West Valley Grab Sampler Prototype
Test Report

Oak Ridge National Laboratory

INTRODUCTION

As part of a remediation project of underground waste tanks at the West Valley Demonstration Project (WVDP), Oak Ridge National Laboratory (ORNL) is developing a sampling device to characterize the cleanup efforts of the West Valley tanks. This sampler will take a representative scrape sample from inside the tank that will determine the per-square-inch contamination of the tanks. From these samples an estimate of the total contamination inside the tank can be determined.

The sampler will take scrape samples from the carbon steel tanks using milling machine bits. A vacuum and filter system will collect the scraped material and contain it for delivery to a laboratory for analysis. The major components of the design are the milling bit, filter housing for retaining the sample, drill and bit extension motors, vacuum pump, and mounting base.

SPECIFICATIONS

Attached are the latest available Summary Design Criteria for the sampler, Revision 0.

OVERALL CONCEPT

The heart of the sampler is the milling bit, which is a 1-in. diameter end mill. The bit drills straight into the steel wall for roughly 1/32-in. The bit is mounted in a tube similar to a vacuum cleaner nozzle such that the vacuum will collect any material scraped up by the bit. The vacuum draws the material into a filter that retains it for delivery to a laboratory.

Because of the expected radioactivity of the sample, the filter system must be small enough to fit inside a lead-shielded container. Furthermore, to prevent cross contamination, a new milling bit and filter will be used for each sample. The system is modularized such that the disposable bit and filter section, also known as the sample housing, is compact and easily detachable from the system base unit.

The system base unit consists of hardware that drives the sample housing. The base unit contains the drill motor for turning the drill bit, a linear slide to axially advance the bit, a motor to drive the slide, a spring system to limit the axial drive force, and a vacuum generator. The motors are lightweight pneumatic units and the vacuum generator is an air driven venturi unit.

DESIGN DETAILS

The complete sampler device is shown in Fig. 1. All of the custom parts are anodized aluminum. The round base attaches to a robot arm that will be deploying the device into the tank and up to the tank walls. The arm is a water-hydraulic unit provided by West Valley Nuclear Services. Mounted to the base is a linear slide table that advances the sampler to contact the wall. A second slide on the table connects with a force-limiting spring mechanism to limit the forces that the sampler can press on the wall. An ACME screw and a 1/20-hp pneumatic bi-directional motor advance the sampler into contacting the wall. The direction of the advancing motor is changed by an electropneumatic valve mounted on the base plate. The drill motor is a 1/2-hp pneumatic unit spinning at 225 RPM. The venturi vacuum pump generates up to 30-CFM flow although it can be adjusted for lower flow. All the pneumatic systems are driven by 100-psi air.

To minimize the size of the equipment that transports the sample to the laboratory, the bit, filter, and sample housing were made compact and easily detachable from the base as illustrated in Fig. 2. The sample housing is held to the base by two captive screws and a simple mechanical coupler engages the drill shaft. The vacuum connection is

sealed with an O-ring gasket. A threaded hole is also provided to allow screwing in a temporary handle so the device can be grasped with long handle tools. The overall size of the housing is 3.5 by 3.4 by 2.3 in. and the weight is about 500 grams.

