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Compressibility of Granulated Rock Salt

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ABSTRACT

Crushed rock salt will be used extensively at the Waste Isolation Pilot Plant as a material for backfilling underground openings. This document addresses one of the characteristics of crushed salt which must be known to assess the consequences of its usage, namely, compressibility.

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I. Introduction

At the Waste Isolation Pilot Plant, crushed rock salt (henceforth referred to as salt) will be used as a filler material to refill underground excavations. Example uses are: 1) to backfill the void space in waste-filled storage rooms, 2) to backfill unused or obsolete ventilation ways, access corridors, and experimental rooms, 3) to construct ground motion accomodating ventilation barriers, 4) as a mitigating material to isolate structures from loads imposed by ground motion, and 5) to fill all underground openings upon decommissioning of the WIPP.

Since crushed salt is scheduled for so many uses at the WIPP, it is apparent that an effort should be made to determine its characteristics. This document describes one such effort, namely, a test series to establish the compressibility of granulated salt at pressures to 3000 psi and temperatures up to 180°F.

II. Test Apparatus and Procedures

The test apparatus used to conduct the granulated salt compression tests is pictured in Figure 1. The apparatus consists of a reservoir graduated in milliliters, a hand actuated piston pump, pressure gauges, a hydrostatic chamber, and a heater. The chamber assembled and disassembled is shown in Figures 2 and 3. Figure 4 is a schematic of the test apparatus. The procedure for tests at ambient temperature is:

FIGURE 1

HYDROSTATIC CHAMBER
ASSEMBLY

FIGURE 2

HYDROSTATIC CHAMBER
(DISASSEMBLED)

FIGURE 4

1. Open chamber and install sample to be tested; replace chamber.
2. Connect chamber to output piping from pump.
3. Fill reservoir and open bleed valve on chamber; allow liquid to flow into chamber until liquid is dispelled from chamber outlet. (Note: The inside face of the chamber is concave--the bleed penetration intersects the concave surface at its apex so that air cannot be removed during purging process.)
4. Close bleed valve and refill the reservoir; record reservoir volume as the initial data point at zero pressure.
5. Open valve to the 10 psig gauge.
6. Using pump, pressurize chamber to desired initial pressure; record reservoir volume at each desired pressure.
7. At a pressure of 10 psig, close the valve in the line to the 10 psig gauge. From this point on, pressurize chamber to desired levels using the 3000 psig gauge. Record reservoir volume at the desired pressures.

Commencing with step 6 above, the time required to complete a test is approximately two minutes.

III. Sample Description and Preparation

The samples used for conducting the tests reported in this document were made from salt taken from a Carlsbad, New Mexico, vicinity potash mine. Samples were made by crushing salt blocks and sieving the crushed material to segregate sufficient quantities of the sizes desired. The material used consisted of the following major constituents:

Halite	88%
Sylvite	3%
Polyhalite	5%
Kainite	4%

To conduct the compressibility tests, the crushed salt sample is placed inside a thin-walled molded rubber bottle which is subsequently closed by a seal plug and clamp band (see Figure 5). The seal plug, the seal band, and the band expanding ball are shown on Figure 6. The amount of material placed into the test bottle was the maximum that could be inserted without mechanical tamping. The weight of the sample, along with the bottle volume, was used to calculate the pretest densities for the three materials tested. The pretest densities are recorded in the size designation table in paragraph IV. For the two coarser materials, the pretest densities recorded are the same as the densities obtained in independent density determinations using vibration techniques to fill rigid containers. For the fine material, the

RESIDUENT HOLDER

BOTTLE

SAMPLE

PLUG

SEAL RING

FIGURE 5

BOTTLE NEAL SYSTEM

FIGURE 6

density recorded is not the maximum density to which the material can be packed by vibration in a rigid container, i.e., 1.98 gm/cc or 1.75 gm/cc. An attempt to vibrate the sample into a higher density than that the maximum sample density could be obtained would be counterproductive to the elastic nature of the material. In order to achieve the maximum sample density, count that the sample has an extra amount of air in the sample that is above that required to fill the legitimate void spaces; as a consequence, the extra air is trapped by the extra air. The test results speak for themselves. Basically the effect is an exaggerated compression of the sample prepared.

17. Test Parameters

Tests were conducted on the following three

<u>Size Designation</u>	<u>Size Range (mm)</u>	<u>Number of Samples</u>
A	0.150-0.425	10
B	0.0460-0.150	10
C	0.150-0.425	10

For each size will be conducted at the following temperatures:

Temperature
Designation

X

Y

Z

Temperature
°C

Ambient 75°

120

180

For elevated temperature test the hydrostatic chamber was placed into an insulated hot water bath and allowed to soak for a time sufficient to assure that the sample would reach the desired test temperature.

Three tests were conducted on each combination of salt size and temperature, this resulted in a total of 27 tests.

11. Data Recording and Reduction

The form used to record and reduce the data on salt compressibility is shown on Figure 7. The upper portion of the form provides for recording pertinent test data such as sample size, test date, etc. The remaining portion of the form as it affects data recording and data reduction is explained as follows, proceeding from left to right across the labeled columns:

Pressure (psi)

This column contains the preselected pressures at which data is to be recorded; pressures listed were selected from preliminary test data.

