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Non-Destructive Examination
of Grouted Waste

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1.0 INTRODUCTION

This data report contains the results of ultrasonic pulse velocity and unconfined compressive strength measurements on a grouted simulant of 106AN tank waste. This testing program was conducted according to the requirements detailed in WHC-1993a. If successful, these methods could lead to a system for the remote verification of waste form quality.

The objectives of this testing program were:

- To determine if a relationship exists between the velocity of ultrasonic compression waves and the unconfined compressive strength of simulated grouted waste, and if so, determine if the relationship is a valid method for grout quality assessment.
- To determine if a relationship exists between the attenuation of wave amplitude and the age of test specimens.

The first objective was met, in that a relationship between the ultrasonic pulse velocity (UPV) waves and unconfined compressive strength (USC) was determined. This method appears to provide a valid measure of the quality of the grouted waste, as discussed in Sections 3.0 and 4.0. The second objective, to determine if the attenuation of UPV waves was related to the age of test specimens was partially met. A relationship does exist between wave amplitude and age, but it is doubtful that this method alone can be used to verify the overall quality of grouted waste.

Section 2.0 describes the test methods, with the results detailed in Section 3.0. A discussion of the results are provided in Section 4.0.

2.0 METHODS

2.1 MIXING AND CASTING TEST SPECIMENS

Test specimens were cast according to GEL-11, "Preparation and Mixing of Cement and Particulate Grout," (WHC-1993b).

Test specimens were prepared using a simulated waste representative of the waste in tank 106AN. The specimens were prepared in accordance with the requirements of Appendix A, Section A.1.1 of Riebling, et. al. (1991), except the dry materials were blended for approximately 1 hour instead of 23 hours. The grout was prepared using a standard grout mixer with a wire whip. The mixing sequence was: Measure out the heat simulated waste and add to the mixer bowl, measure out and add the dry materials to the simulated waste, blend for 30 s on low speed, followed by 30 s on medium speed. The mix ratio was 8.4 lb. dry materials to 1 gallon of liquid waste simulant. All the grout

specimens were cast and cured in either standard concrete plastic cylinders measuring 5 cm in diameter and 10 cm long, or in the attenuation cell, which is a cube, 15 cm on a side. All cylinder specimens were cured in water at the lab ambient temperature of approximately 20°C until tested, or until 28 days. Specimens were then removed from the tank and continued curing on a bench top until tested. They were not removed from the molds until tested.

2.2 PULSE VELOCITY MEASUREMENT

Pulses of compressional waves were generated by an electro-acoustical transducer, which was held in contact with one surface of the specimen under test. After traversing through the grout, the pulses are received and converted into electrical energy by a second transducer in contact with the opposite end of the specimen.

The pulse generator consists of circuitry for generating pulses of voltage. The transducer transforms part of these electronic pulses into wave bursts of mechanical energy. For this study, 54 kHz transducers were used. The transducer is constructed of piezoelectric, housed for protection. A triggering pulse is produced to start the time measuring circuit. The receiving transducer is similar to the transmitting transducer. The voltage generated by it was amplified to produce adequate signal levels at the data acquisition card. The time-measuring circuit and the associated triggering pulses are initiated by a triggering voltage from the pulse generator. The time-measuring circuit provides an output when the received pulse is detected, and this output was used to determine the transit time displayed on the time-display unit. The time-measuring circuit is insensitive to operating temperature and voltage changes in the power source.

The specimens were stripped from the molds, and the ends were ground smooth and parallel using a lap table. An appropriate coupling agent (such as petroleum jelly or vacuum grease) was applied to the transducer diaphragms. The faces of the transducers were pressed against the ends of the grout specimens assuring good contact between the two, and the transit time was then measured. The length of the shortest direct path between the centers of the diaphragms was measured.

The pulse velocity was calculated as follows:

$$V = L/T$$

where:

V = pulse velocity, m/s (ft/s),

L = distance between transducers, m (ft), and

T = effective transit time, s (measured time minus zero time correction and corrected for calibration errors).

2.3 COMPRESSIVE STRENGTH/DENSITY

After NDE measurements were taken, the specimens were carefully measured and weighed for bulk density determination. The appropriate sections of GEL-16 were used to define locations, and number of measurements. The specimens were then placed in a load frame for unconfined compressive strength measurement, following GEL-05. The specimens were centered between the upper and lower platens, and loaded to failure.

