# A SAMPLING END EFFECTOR FOR STEEL WASTE TANK WALLS*

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ABSTRACT

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

The goals for the sampler were to take an accurate sample and yet minimize any damage to the tank walls. Furthermore, the device had to be compatible with the high-radiation tank environment and must not add any undesirable oils into the tank. Since the sampler will be highly radioactive after a sample is taken, the sampler must be small, lightweight, and quick to retrieve to minimize exposure to personnel.

The sampler takes a scrape from the tank walls using an end-mill-type milling machine bit. The bit makes an essentially flat cut 0.5-in. in diameter and 0.030 in. deep. This shallow penetration collects all of the surface contamination while still being a near non-destructive test. A vacuum and filter system is used to collect all of the scraped shavings and a collar around the bit is used to collect any shavings that are flung out. The bit and filter are in a small housing assembly, which can be detached from the sampler base such that the sample will fit in a small lead container for shielding. The assembly is designed to be easily detachable from the sampler base using long-handle tools.

## 1. INTRODUCTION

The remediation activities at the WVDP high-level waste (HLW) tanks and the Gunite and Associated Tanks at ORNL are similar in that both efforts needed a measurement of the remaining contamination in the tanks after the cleanup process was completed. ORNL

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developed a device for sampling its tanks and offered its expertise to the WVDP to help characterize the West Valley tanks. The two situations are different in that the ORNL tanks are concrete and the WVDP tanks are carbon steel; also the WVDP tests were to be mostly non-destructive as compared to the ORNL tests. In late 1999, the two facilities began collaborating on a design for a sampling system for the steel tanks, with ORNL concentrating on the sampler device itself and WVDP concentrating on the deployment robot.

Unlike the concrete tanks at ORNL, it is assumed that the waste materials in the West Valley tanks have not permeated into the steel walls; therefore, only a surface scrape is necessary to characterize the tank. The new device takes this surface scrape with a plunge-cutting type end-mill bit and collects the scraped material in a filter for delivery to a laboratory for analysis. The area to be scraped is a 0.5-in. diameter circle, and the average weight of the collected sample is 0.5 g.

The development of such a sampler was an engineering exercise that took into account the accuracy needed, cost, compatibility with the chemicals and radioactivity in the tank, reliability, and simple, safe, low-exposure operation for personnel.

## 2. OVERALL CONCEPT

The heart of the sampler is the milling bit, which is mounted in a tube similar to a vacuum cleaner nozzle so that the vacuum will collect any material scraped up by the bit. The vacuum draws the material into a filter, which 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's base unit.

The base unit consists of hardware, which 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.

## 3. DESIGN DETAILS

The complete sampler device is shown in Fig. 1. The base attaches to a robotic arm, which will deploy the device into the tank and up to the tank walls. This arm is a water-hydraulic unit, which is provided by West Valley Nuclear Services (WVNS). Mounted to the base is a linear slide table, which is driven by an ACME screw and a small pneumatic bi-directional motor to advance 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. This force limit is presently 22 lb, although this value could easily be changed with different springs. The drill motor is a 0.5-hp pneumatic unit, which spins at 225 rpm and the venturi vacuum pump generates up to 30-$ft^3$/minute flow.  The pneumatic systems are driven by 100-psi air and all of the custom parts are made of anodized aluminum.