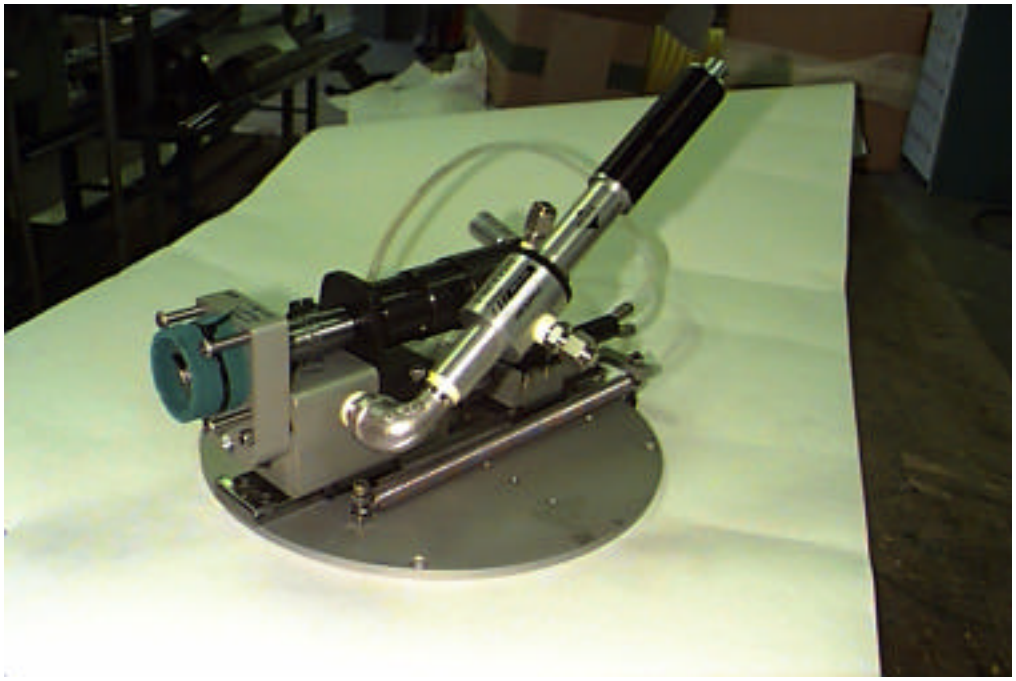

Fig. 1. Complete Grab Sampler System

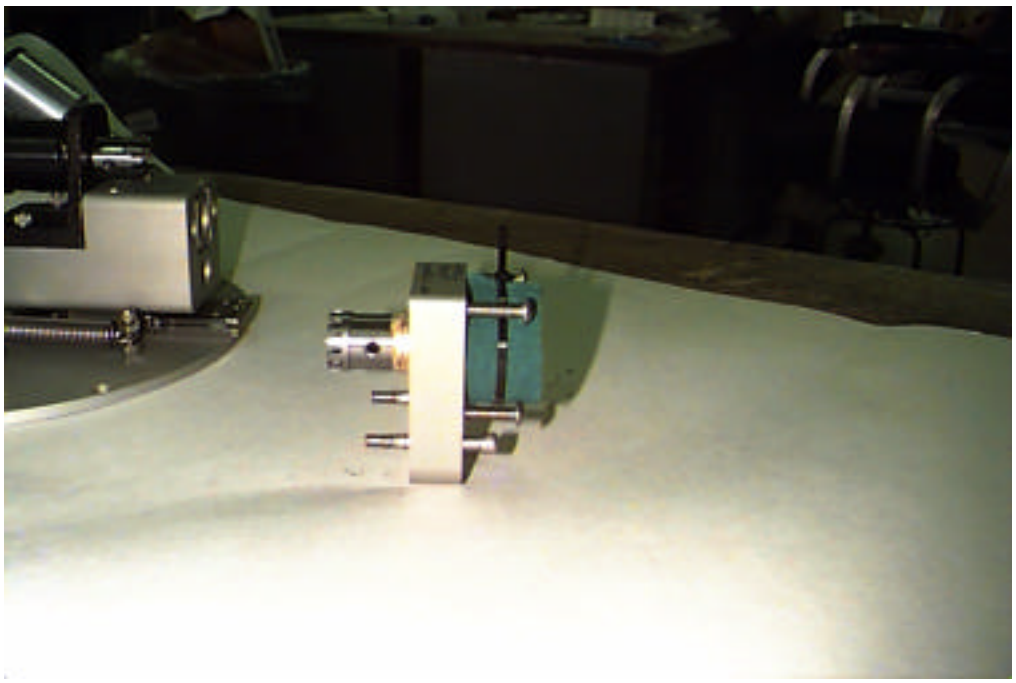

Fig. 2. Sample Housing Detached from Base

During the design process, components where selected that would survive the radioactive and corrosive environment inside the tank. Stainless steel and aluminum parts were selected where possible, and the pneumatic motors were studied to identify any internal radiation sensitive parts. The drill motor is carbon steel and will need to be painted,

and radiation tolerant air hoses will eventually be selected by WVDP. The sample housing does have sensitive nylon components and the bit is carbon steel; however, since the housing will be in the tank for only a short time, these materials were judged to be acceptable.

A direct view of the milling bit is shown in Fig. 3. The bit is a standard 1-inch diameter two-flute unit with a 1/2-in. shaft. Other standard bits could be used without changing the housing design. The selection of the bit involves some compromises, and overall we still had to custom grind the bit to get the desired performance. The various compromises were the need to minimize the housing size, smoothness of the cutting operation, center (plunge) cutting, and minimal custom modifications. Multiple flute bits were available that would promise smoother operation, however these bits were either too large or were not center cutting. The final solution was to take the two-flute unit and re-grind to have a tip similar to a conventional drill bit except have the tip angle of only 2.3 degrees. Normal end mills are not available this way because using such a bit would not result in a flat surface, however for this application the compromise was good because of the much smoother operation, plunge only cutting, and minimal cutting of steel below the initial surface. Unlike conventional drilling, no lubricants are permitted in the tank so the drill is run dry.