The density was determined by averaging the length and diameter measurements, and calculating the density according to:

$$D = M/V$$

where:

D = Density
M = Specimen Mass
V = Specimen Volume (A x L)
A = Cross sectional area of specimen

Unconfined Compressive Strength (UCS) was determined according to:

$$UCS = F/A$$

where:

F = Total Force (Load)

2.4 AMPLITUDE ATTENUATION

The attenuation of the amplitude of the compression wave was measured in the attenuation cell. This cell consisted of a plexiglass cube, 15 cm on each side. On two, opposite sides, holes were drilled through the center, into which UPV transducers could be fit. The holes were covered with a commercial parafilm film. The cell was filled with grout and allowed to cure. At intervals, 24, 54 and 150 kHz transducers were inserted into the holes and the UPV was measured. At this time, the amplitude of the UPV signal was also measured and recorded.

3.0 RESULTS

Compressive Strength/Ultrasonic Pulse Velocity

The first date at which the grout exhibited sufficient strength to be stripped from the molds and tested was at 14 days. The average compressive

strength at this age was 160 psi, the UPV was 6163 fps, the data is summarized in Table 1, and plotted in Figure 1. Similar tables and plots are provided for 21 day age (Table/Figure 2), 28 day (Table/Figure 3) 56 day (Table/Figure 4) and 90 day (Table/Figure 5).

Wave Amplitude Attenuation

Wave amplitudes for the 24, 54, and 150 kHz transducers over a three week period are detailed in Table 6 and plotted in Figure 6. Wave amplitude for each transducer began to rise significantly at about 10 days.

Specimen Density

Densities, measured and plotted as a function of time are shown in Figure 7. Overall, density decreased over time. Specimen volume is also plotted, and is shown in Figure 8.

4.0 DISCUSSION

A relationship was found between the UCS and the UPV of grouted waste. A plot of this relationship is shown in Figure 9. The correlation is $R^2 = 0.811$, which is not as high as hoped for when the study began, but it is good enough to indicate that a relationship clearly exists between these two physical properties. Descriptive statistics for the data at each age, Table 7, shows a decreasing standard deviation for the UPV from 14 days to 28 days, with a large increase at 56 and 90 days. This indicates that the curing process is continuing for long periods, and although the compressive strength remains high, internal changes in the microstructure are occurring. In fact, most measures of grout "quality" show a maxima at 28 days age.

The density of the grout specimens drops gradually from 14 days to 56 days age (Figure 7) but the 90 day old specimens show a marked decrease in the density. This is due to a decrease in both volume and mass. The mass of each specimen is shown in Tables 1 through 5, and the volume is plotted against age in Figure 8. Although the specimens were left in the molds for the entire curing period, it is evident that they began losing mass after 28 days, most likely due to drying. Drying of cementitious materials usually leads to shrinkage and cracking. The scatter in both UPV and UCS data increases after 28 days, which supports the micro-cracking theory. The scatter in the UPV and UCS can be seen in Figures 10 and 11. Because UPV is proportional to the density and modulus of elasticity this decrease in density explains the drop in UPV after 56 days age.

5.0 REFERENCES

Riebling 1991,

WHC-1993a, Measurement of Pulse Velocity/Compressive Strength Relationship of Grouted Waste, WHC-SD-WM-TP-171, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC-1993b, Geotechnical Engineering Laboratory Procedure Manual, WHC-IP-0635, Westinghouse Hanford Company, Richland, Washington.

6.0 TABLES AND FIGURES

Table 1. UPV AND Compressive Strength Results
14 Day Samples

SAMPLE #	WEIGHT (g)	LENGTH (in)	DIAMETER (in)	ARR. 1ST WAVE (us)	UPV (fps)	CS (psi)	AMP. 1ST WAVE
3-1568-1	292.86	3.720	2.002	47	6596	156	4.43 V
3-1568-2	302.80	3.830	1.993	51	6258	156	2.60 V
3-1568-3	303.89	3.856	1.995	50	6427	162	718 mV
3-1568-4	307.87	3.936	1.992	54	6074	153	3.92 V
3-1568-5	297.78	3.800	2.008	50	6333	124	2.65 V
3-1568-6	304.61	3.890	1.990	51	6356	147	2.94 V
3-1568-7	303.91	3.875	1.985	55	5871	175	2.42 V
3-1568-8	299.97	3.803	1.997	54	5869	168	1.54 V
3-1568-9	305.07	3.878	1.985	54	5985	191	3.04 V
3-1568-10	290.95	3.870	1.988	55	5864	182	2.21 V
AVERAGE	300.97	3.846	1.994	52	6163	161.4	N/A