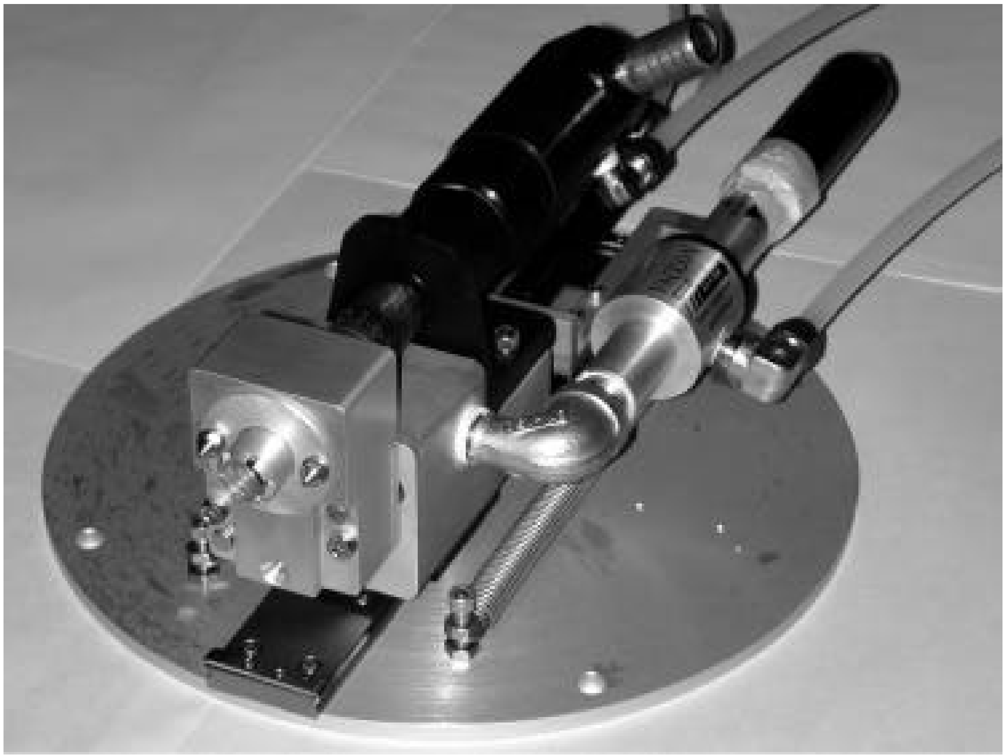

**Fig. 1. Complete grab sampler system.**

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 is illustrated in Fig. 2.  The sample housing is held to the base by two captive screws, a simple mechanical coupler engages the drill shaft, and an O-ring gasket is used to seal the vacuum connection.  A threaded hole is also provided to allow the screwing in a temporary handle so that the device can be grasped with long-handle tools.  The overall size of the housing is 3.5 x 3.4 x 2.3 in., and the weight is about 500 g.

