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Department of Energy

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OCT 2 1 1996

DOE-0073-97

Mr. James A. Saric, Remedial Project Director
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Region V - 5HSF-5J
77 W. Jackson Boulevard
Chicago, Illinois 60604-3590

Mr. Tom Schneider, Project Manager
Ohio Environmental Protection Agency
401 East 5th Street
Dayton, Ohio 45402-2911

Dear Mr. Saric and Mr. Schneider:

OPERABLE UNIT 4 VITRIFICATION PILOT PLANT PHASE I INTERIM TREATABILITY STUDY REPORT - CAMPAIGN 1

The purpose of this letter is to transmit the *Operable Unit 4 Vitrification Pilot Plant Phase I (Campaign 1) Interim Treatability Study Report*. This transmittal satisfies the recently proposed amendment to the reporting requirements for Phase I. As previously discussed and documented in the September 26, 1996, letter titled *Operable Unit 4 Vitrification Pilot Plant, Phase I Treatability Study Reporting*, the Department of Energy, Fernald Environmental Management Project (DOE-FEMP) proposed the submittal of interim reports following the completion of each of the Phase I campaigns in lieu of bi-monthly reports. The DOE-FEMP feels these reports, along with the weekly status meetings currently being held, will provide a better means for reporting status and facilitating decisions concerning the Vitrification Pilot Plant (VitPP).

As you are aware, the objectives of Campaign 1 were to establish Melter control, synchronize the operation of the Melter and the Gem Machine, and attempt to increase the glass output of the Melter. The enclosed report contains (1) a description of the work performed to meet these objectives; (2) pertinent data collected from both laboratory and pilot plant operations; (3) results with technical discussion and interpretation of the data; and, (4) lessons learned.

If you have any questions or concerns, please contact Nina Akgunduz at (513) 648-3110.

Sincerely,

Johnny Reising

Johnny W. Reising
Fernald Remedial Action
Project Manager

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OPERABLE UNIT 4 VITRIFICATION PILOT PLANT PHASE I INTERIM TREATABILITY STUDY REPORT

Campaign 1

40110-WP-0001
Revision 0

FLUOR DANIEL FERNALD

October 14, 1996
Fernald Environmental Management Project
Fernald, Ohio

OPERABLE UNIT 4
VITRIFICATION PILOT PLANT

PHASE I INTERIM TREATABILITY STUDY REPORT

40110-WP-0001-Campaign 1
Revision 0

Approval:

Don Paine (signature)

Silos Project Manager - Don Paine

10/16/96

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October 8, 1996

Fernald Environmental Management Project
Letter No. C:WMTSP(SP):96-0022

Ms. Nina Akgunduz
Department of Energy
Fernald Area Office
P. O. Box 538705
Cincinnati, Ohio 45253-8705

Dear Ms. Akgunduz:

OPERABLE UNIT 4 VITRIFICATION PILOT PLANT PHASE I INTERIM TREATABILITY STUDY REPORT -- CAMPAIGN 1

Enclosed is the Operable Unit 4 Vitrification Pilot Plant, Phase I, Interim Treatability Study Report for Campaign 1. All DOE-Fernald comments have been incorporated into this revision of the document.

If you have any questions or concerns on this matter, or require additional copies for transmittal to the agencies, please contact Rod F. Gimpel at (513) 648-4842 or Dennis A. Nixon at (513) 648-4800.

Sincerely,

Don Paine
Silos Project Manager

Fernald Environmental
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Ms. Nina Akgunduz
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Program Project #40110

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LIST OF COMMON ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirements
AWWT	Advanced Wastewater Treatment
AWWTS	Advanced Wastewater Treatment System
Ba	Barium
BAT	Best Available Technology
BST	Building Sump Tank
°C	degrees Celsius or Centigrade
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci/yr	curies per year
cm^2	square centimeter
Cr	Chromium
DACS	Foxboro Data Acquisition and Control System
DCS	Distributed Control System
DOE	U.S. Department of Energy
EOG	emergency off-gas
EOGS	normal emergency off-gas system
EOS	Emergency Off-gas System
EPA	Environmental Protection Agency
°F	degrees Fahrenheit
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
ft	feet (foot)
ft^2	square feet
ft^3	cubic feet
FACTS	Fernald Analytical Computerized Tracking System
gal/hr	gallons per hour
gpm	gallons per minute
HEPA	high efficiency particulate air
HNT	High Nitrate Tank
HVAC	heating, ventilation and air conditioning
HWMU	Hazardous Waste Management Units
kg/m^3	kilogram per cubic meter
KVA	kilovolt-amp
LAN	local access network
lb/d	pound per day
lb/hr	pound per hour
m^3	cubic meter
MAWS	Minimum Additive Waste Stabilization
MEF	Material Evaluation Form
MEPA	medium efficiency particulate air
mg/kg	milligram per kilogram
mg/l	milligram per liter
mrem/yr	millirem per year

MT	metric ton
MT/d	metric ton per day
NESHAP	National Emission Standards for Hazardous Air Pollutants
No.	number
NO_x	nitrogen oxides
OAC	Ohio Administrative Codes
OATP	Ohio Air Toxics Policy
OGS	off-gas system
OU1	Operable Unit 1
OU4	Operable Unit 4
OU5	Operable Unit 5
Pb	lead
PbO	lead oxide
PPE	Personal Protective Equipment
PSP	Project Specific Plan
RCRA	Resource Conservation and Recovery Act
RH	relative humidity
ROD	Record of Decision
SCFM	standard cubic feet per minute
S/cm	Siemens/cm, units for conductivity, equivalent to one ampere per volt per cm.
Se	selenium
SOP	System Operating Procedure
SOT	System Operability Test
SO_x	sulfur oxides
TBC	to be considered
TC	toxicity characteristic
TCLP	toxicity characteristic leaching procedure (RCRA)
TDS	total dissolved solids
TSS	total suspended solids
V	volt
VitPP	Vitrification Pilot Plant
VSL	Vitreous State Laboratory of the Catholic University of America, Washington, D.C.
W.C.	water column
WMB	white metal boxes
wt%	weight percent

1.0 EXECUTIVE SUMMARY AND TEST OBJECTIVES

1.1 Executive Summary

Testing and operation of the Vitrification Pilot Plant (VitPP) at the Department of Energy's Fernald Environmental Management Project (FEMP) near Fernald, Ohio has begun. The pilot program objective is to aid in demonstration and development of the vitrification of the K-65 residues that are currently stored in three concrete silos. A full-scale facility, with a capacity of 25 MT/d of glass, would take approximately 3 years to complete remediation. Due to the large capacity of the vitrification process and the nature of the silo wastes, a graded or phased development approach from laboratory to the full-scale facility was adapted to help assure success. This report summarizes development activities[1] through startup and Campaign 1 of the VitPP using a non-toxic, non-radioactive glass recipe know as "benign" glass. Further campaigns, that use "surrogates" to simulate the chemical makeup of the silo residues, will be performed in the near future and will be reported in separate reports. A final report, summarizing all the VitPP test Campaigns will be issued. A total of four campaigns has been planned for run for Phase I testing of the VitPP. They are:

Campaign 1 -- Startup and benign glass runs (this report)
Campaign 2 -- Glasses made from the blending of the silo residue surrogates
Campaign 3 -- Silo 3 surrogate glass recipes (being considered for omission)
Campaign 4 -- Silo 1 and 2 surrogate glass recipes

The VitPP has a high-temperature (up to 1400°C) Joule-heated[2] ceramic Melter rated at 1 metric ton of glass per day (MT/d) from slurries. The Melter is of a unique three-chamber design to protect the electrodes from the corrosiveness of the silo wastes[3]. The electrodes are protected from the center chamber glass pool

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[1]Development activities prior to operation of the VitPP are documented in other reports. However, their results will be summarized in this report and the future campaign reports to help make the contents of these documents more meaningful.

[2]Heat produced from current passing through a conductive material. In this case molten glass.

[3]The K-65 Silos are high in silica content, which is good for vitrification, but is also high in lead (Pb, 7 to 15 wt% Pb as PbO) and contains significant amounts of sulfates (approximately 2 w% as SO_3). Glass can normally hold only approximately 0.5 to 1.0 wt% SO_3. The extra SO_3 will then result in effervescence of SOx gases from the glass Melter or form a sulfate (SO_4) salt layer on top. However, techniques to destroy the sulfate layer were developed in the laboratory and bench-scale studies. Silo 3 is lower in silica, but high in magnesium, calcium, and iron, which are good fluxes and glass formers. However, it is also high in sulfates (SO_4) and phosphate (PO_4) (approximately 17 wt% and 11 wt% respectively) which can

which is oxygenated and agitated. The interior surface area of the Melter is 1 yd^2 (9 ft^2, 3 ft x 3 ft). By optimizing glass chemistry with melter design, approximately, 2 MT/d were obtained during this campaign. Production was not limited by the Melter and glass chemistry, but by supporting systems (i.e., slurry feed and off-gas systems).

Bakeout[4] and startup of the Melter went well. Bakeout of the Melter started on May 17, 1996 and ended with the charging of the glass and the insertion of electrodes in the Melter during June 6, 1996 through June 8, 1996.

The primary objectives during Campaign 1 were to:

1. Establish melter control
2. Synchronize the operation of the Melter and Gem Making Machine
3. Attempt to Increase the glass output of the Melter

The objectives were met. Further details are given in the following test and Section 3.2, "Objectives."

Preliminary testing of the Melter was performed between June 20, 1996 and June 23, 1996 by metering water into the Melter. While metering water into the Melter, operations personnel learned to control the Melter Feed Pump and documented the responses of the off-gas systems and the Melter to changes in the feed rate. Near the end of the test, a crack in the partition wall (E-Wall), between the west and main chambers, was noted. It was determined that the crack was due to thermal stress and would not significantly impact the performance of the scheduled test. Therefore, testing was continued.

On June 24, 1996, a slurry formulated to produce a benign glass was prepared and fed to the Melter. Testing and vitrification of benign slurry batches, to accomplish the goals associated with Campaign 1, continued through July 31, 1996. A total of 11 slurry batches and one frit batch (remelting of previously made glass) was processed. Table 1-1 shows the chemistry of the benign glass slurry in the melter. Approximately 55,000 lbs of slurry were vitrified to produce approximately 21,000 lbs of glass. Each slurry batch, of approximately 5700 lbs, produced approximately 2200 lbs (1 metric ton) of glass. The slurries contained an average of about 50 wt% solids. Most of the solids in the slurry produced glass. However, some of the solid compounds in the slurry decomposed to produce carbon dioxide (CO_2) and water (H_2O) that are lost to the off-gas system. For an example, calcium carbonate ($CaCO_3$, a glass additive) broke down to form calcium oxide (CaO, a solid), which becomes part of the glass, and carbon dioxide (CO_2, a gas). Thus, for this

hinder the vitrification process.

[4]Bakeout is a gradual heating of the Melter to protect the Melter refractories from thermo shock resulting in cracking and breakage. Bakeout took a couple of weeks.

Benign Glass for Campaign 1
Table 1-1

Basis: 100 lbs Glass from Slurry

Melter Input -- Feed

Oxide	Oxide's Chemical Name	Glass	Mix dry, wt%	Moisture wt%	Batch
Al2O3	aluminum oxide, alumina	10.92	10.92	2.71	11.22
B2O3	boron oxide	10.58			
CaO	calcium oxide, lime	14.56			
CaCO3	calcium carbonate (chalk)		25.99	0.72	26.17
Na2O	sodium oxide	14.53			
Na2B4O7	sodium tetraborate, borax		15.29	30.90	22.13
Na2CO3	sodium carbonate, washing soda		20.14	3.53	20.87
SiO2	silica dioxide, sand	45.41	45.41		45.41
ZrO2	zirconium oxide, zirconia	4.00	4.00		4.00
Total Solids	na	100.00	121.74	na	129.81
Water for 50 wt% Solids					129.81
Total					259.62

Melter Output

Glass	100.00
CO2 (to off-gas system)	19.79
Water (H2O to off-gas system)	139.83
Subtotal	259.62

Frit Addition Impact

Glass from slurry	100.00
Side chamber leakage (or frit addition), lbs glass:	5.00
Total glass produced, lbs:	105.00

campaign, about 2.6 lbs of slurry produced a 1 lb of glass. Also, glass frit, which was added to the side chambers, eventually flowed to the center chamber. There, the frit became part of the glass produced. Approximately 1900 lbs of glass was added to the side chambers. This increased the amount of glass produced approximately 9% for a total to 23,000 lbs.

The benign slurry was formulated to vitrify into a clear, colorless glass, but depending on the operation of the Melter (glass viscosity, melter temperature, melter retention time, etc.) the glass can have different colors. In Campaign 1, the glasses were different shades of green due to the varying concentration of chromium that eroded from the high-chromium refractories of the interior walls in the Melter. Glass produced by higher-viscosity formulas were lighter shades of green which indicate little erosion of the refractories. Other glasses were deeper shades of green, indicating more erosion.

Slurry and glass samples were collected for each batch and analyzed for chemical and physical characteristics. Analytical results indicated that the levels of chromium in the glass were low. This equates to 10 lbs of Cr_2O_3 being leached from the refractories during Campaign 1 which indicates slow erosion of the Melter refractory walls. Assuming uniform corrosion depths of the refractory surfaces and equal corrosion rates of the two refractories, approximately 0.750 mm of refractory in the Center Chamber, 0.091 mm in the East Chamber, and 0.178 mm in the West Chamber have eroded during Campaign 1. The refractories are 10.24 cm (4 inches) thick. Therefore, under these test conditions the Melter is expected to operate several years before needing to replace walls.

Another encouraging result was the low concentration of molybdenum ($<$0.05 wt% Mo) in the glass, since the amount of molybdenum in the glass is directly related to the electrode wear. This equates to 2.75 lbs of molybdenum in the glass produced during Campaign 1. There are approximately 1500 lbs of molybdenum in the electrodes. Future campaigns with the silo slurries will better define the expected life of the Melter.

Another characteristic of the Melter that was determined by chemical and physical analysis was the mixing ability. A blue tracer, cobalt, was introduced (in minute amounts) into one of the batches to determine the effectiveness of the Melter's agitation (due to the air bubblers located in the bottom of the Melter). Buildup and decay of blue in the succeeding batches were noted and recorded. Test results indicate that the Melter mixes glass well.

The maximum operating temperature for the Melter during this campaign was 1250°C ±20°C. (The Melter is scheduled to be operated and tested at 1350°C during Campaign 2.) Glass was produced up to 2 MT/d with slurries between 20 and 50 weight percent solids as determined by laboratory personnel. Campaign 1 testing provided evidence that the Melter has the capacity of producing glass at rates greater than 2 MT/d. The slurry feed system and the off-gas system were the limiting support systems of the Melter.

The Melter operated well, with one significant exception. This was occasional plugging at the discharge chamber. Originally, it was thought the glass was getting too viscous, but the glass measured only 47 poise which is well within expected operating range of the Melter of 10 to 80 poise. The plugging was later attributed to two problems:

1. The Melter and the discharge chamber were both operated at or above 1250°C. Consequently, the temperature in the wall(s) separating the two chambers is also around 1250°C which allowed glass to slowly creep between the refractories of the Melter and migrate to the discharge opening where it cooled and sealed it off. A cooling dam was placed in the discharge chamber to prevent the migration of the glass.

2. A common partition wall between the Melter and the discharge chamber is sufficiently porous to allow enough air to be drawn through the discharge chamber into the Melter to cool the glass, making it more viscous and sluggish as it flows through the discharge orifice. Attempts to restrict the flow during the campaign were only marginally successful. Monolithic pours into drums were generally successful. However, the ability to deliver a steady, a non wavering glass stream to the Gob Cutter of the gem-making machine[5] appeared to be frequently hampered by the inflow of air. More glass was poured into drums than was made into gems. This problem will be resolved in future campaigns.

Most of the problems that were encountered during Campaign 1 where not directly related to vitrification. But rather, they were due to other supporting systems. Most notably, the slurry feed and off-gas systems.

Since the Melter was operating with benign glass, several components of the off-gas treatment system were not activated. Figure 3-1 shows a schematic of the VitPP. The components that cooled and removed particulates from the exhaust gases were needed. Hot exhaust from the Melter is mixed with cool ambient air in a Film Cooler to reduce its temperature. This cooling is required to prevent plating out of glass-forming residues in the off-gas piping. The Quench Tower, in turn, drops the temperature (to approximately 130°F) so the rest of the wet off-gas treatment system can function properly.

Several restrictions or blockages occurred initially during Campaign 1 in the Film Cooler and the section of line going to the Quench Tower. These

[5]The VitPP has a Gem Making Machine designed and installed to work with the Melter to produce glass gems. A gem is a small semi-spherical piece of glass (about 5 grams) that looks like a squashed marble.

blockages appeared to be caused from molten particulates collecting and sticking to the interior walls of the Film Cooler and the pipe. An air lance was placed at the entrance of the Melter exhaust. This appears to supply enough cooling so the molten particulates freeze and pass through the Film Cooler and the pipe without sticking. Much less downtime is now experienced due to blockages in the off-gas system. It was also discovered that the off-gas fan did not have sufficient capacity to establish the required flow rates in the piping and the negative 2 inches WG target, so it was replaced with a new larger fan. The larger fan provided additional capacity but it still is not sufficient and further modifications are being considered.

Downtime experienced during Campaign 1 was frequently caused by problems with the slurry preparation and feed system, and to a lesser extent, the off-gas treatment system. A significant amount of time was spent on removing clogs from piping, repairing/replacing Slurry Tank Pumps, and repairing the Melter Feed Pump. The following are the causes identified which led to these problems.

Slurry Feed System

- Sharp bends (elbows) in the piping provide sites for the solids to collect.
- The piping is too small for the long runs, thereby, restricting the flow.
- Pump design, seal design, and materials of construction selected were not appropriate for the task of transferring the abrasive slurry. The slurry appears to wear at the diaphragms, internal valves, seals, and shafts of the pumps excessively.
- Clogging of pipes between the bag dump station (where dry chemicals are introduced to the slurry system) and the slurry tanks were caused by a combination of moisture in the system, chemical, and physical characteristics of the materials used, and limited ability of the mechanical system. Operational steps were taken to address the problem which included adding the bags of material slowly and adjusting the order in which the materials were added.

Off-gas Treatment System

- Frequently, the (normal) off-gas treatment system had insufficient capacity to handle the pressures developed when the cold cap collapsed, clogs in the Melter feed pump line dislodged, or flush water was introduced into the Melter. The emergency off-gas tripped when these scenarios occurred.

Normally the emergency off-gas systems activated for only a few seconds.

Prior to the operation of the VitPP Melter, it was understood that there would be a migration of glass between the Melter chambers. To protect the molybdenum electrodes, a non reactive glass was developed to bathe and protect the electrodes. The side chambers were not expected to be leak-tight. Therefore, migration from the side chambers to the center chamber is encouraged. It was estimated that approximately 100 pounds of glass frit would need to be added to the side chambers (50 pounds per chamber) daily to ensure flow from the side chambers to the center chamber instead of vice versa. As Campaign 1 testing progressed, it became apparent that glass migrated more from the west chamber to the center chamber than from the east chamber to the center chamber. The frit addition hoppers for the side chambers clogged during bakeout and frit is now added with a portable funnel through side-chamber view ports located on the top of the Melter.

Operation of the Gem Making Machine did not cause downtime, but was a hindrance to keep operating. Continuous operation and production of the Gem Making Machine were not consistent. During early testing, it was observed that the benign glass was too viscous for successful gem making. The glass would stick to the Gob Cutter, string around the Gob Cutter, or spatter off the Gob Cutter; resulting in the production of irregularly shaped gems, gems with "tails," and fiberglass. Later, there were problems with the lubrication system. As testing proceeded, the lubrication methods were changed, but the problem persisted. Additionally, some solutions resulted in filling the glass receiving drum with the lubricating solution (graphite in water). Then it became apparent. The Gob Cutter was getting too hot, and thereby, allowing the glass to stick and "gum-up" on the cutter. Redirecting air flow helped cool the cutters somewhat and allowed the production of a few tons of gems. However, better means of cooling (e.g., water cooling) the cutter is needed for long production runs and is being investigated.

1.2 Objectives

In accordance with the OU4 VitPP Phase I Test Plan (18-SU-0003, Rev. 2), three objectives were to be accomplished during Campaign 1. Results of Campaign 1 relative to each objective follow.

Objective 1 - Establish Melter Control

Data presented in this report shows that a good understanding of the operation of the Melter has been achieved. Temperature of the main bath was maintained within an acceptable range during steady-state and transient conditions throughout Campaign 1. The empirical data supports theoretically calculated values. For example, theoretical calculations showed that the side chambers (even though they contain the electrodes and are stagnant) run at lower temperature(s) than the main center bath. The amount of power needed to maintain a temperature in the Melter for various operating scenarios is understood. For example, the following power requirements are needed for benign glass in the Melter at 1250°C:

Condition	Kilowatts
Running Idle	100 - 135
Power to process 1 metric ton/glass, 50 wt% solids	170 - 210
Power to run idle at 1150°C	90 - 100
Approximate transient power to increase/ decrease Melter main bath 100°C	40 - 50

The glass chemistry for this campaign appears to be complimentary to the Melter design. The glass chemistry allows the Melter to operate at voltages and amperages well within the operating range of the Melter. Also, the Melter functions properly with the viscosity ranges of the glass.

All pilot plant crews (and laboratory personnel) participated in Campaign 1 and received hands-on experience operating the VitPP Melter and its associated systems and programs. The laboratory analyses validated that the batches were mixed properly and that the Melter produced the correct recipe glass.

Objective 2 - Synchronize the Operation of the Melter and Gem Making Machine

Synchronization of the Melter and Gem Machine was achieved during Campaign 1. Glass gems were made after melter control was established and its operation was understood. A few metric tons of glass gems were produced. It was determined that the preferred method for making gems is in batches (or sometimes called lifts). This is accomplished by letting the Melter acquire glass for an hour or two and then discharge for one-half to one hour. The extra heat associated with the higher flow at the Melter discharge seems to work better. The major problems encountered with making gems are those previously mentioned about the Gob Cutter overheating and the wavering of the glass from the discharge chamber. These will be addressed further in subsequent campaigns.

Objective 3 - Attempt to Increase the Glass Output of the Melter

As mentioned, the Melter produced at a rate of approximately 2 MT/d of glass at 1250°C. The Melter appeared to be capable of producing more than 2 MT/d of glass except feed and off-gas system shortfalls would not allow the Melter to produce at a higher rate. Corrections to the off-gas system increased its capacity toward the end of the campaign; however, the feed pump could not deliver feed at rates more than 2 MT/d. Another run is planned for Campaign 4 at 1350°C with a new feed pump. Increasing the temperature normally increases production rates and should allow production rates of 3 MT/d and greater. Bench studies done at the Catholic University of America's Vitreaous State Lab estimate that the Melter could produce rates between 3 to 5 MT/d glass at 1350°C.

1.3 Future Phase I Campaigns, Testing, and Work

Following campaign 1, the following testing is scheduled:

Campaign 2 -- Glasses made from the blending of the silo residues (Series D[6])

Campaign 4 -- Silo 1 and 2 glass recipes (Series A and B)

Campaign 3 -- Silo 3 glass recipes (Series C, presently being considered for omission)

Additionally, modifications may be necessary to the VitPP's facilities and to the glass chemistry during execution of the campaigns, to improve performance. Key findings (as cited in the Executive Summary) are that the present slurry feed and the off-gas systems need modifications to increase the availability of the VitPP. Potential modifications needed are being evaluated and plans are being made to incorporate the selected modifications into the VitPP facilities between Campaigns 2 and 4.

A brief discussion of each of the remaining campaigns is described in below:

1.3.1 Campaign 2

Campaign 2 will be performed with Series D surrogates. This campaign will be completed in two runs.

[6]During glass formula development studies, the glasses made were grouped according to the silo wastes they contained (or simulated). This designation has continued. Series A contains a blend of Silos 1 and 2. Series B is the same as Series A except it also contains high concentrations of the bentonite cap in the Silos. Series C contains only Silo 3. Series D contains a blend of all three silos.

The first run is known as the "Acceptance Test" and will be performed in accordance with the procurement specifications for the VitPP's Melter and Gem Making Machines. The prescribed glass slurry recipe contains one-third each of the silos surrogates blended with bentonite. The blend purposely has higher than average sulfate and phosphate concentrations to functionally test the Melter. The Melter must successfully process this slurry at a rate of 1 MT/d for 36 hours and produce glass gems for 8 hours before the Melter can be accepted. The glass will be processed at 1350°C.

The second run will be performed with a representative blending of the silo wastes. The purpose of this run is to demonstrate the VitPP's capability for processing the optimal Series D formulation. This glass will be processed at 1250°C which is the midrange operating temperature of the Melter.

This campaign will collect information relating to three areas of the glass formula, melter, and off-gas system capabilities.

a. The effects of lead, sulfate, nitrate, and phosphates on the Melter performance and the glass formula.

b. SO_x and NO_x handling capabilities of the off-gas system.

c. Devitrification potentials of the poured glass.

1.3.2 Campaign 4

Campaign 4 will be performed with Series A and Series B surrogate formulation. These runs are planned to be performed at 1250°C. A third run may be performed at 1150°C depending on performance of the first two runs. The major concern is that the destruction of sulfates at 1150°C may not be possible. Specialized glass formulations may be required to facilitate running at 1150°C in an effort to maintain reasonable waste loading. However, if the sulfates are destroyed (or contained by the glass), then a low temperature melter may be considered in future design.

The operation of the thickener will also be tested during this campaign. Bentonite is considered to be the hardest constituent to be handled by the thickener.

1.3.3 Campaign 3

The Campaign 3 run will be performed with Series C glass formulation. This run will collect information in the areas described in Campaign 2. However, the effects of sulfate, nitrate, and phosphate will be more significant since the constituents of a Series C (Silo 3) slurry contains higher concentrations of these constituents.

This campaign is currently being considered for elimination from the Phase I testing as Silo 3 material would be blended with K-65 material (Silos 1 and 2 residues) in the event it is finally vitrified.

2.0 GLASS FORMULA DETERMINATION

During Campaign 1 a non radioactive benign startup glass (containing none of the hazardous or radioactive constituents of K-65 material) was used to focus on melter control, Gem Machine operation, and increasing the output of the Melter to its maximum capacity. The effects of processing material that is chemically similar to K-65 material will be dealt with by using surrogate glass formulas in subsequent campaigns. This section will discuss the glass chemistry necessary to operate the Melter and detail the characteristics of the startup and electrode glass.

2.1 Glass Chemistry

Chemistry of the molten glass is tailored to match the Melter design. In return, the Melter is tailored to match the glass chemistry. Technically, it is very difficult, or even impossible, to dissociate the two, but it is commonly done from a development perspective. Additionally, glass chemistry is tailored to meet glass product forming, as well as disposal requirements.

2.1.1 Viscosity vs. Temperature

Viscosity is probably the most important parameter to characterize for a prescribed glass. If the glass melt becomes too thick, the waste dissolution (glass production) rates will decrease and may result in possible stoppage and/or pluggage of the Melter. If the glass melt is too thin, glass can leak through joints and result in problems causing premature corrosion and erosion of the equipment. Additionally, glass form production (e.g., gem production) is sensitive to glass viscosity.