Figure 1. UPV AND Compressive Strength Data
14 Day

Table 2. UPV and Compressive Strength Results
21 Day Samples

SAMPLE #	WEIGHT (g)	LENGTH (in)	DIAMETER (in)	ARR. 1ST WAVE (us)	UPV (fps)	CS (psi)	AMP. 1ST WAVE
3-1569-1	298.79	3.911	2.000	51	6391	541	1.47 V
3-1569-2	297.80	3.900	2.000	51	6373	452	463 mV
3-1569-3	293.25	3.867	2.000	49	6577	503	2.56 V
3-1569-4	295.98	3.878	2.000	48	6377	503	977 mV
3-1569-5	297.63	3.880	2.000	48	6736	487	846 mV
3-1569-6	298.00	3.895	2.000	48	6762	515	2.81 V(OL)
3-1569-7	296.75	3.851	2.000	50	6418	512	2.87 V(OL)
3-1569-8	298.83	3.891	2.005	49	6617	500	5.00 V(OL)
3-1569-9	295.70	3.876	2.005	49	6592	506	2.85 V
3-1569-10	295.78	3.854	2.003	48	6691	506	5.00 V(OL)
AVERAGE	296.85	3.880	2.001	49	6589	502.5	N/A

Figure 2. UPV and Compressive Strength Data
21 Day

Table 3. UPV and Compressive Strength Results
28 Day Samples

SAMPLE #	WEIGHT (g)	LENGTH (in)	DIAMETER (in)	ARR. 1ST WAVE (us)	UPV (fps)	CS (psi)	AMP. 1ST WAVE
3-1570-1	293.26	3.819	1.999	46	6918	564	5.00 V(OL)
3-1570-2	300.05	3.856	2.000	47	6837	561	63 mV
3-1570-3	301.94	3.884	1.999	47	6887	500	183 mV
3-1570-4	305.10	3.948	1.999	47	7000	545	625 mV
3-1570-5	298.86	3.910	2.000	47	6933	576	131 mV
3-1570-6	299.50	3.899	2.003	47	6913	532	1.21 v
3-1570-7	289.72	3.904	2.005	48	6778	570	502 mV
3-1570-8	298.19	3.835	2.001	47	6800	596	1.86 V
3-1570-9	302.93	3.907	.001	47	6927	548	1.57 V
3-1570-10	300.49	3.898	2.004	47	6911	611	579 mV
3-1570-11	303.18	3.934	2.004	47	6975	576	918 mV
3-1570-12	303.58	3.942	2.002	47	6989	554	457 mV
3-1570-13	298.76	3.926	2.001	47	6961	592	289 mV
3-1570-14	296.40	3.870	2.002	46	7011	611	1.11 V
3-1570-15	299.16	3.907	2.001	47	6927	605	1.69 V
1-1570-16	300.90	3.918	2.001	48	6802	570	808 mV
1-1570-17	296.08	3.870	2.004	46	7001	618	1.08 V
3-1570-18	291.29	3.860	2.000	46	6993	688	2.51 V
3-1570-19	294.63	3.878	2.001	46	7025	618	2.03 V
3-1570-20	294.95	3.881	2.001	47	6881	611	1.26 V
AVERAGE	298.45	3.892	2.001	47	6924	582.3	N/A

