

**SUMMARY OF RESULTS FROM SIMULATED  
TANK 8/40 BLEND RUN IN MINIMELTER (U)**

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**Publication Date: October 12, 2001**

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## **SUMMARY OF RESULTS FROM SIMULATED TANK 8/40 BLEND RUN IN MINIMELTER (U)**

### **1.0 INTRODUCTION**

The initial run on the 786-A minimelter was used to establish standard operating conditions and for equipment checkout. After charging with ground DWPF cold run glass, the melter was slurry fed and operated using Tank 42 simulant. This report covers the testing completed as the melter was transitioned from Tank 42 simulant to a simulated blend of Tank 8/40. The testing was outlined in Task Technical and QA Plan: WSRC-RP-2001-00590, Mini-melter Run with Macrobatches 3 Baseline Feed. The run plan detailing the steps for testing was SRT-GPD-2001-00047: Run Plan for Minimelter Run with Macrobatches 3 Baseline Feed (U). The laboratory notebook used for recording the observations and results was WSRC-NB-2000-00186: 786-A Minimelter.

### **2.0 SUMMARY**

The general objectives of the run were:

- Establish a baseline for the mini-melter using Tank 8/40 feed with frit 200.
- Determine off-gas composition under a variety of test conditions.
- Record parameters for determining melt rate comparisons.

The objectives of the task plan were met during testing. Steady state operating conditions were established and the melter was operated in a continuous feed and pour mode. General melt rate values were determined at several temperatures, which can be used to compare to future process changes. The off-gas generation rates were determined at several plenum temperatures. Data was collected that can be used to estimate the difference between actual and indicated plenum temperature.

### **3.0 DISCUSSION**

The 786-A minimelter is joule heated with a one-foot diameter K3 refractory pot. The electrodes and plenum are made of inconel 690. There are two vertical Kanthol lid heaters that are capable of supplying 5000 watts each. The overflow spout is heated by a split clam shell 1500W resistance heater. The melter is kept under vacuum with an air eductor and pressure is controlled with the addition of air. The off-gas passes through a quencher/scrubber and then through a mist eliminator prior to exiting a stack. Sample ports allow the off-gas to be sampled at the melter exit and after the condensate tank. Two gas chromatographs (GC) and an electrochemical cell (ECC) are used for analysis. A sketch of the melter system is shown in Attachment A.

Most testing was conducted on days, but the final continuous feed experiment carried over into two shifts. Several problems were overcome during the testing including loss of the spout tip heater and air flow instrumentation. Off-gas data analysis requires close monitoring and improvements are planned for future runs. Operating at abnormal conditions such as very low plenum temperatures is difficult due to the well insulated design of the plenum. This limits the amount of time available for testing since several conflicting factors are involved. Changes to the system could be made, but this would require a fairly long outage. The individual tests conducted along with results are described below.

### 3.1 Short Term Melt Rate

The test was conducted by quickly feeding ~ 750 cc of feed to the melter and visually determining the time required to burn off the cold cap. A VCR recorded the surface for comparison to later tests. The duration of volatile generation was also recorded. The melt pool and plenum temperature were in auto control at 1150°C and 850°C. The corrected purge air flow was 1.8 scfm and the corrected dilution flow was 5.5 scfm. The visual burn off was determined by the absence of any remaining feed on the surface. There is a residual texture to the surface for a long period after feeding, but this was not considered during this test. The tank 8/40 simulant feed used during this testing had a 47.5 wt % solids. When all the feed was introduced, there was nearly complete cold cap coverage.

The volatile concentrations were measured using both the gas chromatograph (GC) and electrochemical cells (ECC). The sample point selected was directly after the addition of the dilution air. Since the concentrations were low, the absolute value of the reading is probably not accurate, but it does indicate the presence of the compound. Durations were counted for the period that the concentration was above the background value. The CO<sub>2</sub> concentrations were very low and had occasional gaps, but the duration was counted from the initial to the final non zero value. The duration for both the volatile concentration and visual observation are show in Table 1 below. The average feed rate is based on the data recording system. Each test involved cycling the feed system on for five minutes with a set point of 150 cc/min.

**Table 1 Volatile Generation During Short Term Melt Rate Test**

Test #	Feed Rate cc/min	NO <sub>2</sub> Duration (min)	CO Duration (min)	CO <sub>2</sub> Duration (min)	Visual Cold Cap Burn Off(min)
1	146	12	23	9	20
2	138	13	19	9	23
3	142	11	9	8	15
Average	142	12	17	8.3	19.3

Another observation during the testing was the time required for each volatile component to be detected. Since a water flush is required prior to each feed initiation, there may be a spike in a plot of feed rate vs. time. This can also vary depending on the timing of the flush vs. the one minute frequency of data collection. The first test used a 30 second flush, while the next two tests used 20 second flushes. For purposes of this report, the feed initiation was considered to

start at the first of 5 consecutive readings in the range of the set point for feed rate. Table 2 shows the time delay between the initiation of feed and the detection of the volatile component.