The desired viscosity of the molten glass in the Melter is between 10 and 80 poise. Due to temperature loss during Melter discharge and glass form production, the viscosity of the glass may increase. For gem production, it is expected that the viscosity of the glass gob should not be below 200 poise when it reaches the conveyor. This allows the gob of glass to flow and have enough time to "pull" itself together, much like water "beads" on the surface of freshly a waxed car. If the glass is too thick, the glass does not have enough time to form a gem before it freezes.

2.1.2 Conductivity vs. Temperature

Like viscosity, characterization of the glass conductivity is necessary for joule-heated melter operation. The VitPP is a joule-heated melter where electrical resistance of the glass produces the heat for melting. A low conductive glass requires electrical transformer taps that produce power at a higher voltage and lower amperage, compared to a high conductive glass that requires electrical transformer taps that produce power at a lower voltage and higher amperage.

In the VitPP, if a glass is too conductive, excessive heat is generated in the Melter, electrode chambers and/or the electrically semi-transparent walls, resulting in less heat transfer to the glass melt. This could cause melter failure or premature deterioration of key melter components. Increasing resistivity of the glass melt requires increasing voltage in order to put in the same amount of power. A glass that is too resistive may exceed the voltage capability of the Melter. With the three-chamber melter design, the conductivity of the side chamber (electrode chamber) glass is also very important. Originally, it was felt that the side-chamber glass should be of much higher conductance (five times higher) than the waste glass in the main chamber so that the side chamber glass generates less heat (this allows most of the heat to be generated in the main chamber glass). However, recent minimelter runs and calculations show the side chamber should remain cool even with more resistive glasses. Current design values for glass conductivity (resistivity) have been approximated at 1.0 Siemens/cm (S/cm, 1.0 ohm·cm) for the side chamber glass and 0.15 to 0.33 S/cm (3.0 to 6.7 ohm·cm) for the main chamber.

2.1.3 Liquidus Temperature Range

Liquidus temperature range is a temperature band below (and often near) the melting point of glass where crystallization, precipitation, and/or phase separation occurs within the glass melt given enough time. Different glass compositions have different liquidus temperature range profiles. The best liquidus temperature profile is one that is narrow, allows a low melting point of the glass, and has minor sensitivity to compositional changes. A wide profile, or one that approaches the melt temperature, can make pouring and forming glass difficult because the glass can crystallize or separate (decompose) as it cools before it has a chance to solidify. Likewise, a liquidus temperature profile that approaches the operating temperature can result in high viscosity and blockage(s) where the temperature can drop (e.g., the discharge chamber). A liquidus temperature profile that is sensitive to compositional changes can result in blockage of a melter if the melter feed composition inadvertently drifts.

For operation of the VitPP, the glass will automatically pass a liquidus temperature evaluation if visible crystals, phase separation, or other defects are not detected at a temperature 200°C below the glass's operating conditions in the Melter. Minor crystallization (precipitation) may be acceptable if the glass melt appears it can keep the crystals suspended without bunching together since such a condition may not cause blockage within the Melter.

2.1.4 Redox[7] Control

Redox control in the VitPP Melter is a significant concern when processing actual waste since it has the potential for adverse effects on the electrodes. It is not a

[7] Redox is a term used to describe the amount of oxygen in a system. It is short for Reduction oxygen potential.

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concern in Campaign 1 using the benign glass formulas. For actual waste materials and surrogates, adverse reduced redox conditions in the VitPP Melter are mitigated because the electrodes are protected in the side chambers and oxygen feed to the melt bath with the agitation air should keep sufficient oxygen to prevent the "soft" metals, such as lead (Pb), from precipitating. Their precipitation would put elemental metal(s) in the glass melt and possibly produce a short across the electrodes. High temperatures and/or running idle with low agitation may result in some reduction in the redox state. Urea may be used, as a reductant, to destroy/control sulfate at the molten glass surface. However, it should not significantly affect the redox of the molten glass in the bath.

2.1.5 Foaming

Foaming is a release of gases within the glass bath which causes the whole glass mass to swell (or foam). It becomes less likely for foaming to happen if the reactions happen closer to the surface and the gases can be easily released. Thin (less viscous) glasses are less likely to foam because the bubbles that trap the gases "pop" at the surface and do not have the chance to collect and build up a "head." Foaming of the glass melt was shown to be a potential problem in the Battelle Pacific Northwest Laboratory (PNL) crucible melts and several of the Fernald melts.

Conditions that cause foaming can be a change in redox or temperature. It was found in minimelter Vitreous State Laboratory (VSL)[8] runs that the latter appears to be the case with the silo wastes. Foaming seems to have occurred in the minimelter runs when the glass was discharged, feed to the melter ceased, or the temperature of the melter was ramped up too quickly. The minimelter is not temperature controlled, but rather, power controlled. Therefore, when the glass was discharged or the feed to the melter ceased, the same amount of power went into the smaller volume of glass. The net increase of power per unit mass of glass resulted in the temperature climbing. Since gas solubility decreases with increasing temperature, the saturated molten glass released dissolved SO_4 as a gas. Provided the glass is viscous enough and the temperature increase is quick enough, foaming occurs.

Foaming events were controlled in the minimelter by decreasing the viscosity of the glass through glass chemistry, increasing power into the melt slowly, and destroying sulfates with urea. Foaming events were noticed in the minimelter with Silos 1, 2, and 3 surrogate glasses.

2.1.6 Devitrification

Devitrification (opacity, crystal formation, precipitation formation) upon cooling of the final product is permitted as long as it does not cause the final product to fail

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[8]VSL is part of the Catholic University of America located in Washington, D.C.

the Environmental Projection Agency's Toxicity Characteristics Leaching Procedure (EPA TCLP) test, or impair the glass forming or handling properties of the glass (e.g., create excessive breakage in gems). Silo 3 glasses are more prone to devitrification because the glass is more "basic" (which generally implies less glass formers) in nature than the Silos 1 and 2 glasses. The silo glasses devitrify and form crystals at their liquidus temperatures much like their igneous "ultra basic" mineral/rock counterparts. Below is the general characterization of glasses (and igneous rocks):

Acid	Mostly made of glass formers. Over 65 wt% silica.
Basic	Contains 45 wt% to 55 wt% silica. Generally rich in ferro-magnesium type minerals.
Ultra Basic	Contains less than 45 wt% silica. Contains significant amounts of alkali and alkaline metal oxide, etc. Prone to form crystals like spinels, etc.

The study of igneous rocks and minerals gives additional insight of how the silo glasses may behave and what precipitates and crystals may form within the glasses, provided conditions are right.

2.1.7 Additives

Additives are necessary to impart the desired properties necessary to make glass in the Melter. The following paragraphs list and summarize additives used during the development program. A brief summary is provided to discuss the effect of the additives.

Fluxes: these lower the melting point of the glass formers.

- Sodium oxide (added as soda ash, Na_2CO_3)
- Calcium oxide (added as chalk, $CaCO_3$)
- Lithium oxide (added as lithium carbonate, Li_2CO_3)
- Boron oxide (added as boric acid or borax pentahydrate)
- Fluoride (metal fluorides)

All fluxes lowered the viscosity of the glasses and all, except fluoride, could be used as fluxes in the final glass formulas. Lithium (Li) is the most effective flux (produces the highest waste loading), but is also the most expensive. Boron (B) is the next most expensive. Studies may be necessary to determine if the extra material costs are warranted.

Modifiers: impart some desired property to glass.

- Aluminum oxide -- used to help the dissolution of phosphates into the glass and improve durability of the glass (added as alumina).

- Boron oxide -- used to make the melt more vitreous and help prevent devitrification of the glass upon cooling (added as boric acid or borax pentahydrate).

- Calcium oxide -- used to stabilize the glass and possibly aid in the handling and destruction of sulfates in the glass (added as chalk, $CaCO_3$).

- Urea -- used as a reductant. It is used successfully to destroy sulfates without reducing lead from the glass melt.

2.1.8 Additive Moisture and Type vs. Cost

The feed system to the Melter is only capable of pumping slurries up to some certain wt% solids (possibly, 50 wt%). The extra moisture may be in the form of hydration. Even though it is water, water of hydration adds to wt% solids from a pumping standpoint, but actually reduces the wt% of solids delivered to the Melter from a vitrification standpoint. Therefore, chemicals with lower water of hydration are preferred. However, with some chemicals there may be no choice because once they are introduced into the water, they will automatically hydrate to a level they naturally prefer.

2.1.9 Retention Time

Melters in the commercial glass industry tend to be large with long retention times. Long retention times, on the order of several days, are required to make a good optical glass. This is because it takes time for all chemical reactions to come to completion. What is more important, it takes time for the gases and minute bubbles to leave the bath and all thermogradients in the glass to disappear and give an optically pleasing glass. However, this is not necessary in making a waste glass destined for disposal. Melters tend to make glass that is more durable and do better with the TCLP test than the crucible melts. This is largely because the glass generally spends more time forming in the Melter. The crucible melts are heated between one and four hours. The retention time in the Melter is normally several hours to a couple days.

For silo materials and surrogates, retention time is closely related to sulfate destruction and cold cap formation, which is in turn, is related to the production rate. If the retention time is too short, sulfate layers can form because the sulfates are not being destroyed fast enough. Likewise, a cold cap will form, when the production rate limit (for a given glass formula, temperature, agitation, etc.) is approached.

2.2 Startup Glass

The startup glass was picked from a series of historical glass melts not related to the OU4 project. However, the properties of these glass melts had characteristics desirable as a startup glass -- for example, startup glass is used to "season" the melter and seal the refractories prior to the introduction of potentially corrosive glass formulations. The startup glass is sometimes referred to as the "Wet-16" glass[9]. Other parameters for the glass were:

1. The glass must contain no toxic/RCRA components.

2. The glass must be clear and colorless so color changes, indicative of process, could be seen in the glass produced.

3. The glass must be non corrosive to the Melter parts. This is the main reason for placing zirconium in the glass. Zirconium has been known to coat refractory bricks and limit corrosion/erosion.

4. The glass must assist bake-in and sealing the refractories in the Melter during Melter startup. The VitPP Melter glass was preformed into glass frit and then directly added to the Melter during bake-in and startup of the Melter.

5. The glass must be relatively inexpensive.

Tables 2-1, 2-2, and 2-3 list relevant chemical and physical properties for the VitPP Melter startup glass.

[9]"Wet" refers to a series of laboratory crucible melts performed to develop the glass chemistry for a non-Fernald related project at VSL. However, some of these glasses have the properties desirable for the VitPP's benign glass. The one chosen was the 16th melt; thus, "Wet -16."

Table 2-1
Startup Glass Makeup and Properties

Component	**Startup Glass** Wet-16 Component (wt%)	**Startup Glass Mix** Slurry Feed, Typical Component (wt%)
Al_2O_3, aluminum oxide	10.92	10.92
B_2O_3, boron oxide	10.58	
CaO, calcium oxide	14.56	
$CaCO_3$, calcium carbonate		25.99
Na_2O, sodium oxide	14.53	
$Na_2B_4O_7$, borax		15.29
Na_2CO_3, sodium carbonate		20.14
SiO_2, silicon dioxide	45.41	45.41
ZrO_2, zirconium oxide	4	4
Total	100	121.74
Appearance upon cooling	Clear and colorless	Above amount will make 100 units of startup glass.
Liquidus Temperature	<850°C	
Density, g/cm^3	2.6	

Table 2-2
Temperature vs. Conductivity for Startup Glass

Temperature (°C)	Conductivity(S/cm)
1000	0.09
1050	0.11
1100	0.15
1150	0.18
1200	0.23
1250	0.28

Table 2-3
Temperature vs Viscosity for Startup Glass

Temperature (°C)	Viscosity (poise)
1000	588
1050	258
1100	135
1150	79
1200	51
1250	35

2.3 Electrode Glass

The electrode glass is a benign (or clean) glass that is placed in the side chambers to protect the molybdenum electrodes from oxidation and corrosion and conduct electrical power from the electrodes to the partition wall. The electrode glass, C4EG-10[10], was selected from a series of 14 crucible glass melts. The electrode glass's composition and properties are listed in Table 2-4. A criterion for performing the melts was to select a glass with the following properties:

1. Same density as the proposed surrogate waste glass, 2.6 g/ml.

2. Conductivity four times the proposed surrogate waste glass, 0.9 S/cm at 1300°C.

3. Appropriate viscosity in the temperature range of 1200°C to 1350°C (i.e., 43 poise at 1300°C.)

4. Liquidus below 1000°C.

5. No significant volatility of glass components (0.5 wt% max) after 72 hours at 1350°C.

6. Minimal corrosion of molybdenum, E-brick™, and K-3™[11] brick (Melter's refractories) after 72 hours at 1400°C.

Included in Table 2-4 are analyses of samples taken of the electrode glass from the East and West chambers after Campaign 1. Notice that some of the startup glass from Campaign 1 has flowed into the electrode glass. This is evident by the lower lithium concentration and the appearance of boron in the glass. Knowing the components that make up the startup glass (as shown in Table 2-4) one can calculate the amount of startup glass that flowed into the electrode glass. Approximately 18% of the side chamber glass comes from the main chamber glass. This number was evaluated using both lithium and boron concentrations as a basis. Tables 2-5 and 2-6 show the change in glass viscosity and conductivity with respect to temperature.

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[10]A series of crucible melts to determine a good electrode glass was performed. The series is called C4EG for "CRU4 Electrode Glass" and the "-10" is the 10th melt done in this series.

[11]E brick and K-3 bricks are trademark names for high-chromium containing refractory bricks supplied by Carborundum. The E brick contains very high chromium, and is therefore, there is more conduction and is used for the Melter's partition walls.

Table 2-4
Frit and Chamber Glass Makeup and Properties

Component	**Electrode Frit Glass** C4EG-10 Comp. (Wt%)	**East Chamber Glass** Aug. 12, 1996 Comp. (Wt%)	**West Chamber Glass** Aug. 12, 1996 Comp. (Wt%)
Al_2O_3, aluminum oxide	12.7	12.47	12.42
B_2O_3. boron oxide		1.89	1.87
BaO, barium oxide		0.61	0.67
CaO, calcium oxide	6.4	6.69	6.85
Cr_2O_3, chromium oxide		0.13	0.11
Fe_2O_3, iron oxide		0.42	0.27
K_2O, potassium oxide		0.25	0.22
Li_2O, lithium oxide	10.1	8.38	8.17
MgO, magnesium oxide	4.1	4.1	3.5
Na_2O, sodium oxide	5.3	6.14	6.23
SiO_2, silicon dioxide	55.3	54.34	54.09
ZrO_2, zirconium oxide	6.1	4.87	5.32
Total	100	100.29	99.72
Appearance upon cooling	Clear pale-green	Dark green	Dark green
Liquidus temperature	<900°C	<900°C	<900°C
Density, g/cm^3	2.6	2.6	2.6

Table 2-5
Temperature vs. Viscosity for Electrode Frit Glass

Temperature (°C)	Viscosity (poise)
1150	144
1200	91
1250	61
1300	43
1350	31

Table 2-6
Temperature vs. Conductivity for Electrode Frit and East Chamber Glass

Temperature (°C)	Electrode Frit Glass Conductivity (S/cm)	East Chamber Glass Conductivity (S/cm)
1000		0.238
1050		0.336
1100		0.461
1150	0.36	
1200	0.51	
1250	0.69	
1300	0.92	

3.0 VitPP SYSTEMS

The operation of various systems in the VitPP during Campaign 1 is detailed in the following subsections. Figure 3-1 is a process flow diagram which shows the movement of material through the VitPP. Deviations from this diagram are noted since some systems were not required to operate during Campaign 1.

3.1 Feed Preparation

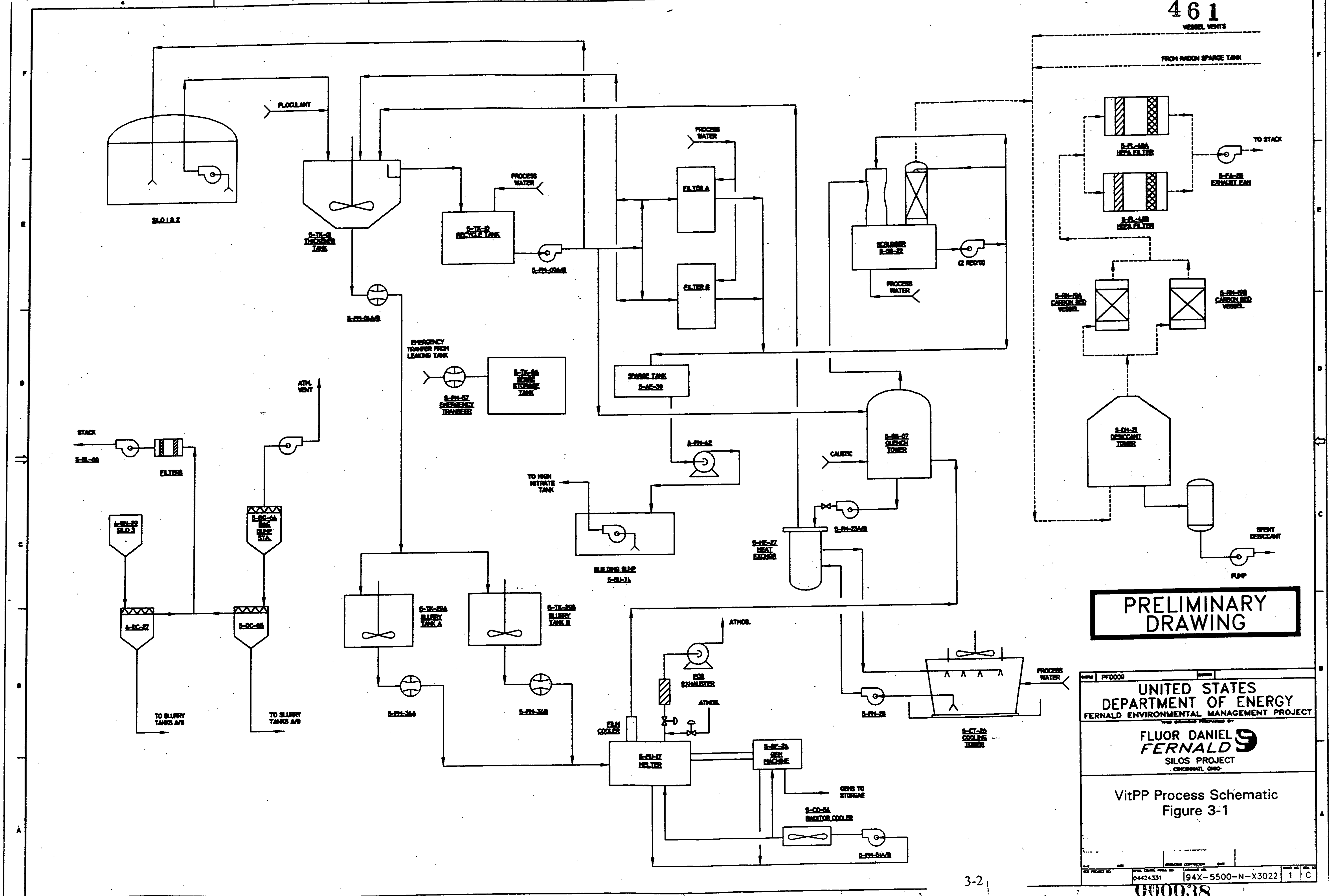
The equipment for introducing additives to the feed includes a standard industrial bag slitting and dumping station. The bag dump station has its own ventilation fan and includes filters to control fugitive dust during the dumping operation. The surrogate and additive materials, which are introduced as dry powders, are pneumatically conveyed to a filter/receiver unit. Exhaust from the filter/receiver is vented by a vacuum blower (that draws through a HEPA filter unit) prior to release through the VitPP exhaust stack.

Solids from the filter/receiver fall into one of two slurry tanks for mixing with water. Slurry is agitated with turbine agitators and re circulated with double-diaphragm slurry transfer pumps to maintain the slurry in suspension. The slurry transfer pumps re circulate the slurry through either (1) a short loop directly back to the slurry tank or (2) through a longer loop to the Melter Feed Pump and back to the slurry tank.

During Campaign 1[12], all of the slurry feed ingredients were added directly to one of the Slurry Tanks (A or B). The Thickener Tank was not used. Water was added to a Slurry Tank. Dry ingredients were pre weighed and added to a Slurry Tank via the pneumatic transfer system. The slurry was mixed using the tank agitators and re circulated through the Melter feed loop for feed to the Melter or through the bypass loop if the slurry was being held in standby.

Throughout Campaign 1, the feed preparation and slurry systems provided many operational challenges. The pipes of the pneumatic material transfer system and the slurry re circulation and Melter feed system frequently clogged. Clogging was a result of two primary issues: (1) poorly designed piping with too many 90 degree bends, horizontal sections, and dead sections with too few access ports for flushing and cleaning; and (2) the physical and chemical characteristics of the slurry. In combination with the clogging issues, components of the slurry transfer pumps and Melter Feed Pump wore down rapidly with constant exposure to the abrasive slurry.

[12]It must be noted that during this phase of testing, all materials are added through this system and therefore large quantities must be processed manually. During operations with slurry from the thickener, the quantities of additives will be reduced significantly as would be the case with actual remediation.



VitPP Process Schematic
Figure 3-1

The diaphragms, balls, and seats, of the double-diaphragm slurry transfer pumps as well as the seals on the Melter Feed Pump were frequently replaced.

While the inherent problems of the system still exist, Operations and Maintenance personnel have developed techniques to lengthen the life of the components and quickly replace or rebuild the components when they do fail.

Operational experience gained during Campaign 1 also provides evidence that the agitation system in the tanks and the shape of the tanks are inadequate. The agitator is incapable of independently mixing the slurry and preventing solids from depositing on the bottom of the tank. This is a critical issue considering the frequency that the slurry transfer pumps fail. Even with the combined mixing effort of the slurry pumps and the agitator, the slurry is not homogeneous throughout the batch. Operations personnel have learned to anticipate the changing percent solids of the slurry and the effects it has on the Melter.

Examination of the slurry tanks after a series of batches revealed that the current configuration of the tanks is inadequate for the slurry preparation and feeding process. Significant quantities of material are retained in the tank due to the various ledges and access ports in each tank. This design oversight was addressed with a combination of forgiving slurry formulas and occasional labor-intensive tank cleanings. Redesign of this system will be considered prior to Phase II testing.

3.2 Melter, Glass Forming, and Water Cooling

3.2.1 Vitrification and the VitPP Melter

Glass is normally an excellent electrical insulator. However, glass does become conductive when it melts at high temperatures. Once glass becomes soft, its ability to conduct electricity increases with temperature, although it always offers some electrical resistance to the electricity flowing through it. This resistance results in heat. "Joule" heat is the name given for heat that is generated from electricity passing through a material. The glass, itself, generates the heat in a joule-heated melter.

Electrical power, and thus heat, is added to the molten glass via the in-bed electrodes. A secondary heat source is required to initially melt glass before the electrodes are inserted into the molten glass and energized. The electrodes are not functional until the glass softens and becomes conductive. Electrical resistance heaters above the bath (molten glass in the Melter) provide the heat to melt the startup glass and initiate the joule-heating process.

Slurry feed enters the Melter from the top and collects on the surface of the bath. Typically, joule-heated melters operate with a "cold cap." The cold cap is defined as a mass of solid materials that collects on top of the molten glass after entering the melter. When the materials come to temperature, technically, they do not melt, but rather, dissolve into the molten glass like sugar into water. This is evident because most of the constituents in the glass have higher melting points than the glass itself (e.g., SiO_2 and $CaCO_3$ both melt above 1700°C).

Melter production is largely dependent on the rate of the dissolution at the cold-cap/molten-glass interface. Increased agitation and temperature can increase this rate. However, constituents that do not readily dissolve in the melt can form layers at the interface or wick into the cold cap. These effects can hinder (or even poison) dissolution, and thus, decrease the glass production rate. Conversely, these effects can increase the production rate if they help to conduct the heat into the cold cap without poisoning the dissolution.

A melter that is not operating with a cold cap is probably not working at full capacity, unless the Melter cannot deliver more power to the glass melt. The VitPP Melter appears to be no different. A change in glass chemistry can help match parameters with the Melter to increase power delivery.

The general arrangement of the Melter is shown in Figure 3-2. The Melter was designed and manufactured by GTS Duratek. Some parts of this melter design are proprietary and/or patented by GTS Duratek. [redacted]

3.2.1.1 Melter Agitation

[redacted]

[redacted]

Figure 3-2: Melter Layout

3.2.1.2 Wet Feed

The wastes from the silos will be removed from the silos as a wet slurry. Early designs for the VitPP included a dryer which sent dry feed to the Melter. However, this was eliminated when it was found that the Minimum Additive Waste Stabilization (MAWS) Project[13] melter ran with high rates with a wet slurry feed. Also, some of the steam flashing concerns about placing water atop molten glass were eliminated.

Glass is a poor conductor of heat. Therefore, glass cannot deliver heat fast enough to boil water fast enough to cause a steam excursion at the surface. Water actually puddles and/beads on the surface of molten glass and boils. Large quantities of water would have to be injected into the interior of the glass melt bath to cause a steam excursion.

It is possible for a melter to perform better with a wet or slurry feed. The agitation of the boiling water can enhance heat transfer and dissolution of the slurry constituents into the molten glass. There have been some melter studies that have started as dry feed systems, but their production rates were less than expected. The dry feed formed a stagnate interface with molten glass. However, when the same feeds were fed wet, the production rates increased, even though more heat was needed by the Melter to boil the water.

3.2.1.3 Melter Discharge

Molten glass can be discharged from the Melter in a continuous or batch mode. The continuous mode is accomplished by the molten glass passing through the discharge chamber and out the discharge trough. The batch method is accomplished by using a unique air lift feature located in the bottom of the discharge chamber. The air lift injects air bubbles that lift molten glass into the discharge chamber over the edge of the trough. The rate of discharge can be controlled by the rate of air flow applied. The air lift gives flexibility in the control of glass flow through the Melter and to the Gem Making Machine. The ability of the Gem Making Machine (discussed later) appears to be largely dependent on the ability of the Melter to deliver a consistent stream of molten glass.

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[13]The MAWS is a vitrification process installed in Plant 9 at Fernald. It also has a joule-heated melter, but it has only one chamber with Inconel 690™ plate electrodes. Its maximum operation temperature was 1150°C. Its capacity was 1/3 to 1 MT/d. The vitrification process was linked to other waste minimization processes to establish synergy in waste volume reduction and minimization of the need for addition additives, hence its name, the Minimum Additive Waste Stabilization Project.

3.2.1.4 Melter Cooling and Wall Design

The VitPP Melter's walls are designed for air cooling. This requires the melter to have thicker walls and insulation when compared to common water-cooled melters. Both air and water-cooled melters require a temperature drop across the thickness of the walls to prevent the seepage of molten glass past the refractory bricks. The VitPP Melter's walls need to be and are rather thick to keep the exterior temperature of the Melter within reasonable limits (≤100°C). Water-cooled melter walls are thin because cooling plates are placed on the walls to absorb the extra heat and drop the temperature to prevent the flow of glass through the wall. Also, water-cooled melters are prone to damage in the event of power failures and other unexpected shutdowns. The extra mass of the walls in an air-cooled melter stores heat and helps keep the melter warm. The VitPP Melter appears that it could hold enough heat for about 8 hours before the glass gets too cold (900 °C). The VitPP Melter also has an intermediate shell made of Inconel™, to stop the flow of glass should it start to advance.