Figure 3. UPV and Compressive Strength Data
28 Day

Table 4. UPV and Compressive Strength Results
56 Day Samples

SAMPLE #	WEIGHT (g)	LENGTH (in)	DIAMETER (in)	ARR. 1ST WAVE (us)	UPV (fps)	CS (psi)	AMP. 1ST WAVE
3-1571-1	286.30	3.780	2.000	37	8514	1287	N/A
3-1571-2	292.72	3.839	2.000	40	7998	1296	N/A
3-1571-3	291.89	3.835	2.000	40	7990	1624	N/A
3-1571-4	293.70	3.830	2.001	40	7979	1134	N/A
3-1571-5	293.16	3.833	2.001	38	8406	1656	N/A
3-1571-6	286.29	3.818	1.995	41	7760	1169	N/A
3-1571-7	289.52	3.856	2.002	40	8033	1083	N/A
3-1571-8	294.88	3.873	1.998	40	8069	1108	N/A
3-1571-9	282.50	3.880	2.000	41	7886	895	N/A
3-1571-10	282.81	3.825	2.002	44	7244	761	N/A
3-1571-11	285.90	3.795	2.001	42	7530	774	N/A
3-1571-12	288.23	3.815	2.003	42	7569	783	N/A
3-1571-13	282.97	3.800	2.002	44	7197	780	N/A
3-1571-14	282.09	3.841	2.003	44	7275	710	N/A
3-1571-15	279.17	3.816	2.001	44	7227	678	N/A
3-1571-16	285.18	3.804	2.004	41	7732	901	N/A
3-1571-17	285.99	3.846	2.003	44	7284	688	N/A
3-1571-18	285.64	3.780	2.003	42	7500	860	N/A
3-1571-19	289.05	3.780	2.001	40	7875	1045	N/A
3-1571-20	292.36	3.830	2.01	41	7785	917	N/A
AVERAGE	287.52	3.824	2.001	41	7743	1007.5	N/A

Figure 4. UPV and Compressive Strength Data
56 Day

Table 5. UPV and Compressive Strength Results
90 Day Samples

SAMPLE #	WEIGHT (g)	LENGTH (in)	DIAMETER (in)	ARR. 1ST WAVE (us)	UPV (fps)	CS (psi)	AMP. 1ST WAVE
3-1572-1	253.39	3.822	1.999	43	7407	1067	995 mV
3-1572-2	251.97	3.781	2.000	41	7685	1099	Clipped
3-1572-3	241.70	3.738	1.996	46	6772	688	Clipped
3-1572-4	245.38	3.772	1.993	40	7858	1178	1.03 v
3-1572-5	251.57	3.780	2.000	43	7323	885	Clipped
3-1572-6	245.58	3.670	2.000	41	7459	1048	Clipped
3-1572-7	248.16	3.711	2.002	43	7197	920	Clipped
3-1572-8	249.49	3.784	1.995	45	7007	873	Clipped
3-1572-9	246.34	3.743	1.998	44	7089	787	Clipped
3-1572-10	245.76	3.722	1.995	44	7049	955	Clipped
3-1572-11	244.07	3.731	1.995	45	6909	885	Clipped
3-1572-12	251.25	3.795	1.997	44	7188	876	Clipped
3-1572-13	247.71	3.735	1.995	43	7238	1035	Clipped
3-1572-14	255.03	3.804	1.995	44	7205	1118	Clipped
3-1572-15	252.18	3.785	2.002	43	7335	1022	Clipped
3-1572-16	253.35	3.807	2.001	43	7378	1000	Clipped
3-1572-17	252.40	3.814	2.001	45	7063	812	Clipped
3-1572-18	249.41	3.785	1.995	44	7169	688	Clipped
3-1572-19	242.79	3.824	2.001	50	6373	564	Clipped
3-1572-20	245.48	3.779	1.995	46	6846	809	Clipped
AVERAGE	248.65	3.769	1.998	44	7177	915.5	N/A

Figure 5. UPV and Compressive Strength Data
90 Day

Table 6. Ultrasonic Pulse Velocity Attenuation Cell Data
(Page 1 of 5)

CURING DAY	TRANSDUCER (kHz)	ARR. 1ST WAVE (g)	PATH LENGTH	UPV (fps)	AMP. 1ST WAVE
3	24	0.000207	0.5	2415	208 mV
3	54	0.000212	0.5	2358	49 mV
3	150	N/A	N/A	N/A	N/A
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000023	PERCENT REC. =	88.5	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A
4	24	0.000159	0.5	3145	116 mV
4	54	0.000181	0.5	2762	23 mV
4	150	N/A	N/A	N/A	N/A
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000025	PERCENT REC. =	96.2	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A
5	24	0.000156	0.5	3205	106 mV
5	54	0.000156	0.5	3205	43 mV
5	150	N/A	N/A	N/A	N/A

Table 6. Ultrasonic Pulse Velocity Attenuation Cell Data
(Page 2 of 5)