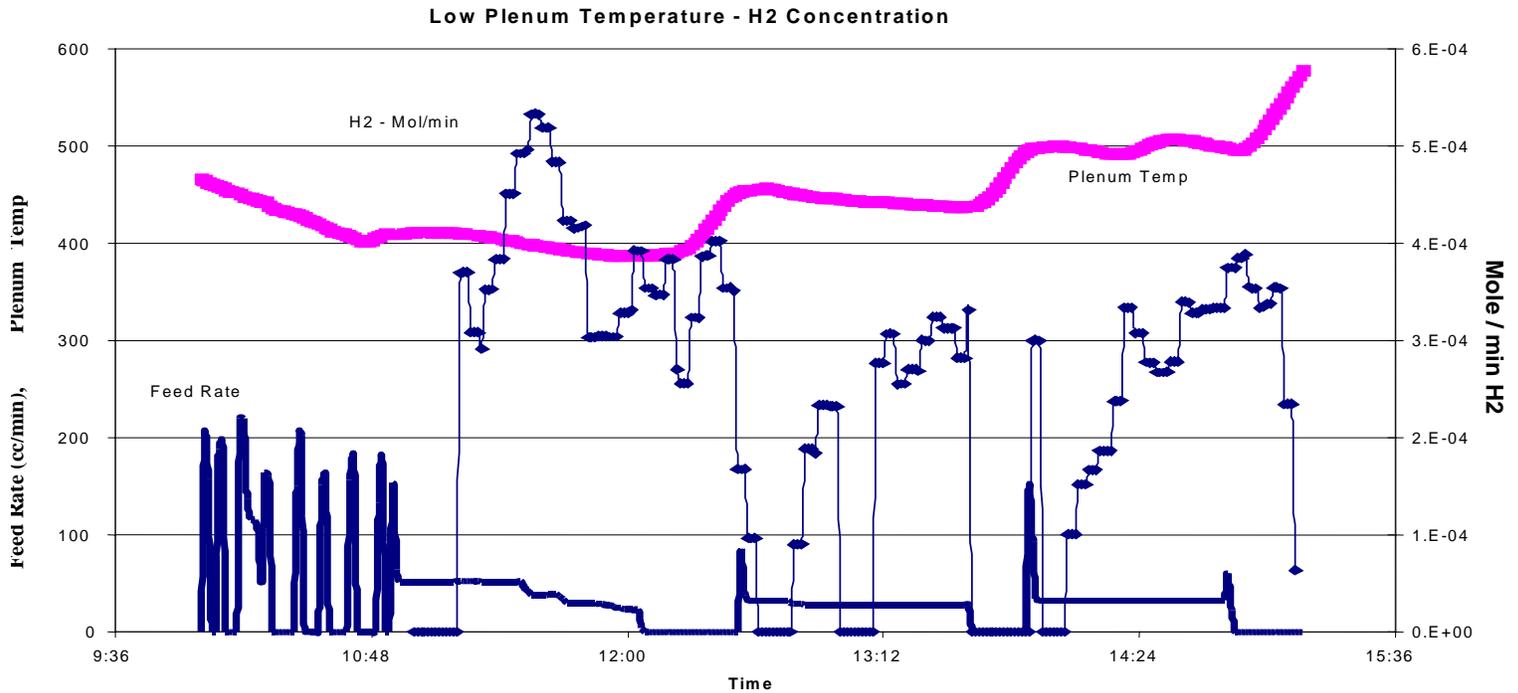
**Table 2 - Volatile Initiation During Short Term Melt Rate Test**

Test #	NO2 Initiation (min)	CO Initiation (min)	CO2 Initiation (min)
1	2	1	8
2	1	1	8
3	3	4	8
Average	2	2	8

### 3.2 Low Plenum Temperature

In order to obtain data for verification of the DWPF off gas model, testing was conducted at plenum temperatures lower than normal operating conditions. The presence and generation rate of hydrogen was of particular interest. Plenum temperatures were lowered by initially operating the melter with no lid heaters. Excess purge air was introduced into the melter along with water through feed tube flushing. As the temperature approached the desired level of ~400 °C, feed was introduced to form a cold cap and reduce the shine from the glass pool. The amount of purge air used is limited because it decreases the sensitivity of the GC especially at low concentrations. Once the temperature was reached, continuous feeding was started. The feed rate was gradually reduced due to the large cold cap being formed at the low plenum temperatures. After feeding for approximately 1 hour, the plenum temperature was raised to ~450 °C by decreasing the purge air. Feeding was restarted and off-gas data was collected for approximately one hour. Feeding was again stopped and the lid heaters were energized to raise the plenum temperature to 500 °C. A feed rate of 34 cc/min was maintained while the plenum was operating at that temperature. A plot of hydrogen generation versus plenum temperature is shown in Figure 1. The purge and dilution air flows were changed during the test to balance plenum temperature with GC sensitivity. The spikes in the feed rate shown early in the plot are water flushes and brief feed periods used to lower temperature. Based on the information during this testing, the hydrogen generated at the three temperatures is similar. Longer term testing would be necessary to obtain more detailed information. This would probably require modifications to the plenum to provide external cooling. The results from this testing will be compiled and analyzed along with the actual versus indicated plenum temperature calculations. The verification of the offgas model will be covered under a separate report.