Cooling of the molybdenum electrodes, where exposed to air, is essential because molybdenum will start to oxidize in air at 400°C and burn at higher temperatures. Therefore, the electrode holders are water-cooled to drop the temperature of the molybdenum electrodes below 400°C within 15 cm of the hot side of the Melter wall. Molten glass flows around the inner portion of the electrode and freezes to prevent oxidation. The electrode can wear down with use requiring more electrode material to be inserted. This is done by temporarily turning off the cooling water and letting the glass around the electrode soften until the electrode can be pushed in with a new section of molybdenum added.

The feed ports and drains are also water-cooled. Drains work by freezing glass above the drain pipe with cooling water. Then, when needed, the cooling water is turned off, the glass plug thaws and a mechanism is used to push the plug into the Melter before backing out the mechanism to allow the glass to flow out.

3.2.1.5 Melter Refractories and Operating Temperature

Most commercial melters are made of alumina or alumina/zirconium type refractories because they do not impart color to the glass and they have fairly good erosion/corrosion resistance against normal glasses. However, these refractories would not be effective against the erosiveness of the silo wastes. Also, a good portion of the waste is alumina which makes alumina refractories less desirable. Refractories high in chromium are commonly used for this application. The major drawbacks with chromium refractories are that they are expensive and they may need to be treated as Resource Conservation Recovery Act (RCRA) material when the melter is dismantled.

The refractories in the Melter walls and the partition walls are expected to allow operating temperatures above 1400°C; however, the lives of these components and melter would be greatly reduced. Therefore, the stated melter design temperature is 1400°C with a maximum operating temperature of 1350°C. Direct temperature measurements of the bath, using thermocouples in thick platinum thermowells, are presently working well. However, this may not always be possible because the thermocouple wells may corrode/erode away. Correlations with other thermocouples in the Melter and other methods to determine the bath temperature are being developed and are presented in this report.

3.2.2 Mass and Energy Balance Around the Melter

Large amounts of mass and energy pass through the Melter during the vitrification process. Most of the mass transfer takes place in the center chamber; however, energy transfer takes place in both the side and center chamber. The amount of power that needs to be supplied to the Melter by the electrodes is the summation of all the heat losses throughout the Melter. Table 3-1 contains calculated heat loss for the Melter producing 1 MT/d of startup glass (known as Wet 16 glass) from a 50 wt% slurry.

Notice, that the lid heater banks are shown as negative values because they are minimally energized to prolong their lives. The basis for the numbers is summarized in Table 3-2.

Table 3-1
Melter Heat Loss

Power Requirements	Amount kg/hr	Amount Each	q' watts/unit	Q watts
Feed Moisture -- evaporate	53.26	--	1,031	54,900
Gas Generation	11.52	--	195	2,200
In-leakage & bubbler	66.67	--	195	13,000
Radiant/convection shell loss	--	--	52,000	52,000
Cooling -- Electrodes	--	10	500	5,000
Cooling -- Ports	--	5	3,000	14,400
Cooling -- Drains	--	4	3,500	13,700
Vitrification, glass	41.76	--	408	17,000
Lid heater banks	--	2	-1,000	-2,000
Total	--	--	--	170,200

Table 3-2
Melter Heat Loss Calculation Basis

Power Requirements	Basis
Feed Moisture -- evaporate	Heat to boil and raise the temperature of water vapor to exhaust temperature, X°C.
Gas Generation	Heat to the temperature of air to exhaust temperature, X°C.
In-leakage & bubbler	Heat to the temperature of air to exhaust temperature, X°C. In-leakage is assumed 30 scfm and the bubbler 2 scfm for the calculations in the chamber. However, the in-leakage has been determined to be as high as 80 to 100 scfm. If so, this can increase the heat demand approximately 20 to 40 more kilowatts. Air in-leakage from the discharge chamber is already preheated to approximately 1250°C, and therefore, requires no additional heating.
Radiant/convection shell loss	The MAWS melter (located at the Fernald Site and of similar construction) lost approximately 16,600 watts at 1150°C and has a surface area of approximately 116 ft^2. The VitPP has approximately 338 ft^2 and is at 1250°C. Therefore: $q_p \approx$ 16,600 watts x (338 ft^2/116 ft^2) x (1250°C-20°)/(1150°C-20°C) $q_p \approx$ 52,000 watts
Cooling -- Electrodes	Calculated by the amount of heat that can pass along the axis of a 3-in molybdenum metal cylinder between the temperatures of approximately 1150°C and 400°C.
Cooling -- Ports	Reference
Cooling -- Drains	Reference
Vitrification, glass	Heat capacity, C_p, of the glass was experimentally determined in the lab by pouring molten glass into water and measuring the temperature rise of the water. The C_p = 0.33 watt-hours/kg°C. This equates to 17,000 watts/metric ton to heat the glass to 1250°C.
Lid heater banks	Measured in the field.

3.2.3 Energy Balance Around the Side Electrode Chamber

The ability to put power into the Melter is best understood by doing an energy balance around a side electrode chamber. Calculations showed that the electrode chamber would normally run cooler than the center chamber and this was proven in the campaign runs. Figure 3-3 shows the model used to perform the calculations.

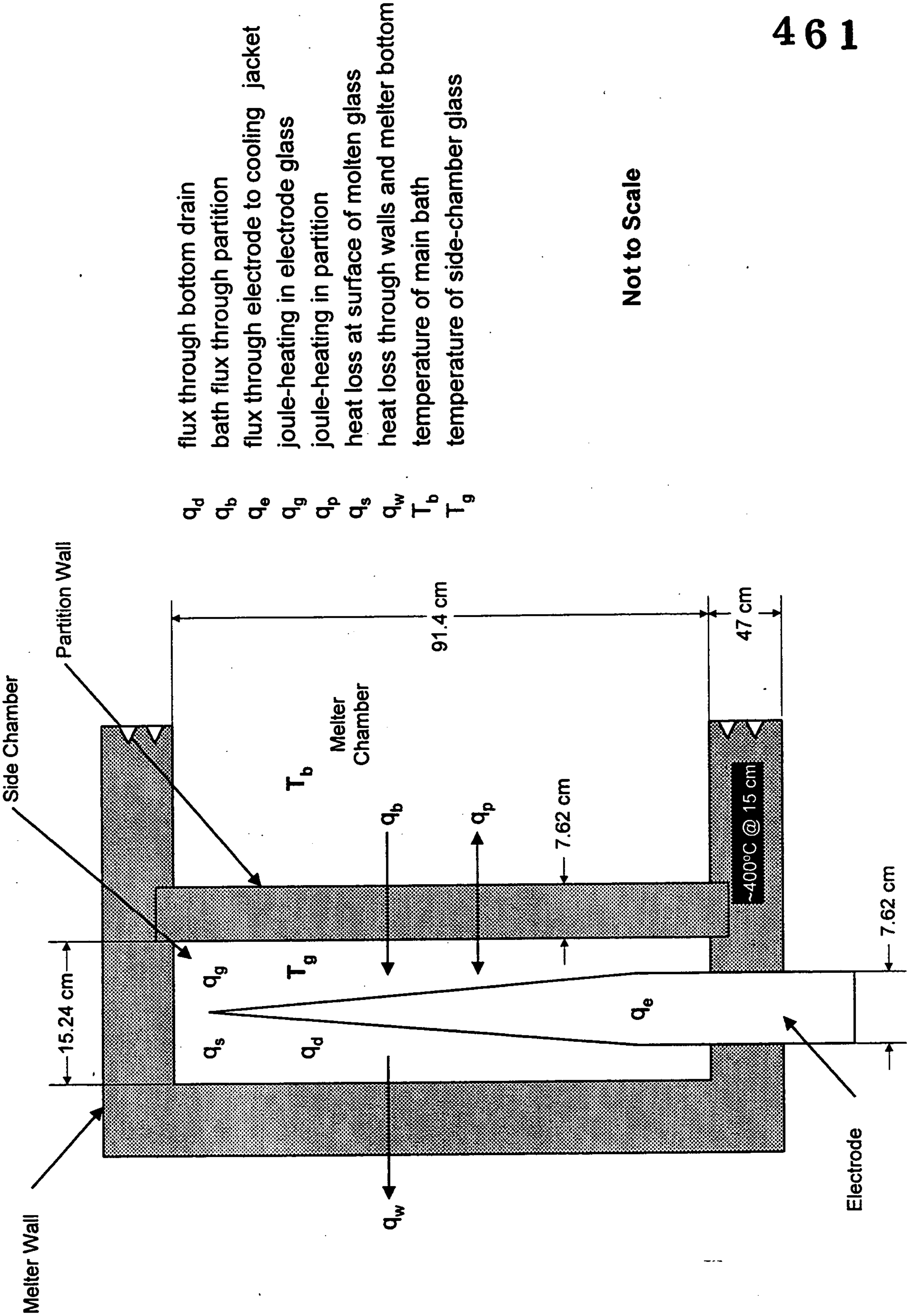
The heat balance for the side chamber is mathematically as follows:

Accumulation, $a_c = \sum in - \sum out$ (Equation 3-1)

$a_c = q_b + q_g + q_p - q_e - q_s - q_w - q_d$ (Equation 3-2)

Each flux was individually broken down into equations and entered into fields in a spreadsheet so values could be calculated for different scenarios. Figure 3-4 shows the spreadsheet calculating the results for producing startup glass at 1 MT/d at 1250°C from 50 wt% solids in the slurry. The basis for the temperature profile through the partition wall is given in the appendix. The temperature profile across the thickness of the partition wall is also shown in Figure 3-4. Notice that the partition wall can get hotter than the surrounding glass; however, this depends on the conductance of the center chamber glass conductivity, center bath temperature, and production rate of the Melter. Figure 3-5 shows the Melter producing the same glass at 3 MT/d. This glass rate puts undue hardship on the Melter because it requires high amperage.

The Melter can behave quite differently from one glass to the next. Compare Figure 3-4 against Figure 3-6. Both are producing glass at 1 MT/d at 1250°C from 50 wt% solids in the slurry, but notice the difference in voltage, amperage, temperature profile of the partition wall, and the temperature in the side chamber. They are greatly different because of the differences in the conductivity of the glasses. This was evident when sodium carbonate was added directly to the Melter to reduce the viscosity of the glass during Campaign 1 (see Section 5.14). Increasing the temperature also changes the conductivity of the glass as shown in Figure 3-7. Notice that the conductivity of the side chamber glass and the partition wall also change. Together these show that the Melter is sensitive to the conductivity of the glass and vice versa. They become more sensitive at higher production rates and the operating envelope narrows. This is because at high power the conductivity of the glass needs to be just right so power can be put into the Melter at the proper volts to amps ratio. Figure 3-8 shows how this envelope looks. This envelope is only preliminary and will be refined with data from future Melter runs.



Melter Heat Balance
Figure 3-3

Melter Heat & Power Profile Rod F. Gimpel 08/13/9

E-ST09x.WK

Scenario: **Startup Glass (Wet16) – 50 wt% Slurry, 1 tonnes/day glass**
Estimate

Waste Glass: **Startup** Electrode Glass: **C4EG-10**

S, watts/cm3:	0.4937
k, watts-cm/cm2-^C:	0.0577
A, cm2:	7,431
Te, ^C:	1,138
Tb, ^C:	1,250

Inputs:		Calculated:		Qout/Qin:
Bath temp., ^C	1,250	S. chamber temp, ^C:	1,138	1.00
Bath level, cm	81.3	Glass, tonnes/day	1.00	
S.Chamber depth, cm	4.50			
Feed rate, L/hr	72.00	Inputs:		
kg glass/L feed	0.58	Air Inleakage, scfm	30	
% Moisture	50.00	Bubbler, scfm	2	
Feed density, g/cm3	1.48	Radiant heat sink, ^C:	450	

Needed Power	Amount kg/hr	Amount each	q' watts/unit	Q watts
Moisture	53.28		1,031	54,932
Gas generation	11.52		195	2,246
Inleakage & bubbler	66.67		195	13,000
Radiant losses	–		52,000	52,000
Cooling - Electrodes		10	481	4,808
Cooling - Ports		5	2,880	14,400
Cooling - Drains		4	3,425	13,700
Vitrification, glass	41.76		408	17,038
Lid heater banks		2	(1,000)	(2,000)
	173.23	19	na	170,124

Power Calc.	Conduct. S/cm	Resist. ohm-cm	Resist. ohm	Power watts	Voltage Drop, v	%
Left cham.	0.333	3.00	0.0018	4,788	2.95	2.81
L. partition	0.096	10.38	0.0106	27,954	17.21	16.43
Main	0.310	3.23	0.0397	104,639	64.43	61.51
R. partition	0.096	10.38	0.0106	27,954	17.21	16.43
Right cham.	0.333	3.00	0.0018	4,788	2.95	2.81
Total	na	na	0.0645	170,124	104.76	100.00
				Amps:	1,623.95	

Ac	Qg	Qx	Qe	Qd	Qs	Qw
44	4,788	20,279	(2,404)	(2,000)	(5,019)	(15,600)

Part. depth X, cm	Temp. C	Conduction Only, ^C	Generation Only, ^C	Q(x) watts
0.00	1,138	1,138	1,138	20,27
0.25	1,150	1,142	1,146	19,36
0.50	1,161	1,145	1,153	18,44
0.75	1,171	1,149	1,160	17,52
1.00	1,181	1,153	1,166	16,61
1.25	1,190	1,156	1,172	15,69
1.50	1,199	1,160	1,177	14,77
1.75	1,208	1,164	1,182	13,85
2.00	1,215	1,167	1,186	12,94
2.25	1,223	1,171	1,190	12,02
2.50	1,230	1,175	1,193	11,10
2.75	1,236	1,178	1,195	10,191
3.00	1,241	1,182	1,197	9,27
3.25	1,247	1,186	1,199	8,35
3.50	1,251	1,189	1,200	7,43
3.75	1,255	1,193	1,200	6,52
4.00	1,259	1,197	1,200	5,60
4.25	1,262	1,200	1,199	4,68
4.50	1,264	1,204	1,198	3,771
4.75	1,266	1,208	1,196	2,85
5.00	1,268	1,211	1,194	1,93
5.25	1,268	1,215	1,191	1,01
5.50	1,269	1,219	1,188	10
5.75	1,269	1,223	1,184	(81
6.00	1,268	1,226	1,180	(1,73
6.25	1,266	1,230	1,175	(2,64
6.50	1,265	1,234	1,169	(3,56
6.75	1,262	1,237	1,163	(4,48
7.00	1,259	1,241	1,157	(5,401
7.25	1,256	1,245	1,149	(6,31
7.50	1,252	1,248	1,142	(7,23
7.62	1,250	1,250	1,138	(7,67

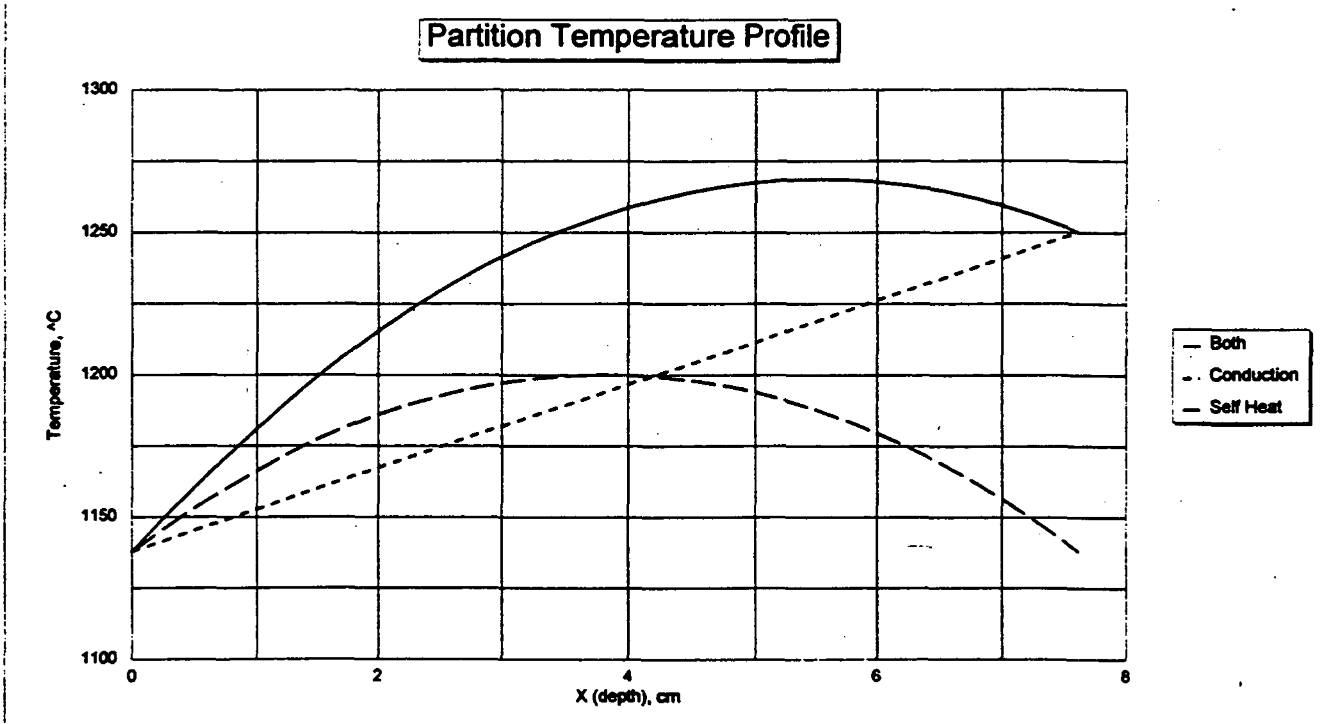


Figure 3-4

Melter Heat & Power Profile

Rod F. Gimpel 08/13/96

E-ST11x.WK4

Scenario: **Startup Glass (Wet16) -- 50 wt% Slurry, 3 tonnes/day glass**
Estimate

Waste Glass: **Startup** Electrode Glass: **C4EG-10**

S, watts/cm3:	0.7613
k, watts-cm/cm2-^C:	0.0577
A, cm2:	7,431
Te, ^C:	1,242
Tb, ^C:	1,250

Inputs:		Calculated:		Qout/Qin:
Bath temp., ^C	1,250	S. chamber temp, ^C:	1,242	1.00
Bath level, cm	81.3	Glass, tonnes/day	3.00	
S.Chamber depth, cm	4.50			
Feed rate, L/hr	215	Inputs:		
kg glass/L feed	0.58	Air Inleakage, scfm	30	
% Moisture	50.00	Bubbler, scfm	2	
Feed density, g/cm3	1.48	Radiant heat sink, ^C:	450	

Needed Power	Amount kg/hr	Amount each	q' watts/unit	Q watts
Moisture	159.31		1,031	164,246
Gas generation	34.44		195	6,717
Inleakage & bubbler	66.67		195	13,000
Radiant losses	--		52,000	52,000
Cooling - Electrodes		10	559	5,588
Cooling - Ports		5	2,880	14,400
Cooling - Drains		4	3,425	13,700
Vitrification, glass	124.86		408	50,944
Lid heater banks		2	(1,000)	(2,000)
	385.28	19	na	318,594

Power Calc.	Conduct. S/cm	Resist. ohm-cm	Resist. ohm	Power watts	Voltage Drop, v	%
Left cham.	0.657	1.52	0.0009	5,155	2.18	1.62
L partition	0.133	7.54	0.0077	43,109	18.22	13.53
Main	0.310	3.23	0.0397	222,065	93.87	69.70
R. partition	0.133	7.54	0.0077	43,109	18.22	13.53
Right cham.	0.657	1.52	0.0009	5,155	2.18	1.62
Total	na	na	0.0569	318,594	134.67	100.00
				Amps:	2,365.74	

Ac	Qg	Qx	Qe	Qd	Qs	Qw
(27)	5,155	22,005	(2,794)	(2,000)	(6,793)	(15,600)

Part. depth X, cm	Temp. C	Conduction Only, ^C	Generation Only, ^C	Q(x) watts
0.00	1,242	1,242	1,242	22,005
0.25	1,254	1,242	1,254	20,590
0.50	1,266	1,243	1,265	19,176
0.75	1,277	1,243	1,276	17,762
1.00	1,287	1,243	1,286	16,347
1.25	1,296	1,243	1,295	14,933
1.50	1,304	1,244	1,303	13,519
1.75	1,312	1,244	1,310	12,104
2.00	1,318	1,244	1,316	10,690
2.25	1,324	1,244	1,322	9,276
2.50	1,329	1,245	1,326	7,861
2.75	1,333	1,245	1,330	6,447
3.00	1,337	1,245	1,333	5,033
3.25	1,339	1,245	1,336	3,618
3.50	1,341	1,246	1,337	2,204
3.75	1,342	1,246	1,338	790
4.00	1,342	1,246	1,338	(625)
4.25	1,341	1,246	1,336	(2,039)
4.50	1,339	1,247	1,335	(3,453)
4.75	1,337	1,247	1,332	(4,868)
5.00	1,334	1,247	1,328	(6,282)
5.25	1,330	1,248	1,324	(7,696)
5.50	1,325	1,248	1,319	(9,111)
5.75	1,319	1,248	1,313	(10,525)
6.00	1,312	1,248	1,306	(11,939)
6.25	1,305	1,249	1,298	(13,354)
6.50	1,297	1,249	1,290	(14,768)
6.75	1,288	1,249	1,281	(16,182)
7.00	1,278	1,249	1,271	(17,597)
7.25	1,267	1,250	1,260	(19,011)
7.50	1,256	1,250	1,248	(20,426)
7.62	1,250	1,250	1,242	(21,104)

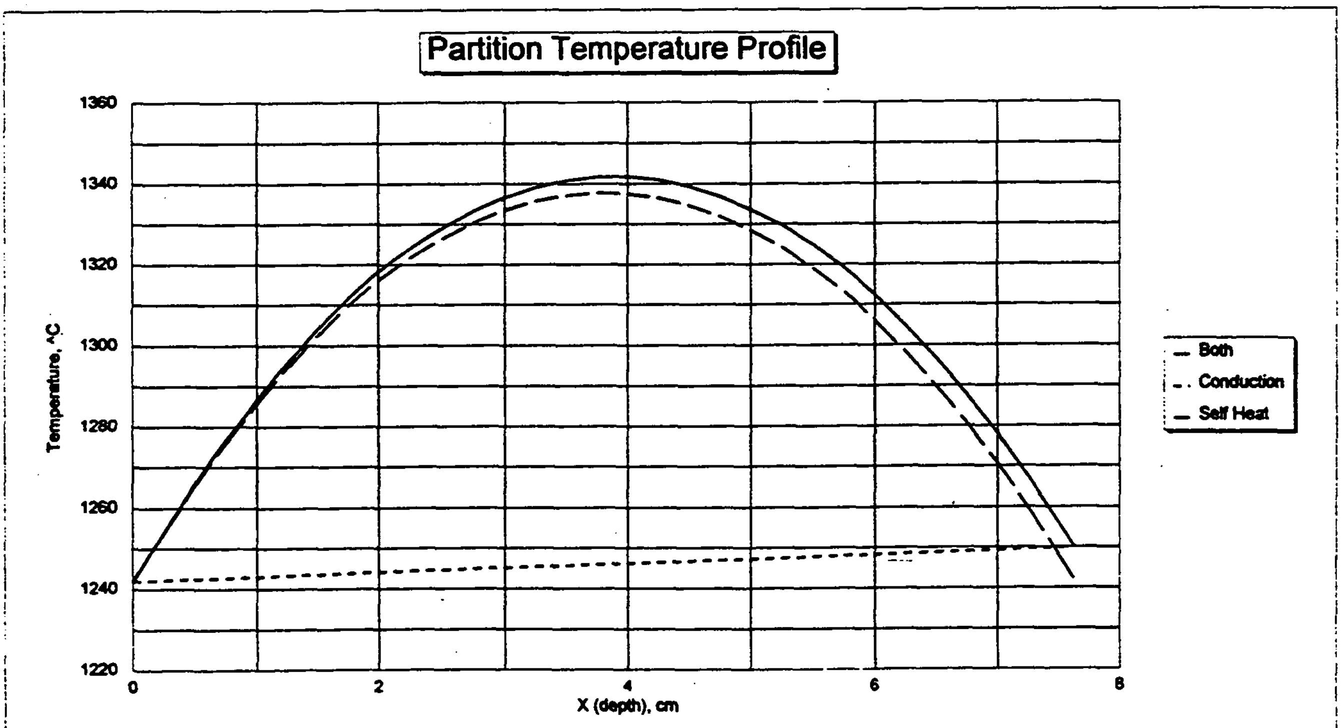


Figure 3-5

Scenario: **Series A Glass at 1 tonne/day glass, 50 wt% slurry**

Waste Glass: **C4A-03** Electrode Glass: **C4EG-10**

S, watts/cm3:	0.2331			
k, watts-cm/cm2-^C:	0.0577			
A, cm2:	7,431			
Te, ^C:	1,025			
Tb, ^C:	1,250			

<u>Inputs:</u>		<u>Calculated:</u>		<u>Qout/Qin:</u>
Bath temp., ^C	1,250	S. chamber temp, ^C:	1,025	1.00
Bath level, cm	81.3	Glass, tonnes/day	1.00	
S.Chamber depth, cm	4.50			
Feed rate, L/hr	72.00	<u>Inputs:</u>		
kg glass/L feed	0.58	Air Inleakage, scfm	30	
% Moisture	50.00	Bubbler, scfm	2	
Feed density, g/cm3	1.48	Radiant heat sink, ^C:	450	

Needed Power	Amount kg/hr	Amount each	q' watts/unit	Q watts
Moisture	53.28		1,031	54,932
Gas generation	11.52		195	2,246
Inleakage & bubbler	66.67		195	13,000
Radiant losses	–		52,000	52,000
Cooling - Electrodes		10	396	3,960
Cooling - Ports		5	2,880	14,400
Cooling - Drains		4	3,425	13,700
Vitrification, glass	41.76		408	17,038
Lid heater banks		2	(1,000)	(2,000)
	173.23	19	na	169,276

Power Calc.	Conduct. S/cm	Resist. ohm-cm	Resist. ohm	Power watts	Voltage Drop, v	%
Left cham.	0.141	7.10	0.0043	3,778	4.03	2.23
L. partition	0.068	14.68	0.0150	13,198	14.07	7.80
Main	0.080	12.50	0.1538	135,323	144.24	79.94
R. partition	0.068	14.68	0.0150	13,198	14.07	7.80
Right cham.	0.141	7.10	0.0043	3,778	4.03	2.23
Total	na	na	0.1923	169,276	180.43	100.00
				Amps:	938.16	

Ac	Qg	Qx	Qe	Qd	Qs	Qw
(31)	3,778	19,259	(1,980)	(2,000)	(3,489)	(15,600)

