RELEASE AUTHORIZATION

Document Number: WHC-SD-WM-TRP-229, REV 0

Document Title: TEST REPORT - PROTOTYPE CORE SAMPLER

Release Date: 1/17/95

This document was reviewed following the
procedures described in WHC-CM-3-4 and is:

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

Kara M. Broz

January 17, 1995

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A-6001-400.2 (09/94) WEF256

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SUPPORTING DOCUMENT		1. Total Pages 13
2. Title TEST REPORT - PROTOTYPE CORE SAMPLER	3. Number TRP-229 WHC-SD-WM-TR-056-4/	4. Rev No. 0
5. Key Words Core Sampler, Sampler, Waste Tank, Characterization	6. Author Name: C. G. Linschooten Signature: <i>[Signature]</i> 1-17-95 Organization/Charge Code N4108/71510	
7. Abstract This document describes the Test Procedure for studying the feasibility of the prototype core sampler.		
8. RELEASE STAMP OFFICIAL RELEASE 5 BY WHC DATE JAN 17 1995 <i>stor. 4</i>		

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TEST REPORT PROTOTYPE CORE SAMPLER

1.0 INTRODUCTION

The purpose of this test is to determine the adequacy of the prototype Sampler, provided to Westinghouse Hanford Company (WHC) by DOE-RL. The sampler was fabricated for DOE-RL by the Concord Company by request of DOE-RL. This prototype sampler was introduced as a technology that can be easily deployed (similar to the current auger system) and will reliably collect representative samples. The sampler is similar to the Universal Sampler i.e., smooth core barrel and piston with an O-ring seal, but lacks a rotary valve near the throat of the sampler. This makes the sampler inappropriate for liquid sampling, but reduces the outside diameter of the sampler considerably, which should improve sample recovery.

2.0 METHODOLOGY

Recovery testing was performed with the supplied sampler in three different consistencies of Kaolin sludge simulants. The test were conducted per Test Plan WHC-SD-WM-TC-066 on December 6, 1994 in the 336 building/300 Area. The test were performed by Kyle Isakower, DOE mentor, and Chris Linschooten from WHC Characterization Equipment. The only variant was the deletion of the test with the colored rings as mentioned in paragraph 2.3. of the test plan. Colored rings were not mixed into the simulant due to an anticipated difficulty in measuring ring depth and condition after simulant preparation. Since we could not verify the condition of the colored rings before testing, it made no sense to look for the changes in the colored rings after extrusion.

The simulant preparation was done at Pacific Northwest Laboratory (PNL) by the Chemical Separations And Slurry Processing Group. The mixer used has a capacity of approx. 75 liters (20 gallons) Model No. FM-130-D made by Littleford Polyphase Mixers, Dryers and Reactors, Florence, Kentucky. The mixer was driven by a 10 Hp electric motor through a gearbox. Simulant compositions were chosen in an effort to approximate the shear strengths of the loosest and stiffest sludges (ie: nearing the liquid and plastic limits) as well as an intermediate sludge. Simulants were mixed in an effort to obtain a moisture content accuracy $\pm 0.5\%$. To verify accuracy, during the mixing of the kaolin three samples of each batch were taken and analyzed for moisture content. The results were as follows:

- 33% water by weight sludge had an observed average of 32.98% water by weight.
- 35% water by weight sludge had an observed average of 35.41% water by weight.

- 45% water by weight sludge had an observed average of 46.84% water by weight.

During testing, a second set of samples for each batch of kaolin sludge were taken at both the surface and at 10-inch depth, then analyzed for moisture content. The results were averaged to give the following observed moisture content readings:

- 33% water by weight sludge had an observed average of 32.17% water by weight.
- 35% water by weight sludge had an observed average of 35.02% water by weight.
- 45% water by weight sludge had an observed average of 45.12% water by weight.

For more detailed information see attachment 3.

While two of the observed sample batches did not adhere to the $\pm 0.5\%$ goal (45% water by weight sludge pre-test measurement and the 33% water by weight sludge during-test measurement) the variations were not deemed significant to the results of this test. If a variation in the test plan were made, it would only be to note that the mixtures may be simulating even greater extremes of the tank waste (ie: wastes with higher or lower shear strengths than originally planned).