SAMPLE NO. _____ TEST DATE _____

MATERIAL TESTED _____ TEST TEMP. _____

SAMPLE SIZE _____ SAMPLE WEIGHT _____

SAMPLE DENSITY (COMPRESSED) _____

SAMPLE DENSITY (UNCOMPRESSED) _____

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200				
300				
400				
500				
750				
1000				
1500				
2000				
2500				
3000				

Reservoir Volume (ml.)

The volume remaining in the reservoir after the desired pressure is reached.

Gross Change in Volume (ml.)

Values in this column are the differences between the initial reservoir volume and the remaining volume at a particular pressure.

Net Change In Volume (ml.)

The chamber was pressurized with a quasi-noncompressible fluid filled dummy sample to establish the tare values which must be subtracted from the gross volume changes to account for system expansion. The net volume change column reflects this subtraction. At ambient and 120°F the tare values are essentially the same; therefore only two sets of tare values were used, i.e., one for ambient and 120°F, and the second for 180°F. Tare values (identified as calibration data) are included with the data in Appendix A.

Percent Change in Volume

The net change in the apparatus reservoir volume is the compression of the specimen inside the chamber; therefore the

percent compression of the specimen is:

$$\text{Percent Compression Specimen} = \frac{\text{Net Volume Change}}{\text{Original Sample Volume}} \times 100$$

Where the original sample volume is obtained from the uncompressed sample density.

VI. Test Results

Tabulated test data and test results for all 25 tests conducted are included in Appendix A. Plots of the test results are shown on Figures 8 through 16. The values plotted represent the arithmetic average of the results obtained for each of the three specimens tested at each combination of parameters. (Note: The maximum spread in the results for the three tests conducted at a particular combination of test parameters in all cases was less than 10%.) Figures 17 through 21 are plots which superimpose various data to illustrate the effects of temperature and specimen size.

Figure 22 depicts the results of a test conducted to examine the effects of repressing a sample of the .0017 inch material. This test illustrates that no additional compression of the sample occurs on repressing. The curve representing the second pressing on Figure 22, fictitiously demonstrates sample compressibility at

FIGURE 8

FIGURE 9

FIGURE 10

FIGURE 12

FIGURE 13

FIGURE 14

FIGURE 15

FIGURE 16

FIGURE 17

FIGURE 19

FIGURE 20

FIGURE 21

FIGURE 22

pressures less than 50 psi; in reality the apparent compressibility at less than 50 psi results from the free air in the test bottle being driven back into the available porosity of the sample.

In all tests the smallest salt (-0.0017) recombined to result in a very hard briquette similar to cast plaster of Paris. See Figures 23 and 24. The coarsest salt failed to totally recombine in all cases; however, at 180°F some of the mid-sized salt did partially recombine into a friable slug.

Tabulated in Table I are the posttest calculated and measured densities for all tested specimens of the -0.0017 mesh sized salt. Table I also includes calculated posttest densities for the mid-sized and coarsest salts. The posttest calculated densities were derived from the test data using the following relationship:

$$\text{Density} = \frac{\text{Pretest Density (Ref. Para. IV)}}{1.00 - \% \text{ Compression}/100}$$

The measured posttest densities are actual densities determined by applying immersion techniques to the compressed briquettes. Agreement between the posttest densities calculated from the test data and the measured values are generally good.

CRUSHED SAMPLE

TABLE I
SALT DENSITIES AFTER ISOPRESSING

SPECIMEN I.D.	MATERIAL SIZE (IN)	TEST TEMP (° F)	CALCULATED DENSITY (GM/CC)	MEASURED DENSITY (GM/CC)
CX1	<.0017	AMB	1.64	1.59
CX2	"	"	1.67	1.61
CX3	"	"	1.64	1.60
CY1	<.0017	120	1.67	1.62
CY2	"	"	1.64	1.55
CY3	"	"	1.74	1.58
CZ1	<.0017	180	2.03	1.63
CZ2	"	"	1.87	1.64
CZ3	"	"	1.85	1.63
*BX	0469-0937	AMB	1.92	**
*BY	"	120	2.01	**
*BZ	"	180	1.98	**
*AX	.187-.371	AMB	2.04	**

* AVERAGE OF 3 TESTS

** DID NOT RECOMBINE SUFFICIENTLY TO
ALLOW DENSITY MEASUREMENT

NOTE: DENSITY FOR CRYSTALLINE NaCl IS 2.165 GM/CC

VII. Conclusions/Observations

Most conclusions will be left to the reader; however, a few general conclusions and pertinent observations specific to the use of crushed salt as a backfill material at the WIPP are:

1. The finely powdered material tends to be properly entrained in air thus it will be difficult to pack this material as a backfill to densities greater than 0.9 gm/cc.
2. The flocculent characteristic of the fine material, resulting from the entrained air make it an excellent degassing and thermal isolator, since it undergoes a high percentage of volume change before it transmits significant heat. Figure 24 illustrates this fact. Note, Figure 25 represents the compressibility of a sample of 0.0017 inch material which was not entrained, tamped or otherwise compacted prior to testing. The initial density of this sample was 0.80 gm/cc.
3. Temperatures up to 180°F have little effect on compressibility.
4. Material size has little effect on compressibility.
5. For the two coarser materials, the compressibility can be approximated at pressure (P) by the relationship:

$$C = KP^{1/4}$$

This relationship with the constant (K) evaluated and an average exponent is shown for the two coarser salts at ambient temperature on Figures 11 and 14.