Part. depth X, cm	Temp. C	Conduction Only, ^C	Generation Only, ^C	Q(x) watts
0.00	1,025	1,025	1,025	19,25
0.25	1,036	1,032	1,029	18,82
0.50	1,047	1,040	1,032	18,39
0.75	1,058	1,047	1,035	17,96
1.00	1,068	1,055	1,038	17,52
1.25	1,078	1,062	1,041	17,09
1.50	1,088	1,069	1,044	16,66
1.75	1,097	1,077	1,046	16,22
2.00	1,107	1,084	1,048	15,79
2.25	1,116	1,091	1,049	15,36
2.50	1,125	1,099	1,051	14,92
2.75	1,133	1,106	1,052	14,49
3.00	1,142	1,114	1,053	14,06
3.25	1,150	1,121	1,054	13,63
3.50	1,157	1,128	1,054	13,19
3.75	1,165	1,136	1,054	12,76
4.00	1,172	1,143	1,054	12,33
4.25	1,179	1,150	1,054	11,89
4.50	1,186	1,158	1,053	11,46
4.75	1,193	1,165	1,053	11,03
5.00	1,199	1,173	1,051	10,59
5.25	1,205	1,180	1,050	10,16
5.50	1,211	1,187	1,049	9,73
5.75	1,217	1,195	1,047	9,30
6.00	1,222	1,202	1,045	8,86
6.25	1,227	1,210	1,042	8,43
6.50	1,232	1,217	1,040	8,00
6.75	1,236	1,224	1,037	7,56
7.00	1,240	1,232	1,034	7,13
7.25	1,244	1,239	1,030	6,70
7.50	1,248	1,246	1,027	6,26
7.62	1,250	1,250	1,025	6,00

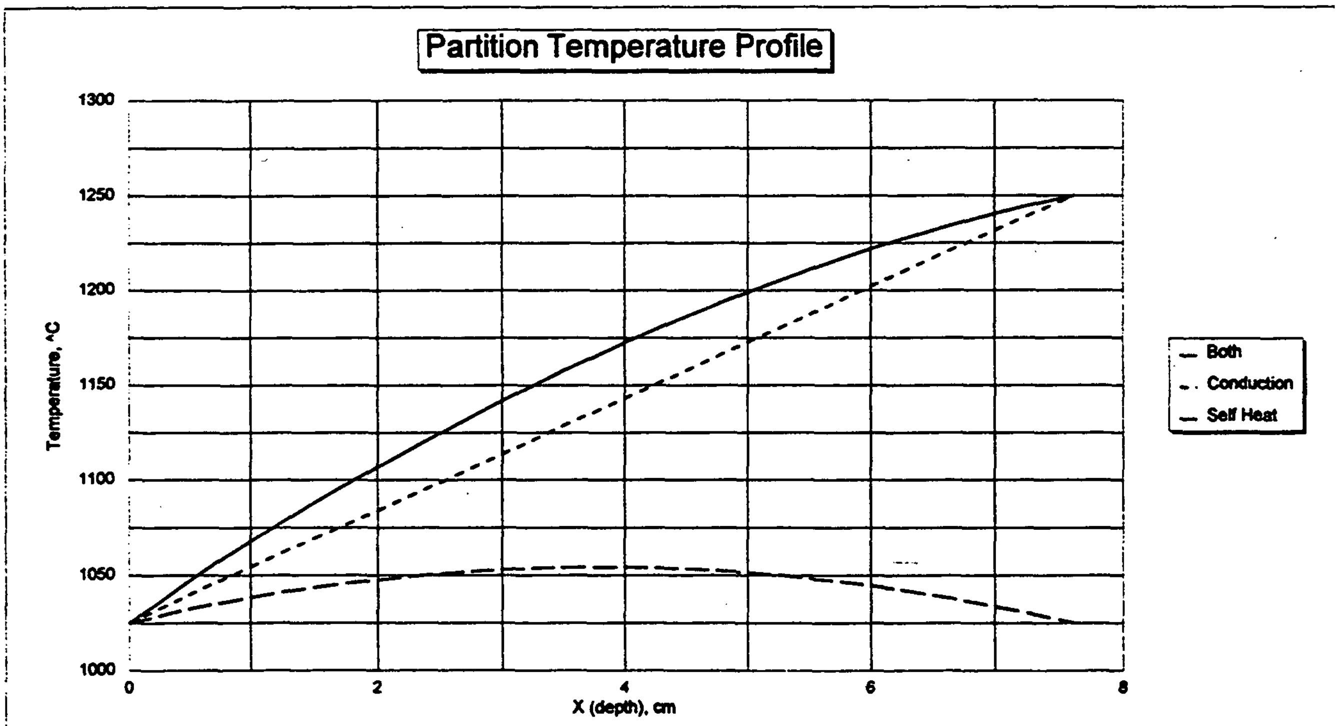


Figure 3-6

Melter Heat & Power Profile — Rod F. Gimpel 08/13/96

E-ST10x.WK4

Scenario: **Startup Glass (Wet16) -- 50 wt% Slurry, 1 tonnes/day glass**
Estimate

Waste Glass: **Startup** Electrode Glass: **C4EG-10**

S, watts/cm3:	0.5181
k, watts-cm/cm2-^C:	0.0577
A, cm2:	7,431
Te, ^C:	1,204
Tb, ^C:	1,350

Inputs:		Calculated:		Qout/Qin:
Bath temp., ^C	1,350	S. chamber temp, ^C:	1,204	1.00
Bath level, cm	81.3	Glass, tonnes/day	1.00	
S.Chamber depth, cm	4.50			
Feed rate, L/hr	72.00	Inputs:		
kg glass/L feed	0.58	Air inleakage, scfm	30	
% Moisture	50.00	Bubbler, scfm	2	
Feed density, g/cm3	1.48	Radiant heat sink, ^C:	450	

Needed Power	Amount kg/hr	Amount each	q' watts/unit	Q watts
Moisture	53.28		1,031	54,932
Gas generation	11.52		195	2,246
Inleakage & bubbler	66.67		195	13,000
Radiant losses	–		58,118	58,118
Cooling - Electrodes		10	530	5,303
Cooling - Ports		5	3,219	16,094
Cooling - Drains		4	3,828	15,312
Vitrification, glass	41.76		441	18,401
Lid heater banks		2	(1,000)	(2,000)
	173.23	19	na	181,405

Power Calc.	Conduct. S/cm	Resist. ohm-cm	Resist. ohm	Power watts	Voltage Drop, v	%
Left cham.	0.518	1.93	0.0012	5,377	2.51	2.96
L. partition	0.160	6.23	0.0064	29,334	13.67	16.17
Main	0.506	1.98	0.0243	111,984	52.17	61.73
R. partition	0.160	6.23	0.0064	29,334	13.67	16.17
Right cham.	0.518	1.93	0.0012	5,377	2.51	2.96
Total	na	na	0.0394	181,405	84.52	100.00
				Amps:	2,146.34	

Ac	Qg	Qx	Qe	Qd	Qs	Qw
72	5,377	22,882	(2,651)	(2,000)	(6,101)	(17,435)

Part. depth X, cm	Temp. C	Conduction Only, ^C	Generation Only, ^C	Q(x) watts
0.00	1,204	1,204	1,204	22,882
0.25	1,217	1,209	1,212	21,919
0.50	1,230	1,214	1,220	20,957
0.75	1,242	1,218	1,227	19,995
1.00	1,253	1,223	1,234	19,032
1.25	1,264	1,228	1,240	18,070
1.50	1,274	1,233	1,245	17,107
1.75	1,284	1,238	1,250	16,145
2.00	1,293	1,242	1,254	15,183
2.25	1,301	1,247	1,258	14,220
2.50	1,309	1,252	1,261	13,258
2.75	1,317	1,257	1,264	12,296
3.00	1,324	1,261	1,266	11,333
3.25	1,330	1,266	1,268	10,371
3.50	1,336	1,271	1,269	9,408
3.75	1,341	1,276	1,269	8,446
4.00	1,346	1,281	1,269	7,484
4.25	1,350	1,285	1,268	6,521
4.50	1,353	1,290	1,267	5,559
4.75	1,356	1,295	1,265	4,596
5.00	1,359	1,300	1,263	3,634
5.25	1,360	1,305	1,260	2,672
5.50	1,362	1,309	1,256	1,709
5.75	1,362	1,314	1,252	747
6.00	1,363	1,319	1,248	(215)
6.25	1,362	1,324	1,242	(1,178)
6.50	1,361	1,329	1,237	(2,140)
6.75	1,360	1,333	1,230	(3,103)
7.00	1,358	1,338	1,223	(4,065)
7.25	1,355	1,343	1,216	(5,027)
7.50	1,352	1,348	1,208	(5,990)
7.62	1,350	1,350	1,204	(6,452)

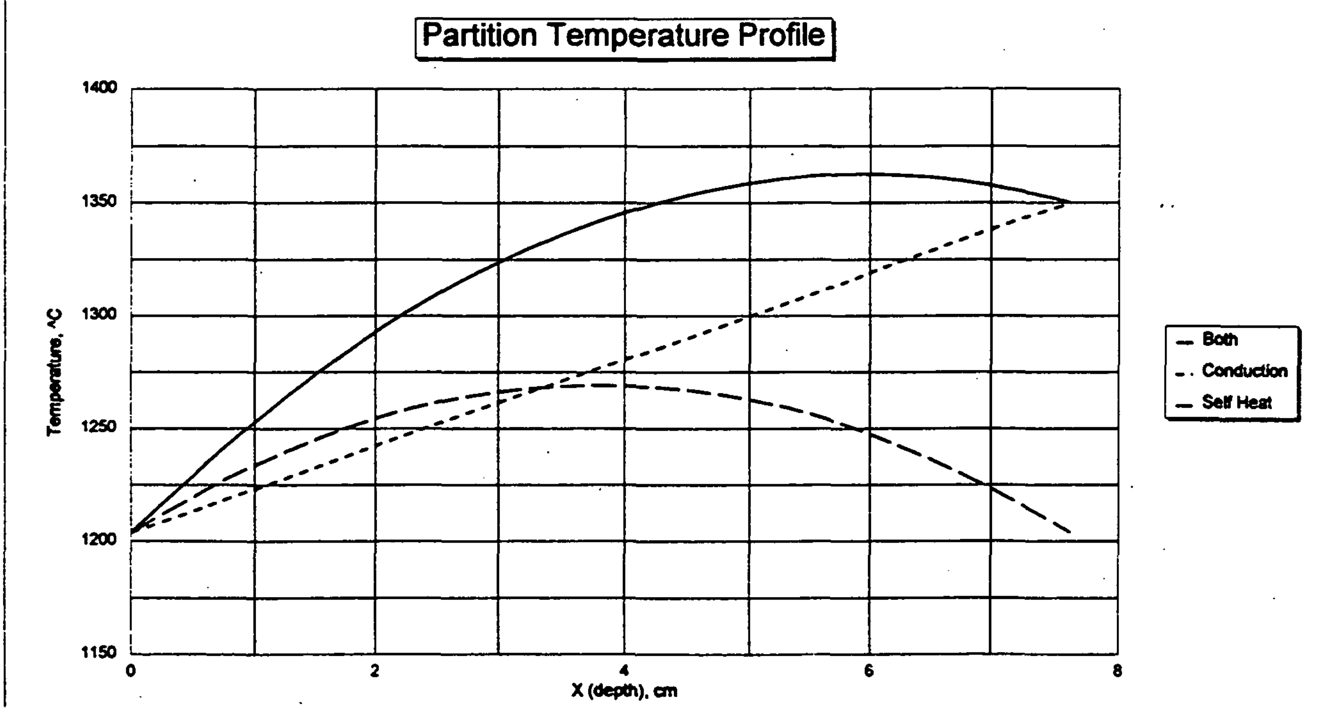


Figure 3-7

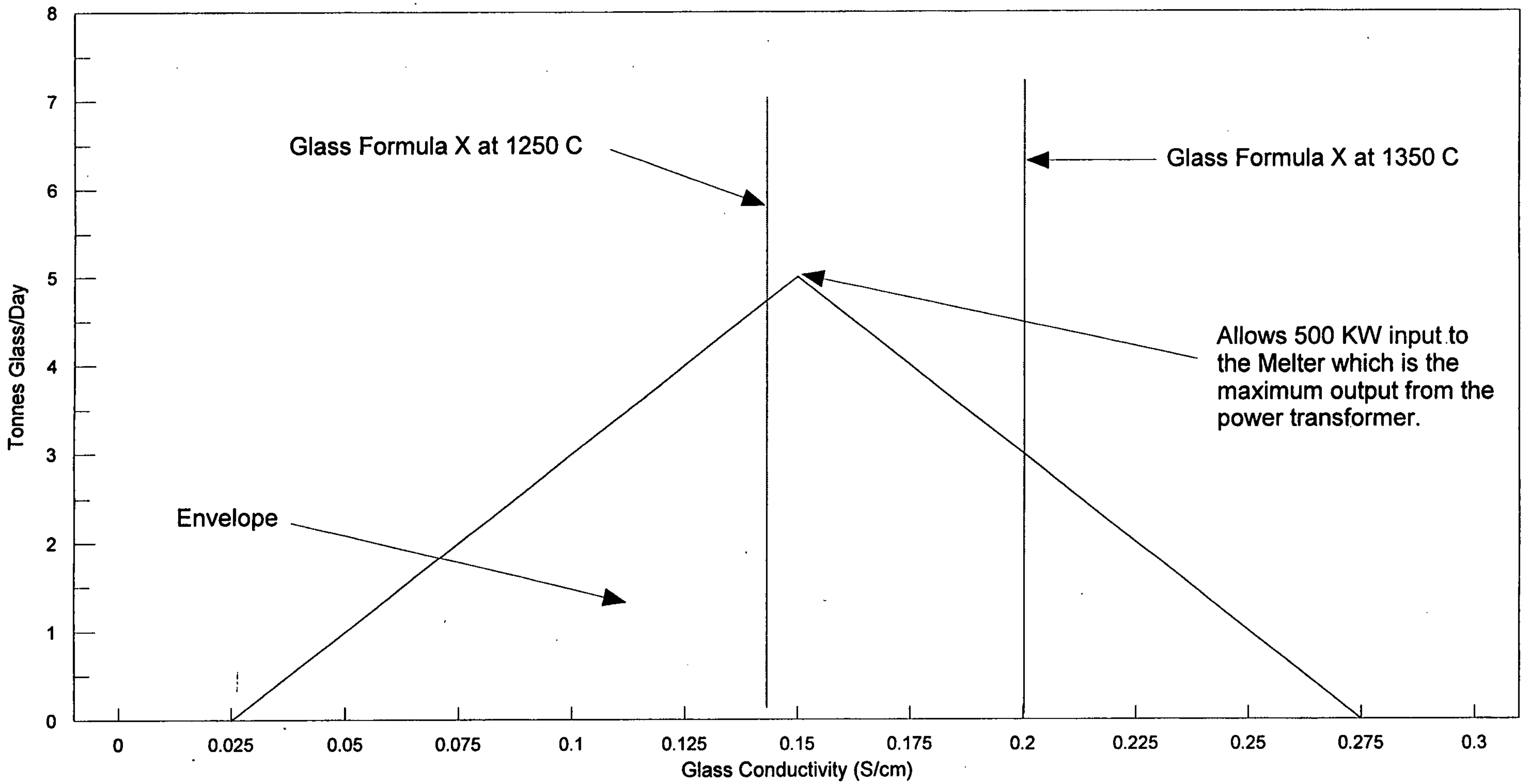


Figure 3-8: Melter and Glass Conductivity Envelope

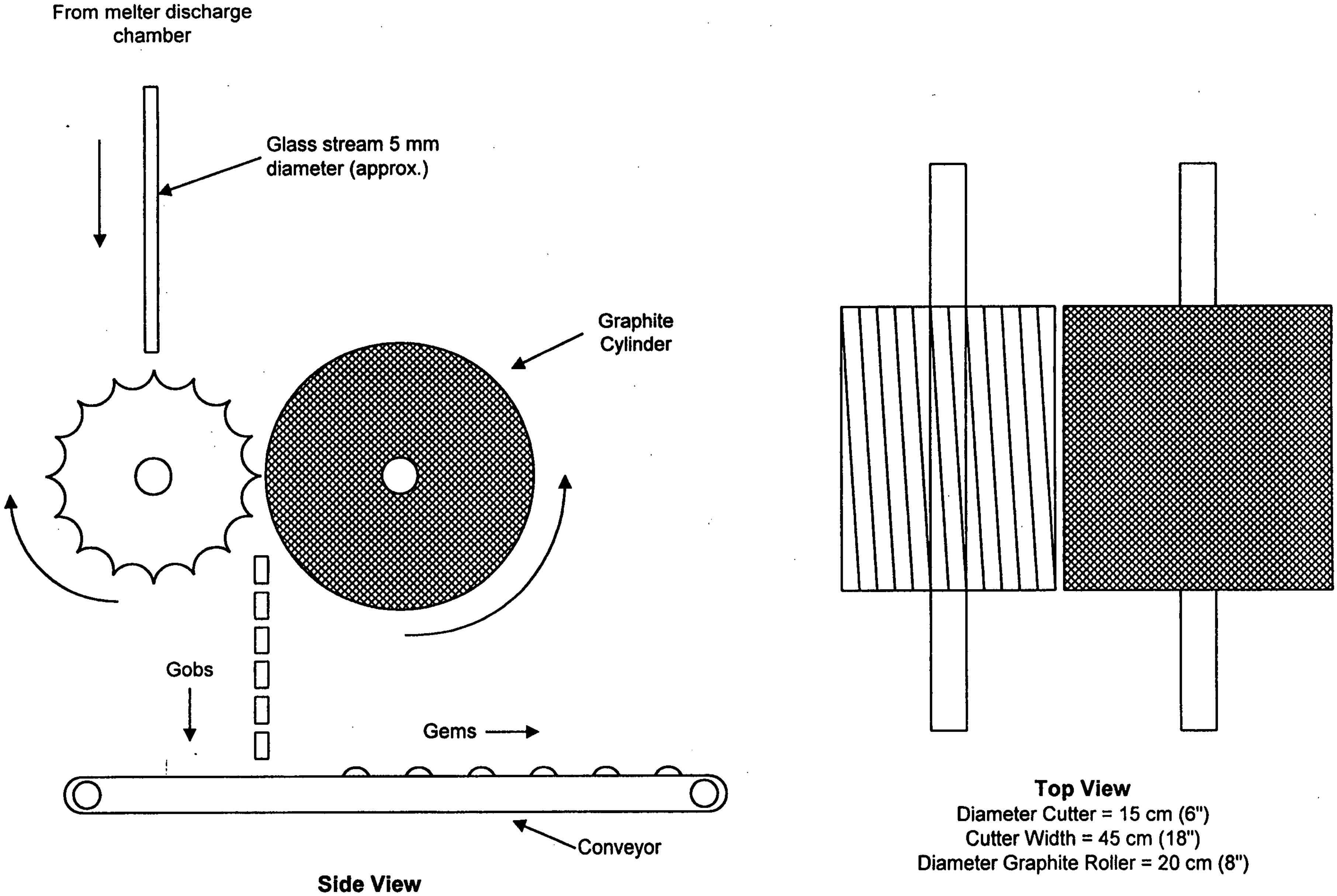
3.2.4 Glass Form

The VitPP is equipped to turn the molten glass into gems. Gems are hemispherical pieces of glass that look like "flattened marbles." The VitPP has a conveyor-type Gem Making Machine that is connected to the discharge chamber of the Melter. Gems are made by cutting the molten glass stream from the Melter into individual pieces, called gobs. The gob cutting mechanism, shown in Figure 3-9, is composed of two rotating cylinders that turn into each other. One cylinder is made of steel and has hollowed grooves that capture the falling glass as it turns. The crest of the grooves then touch the opposing smooth cylinder made of graphite and momentarily pinches off the flow (or cuts) the glass. The glass gobs fall onto a conveyor where they are quickly cooled and solidified. However, before the glass solidifies, the gob has time to form a puddle on the plate and pull itself together as a gem because of surface tension.

The VitPP has produced gems and monolithic pours into drums but not enough of either have been made to effectively determine which is better for OU4. Some glasses (monolithic pours) will devitrify when poured into slowly cooling drums. Bench studies showed that devitrification did not happen for any of the silo glasses when made into gems. However, the Series C and D glasses did devitrify (turned a milky color -- mostly green) when cooled slowly. Consequently, better volume may be gained by using gems to prevent devitrification. This is because the monolithic glass would have to be made with a much lower waste loading, with a resulting increase in volume, to prevent devitrification within the drum. Also, the drums may not be poured completely full because they will need to be moved with molten glass in them during full-operation. Series A glasses show promise that they may not devitrify even with slow cooling. This is probably because of higher silica and lesser phosphate content in the Series A glasses.

The void fraction for the gems will be measured once the production of gems is perfected in later runs. Gems typically have a void volume of approximately 20% to 30% which is better than marbles and significantly better than frit or cullet which is 50% void volume.

Another consideration is the high cost of containers designed to withstand the high temperature of molten glass. The integrity of the container will be monitored during the monolithic pours. The outside surface of the drums poured thus far, at 1250°C, melter temperature, appear to have withstood the heat.



Gob Cutter
Figure 3-9

3.2.5 Water Cooling for the Melter and Gem Making Machine

The Melter and the Gem Machine have a separate devoted water cooling system. The water is fed to the electrode holders, ports, and parts of the Gem Making Machine to keep components from overheating and stop the advance of molten glass into the ports. The cooling water is recycled. Heat is removed from the cooling water by an air-cooled radiator. The temperature and flow rate of the water leaving each port, etc., are measured and recorded. High purity water is needed to limit high-temperature corrosion/erosion problems. The cooling water originally contained an antifreeze (50/50 mixture of water and glycol); however, it was later discovered the antifreeze contained a small concentration of chloride that may have lead to corrosion problems. It is questionable if the low amount of chloride could cause the corrosion problems, but it was removed from the cooling system during Campaign 1 for assurance at this time (see Section 6.4). This is being investigated.

3.3 Off-gas and Film Cooler

Sources of off-gas are the Melter and the VitPP tank vents. The off-gas treatment system consists of a Film Cooler, Quench Tower, Scrubber, Desiccant Tower, radon absorption carbon beds, HEPA filters, blower and stack. The temperature of the hot Melter off-gas (800 °C) is reduced by the Film Cooler and direct heat loss through the pipe wall to the surrounding atmosphere. The Quench Tower then receives the Melter off-gas and cools it further using recycled water. The off-gas from the Quench Tower flows into the Scrubber/Venturi system for removal of sulfur oxides using caustic solution. Next, the off-gas flows to the Desiccant Tower which reduces the water content of the off-gas to 15 percent relative humidity (15% Rh) using a deliquescent material such as calcium chloride ($CaCl_2$). Since no radon (Rn-223) producing material will be processed during Phase I of the VitPP, the carbon beds are bypassed. HEPA filtration for final particulate removal is the last off-gas treatment step prior to discharge through the exhaust fan and the stack.

As discussed in Section 5.16.1, the Desiccant Tower was overwhelmed by the moisture entering it. The exit off-gas was about 57% RH until the two-week idle period at the beginning of July when the desiccant was allowed to dissolve away. Afterward the Desiccant Tower did no dehumidifying. Different dehumidifying technologies are being investigated for future designs.

During Campaign 1, the Scrubber was operated with water only (no caustic). The split in the Scrubber re circulation loops was 8 gpm to the packed tower and the rest to the ejector-venturi. The Desiccant Tower was charged with the deliquescent desiccant tablets. All the various tank vents were initially open to the off-gas system and balanced per procedure. The tank vents were closed early in Campaign 1 because of problems holding sufficient negative pressure in the Melter.

3.4 Recycle Water

The recycle water loop starts with the Recycle Water Tank which holds a controlled inventory of recycle water. Recycle water is pumped from the Recycle Water Tank by one of two recycle water pumps to the Quench Tower form melter off-gas cooling via direct, water-spray contact. Recycle water collects in the base of the Quench Tower and is pumped by one of two Quench Tower pumps to the Heat Exchanger where the recycle water is cooled against Cooling Tower Water. The recycle water then flows to the Thickener which runs full and overflows to the Recycle Water Tank to complete the loop. Additionally, recycle water is piped to various slurry lines for flushing purposes.

The recirculating flow (Recycle Water Tank to Quench Tower to Heat Exchanger to Thickener and back to Recycle Water Tank) was initially about 27 gpm vs. a design flow of 40 gpm. This was initially attributed to plugging of the spray nozzles in the Quench Tower. It was determined that 27 gpm water flow to the Quench Tower was acceptable for startup.

3.5 Data Gathering

The Vitrification Pilot Plant System (VPPS) is an ORACLE-based system developed to provide data management support for the VitPP. ORACLE is a data base program by ORACLE Corporation that is leased and used at the Fernald site. The database contains specific tables, fields, and programs to support the VPPS. VPPS acts as a central repository for several types of data collected during the operation of the VitPP. The system consists of a central database and related data collection and reporting software as shown on the simplified Data Flow Diagram, Figure 3-10 below.

3.5.1 System Overview

The core of VPPS is an ORACLE-based relational database running on one of the FEMP's VAX (trade name of computer) mainframe computers. Data from the various VitPP data streams are loaded into this data base.

The operation of the VitPP currently produces data streams from the following sources:

1. Process data is collected via the Foxboro Distributed Acquisition and Control System (DACS). The Foxboro system automatically records and temporarily stores the plant process data. The system has data storage capacity for approximately 24 hours. After this time period, the stored data is overwritten and replaced with current data. The Foxboro acquisition cycle is approximately 1 minute. Three programs perform the data transfer to ORACLE:

IMMRUN, which is a computer program, sends the data for selected data tags to a port on the VitPP control FOXBORO.

GETDATA.WAX is a computer program that creates data files from the IMMRUN output. Files are saved locally until picked up by the computer program VPPSLOAD.

VPPSLOAD computer program copies the waiting files to the FEMP network and loads the files onto ORACLE. All files are saved in the ARCHIVE program; rejected files are saved in a separate directory known as BAD.

2. Analytical data from on- and off-site labs as well as the VitPP lab will be available in the site FACTS (Fernald Analytical Computerized Tracking System).