Figure 1



### 3.3 Melt Rate vs. Plenum Temperature

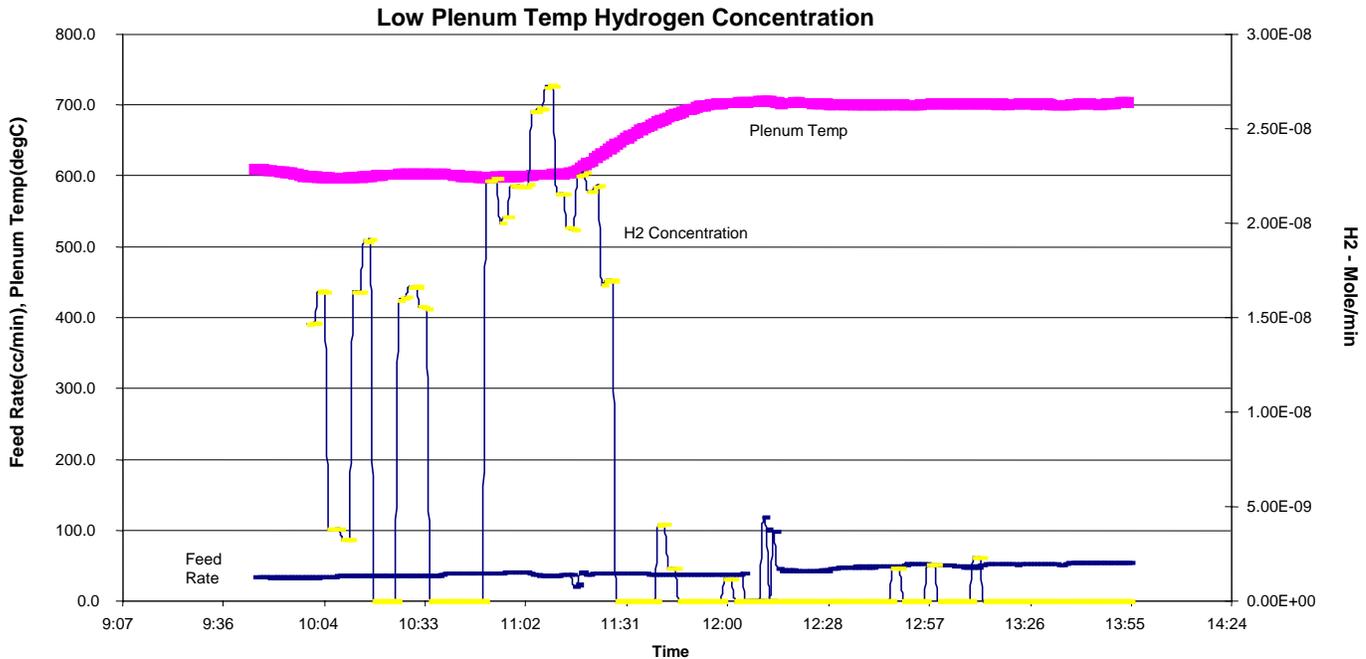
Most of the data collected while running the Tank 42 simulant was with a plenum temperature of  $\sim 850^{\circ}\text{C}$ . In addition to the low temperature plenum testing described above, several additional runs were made to determine relative melt rate at different temperatures. The plenum temperature was initially lowered to  $600^{\circ}\text{C}$  by adding purge air. Once the temperature was reached, the lid heaters were energized with a set point of  $600^{\circ}\text{C}$ . The feed rate was initially set at  $34\text{ cc/min}$  and was gradually increased while the cold cap was observed. The goal during the testing was to maintain a consistent cold cap coverage of  $\sim 85\text{-}90\%$ . This is a subjective measurement but generally the presence of several vent holes or a small area of glass constitutes normal coverage. Once steady state was obtained, the plenum temperature was raised to  $700^{\circ}\text{C}$  and the test was repeated.

The testing indicated that a steady rate of  $38\text{-}40\text{ cc/min}$  could be maintained with a plenum temperature of  $600^{\circ}\text{C}$  and the glass pool in automatic control with a set point of  $1150^{\circ}\text{C}$ . The increase to a  $700^{\circ}\text{C}$  plenum temperature yielded an estimated steady state feed rate of  $48\text{-}50\text{ cc/min}$ . A sample of the feed used for this testing had a measured density of  $1.1\text{ g/cc}$  and a  $47.4\text{ wt. \%}$  solids.

The off-gas was analyzed during this lower plenum temperature testing and the generation rates are shown in Figure 2. The data collected during this time was not consistent. The hydrogen concentration would remain steady for a few minutes and then disappear. The main

conclusion drawn from this test was that the hydrogen concentration was several orders of magnitude lower than that at 400 °C.

Figure 2



Although the main purpose of the 400-500° C plenum testing was not to determine melt rate, some observations were made. In order to maintain the lower plenum temperature, the cold cap was allowed to completely cover the glass surface. Visually observing the behavior of the cold cap during brief periods when feeding stopped allowed the maximum feed rate to be estimated. These values are shown in the table below.

<u>Plenum Temp</u>	<u>Estimated Feed Rate</u>
400 °C	25 cc/min
450 °C	29 cc/min
500 °C	34 cc/min.

The feed used during this test had a measured density of 1.2 and a 46.1 wt.% solids,

### 3.4 Continuous Operation

The final testing involved attempting to continuously pour the melter with a slightly negative pressure rather than using positive pressure pours as had been the previous practice. This was attempted because it would allow longer testing under normal conditions without having to stop and pressurize the melter. Since the glass stream from this condition is very fine, a method was developed to prevent the stream from hardening quickly and overflowing the container.

The glass stream also has a tendency to fall over to the side of the spout tip heater interior wall. A turntable was built and placed under the bucket beneath the pour spout. This allowed the glass stream to be continuously collected because the stream would harden in a horizontal plane rather than vertical. This method requires changing buckets several times an hour but was a vast improvement over earlier attempts. The continuous pour method allows testing to be extended without hitting the high glass level alarm and stopping the test to pour.