FIGURE 25

APPENDIX

SAMPLE NO. CHAMBER CALIBRATION TEST DATE 4 - 30 - 79

MATERIAL TESTED TEST TEMP. AMB & 120° F

SAMPLE SIZE SAMPLE WEIGHT

SAMPLE DENSITY (COMPRESSED)

SAMPLE DENSITY (UNCOMPRESSED)

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0	100	0		
1	99.75	.25		
2	99	1.0		
3	98.75	1.25		
4	98.25	1.75		
5	98	2.0		
6	97.8	2.2		
7	97.5	2.5		
8	97.25	2.75		
9	97	3.0		
10	96.9	3.1		
50	95.2	4.8		
100	95	5.0		
200	94.75	5.25		
300	94.5	5.5		
400	94.25	5.75		
500	94.15	5.85		
750	94	6.0		
1000	93.8	6.2		
1500	93.25	6.75		
2000	93	7.0		
2500	92.75	7.25		
3000	92.25	7.75		

CHAMBER
 SAMPLE NO. CALIBRATION TEST DATE 4-30-79
 MATERIAL TESTED _____ TEST TEMP. 180" F
 SAMPLE SIZE _____ SAMPLE WEIGHT _____
 SAMPLE DENSITY (COMPRESSED) _____
 SAMPLE DENSITY (UNCOMPRESSED) _____

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0	100	0		
1	99.5	.5		
2	99	1		
3	98.25	1.75		
4	97.5	2.5		
5	97.25	2.75		
6	97	3		
7	96.75	3.25		
8	96.25	3.75		
9	96	4		
10	95.8	4.2		
50	93.5	6.5		
100	93.1	6.9		
200	92.9	7.1		
300	92.75	7.25		
400	92.5	7.5		
500	92.25	7.75		
750	92.1	7.9		
1000	91.9	8.1		
1500	91.75	8.25		
2000	91.25	8.75		
2500	91	9		
3000	90.5	9.5		

SAMPLE NO. 4X1 TEST DATE 6/21/79
 MATERIAL TESTED SALT TEST TEMP. AMB
 SAMPLE SIZE .187-.371 SAMPLE WEIGHT 111 GMS
 SAMPLE DENSITY (COMPRESSED) _____
 SAMPLE DENSITY (UNCOMPRESSED) .94 G/CC

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% CHANGE IN VOLUME
0	95	0	0	
1	95	1	.75	.8
2	95	2	1	1.1
3	97	3	1.75	1.3
4	96	4	2.25	2.4
5	95.2	4.5	2.3	2.5
6	94.5	5.5	2.8	3.0
7	93.75	6.25	3.75	4.0
8	93	7	4.25	4.5
9	92.5	7.5	4.5	4.7
10	92	8	4.9	5.0
50	82	18	3.2	14.1
100	75	21	1.6	14.2
200	75	23	19.5	14.2
300	72.5	27.5	22	23.7
400	71	29	23.25	23.7
500	69.75	30.75	24.5	23.7
750	66.8	33.5	27.5	28.6
1000	65	35	28.8	27.7
1500	62	38	31.25	33.5
2000	59.5	40.5	33.5	36
2500	57.5	42.5	35.25	38
3000	55.25	44.75	37	40

SAMPLE NO. 212 TEST DATE 11/21/74
 MATERIAL TESTED SALT TEST TEMP. 25.5
 SAMPLE SIZE .57-.371 SAMPLE WEIGHT 1.00
 SAMPLE DENSITY (COMPRESSED) 2.055 11/21/74
 SAMPLE DENSITY (UNCOMPRESSED) 1.44 11/21/74

PRESSURE (PSI)	RESERVOIR VOLUME (ML)	GROSS CHANGE IN VOLUME (ML)	NET CHANGE IN VOLUME (ML)	% CHANGE IN VOLUME
0	100	0	0	0
1	99	1	.75	.75
2	98	2	1	1.0
3	97	3	1.75	1.75
4	96	4	2.25	2.25
5	95	5	3	3.0
6	94	6	3.5	3.5
7	93	7	4.1	4.1
8	92.25	7.75	5	5.4
9	91.5	8.5	5.5	6.0
10	91	9	5.9	6.5
15	87.5	18.5	13.7	14.7
20	84.25	22.75	17.75	19.0
25	81	27	21.75	23.4
30	78.25	29.75	24.25	26.1
35	75.5	31.5	25.75	27.7
40	73	33	27.15	29.2
45	70.25	36.75	30.75	33.1
50	67.75	38.25	32.05	34.0
55	65.5	40.5	33.75	36.3
60	63.25	42.75	35.75	38.4
65	61.25	44.75	37.5	40.0
70	59.25	46.75	39	41.9