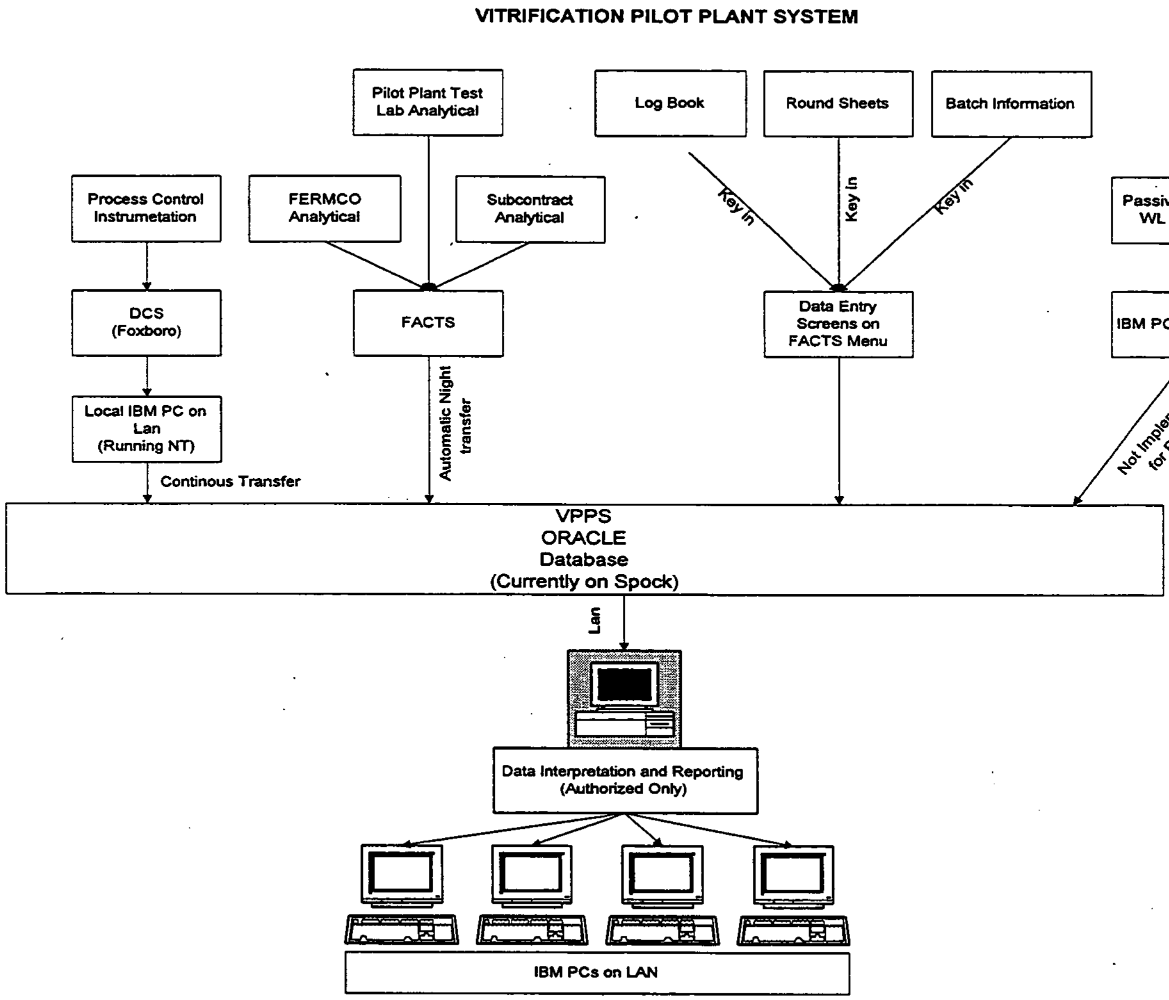
3. Operations log book information such as the Test Coordinators' Log, Shift Turnover Log, and operator's comments may be manually keyed into the data base using the VPPS Data Entry Module. This module is accessed using the FACTS system in a manner similar to the analytical VPPS combines these data streams into a set of tables that can be accessed for reporting and analytical data. VPPS combines these data streams into a set of tables that can be accessed for reporting and

4. Data from shift Roundsheets and other special data collection sheets may be entered into the ORACLE data base manually using the Data Entry Module. The Roundsheet data are collected by plant operators on a routine time cycle throughout an operating shift.

VPPS combines these data streams into a set of tables that can be accessed for reporting and analysis.

3.5.2 Reporting

The VPPS database is accessed through the VPPS Reporting Application available on the Local Access Network (LAN) to selected users. Individual data tags or groups of data tags as specified by the user may be accessed on an hourly averaged basis or a minute-by-minute basis. Reports may be printed or read to file.



Data Flow Diagram
Figure 3-10

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4.0 DATA ACQUISITION AND PROCESS CONTROL

4.1 Data Acquisition

For Melter control, the process instrumentation system and Melter observation points provide the means to measure and respond to changes in the Melter vitrification process to maintain steady-state conditions. The following "real-time" parameters are measured or observation noted:

Melter Chamber

- Glass temperature - thermowells into the waste chamber glass
- Amperage, voltage, and power Silicon Control Rectifier (SCR) to resistance heaters - SCRs 3, and 4 to resistance heaters for the main chamber lid and the glass discharge chamber
- Agitation - air flow rate to bubblers
- Glass discharge - air pressure to the glass air lift between the main chamber and the discharge chamber
- Glass level in the main chamber - observation ports
- Glass surface of melt - observation ports
- % cold cap and appearance - observation ports
- Foaming - observation ports
- Response time to changed conditions - process instrumentation recorded on the Data Acquisition and Control System (DACS)
- Chamber glass - periodic sampling
- Feeder tubes - surface thermocouples, cooling water temperature, and water flow rate
- Main chamber drains - 2 bottom drains, surface thermocouples, cooling water temperature, and water flow rate
- Refractory wall - thermocouple behind refractory in main chamber

Electrode Chamber(s)

- Electrode amperage, volts, and power - SCR 1
- Temperature - thermowells into the glass and optical infrared glass surface measurement
- Electrode holders - surface thermocouple, cooling water temperature, and water flow rate
- Chamber glass level - level probes molybdenum disilicide electrical contacts
- Chamber glass - periodic sampling
- Drains - surface thermocouples, cooling water temperature, and water flow rate

Glass Discharge Chamber

- Glass temperature - thermowell into glass

- Amperage, voltage, and power to resistance heaters - SCR 2 to resistance heaters for the glass discharge chamber
- Glass transfer to discharge chamber - air lift flow rate and pressure
- Appearance and thickness of glass discharged - observation ports
- Plenum temperature - thermowell into plenum area

Feed

- Glass feed composition - batch formulation sheets
- Feed rate - Melter feed pump RPM and feed rate calibration, feed slurry tank weight
- Percent Solids - laboratory analysis

Off-gas and Melter Plenums

- Melter pressure - differential pressure between room and Melter, emergency off-gas system and Melter, and furnace off-gas system and Melter
- Plenum temperature - thermowells into plenum area of each electrode chamber
- Film Cooler - air flow rates, temperature, and pressure drop
- Off-gas system - pressure, temperature, and flow in lines and at components
- Constituent gases - concentration and makeup from sample points
- Volatilization and particulate carry over - prefilters and HEPA filters, observation of lines and components
- Moisture content - moisture instrumentation

Gem Machine

- Enclosure pressure - differential pressure between room and enclosure
- Enclosure temperature - thermocouples at top, bottom, and expansion joint
- Conveyor - head and tail component temperatures, cooling water temperature and flow rate, speed
- Gem roller and cutter - component temperatures, cooling water temperatures, and cooling water flow rate, speed
- Glass diverters - cooling water temperature and flow rate, position indicators
- Material receivers - emergency, startup, and gem receivers; infrared temperature detectors at each receiver

Closed-Loop Cooling Water

- System water - level indicators, flow rate, supply and return pressure and temperature
- Pumps - discharge pressure, operating mode
- Water to air cooler - fan speed, operating mode

4.2 Process Control

4.2.1 Melter Control

Control focuses on maintaining the main chamber glass at an optimal temperature. When the temperature of the glass drops, more heat is imparted to the glass (joule heating of the glass from current flow between the electrodes) until the temperature is again reached. Heat to the main chamber glass is controlled by a 60 hertz, single phase, SCR 1. SCR 1 may be operated using voltage, temperature, current, or power set points. All Campaign 1 operations have been performed using the power set point selected to maintain the main chamber glass at various operating temperatures.

There are four basic parameters or characteristics of the glass melt that effect the operation of the Melter, but are not readily measurable. These are (1) viscosity, (2) electrical conductivity, (3) liquidus temperature, and (4) redox[14]. The relation of these parameters with the Melter feed are described in Section 2.1.

4.2.2 Batch Operation and Analytical Process Control

Melter runs were performed with slurry feed batches prepared in accordance with Batch Sheets to provide slurries of 15 to 55 wt.% solids.

Samples were taken for each slurry batch during slurry mixing/preparation [Sample points S-04A/04B] and as a batch was being fed to the Melter [Sample points S-05/05A]. The samples were tested by the laboratory for physical and chemical properties following the analysis procedures specified in the Project Specific Plan for Phase I process sampling [document 2504-SU-0011]. Table 4-1 shows the laboratory results reported for the property wt.% solids.

Variation between the calculated wt.% solids and the laboratory results are being reviewed to resolve the range of variability. The calculated slurry percent solids is based on the formula weight of the solids additives which in some cases includes water of hydration. The measured slurry percent solids values are determined in the laboratory by drying the slurry sample. This method drives off some of the hydrated water which accounts for some of the variation between the calculated and the measured percent solids. Also VitPP operations problems with slurry mixing and pumping the slurry on occasion have required that water additions be made to the slurry during processing. Individual analysis samples that were taken of a diluted slurry and subsequently measured in the laboratory may account for low measurements of percent solids.

[14]Redox is a term used to describe the amount of oxygen in a system. It is short for Reduction oxygen potential.

Table 4-1
Weight Percent Solids by Batch Number

Batch No.	Calculated Weight % Solids	Laboratory Weight % Solids
C1B01	15	13.3
C1B02	34	31.4 to 39.5
CIB03	N/A	Frit charged
C1B04	N/A	Frit charged
C1B05	34	22.9 to 37.0
C1B06	35	23.5 to 35.2
C1B07	46	Not sampled
C1B08	45	42.6 to 45.0
C1B09	25	26.3
C1B10	55	Not sampled
C1B11	50	49.3 to 50.3
C1B12	50	49.6
C1B13[15]	50	53 to 54.7

[15]Batch numbers refer to Campaign 1, Batch No. 1 (C1B01).

5.0 CAMPAIGN 1 RESULTS

5.1 Refractory Bakeout

Due to its size and construction, the Melter had to be brought up to operating temperature slowly -- approximately two weeks. This process allowed a slow curing and thermal expansion of the walls and prevents the thermo shock that may impact the materials of construction. The initial temperature showed no significant rise during the first few days of the bakeout due to low amperage per hour limits set by the vendor. At the request of Fluor Daniel Fernald personnel, the vendor increased the amperage per hour limit and from that point, the bakeout progressed smoothly. Figure 5-1 graphically shows how heat up of the Melter progressed.

5.2 Empirical Melter Heat Losses

Heat losses from the Melter are best observed after it has been subjected to the lid heaters for a considerable amount of time and reached an equilibrium condition. Table 5-1 shows that 95,594 watts of heat were produced by two banks of molybdenum disilicide heaters in the Melter lid during an equilibrium condition on June 5, 1996. According to calculations also contained in Table 5-1, the majority of the heat input is lost through the Melter shell (44,414 watts) and Melter exhaust (25,188 watts).

The Melter vendor originally anticipated a higher heat loss from the Melter shell, so that it would reach a contact temperature of 400 °F. The Melter contact temperature measured using a contact pyrometer, is below 200 °F and can be momentarily touched with the fingers without burning. The building ventilation system keeps the Melter room cool.

5.3 Electrode Insertion into the Melter

Ten electrodes were inserted into the Melter during startup activities. Each electrode is 3 inches in diameter, approximately 6 feet long and weighs 150 pounds. The electrodes taper to a point at the end that is inserted into the Melter. The tapered electrodes simulate a worn electrode allowing them to erode uniformly.

The electrodes were inserted in lifts with hammers and large wrenches. Frit was placed in each chamber as necessary to cover the electrode after it was inserted. This keeps the molybdenum electrodes from oxidizing. As each electrode was inserted, a temporary plug that prevents frit leakage was knocked out and the surrounding frit was melted. The procedure continued until all the electrodes were inserted into the chambers. Joule heating of the glass frit was limited to 600 amps per electrode during this procedure.

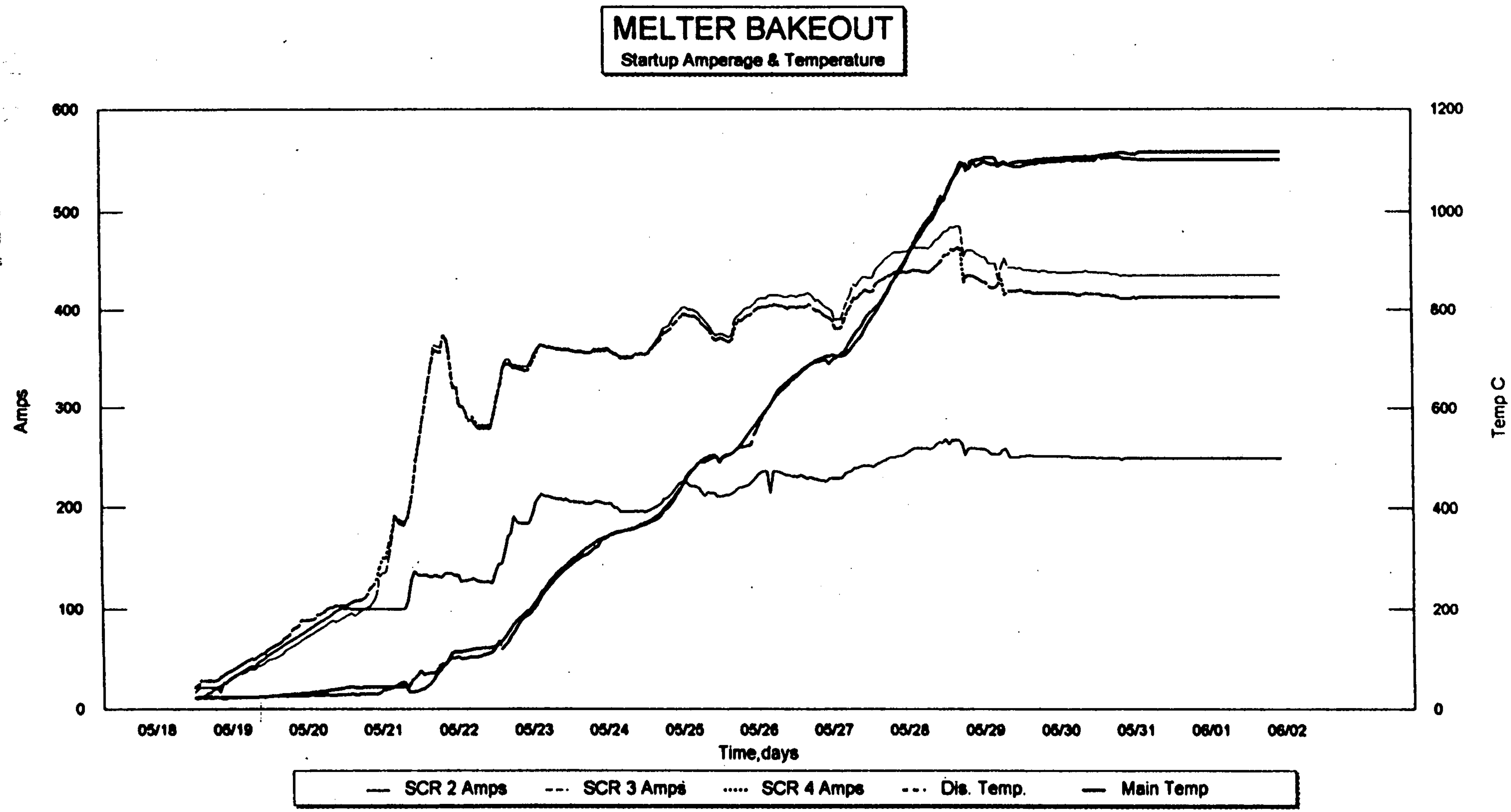


Figure 5-1
Melter Bakeout Graph

Table 5-1
Heat Input from the Lid Heaters During Bakeout
June 5, 1996

Lid Heater Bank 1 (SCR #3)			Lid Heater Bank 2 (SCR #4)		
Volatage	Amps	Watts	Volatage	Amps	Watts
59	415	24,485	68	396	26,928
63	419	26,397	45	393	17,685
		50,882			44,613
			Bank 1 and 2 total:		95,495

Bath temp., °C:	1,126
East chamber temp., °C:	1,028
Air inleakage, scfm:	60
Bubbler, scfm:	2

Heat Losses (Calculated)	Amount kg/hr	Amount each	q' watts/unit	Q watts
Moisture	0		1,031	0
Gas generation	0		195	0
Inleakage & bubbler	129		195	25,188
Radiant losses	--		44,414	44,414
Cooling - Electrodes **		10	199	1,991
Cooling - Ports		5	2,460	12,299
Cooling - Drains		4	2,925	11,701
Vitrification, glass	0		368	0
Lid heater banks		2	0	0
	129	19	na	95,594

d:heatup.wk4

** Electrodes were not installed, but the holders were,
Used 1/2 the electrode value.

5.4 Heat Loss Via the Electrode Chambers and Melter Ports

After the electrodes were inserted, the heat was supplied by joule-heating from the electrodes. However, the heat losses from the Melter do not change much. The major changes are as follows: (1) air in-leakage has been reduced since the electrodes have filled the holes in the Melter wall; and, (2) the electrodes themselves draw heat from the East and West side chambers. The heat drawn by the electrodes from the glass is less than the electrode-holder vendor suggested (2,000 watts/holder or electrode). Data shown in Table 5-2, taken on July 7, 1996, show the requirement is much less than the vendor's estimate. The most probable reasons for this difference are as follows: (1) that the side chambers run significantly cooler than most molybdenum electrode applications; and, (2) the distance between the hot glass and the electrode holder is greater than typically seen.

The temperature in the side chambers varies from top to bottom. A rod with thermocouples along its length was inserted in the East Chamber to obtain a temperature profile. Table 5-3 presents the temperature profile as measured at different times. Depths are measured from the top of the Melter. The thermocouples were installed to support replacement of the bottom drain which was done August 18, 1996. The side chamber appears to be hottest in the center and coolest at the bottom. This is a typical type heat pattern seen in commercial non agitated melters.

5.5 Melter Power Requirements

This section discusses the power requirements of the Melter for idle conditions, transition, slurry feed operations, and Melter glass and component temperatures relationship.

5.5.1 Power Requirements for the Melter to Run Idle

Tables 5-4 and 5-5 show typical power requirements for the Melter to idle at approximately 1050°C and 1123°C respectively. The power required is approximately 84 and 92 kilowatts. Table 5-6 shows typical power requirement for the Melter to idle at 1250°C. The Melter was never allowed to idle during Campaign 1 at 1250°C long enough for the Melter to come to equilibrium at 1250°C long enough for the melter to come to equilibrium at 1250°C. On June 29, 1996, the Melter was held for a short time in transition between a run at 1250°C and idle at 1150°C. However, the results show that it requires about 104 kilowatts respectively to idle at 1250°C or approximately 20 kilowatts more than it takes to idle at 1150°C.

Table 5-2
Electrode and Other Port Heat Losses
August 7, 1996

Electrode/ CW in	Holder Temp, °F	CW Out Temp, °F	Delta T. Temp, °F	CW gpm	Heat Loss kw
Cooling water temp., °F:			104.15		
Cooling water (50% glycol) Cp, cal/g-°C:			0.75		
East Chamber Electrodes		(glass 1171°C)			
D	571	107.3	2.6	2.60	0.74
E	510	106.66	2.6	2.60	0.74
F	557	107.3	2.6	2.80	0.80
G	544	107.3	1.6	1.00	0.18
H	316	111.71	0.8	0.60	0.05
Average	499.6	108.054	2.04	1.92	0.50
West Chamber Electrodes		(glass 1136°C)			
I	512	112.02	1.2	1.00	0.13
J	438	110.76	1.2	0.60	0.08
K	570	107.93	2.8	2.80	0.86
L	524	106.66	2.8	2.80	0.86
M	432	112.65	0.8	0.50	0.04
Average	495.2	110.004	1.76	1.54	0.40
Total	–	–	–	17.30	4.49
Average	497.4	109.029	1.9	1.73	0.45
Other Ports					
Cooling water temp., °F:		104.15			
Center Chamber Feed		111	6.85	1.80	1.35
West Chamber Feed		134	29.85	1.80	5.90
East Chamber Feed		128	23.85	1.80	4.72
Bottom Drain #1		122	17.85	3.10	6.08
Bottom Drain #2		114	9.85	1.80	1.95
Center Frit Tube		110	5.85	3.00	1.93
Bottom Drain #3		107	2.85	2.20	0.69
Spare Bottom Drain		124	19.85	2.30	5.02
East Chamber Infrared Detector		OOS	OOS	0.00	0.00
West Chamber Infrared Detector		OOS	OOS	0.00	0.00
Surface Drain		109	4.85	1.00	0.53
Total		–	–	18.80	28.17
Average		96.27	11.06	1.71	2.56

d:e-cool.wk4

Table 5-3
Temperature in the East Side Chamber vs. Depth

Depth (inches)	Temperature, °C			
	8/10/96, (2000 hrs)	8/12/96, (2000 hrs)	8/14/96, (2000 hrs)	8/16/96, (2000 hrs)
48	998	1007	999	1018
60	997	1001	1001	1015
72	1106	1116	1124	1123
84	1052	1056	1060	1060
96	924	927	933	930
Melter Bath	1130	1130	1130	1131

Table 5-4
Melter Idle Conditions at 1050°C
June 17, 1996 around 0700 hrs.

Bath temp., °C:	1,050	<u>Electrode</u>	
East chamber temp., °C:	1,030	EMF, volts:	104
Air inleakage, scfm:	50	Current, amps:	815
Bubbler, scfm:	2	Power, watts:	84,560

Heat Losses (Calculated)	Amount kg/hr	Amount each	q' watts/unit	Q watts
Moisture	0		1,031	0
Gas generation	0		195	0
Inleakage & bubbler	108		195	21,125
Radiant losses	--		39,765	39,765
Cooling - Electrodes		10	389	3,885
Cooling - Ports		5	2,202	11,012
Cooling - Drains		4	2,619	10,476
Vitrification, glass	0		343	0
	108	19	--	86,263
Minus heat from lid heaters				(2,000)
Electrode power needed (compare above)				84,263

d:Idle-4.wk4

Table 5-5
Melter Idle Conditions at 1123°C
June 17, 1996 around 1700 hrs.

Bath temp., °C:	1,123	Electrode	
East chamber temp., °C:	1,067	EMF, volts:	97
Air Inleakage, scfm:	50	Current, amps:	955
Bubbler, scfm:	2	Power, watts:	92,510

Heat Losses (Calculated)	Amount kg/hr	Amount each	q' watts/unit	Q watts
Moisture	0		1,031	0
Gas generation	0		195	0
Inleakage & bubbler	108		195	21,125
Radiant losses	–		44,414	44,414
Cooling - Electrodes		10	425	4,253
Cooling - Ports		5	2,460	12,299
Cooling - Drains		4	2,925	11,701
Vitrification, glass	0		368	0
	108	19	–	93,792
Minus heat from lid heaters				(2,000)
Electrode power needed (compare above)				91,792

d:Idle-3.wk4

Table 5-6

Melter Idle Conditions at 1250°C (Calculated **)

Bath temp., °C:	1,250	Electrode		
East chamber temp., °C:	1,132	EMF, volts:		83
Air Inleakage, scfm:	50	Current, amps:		1,252
Bubbler, scfm:	2	Power, watts:		103,988

Heat Losses (Calculated)	Amount kg/hr	Amount each	q' watts/unit	Q watts
Moisture	0		1,031	0
Gas generation	0		195	0
Inleakage & bubbler	108		195	21,125
Radiant losses	--		52,000	52,000
Cooling - Electrodes		10	476	4,763
Cooling - Ports		5	2,880	14,400
Cooling - Drains		4	3,425	13,700
Vitrification, glass	0		408	0
	108	19	--	105,988
Minus heat from lid heaters				(2,000)
Electrode power needed (compare above)				103,988

d:idle-2.wk4

** Numbers are calculated because the melter never came to idle equilibrium at 1250°C. However, the melter hovered idle around 1250°C 7/29/96 after a run then dropping to 1150°C idle.

The lid heaters are only supplying a small amount of Heat at this time. This is because the heaters were kept slightly hotter than their surroundings to help extend their life. This prevents the formation of deposits on the heaters that may be corrosive. The power requirement is estimated to be 1 to 2 kilowatts which is not a significant contribution to the Melter system.

Four long-term idle conditions selected for main chamber glass temperatures of 1120, 1130, and 1250°C are presented below in Table 5-7.

Table 5-7
Power Readings During Idle Conditions

Main Chamber Glass Temperature C	SCR 1 to Electrodes	
	Power k-Watts	Current Amps
1120	90	1115
1130	106	1001
1130	100	915
1250	135	1364

Power can vary approximately 30 or 40 Kilowatts for what appears to be the same setting. However, conditions can be different. For example, air in-leakage may vary from 30 to 80 scfm. This difference alone can account for the difference in the power requirement. Likewise, air in-leakage from the discharge chamber is already preheated to approximately 1250°C which requires no additional heat from the Melter. Also, taking measurements during transient conditions will give different readings.

5.5.2 Power Requirements for the Melter for Transition

Initially, a knowledge of the Melter transients was gained by pumping water to the Melter in lieu of a slurry feed during the month of June 1996. The above shows at least 10 kilowatts continuous (at equilibrium) is needed to transition 100°C, but more power is needed (temporarily) to change the temperature of the glass bath and the surrounding Melter mass -- mainly the refractories. The refractories will increase an average 50°C. Therefore, the approximate amount of power required for transition is given in Table 5-8.

Table 5-8
Chamber Power Needs During Transient Conditions

Main chamber glass:	(0.33 kWh/tonne glass °C)(1.82 tonne glass) x (100°C) = 60 kWh
Side chamber glass:	(0.33 kWh/tonne glass °C)(0.5 tonne glass) x (100°C) = 16 kWh
For the Melter:	(0.33 kWh/tonne refractories °C)(20 tonne refractories, needs to be verified) x (50°C) = 330 kWh (this does not include metal around the Melter)

The above calculations show approximately 400 kWh are needed for a 100°C transition. The heating of the glasses will be rather immediate. A 20°C/hr temperature change was administratively set to limit thermo shock to the Melter. At 20°C, this equates to an increase of 19 kilowatts. However, the refractories absorb heat from the glass and additional power is required. Empirically, it appears approximately 40 more kilowatts are needed for transition in addition to the 10 kilowatts to maintain the higher 100°C temperature. This transitional need will eventually drift to zero. Therefore, the Melter bath temperature normally creeps up and the operators are continually readjusting the power set point for the Melter until equilibrium is reached a day or so later. The reverse can be true if transitioning from a high to a lower temperature.

5.5.3 Power Requirements to Process Slurry

The amount of power necessary to process a slurry is largely dependent on its percent solids content. The more water the slurry has, the more power it takes up to just evaporate the water. The Melter appears to behave best at approximately 40 to 50 wt% solids. Table 5-9 shows the average power requirement for the Melter at different wt% solids and temperatures. It takes approximately 70 to 75 more kilowatts power than the idle power requirement to process a metric ton of glass at approximately 50 wt% solids. The first metric ton is often shown to require the most power to process since the idle power requirement is factored in. Each additional metric ton requires significantly less power to process. Most of the extra power to process the glass is in (1) evaporating water (~73%), (2) vitrification (~24%, raising the glass to melt temperature), and heating off-gases (~3%).

Table 5-9
Power Needed To Process Slurry

Date	Time Hours	Temp. (°C)	Solids (wt% Solids)	Rate (Eq MT/d Glass)	Power (kilowatts)
7-16-96	1900	1246	35	0.8	177
7-18-96	2300	1252	35	1.1	182
7-23-96	1900	1246	45	1.7	201
7-27-96	0800	1254	50	1.8	212
7-28-96	1100	1252	55	1.7	154

The Melter system can deliver 500 kilowatts of power (or Heat) to the Melter. Indications are that this is sufficient power to process 5 to 6 metric tons of glass per day from slurry at 40 to 50 wt% solids. However, the operation envelope narrows because amperage limits can become more limiting than the power ceiling of 500 kilowatts. As power increases in the Melter, the allowable ratio of amps to volts (electrical conductivity) of the glass narrows. Generally, it appears the glasses need to be made less conductive so the power can be delivered at higher volts and lower amps. Figure 3-8 shows how the envelope can collapse at higher production rates due to conductivity.