CURING DAY	TRANSDUCER (kHz)	ARR. 1ST WAVE (S)	PATH LENGTH (ft)	UPV (fps)	AMP. 1ST WAVE
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A
6	24	0.000141	0.5	3546	153 mV
6	54	0.000141	0.5	3546	48 mV
6	150	N/A	N/A	N/A	N/A
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A
7	24	0.000120	0.5	4167	162 mV
7	54	0.000126	0.5	3968	67 mV
7	150	0.000126	0.5	3968	18 mV
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A

Table 6. Ultrasonic Pulse Velocity Attenuation Cell Data
(Page 3 of 5)

CURING DAY	TRANSDUCER (kHz)	ARR. 1ST WAVE (s)	PATH LENGTH (ft)	UPV (fps)	AMP. 1ST WAVE
8	24	0.000124	0.5	4032	396 mV
8	54	0.000134	0.5	3731	87 mV
8	150	0.000130	0.5	3846	17 mV
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A
9	24	0.000121	0.5	4132	347 mV
9	54	0.000126	0.5	3968	89 mV
9	150	0.000121	0.5	4132	16 mV
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A
10	24	0.000118	0.5	4237	1.10 V
10	54	0.000115	0.5	4348	389 mV
10	150	0.000103	0.5	4505	35 mV

Table 6. Ultrasonic Pulse Velocity Attenuation Cell Data
(Page 4 of 5)

CURING DAY	TRANSDUCER (kHz)	ARR. 1ST WAVE (s)	PATH LENGTH (ft)	UPV (fps)	AMP. 1ST WAVE
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000025	PERCENT REC. =	96.2	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A
13	24	0.000115	0.5	4348	426 mV
13	54	0.000117	0.5	5274	137 V
13	150	0.000111	0.5	4505	35 mV
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A
14	24	0.000111	0.5	4505	1.02 V
14	54	0.000113	0.5	4425	278 mV
14	150	0.000103	0.5	4854	182 mV
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A

Table 6. Ultrasonic Pulse Velocity Attenuation Cell Data
(Page 5 of 5)

CURING DAY	TRANSDUCER (kHz)	ARR. 1ST WAVE (s)	PATH LENGTH (ft)	UPV (fps)	AMP. 1ST WAVE
17	24	0.000105	0.5	4762	743 mV
17	54	0.000105	0.5	4762	214 mV
17	150	0.000098	0.5	5102	271 mV
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A
21	24	0.000140	0.5	3571	67 mV
21	54	N/A	0.5	N/A	N/A
21	150	N/A	0.5	N/A	N/A
CALIBRATION	24	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	54	0.000024	PERCENT REC. =	92.3	N/A
CALIBRATION	150	0.000024	PERCENT REC. =	92.3	N/A

Figure 6. Plot of amplitude changes over time for 24, 54, and 150 kHz transducers

Figure 7. Specimen density as a function of age

Figure 8. Volume stability of specimens over time

Figure 9. Relationship between unconfined Compressive Strength and Ultrasonic Pulse Velocity

Table 7. Descriptive statistics for UPV/UCS
data at each age

Age 14

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
UCS	161.400	19.045	6.023	10	124.000	191.000	2
UPV	6164.500	264.430	83.620	10	5864.000	6596.000	2

Age 21

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
UCS	505.500	22.486	7.111	10	452.000	541.000	2
UPV	6590.300	149.389	47.241	10	6373.000	6771.000	2

Age 28

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
UCS	582.300	40.283	9.008	20	500.00	688.000	1
UPV	6923.850	75.056	16.783	20	6778.000	7025.000	1

Age 56

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
UCS	1007.450	289.447	64.722	20	678.000	1656.000	1
UPV	7742.650	385.523	86.206	20	7197.000	8514.000	1

Age 90

	Mean	Std. Dev.	Std. Error	Count	Minimum	Maximum	# Missing
UCS	915.450	160.475	35.883	20	564.000	1178.000	1
UPV	7177.400	324.814	72.631	20	6373.000	7858.000	1

Figure 10. UPV data scatter at different ages

Figure 11. Range of UCS data for each age

Appendix A

This appendix contains the raw upv data, as taken from the screen of the data logging equipment. Each specimen is identified with a unique number. The first four digits of the number is a numerical laboratory number assigned to specimens in the lab. The next two digits indicate the replication number. Thus 1568143 indicates that the specimen came from batch 1568, was cured for 14 days, and is replicate 3 at that age. Likewise 15702815 is batch 1570, was cured for 28 days, and is replicate 15. Data for the amplitude study follows the UPV data.

