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LOSS & GAIN ON IGNITION TEST REPORT

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Loss/Gain On Ignition Test Report

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Abstract: Document provides the results of tests done on Product Cans from the HC-21C sludge stabilization process. Tests included running a simulated Thermogravimetric Analysis, TGA, on the processed material that have received Loss On Ignition (LOI) sample results that show a gain on ignition or a high LOI and reprocessing product cans with high LOIs. Also, boat material temperatures in the furnace were tracked during the testing.

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1 INTRODUCTION

This test report documents the results that were obtained while performing, test procedure WHC-SD-CP-TP-082, "Loss/Gain on Ignition Testing for HC-21C", Rev.1.

The HC-21C thermal stabilization process stabilizes reactive plutonium bearing material for long term vault storage. Loss On Ignition (LOI) analyses are performed on all materials stabilized in the muffle furnaces prior to being stored in the vaults to ensure suitability for vault storage. According to Operating Specifications Documents (OSD), OSD-184-00013, Rev. I-2 "Special Nuclear Material (SNM) Storage", the material is required to have a LOI of less than 1%, with the exception that material packaged after May 1995 with $\geq 50\%$ plutonium must have a LOI of $< 0.5\%$. The LOI analysis is performed to assure that volatiles that could potentially pressurize the sealed containers over long periods of time, at expected storage temperatures, have been removed. During the recent sludge stabilization campaign, which stabilized oxides, sludges, and oxalates, some of the LOI results were out of the OSD limits so testing was done to understand the problem and how to solve it.

The primary objective of the test plan was to determine if there was a problem with having a GOI (Gain On Ignition) or positive LOI result on the processed material and what was causing the GOI. Also, information was to be gathered on high LOI ($> 1.0\%$) problems.

2 DESCRIPTION OF TEST

2.1 Reprocess Material Test

This test reprocessed product cans that had LOI results that were out of the operating specifications. Six product cans were reprocessed to determine how additional processing time affected the material and to meet operating specifications defined in OSD for vault storage. The LOI results on the product cans to be reprocessed were either GOI results, or LOI results $> 1.0\%$ (or very close to the limit.) The product cans were reprocessed under Program #7, which holds the material at a 1000°C for three hours. A 500 gram charge size was used to reprocess the material.

The reprocessed material was placed in product cans and sampled for LOI analysis. The contents of the product cans differ from the original reprocessed cans' contents due to some consolidation of materials when processing a 500 gram charge size.

2.2 Simulated TGA Test

The simulated TGA test recorded weight changes at different temperatures. This is different when compared to a LOI test which is a single point TGA test. The simulated TGA was performed to understand the weight changes leading up to the temperature at which the LOI is executed. There were two types of simulated TGA tests performed by the Plutonium Finishing Plant (PFP) Analytical Laboratories. The two tests were run on four different product can samples. The four product cans chosen, 64-95-03-60, 64-94-04-67, 64-95-04-68, and 64-95-04-80, had LOI results that were not acceptable for storage after initial processing. Two of the product cans had GOIs and two had LOIs. In-depth information about the product cans tested can be found in Table 1, Appendix A.

The first TGA test heated a portion of the sample material to temperatures of 125°, 150°, 175°, 200°, 450°, 750°, and 1000°C. Each temperature was held for 1 hour and then cooled down in a desiccator. The sample was then weighed before being heated to the next temperature. The second TGA test was done using a new portion of the sample material. The sample was heated to 1000°C and held at temperature for one hour. The sample was cooled and then weighed. This procedure was then repeated a number of times.

In addition to the 4 product samples tested, a standard of low-fired pure PuO_2 was tested for comparison.

2.3 TGA with Mass Spectroscopy on Off-Gas Test

The test plan included analyzing a sample using a TGA instrument with mass spectroscopy on the off-gas. No TGA instrument that could run contaminated samples was available for analyzing the sludge stabilization LOI samples. This test would help to determine what the reaction's off-gas constituents were and at what temperatures the reactions happen. This information is needed to determine what reactions occur.