5.5.4 Melter Response

The temperature of the Melter or the reference temperature of the Melter has historically been defined as the bottom bath temperature, which is measured by a thermocouple located in a platinum thermocouple well protruding into the bath 6 inches from the bottom of the Melter. The other key thermocouples normally read less than the Bottom Main Thermocouple. Table 5-10 shows approximately how much less the key thermocouples read at 0.8 MT/d glass production at 1250°C (July 17, 0300 hrs).

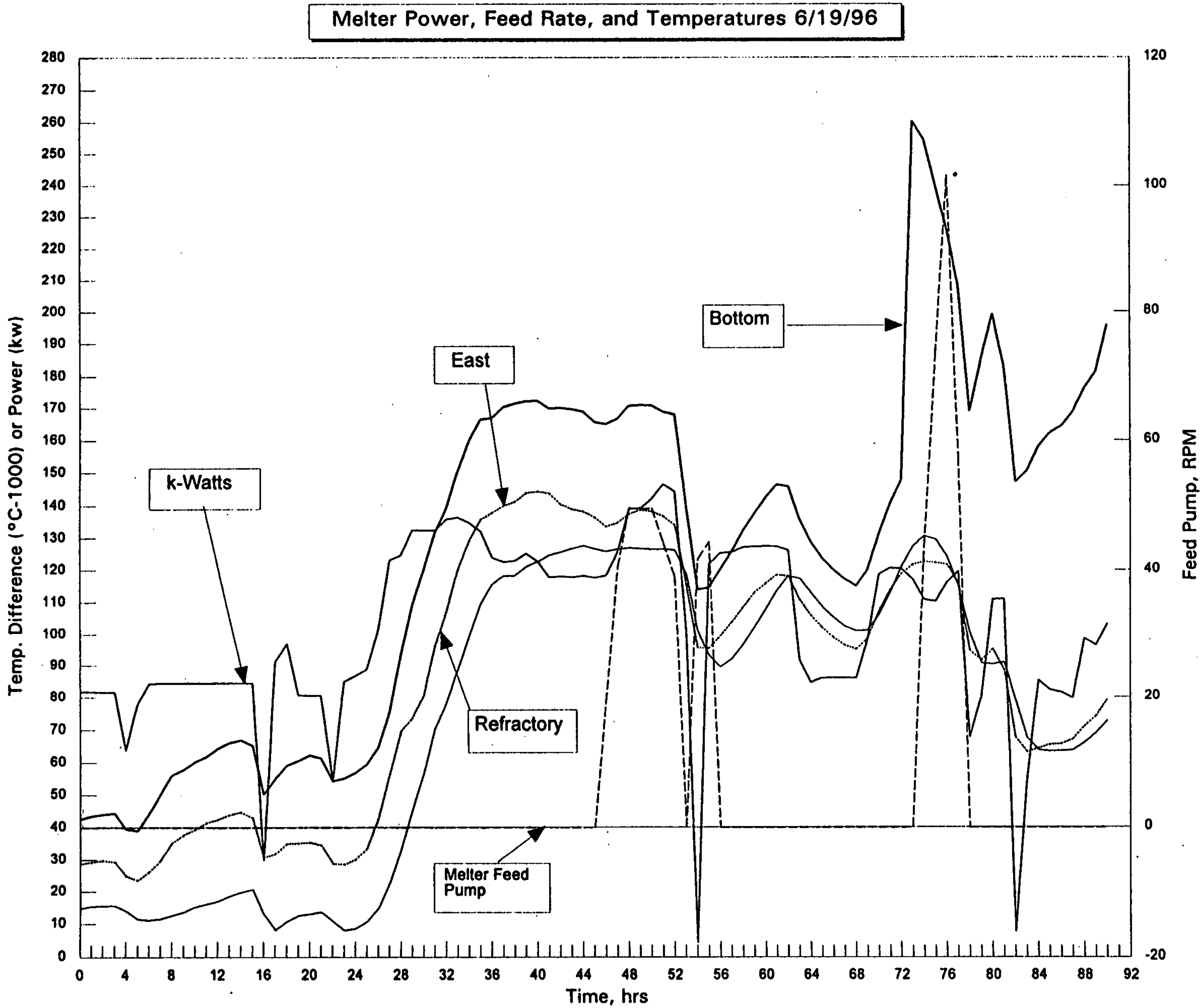
Table 5-10
Melter Temperatures at Steady State (1 MT/d)

Thermocouple	Reading, °C	Difference, °C
Bottom Main	1257	0
Top Main	1211	-46
Wall Refractory, 1" in from bath	1127	-130
East Side Chamber	1109	-148
West Side Chamber	1141	-116

However, the relationship of these temperatures can vary greatly at different (1) power levels, (2) glass conductances, and (3) during transients. Figure 5-2 shows how the temperatures varied for 48 hours after the Table 5-10 reading. Figure 5-3 is similar to Figure 5-2, except all the temperatures are set to "zero" at 0300 hrs to show how the transients vary thereafter. Unfortunately, the thermocouple in the West Chamber was lost at this time and no more information is available for this chamber. However, up until this time this side chamber appeared to run about 30 to 40°C hotter than the East Side Chamber. Response of the Melter will be further studied during the subsequent campaigns to better understand its response so control can be maintained in the event of loss of thermocouples in the bath. If these thermocouples were lost, the refractory thermocouple would most likely become the one used for controlling the Melter. However, temperature and power changes would have to be made slowly because the refractory thermocouple response appears to lag 1 to 3 hours behind the Main Bottom Bath Thermocouple.

5.6 Frit Leakage from the Side Chamber

Up to 100 lbs/day (50 lbs/chamber) of side chamber electrode glass were expected to leak into the main chamber. Table 5-11 shows the amounts of frit added to maintain a protective glass level over the molybdenum electrodes. The leakage of the electrode glass into the main chamber is not a complete loss or waste of material. The electrode glass is high in lithium and aluminum which are additives required in making glass of the silo wastes. So the amount of the constituents in the electrode glass can be subtracted from the amount for the additives. Lithium is the most expensive additive; therefore, the loss of side chamber glass may not be as costly as it first appear.



Melter Power, Feed Rate, and Temperatures 6/19/96
Temp. Difference (°C-1000) or Power (kw)
Feed Pump, RPM
Time, hrs
k-Watts
East
Refractory
Bottom
Melter Feed Pump

Figure 5-2

Change of Temperature and Power vs. Time 6/19/96

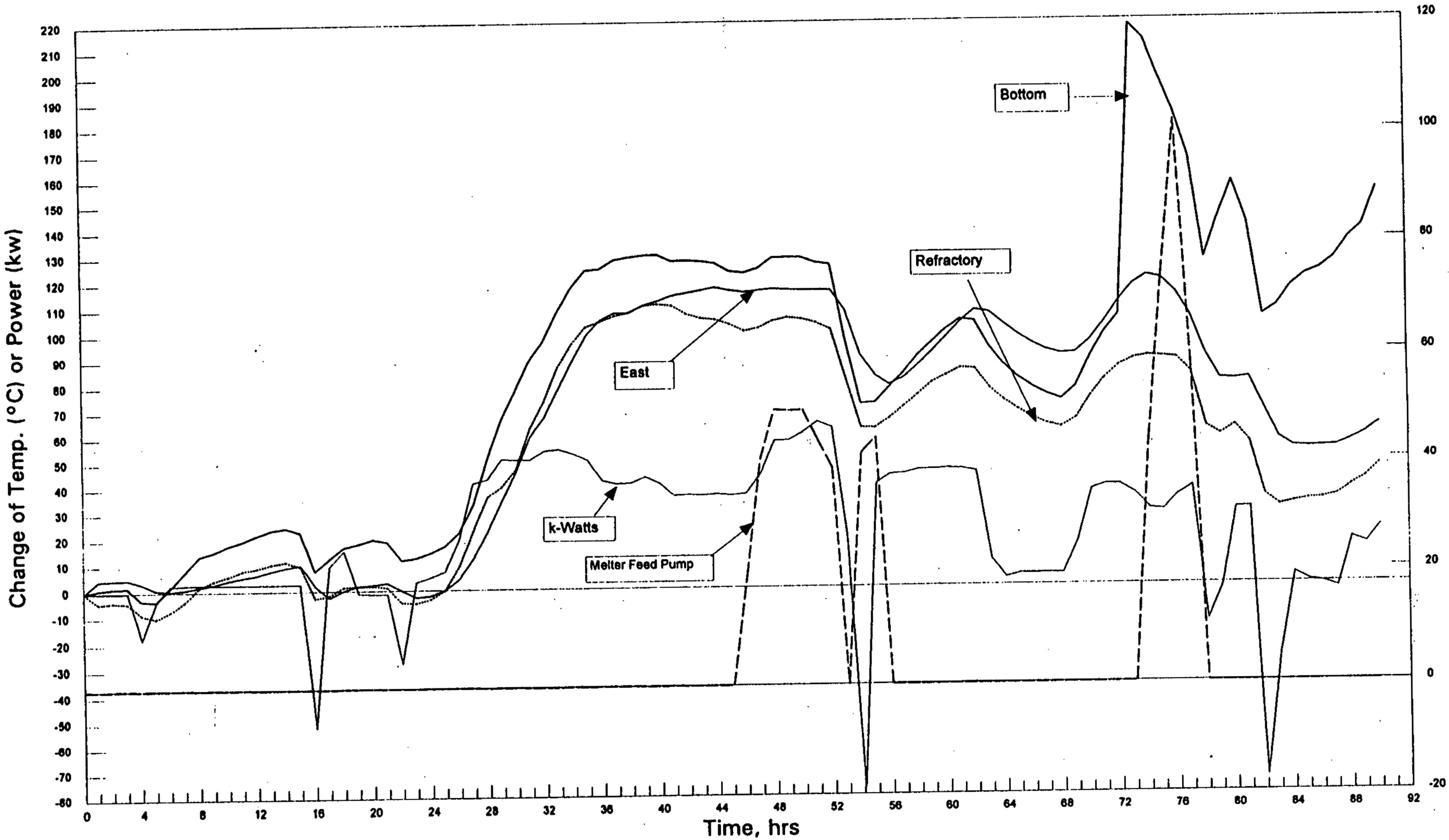


Figure 5-3

Table 5-11
Frit Usage per Batch

Batch Number	East Chamber (lbs)	West Chamber (lbs)
1	75	250
2	50	75
3	25	25
4	25	75
5	25	50
6	50	100
7	50	25
8	25	75
9	0	0
10	225	400
11	0	125
12	0	75
13	25	50
Total	575	1325

5.7 Cold Cap vs. Production Rate and Off-gas Control

Experience, thus far, has shown that the pilot system performs best with a cold cap. A cold cap is a mass of dry slurry that collects on top of the molten glass surface that has not yet dissolved into the molten glass underneath. Operating with a cold cap appears to reduce the temperature and particulate overflow to the off-gas system. The Film Cooler needs cleaning less frequently when operating with a cold cap. A cold cap can reduce the off-gas temperature several hundred °C, which significantly reduces the demand on the off-gas system. The Bubbler agitators and the Melter Feed Pump rate are used to develop the optimal cold cap. The Bubblers tend to be a course adjustment and the feed pump rate is a finer adjustment.

5.8 Agitation -- Bubbling Rate in the Main Bath

A correlation between bubbling rate and agitation has not been directly studied. However, Agitation does appear to play a factor in the production rate of glass. The bubbler rate (along with feed rate and power) has normally been changed to control the cold cap size and percent of glass surface coverage. Higher bubbler rate appears to break up the cold cap and accelerate its dissolution, but a direct correlation has not been measured. The bubblers are normally over 4 scfh. This rate appears to significantly increase the production rate over the traditionally accepted norm of 1 MT/d glass produced per square meter.

5.9 Electrical Grounding of the Melter

Since the refractory conductivity is related to temperature, some electrical current is expected to flow to ground and does so as measured and is recorded in Table 5-12. Notice that the amounts are not much; however, if the numbers were to increase significantly, it could be an indication that glass is beginning to flow into the Melter liner or ports and would probably warrant corrective action. Amperage to ground the Northwest corner of the outer shell has also been measured at an average of 0.5 amps.

Table 5-12
Voltage Reading to Ground on the Melter, 8/28/96

Bottom Drain 1	1.19	Inner Shell	0.63
Bottom Drain 2	2.1	Outer Shell	0.05
Bottom Drain 3	0.67	Air Lift	2.9
Bottom Drain Spare	0.39	Thermowell 1	3.9
		Thermowell 3	4.1
		Thermowell 5	43.1

Melter Conditions:

RMS Voltage:	101 volts
RMS Current:	1274 amps
Power:	125 kilowatts
Bath temp.:	1281°C

5.10 Description of Slurry Batches and Glass Product

Table 5-13 summarizes the Campaign 1 slurry batches. A slurry Batch Sheet was prepared specifying the additive glass forming constituents and mixing water. The batch formulation was prepared on the basis of producing 1 metric ton of product glass. The formulation accounted for the necessary additives to meet the requirements for an acceptable glass, achieve the target slurry solids weight %, achieve the necessary molten glass viscosity, and provide the proper conductivity for the molten glass to maintain the desired Melter main chamber operating temperature.

Table 5-13
Campaign Batches

Test Plan[a] Run No.	SOT[b] Test No.	Batch No.	Calculated Slurry% Solids (wt %)	Measured Slurry % Solids (wt %)	Calculated Glass Product (lbs)	Glass Produced from Slurry Feed (lbs)
1	7.1	N/A	Water Feed	N/A	N/A	N/A
1	7.2	C1B01	20	13.3	975	462
1	7.2	C1B02	40	32-45	3371	2271
1	7.3	C1B05	40	23-37	2240	1540
2	7.4	C1B06	40	23-35	1760	2272
2	7.4	C1B07	50	Not Reported	2240	1982
2	7.4	C1B08	50	43-45	2240	1993
2	7.4	C1B09	50	26.3	1880	236
3	7.5	C1B10	50	Not Reported	3838	3038
3	7.5	C1B11	50	49-50	800	1977
3	7.5	C1B12	50	49.6	2240	2105
3	7.5	C1B13	54	53-55	2240	2714
CAMPAIGN 1 TOTALS					19,880	21,090

a: Operable Unit Vitrification VitPP Phase I Treatability Study Work Plan, WP-25-0007, Revision 2, June 1996.
b: Vitrification Pilot Plant Startup Program Phase I Pilot Plant Systems Operability Test Procedure Melter Campaign 1, Test Procedure 2504-SU-0034, Revision 1, June 1996.

Detailed information for all batches and the glass produced from each batch is presented in the Test Performance Parameters sheets that are in the Appendix A to this report.

The calculated slurry percent solids is based on the formula weight of the solids additives which in some cases includes water of hydration. The measured slurry percent solids values are determined in the laboratory after heating a slurry sample to dryness. This method drives off the hydrated water which accounts for some of the variation between the calculated and the measured percent solids. Also, VitPP operations problems with slurry mixing and pumping the slurry on occasion have required that water additions be made to the slurry during processing. Individual analysis samples that were taken of a diluted slurry, and subsequently measured in the laboratory, account for the excessively low measured percent solids values.

Differences between the expected glass product value and the produced glass value are attributable to two sources. The product glass yield for a slurry formulation is based on estimating the volatile elements of a slurry formulation that are released to the furnace off-gas system. The current slurry formulation calculations include a factor of 20% to account for the release of the volatile components; i.e., a yield factor of 80% of the slurry solids that become glass product. Revised laboratory slurry sample drying methods are being evaluated to improve the estimate of glass yield from the slurry. The column "produced glass product" is the glass product form and other glass material recovered from the Gem Making Machine. A "lesson learned" from the Campaign 1 operations has identified the need for tighter controls to be implemented with regard to retrieving and segregating all product glass for each designated glass batch. Also, identifying the in-process slurry batch affected when frit additions are made to the Melter will improve individual batch correlation between calculated versus produced product glass. Overall, for all of the Campaign 1 tests, the produced glass product value is approximately 90% of the calculated glass product value.

5.11 Analytical Results for Batch Glasses

The physical and analytical analysis of the glasses are given in Table 5-14. The glass chemistry appears to be rather consistent except for Batch 8 and 13 where the silica content appears low. However, a good glass was still made. Also, most of the viscosity and conductivity numbers appear rather consistent, except a few numbers appear to be significantly out of the expected range which indicates possible analysis error.

Analytical Results for Batch Glass

	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8	Batch 10	Batch 11	Batch 12	Batch 13	Average
SiO_2	48.03	50.10	51.31	51.11	50.56	52.08	42.73	39.73	43.52	40.12	40.54	38.12	45.66
B_2O_3	8.86	10.47	10.67	8.20	9.97	10.61	9.82	9.79	9.87	10.32	11.04	9.14	9.90
Li_2O	2.71	2.80	2.36	2.18	2.21	1.94	1.50	1.17	1.86	0.94	0.46	1.39	1.79
Al_2O_3	10.57	10.56	9.34	11.41	10.92	10.31	8.84	9.67	9.95	9.77	9.22	9.51	10.01
BaO	0.05	0.12	0.06	0.07	0.05	0.04	0.02	0.02	0.04	0.03	0.03	0.00	0.04
CaO	10.42	10.77	9.34	11.58	10.91	11.74	11.30	12.35	11.89	12.56	12.52	11.62	11.42
Fe_2O_3	0.17	0.19	0.14	0.19	0.17	0.16	0.11	0.12	0.15	0.11	0.11	0.13	0.15
K_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.14	0.00	0.22	0.00	0.00	0.04
MgO	0.96	0.98	0.76	1.11	0.86	0.75	0.56	0.61	0.82	0.54	0.50	0.77	0.77
Mn_3O_4	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00
PbO	0.02	0.02	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
V_2O_5	0.02	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Na_2O	12.23	11.32	12.27	11.26	10.81	10.58	9.97	10.27	10.15	11.01	10.74	10.73	10.95
ZrO_2	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31	4.31
Cobalt	0.0015	0.0001	0.0016	0.0012	0.0033	0.0383	0.0451	0.0244	0.0174	0.0081	0.0069	0.0049	0.0127
Molybdenum	0.0400	0.0100	0.0300	0.0300	0.0200	0.0200	0.0000	0.0000	0.0100	0.0000	0.0100	0.0200	0.0158
Cr_2O_3	0.1168	0.1168	0.0876	0.1022	0.1168	0.0876	0.0438	0.0584	0.0730	0.0438	0.0438	0.0584	0.0791

	Batch 1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7	Batch 8	Batch 10	Batch 11	Batch 12	Batch 13	Totals
Total Percent	98.5183	101.79	100.69	101.59	100.95	102.69	89.39	88.27	92.68	89.99	89.55	85.82	
Glass Prod. (lbs.)	537	1135	1566	497	1435	2364	2126	2153	2964	1979	2341	3169	22266
Total Cr_2O_3 (lbs.)	0.627	1.326	1.372	0.508	1.676	2.071	0.931	1.257	2.164	0.867	1.025	1.851	15.675
Total Mo (lbs.)	0.215	0.114	0.470	0.149	0.287	0.473	0.000	0.000	0.296	0.000	0.234	0.634	2.871
Conductivity (mS/cm)													
@ 1050 C	121.5	111.2	176.6	156.1	130.8	82.0	89.2	61.1	84.6	76.2	58.3	59.0	
@ 1150 C	162.3	180.5	211.3	194.8	186.4	128.5	143.4	103.6	125.7	102.2	100.1	101.0	
@ 1250 C	366.0	229.2	217.5	328.5	403.6	366.3	199.4	147.4	175.0	147.0	142.8	143.4	
@ 1350 C	3436.7	282.2	197.4	2964.2	579.0	1241.4	252.6	190.5	205.6	165.6	197.7	183.0	
Viscosity (Poise)													
@ 1250 C	36.78	47.48	23.12	46.39	28.17		47.48	43.77	52.47	43.27	43.3	34.71	
@ 1350 C	18.33			23.67	13.88		22.33	19.2	24.4	18.98	23.15	15.23	
Density (g/cc)	NR	2.27	1.71	NR	2.61	1.57	2.54	2.60	2.63	2.63	2.62	1.68	

Table 5-14
Analytical Results For Batch Glasses

5.12 Mixing - Cobalt Tracer

In order to determine the mixing characteristics of the Melter, a cobalt tracer was introduced during the Batch 5 slurry preparation. Glass samples were taken during consecutive batch runs for analysis of the weight percent of cobalt (Co) and to observe the color of the glass. This data was used to develop a mixing profile and determine a stay time for components in the Melter.

The glass sample taken during the feed of Batch 5 slurry (referred to as Batch 5 glass) displays the same emerald green color as previous batches. The characteristic blue from the cobalt tracer did not become apparent by visual inspection until Batch 6 glass which showed a slight blue tint but remained predominantly green. Batch 7 and Batch 8 glass were unmistakably blue. The green color was prevalent again at the time the batch 10 glass sample was taken indicating a substantial decrease in the concentration of cobalt.

Laboratory analyses of the batch glass shows the initial presence of cobalt in Batch 6 glass at a concentration of 0.0383 wt% cobalt. The cobalt concentration reaches a maximum of 0.0451 wt% in Batch 7 glass and decrease to 0.0174 wt% by batch 10 glass. In batch 11 glass, the cobalt concentration is below the reportable detection limit. The weight percent of cobalt in glass for each batch glass sample is shown in Figure 5-4 and reported in Table 5-14. Laboratory results and visual observation show the Melter to be characteristic of a well-mixed tank rather than a plug flow operation and has a flush volume of approximately 4 batch feeds.

5.13 Effect of Air In-leakage on Glass Discharge Capability

The balance of pressure between the Melter and the Gem Machine housing was designed such that leakage between the two, through the pour spout, would be minimal. However, it became apparent that air in-leakage through the Melter pour spout was detrimental because it tended to cool the glass stream being discharged. This would cause the pouring glass to thicken and possibly plug the pour spout. The only means of minimizing this in-leakage was to try to balance the pressure in the Melter with the pressure in the Gem Machine housing. This proved to be tricky and frequently inefficient.

5.14 Effect of Glass Chemistry on Conductivity and Viscosity

There are possible shortfalls of the Melter's ability (specifically the discharge

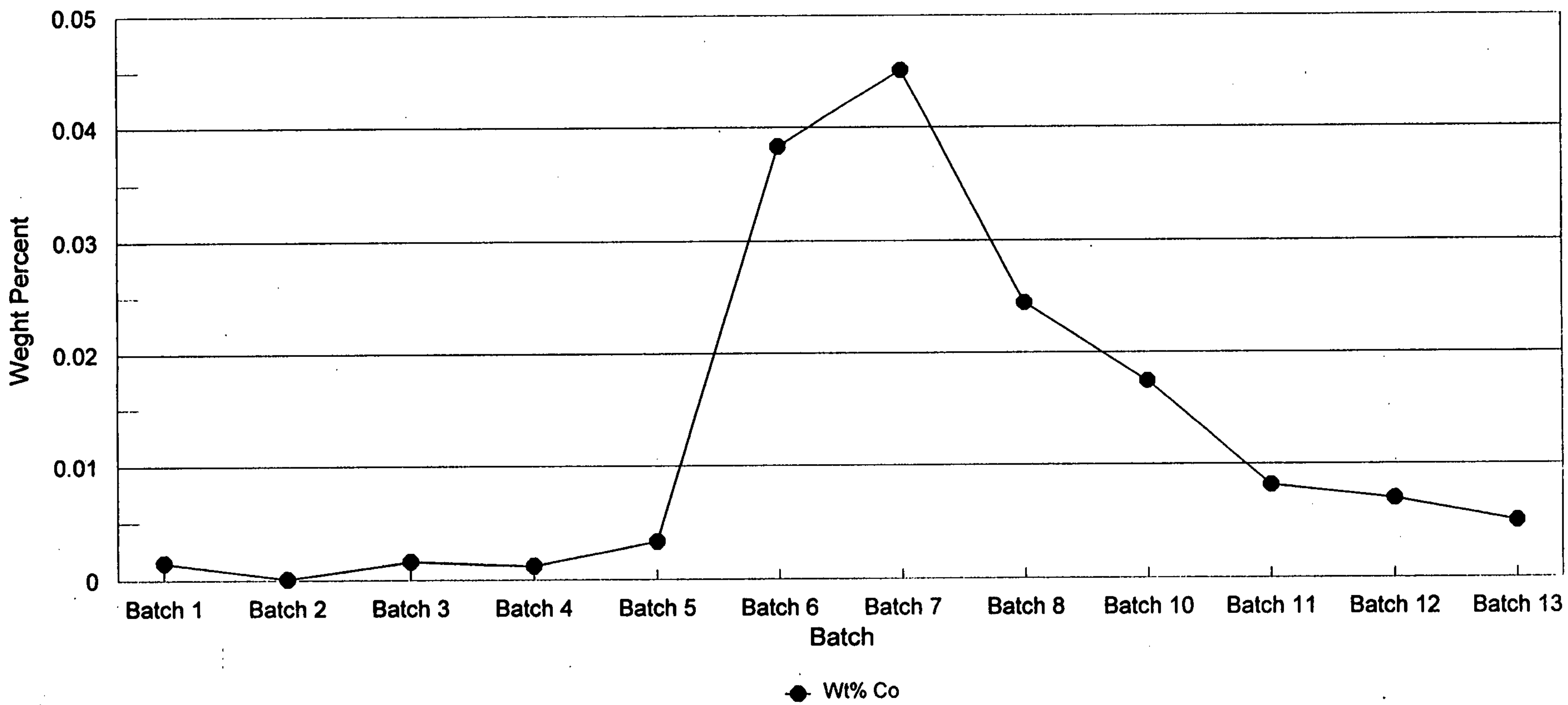


Figure 5-4
Weight Percent Cobalt in Glass

chamber's ability) to handle the necessary glass viscosities during some of the campaigns and deliver these glasses to the Gem Machine's Gob Cutter. This has become evident while processing with Campaign 1 startup glass.

When it was noticed that the partition wall of the VitPP Melter appeared hotter than anticipated, there was concern that the excess temperature could cause unnecessary erosion of the partition wall. It was agreed to reduce the Melter amperage by decreasing the conductivity of the glass. This was accomplished by decreasing the sodium oxide content in the next batches. The sodium oxide content of the next two batches was decreased from 14 wt% down to 7.25 wt%[16]. Thereafter, the batches were increased to 11 wt%.

During the batch on 7/28/96, the VitPP and GTS Duratek personnel had problems with discharging glass. The reason cited was that the glass appeared to be too thick (viscous). It was noted that the glass "flows like molasses." Later, the discharge plugged at and below the discharge hole of the discharge chamber. It is true, the glass appeared thicker than it did during the initial batches, but the Melter was designed to handle glass that flows "like molasses." The blockage was removed by melting the glass from underneath with a torch.

The glass was then thinned by adding sodium carbonate mixed with 10% glass frit to help wet the carbonate and assist dissolution of the sodium into the glass. Initially, 125 lb of sodium carbonate was added directly to the Melter bath. However, the glass was judged to still be too thick. Then a total of 250 lb of sodium carbonate (equivalent to 150 lb sodium oxide Na_2O) was added to the melt. This increased the sodium oxide content of the melt back to its original concentration of 14.5 wt%.

This exercise helped to define the Melter's operational envelope. Table 5-15 presents Fluor Daniel Fernald measured values that illustrate the envelope at 1250°C according to the bottom bath thermocouple.