WHC-SD-WM-TP-193 Rev. 0

UPV DATA

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0
Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT -2.14 V
0.062 mS

LT 2.28 V
0.054 mS

RT-LT -4.43 V
0.008 mS

1568141

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0
Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT -1.42 V
0.068 mS

LT 1.18 V
0.058 mS

RT-LT -2.60 V
0.010 mS

1568142

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0
Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT 123 mV
0.064 mS

LT 841 mV
0.057 mS

RT-LT -718 mV
0.007 mS

1568143

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT -1.33 V
0.975 mS

LT 1.09 V
0.965 mS

RT-LT
-2.42 V
0.810 mS

1568147

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT -265 mV
0.979 mS

LT 1.28 V
0.970 mS

RT-LT
-1.54 V
0.908 mS

1568148

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT -1.65 V
0.972 mS

LT 1.38 V
0.963 mS

RT-LT
-3.04 V
0.909 mS

1568149

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0
Buffer 0.5 mS

CURSOR MODE
Left - 1
Right - 1

RT 497 mV
0.066 mS
WT 586 mV
0.058 mS
RT-LT -89 mV
0.008 mS

1569211

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0
Buffer 0.5 mS

CURSOR MODE
Left - 1
Right - 1

RT -52 mV
0.087 mS
WT 1.41 V
0.077 mS
RT-LT -1.47 V
0.010 mS

1569211

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0
Buffer 0.5 mS

CURSOR MODE
Left - 1
Right - 1

RT 397 mV
0.063 mS
WT 859 mV
0.058 mS
RT-LT -463 mV
0.005 mS

1569212

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT1 -413 mV
0.064 mS

RT2 2.15 V
0.057 mS

RT3 -2.56 V
0.007 mS

1569213

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT1 -153 mV
0.061 mS

RT2 824 mV
0.055 mS

RT3 -977 mV
0.006 mS

1569214

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT1 228 mV
0.062 mS

RT2 1.07 V
0.055 mS

RT3 -846 mV
0.007 mS

1569215

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

PT1 -308 mV
0.063 mS

PT2 2.50 V
0.056 mS

PT3 -2.81 V
0.007 mS

1569216

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

PT1 -376 mV
0.064 mS

PT2 2.50 V
0.057 mS

PT3 -2.87 V
0.007 mS

1569217

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

PT1 -2.50 V
0.064 mS

PT2 2.50 V
0.056 mS

PT3 -5.00 V
0.008 mS

1569218

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: -2.50 V
0.981 mS

MT: 2.50 V
0.834 mS

RT-LT: -5.00 V
0.027 mS

1570281

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: 87 mV
0.059 mS

MT: 150 mV
0.054 mS

RT-LT: -63 mV
0.005 mS

1570282

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: 34 mV
0.059 mS

MT: 217 mV
0.054 mS

RT-LT: -183 mV
0.005 mS

1570283

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE
Left - 1
Right - 1

CH1 236 mV
0.059 mS

CH2 861 mV
0.054 mS

RT-AT -625 mV
0.005 mS

1570284

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE
Left - 1
Right - 1

CH1 19 mV
0.059 mS

CH2 140 mV
0.053 mS

RT-AT -131 mV
0.006 mS

1570285

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE
Left - 1
Right - 1

CH1 -502 mV
0.053 mS

CH2 710 mV
0.052 mS

RT-AT -1.21 V
0.006 mS

1570286

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS
 CURSOR MODE
 Left - 1
 Right - 1
 RI- 50 mV
 0.059 mS
 AI- 552 mV
 0.054 mS
 RI-LI- -502 mV
 0.006 mS

1570287

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS
 CURSOR MODE
 Left - 1
 Right - 1
 RI- 10 mV
 0.059 mS
 AI- 1.87 V
 0.054 mS
 RI-LI- -1.86 V
 0.005 mS

1570288

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS
 CURSOR MODE
 Left - 1
 Right - 1
 RI- -291 mV
 0.059 mS
 AI- 1.28 V
 0.053 mS
 RI-LI- -1.57 V
 0.006 mS