2.4 Boat Temperature

This test was used to obtain the temperature of the boat material during processing. To gain this information, temperatures were recorded from 3 different locations during furnace operation. The three different locations where the temperatures were taken were the furnace temperature controller (TIC-1 and TIC-2), the boat material temperature, and the inside furnace temperature. The furnace controller temperature was recorded to give a reference point of where the furnace temperature should be. Temporary type K thermocouples were placed in the glovebox for measuring the boat material temperature and the temperature inside the furnace. Temperature profiles were recorded from seven different charges using both furnaces. For the first three charges only the boat material temperature and furnace controller temperature were recorded. Charge information for each temperature test was also recorded to help identify material types being monitored.

3 TEST RESULTS

3.1 Reprocess Material Test

The six reprocessed product cans' original results and the reprocessed results are listed below in Table 2, Appendix A. The results from the six cans reprocessed showed an improvement over the original LOI results.

All six cans were researched to determine where the feed material originated, the percent of plutonium (Pu) in the material and amount of organic in the feed material. This information was reviewed to discover any similarities or trends which might provide explanations to the results of tests performed. From the research the only clear pattern noticed was that the percent Pu in the product cans was below 37%. Other parameters reviewed such as percent organic, type of material, only showed ambiguities.

3.2 Simulated TGA Test

All information recorded from the first set of simulated TGA tests is in Table 3, Appendix A. From this information the percent of weight change was calculated by subtracting the before and after sample weights and dividing by the sample weight. The results are shown in Graph I, Appendix A.

The results from the second TGA tests are in Table 4, Appendix A. The percent of weight change was calculated the same as on the first simulated tests. The results are graphically represented in Graph II, Appendix A.

Laboratory testing, data calculations and graphs were done by Sam Hurlbut, Chemist at PFP Analytical Laboratories.

3.3 TGA with Mass Spectroscopy on Off-Gas Test

Test was not completed. When equipment currently being installed in the Plutonium Process Support Laboratory (PPSL) becomes available to the plant and additional information on LOI is needed, samples will be run. The test will provide information on what compounds in the sample decompose over time and what gaseous products are released that could potentially pressurize the container.

3.4 Boat Temperature

The data sheets from this test are in Appendix B. Additional information gathered on the type of material being processed can be found in Table 5, Appendix A. Test results were graphed to display the temperature each boat's material reached and are shown in Graph III, Appendix A. Additional graphs were done to compare the boat's material temperature to the furnace temperature. This information can be found in Appendix A, Graph IVA, IVB, and IVC.

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4 CONCLUSION FROM TESTS

4.1 Reprocess Material Test

Each of the six items reprocessed had a lower LOI when re-stabilized for an additional 3 hours at 1000°C.

4.2 Simulated TGA Test

FIRST TEST

The first set of TGA tests demonstrated that at 125°C and 150°C, the temperature where water should be driven off, little weight loss occurred with high-fired material samples. The standard sample at 125°C and 150°C showed a significant weight loss. These results support our expectation that the high-fired material had little to no free moisture present in the material.

While some weight loss and gain occurred between 450°C and 750°C, the majority of the weight changes occurred between 750°C and 1000°C in all the samples. The weight loss from 450° - 750°C may be due to absorbed CO₂ and CO being released. Information from an internal memo, "Basis for OSD-Z-184-00013 Loss-On-Ignition Specification", 12242-88-JHK-051, suggests decomposition of these intermediates when low-fired oxide is heated up to 950°C. This reaction will cause a weight loss.