The continuous pour was started by initially feeding with a pressure of -4 inwc. After the glass level was increased the pressure was changed to + 4 inwc to initiate a pour. The set point was then placed at -0.1 inwc and the stream continued to pour. Feeding was reinitiated and both operations continued for ~ 12 hours. A few brief interruptions were encountered, but the system performed well. Hopefully future testing can be carried out using a continuous pour method. Since the pour rate with a full melter is greater than the current melt rate, it may be necessary to stop feeding periodically or delay the onset of pouring until a large glass inventory is obtained. This continuous operation would be more difficult at lower plenum temperatures since the feed rate is reduced. The feed rate sustained during this testing was ~ 53-55 cc/min. This glass pool was maintained at 1150°C and the plenum temperature was 800° C. The feed used during this testing had a measured density of 1.21 and a 46.2 wt% solids.

### 3.5 Actual vs. Indicated Plenum Temperature

In production melters the actual gas temperature differs from the measured temperature for a variety of reasons. The configuration of the thermowell and shine from the glass are two factors. Studies have been conducted to calculate the difference in several melters. Data was gathered during a variety of plenum temperatures and feed conditions to allow an estimate of this parameter in the minimelter. The data is summarized in Table 3. The actual raw data collected during this testing will be used to calculate the temperature difference. This information will be used in off- gas modeling and will be covered in a separate report. The feed used for all of the different test conditions had a total formate concentration of 43000 mg/l.

**Table 3 Plenum Temperature Conditions**

Date-Start/ Finish	Plenum Temp 3A(°C)	Plenum Temp 3B(°C)	Off-gas Temp T103(°C)	Off-gas Flow scfm	Purge Air scfm	Dilution Air scfm	CO2 flow #Mole/min	Feed Rate cc/min	Feed % Solids	Feed Density g/cc
7/26-10:35/15:58	799.9	801.6	157.8	3.9	3	1	7.05 E-5	55.3	46.2	1.21
7/24-13:55/14:43	499.6	501.2	92.9	4.0	1.8	1.8	5.71 E-5	32.9	46.1	1.24
7/25-9:40/11:00	599.8	601.5	119.9	3.9	3.1	0.93	5.74 E-5	36.6	47.4	1.11
7/25-12:50/2:00	699.9	701.7	142.6	3.9	2.7	0.93	7.73 E-5	52.8	47.4	1.11

### **3.6 Air Flow Measurement**

The off-gas flow is calculated using a helium tracer gas that is detected by the gas chromatograph. A known amount of helium is introduced into the off-gas line prior to the sample port. The helium concentration is measured and the total flow can be calculated. The known air supplies to the off-gas line prior to the sample port are the melter purge and the dilution air. Testing prior to feeding allow the inleakage to be estimated since it would be the only other source of air not being intentionally supplied. Initial testing indicated that there were errors in either the air flow meters or in the helium flow control. New MKS flow meters were calibrated and installed to measure the purge and dilution air flows. Since the flow meters were calibrated with equipment certified at STP, a correction factor must be used. The helium flow meter was checked using water displacement in a graduated flask. Actual helium flow was higher than indicated and a correction factor was added in the calculation. This factor was not added until near the end of the run, so the data in the files must be treated differently depending on the run date. The correction factors used are shown in Attachment E.

### **3.7 Feed System**

Part of the testing was completed with the new feed tube. This tube has a larger inside diameter (.180" vs .125") and a corresponding larger rod for plug removal. The system fed for much longer periods without plugging using the new tube. This enabled testing to be completed without the disruptions caused by plugging which leads to better steady state data. One observation during testing was the gradual drop in feed rate as the upper feed tank level was lowered. More frequent transfers may alleviate this problem. Another observation was that plugs frequently occurred immediately after a transfer. This may be due to particles passing through the lower strainer or particles falling from the side walls of the feed tank. A non-statistical review of the feed and glass sample results indicates that the feed system delivers a representative product to the melter. No consistent trends indicate that separation is occurring during the transfer and delivery process.

### **3.8 Feed Transition**

The feed remaining in the melter at the start of this run was a tank 42 simulant prepared in the Glass Feed Prep System (GFPS). An analysis of the tank 42 and the tank 8/40 blend feed is shown in Attachment B. Approximately one melter volume of the tank 8/40 blend material was fed to the melter prior to the start of low plenum temperature testing. Pour samples were taken periodically for analysis to determine the glass composition. Since the compositions of the two feeds were similar, it is difficult to determine turnover percentage based on chemical analysis. Descriptions and results from samples taken during testing are shown in Attachments C and D.

### **3.9 Process Parameters**

Data collection occurs automatically during testing. Additional information is recorded in the laboratory notebook, including setpoint and output changes. Table 4 represents average values during normal operation with feed rate of ~ 55 cc/min.

**Table 4 - Average Heater Parameters During Operation**

	Electrode	Spout	Lid Heater	Spout Tip
Set Point °C	1150	1100	850	1150
Amps	146	8	76	5.2
Volt	27	124	80	217
kW	6.1	1.1	6.1	1.1

During idle conditions the spout tip and lid heaters are turned off. The electrodes are in manual with an output of 28%. The spout heater is in manual with an output of 51%. This yields a glass pool temperature of ~1145 °C and a spout heater temperature of ~ 1000 °C. The spout heater temperature can vary depending on thermocouple placement, but the output is based on current and power rather than temperature.