The length of extruded sample was measured using a flexible tape measure. Some cores extruded sinuously, so some approximation was necessary in determining core length. The volume of the sample was measured by putting it in a 1000 cc measuring glass partially filled with tap water and reading the increase in volume. The markings were in 10 cc intervals and could be interpreted at 5 cc intervals. The volume measurement was done after the weight was taken. The weight of the sample was measured on a calibrated electronic scale with an accuracy of 0.01 gram. The moisture content was obtained with a Moisture Analyzer Model IR 100 from the Denver Instrument Co. at the Chemical Engineering Laboratory in the 200 East Area. Using a calibrated brass weight, the moisture analyzer is self calibrating $\pm 0.01\%$.

3.0 RESULTS

Both volume and length of the extruded samples were considered for evaluation of recovery. The length of the extruded sample was measured, but it was noted that depending on the toughness of the sample the length could be varied by extruding at a faster rate. If the material was soft it was flowing out of the sampler faster and extruded on top of itself forming a little pile. By extruding faster this could be avoided. The softer the sample material the easier this stretching was to do. In other words, if a sampler is not quite full but the extrusion is done fast the length of the sample might indicate

longer than actually recovered. For this reason the volume of the sample material was used to evaluate recovery (mass and density measurements closely resemble the volume data as well).

A Volume "A" was designated as the largest possible volume when the sampler was filled with water (230 cm³). A volume "B" was designated as the hardcore volume, being a core with a diameter of the throat opening (throat area) times the length of the sampling stroke (164.9 cm³).

The lowest observed recovery amount was 43.5% based on Volume "A" or 60.6% based on Volume "B." The highest recovery amount was 100.0% (Volume "A") or 139.5% (Volume "B"). Lowest recoveries were found in the most dense simulant (33% water by weight), while highest recoveries were consistently found in the softest material (45% water by weight).

In the soft kaolin sludge, 45% water by weight, the average recovery based on Volume "A" was 84.8%. In the 35% water by weight mix the average recovery was 75.0% and for the 33% water by weight mix the average recovery was 46.8%. The overall average Volume "A" recovery was therefore 68.8%. Average recoveries based on Volume "B" are 118.3% for 45% water by weight, 104.6% for the 35% waste by weight, and 65.3% for the 33% water by weight simulant. The overall average Volume "B" recovery was therefore 96.0%. The data sheets (#'s 1 and 2) noting results of the testing are presented as Attachment 1. Graphs of sample recovery versus kaolin simulant moisture content are presented as Attachment 2.

4.0 OBSERVATIONS

In the 35 and 33% mixes it was noted that the piston was jumping back after a sample was taken. Apparently the sampler might be rather full when depressed into the simulant but the cohesion of the material pulls some of the material back out of the sampler when the sampler is retrieved. When the sampler piston is held in position a vacuum is created and at a giving moment the sample material breaks and part of the simulant stays in the sampler. An air gap is created. It might be that if the piston is not held in position rigidly that we could loose all the sample simulant. It might be possible that the clay sample breaks at several places and the individual sample pieces act as pistons and an air gap is created between the broken sample string. Perhaps this phenomena explains the air gaps any where in the sludge sample when extruding. Sometimes an air gap was observed in the beginning and sometimes in the middle of the extrusion. It is conceivable that there is only one break or more than one break in the sludge string or some sample pulls out at the bottom of the sampler. The air gaps therefore may not be "missing pieces" of the core, but simply a break in the collection of a continuous core.

The best recovery was achieved while starting at 10 inches below the surface. Apparently the hydrostatic head helps fill up the sampler. Therefore, recoveries may well increase as the sampler is used near the base of deeper waste cores, and these tests may underestimate deeper core recoveries.

Unanswered questions:

1. The questions arise concerning the time to take a sample (rate), will the sampling time result in a better or worse sample. Question: What is the best sampling time (rate) and extrusion time (rate) for what consistency of material.
2. During testing the sampler was extruded a short distance away from the drum and the sampling set-up. No loss of material out of the sampler was noted during this transfer. But this could be of consequence during longer vertical recovery distance in the tank and horizontal transfer over land to the hot cells.
3. Sample recovery - It was told to us by mining equipment manufacturers, Longyear and Christensen, Salt Lake City, Utah, that the closer the outside of the sampler or drill equipment is to the core diameter of the sample the better the recovery will be. In the Concord Sampler this is $0.81/1.26 = 0.64$ for the Universal Sampler this number is $1.06/2.53 = 0.42$. The closer this quotient is to 1 the better the recovery rate will be.