For the weight changes taking place above 750°C, research was done on elements in the material and their reactions to identify potential causative agents. Due to restricted laboratory analysis capability the amount of information was limited. Some of the possibilities that could cause weight changes to have occurred in this temperature range are as follows:

One explanation is that the metal present in the product material is continuing to oxidize. The boats used in the process were made of 304L SS that degrade from high temperatures and corrosive feed. On average, boats lost 40 - 45 grams per furnace cycle of stainless steel material of which a portion would go out with the product material. The metals may not have been fully oxidized causing a weight gain. Also, there is an assortment of metals in the feed material from past processes that may not fully oxidize when processed for 1 hour at 1000°C. When the material is heated again to 1000°C for a LOI test, further oxidization of the metal occurs and a weight gain is detected.

Another explanation is that salts present in the product material start to break down at these high temperatures. Possible salts present in the product material are phosphates, nitrates and possibly a few chlorides. When the salts are broken down a weight loss is seen due to volatilization.

4.2 Simulated TGA Test (cont.)

Information from past data on extensive testing that was done on oxide material ("Thermal, Chemical, and X-ray Analyses of Rocky Flats Oxide Feed", C. H. Delegard/D. G. Bouse) was used to better understand the weight changes. The test performed TGA and Differential Thermal Analyses, DTA, analysis on 25 items and of those 6 were also chemically analyzed. Two weight gains were seen in the 25 items tested and the majority of the weight changes were associated with an endothermic response and very few exothermic responses. An in-depth explanation was not given for the weight gains, but it did state that the salts present started melting and breaking down which contributed to the weight changes. This information confirmed that it is not abnormal to receive a weight gain when performing a LOI analysis. The chemical analyses from the 6 samples were done on different percent PuO_2 ranging from 12% to 70%. A variety of metals and salts were seen in the samples.

The above discussions are preliminary theories to try and explain the weight change from 750 - 1000°C. To fully understand the phenomenon, additional testing and more information would be needed.

SECOND TEST

The second set of TGA tests were done to determine how long the material needed to be reprocessed to achieve acceptable LOI results for long term storage. Both LOI samples, B3217 and B3222, lost the majority of the weight within the first hour but then stabilized out at about three to four hours. One of the GOI samples, B3211, exhibited a slight GOI during the first hour, lost a slight amount of weight in the second hour, and then stabilized. This may be due to experimental error on the LOI test. The experimental error for LOI testing is $\pm 0.136\%$. This experimental error was determined by calculating the standard deviation on all samples done during the sludge stabilization campaign. The other GOI sample, B3213, which had a significant GOI, only gained weight during the first hour and then lost weight during the remainder of the time. The rate of weight change never leveled off.

4.3 TGA with Mass Spectroscopy on Off-gas Test

No information available at this time. New instrumentation being installed in the PPSL should provide this capability during Fiscal Year 1996. At that time, LOI samples will be selected and analyzed.

4.4 Boat Temperature

The boat temperatures were taken to discover what the temperature of the material was when the furnace controller's temperature was 1000°C. The highest temperature the material reached was 952°C. The charges tested were made up of several different types of material and all material had been reprocessed for three hours at 1000°C previous to this test, with the exception of the June 2 charge, that had only been processed for one hour at 1000°C. The maximum temperature the material reached ranged between 618°C - 952°C. Each charge differed in the maximum material temperature reached.

One explanation for the lower temperatures is that an endothermic reaction is occurring and thus not allowing the material to reach a higher temperature until the reaction is complete. Supporting this theory were the results from the simulated TGA analysis that was performed on different types of feed material (see section above). The TGA analysis shows a potential endothermic reaction that could be responsible for the material not reaching 1000°C.

Another factor that could have influenced the result was the thermocouple performance and placement. High temperature corrosion may have affected the thermocouples reliability during the later tests resulting in lower temperatures. Also, the placement of the thermocouples differed slightly from test to test due to the problems of getting the thermocouples to stay in place when the furnace door was closed.

In addition, the slightly lower temperature differences (<50°C) could be due to heat diffusion properties of the material.

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5 RECOMMENDATIONS

Change LOI specification found in Special Nuclear Material Storage, Operating Specification Document OSD-Z-184-00013, Section 13.B to allow a GOI of <0.5% and LOI of <1.0%, for material of <50% Pu with test performed at 450°C.