### 3.10 Material Balance

In order to confirm the data collected during the run, a material balance was performed at several conditions. Calculations for two conditions are shown below.

CO<sub>2</sub> Balance:

Test date 7/26 from 10:35 to 15:58

CO<sub>2</sub> generation from feed:

$$\frac{55.3 \text{ cc}}{\text{min}} \times \frac{1.21 \text{ g}}{\text{cc}} \times \frac{1-.462 \text{ g supernate}}{\text{g feed}} \times \frac{43.1 \text{ g Formate}}{\text{L supernate}} \times \frac{1 \text{ L}}{1000\text{g}} \times \frac{1\text{mole COOH}}{45 \text{ g COOH}} \times \frac{1\text{mole CO}_2}{1\text{mole COOH}} = \underline{3.4 \text{ E-2 mole}} \text{ min}$$

CO<sub>2</sub> detected in off-gas:

$$\frac{0.0064 \text{ cu ft CO}_2}{\text{cu ft off-gas}} \times \frac{3.99 \text{ scf off-gas}}{\text{min}} \times \frac{\text{lb}}{359 \text{ scf}} \times \frac{454 \text{ g}}{\text{lb}} = \underline{3.2 \text{ E-2 mole}} \text{ min}$$

CO<sub>2</sub> Balance:

Test date 7/25 from 9:40 to 11:00

CO<sub>2</sub> generation from feed:

$$\frac{36.6\text{cc}}{\text{min}} \times \frac{1.11 \text{ g}}{\text{cc}} \times \frac{1-.474 \text{ g supernate}}{\text{g feed}} \times \frac{43.1 \text{ g Formate}}{\text{L supernate}} \times \frac{1 \text{ L}}{1000\text{g}} \times \frac{1\text{mole COOH}}{45 \text{ g COOH}} \times \frac{1\text{mole CO}_2}{1\text{mole COOH}} = \underline{2.1 \text{ E-2 mole}} \text{ min}$$

CO<sub>2</sub> detected in off-gas:

$$\frac{0.0052 \text{ cu ft CO}_2}{\text{cu ft off-gas}} \times \frac{3.96 \text{ scf off-gas}}{\text{min}} \times \frac{\text{lb}}{359 \text{ scf}} \times \frac{454 \text{ g}}{\text{lb}} = \frac{2.6 \text{ E-2 mole}}{\text{min}}$$

Balances using nitrogen are off by an order of magnitude. This is due to the difficulty in measuring NO and NO<sub>2</sub> in low concentrations.

### 3.11 Spout Heater

The lower coil of the spout heater failed during the last stages of feeding the tank 42 material. This did not effect the ability to pour since there was still enough heat in the area around the spout tip. The spout tip heater failed during the transition from tank 40 to tank 8/40 material. Additional insulation was added around the spout heater and pouring continued. The area around the spout tip was colder than before, but pouring was still possible. The addition of the turntable under the pour spout allowed the cooler glass to be collected in a more efficient manner. After the run was completed, the upper spout heater element failed. Both upper and lower spout heaters were replaced. The spout tip heater was not replaced. The element from the failed spout tip heater was removed leaving a larger diameter opening for glass to flow through during pouring. Since contact with glass caused the spout tip to fail, and pouring was successful without the tip heater, this option was chosen.

### 3.12 Predicted Properties

The analysis from the last pour sample (#MMG 016) of the run was used to predict the properties of the glass. Normally multiple samples are taken for use in the prediction model, but this was an attempt to provide a quick estimate of the values. The results indicate that the estimated values for liquidus, viscosity, homogeneity, and durability all fall within the accepted ranges using the PAR criteria. Both the current and new liquidus models were used. The results for all properties are shown in Attachment F for reference.

### 3.13 Improvements and Path Forward

Testing revealed several areas of improvement for the minimelter. Some were incorporated during this campaign such as the new feed tube and the turntable. Others will be delayed until future testing or may require an outage to incorporate. Prior to the next run the GC modules will be replaced for improved performance. A scale to measure glass pour rate will also be installed. Long term possible improvements include replacing the eductor with a blower and modification to the plenum to allow better cooling. A list of improvements is being developed for future consideration.