SAMPLE NO. AX3 TEST DATE 6/21/61
 MATERIAL TESTED SALT TEST TEMP. AMB
 SAMPLE SIZE .187 - .371 SAMPLE WEIGHT 1.1 GMS
 SAMPLE DENSITY (COMPRESSED) 2.065 GM/CC
 SAMPLE DENSITY (UNCOMPRESSED) 1.194 GM/CC

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% CHANGE IN VOLUME
0	100	0	0	0
1	99	1	.75	.8
2	98	2	1	1.1
3	97	3	1.25	1.3
4	96	4	1.5	1.5
5	95	5	2	2.1
6	93	6	2.25	2.3
7	91.5	6.75	2.5	2.5
8	90.5	7.5	2.75	2.8
9	89	8	3	3.1
10	87.25	8.75	3.25	3.3
50	82	18	13.2	14.2
100	77.5	22.5	17.5	18.5
200	73	27	21.75	23.4
300	70.5	29.5	24	25.8
400	69	31	25.25	27.2
500	67	33	27.5	29.2
750	64.25	35.75	29.75	31
1000	62.75	37.25	31.05	33.4
1500	59.5	40.5	33.75	36.3
2000	57.5	42.5	35.5	38.2
2500	55.5	44.5	37.25	40.1
3000	53	47	39.25	42.2

SAMPLE NO. 27 TEST DATE
 MATERIAL TESTED TEST TEMP.
 SAMPLE SIZE SAMPLE WEIGHT
 SAMPLE DENSITY (COMPRESSED)
 SAMPLE DENSITY (UNCOMPRESSED)

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200				
300				
400				
500				
750				
1000				
1500				
2000				
2500				
3000				

SAMPLE NO. AVP TEST DATE 11/11/68

MATERIAL TESTED SALT TEST TEMP. 60

SAMPLE SIZE 1.0000 SAMPLE WEIGHT 1.0000

SAMPLE DENSITY (COMPRESSED) 1.0000

SAMPLE DENSITY (UNCOMPRESSED) 1.0000

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000
200	0.0000	0.0000	0.0000	0.0000
300	0.0000	0.0000	0.0000	0.0000
400	0.0000	0.0000	0.0000	0.0000
500	0.0000	0.0000	0.0000	0.0000
750	0.0000	0.0000	0.0000	0.0000
1000	0.0000	0.0000	0.0000	0.0000
1500	0.0000	0.0000	0.0000	0.0000
2000	0.0000	0.0000	0.0000	0.0000
2500	0.0000	0.0000	0.0000	0.0000
3000				

SAMPLE NO. AY TEST DATE MATERIAL TESTED SALT TEST TEMP. SAMPLE SIZE SAMPLE WEIGHT SAMPLE DENSITY (COMPRESSED) SAMPLE DENSITY (UNCOMPRESSED)

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0	1			
1	1	1	1	
2	1	2	2	
3	1	3	3	
4	1	4	4	
5	1	5	5	
6	1	6	6	
7	1	7	7	
8	1	8	8	
9	1	9	9	
10	1	10	10	
50	1	11	11	
100	1	12	12	
200	1	13	13	
300	1	14	14	
400	1	15	15	
500	1	16	16	
750	1	17	17	
1000	1	18	18	
1500	1	19	19	
2000	1	20	20	
2500	1	21	21	
3000	1	22	22	

SAMPLE NO. 27 TEST DATE 11/1/55

MATERIAL TESTED SALT TEST TEMP. 75

SAMPLE SIZE 1.00 SAMPLE WEIGHT 1.00

SAMPLE DENSITY (COMPRESSED) 1.00

SAMPLE DENSITY (UNCOMPRESSED) 1.00

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1		1.00	1.00	100.00
2		2.00	2.00	200.00
3		3.00	3.00	300.00
4		4.00	4.00	400.00
5		5.00	5.00	500.00
6		6.00	6.00	600.00
7		7.00	7.00	700.00
8		8.00	8.00	800.00
9		9.00	9.00	900.00
10		10.00	10.00	1000.00
50	1.00	22.50	21.50	215.00
100	2.00	35.00	33.00	165.00
200	3.00	47.50	44.50	148.33
300	4.00	60.00	56.00	140.00
400	5.00	72.50	67.50	135.00
500	6.00	85.00	79.00	131.67
750	8.00	110.00	104.00	130.00
1000	10.00	135.00	129.00	129.00
1500	15.00	182.50	176.50	117.67
2000	20.00	230.00	224.00	112.00
2500				
3000				

SAMPLE NO. AV TEST DATE 11/1/57
 MATERIAL TESTED ALT TEST TEMP. 100 F
 SAMPLe SIZE 1.000 SAMPLe WEIGHT 1.000
 SAMPLe DENSITY (COMPRESSED) 1.000
 SAMPLe DENSITY (UNCOMPRESSED) 1.000

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200				
300				
400				
500				
750				
1000				
1500				
2000				
2500				
3000				

SAMPLE NO. _____ TEST DATE _____

MATERIAL TESTED _____ TEST TEMP. _____

SAMPLE SIZE _____ SAMPLE WEIGHT _____

SAMPLE DENSITY (COMPRESSED) _____

SAMPLE DENSITY (UNCOMPRESSED) _____

PRESSURE (PSI)	RESERVOIR VOLUME (ML)	GROSS CHANGE IN VOLUME (ML)	NET CHANGE IN VOLUME (ML)	PERCENT CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200				
300				
400				
500				
750				
1000				
1500				
2000				
2500				
3000				