Continue gathering information on product cans stabilized in the muffle furnaces. Perform additional testing as instrumentation becomes available in the plant.

An extensive testing program on sludge material only is not justified, as other types of material will be processed. It should be recognized that much of the material stabilized in the muffle furnaces will be < 50 % Pu, containing a wide variety of contaminating constituents. A separate effort to provide a limited chemical/elemental sampling of materials scheduled for stabilization is currently underway via Test Plan WHC-SD-CP-TP-086, "Plan to Examine SNM and the Food pack Can Storage Containers at the PFP Storage Vaults." In addition, as different types of material are stabilized further testing may need to be completed.

Another area that has been partially researched but will need to be further investigated is that a LOI for <50% Pu material may not be a good test of stability for long term storage. One type of test that could be considered is a TGA that demonstrates that no volatiles or reactive components are released at or below temperatures expected during storage. Additionally testing could be done using a TGA with mass spectroscopy of the off-gas. This test could provide what compounds will decompose from radiation over time causing pressurization of the container from the gaseous products released. Other tests for presence of volatiles may be applicable and more appropriate for determining stability for long term storage and should be researched.

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APPENDIX A

GRAPH I - SIMULATED TGA

GRAPH II - SIMULATED TGA

GRAPH III - BOAT TEMPERATURES

GRAPH IVA - BOAT TEMPERATURE VS. FURNACE TEMPERATURE

GRAPH IVB - BOAT TEMPERATURE VS. FURNACE TEMPERATURE

GRAPH IVC - BOAT TEMPERATURE VS. FURNACE TEMPERATURE

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TABLE 1 - Sample Information for Simulated TGA Tests

Product Can Information on the Four Tested on the Simulated TGA

TGA SAMPLE #: 64-95-03-60 ~ B3211
64-95-03-67 ~ B3213
64-95-03-68 ~ B3217
64-95-03-80 ~ B3222

Product CAN	LOI	% Pu	Organic Wt. (g)	TYPE OF MATERIAL						
				Cent. Sldg	PRF Sldg	RMC Swps	RMC Oxa.	MT-5 Sldg	MT-6 Sldg	Sludge
64-95-03-60	0.041	22.5%	5.3	25.0%	8.0%	67.0%	0.0%	0.0%	0.0%	33.0%
64-95-03-67	0.2946	21.3%	14.59	33.5%	33.3%	33.3%	0.0%	0.0%	0.0%	66.7%
64-95-03-68	-0.891	34.4%	18.33	39.3%	32.2%	22.7%	5.8%	0.0%	0.0%	71.5%
64-95-03-80	-1.542	27.0%	10.45	11.7%	4.9%	2.3%	0.0%	63.4%	17.7%	97.7%

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TABLE 2 - Reprocessed Cans

Product Can Number	*Original LOI Result	Reprocessed Can Number	LOI Result (Reprocessed)
64-95-04-68	-0.891 & -0.9566 (2 LOI samples taken)	64-95-06-139 64-95-06-140	-0.7836 -0.3639
64-95-04-80	-1.5422	64-95-04-80-1 64-95-06-139	-0.419 -0.7836
64-95-04-82	-1.1088	64-95-04-80-1 64-95-04-82-1	-0.419 -0.544
64-95-04-92	+0.089 @ 450°C +0.315	64-95-06-140 64-95-06-141 64-95-06-150	-0.3639 -0.4752 -0.777
64-95-05-100	-0.998	64-95-06-141 64-95-06-150	-0.4752 -0.777
64-95-05-128	-1.1018	64-95-06-150	-0.777

* All LOI samples were performed at 1000°C unless temperature specified.

