shown in figure 4, provides a sample of the loose material in the evaporator cone and material floating in the supernate also located in the lower portion of the evaporator. The device uses a suction assembly with a venturi effect jet pump, a straining section with a sample filter, a container vial for shipping containment, flexible extension poles, and two submersible cameras and lights.

The suction assembly is composed of a small-modified jet pump, an air inlet hose, a sample suction hose and a filter vial for straining the sample. The air inlet hose provides the air to create the suction within the jet pump and the suction hose collects the sample and sends it to the filter. The filter strains the solid sample from the liquid and is placed into a stainless steel vial for shipment in a transport package. The flexible extensions are used to deploy the sampler to the bottom of the evaporator pot where it pumps the supernate through the strainer to obtain a solid sample. The inspection systems are mounted above the filter to provide viewing of the straining and at the suction intake to observe the sampling.

The sampler is inserted into the evaporator through a 3" diameter access riser and lowered until the open end of the suction hose is in the bottom of the cone of the evaporator. The input air is added through the inlet hose, creating suction in the sample hose that guides the sample to the filter. The sample is strained by the filter and the strained liquid flowing from the filter is observed by the operator using the inspection system. The sample intake is raised and lowered during the sampling process and the input air is valved on and off several times to promote an unobstructed flow of sample. Upon completion of the sampling, the air is valved off and the sampler is retrieved. The filter is then removed, placed into its container vial and placed in a uranium doorstop for shipment.

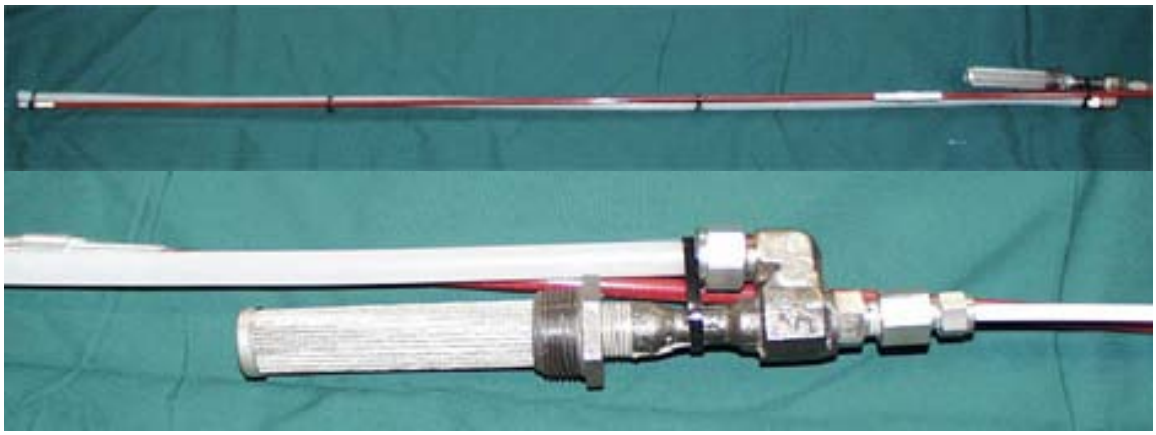

Figure 4. Suction and Strain Sampler

Circle Scrape Sampler

The Circle Scrape Sampler, shown in Figure 5, was designed to obtain samples from a very thin waste material layer on a tank floor. The sampler is composed of a sampling head that is attached by a hinge to a sample mast. The sampling head has an opening along its length with a sharpened edge to separate the material from the tank floor. The sampling head also has a cavity to retain the sample when the sampling head is returned to an upright position during sampler retrieval from the tank. During deployment through the tank riser, the sampling head rotates inline with the sampling mast, composed of several connected extension tubes. Upon contact with the tank floor, the sample head swivels and reorients parallel to the floor. The extension mast is then rotated causing the scrape head to travel in a

circular path, sampling the material on the tank floor surrounding the extension mast. The mast is then retrieved up through the riser with the sampling head rotated inline. The sampling head is disconnected and placed in a transport package for shipment to the laboratory.

Figure 5. Circle Scrape Sampler

Small Scrape Sampler

The Evaporator Scrape Sampler, shown in Figure 6, is used to obtain a sample of waste material from within an evaporator adhering to the sides of the evaporator pot and coils. The scrape sampler consists of a scrape head and sample catch vial or filter mounted to a flexible extension assembly. The scrape head has a curved scraping surface attached to a duct that directs scraped material down into the filter or sample vial. The filter is used when the scrape sampler is submerged below liquid supernate within the evaporator to allow draining after sampling, and the sample vial is used if the sampler is not submerged during sampling. Both sample filter and sample vial fit into a standard "doorstop" transport package. A submersible camera is attached directly above the scrape edge to provide feedback to the operator. The sampler is inserted through a 3" diameter or larger access riser port in the top of the evaporator, pushed down into the evaporator cone, and pulled up, scraping the inside walls of the evaporator and obtaining a sample of material fixed to the evaporator walls. The sampler is then removed from the evaporator, the vial or filter removed and placed in a transport package, and shipped to the shielded cells for unloading and analysis.