SAMPLE DENSITY (UNCOMPRESSED) 0.5

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0	100	0	0	0
1	100	1.5	1.2	1.2
2	100	2.5	1.2	1.2
3	100	3.5	1.2	1.2
4	100	4.5	1.2	1.2
5	100	5.5	1.2	1.2
6	100	6.5	1.2	1.2
7	100	7.5	1.2	1.2
8	100	8.5	1.2	1.2
9	100	9.5	1.2	1.2
10	100	10.5	1.2	1.2
100	100	20	1.2	1.2
200	100	30	1.2	1.2
300	100	40	1.2	1.2
400	100	50	1.2	1.2
500	100	60	1.2	1.2
750	100	80	1.2	1.2
1000	100	100	1.2	1.2
1500	100	150	1.2	1.2
2000	100	200	1.2	1.2
2500	100	250	1.2	1.2
3000	100	300	1.2	1.2

SAMPLE NO. BX2 TEST DATE 6/21/70
 MATERIAL TESTED SALT TEST TEMP. AMB
 SAMPLE SIZE 0460-0937 SAMPLE WEIGHT 116 GMS
 SAMPLE DENSITY (COMPRESSED) 1.878 GM/CC
 SAMPLE DENSITY (UNCOMPRESSED) 1.247 GM/CC

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0	100	0	0	0
1	99	1	.75	.8
2	98	2	1	1.1
3	97	3	1.75	1.9
4	96	4	2.25	2.4
5	95.25	4.75	2.75	3.0
6	94.75	5.25	3.05	3.3
7	94	6	3.5	3.6
8	93.5	6.5	3.75	4
9	93	7	4	4.3
10	92.5	7.5	4.4	4.7
50	85.5	14.5	9.7	10.4
100	83	17	12	12.9
200	80	20	14.75	15.9
300	77.75	22.25	16.75	18
400	76.25	23.75	18	19.4
500	75	25	19.75	20.6
750	72.5	27.5	21.5	23.1
1000	70.5	29.5	23.3	25.1
1500	67.5	32.5	25.75	27.7
2000	65	35	28	30.1
2500	63	37	29.75	32
3000	61	39	31.25	33.6

SAMPLE NO. BX3 TEST DATE 6/21/77
 MATERIAL TESTED SA T TEST TEMP. AVB
 SAMPLE SIZE 0483-0937 SAMPLE WEIGHT 1.0015
 SAMPLE DENSITY (COMPRESSED) _____
 SAMPLE DENSITY (UNCOMPRESSED) 1.247 377/77

PRESSURE (PSI)	RESERVOIR VOLUME (ML)	GROSS CHANGE IN VOLUME (ML)	NET CHANGE IN VOLUME (ML)	% CHANGE IN VOLUME
0	00	0	0	0
1	99		.75	.8
2	97.5	2.5	1.5	1.6
3	96.5	3.5	2.25	2.4
4	95.5	4.5	2.75	3
5	94.5	5.5	3.5	3.5
6	94	6	3.8	4.1
7	93.5	6.5	4	4.2
8	92.75	7.25	4.5	4.6
9	92.25	7.75	4.75	5.1
10	92	8	4.9	5.2
50	84.75	15.25	10.41	11.1
100	81.5	18.5	13.5	14.2
200	78.5	21.5	16.25	17.5
300	76	24	18.5	19.9
400	74.75	25.25	19.5	21
500	73	27	21.15	22.7
750	70.75	29.25	23.25	25
1000	68.5	31.5	25.3	27.2
1500	65.25	34.75	28	30.1
2000	63.25	36.75	29.75	32
2500	61.5	38.5	31.25	33.6
3000	59.5	40.5	32.75	35.2

SAMPLE NO. BY _____ TEST DATE _____
 MATERIAL TESTED WAT _____ TEST TEMP. ° F _____
 SAMPLE SIZE _____ SAMPLE WEIGHT _____
 SAMPLE DENSITY (COMPRESSED) _____
 SAMPLE DENSITY (UNCOMPRESSED) _____

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	TOT CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200				
300				
400				
500				
750				
1000				
1500				
2000				
2500				
3000				

SAMPLE NO. PY TEST DATE MATERIAL TESTED WALT TEST TEMP. SAMPLE SIZE SAMPLE WEIGHT SAMPLE DENSITY (COMPRESSED) SAMPLE DENSITY (UNCOMPRESSED)

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200				
300				
400				
500				
750				
1000				
1500				
2000				
2500				
3000				

SAMPLE NO. PY# TEST DATE

MATERIAL TESTED GALT TEST TEMP. 100°F

SAMPLE SIZE 1.00 in. dia. SAMPLE WEIGHT 21.00 gms.

