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Techniques for Determining Mechanical Properties of Wastes and Sampling Waste Tank Contents

**by
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Fuels and Materials Department**

July 1975

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Battelle
Pacific Northwest Laboratories

BNWL-1930

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TECHNIQUES FOR DETERMINING MECHANICAL
PROPERTIES OF WASTES AND SAMPLING WASTE
TANK CONTENTS

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Battelle
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Richland, Washington 99352

SUMMARY

At the request of the Atlantic Richfield Hanford Company, Battelle-Northwest developed techniques and equipment for characterizing the radioactive wastes stored in tanks on the Hanford Reservation, for performing in situ tests of waste tank contents, and for sealing perforated wells with an asphaltic emulsion. The equipment and sampling methods developed were shown to be effective for the wide variety of waste materials stored in the Hanford waste tanks.

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TECHNIQUES FOR DETERMINING MECHANICAL
PROPERTIES OF WASTES AND SAMPLING WASTE
TANK CONTENTS

R. C. Lawrence

INTRODUCTION

The waste materials stored in tanks on the Hanford Reservation vary in consistency over a wide range, from liquid to rock-like hardness. Often one tank contains a number of different materials. The mechanical properties of these wastes have not previously been investigated, nor have effective sampling and data collection techniques been developed for this wide range of materials.

To develop suitable waste sampling equipment and techniques, ARHCO sponsored a study aimed at characterizing the mechanical properties of the wastes; identifying effective means of measuring radiation levels, temperatures, and neutron movements in situ in the wastes; and developing a prototype waste core sampler.

Battelle-Northwest carried out this work over 15 months in the following progression:

- determination of the mechanical properties of typical waste materials;
- development and field testing of in situ waste tank inspection techniques;
- development of prototype waste sampling equipment; and
- development of a procedure for sealing perforated wells with asphaltic emulsion.

The development work was done at the 200 Area tank farms of the Hanford Reservation and in BNW laboratories. Actual prototype testing was done at the tank farm.

PROGRAM DESCRIPTION

Work on the program was carried out in four phases, as described above. The objective of the first phase was to identify the mechanical properties of the wastes. This information was used in later phases to develop waste sampling equipment and to make radioactivity and temperature measurements inside the waste tanks.

DETERMINING MECHANICAL PROPERTIES OF WASTES

Various specifications were evaluated to identify a standard reference for relating waste hardness to that of conventional materials for which mechanical properties have been defined. ASTM 68-D1 was selected as the standard, so that methods used to characterize waste hardness would be compatible with highway and building construction soil testing techniques. This system gives compression strength data in PSI.

Accordingly, compression tests were conducted on as complete a range as possible of simulated tank material (salt cake, gelatinous mass, liquid waste, etc.). Compressive strengths of the different waste forms varied significantly. Figure 1 relates the measurements to ASTM standards.

IN SITU MEASUREMENT AND DATA COLLECTION IN WASTE TANKS

The objective of this phase was in situ measurement of radiation levels and temperatures inside waste tank 105B. The first task was to insert a casing into the waste through which measuring devices could be lowered to characterize tank contents throughout the entire tank depth. On the basis of the compression tests described above, a 2 in. ID stainless steel pipe with a pointed end was selected as a casing.

FIGURE 1. Compression Strengths of Various Waste Materials
(as compared to ASTM standards)

The pipe was manually driven through the waste with a 15-pound slap hammer to the 34 foot level (Figure 2). Table 1 indicates the relative hardnesses of different waste layers encountered according to the number of hammer blows required to penetrate 1 foot of waste.

Radiation and Temperature Measurements

A stainless steel closed probe consisting of a CP extension R/hr meter was lowered to the bottom of the waste tank through the casing. This permitted measurement of radiation at 1-foot intervals from the bottom of the tank upward. These results are shown in Table 1.

Temperatures in the various waste layers were measured in the same way. A calibrated chromel-alumel thermocouple was lowered to the tank bottom through the pipe and measurements were taken at each foot of depth. These results are also shown in Table 1.

Neutron Flux Measurements

A special remote neutron monitoring technique was developed to detect the presence of plutonium in the waste layers. This method involves exposing various metals to neutron activity and subsequently measuring the radioactivity induced. Plutonium quantities can then be estimated from these measurements.