In summary, it is felt the Melter should and can perform better than these data indicate. However, the discharge chamber must be modified to allow this (and did prove so in later campaigns).

[16] Note that lithium oxide (Li_2O) from the in-leakage of the side-chamber glass helps compensate for some of the sodium oxide decrease. Analysis shows that the glass contains approximately 0.6 to 0.7 wt% lithium oxide in the glass from in-leakage. Lithium has two to three times the fluxing capability of sodium. Therefore, the effect of the sodium oxide is less significant.

Table 5-15
Direct Use of Na_2O To Thin the Glass in The Melter

Na_2O in Glass (wt%)	Viscosity (Poise)	Discharge Operability	Melter Resistance (ohms)
7.25	46.9	Plugged in discharge chamber spout	0.080
11	30.6	Blockage at under-side of pour spout	0.072
14.5	24.8	Functioned	0.060

Table 5-15 shows that the maximum viscosity that can be successfully discharged is approximately 25 poise. This is much lower than projected. For comparison, the minimelter at VSL ran at over 300 poise during Series A, 1-MT/d equivalent. Also, the minimelter's discharge chamber operated at a significantly lower temperature (1180°C) than the VitPP's discharge chamber (1300°C).

Table 5-16 implies that the Melter (in particular, the discharge chamber) may not function properly during some of the Campaigns. The table gives the viscosities of the Acceptance Glass and other Campaign Glasses as measured by VSL[17]. The glasses marked in ***bold letters*** can be processed. The Acceptance Glass is on the envelope's boundary at 1350°C.

The procurement Technical Specification, No. RHN02-40-062, for the Melter, entitled "Joule-Heated Vitrification Furnace" defines (in Table 1 of the procurement specification) the viscosities of the glasses expected to be run in the Melter at that time. The glass viscosities have been lowered through further development activities to help assist the Melter and production rates. Even though, the Melter capability appears to falls short of the specification (see Table 5-17) at this time, it is felt the problems are due mainly to air in-leakage and cooling in the discharge chamber. The Melter should function desirably when modifications are made to the discharge chamber. (Campaign 2 showed this to be the case.)

[17] VSL's measured viscosity values have generally been lower than FD Fernald's. There is some question who's measurement is the more correct. This is being investigated.

Table 5-16
Viscosity Envelope of the Melter

Viscosity, Poise -- Per VSL Development Work					
Temperature °C	**Campaign 2 Acceptance**	**Campaign 2 Series D**	**Campaign 3 Series C**	**Campaign 4 Series A**	**Campaign 4 Series B**
1150	161	53	53	234	≥234
1200	93	35	34	123	≥123
1250	58	***24***	***24***	76	≥76
1300	39	***17***	***16***	53	≥53
1350	28	***13***	***11***	39	≥39

Table 5-17
Viscosity per the Melter Procurement Specification

Viscosity, Poise -- Per the Procurement Specification				
Temp.°C	**Series A**	**Series B**	**Series C**	**Series D**
1150	765	3511	2003	1256
1250	296	1317	220	433
1350	129	557	32	170
1450	62	260	6	75

5.15 Yellow Sparks in the Side Chambers

Soon after slurry was fed to the Melter during the last week of June 1996, sparks were observed at the surface of both side chambers. More specifically, flashes of bright yellow light about 0.25 inch in diameter and occurring every 5 seconds or so were observed through the side chamber sight glasses. The sparks appeared to result from bubbles of gas breaking at the surface of the melt. These sparks caused no operational difficulties and would disappear for periods of time.

Initial speculation was that the molybdenum electrodes were flaking off small bits that were carried to the surface where they burned (molybdenum is pyrophoric, it can rapidly oxidize at 400°C). This theory does not explain the gas bubble, that breaks to produce the spark. Molybdenum trioxide (Mo_2O_3) is a gas at 1250°C and could form a bubble but it would not further combust when it broke the surface.

One possible explanation is that, because the side chambers are starved for oxygen, sodium oxide in the melt may be being reduced to elemental sodium. Since sodium metal boils at 892°C, microgram quantities might be forming bubbles and flashing (burning) when the bubbles break and contact the air. The possible mechanism for the reduction of sodium involves a weak electrolytic potential forming between two electrodes in the same side chamber but at different temperatures.

5.16 Off-gas

Soon after filling the Melter with molten glass, it was observed that the Melter pressure could not be controlled at the desired -2 to -4"WC (inches water column). Even after all the tank vents to the vent header were closed, the Melter pressure could not be controlled at much lower than -0.5"WC. The tank vents remained closed for the remainder of Campaign 1. The Melter air in-leakage at this Melter vacuum was estimated to be 55 SCFM (total flow of 175 SCFM minus a Film Cooler air flow of 120 SCFM). It appeared that most in-leakage was through the 3" diameter glass pour spout. The pressure in the Gem Machine housing was kept just a few tenths inch WC higher than the pressure in the Melter to minimize in-leakage through the pour spout. Operation of the Melter at -0.5 inches WC was considered acceptable for the initial runs. Eventually, this problem will need to be resolved by modification to the off-gas system.

5.16.1 Water Runs

Initial feeding of the Melter with water occurred between 2200 hrs, 6/20/96 and 0230 hrs, 6/24/96.The maximum water feed rate over a four-hour period was 1.0 L/min, which is the water equivalent to about 1.2 MT/d glass production. The temperature of the off-gas from the Film Cooler was about 960°F and the off-gas cooled to about 530°F as it traversed the off-gas line to the Quench Tower. The temperature of the off-gas leaving the Quench Tower was 120°F vs. a design temperature of 97°F. This was due to a water flow to the Quench Tower spray nozzles of 17 gpm vs. a design flow of 40 gpm. Inspection of the lines at the Quench Tower nozzles revealed gross scaling on the inner surfaces. This scaling was apparently caused by an inadvertent introduction of Desiccant Tower condensate (containing magnesium and calcium salts) into the recycle water loop via the Spare Storage Tank piping. High pressure drops in the lines from the Quench Tower to the Heat Exchanger and onto the Recycle Water Tank, along with the fact that the Quench Tower level control valve typically ran about 80% open, indicated that the entire recycle water loop was heavily scaled. Chemical cleaning of this loop is planned before Phase II operations.

During early operation before Campaign 1, the Desiccant Tower reduced the off-gas humidity to about 15% RH as designed. However, this effectiveness lasted only about two weeks vs. a design period of four weeks between recharges. The decision was made to limit recharging the desiccant material which caused the humidity from the Desiccant Tower to hover about 55% RH. This was satisfactory for protecting the downstream HEPA Filters. During the four-hour run discussed above, the temperature of the off-gas entering the Desiccant Tower was about 115°F and the temperature leaving was about 150°F due to adiabatic condensing of the moisture.

5.16.2 13 wt% Slurry Feed

A nominal 13 wt% slurry was fed to the Melter between 2300 hrs, 6/24/96 and 0900 hrs, 6/25/96. The feed rate for this run was 1.0 L/min, a water equivalent to about 1 MT/d glass production with a 50 wt% slurry. Off-gas temperatures were similar to the water run above. During a steady operating period, with 17 gpm going to the Quench Tower, the Heat Exchanger was cooling the Quench Tower bottoms from 115°F down to 80°F. The recycle water was heated back up to 90°F as it passed through the Recycle Water Pump on its way back to the Quench Tower.

5.16.3 40 wt% Slurry Feed

A nominal 40 wt% slurry was fed to the Melter between 1600 hrs, 6/26/96 and 0330 hrs, 6/28/96. The feed rate for this run varied widely from 0.5 L/min (0.3 MT/d glass rate) toward the beginning of the run, to 1.8 L/min (1.1 MT/d glass rate) for the last two hours of the run. By the end of this run, it was clear that plugging in the Film Cooler was a serious problem; the Melter could be operated (i.e., was fed slurry) only 4 to 6 hours before the Melter pressure could not be held at -0.5"WC due to the Film Cooler plugging. It was also noticed that the off-gas line downstream of the Film Cooler was steadily increasing in pressure drop. At this time, Film Cooler air flow was still about 120 SCFM and total exhaust flow was about 175 SCFM indicating that Melter in-leakage was still about 55 SCFM (tank vents remained valved off). Off-gas system temperatures were, again, similar to the 1.0 L/min water test described above because no significant cold cap was allowed to form.

During a two week shutdown after this run (Melter idle), corrective actions were taken. The immediate fix was to vacuum out the horizontal section of line just downstream of the Film Cooler, and to install a new Exhaust Fan. The original centrifugal Exhaust Fan was capable of producing a pressure of -31"WC at 200 SCFM at the fan suction. On 7/11/96, a new Spencer turbine blower was installed in its place which was capable of producing a pressure of less than -80"WC at 200 SCFM at the fan suction. This new blower allowed the Melter control pressure to be reduced to -0.75"WC. It was clear that, because of the inherently high frictional pressure drop in the entire off-gas system, significantly lower pressures in the Melter could not be achieved simply by putting a higher-vacuum exhauster at the end of the off-gas train. Also, addressed was the Desiccant Tower. The desiccant material was allowed to completely dissolve away. To protect the HEPA Filters from moist air, the off-gas line from the Desiccant Tower to the HEPA Filters was electric heat traced and insulated. The intent was to Heat the off-gas by about 15°F to reduce the moisture to about 70%RH.

Also during the shutdown, a sample was taken on 7/3/96 of the solids that had accumulated in the Film Cooler. The results are given in Table 18 (reported as oxides). This material had a sulfur yellow-color, presumably due to the chromium content. Chromium is the only element listed in Table 5-18 that produces a sulfur-yellow color. The high sodium and boron content give the material it low melting, sticky characteristic.

Table 5-18
Oxides in the Clogging Material in the Film Cooler

Oxide	Result
Aluminum	1.6 wt%
Barium	38 ppm
Boron	14 wt%
Calcium	12 wt%
Chromium	0.13 wt%
Iron	0.14 wt%
Magnesium	0.3 wt%
Molybdenum	0.7 wt%
Silicon	32 wt%
Sodium	22 wt%

5.16.4 Continuous Slurry Feed to Melter

The next set of runs occurred between 1830 hrs, 7/15/96 and 1400 hrs, 7/17/96 and focused on establishing continuous feed to the Melter for as long as possible. During the (approximate) 12 hours of feeding nominal 40 wt% slurry to the Melter at about a 1.2 MT/d glass production rate, the Film Cooler had to be cleaned out three times. However, the off-gas line just downstream of the Film Cooler remained clear. During this run, the Melter pressure varied between -0.6 and -0.8"WC with the off-gas control valve (FCV-250) open

100% much of the time. Total off-gas flow varied between 177 and 257 SCFM and Film Cooler air flow between 70 and 160 SCFM. The difference between these two flows was the Melter in-leakage air flow and it varied between 85 SCFM and 187 SCFM. The raw data is included in Table 5-19 in order to demonstrate the variability. Unfortunately, given these data, it was not possible to synthesize a coherent theory which would allow in-leakage to be predicted given Melter and Gem Machine pressures.

These were the first runs where it was standard procedure to establish a significant cold cap in the Melter (75 to 85% coverage of the center chamber). The cold cap benefitted the off-gas system by lowering the temperature in the Melter plenum and therefore the temperature of the Melter off-gas leaving the Film Cooler. Under similar operating conditions, the temperature leaving the Film Cooler was reduced from about 960°F to about 800°F. This was felt to be instrumental in preventing buildup (plugging) in the off-gas line downstream of the Film Cooler. Plugging in the Film Cooler itself was becoming an untenable situation. The Film Cooler was not providing adequate air injection in the first 6" or so out of the Melter plenum. The semi-molten material that built up was a "sticky goo" that could not be easily removed. At the end of these runs, an Inconel™ cleaning brush inserted to clean the Film Cooler was stuck to the extent that it finally had to be forced into the melt pool to clear the Film Cooler.

Table 5-19
Campaign 1 Melter Air In-leakage

Date	Time (hrs)	Film Cooler Air Flow (scfm)	Total Air Flow (scfm)	Melter In-leakage (scfm)	Melter Pressure (in WC)	Gem Machine Pressure (in WC)
7/16/96	12:35	140	250	110	-0.75	-0.56
7/16/96	12:55	160	257	97	-0.7	-0.53
7/16/96	13:01	150	252	102	-0.7	-0.54
7/16/96	13:46	75	177	102	-0.9	-0.64
7/16/96	14:14	150	270	120	-0.75	-0.53
7/16/96	15:04	130	257	127	-0.63	-0.58
7/16/96	15:34	70	257	187	-0.63	-0.56
7/16/96	17:17	150	245	95	-1	-0.52
7/16/96	17:30	150	235	85	-0.6	-0.49
7/16/96	21:30	120	230	110	-0.7	-0.57
7/16/96	22:40	120	230	110	-0.66	-0.66
7/16/96	22:41	110	220	110	-0.66	-0.59
7/17/96	00:54	100	225	125	-0.68	-0.62

5.16.5 Run Melter and Gem Machine Together

Runs between 2100 hrs, 7/18/96 and 1100 hrs, 7/24/96 were to coordinate operation of the Melter and Gem Machine. Before these runs were started, an air lance was added to the Film Cooler. This was a pipe fabricated from stainless steel with the end sealed and radial holes drilled at the sealed end. The pipe was inserted into the Film Cooler to introduce compressed air at the beginning of the off-gas line as it leaves the Melter plenum. This modification was immediately successful in that no Film Cooler cleanings were necessary for the duration of these runs.

Melter feed rates varied between 1.0 L/min and 2.7 L/min. The longest period of stable operation occurred between 2000 hrs, 7/21/96 and 0150 hrs, 7/22/96. The Melter feed rate was 1.8 L/min of nominal 40 wt% slurry, equivalent to a glass rate of about 1.1 MT/d. During this period, total off-gas flow was 230 SCFM. The off-gas exited the Film Cooler at 720°F and cooled to 520°F before entering the Quench Tower. Off-gas leaving the Quench Tower was at 133°F (significantly above the design temperature of 97°F) which again demonstrated how the low water flow to the nozzles was hurting Quench Tower operation.

5.16.6 Maximize Melter Throughput Rate

The final runs of Campaign 1 occurred between 1300 hrs, 7/26/96 and 0700 hrs, 7/31/96. These runs had the goal of determining the maximum sustainable slurry feed rate to the Melter. Melter temperature was a nominal 1250°F (as it had been throughout Campaign 1). Significantly, no Film Cooler clean outs were required during these runs.

With slurry at about 50 wt% solids, there were two runs at a Melter feed rate of 2.9 L/min which equates to about 2.5 MT/d glass production rate. For present purposes, call these runs A and B. Both runs A and B had large cold caps in the Melter, and intermittent breaking up of the cold cap produced pressure pulses in the Melter plenum which activated the Emergency Off-gas (EOG) System numerous times. Run A occurred between 0930 hrs and 1420 hrs, 7/27/96 and experienced EOG System activations at 0939, 1048, 1225, 1315, 1348, and 1415 hrs. Run B occurred between 1030 hrs, 7/27/96 and 0245 hrs, 7/28/96 and experienced EOG System activations at 0134, 0219, and 0241 hrs. A few EOG activations were observed to be accompanied by a puff of steam from the Melter into the furnace room indicating a positive pressure momentarily in the Melter.

Off-gas parameters for runs A and B are shown in Table 5-20.

Table 5-20
Off-gas Measured Parameters

Parameter	Run A	Run B
Off-gas flow	200 scfm	220 scfm
Off-gas flow valve	45% open	50% open
Temperature from Film Cooler	660°F	615°F
Temperature to Quench Tower	490°F	460°F
Temperature from Quench Tower	145°F	142°F
Water flow to Quench Tower	16.3 gpm	16.3 gpm
Water to Quench Tower nozzles	89°F	90°F
Water from Quench Tower	131°F	129°F
Quench water to Heat Exch.	133°F	130°F
Quench water from Heat Exch.	85°F	84 °F

The above data clearly demonstrated the benefits to the off-gas line of operating with a large cold cap in the Melter. Off-gas temperatures from the Film Cooler and to the Quench Tower were satisfactorily low and neither the Film Cooler nor the off-gas line accumulated any solids. The off-gas temperatures from the Quench Tower were high due to the high steam condensing load at this rate, and as discussed previously, the restricted water flow to the Quench Tower nozzles. The large cold cap produced pressure pulses which the off-gas system could not handle adequately. It is anticipated that at Melter pressures of -2 inches WC that these pulses would be adequately dissipated without the emergency off-gas initiating.

5.17 Snapshot

The selected representative run for Campaign 1 is the run starting approximately 1200 hours on July 26, 1996, and completing approximately 1200 hours on July 28, 1996. Slurry feed batches C1B10, C1B11, and C1B12 were prepared alternately in slurry tanks A and B and fed consecutively to the Melter via the Melter feed pump. The feed slurries were nominally 50 weight % solids fed at rates of 1.3 and 1.8 equivalent MT glass/day over a total run period of approximately 40 hours. The feed slurries are characterized in other sections of this report.

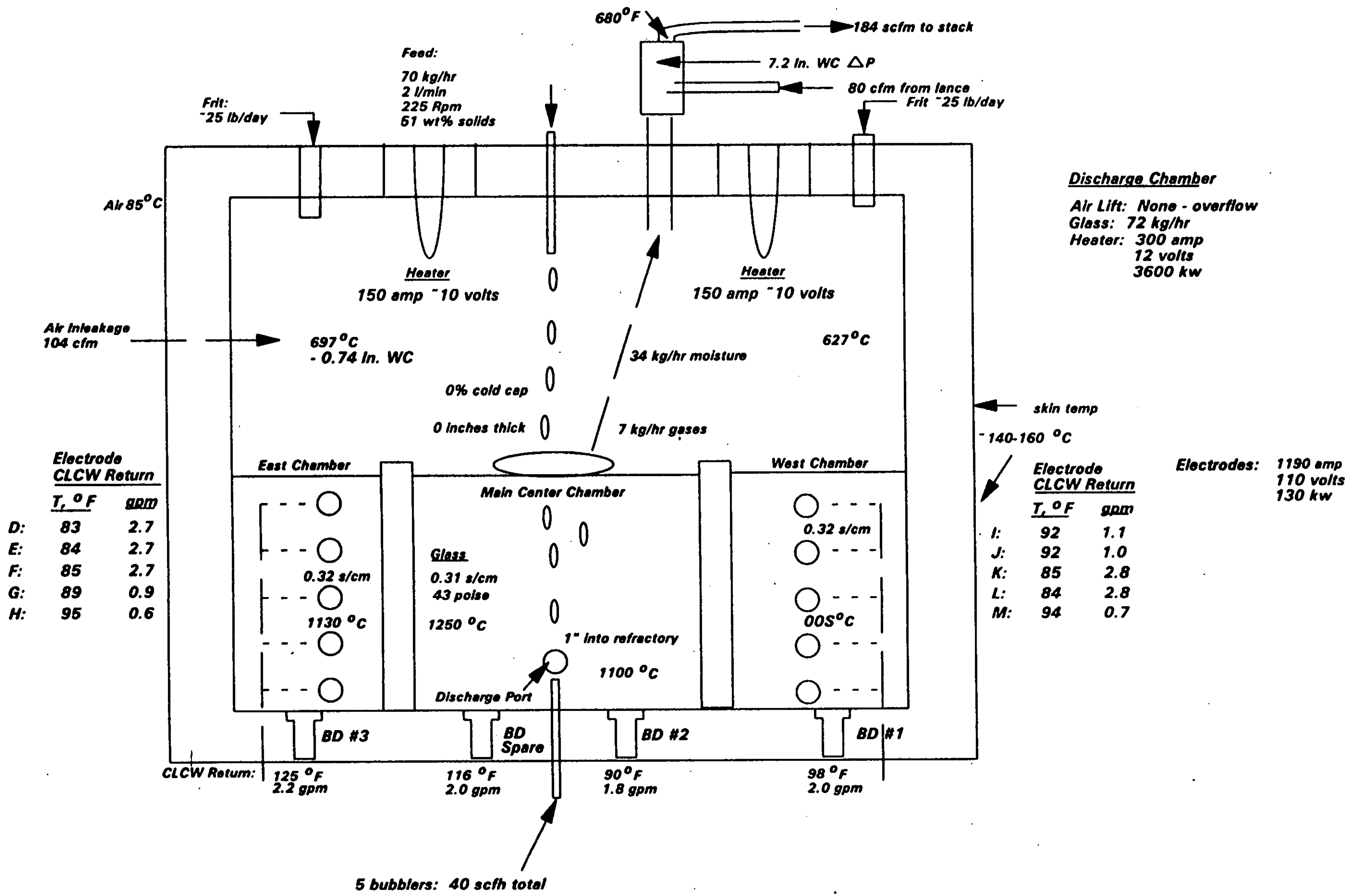
Figure 5-5 shows the overall parameters of the Melter components, glass and internal conditions, off-gas, and the discharge chamber at a representative time during the run.

The Melter was operated with the main chamber bottom glass temperature controlled to nominally 1250°C. SCR 1 power input to the electrodes ranged between 120 and 290 kilowatts, averaging about 200 kilowatts. Several Melter pressurization events occurred during the run. These were attributed to situations when the slurry mix tanks A or B were nearly depleted of a feed batch which leaves only the slurry material below the level of the tank agitators. Additional water was added to the slurry in the tanks to enable continued feed to the Melter feed pump. This resulted in relatively larger quantities of water being converted momentarily to steam as the diluted slurry was fed to the Melter which resulted in a short term Melter pressure surge occurring before the Melter off-gas system could reestablish the normal Melter reduced pressure. In each of these events the EOG system responded normally until the Melter reduced operating pressure was reestablished.

Glass produced from the slurry feed equaled 5080 lbs. During this run monolith glass was produced from batches C1B10 and C1B12. During batch C1B11, 118 lbs of glass gems were produced and the balance of the glass was produced as monolith. The gem cutter, gem roller, and the Gem Machine conveyor were operated throughout the run. The overall glass production rate from the slurry feed, measured from the product drums, was equivalent to 1.9 MT glass/day. The range was from 2.4 MT/day (Batch C1B10) to 1.6 MT/day (C1B12).

The Melter off-gas system and the emergency off-gas system performed normally throughout the run. The air-cooled lance installed at the furnace off-gas Film Cooler substantially corrected earlier problems experienced with plugging of the Film Cooler.

Tabulations and plots presenting the data collected for these runs is in the Appendix B to this report. The data are organized by VitPP systems; Feed Preparation System, Furnace System, Gem Machine System, and Furnace Off-gas System.



Legend: BD: Bottom Drain
OOS: Out of Service
CLCW: Closed Loop Cooling Water

Snapshot of Melter Operation

July 27, 1996, 8:00 a.m. Averaged
Campaign 1, Startup Glass 51 wt% Slurry 0.8 Tonne Glass/Day

Figure 5-5
Snapshot of Melter Operations

6.0 Campaign 1 Maintenance Actions, Equipment Wear and Expected Longevity

6.1 Chromium Oxide Balance

The Melter walls are comprised of two types of refractory. The Partition wall is constructed of Monofrax Type E Fused Cast Refractory, consisting of 77.7% chromium oxide Cr_2O_3. The remaining Melter walls are constructed of Monofrax Type K-3 Fused Cast Refractory, consisting of 27.1% Cr_2O_3.

A chromium oxide mass balance performed around the Melter determined the amount of refractory wall corrosion. No Cr_2O_3 was introduced into the system through batch feed or frit addition, therefore all Cr_2O_3 present in the glass was attributed to corrosion of the refractory. Cr_2O_3 analysis of the glass samples taken from each consecutive batch shows that approximately 16 lbs of Cr_2O_3 have leached from the Melter walls (see Table 5-2 and Figure 6-1). Assuming uniform corrosion depths of the refractory surfaces and equal corrosion rates of the two refractories, approximately 0.750 mm of refractory in the Center Chamber, 0.091 mm in the East Chamber, and 0.178 mm in the West Chamber have eroded during Campaign 1. Although the E refractory's higher Cr_2O_3 content would suggest a greater resistance to corrosion, the current running through the wall may sputter the Cr_2O_3 molecules and thus compromise its lower corrosion rate.

6.2 Molybdenum Balance

The amount of molybdenum reported in the glass samples remained near the detection limit indicating little erosion of the electrodes. This was supported by physical observation which showed little erosion. Laboratory analysis showed that approximately 2.75 lbs. of molybdenum were detected in the glass samples (see Table 5-10 and Figure 6-2) and a that there was a presence of molybdenum on the filters from the off-gas stream.