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TABLE 3 - Simulated TGA

Sample Weighed at TEMPERATURE (°C)			125° C	150° C	175° C	200° C	450° C	750° C	1000° C
SAMPLE - STANDARD (PuO₂)									
GROSS WT (g)	25.5885	AFTER WT (g)	25.5557	25.5525	25.5472	25.5511	25.5355	25.4961	25.4907
TARE WT (g)	20.8583	% CHG	-0.69	-0.76	-0.87	-0.79	-1.12	-1.95	-2.07
SAMPLE # - B3211									
GROSS WT (g)	24.2608	AFTER WT (g)	24.2609	24.2606	24.2605	24.2608	24.2636	24.2643	24.2756
TARE WT (g)	18.1078	% CHG	0.00	0.00	0.00	0.00	0.05	0.06	0.24
SAMPLE # - B3213									
GROSS WT (g)	24.2122	AFTER WT (g)	24.2132	24.2133	24.2130	24.2132	24.2192	24.2253	24.2505
TARE WT (g)	18.0345	% CHG	0.02	0.02	0.01	0.02	0.11	0.21	0.62
SAMPLE # - B3217									
GROSS WT (g)	24.3975	AFTER WT (g)	24.3965	24.3965	24.3963	24.3961	24.3958	24.3905	24.3555
TARE WT (g)	18.0099	% CHG	-0.02	-0.02	-0.02	-0.02	-0.03	-0.11	-0.66
SAMPLE # - B3222									
GROSS WT (g)	23.6332	AFTER WT (g)	23.6327	23.6326	23.6321	23.6319	23.6319	23.6217	23.5685
TARE WT (g)	18.4211	% CHG	-0.01	-0.01	-0.02	-0.02	-0.02	-0.22	-1.24

TABLE 4 - Cum. % Mass Change vs. Time @ 1000°C

Time Sample Held at 1000°C			1 hr	2 hr	3 hr	4 hr	5 hr
SAMPLE - STANDARD (PuO₂)							
GROSS WT (g)	25.4775	AFTER WT (g)	25.4114	25.4110	25.4110	25.4110	25.4109
TARE WT (g)	20.9012	WT CHG (g)	-0.0661	-0.0665	-0.0665	-0.0665	-0.0666
SAMPLE WT (g)	4.5763	% CHG	-1.44	-1.45	-1.45	-1.45	-1.46
SAMPLE # - B3211							
GROSS WT (g)	22.2967	AFTER WT (g)	22.2973	22.2955	22.2939	22.2929	22.2922
TARE WT (g)	18.4274	WT CHG (g)	0.0006	-0.0012	-0.0028		-0.0007
SAMPLE WT (g)	3.8693	% CHG	0.02	-0.03	-0.07		-0.09046
SAMPLE # - B3213							
GROSS WT (g)	21.7877	AFTER WT (g)	21.7928	21.7857	21.779	21.7731	21.7666
TARE WT (g)	17.9874	WT CHG (g)	0.0051	-0.002	-0.0087	-0.0146	-0.0211
SAMPLE WT (g)	3.8003	% CHG	0.13	-0.05	-0.23	-0.38	-0.56
SAMPLE # - B3217							
GROSS WT (g)	21.4986	AFTER WT (g)	21.4710	21.4659	21.4636	21.4620	21.4605
TARE WT (g)	18.0243	WT CHG (g)	-0.0276	-0.0327	-0.035	-0.0366	-0.0381
SAMPLE WT (g)	3.4743	% CHG	-0.79	-0.94	-1.01	-1.05	-1.10
SAMPLE # - B3222							
GROSS WT (g)	22.7133	AFTER WT (g)	22.6442	22.6391	22.6375	22.6367	22.6359
TARE WT (g)	18.0909	WT CHG (g)	-0.0691	-0.0742	-0.0758	-0.0766	-0.0774
SAMPLE WT (g)	4.6224	% CHG	-1.49	-1.61	-1.64	-1.66	-1.67