Two types of metal neutron detectors are used: a long copper strip and packets of metal discs suspended at intervals on glass tape (Figure 3). The copper strip (1/4 inch by 2 inches by 96 inches) is lowered into the steel pipe which has been placed in a high-level liquid waste storage tank. Thermal neutrons from (d/n) reactions with oxygen in the highly moderating medium are captured by the copper via the $^{63}\text{Cu}(n,\gamma)^{64}\text{Cu}$ reaction. Subsequent determinations of the ^{64}Cu activity permit estimates of the plutonium concentration in the tank. This technique has a sensitivity limit as low as 270 weight parts per billion.

FIGURE 2. Probe and Core Sampler in Waste Tank

TABLE 1. In Situ Measurements, Tank 105B

Depth Under Riser Flange (ft)	Temp. (°F)	Radiation Reading Outside (mR)	Inside ^a (mR)	Neutron Flux ^b cm ⁻² /sec ⁻¹	Penetration ^c Blows/ft	Remarks
0		50				
17			100			
18		950	100			No resistance
19			300			
20			550			
21		1500	600			
22			625			
23			650			
23-1/2	Crust level					
24			700		30	
25	76		750	<0.004	33	Crust layer 1-1/2" to 1-3/4" thick
26	68.5		1150		59	
26-1/2			1900			
27			950		44	
28	67.5		700	<0.002	58	
29			800		24	
30	65.5		1150	<0.004	α	Encountered extremely hard object or layer; penetration exposed liquid beneath layer
31	66		1000			
32	67		1000	<0.018 ²		
33	67		750			
34	66.5		550	<0.009; <0.003		
35	67		800			
36			4700	<0.005		
36-1/4	67					
38	Tank bottom					

^a500 Rad. H.R.T.P. 2" ID, 0.154" SS pipe

^bBrodzinski, BNW measurements, ~6 wppm Pu

^c3/4" pipe bore with 15# slap hammer, 3' nominal drop

FIGURE 3. Metal Discs for Detecting Neutron Activity in the Waste Tank

The packets of metal discs suspended on glass tape are used in the same way. Each packet contains metal discs, each 1/4 inch thick. A packet will pass through a pipe as small as 2 inches ID. As with the copper strip, the activation products produced in the metals can be measured and related to the neutron activity present. The metals used, the reactions involved, and the neutron energy relevant to each disc are:

- cadmium-covered copper - $^{63}\text{Cu}(n,\gamma)^{64}\text{Cu}$, epithermal
- nickel - $^{58}\text{Ni}(n,p)^{58}\text{Co}$, fast (primarily from (d,n) reactions)
- magnesium - $^{24}\text{Mg}(n,p)^{24}\text{Na}$, fast (primarily from spontaneous fission)
- titanium - $^{48}\text{Ti}(n,p)^{48}\text{Sc}$, fast (primarily from spontaneous fission)

- zinc - $^{64}\text{Zn}(n,p)^{64}\text{Cu}$, fast (primarily from (d,n) reactions)
- copper - $^{63}\text{Cu}(n,\gamma)^{64}\text{Cu}$, thermal

Fairly precise determinations of the isotopic ratios of plutonium and estimates of the chemical form are possible with the multiple disc technique. For example, in a contaminated facility of over 800 square feet, tests have measured a ^{240}Pu presence of less than $150 \mu\text{cm}^{-2}$.

Plutonium Measurement in 361-Z Tank

The foregoing technique was used to measure the plutonium concentration in the 361-Z tank. The following reported plutonium concentrations are based on the assumptions that the tank contains 93.7 percent ^{239}Pu , 6 percent ^{240}Pu , and 0.3 percent ^{241}Am , all as the oxide, in an aqueous medium with an average neutron crow-flight distance of 8.46 cm.

Plutonium Concentration (in mg/cm^3)

Top	3.78
	7.59
	9.07
	7.03
	4.01
Bottom	0.798

SAMPLE REMOVAL FOR LABORATORY ANALYSIS

The third phase of the program addressed the need for a simple, reliable and rapid method of extracting samples from the waste storage tanks. An extensive review indicated that no commercial product is available which can be used or modified to retrieve as wide a range of materials as is found in the waste tanks (i.e., liquids to concrete-like substances). BNW therefore agreed to design, fabricate and test a prototype waste core sampling device.