Fig. 3. 3View of the Milling Bit

The sampler has other features that support the drilling operation. A nylon kitchen scouring pad, similar to a Brillo pad, is wrapped around the collar to catch any flung chips yet still allow air to flow in to draw particles into the filter. The pad is flexible and rests against the wall before the bit begins to make contact. Four screw-in bolts around the collar can be adjusted in depth, to act as depth limiters, to prevent drilling too far into the wall and to help position the sampler perpendicular to the wall. These bolts could also be adjusted for special cases, such as drilling columns and other non-flat surfaces.

The filter is in a milled out pocket in the lower half of the sample housing. Development of the filter uncovered some problems because the ground and fluffed up sample material occupied a larger volume than expected. A second version of the filter housing was built with a larger collection area. The new volume is now 0.8 cubic inches and the area of the filter paper is 1.6 square inches. The new filter now works very well and no further problems are anticipated provided the sampler will not encounter unusually thick crusts on the walls.

Selection of the filter paper for the sampler has been difficult. Various types of paper were tried, from the PTFE material used in radioactive air monitors to bags from household vacuum cleaners. The best compromise for flow, durability, and particle retention was determined to be paper from an automotive air cleaner. As described in the test

results below, this still required two layers of paper to get satisfactory results. The housing uses industry standard 47-mm size elements, and there are a wide variety of elements available in this size that we can investigate later.

TEST RESULTS

Presented here are the results from the latest version of the sampler. Some of the previous versions had unacceptable results because the milling operation was unsteady and the filter filled up too soon. Although the performance of this prototype unit is now considered to be acceptable, ORNL and WVDP anticipate improving the design after we gain experience during our cold tests.

The test arrangement consisted of the sampler base clamped to a tabletop and a test piece of steel also clamped to the table. The tests were indoors at room temperature. Air was supplied by the building instrument air supply but the pressure dropped to about 30 psi when all three pneumatic devices were turned on. This problem will be corrected in the future; however, the devices still performed well and performance is expected to only get better when a better air supply is obtained.

Other tests were conducted to make sure that the sampler housings could be swapped using long handle tools. Example operations with these tools showed that these operations could be performed without difficulty.

Another operations concern is whether the operators will be able to adequately view the device through television cameras well enough to operate it correctly. Experiments have shown that if the device is not flat against the wall, the device will still cut smoothly, although a round circle will not be cut. If the flatness is poor, the depth limiting bolts will prevent the bit from making contact. Another concern is whether the operators can see well enough to properly advance the bit into the steel at the proper rate. The advancing mechanism moves the bit forward at a rate of 0.050 inches per second, however to cut the desired depth of 1/32 in. requires about 3 minutes. Therefore, another mechanism will be needed to properly advance the drill. Fortunately the force limiting springs can be used to apply a constant pressure to the target area. Presently the springs apply about 20 pounds of force to the site and this has provided good results. Different forces could be applied by changing the springs or adjusting the pre-load. Presently the best method of operation is to simply drive the bit into the wall until it makes contact, allow it to drill for 3 minutes, and then pull back. ORNL and WVDP will continue to conduct operations tests in this area to further refine the operational techniques.

The key test of the system was to precisely weigh the sampler housing and the test piece of steel and measure them again after a sample is taken from the steel. Ideally, all of the weight that disappeared from the test steel would appear in the sample housing. The first test with the latest sampler housing resulted in 1.04 grams removed from the steel and 1.01 grams appearing in the sampler, which is a 97% recovery of the removed material. Upon visual inspection it was noticed that a small amount of the steel primer paint dust was getting through the filter, which would explain why the results were not 100%. The test was run again except two layers of filter paper were used instead of one, and the results were 1.41 grams of steel removed and 1.41 grams appeared in the sampler. Since we are near the accuracy limit on our scale, we are claiming the recovery to be 99+%. A very fine dusting of the primer paint was still barely perceptible on the filter output. The paint is a small percentage of the total sample because the weight of the underlying steel dominates the measurement. However, the paint represents where most of the contamination may be, so the uncaptured paint is still a concern. New filter material will still be considered to improve performance in this area even further.

CONCLUSIONS

The prototype West Valley Grab Sampler has been a very successful design activity and is anticipated to be an accurate, reliable, and robust device for samples at the WVDP tanks. ORNL will continue to support WVDP in qualifying and fielding the system by preparing NQA-1 documentation and offering consulting services as time and funds permit.