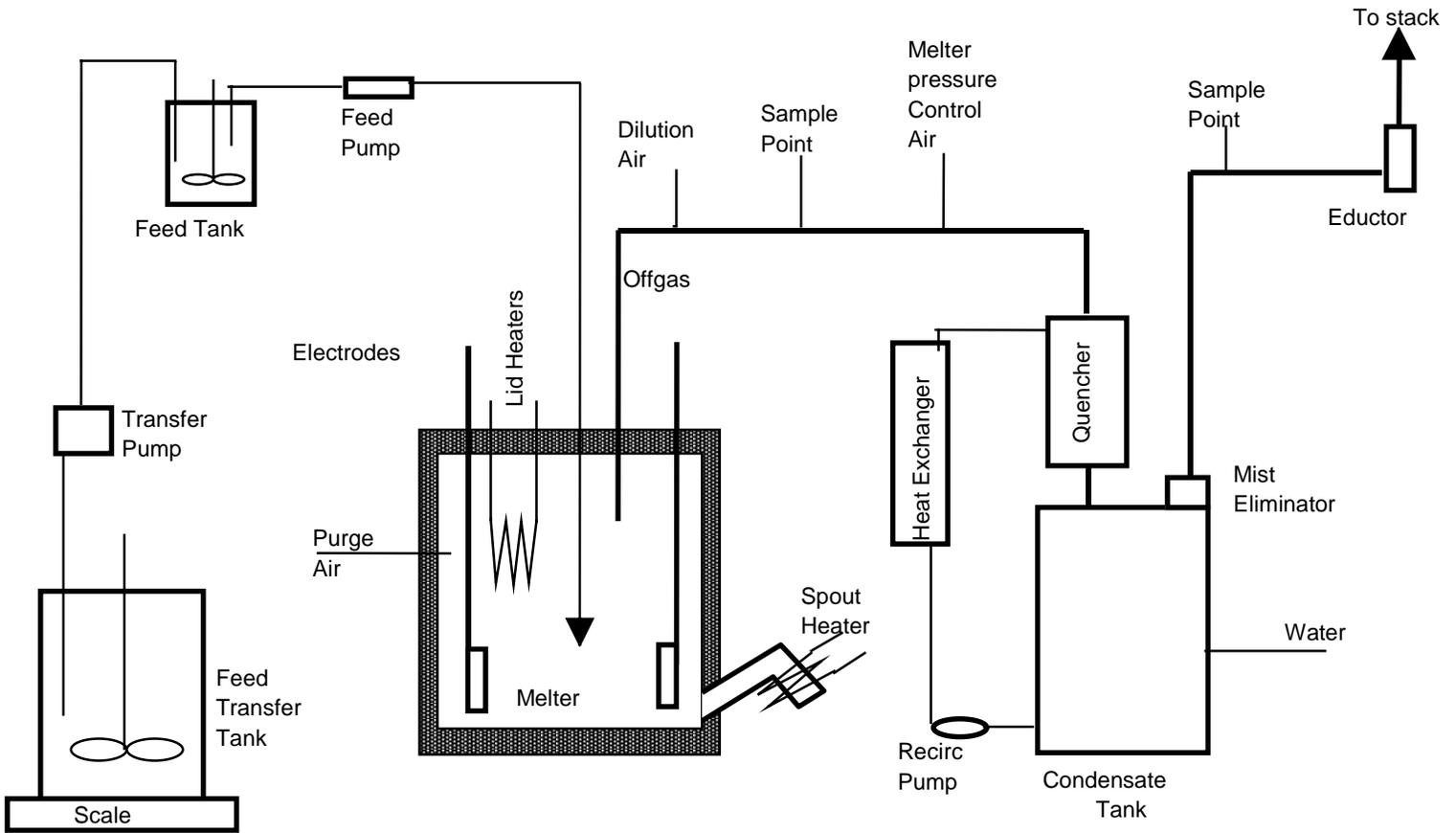
## 4.0 CONCLUSIONS

The testing allowed relative melt rates to be determined for several different conditions using the tank 8/40 blend and frit 200. This baseline should be useful in evaluating process or material changes designed to improve melt rate. The ability to continuously feed and pour for

extended periods will allow longer test times in the future. The new feed tube performed well in reducing the number of plugs. Process data collected during testing will be used in the future to estimate differences between actual and indicated plenum temperatures. The off gas analyzer system needs improvement and replacement modules have been procured for future tests. Additional instrumentation may be necessary depending on the type of analysis required. Baseline operating parameters were determined that can be used for comparisons in future campaigns.

### Attachment A

### 786-A Minimelter System



**Attachment B – Tank 42 and Tank 8/40 Blend Simulated Feed Composition**

<b>Oxide Wt %</b>	<b>Tank 42 Sample # MMF003</b>	<b>Tank 8/40 Blend Sample # MMF009</b>
Al <sub>2</sub> O <sub>3</sub>	5.44	5.24
B <sub>2</sub> O <sub>3</sub>	9.37	8.57
BaO	0.030	0.103
CaO	1.29	1.29
Cr <sub>2</sub> O <sub>3</sub>	0.127	0.138
Cu <sub>2</sub> O	0.012	0.057
Fe <sub>2</sub> O <sub>3</sub>	11.3	11.2
K <sub>2</sub> O	1.61	1.10
Li <sub>2</sub> O	3.68	3.35
MgO	2.22	1.52
MnO	1.44	1.12
Na <sub>2</sub> O	10.9	11.2
NiO	0.156	0.067
P <sub>2</sub> O <sub>5</sub>	0.224	0.081
PbO <sub>2</sub>	0.035	0.067
PdO	0.016	0.013
RhO	0.04	0.07
RuO <sub>4</sub>	0.005	.016
SiO <sub>2</sub>	52.6	49.4
ZnO	0.089	0.156
ZrO <sub>2</sub>	0.143	0.273

### Attacment C - Mini-melter Sample Log

Sample Number	Date	Description
MMF 003	5/31/01	Feed tank during short melt rate testing - Tank 42
MMG 004	5/31/01	Glass sample at end of pour
MMF 005	6/5/01	Feed tank
MMG 006	6/5/01	Glass sample near end of pour
MMG 008	6/18/01	Glass sample near end of pour
MMF 009	7/12/01	Transfer from hold tank to feed tank
MMG 010	7/12/01	Glass sample near end of pour
MMF 011	7/24/01	Transfer from hold tank to feed tank
MMG 012	7/24/01	Glass sample from end of pour
MMF 013	7/25/01	Sample from feed tank - very thick
MMG 014	7/25/01	Glass sample at end of pour
MMF 015	7/26/01	Upper feed tank
MMG 016	7/26/01	Glass sample at end of pressure pour