Using data acquired during earlier phases of the program, the waste core sampler shown in Figure 4 was designed and fabricated. When lowered into liquid waste, the rubber tube inside the steel sleeve fills with 800 cc of liquid (Figure 5). It is then closed off at the bottom and withdrawn. This closure method is effective and prevents loss of sample. As an added precaution, however, the sampler is drawn up into a special protective cask (Figure 6). Encased in the cask, the unit is transported to a hot cell where it is remotely dismantled. This device has been successfully used to collect samples of liquids and materials with sludge-like or gelatinous consistencies.

For harder waste materials, the sampler incorporates carbide-tipped cutting teeth (Figure 7) which bore into the waste to remove a core sample. Power is furnished by an electric drill motor. As with liquid or soft materials, the filled sampler is drawn up into the cask for transport to the hot cell. The unit is easily decontaminated after use.

Waste Core Sample From 361-Z Tank

ARHCO personnel had requested that a sample be removed from 361-Z Tank for laboratory analysis. Prior to sample collection, preliminary tests were run to determine waste hardness and neutron flux and radiation measurements.

A stainless steel probe was inserted into the tank. The very soft tank contents allowed passage to the tank bottom. Radiation readings taken at 1-foot intervals were consistently <30,000 c/m throughout the tank depth. The neutron measurements are described in the preceding section.

Using data acquired from the probe and the waste core sampler, a sample was removed from the bottom of the tank. The sampler was moved into position and the rubber bladder was closed and locked to contain the sludge material. The sampler was

FIGURE 4. Waste Core Sampler in Collection Tray

FIGURE 5. Waste Core Sample Removal Unit

FIGURE 6. Extraction of Filled Waste Core Sampler into Cask

FIGURE 7. Carbide-Tipped Cutting Teeth on Sampler Which Enable Samples of Rock-Hard Materials to be Extracted

pulled up into a plastic sleeve, placed in a transport container, and transported to the analytical laboratory. (Figures 8 and 9 show the sludge-like material in the sampler after dismantling in the glove box.) On this first attempt to recover Pu-containing sludge the sampling unit worked very satisfactorily.

SEALING OF WELLS WITH ASPHALTIC EMULSION

Midway through the program, a fourth objective was added which was largely unrelated to the preceding efforts. Over the years, for data collection purposes, many wells were drilled on the Hanford Reservation in the areas of the waste storage tanks. To prevent well and groundwater contamination in the event of waste leakage from the tanks, a method was needed to seal the wells against entry of liquid. This task required identification of a suitable sealing material and application technique. Figure 10 shows a test well. The perforations to be filled with sealant are visible in the wall.

A unit was designed and assembled to inject the sealant into the well and measure the pressure forces on the sealant during injection (Figure 11). Injections of cement slurry and asphalt grout were tried, but penetration into the soil was poor and the process was plagued by excessive pressure buildup. It was therefore decided to try asphaltic emulsion as a sealing material.

Results of the asphaltic emulsion injection into various types of soil indicated that the technique works well in moist, porous soil; in fine or dry soil it is also successful, but only if the emulsion is diluted. Figures 12 and 13 show examples of the bonding of the emulsion with the soil.

FIGURE 8. Dismantled Sampler in Glove Box

FIGURE 9. Sludge Sample Extracted by Waste Core Sampler (taken inside glove box)

FIGURE 10. Perforated Well, to be Filled With Sealant

FIGURE 11. Unit for Injecting Sealant into Well
and Measuring Pressure Forces on Sealant

FIGURE 12. Test Well After Sealing With Asphaltic Emulsion

FIGURE 13. Sealed Well Perforation, Showing Bonding of Asphaltic Emulsion With Soil

Although these tests do not duplicate field conditions, the parameters of moisture content, particle size, and porosity which significantly influenced test results will also be important in determining field results. Such a small-scale approach is extremely useful in establishing critical factors which could lead to success or failure in the field.

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