SAMPLE DENSITY (COMPRESSED)

SAMPLE DENSITY (UNCOMPRESSED) 1.27 gm/cc

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1		1	0.000	0.0
2		2	0.000	0.0
3		3	0.000	0.0
4		4	0.000	0.0
5		5	0.000	0.0
6		6	0.000	0.0
7		7	0.000	0.0
8		8	0.000	0.0
9		9	0.000	0.0
10		10	0.000	0.0
50		5	0.000	0.0
100		10	0.000	0.0
200		19	0.000	0.0
300		28	0.000	0.0
400		37	0.000	0.0
500		46	0.000	0.0
750		70	0.000	0.0
1000		94	0.000	0.0
1500		143	0.000	0.0
2000		192	0.000	0.0
2500		241	0.000	0.0
3000		290	0.000	0.0

SAMPLE NO. _____ TEST DATE _____
 MATERIAL TESTED _____ TEST TEMP. _____
 SAMPLE SIZE _____ SAMPLE WEIGHT _____
 SAMPLE DENSITY (COMPRESSED) _____
 SAMPLE DENSITY (UNCOMPRESSED) _____

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200				
300				
400				
500				
750				
1000				
1500				
2000				
2500				
3000				

SAMPLE NO. EC TEST DATE 6.27

MATERIAL TESTED SALT TEST TEMP. 7F

SAMPLE SIZE 1.00 SAMPLE WEIGHT 1.00

SAMPLE DENSITY (COMPRESSED) 1.00

SAMPLE DENSITY (UNCOMPRESSED) 1.00

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200				
300				
400				
500				
750				
1000				
1500				
2000				
2500				
3000				

SAMPLE NO. _____ TEST DATE _____

MATERIAL TESTED SALT TEST TEMP. _____SAMPLE SIZE 100 SAMPLE WEIGHT _____

SAMPLE DENSITY (COMPRESSED) _____

SAMPLE DENSITY (UNCOMPRESSED) _____

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% OF CHANGE IN VOLUME
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200		26.75	10.0	10.0
300		36.25	10.0	10.0
400		38.25	10.0	10.0
500		39.25	10.0	10.0
750		41.25	10.0	10.0
1000		42.25	10.0	10.0
1500		43.25	10.0	10.0
2000		44.25	10.0	10.0
2500	56.25	44.25	10.0	10.0
3000	57	44	10.0	10.0

SAMPLE NO. CX1 TEST DATE 6/13/79
 MATERIAL TESTED SALT TEST TEMP. AMB
 SAMPLE SIZE <.0017 SAMPLE WEIGHT 90 GMS
 SAMPLE DENSITY (COMPRESSED) _____
 SAMPLE DENSITY (UNCOMPRESSED) .968 GM/CC

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% CHANGE IN VOLUME
0	100	0	0	0
1	99	1	.75	.8
2	98	2	1.0	1.1
3	96.5	3.5	2.25	2.3
4	95.25	4.75	3	3.2
5	94	6	4	4.3
6	93	7	4.8	5.2
7	92	8	5.5	5.9
8	91	9	6.25	6.7
9	90	10	7	7.5
10	89.5	10.5	7.4	8
50	74.75	25.25	20.45	22
100	71	29	24	25.5
200	66	32	26.75	28.7
300	66.5	33.5	28	30.1
400	65.5	34.5	28.75	30.9
500	64.5	35.5	29.65	31.9
750	62.5	37.5	31.5	33.0
1000	61	39	32.8	35.3
1500	56.5	41.5	34.75	37.4
2000	57	43	36	38.7
2500	55.25	44.75	37.5	40.3
3000	54	46	38.25	41.1

SAMPLE NO. CX2 TEST DATE 6/13/79
 MATERIAL TESTED SALT TEST TEMP. AMB
 SAMPLE SIZE .0017 SAMPLE WEIGHT 90 GMS
 SAMPLE DENSITY (COMPRESSED) _____
 SAMPLE DENSITY (UNCOMPRESSED) .968 GMS/CC

PRESSURE (PSI)	RESERVOIR VOLUME (MI)	GROSS CHANGE IN VOLUME (MI)	NET CHANGE IN VOLUME (MI)	% CHANGE IN VOLUME
0	100	0	0	0
1	99	1	.75	.75
2	97.75	2.25	1.25	1.25
3	96	4	2.75	2.75
4	94.75	5.25	3.5	3.5
5	93.5	6.5	4.5	4.5
6	92.5	7.5	5.3	5.3
7	91.5	8.5	6	6
8	90.5	9.5	6.75	6.75
9	89.5	10.5	7.5	7.5
10	89	11	7.5	7.5
50	74	26	21.2	21.2
100	70	30	25	25
200	66.5	33.5	28.25	30.4
300	65.25	34.75	29.25	31.5
400	64	36	30.25	32.5
500	63	37	31.15	33.5
750	61	39	33	35.4
1000	60	40	33.8	36.3
1500	57.5	42.5	35.75	38.4
2000	55.75	44.25	37.25	40.1
2500	54.5	45.5	38.25	41.1
3000	53	47	39.25	42.2