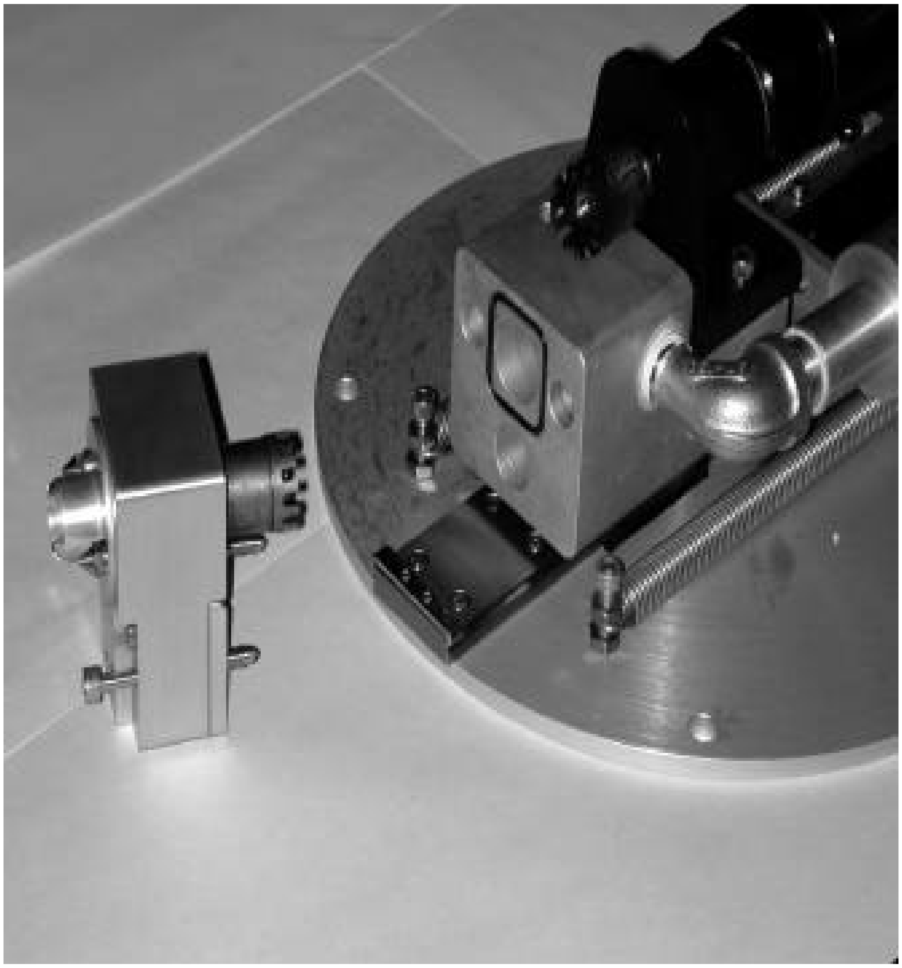

**Fig. 2. Sample housing detached from base.**

During the design process, components were selected that would survive the radioactive and corrosive environment inside the tank. Stainless steel and anodized 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 WVNS.

A direct view of the milling bit is shown in Fig. 3. The bit is a standard 0.5-in. diameter, two-flute unit with a 3/8-in. shaft. Other standard bits could be used without changing the housing design. Unlike conventional drilling, no lubricants are permitted in the tank, so the drill is run dry.

**Fig. 3.  View of the milling bit.**

The sampler has other features that support the drilling operation.  The collar around the bit is telescoping and spring-loaded in order to surround the bit until it is pressed against the wall during drilling.  Air vents on the end of the collar permit suction air to flow in while catching any particles that are flung from the bit.  To prevent the bit from drilling too deeply into the wall, cone-shaped bolts, which are 0.030-in. behind the end of the bit, are mounted on the housing. These bolts could also be adjusted for special cases, such as for drilling into columns and other non-flat surfaces.  Since the 0.030-in. depth limit is for the steel wall and not for any scale that may be present, sharpening the bolt cone tips may be necessary to penetrate the scale.

The filter is in a milled out pocket in the lower half of the sample housing, as is shown in Fig. 4.  The volume of this cavity is 0.8 in.$^3$, and the surface area of the filter is 1.5 in.$^2$  Although this may seem large for shaving only 0.030 in. of material, experience has shown that the shaved sample is fluffed up and occupies a larger volume than expected; also, scales of significant thickness may also be encountered.

The filter media is based on a fiberglass high-efficiency particulate air (HEPA) element. Paper-based elements were also tried; however, the paper was degraded by wet sampling surfaces, and the dust particle capture performance was not as good as that of the HEPA elements.  The WVDP also had concerns about the cellulose in the paper degrading its analysis results.