TABLE 5 - Boat Material Information For Temperature Test

DATE	FURNACE	BOAT MATERIAL (PROCESSED FEED)	FRESH FEED TYPE
6/2/95	1	64-95-04-80	See Table 1 and TGA Graphs I & II
6/5/95	1	64-95-04-80 64-95-04-68	See Table 1 and TGA Graphs I & II
6/5/95	2	64-95-04-68	See Table 1 and TGA Graphs I & II
6/6/95	2	64-95-04-68	See Table 1 and TGA Graphs I & II
6/7/95	2	64-95-04-92	RMC Line Sweeps
6/8/95	2	64-95-05-100	PRF Solids, Sludges, & Canyon Sludges
6/9/95	2	64-95-04-92 64-95-05-100 64-95-05-128	See above for can 92 & 100, PRF Solids and Sludges for 128.

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APPENDIX B

TEMPERATURE DATA SHEETS

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TIME	TIC-1 Temp	Boat 1 temp	TIC-2 temp	Boat 2 temp
11:45	437	448		
12:00	508	516		
12:15	562	567 566		
1240	641	637		
1245	661	655		
1300	708	695		
1315	737	719		
1330	768	748		
1345	800	775		
1400	832	804		
1415	862	834		
1430	893	864		
1445	916	883		
1500	933	898		
1515	952	914		
1530	972	931		
1545	989	945		
1600	1003	952		
1615	1000	946		
1630	1000	944		
1645	1000	943		
1700	988	910		
1715	871	898		
1730	793	732		
1745	723	666		
1800	692	608		
1815	618	570		
1830	558	501		
1845	519	464		
1900	484	429		

June 2, 1995

[illegible]

TEMPERATURE DATA SHEETS (Cont.) June 65

Time	Fur 1 temp	Boat 1 temp	Fur 2 temp	Boat 2 temp
0915	176	105	186	113
0930	269	161	278	170
0945	362	238	370	221
1000	414	283	425	261
1015	475	332	484	307
1030	538	393	545	360
1045	602	448	608	421
1100	634	477	641	446
1115	691	529	697	508
1130	728	566	732	545
1145	758	592	762	586
1200	781	614	784	609
1215	819	649	822	652
1230	849	684	858	686
1245	878	709	883	715
1300	908	742	916	745
1315	933	757	925	760
1330	942	778	946	781

6/16/65

TEMPERATURE DATA SHEETS (Cont.)

JUNE 15

Time	Fur 1 temp	Boat 1 temp	Fur 2 temp	Boat 2 temp
1345	966	803	968	806
1400	980	817	982	821
1415	998	835	1000	840
1430	1001	843	1001	845
1445	1000	842	1000	843
1500	1000	843	1000	844
1515	1000	842	1000	843
1530	1000	842	1000	844
1545	1000	842	1000	846
1600	1000	841	1000	841
1615	1000	840	1000	844
1630	1000	840	1000	844
1645	1000	840	1000	845
1700	1000	840	1000	844
1715	1000	839	1000	840

TEMPERATURE DATA SHEETS (Cont.)

6th June 1995

Time	FUR 2 TEMP	THERMOCOUPLE #1 TEMP	THERMOCOUPLE #2 TEMP	
	Fur 1 temp	Boat 1 temp	Fur 2 temp	Boat 2 temp
0830	121	96	189	
0845	124	55	100	
0900	200	86	161	
0915	271	119	241	
0930	346	162	320	
0945	420	207	399	
1000	496	265	484	
1015	547	311	545	
1030	602	346	599	
1045	649	381	645	
1100	700	415	697	
1115	728	437	731	
1130	762	467	762	
1145	792	498	792	
1200	826	536	826	
1215	856	567	855	
1230	890	606	888	
1245	912	629	912	
1300	932	655	931	

* BOTH THERMAL COUPLES IN BOAT 95-06-005 IN FURNACE #2

TEMPERATURE DATA SHEETS (Cont.)