SAMPLE NO. CX3 TEST DATE 6/13/79

MATERIAL TESTED SALT TEST TEMP. AMB

SAMPLE SIZE <.0017 SAMPLE WEIGHT 90 GMS

SAMPLE DENSITY (COMPRESSED) _____

SAMPLE DENSITY (UNCOMPRESSED) .968 GMS/CC

PRESSURE (PSI)	RESERVOIR VOLUME (ML)	GROSS CHANGE IN VOLUME (ML)	NET CHANGE IN VOLUME (ML)	% CHANGE IN VOLUME
0	100	0	0	0
1	99		.15	.15
2	97.75	2.25	1.25	1.3
3	96.25	3.75	2.5	2.5
4	95	5	3.25	3.5
5	93.8	6.2	4	4.2
6	92.8	7.2	5	5.2
7	92	8	5.5	6.2
8	91	9	6.25	6.7
9	90	10	7	7.7
10	89.5	10.5	7.4	8.2
50	75.5	24.5	19.7	20.2
100	71.25	28.75	23.75	25.5
200	68	32	23.75	28.7
300	66.5	33.5	26	30.1
400	65.5	34.5	28.75	30.9
500	64.5	35.5	29.75	31.3
750	62.75	37.25	31.25	31.7
1000	61	39	32.6	33.3
1500	56.75	41.25	34.5	37.7
2000	57	43	36	38.7
2500	55.5	44.5	37.25	40.
3000	54	46	38.25	41.1

SAMPLE NO. _____ TEST DATE _____
 MATERIAL TESTED _____ TEST TEM. _____
 SAMPLE SIZE _____ SAMPLE WEIGHT _____
 SAMPLE DENSITY : COMPRESSED _____
 SAMPLE DENSITY : UNCOMPRESSED _____

TEST LOAD (LBS)	RESERVOIR VOLUME (ML)	GROSS CHANGE IN VOLUME (ML)	NET CHANGE IN VOLUME (ML)	NET CHANGE IN WEIGHT (LBS)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
50				
100				
200				
300				
400				
500	57.7	34.7	22.75	17.2
750	61.7	38.7	22.25	17.2
1000	62.25	39.75	22.45	17.2
1500	66	42	25.25	19.6
2000	68	44	27	20.8
2500	69.7	45.7	28.25	21.8
3000	73	47	29.25	22.8

SAMPLE NO. 012 TEST DATE 11/1/54
 MATERIAL TESTED SST TEST TEMP. 70
 APPARENT DENSITY (COMPRESSED) 1.25 SAMPLE WEIGHT 100 MG
 APPARENT DENSITY (UNCOMPRESSED) 1.25

	TEST TIME (MIN)	GROSS CHANGE IN VOLUME (ML)	NET CHANGE IN VOLUME (ML)	NET CHANGE IN VOLUME (ML)
	0	0	0	0
	1	1	1	1
	2	2	2	2
	3	3	3	3
	4	4	4	4
	5	5	5	5
	6	6.25	6.05	6.05
	7	7.25	7.05	7.05
	8	8.25	8.05	8.05
	9	9	9	9
	10	10	10	10
	11	11	11	11
	12	12.25	12.05	12.05
	13	13.25	13.05	13.05
	14	14.25	14.05	14.05
	15	15.25	15.05	15.05
	16	16.25	16.05	16.05
	17	17.25	17.05	17.05
	18	18.25	18.05	18.05
	19	19.25	19.05	19.05
	20	20.25	20.05	20.05
	21	21.25	21.05	21.05
	22	22.25	22.05	22.05
	23	23.25	23.05	23.05
	24	24.25	24.05	24.05
	25	25.25	25.05	25.05
	26	26.25	26.05	26.05
	27	27.25	27.05	27.05
	28	28.25	28.05	28.05
	29	29.25	29.05	29.05
	30	30.25	30.05	30.05
	31	31.25	31.05	31.05
	32	32.25	32.05	32.05
	33	33.25	33.05	33.05
	34	34.25	34.05	34.05
	35	35.25	35.05	35.05
	36	36.25	36.05	36.05
	37	37.25	37.05	37.05
	38	38.25	38.05	38.05
	39	39.25	39.05	39.05
	40	40.25	40.05	40.05
	41	41.25	41.05	41.05
	42	42.25	42.05	42.05
	43	43.25	43.05	43.05
	44	44.25	44.05	44.05
	45	45.25	45.05	45.05
	46	46.25	46.05	46.05
	47	47.25	47.05	47.05
	48	48.25	48.05	48.05
	49	49.25	49.05	49.05
	50	50.25	50.05	50.05

SAMPLE NO CZ1 TEST DATE 06-20-78
 MATERIAL TESTED A TEST TEMPERATURE 70
 SAMPLE WEIGHT 100 SAMPLE WEIGHT 100
 SAMPLE DENSITY : COMPRESSED 1
 SAMPLE DENSITY : UNCOMPRESSED 1