5.0 CONCLUSIONS

The sampler will take sludge samples as noted, but configuration changes will be required for this sampler to be used with the present auger sampling system. If it were deemed prudent to consider this sampler for future use, a deployment and recovery system would be required to complete the process. This would include riser adapters, guide tubes, transfer cask, unloading (extruder) equipment compatibility check and hot cell handling process reviews.

It is important to understand this sampler's limitations (i.e., it is not appropriate for collection of liquids or salt cake, and some modifications would be required to ensure that a sample is not lost during transport) but the tests identified that this system can collect sludges within the shear strength ranges found in the high-level waste tanks. As such, this system may be able to assist in the completion of the waste tank characterization effort. Additional study to identify deployment options for this technology is recommended.

DATA SHEET #1

DATE:	WEIGHT TRAY+SAMPLE in GRAMS	WEIGHT TRAY in GRAMS	NET. WEIGHT SLUDGE in GRAMS	LENGTH SAMPLE in cm	DISTANCE BETWEEN BANDS in cm
10-26-94					
DRUM #1	45% WATER				
SAMPLE #1					#1
Start at 0	1114.5	908.4	206.1	40.6	#2
in. insert.					#3
					#4
SAMPLE #2					#1
At 0 in.	1190.3	908.4	281.9	43	#2
insertion					#3
					#4
SAMPLE #3					#1
At 0 in.	1191.7	908.4	283.3	45	#2
insertion					#3
					#4
DRUM #1	45% WATER				
SAMPLE #1					#1
At 10 in.	1253.4	908.4	345.0	57	#2
insertion					#3
					#4
SAMPLE #2					#1
At 10 in.	1253.5	908.4	345.1	57	#2
insertion					#3
					#4
SAMPLE #3					#1
At 10 in.	1194.4	908.4	286.0	48	#2
insertion					#3
					#4
DRUM #2	35% WATER				
SAMPLE #1					#1
At 0 in.	1244.3	908.4	335.9	53	#2
insertion					#3
					#4
SAMPLE #2					#1
At 0 in.	1253.1	908.4	344.7	54	#2
insertion					#3
					#4
SAMPLE #3					#1
At 0 in.	1213.9	908.4	305.5	51	#2
insertion					#3
					#4

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VOLUME WATER+SLUDGE in cc	VOLUME WATER in cc	NET VOL. SLUDGE in cc	SAMPLE RECOVERY %	COMMENTS
			(A) 60.9	(A) % from Actual Volume (Total Possible Volume) = 230 cu. cm
780	640	140	(B) 84.9	(B) Hardcore (Throat Area) Volume = 164.9 cu. cm
			(A) 62.6	
990	800	190	(B) 115.2	
			(A) 62.6	
950	760	190	(B) 115.2	
			(A) 100.0	6 seconds to take the sample 24 seconds to extrude the sample
960	730	230	(B) 139.5	No jump back of sampler piston.
			(A) 100.0	
940	710	230	(B) 139.5	No jump back of sampler piston.
			(A) 82.6	approx. 10 cm gap in the middle.
900	710	190	(B) 115.2	Some material extruded on top of itself.
			(A) 91.3	
940	730	210	(B) 127.3	
			(A) 91.3	
950	740	210	(B) 127.3	
			(A) 82.6	
920	730	190	(B) 115.2	

DATE:	WEIGHT TRAY-SAMPLE in GRAMS	WEIGHT TRAY in GRAMS	NET WEIGHT SLUDGE in GRAMS	LENGTH SAMPLE in cm	DISTANCE BETWEEN BANDS in cm
10-26-94					
DRUM #2	35% WATER				
SAMPLE #1					#1
Start at 10	1130.7	908.4	222.3	38	#2
in. insert.					#3
					#4
SAMPLE #2					#1
At 10 in.	1112.4	908.4	204.0	37	#2
insertion					#3
					#4
SAMPLE #3					#1
At 10 in.	1174.2	908.4	265.8	44	#2
insertion					#3
					#4
DRUM #3	33% WATER				
SAMPLE #1					#1
At 0 in.	1073.7	908.4	165.3	27	#2
insertion					#3
					#4
SAMPLE #2					#1
At 0 in.	1023.1	908.4	174.7	29	#2
insertion					#3
					#4
SAMPLE #3					#1
At 0 in.	1093.5	908.4	185.1	30	#2
insertion					#3
					#4
DRUM #3	33% WATER				
SAMPLE #1					#1
At 10 in.	1104.1	908.4	195.7	32	#2
insertion					#3
					#4
SAMPLE #2					#1
At 10 in.	1075.9	908.4	167.5	28	#2
insertion					#3
					#4
SAMPLE #3					#1
At 10 in.	1088.0	908.4	179.6	30	#2
insertion					#3
					#4