**Attachment D - Sample Analysis**

Units elementals: Elemental and Oxide wt%  
Units weight percent solids : %

Sample #	B	Li	Al	Ca	Cr	Cu	Fe	K	Mg	Mn	Na	Ni
MMF-003	2.91	1.71	2.88	0.923	0.087	0.010	7.87	0.103	1.34	1.12	8.11	0.123
MMF-013	2.88	1.60	2.77	0.948	0.083	0.043	7.76	0.135	0.886	0.837	8.23	0.433
MMF-015	2.75	1.54	2.82	0.924	0.098	0.044	8.03	0.140	0.915	0.864	8.44	0.440
MMF-005	2.70	1.66	2.78	0.908	0.081	0.012	7.57	0.110	1.33	1.08	8.26	0.116
MMF-009	2.66	1.56	2.77	0.924	0.094	0.046	7.85	0.143	0.915	0.866	8.33	0.433
MMF-011	2.69	1.57	2.79	0.955	0.098	0.043	7.90	0.139	0.929	0.873	8.48	0.444
MMG-004	2.50	1.78	3.20	0.767	0.168	0.152	6.91	1.14	1.18	1.31	7.65	0.331
MMG-006	2.46	1.67	3.18	0.781	0.168	0.134	7.18	1.01	1.22	1.29	7.71	0.225
MMG-008	2.61	1.65	3.01	0.860	0.114	0.088	7.50	0.562	1.08	1.08	8.10	0.325
MMG-010	2.61	1.64	2.98	0.897	0.125	0.072	7.57	0.425	1.01	0.998	8.32	0.354
MMG-012	2.66	1.64	3.02	0.916	0.125	0.071	7.70	0.394	1.01	0.997	8.29	0.369
MMG-016	2.71	1.60	2.96	0.936	0.111	0.057	7.85	0.259	0.959	0.920	8.47	0.415

Sample #	Pb	S	Si	Zn	Zr	Ba	P	Pd	Rh	Ru	Sr	Ti
MMF-003	0.032	0.032	24.6	0.072	0.106	0.027	0.098	0.014	0.003	0.003	0.005	0.103
MMF-013	0.057	0.073	23.3	0.124	0.208	0.091	0.034	0.014	0.004	0.011	0.084	0.042
MMF-015	0.061	0.083	23.3	0.120	0.211	0.092	0.034	0.000	0.007	0.010	0.087	0.044
MMF-005	0.034	0.037	23.1	0.071	0.105	0.027	0.108	0.010	0.003	0.001	0.005	0.094
MMF-009	0.062	0.089	23.1	0.126	0.202	0.092	0.035	0.011	0.006	0.012	0.084	0.036
MMF-011	0.059	0.077	23.7	0.127	0.213	0.092	0.034	0.003	0.006	0.011	0.085	0.038
MMG-004	0.061	0.055	23.3	0.046	0.349	0.046	0.069	0.002	0.007	0.001	0.029	0.149
MMG-006	0.057	0.042	23.4	0.052	0.304	0.043	0.075	0.007	0.008	0.001	0.026	0.142
MMG-008	0.059	0.064	23.7	0.085	0.254	0.067	0.057	0.009	0.004	0.008	0.054	0.090
MMG-010	0.058	0.068	23.3	0.098	0.236	0.078	0.046	0.010	0.007	0.003	0.067	0.071
MMG-012	0.059	0.073	23.8	0.098	0.239	0.079	0.046	0.010	0.006	0.005	0.068	0.069
MMG-016	0.060	0.083	23.9	0.115	0.236	0.088	0.041	0.015	0.006	0.008	0.079	0.053

Sample #	B2O3	Li2O	Al2O3	CaO	Cr2O3	CuO	Fe2O3	K2O	MgO	MnO	Na2O	NiO
MMF-003	9.37	3.68	5.44	1.29	0.127	0.012	11.3	1.61	2.22	1.44	10.9	0.156
MMF-013	9.27	3.44	5.24	1.33	0.120	0.053	11.1	1.06	1.47	1.08	11.1	0.550
MMF-015	8.86	3.31	5.33	1.29	0.143	0.055	11.5	1.10	1.52	1.11	11.4	0.559
MMF-005	8.69	3.57	5.25	1.27	0.118	0.015	10.8	1.60	2.21	1.39	11.2	0.147
MMF-009	8.57	3.35	5.24	1.29	0.138	0.057	11.2	1.10	1.52	1.12	11.2	0.550
MMF-011	8.66	3.38	5.27	1.34	0.143	0.054	11.3	1.11	1.54	1.13	11.4	0.564
MMG-004	8.05	3.83	6.05	1.07	0.245	0.190	9.88	1.42	1.96	1.69	10.3	0.420
MMG-006	7.92	3.59	6.01	1.09	0.245	0.168	10.3	1.46	2.03	1.66	10.4	0.286
MMG-008	8.40	3.55	5.69	1.20	0.166	0.110	10.7	1.30	1.79	1.39	10.9	0.413
MMG-010	8.40	3.53	5.63	1.26	0.183	0.090	10.8	1.21	1.68	1.29	11.2	0.450
MMG-012	8.57	3.53	5.71	1.28	0.183	0.089	11.0	1.21	1.68	1.29	11.2	0.469
MMG-016	8.73	3.44	5.59	1.31	0.162	0.071	11.2	1.15	1.59	1.19	11.4	0.527