TIME (MIN)	REFERENCE VOLUME (ML)	GROSS CHANGE IN VOLUME (ML)	NET CHANGE IN VOLUME (ML)	SAMPLE DENSITY (G/ML)
0	0	0	0	
1	0	0	0	
2	0	0	0	
3	0	0	0	
4	0	0	0	
5	0	0	0	
6	0	0	0	
7	0	0	0	
8	0	0	0	
9	0	0	0	
10	0	0	0	
15	0	0	0	
20	0	0	0	
25	0	0	0	
30	0	0	0	
35	0	0	0	
40	0	0	0	
45	0	0	0	
50	0	0	0	
55	0	0	0	
60	0	0	0	
65	0	0	0	
70	0	0	0	
75	0	0	0	
80	0	0	0	
85	0	0	0	
90	0	0	0	
95	0	0	0	
100	0	0	0	
1500	47.5	42.5	44.25	47.5
2000	48.5	44.5	45.75	48.5
2500	49.25	56.75	47.75	49.25
3000	42	58	48.5	52.2

 

TEST DATE

WATSON, A. LIMITED

TEST TERM

1. *Chlorophyll a* and *Chlorophyll b* were determined by the method of Arar and Collins (1971) using a Shimadzu 1601 UV-Visible Spectrophotometer. The concentration of chlorophyll was expressed in mg/L.

SAMPLE WEIGHT:

ALL RIGHTS RESERVED

CONCLUSIONS

UNCOMPRESSED

[illegible]

SAMPLE NO. _____ TEST DATE _____
 MATERIAL TESTED _____ TEST ROOM _____
 SAMPLE SIZE _____ SAMPLE WEIGHT _____
 APP. DENSITY / COMPRESSED _____
 APP. DENSITY / UNCOMPRESSED _____

| MOISTURE
CONTENT
% | TEST
METHOD | TEST
RESULT | TEST
RESULT | TEST
RESULT |
|--------------------------|----------------|----------------|----------------|----------------|
| 10 | 100 | 100 | 100 | 100 |
| 20 | 200 | 200 | 200 | 200 |
| 30 | 300 | 300 | 300 | 300 |
| 40 | 400 | 400 | 400 | 400 |
| 50 | 500 | 500 | 500 | 500 |
| 60 | 600 | 600 | 600 | 600 |
| 70 | 700 | 700 | 700 | 700 |
| 80 | 800 | 800 | 800 | 800 |
| 90 | 900 | 900 | 900 | 900 |
| 100 | 1000 | 1000 | 1000 | 1000 |
| 110 | 1100 | 1100 | 1100 | 1100 |
| 120 | 1200 | 1200 | 1200 | 1200 |
| 130 | 1300 | 1300 | 1300 | 1300 |
| 140 | 1400 | 1400 | 1400 | 1400 |
| 150 | 1500 | 1500 | 1500 | 1500 |
| 160 | 1600 | 1600 | 1600 | 1600 |
| 170 | 1700 | 1700 | 1700 | 1700 |
| 180 | 1800 | 1800 | 1800 | 1800 |
| 190 | 1900 | 1900 | 1900 | 1900 |
| 200 | 2000 | 2000 | 2000 | 2000 |
| 2500 | 50.5 | 40.5 | 33.25 | 35.8 |
| 3000 | 50 | 40 | 34.25 | 36.8 |
| | | | | |
| | | | | |
| | | | | |

SAMPLE NO 6 TEST DATE 6-2-58
 MATERIAL TESTED Al TEST TEMP 25
 SAMPLE SIZE 1 SAMPLE WEIGHT 1.00
 SAMPLE DENSITY (COMPRESSED) 1.00
 SAMPLE DENSITY (UNCOMPRESSED) 1.00

| TEST NO | REF. TEMP
(°C) | GROSS CHANGE
IN VOLUME
(ml) | NET CHANGE
IN VOLUME
(ml) | NET CHANGE
IN VOLUME
(ml) |
|---------|-------------------|-----------------------------------|---------------------------------|---------------------------------|
| 1 | 25 | 0.00 | 0.00 | 0.00 |
| 2 | 25 | 0.00 | 0.00 | 0.00 |
| 3 | 25 | 0.00 | 0.00 | 0.00 |
| 4 | 25 | 0.00 | 0.00 | 0.00 |
| 5 | 25 | 0.00 | 0.00 | 0.00 |
| 6 | 25 | 0.00 | 0.00 | 0.00 |
| 7 | 25 | 0.00 | 0.00 | 0.00 |
| 8 | 25 | 0.00 | 0.00 | 0.00 |
| 9 | 25 | 0.00 | 0.00 | 0.00 |
| 10 | 25 | 0.00 | 0.00 | 0.00 |
| 50 | 25 | 0.00 | 0.00 | 0.00 |
| 100 | 25 | 0.00 | 0.00 | 0.00 |
| 200 | 25 | 0.00 | 0.00 | 0.00 |
| 300 | 25 | 0.00 | 0.00 | 0.00 |
| 400 | 25 | 0.00 | 0.00 | 0.00 |
| 500 | 25 | 0.00 | 0.00 | 0.00 |
| 750 | 25 | 0.00 | 0.00 | 0.00 |
| 1000 | 25 | 0.00 | 0.00 | 0.00 |
| 1500 | 25 | 0.00 | 0.00 | 0.00 |
| 2000 | 25 | 0.00 | 0.00 | 0.00 |
| 2500 | 25 | 0.00 | 0.00 | 0.00 |
| 3000 | 25 | 0.00 | 0.00 | 0.00 |
| | | | | |
| | | | | |
| | | | | |

* REPRESENTATIVE OF SAMPLE C-11-