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VOLUME WATER+SLUDGE in cc	VOLUME WATER in cc	NET VOL. SLUDGE in cc	SAMPLE RECOVERY %	COMMENTS
			(A) 58.7	
880	745	135	(B) 81.9	Sampler piston jumped back 14.8 cm
			(A) 54.3	
845	720	125	(B) 75.8	No jump back of sampler piston. Big pocket of air at approx. midpoint. Air pocket approx. 15 cm long (estimated)
			(A) 71.7	11 seconds to take sample 18 seconds to extrude the sample
925	760	165	(B) 100.0	Sampler piston jumped back 12.3 cm
			(A) 43.5	
820	720	100	(B) 60.6	
			(A) 45.7	
860	755	105	(B) 63.7	Sampler piston jumped back 24 cm
			(A) 50.0	
820	705	115	(B) 69.7	Sampler piston jumped back 17.3cm
			(A) 50.0	
830	715	115	(B) 69.7	Sampler piston jumped back 7.3 cm
			(A) 43.5	
815	715	100	(B) 60.6	Sampler piston jumped back 24.3 cm
			(A) 47.8	
830	720	110	(B) 66.7	Sampler piston jumped back 22.8 cm

"A" VOLUME SAMPLE RECOVERY % (230 cm³)

**Westinghouse
Hanford Company****Internal
Memo**

From: Chemical Engineering Laboratory 8A400-94-049
Phone: 373-2683 S4-25
Date: December 19, 1994
Subject: MOISTURE PERCENT AND DENSITY RESULTS OF KAOLIN CLAY SAMPLES

To: C. G. Linschooten R1-17
cc: M. J. Schliebe *MS* S4-25
TMH File/LB

Reference: WHC-N-383-1, Controlled Laboratory Notebook, "General Support Studies."

The Chemical Engineering Laboratory (CEL) received six samples of kaolin clay with varying water contents from the Characterization Equipment Organization. Each sample was analyzed for its moisture content and density.

The moisture contents were determined using a Denver Instrument Company moisture analyzer, Model number IR-100. The analyses were performed at 105 °C and were considered completed when the percent moisture changed less than 0.05% per minute. Three analyses were performed for each kaolin clay sample. The results of the analyses are shown in the following table.

WEIGHT PERCENT MOISTURE OF KAOLIN CLAY SLUDGE SAMPLES				
Sample	1st Test	2nd Test	3rd Test	Average
33% water, surface sample	32.10%	32.02%	31.97%	32.03%
33% water, 10" deep sample	32.11%	32.33%	32.46%	32.30%
35% water, surface sample	35.27%	35.53%	35.28%	35.36%
35% water, 10" deep sample	34.90%	34.66%	34.45%	34.67%
45% water, surface sample	45.97%	45.68%	45.80%	45.82%
45% water, 10" deep sample	44.46%	44.31%	44.46%	44.41%

The densities were determined by placing known masses of the kaolin clay samples into calibrated, graduated centrifuge cones. The samples were then centrifuged at a force of 2000 gravities for 20 minutes. This separated some water from the rest of the clay, with the water forming a layer on top. The volume of each sample was assumed to be shown by the level of the meniscus of the water layer. The results of the analyses are shown in the following table.

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DENSITY OF CENTRIFUGED KAOLIN CLAY SLUDGE SAMPLES			
Sample	Sample Mass	Sample Volume	Density
33% water, surface sample	10.0 g	5.9 mL	1.69 g/mL
33% water, 10" deep sample	10.0 g	5.7 mL	1.75 g/mL
35% water, surface sample	10.0 g	6.0 mL	1.67 g/mL
35% water, 10" deep sample	10.0 g	5.9 mL	1.69 g/mL
45% water, surface sample	10.0 g	6.4 mL	1.56 g/mL
45% water, 10" deep sample	10.0 g	6.5 mL	1.54 g/mL

The results of the moisture content and density analyses were documented in a controlled laboratory notebook (Reference). If there are any questions regarding these analyses, feel free to call me on 373-2683.

Ted M. Hohl, Advanced Chemical Engineer
Chemical Engineering Laboratory

tmh