6th June 1995

Time	Fur 2 temp	Thermocouple # 1 temp	Thermocouple # 2 temp	Boat 2 temp
	Fur 2 temp	Boat 1 temp	Fur 2 temp	
1315	954	677	953	
1330	966	691	965	
1345	993	718	990	
1400	1000	729	1000	
1415	1000	727	1003	
1430	1000	724	1001	
1445	1000	728	1000	
1500	1000	729	1001	
1515	1000	729	1000	
1530	1000	728	1000	
1545	1000	735	1000	
1600	1000	730	1000	
1615	1000	751	1000	
1630	1000	752	1000	
1645	1000	752	1000	
1650	1000	730		
1715				
1730				
1745				

Done - went out of Dwell.

TEMPERATURE DATA SHEETS (Cont.)

6-7-95

(In Furnace)
Thermocouple 1(In boat)
Thermocouple 2

Time	Furn 1 temp	Boat 1 temp	Furn 2 temp	Boat 2 temp
0815	137	70	71	
0830	190	139	96	
0845	276	227	140	
0900	344	303	173	
0915	440	404	230	
0930	496	462	268	
0945	560	525	320	
1000	614	586	360	
1015	643	614	387	
1030	706	674	438	
1045	739	710	468	
1100	761	729	488	
1115	802	766	517	
1130	836	795	553	
1145	854	816	579	
1200	884	844	604	
1215	911	873	632	
1230	929	891	652	
1245	948	907	670	
1300	967	925	689	
1315	984	940	706	
1330	1002	957	725	
1345	1000	959	727	
1400	1000	959	728	
1415	1000	958	729	
1430	1000	958	729	
1445	1000	958	729	
1500	1000	957	729	
1515	1000	957	729	
1530	1000	956	728	
1545	1000	955	728	
1600	1000	955	728	

6-7-95

TEMPERATURE DATA SHEETS (Cont.)

(INFURACE)

(A Great)

Thermocouple #1 Thermocouple #2

[illegible]

TEMPERATURE DATA SHEETS (Cont.)
6-8-95

Time	IN FURNACE Temp measured 1		IN BOAT Temp measured 2	
	Fur 1 temp	Boat 1 temp	Fur 2 temp	Boat 2 temp
0800	32	27	43	
0815	106	67	166	
0830	181	148	72	
0845	267	211	99	
0900	211 338	273	120	
0915	403	336	140	
0930	511	441	188	
0945	539	471	205	
1000	606	531	239	
1015	636	559	255	
1030	687	607	280	
1045	705	624	300	
1100	754	677	348	
1115	785	703	381	
1130	821	737	461 416	
1145	848	761	440	
1200	891	803	485	
1215	909	821	509	
1230	925	838	527	
1245	943	855	547	
1300	961	872	567	
1315	979	888	587	
1330	1001	910	608	
1345	1001	913	614	
1400	1000	912	615	
1415	1000	911	617	
1430	1000	910	617	
1445	1000	910	617	
1500	1000	910	618	
1515	1000	910	618	
1530	1000	909	618	

6-8-95

[illegible]

TEMPERATURE DATA SHEETS (Cont.)

* Restarted @ 0515

6-9-95

Boat

2

#1 in ~~Boat~~ furnace#2 in ~~Boat~~ furnace

Time	Fur 1 temp	Boat 1 temp	Fur 2 temp	Boat 2 temp
0800	36	30	25	
0815	Re Mark Both Furnaces			
0830	120	102	63	
0845	179	147	96	
0900	259	217	149	
0915				
0930	396	347	232	
0945	478	432	274	
1000	536	488	306	
1015	583	533	331	
1030	683	632	389	
1045	683	632	389	
1100				
1115				
1130	785	728	464	
1145	821	760	488	
1200	848	785	509	
1215	875	809	530	
1230	907	837	561	
1245	925	853	581	
1300	943	868	598	
1315	961	883	616	
1330	983	905	638	
1345	1000	920	657	
1400	1001	920	663	
1415	1000	918	665	
1430	1000	918	666	
1445	1000	918	667	
1500	1000	917	668	
1515	1000	917	668	
1530	1000	916	668	

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