1570289

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT- 160 mV
0.058 mS

LT- 449 mV
0.053 mS

RT-LT-
-289 mV
0.005 mS

15702813

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT- 31 mV
0.058 mS

LT- 1.14 V
0.052 mS

RT-LT-
-1.11 V
0.006 mS

15702814

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT- -16 mV
0.060 mS

LT- 1.68 V
0.054 mS

RT-LT-
-1.69 V
0.006 mS

15702815

WHC-SD-WM-TP-193 Rev. 0

AMPLITUDE DATA

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: 480 mV
0.047 mS

RT: 481 mV
0.000 mS

RT-LT:
- 1 mV
0.047 mS

1568141

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: 491 mV
0.051 mS

RT: 483 mV
0.000 mS

RT-LT:
7 mV
0.051 mS

1568142

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: 475 mV
0.050 mS

RT: 472 mV
0.000 mS

RT-LT:
2 mV
0.050 mS

1568143

1568144

1568145

1568146

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

HI 498 mV
0.055 mS

LO 464 mV
0.000 mS

RT-AT 34 mV
0.055 mS

1568147

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

HI 483 mV
0.054 mS

LO 477 mV
0.000 mS

RT-AT 6 mV
0.054 mS

1568148

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

HI 480 mV
0.054 mS

LO 477 mV
0.000 mS

RT-AT 2 mV
0.054 mS

1568149

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

CH1 480 mV
0.055 mS

CH2 482 mV
0.000 mS

CH3 - 2 mV
0.055 mS

15681410

9143CAL

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: 480 mV
0.048 mS

LT: 476 mV
0.000 mS

RT-LT:
4 mV
0.048 mS

1569214

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: 476 mV
0.048 mS

LT: 476 mV
0.000 mS

RT-LT:
0 mV
0.048 mS

1569215

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: 476 mV
0.048 mS

LT: 477 mV
0.000 mS

RT-LT:
- 1 mV
0.048 mS

1569216

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0
Buffer 0.5 mS

CURSOR MODE
Left - 1
Right - 1
RT: 481 mV
0.050 mS
RT: 475 mV
0.000 mS
RT-LT: 6 mV
0.050 mS

1569217

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0
Buffer 0.5 mS

CURSOR MODE
Left - 1
Right - 1
RT: 489 mV
0.049 mS
RT: 479 mV
0.000 mS
RT-LT: 1 mV
0.049 mS

1569218

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 2
Display 0
Buffer 0.5 mS

CURSOR MODE
Left - 1
Right - 1
RT: 482 mV
0.049 mS
RT: 476 mV
0.000 mS
RT-LT: 6 mV
0.049 mS

1569219

Trigger EXT
 THRESH 24 mV
 TRG PT- 000000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS

CURSOR MODE

Left - 1
 Right - 1

RT 482 mV
 0.048 mS

RT 480 mV
 0.000 mS

RT 2 mV
 0.048 mS

15692110

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 3
 Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
 Right - 1

RT: 486 mV
 0.024 mS

LT: 482 mV
 0.000 mS

RT-LT:
 4 mV
 0.024 mS

909CAH54

1570281

1570282

1570283

1570284

1570285

1570286

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS
CURSOR MODE
 Left - 1
 Right - 1
RT 49 mV
 0.048 mS
RT 40 mV
 0.000 mS
RT-LT 9 mV
 0.040 mS

1570287

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS
CURSOR MODE
 Left - 1
 Right - 1
RT 44 mV
 0.047 mS
RT 39 mV
 0.000 mS
RT-LT 5 mV
 0.047 mS

1570288

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS
CURSOR MODE
 Left - 1
 Right - 1
RT 42 mV
 0.047 mS
RT 40 mV
 0.000 mS
RT-LT 1 mV
 0.047 mS

1570289

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS

A-31

15702819

15702820

Trigger EXT
THRESH 24 mV
TRG PT- 00000
Sample 1 uS
Expand + 3
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT: 40 mV
0.023 mS

LT: 40 mV
0.000 mS

RT-LT:
0 mV
0.023 mS

916CAL54

1571564

1571565

1571566

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS
CURSOR MODE
 Left - 1
 Right - 1
CH1 42 mV
 0.044 mS
CH2 40 mV
 0.000 mS
CH3 1 mV
 0.044 mS

15715610

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS
CURSOR MODE
 Left - 1
 Right - 1
CH1 42 mV
 0.042 mS
CH2 40 mV
 0.000 mS
CH3 1 mV
 0.042 mS