Sample #	PbO	SO4	SiO2	ZnO	ZrO2	BaO	P2O5	PdO	Rh	RuO2	SrO	TiO2
MMF-003	0.035	0.095	52.6	0.089	0.143	0.030	0.224	0.016	0.004	0.005	0.006	0.171
MMF-013	0.062	0.220	49.9	0.154	0.281	0.102	0.077	0.016	0.006	0.014	0.099	0.070
MMF-015	0.066	0.250	49.9	0.149	0.285	0.103	0.077	<0.010	0.009	0.013	0.103	0.073
MMF-005	0.037	0.112	49.4	0.088	0.142	0.030	0.247	0.012	0.004	0.002	0.006	0.156
MMF-009	0.067	0.267	49.4	0.156	0.273	0.103	0.081	0.013	0.007	0.016	0.100	0.060
MMF-011	0.064	0.230	50.7	0.157	0.288	0.103	0.078	<0.010	0.008	0.014	0.100	0.064
MMG-004	0.066	0.165	49.9	0.057	0.471	0.052	0.158	<0.010	0.009	0.001	0.035	0.249
MMG-006	0.061	0.127	50.1	0.064	0.410	0.048	0.171	<0.010	0.011	0.002	0.031	0.237
MMG-008	0.064	0.193	50.7	0.106	0.343	0.075	0.131	0.010	0.005	0.010	0.063	0.150
MMG-010	0.063	0.203	49.9	0.122	0.319	0.087	0.105	0.012	0.009	0.003	0.079	0.119
MMG-012	0.064	0.218	50.9	0.122	0.323	0.088	0.106	0.012	0.008	0.007	0.080	0.116
MMG-016	0.065	0.250	51.1	0.143	0.319	0.099	0.093	0.017	0.008	0.010	0.093	0.088

	Total Solids	Soluble Solids	Insoluble Solids	Calcined Solids	Density	pH
MMF-003	43.0	5.14	37.9	39.0	1.28	7.18
MMF-013	47.4	5.29	42.1	43.1	1.11	7.31
MMF-015	46.2	5.16	41.1	42.3	1.21	7.00
MMF-005	43.5	5.48	38.0	39.2	1.32	7.24
MMF-009	47.5	5.13	42.4	43.5	1.21	7.12
MMF-011	46.1	5.36	40.7	43.4	1.24	7.12

## Attachment E

### Corrections To 786-A Melter Air Purge and Helium Tracer flows

Correction to He tracer flow, based on volume per time data taken.

500 ml of He was collected in 84 seconds.

The flowmeter read 295 ml/min. The temperature of the He was approximately 29.4 °C. The correction factor  $f$  is then:

$$f = \frac{\frac{500 \text{ ml}}{84 \text{ sec}} \times \frac{60 \text{ sec}}{\text{min}} \times \frac{273.16 \text{ K}}{273.16 + 29.4 \text{ K}}}{295 \text{ ml/min}} = \mathbf{1.093}$$

The resulting flow reading for the He tracer is then in standard ml/min, where standard conditions are 1 atm and 0 °C.

The MKS flowmeters for measuring the Melter Purge Air and Dilution Air were calibrated with 29.92 inHg (1 atm) and 70 °F as the standard conditions. The correction factor  $k$  is then:

$$k = \frac{273.16 \text{ K}}{273.16 + 21.11 \text{ K}} = \mathbf{0.9283}$$

The resulting flow readings for the air purges are then in standard L/min (slpm), where standard conditions are 1 atm and 0 °C. To convert to scfm, divide by 28.316847.

Example using data collected on 7/19/01:

Dilution Air flowrate reading ~6.0 cfm

Melter Air purge flowrate reading = 0

He tracer flowrate reading = 295 ml/min

He concentration in offgas from gas chromatograph = 0.2 ± 0.05 vol%

Melter pressure > 0 inwc (no air leakage)

Corrected Dilution Air flowrate = **5.57** scfm

Corrected He tracer flowrate = 322.4 ml/min

$$\text{Calculated Offgas Flowrate} = \frac{322.4 \text{ ml/min}}{\frac{0.20 \text{ vol\%}}{100}} \times \frac{\text{L}}{1000 \text{ ml}} \times \frac{\text{ft}^3}{28.316847 \text{ L}} = \mathbf{5.69} \text{ scfm}$$

**Attachment F – Predicted Glass Properties**

	$\Delta G_p$	<b>B Leaching</b>	<b>Li Leaching</b>	<b>Na Leaching</b>	<b>Current Liquidus</b>	<b>New Liquidus</b>	<b>High Viscosity</b>	<b>Low Viscosity</b>
<b>Property Value</b>	-8.4918	0.4338	0.5020	0.4476	994.19	996.95	80.40	80.40
<b>Property Unit</b>	kcal/mol	g/L	g/L	g/L	degrees C	degrees C	Poise	Poise
<b>PAR</b>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	<b>Homogeneity</b>	<b>Al2O3</b>	<b>TiO2</b>	<b>Cr2O3</b>	<b>Cu</b>
<b>Property Value</b>	222.68	5.59	0.088	0.162	0.057
<b>Property Unit</b>	wt% oxide	wt% oxide	wt% oxide	wt% oxide	wt% oxide
<b>PAR</b>	Yes	Yes	Yes	Yes	Yes