Figure 6. Small Scrape Sampler

Vial Snapper Grab Sampler

The Vial Snapper Sampler is a pneumatic actuated grab sampler that is remotely operated and has a pair of jaws which scrape together to obtain a sample. The sample jaws also detach from the sampler actuator to allow shipment of the jaws with the sample in a standard sample transport container. Once the jaws with the sample have been removed from the actuator, a set of clean jaws can be mounted for the next sample. Horizontal jaws or "transmount" jaws are used for sampling thin layered waste and vertical jaws are used for sampling deep layers of waste. The jaws are connected to the sampler actuator using quick disconnect pull pins.

Remote control of the sample actuation allows numerous advantages to trip type grab samplers. The Vial Snapper can be opened within the tank which allows the sampler to be closed during deployment, providing the smallest sampler profile for passing through the entry riser. The Vial Snapper can be closed without dropping the sampler to trip closure, which allows the sampler actuator to be kept clean during shallow sampling and also decreases airborne contamination. The Vial Snapper can also be used to scrape a sample from a thin layer of waste on a tank floor. The Vial Snapper can be remotely opened to return a captured sample or object if it is not desired for removal from the tank. The closing force can also be regulated from outside the tank to the force necessary to obtain a sample. The Vial Snapper jaws containing the sample are shipped without the actuator maximizing the shipping space for sample transport.

The Vial Snapper Sampler is actuated closed and lowered into the access riser. Once inside the tank, the sampler is actuated open and lowered until its sample jaws have penetrated the tank waste. The sampler is then actuated closed to obtain a sample. Several iterations of opening and closing might be required to scrape a sufficient sample size. Once this sample is taken, the Vial Snapper Sampler is retrieved out of the riser into the glove bag on top of the riser. A sample bottle, with the lid removed, is placed under the snapper jaws and the snapper lowered until the jaws are inside of the bottle. Quick disconnect pins are then removed, allowing the jaws to slide the remaining inch into the bottle. The bottle is then removed from under the snapper and the lid threaded on. Note that the bottle and jaws are made of SST that will shield the operator from the radioactive sample. The bottle will also be clean on its exterior for low-rad handling within the glove bag while transferring the bottle to a doorstop transport package.

Figure 7. Vial Snapper Grab Sampler

Sampling Device Selection

The samplers developed at SRS have been constructed for use in specific tanks. These samplers can be applied for use in different tanks if the waste is of a similar type for which the sampler was designed and has been found to be successful at sampling. Therefore, a table is used that defines the applicable waste forms for each of the samplers developed (see Table 1). For example, a solid sample could be taken using one of nine different samplers depending of the sampling location. The Dip Filter Sampler can obtain floating organic samples as well as floating solid material. The Soft Core Sampler can obtain solid, sludge or salt samples from directly below the access riser. The Hard Core Sampler can also obtain solid, sludge or salt samples from underneath the entry riser. The Hard Core Sampler will obtain a longer sample core than the Soft Core Sampler and will take the sample from a harder waste material than the Soft Core Sampler. The Suction and Strain Sampler will provide a sample of submerged solids. The Circle Scrape Sampler will provide a sample from a thin layer of solids from directly below the entry riser. The Small Scrape Sampler will obtain sludge and submerged solids adhered to a tank wall and even liquid and suspended solids if needed. Finally, the Vial Snapper Grab Sampler can obtain multiple sample types from directly below the access riser and with a deployment boom, out from under the access riser.

SAMPLING DEVICE	SOLID	SALT	SLUDGE	Submerged Solids	LIQUID	Floating Organics
Floating Organic Sampler						
Dip Filter Sampler						
Surface Skim Sampler						
Supernate Pump Sampler						
38 Liter Supernate Sampler						
Suction & Strain Sampler						
Bottom Suction Sludge Sampler						
Small Scrape Sampler						
Sample Arm Scrape Sampler						
Circle Scrape Sampler						
Vial Snapper Grab Sampler						
Plier Release Grab Sampler						
Wedge Release Grab Sampler						
Hand Release Grab Sampler						
Annulus Wall Scrape Sampler						
Soft Dry Sludge Core Sampler						
Soft Core Sampler						
Hard Core Sampler						
Pipe Wall Scrape Sampler						
Pipe Wall Rotary Scrape Sampler						

Table 1. Sampling Device Selection

Field Use of Sampling Devices

The Dip Filter Sampler has been used successfully within nine tanks. The Soft Core Sampler has been used multiple times within three tanks with its largest sample resulting in over 57 g. The Hard Core Sampler is awaiting use. The Suction and Strain Sampler has been used multiple times within two evaporators with its largest result of 26 g. The Circle Scrape Sampler has been used in a solvent tank successfully. The Small Scrape Sampler has been used several times within one evaporator and on the outside of a second evaporator. The Vial Snapper Grab Sampler is awaiting its first use.

Conclusion

Several sampling devices have been developed at SRS to obtain samples of waste from within tanks. These remote samplers have been designed to provide samples through small openings and in remote locations from within the tanks to allow chemical analysis of the tank contents to be performed. These samplers are used in tanks they were specifically designed for, and using a Sampling Device Selection Table, are applied to tanks that contain similar waste forms. Several of these samplers have been used in multiple tanks and others are awaiting their first usage.

Acknowledgements

This work was supported by the U.S. Dept. of Energy under contract DE-AC09-96SR18500. Special thanks are extended to M. Kyle, T. McCoy, D. Krementz, C. Allgood, and C. Hardin for their efforts.