15715611

Trigger EXT
 THRESH 24 mV
 TRG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0
 Buffer 0.5 mS
CURSOR MODE
 Left - 1
 Right - 1
CH1 42 mV
 0.042 mS
CH2 40 mV
 0.000 mS
CH3 1 mV
 0.042 mS

15715612

15715619

15715620

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT 39 mV
0.043 mS

LT 39 mV
0.000 mS

RT-LT
0 mV
0.043 mS

1572901

Trigger EXT
THRESH 24 mV
TRG PT- 00000

Sample 1 uS
Expand + 2
Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1
Right - 1

RT 701 mV
0.063 mS

LT 1.70 V
0.053 mS

RT-LT
-995 mV
0.010 mS

1572901

1572902

1572903

Trigger EXT
 HRS 24 mV
 RG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1

Right - 1

40 mV

0.044 mS

39 mV

0.000 mS

1 mV

0.044 mS

15729014

Trigger EXT
 HRS 24 mV
 RG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1

Right - 1

39 mV

0.043 mS

40 mV

0.000 mS

1 mV

0.043 mS

15729015

Trigger EXT
 HRS 24 mV
 RG PT- 00000
 Sample 1 uS
 Expand + 2
 Display 0

Buffer 0.5 mS

CURSOR MODE

Left - 1

Right - 1

40 mV

0.043 mS

40 mV

0.000 mS

0 mV

0.043 mS

15729016

NOV 18 1994 ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT No. 700108

2. To: (Receiving Organization)

A. A. Kruger
Projects Technology

3. From: (Originating Organization)

H. L. Benny
Geotechnical Engineering Lab

4. Related EDT No.:

NA

5. Proj./Prog./Dept./Div.: GEL

6. Cog. Engr.: H. L. Benny

7. Purchase Order No.:

NA

8. Originator Remarks:

Approval/Release

9. Equip./Component No.:

NA

10. System/Bldg./Facility:

NA

12. Major Assm. Dwg. No.:

NA

13. Permit/Permit Application No.:

NA

14. Required Response Date:

NA

11. Receiver Remarks:

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Impact Level	(G) Reason for Trans- mittal	(H) Origin- ator Dispo- sition	(I) Receiv- er Dispo- sition
1	WHC-SD-WM-TP-193		0	Non-Destructive Examination of Grouted Waste	--4-	1	1	
					NA			

16. KEY

Impact Level (F)	Reason for Transmittal (G)	Disposition (H) & (I)
1, 2, 3, or 4 (see MRP 5.43)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

(G)	(H)	17. SIGNATURE/DISTRIBUTION (See Impact Level for required signatures)	(G)	(H)
Reason	Disp.	(J) Name (K) Signature (L) Date (M) MSIN (J) Name (K) Signature (L) Date (M) MSIN	Reason	Disp.
1	/	Cog. Eng. H. L. Benny <i>H. L. Benny</i> 10/18/94 15-64 LA-69		
1	/	Cog. Mgr. H. L. Benny <i>H. L. Benny</i> 10/18/94 15-64 LA-69		
		QA (Distr. OSTI 2 copies w/att L8-07)		
		Safety		
		Env.		
3X		A. A. Kruger H5-27		

18.

H. L. Benny
H. L. Benny
Signature of EDT
Originator
Date 10/18/94

19.

Authorized Representative
for Receiving Organization
Date

20.

H. L. Benny
H. L. Benny
Cognizant Manager
Date 10/18/94

21. DOE APPROVAL (if required)

Ltr No. _____

- ☐
- Approved
-
- ☐
- Approved w/comments
-
- ☐
- Disapproved w/comments

RELEASE AUTHORIZATION

**Document
Number:**

WHC-SD-WM-TP-193, Revision 0

Document Title:

Non-Destructive Examination of Grouted Waste

Release Date:

November 9, 1994

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

APPROVED FOR PUBLIC RELEASE

WHC Information Release Administration Specialist:

M. Boston

11/9/94

M.N. Boston

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SUPPORTING DOCUMENT		1. Total Pages 77
2. Title Non-Destructive Examination of Grouted Waste	3. Number <i>mb 11/9/94</i> WHC-SD-SD-WM-TP-193	4. Rev No. 0
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7. Abstract NA		
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