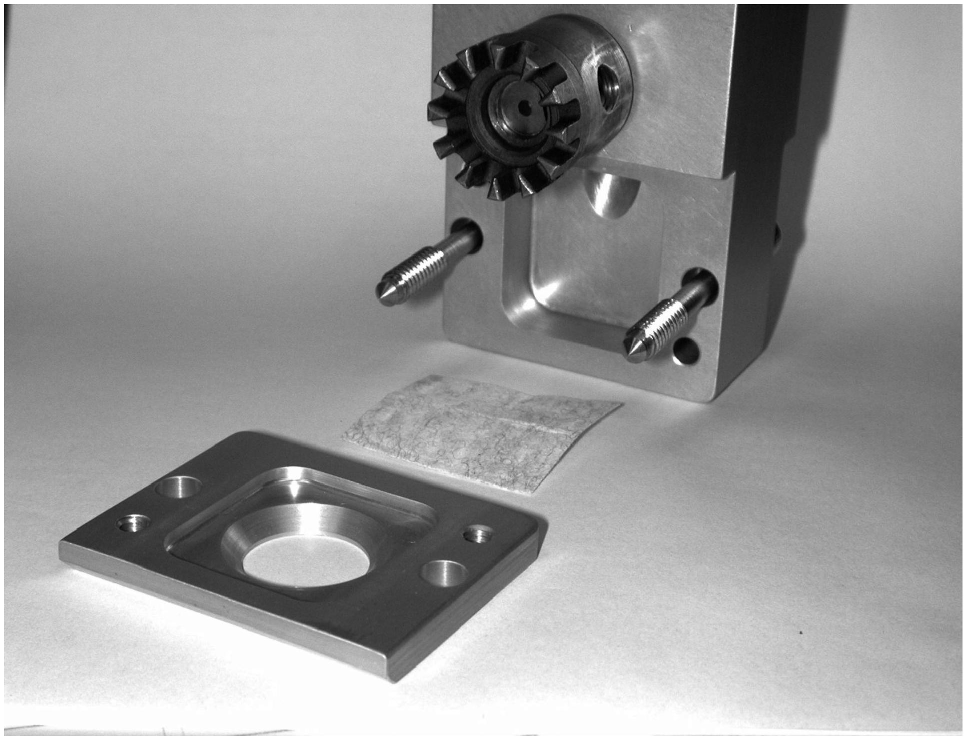

**Fig. 4. Filter cavity area.**

4. TEST RESULTS

The test arrangement consisted of the sampler base, which was clamped to a tabletop, and a test piece of steel, which was clamped to an adjoining table. Two tables were used to simulate compliance effects between the wall and the robot arm. 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.

An operations concern is whether the operators will be able to adequately view the device through television cameras well enough so as to operate it correctly. To make sure the sampler is pressed perpendicular to the wall, WVNS added a compliant wrist to its robot. This wrist presses struts against the wall to ensure perpendicular operation. Since the operators cannot see well enough so as to advance the bit into the steel at the same rate as the actual steel milling, the technique was changed to allow the operators to instead rely on the force-limiting mechanism to apply a constant force with the bit. Since the depth-limiting bolts will prevent the sampler from cutting too deeply, the operators only need to advance the sampler onto the wall and wait a few minutes until the milling is finished

The key test of the system was to precisely weigh the sampler housing and a test piece of steel and measure them again after a sample was taken from the steel. Ideally, all of the weight that disappeared from the test steel would appear in the sample housing. For tests on dry painted steel, the results were very good¾with all of the weight that disappeared from the steel appearing in the sampler. Since we are near the accuracy limit (0.01 g) on our scale, we are claiming the recovery to be 99+%. Weights collected for these samples were about 0.5 g.

Other tests were conducted to simulate performance for walls covered with thick scales. WVDP expects up to 0.25 in. of sodium hydroxide scales, and bars of hand soap 0.25 in. thick were used to simulate these tests. The sampler appeared to collect the simulated scale very well; however, weight measurements showed only 80 to 85% collection efficiency because of compounds evaporating from the soap. Tests were also conducted with the soap wetted down to simulate wet conditions; however, the vacuum system evaporated the water such that the efficiency appeared to be only 50%. However, the main consideration for the wet tests is whether the sticky and wet soap gums up the sampler and prevents it from collecting its sample. Tests have shown that the sampler will still collect the gummy soap; however, the material becomes stuck throughout the inside of the sampler instead of only on the filter paper. This material is still retrievable in the analysis lab although it will need to be scraped out of the sampler head. The weights of materials collected for these tests are 2 to 3 g.

Another consideration is the efficiency of extracting the material from the sample head and getting it into the containers in the analytical laboratory. Tests in this area show an efficiency of 85 to 90%, although this efficiency requires manually scraping the material out of the sampler head if the material is sticky.

## 5. DEPLOYMENT PLANS

Present plans are to deploy the sampler in one of the West Valley HLW tanks in early 2001. The sampler itself is operational although further testing will be required to achieve NQA-1 certification for the device. Further tests with the full robot and sampler system will need to be conducted to verify that the robot is stiff enough to hold the sampler steady during the milling operation. In the future, new versions of the sampler may be considered for tank-floor sampling where the floor is under a few inches of water.

## 6. CONCLUSIONS

The West Valley Grab Sampler has been a very successful design activity and is anticipated to be an accurate, a reliable, and a robust device for samples at the WVDP tanks. Experience gained from designing and operating this device in an actual waste environment will be valuable for future work in waste-tank remediation at other U.S. Department of Energy and industrial sites.