6.3 Film Cooler

Plugging in the Film Cooler and the line leaving it was a serious problem until the installation of the air lance. The air lance was a pipe inserted through the center of the Film Cooler which provided for injection of compressed air at

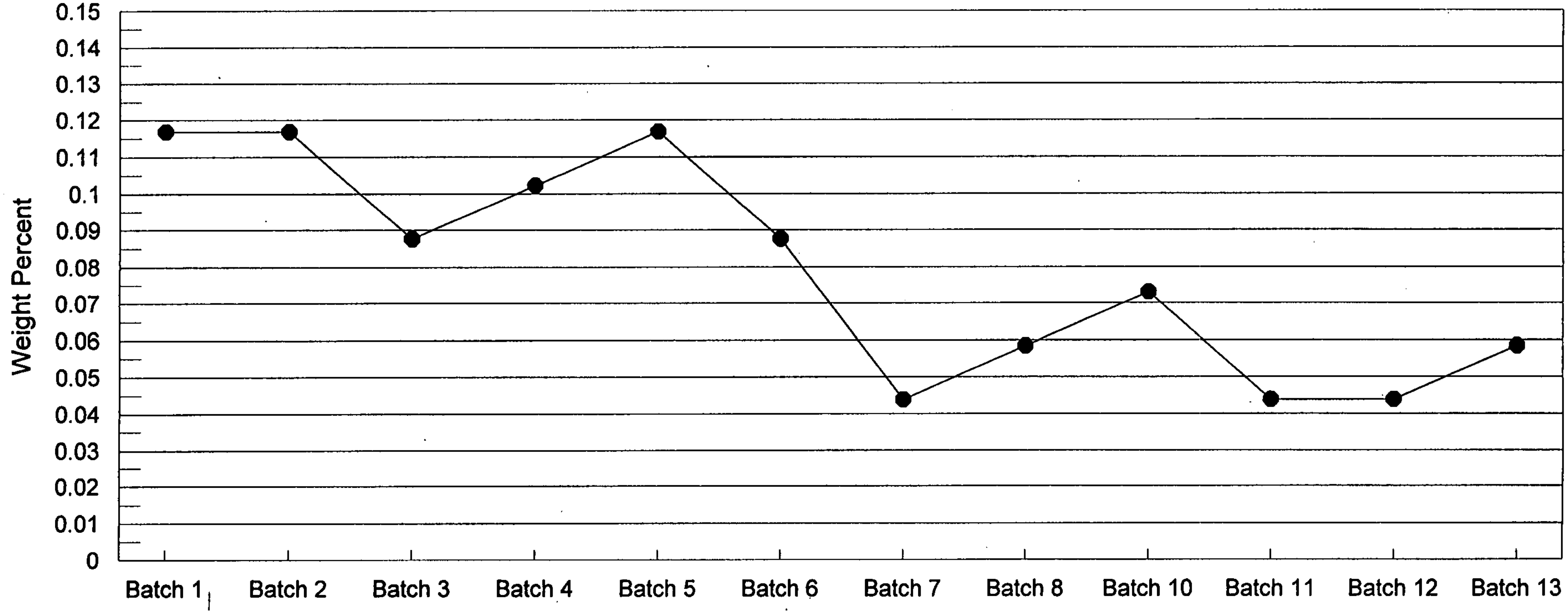


Figure 6-1 Weight Percent Chromium in Glass

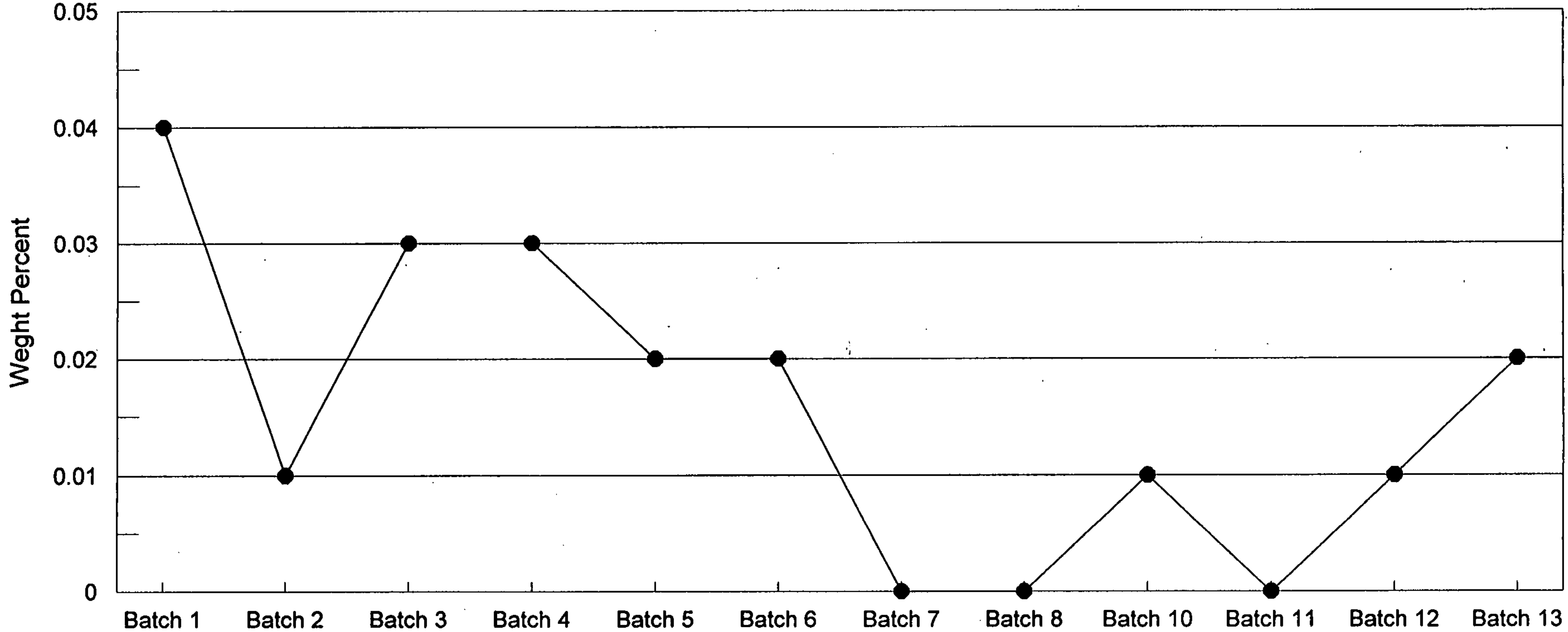


Figure 6-2 Weight Percent Molybdenum in Glass

the point where off-gas leaves the Melter plenum. The original Film Cooler left a gap of about 10" before off-gas leaving the plenum was contacted with compressed air. It also appeared that the method which the original Film Cooler initially introduced compressed air (through four 3/4" diameter holes) was inadequate in that these holes plugged up. The air lance, along with operating the Melter with a cold cap, substantially solved these problems such that Film Cooler and off-gas line plugging were no longer a significant operating impediment.

6.4 Chlorides in Melter Cooling Water

A dedicated, closed cooling water loop is used to cool the Melter electrodes, bottom drains, side drain, IR detectors, feed tubes, the Gem Machine conveyor, and the Gem Machine diverters. For freeze protection, the coolant was a 50:50 volume mix of deionized water and commercially available inhibited propylene glycol. At the end of Campaign 1, flames were observed coming from the molten glass surface of the east side electrode chamber of the Melter. When coolant flow was reduced to the east chamber bottom drain, the flames subsided. It was obvious that the flames were caused by burning antifreeze (propylene glycol) from a coolant leak into the east electrode chamber.

The coolant was analyzed and found to contain 150 ppm chloride which was traced to the commercial glycol antifreeze. The bottom drain consisted of a 304L stainless steel pipe with a welded-on cap made of Inconel™ 690. The chlorides may have attacked this assembly, producing the leak. However, the welding of dissimilar metals could also be the major cause for the cracking. This is being investigated. As a stopgap, the east chamber bottom drain was disconnected from the closed loop system and put on its own water-only cooling loop consisting of a 55-gal drum and a small pump. The glycol solution was replaced with deionized water only, and the bottom drains were slated for replacement.

7.0 ENVIRONMENTAL

The environmental objective for the VitPP treatability testing is to ensure off-site protection of human health and the environment during the various vitrification campaigns. The degree to which the design and operation of the plant has met the environmental objective is determined by evaluation of compliance with the environmental regulatory requirements, as well as the application of environmental ALARA concepts and waste minimization practices during operation of the plant.

Phase I Campaign 1 involves the use of benign glass prepared with silica and other glass forming additives. No RCRA metals, radionuclides, or chemicals that would generate an air toxic regulated under the Clean Air Act were added to the Melter feed during Campaign 1. The off-gas system was used primarily to maintain negative pressure in the Melter, vent moisture, and remove particulate from the Melter off-gas.

7.1 Release Pathways and Monitoring Points

Potential environmental release pathways for contaminants from the VitPP include the following:

- Air - Stack emissions
- Water - Wastewater and stormwater
- Soil - Includes spills or other releases
- Waste - Hazardous or toxic waste managed off-site

Potential sources of discharge, and associated monitoring points for these release pathways are shown in Table 7-1. Note that there are no required monitoring points for releases to soil; monitoring of spills or releases off the plant pad is on a case by case basis.

7.2 Environmental Evaluation of Phase I Campaign 1

The Phase I Campaign 1 testing met all environmental regulatory requirements identified as applicable or relevant and appropriate requirements (ARARs) or environmental "to be considered" (TBC) criteria in the VitPP Phase I Work Plan, in accordance with the signed OU4 Record of Decision (ROD).

Environmental data taken during Campaign 1 included sampling of the air, water, and solid waste release pathways. A summary of environmental data for Campaign 1 is presented in Table 7-1. These data include the source of environmental contaminant, sample point, sample results, and how the contamination was managed. There were no spills or releases to soil during Campaign 1.

Table 7-1: Summary of Environmental Data from Campaign 1

PATHWAY	SOURCE	SAMPLING[1]	DATA	MANAGEMENT
AIR	VitPP Stack	HEPA Filters	Some filters failed TCLP[2] for Cr; also Se and Pb	Filters that fail TCLP managed as Hazardous Waste
		S-12[3]	None. (See footnote 2)	BAT met by HEPA filters
	Bag Dump Station	None - no air toxics or radionuclides added in Campaign 1	NA[4]	BAT includes fabric filter and HEPA filter
WATER	WWTR Filters	S-1[5]	NA[4]	Wastewater treated by AWWT plant[6]
	Bldg Sump	S-17	Passed TCLP for Ba, Cr, Pb TDS 20000 - 285000 mg/l TSS 2.2 - 2216 mg/l	Wastewater sent to AWWT for further treatment
SOIL	Spills	Case by Case	No spills	NA[4]
WASTE	Glass	S-10	All glass passed TCLP for Ba, Cr, Pb	Staged for disposal as solid waste
	Misc. Waste	Characterization per procedure	MEF generated or referenced	Disposal per site procedures

[1] Sampling points are described and shown in the Project Specific Plan for Operable Unit 4 Vitrification Pilot Plant, Phase I, Process Sampling, 2504-SU-0011, Rev.1, May 1996. The "S" numbered sampling points are established locations where samples are routinely taken during operation. Other waste streams are sampled on a case by case basis.

[2] Toxicity Characteristic Leaching Procedure (TCLP) for testing for RCRA characteristic waste.

[3] During Phase I, sampling point S-12 will include isokinetic sampling during Campaign 4. No data from S-12 were taken during Phase I, Campaign 1, operations.

[4] Not applicable. No sampling conducted.

[5] The wastewater filters (effluent sample S-1) require sampling only during Campaign 4.

[6] Normal management of VitPP wastewater and stormwater is by collection in the Building Sump Tank (BST) and discharge to the Advanced Waste Water Treatment (AWWT) plant via the High Nitrate Tank. During Campaign 1, stormwater and BST wastewater was routed to the AWWT plant via the OU1 runoff control system.

7.3 Air

Air sampling during Campaign 1 consisted of samples from HEPA filters and medium efficiency particulate air (MEPA) prefilters. Since there were no air toxics or radionuclides present in the surrogate or feed additives, isokinetic monitoring of the stack at S-12 was not conducted. In addition, no stack performance testing was conducted.

A summary of the sampling events, filter, and sample data is presented in Table 7-2.

HEPA filters and prefilters - Although not identified for routine sampling, samples from HEPA filters and prefilters used during bakeout and Campaign 1 were taken and analyzed for RCRA metals. Both normal off-gas system (OGS) and emergency off-gas system (EOS) filters, including HEPAs used for VitPP building ventilation, were characterized by analysis. Many of the normal OGS and EOS filters failed (exceeded) the TCLP limit of 5.0 mg/l for chromium (Cr). Although chromium was not added to the feed, it is present in high concentrations as a constituent in the refractory lining the Melter. This is the only source of the chromium particulate found on the filters. Selenium also exceeded the TC limit in three filter samples. The source of the selenium is unknown, but is believed to be an impurity in one of the feed additives.

Since the OGS filters became saturated due to high humidity in the off-gas line, water samples from the water collected at the bottom of the filter housing were taken for analysis. The filter liquid also failed (exceeded) the TCLP limits on several occasions as noted in Table 7-2. Excess filter liquid was disposed in the Building Sump Tank (BST). Filters that failed the TCLP were staged in two white metal boxes (WMBs) in Building 80 for disposal as hazardous waste.

Feed Additives - To ensure effluent from the feed additives station meets the Ohio Air Toxics Policy (OATP) off-site limits, the fan exhaust is prefiltered by a fabric filter, then passed through a Medium Efficiency Particulate Air (MEPA) filter before reaching the atmosphere. No RCRA metals or radionuclides were added to the feed in Campaign 1; therefore, no sampling of the bag dump additives MEPA filter has been conducted. A single sample from the "Invincible" prefilter on the dry additives filter/receiver passed the TCLP for all RCRA metals.

Some radionuclides were present in detectable quantities as a contaminant in the zirconia feed additive. Air modeling using the EPA approved CAP-88 code was conducted to determine compliance with 40 CFR Part 61 National Emission Standards for Hazardous Air Pollutants (NESHAP) Subpart H requirements for these contaminants. Input data included stack parameters, a maximum additive feed rate of 88 lb/d (4% feed additive), and a combined radionuclide activity of 1.14 E-4 Ci/yr. Results of the modeling indicated that the dose to off-site receptors from a continuous release of this source term would be below 0.1 mrem/yr; therefore, no additional controls would be required.

Table 7-2
Summary of Campaign 1 Environmental Data from Air Pathway (Filters).

Campaign 1 Stage	Sample Date, Time	Filter - Media	Results (mg/l or as designated)
End of Run 1A	6/24 1600	S48A - Misc. Liquid	Cr^{+6} 37.8
Idle	7/3 0900	SFL48 -Off-gas prefilter (Bank A)	TCLP Cr 314.0 Total Cr 9060. mg/kg
	7/11 No time given	HEPA Dust - 2	Total Cr 633.0 mg/kg
Run 1C	7/15 0838	S48B - Water	Cr^{+6} 0.12
	7/15 0839	S48S - Water	< TCLP Limit
	7/15 0845	S48B - Filter	Cr 0.31 wt %
	7/15 0846	S48B - Off-gas prefilter (Bank B)	Cr 214.7 Total Cr 4130. mg/kg Se 1.3
	7/15 1830	S48A - Off-gas prefilter (Bank A)	TCLP Cr 98.6 Total Cr 1516. mg/kg
	7/17 1613	S37 - EOG filter, water	Cr 56.9
	7/17 1615	S37 - EOG filter	Cr 146.5 Se 1.2
Idle	7/18 1430	S48 - MEPA filter ("Invincible") from any additives filter/receiver	< TCLP Limit
	7/18 1435	S48 - Off-gas prefilter	TCLP Cr 84.8 Total Cr 1520. mg/kg
	7/18 1440	S48 - Off-gas prefilter	TCLP Cr 66.3 Total Cr 766. mg/kg
	7/18 1445	S48 - Off-gas prefilter	TCLP Cr 60.3 Total Cr 980. mg/kg
	7/18 1450	S48 - Off-gas HEPA filter	TCLP Cr 158.0 Total Cr 2008. mg/kg Se 3.4
Run 2	7/19 0925	S48A - Off-gas prefilter (Bank A)	TCLP Cr 76.3 Total Cr 395. mg/kg

Campaign 1 Stage	Sample Date, Time	Filter - Media	Results (mg/l or as designated)
	7/22 1245	S48B - Off-gas prefilter (Bank B)	Cr 84.7 Total Cr 922. mg/kg
	7/23 1200	S85 - Prefilter (HVAC)	Ba 1.81 wt % Cr 0.21 wt %
	7/23 1230	S85 - Prefilter (HVAC)	Ba 1.86 wt % Cr 0.17 wt %
Run 3	7/29 0850	S48 - HEPA liquid	< TCLP Limits
	7/30 0905	S48 - Water	< TCLP Limits
Idle	8/2 0915	S48BH - Water	TSS 7.6
	8/2 0916	S48BH - Water	< TCLP Limits
	8/2 0930	S48A - Water	< TCLP Limits
	8/2 0935	S48B - Water	< TCLP Limits
	8/26 1545	S48B - Water	< TCLP Limits
	8/26 1600	S48 - Off-gas prefilter (Bank B)	Total Ba 6500. mg/kg Total Cr 2200. mg/kg Total Pb 2320. mg/kg
	8/28 1330	S48	Total Ba 11600. mg/kg Total Cr 2360. mg/kg Total Pb 429. mg/kg
Idle	8/28 1330	S48	Total Ba 14400. mg/kg Total Cr 1290. mg/kg Total Pb 321. mg/kg
	9/4 1000	S48	Total Ba 9821. mg/kg Total Cr 3013. mg/kg Total Pb 88728. mg/kg

Emergency Off-gas System (EOS) - The EOS was triggered on various occasions. Some of these occasions were intentional, such as when the Melter or Film Cooler was opened for manual feed of the side chambers, or maintenance activities. Maintenance was generally scheduled during times when the Melter was in idle mode. The EOS was also triggered during the various runs, mainly due to brief "pressure" surges caused by Melter cold cap upset, or the inability of the off-gas system to maintain sufficient vacuum in the Melter. The EOS uses a high temperature HEPA filter and prefilter to remove particulate prior to discharge to the atmosphere. Use of the EOS in Campaign 1, either during planned maintenance or unplanned events, did not violate any regulatory requirements, or result in environmental insult.

A listing of EOS events during bakeout and Campaign 1, along with probable cause and approximate duration, is presented in Table 7-3 below.

7.4 Water and Wastewater

Since the thickener and wastewater filters will be tested during Campaign 4, wastewater was managed primarily through the Building Sump Tank (BST) at sampling point S-17. Wastewater was routinely analyzed for the RCRA metals barium, chromium, and lead; nitrate; total dissolved solids (TDS); and total suspended solids (TSS). Analytical data from S-17 indicate the RCRA metals concentrations in the BST did not exceed the TC limits during Campaign 1.

Due to use by the UNH Neutralization Project, the High Nitrate Tank (HNT) was unable to receive discharge from the BST. During Campaign 1, stormwater from the pad, and wastewater from the BST were sent to the Advanced Wastewater Treatment (AWWT) plant by an alternate route, using the lined trench constructed for the OU1 Runoff Control Removal Action. Wastewater management by this alternate route was approved in advance by OU5 AWWT personnel. Based on analytical data from S-17, no hazardous wastewater was discharged by this route.

Other wastewater discharged during Campaign 1 included slurry heel and slurry tank washout water. This wastewater was tanked and transported to the Plant 8 Sump for treatment. The wastewater contained high total dissolved solids (TDS) and total suspended solids (TSS), which included alumina, calcium carbonate, borax, sodium carbonate, silica, and zirconium oxide. No RCRA metals were present in the slurry wastewater.

Table 7-3
Emergency Off-gas System Usage during Bakeout and Campaign 1

DATE[1]	DURATION[2] (min)	REASON
BAKEOUT 5/18/96 0700	24	Intentional bypass
5/19 0700	28	Same
5/21 2000	8	Improper needle set point
5/23 1100	14	Reason unknown
5/24 1600	15	Reason unknown
5/25 1200	25	Reason unknown
5/25 300	1	Stepped on emergency trip cord to gem maker
5/27 0200	1	Reason unknown
IDLE 6/14 1700	777	Electrode insertion
6/15 0800	102	Same
6/15 1700	1641	Same
6/20 1700	9	Balancing EOS set points
CAMPAIGN 1 Run 1A 6/21 1600	483	Manual override, reason not given; not feeding Melter
6/22 0800	362	Maintenance on gem maker diverters
6/22 2100	5	Melter feed intermittent - steam release
6/23 1100	1	Same
6/24 1900	56	Reason unknown
6/25 0800	5	Melter feed intermittent - steam release
6/26 2200	2	Same
6/27 0400	2	Startup drums removed from discharge while gate still open
6/27 1600	78	Maintenance on Film Cooler
6/29 2300	1	Adding frit to side chamber
7/2 1300	51	Reason unknown, possibly due to maintenance
7/5 1000	7	Reason unknown
7/6 0900	26	Maintenance on normal OGS
7/7 1700	62	Reason unknown
7/11 1000	274	Maintenance on normal OGS form

DATE[1]	DURATION[2] (min)	REASON
7/12 1400	41	Reason unknown
7/13 0300	51	Maintenance on Melter
7/16 1000	57	Clean out of Film Cooler
7/16 1300	9	Cold cap inversion/Clean out of Film Cooler
7/16 1600	8	Cold cap inversion
7/16 2200	1	Cold cap inversion
7/17 0200	714	Reason unknown - Film Cooler out of service; EOS used during repair and manual Clean out
7/18 1300	7	Frit addition to Melter
7/20 0600	3	Melter feed intermittent - steam release
7/22 0500	1	Increased bubbler rate - cold cap collapse
7/22 0800	6	Melter feed intermittent - steam release
7/22 1000	12	Cold cap collapse
7/23 0300	3	Reason unknown
7/23 0600	1	Cold cap collapse
7/23 2300	2	Steam release due to feed or cold cap collapse
7/24 0600	4	Cold cap collapse
7/24 0800	3	Cold cap collapse
7/24 2200	2	Same
7/26 Run 3A 2100	7	Increased bubbler rate - cold cap collapse
7/27 0200	10	Same
7/27 0900	2	Same
7/27 1200	5	Reason unknown
7/28 0100	4	Melter feed intermittent - steam release
7/30 Run 3B 2100	4	Same
7/31 0200	1	Melter feed intermittent - steam release

[1] Times are approximate to the nearest hour.
[2] The duration of EOS usage was determined by examination of the position of the EOS valve FI-370. Total duration for this time period is approximate.

7.5 Soil and Spills

There were no reported spills of hazardous substances to soil during Campaign 1. There were various instances of leaks, pump seal failures, etc., which occurred on the containment pad at the plant. These were minor in nature, and did not contain any hazardous waste, or result in the generation of hazardous waste. Gross material from these leaks was containerized and managed according to procedure, or reintroduced into the Melter feed. Residues on the pad were washed down to the building sump.

7.6 Waste

Waste produced during Campaign 1 included glass product, used air filters, empty feed additive bags, and personnel protective equipment (PPE). Analytical data from glass sampling (sample point S-10) indicate that all the Campaign 1 glass passes the TC limits for Ba, Cr, and Pb. The glass has been drummed and labeled, and is currently staged in the buffer area. While some glass may be reused in the future as Melter feed, the bulk is expected to be disposed as solid waste.

Management of filters was discussed in the previous section. Empty bags and PPE that was not reusable were disposed in dumpsters as solid waste. Miscellaneous waste was characterized by process knowledge, or by sampling on a case by case basis, as required, to determine proper management.

7.7 Problems and Concerns

There are several opportunities for "lessons learned" in the area of environmental protection for future operation of the VitPP. These are discussed below

7.7.1 Off-gas System

7.7.1.1 Desiccant Unit - The Desiccant Tower is a dehumidifier designed to remove excess moisture from the off-gas in order to maximize radon adsorption in the carbon beds. However, during Campaign 1, the high moisture content of the off-gas quickly overwhelmed the unit, allowing moisture and entrained particulate to plug the HEPA filters and prefilters requiring frequent change out. High humidity in the off-gas line increases the risk of filter failures, and free liquids increase the risk of spreading contamination. Installation of a water removal system such as a chiller or heat exchanger prior to the Desiccant Tower would be prudent. The Desiccant Tower could then be used to remove any remaining water and preserve the life of the downstream carbon beds and off-gas filters.

7.7.1.2 Emergency Off-gas System (EOS) - Campaign 1 experienced significant use of the emergency off-gas system. Although the emergency off-gas was HEPA filtered and the EOS met BAT for Campaign 1 runs, this is a concern for future campaigns. There are various reasons why the EOS was initiated; these include both design and operational problems. As designed, the normal off-gas system is unable to maintain target negative pressures in the Melter, causing the valve opening set points in the emergency off-gas line to be exceeded on a routine basis. In addition, frequent maintenance and repair of the Melter or off-gas line (such as Film Cooler Clean out) has resulted in increased use of the EOS. Use of the EOS during times of Melter feeding is of particular concern since there is the increased risk of overwhelming the filters with water vapor, entraining fine particulate from the feed, and during later campaigns, routing SO_x and NO_x directly out the stack without benefit of treatment.

Log entries show that feed to the Melter was not always stopped when the EOS triggered. Since there are no differential pressure alarms on the EOS HEPA, in the campaigns that involve hazardous substances, feed to the Melter must be stopped when the EOS activates.

Use of the emergency off-gas system on a routine basis negates the purpose of the EOS design. Routine use of an emergency off-gas system requires the same controls as a normal off-gas system. Bypassing normal required control systems is not allowed under the OEPA Ohio Administrative Code (OAC). The corrective action alternative is to redesign the normal off-gas system to improve control of the Melter to bring utilization of the emergency off-gas system back to only true emergency use. Since the EOS does not include treatment of the off-gas, feed to the Melter must cease whenever the EOS is being utilized.

7.7.1.3 Melter and Discharge Chamber - The design of the Melter and discharge chamber allows significant in-leakage of outside air to the Melter, which must be processed and exhausted through the off-gas system. This in-leakage further reduces the capability of the off-gas system to maintain design negative pressures in the Melter, contributes to the volume of gas that must be processed, and provides a potential pathway for Melter and off-gases to escape to the work area.

7.7.1.4 The building HVAC system was used for ventilation and dust control while feeding frit into the Melter. This resulted in six changes of HVAC filters. Although not prohibited, a more cost-effective method of dust control prior to redesign of the off-gas system may include routing a vent line to intercept the EOS line downstream of FV-370. This interim design would provide dust control on a temporary use basis. The line would be valued shut during all other times.

7.7.1.5 Particulates in Off-gas - Campaign 1 data show significant quantities of particulate material passing through the off-gas control equipment (Quench Tower, Scrubber, and Desiccant Tower) to become deposited on the HEPA filters. During Phase II, carbon beds will be installed upstream of the HEPA equipment. Based on these Phase I Campaign 1 data, particulate material could enter and load the carbon beds during Phase II operation, resulting in an increase in pressure differential or blinding of the beds which may require bed change out. Since change out is not a part of the design, particulates must be prevented from entering the beds. This can be accomplished by installation of a HEPA filter or roughing filter upstream of the carbon beds.

7.7.2 Wastewater

An issue occurred during Campaign 1 regarding management of hazardous wastewater. Since the High Nitrate Tank was unavailable, wastewater was routed to the AWWT via an alternate path during Campaign 1; i.e., by using the OU1 lined runoff control ditch and Bio-Surge Lagoon. This alternate disposal path was approved by AWWT/OU5 personnel since no hazardous substances were to be used during Campaign 1, or expected in the wastewater.

Prior to implementation, it was stipulated that all wastewater to be discharged in this manner should be contained and characterized before release to verify no hazardous substances were present. In practice, the wastewater was released prior to receipt and review of lab data. Wastewater from the Scrubber, Desiccant Tower, rainwater and pad washdown, and other plant sources is collected in the Building Sump Tank (BST), where it is released to the AWWT as plant wastewater.

In this case, sampling data taken from analyses of the spent Scrubber liquor (sampling point S-7) showed that the Scrubber wastewater was a hazardous waste due to the RCRA characteristic of chromium. However, sampling results were not available until several weeks later. Data from the BST (sampling point S-17) showed the wastewater was no longer hazardous waste. Had the BST data indicated the released wastewater was a hazardous waste, we would have introduced hazardous waste into the OU1 concrete collection sump, and the Bio-Surge Lagoon. These units, along with the ditch and other appurtenances, could have been considered hazardous waste management units (HWMUs) by the OEPA, resulting in the need for RCRA regulation and closure of the units. Since the presence of chromium in high concentrations in the wastewater was not anticipated, this issue could have been programmatically prevented by holding the waste stream back until cleared for release through analytical characterization and timely data review.

7.7.3 Sampling and Data Management

7.7.3.1 Sampling points - New sampling points have been added to the VitPP operation but the Project Specific Plan (PSP) has not been revised. For example, S-22, 23, and 24; S-37 (EOS HEPA filters); and S-85 (Building HVAC filters). Sampling of the graphite solution waste stream should also be added to the PSP.

7.7.3.2 Analytical Data - There is a long time delay between environmental sampling and receipt of sample data (as much as 6 weeks). Field management of material is being restricted by data turnaround times. In addition, environmental data are not entered into an electronic database that is accessible in a timely manner; therefore, access to these data is encumbered by the need for a single point of contact and the physical transfer of data.

7.7.3.3 Data Packages - The data received from the lab are not easily matched with the sampled source. For example, the data for the HEPA filters do not always specify whether the prefilter or HEPA filter was sampled, whether train A or train B filters were sampled, or even whether the filter came from the normal OGS, EOS, plant ventilation MEPA, additives MEPA, or "Invincible" MEPA (on the filter/receiver). In addition, the data do not indicate whether the sample date is the date the HEPA was removed from service date taken to the lab, or the date the filter was processed in the lab. These information gaps and uncertainties make the data difficult to use.

7.7.4 Environmental ALARA

7.7.4.1 Wastewater volume - The unroofed portion of the VitPP pad allows significant quantities of rainwater to collect in the secondary containment catchments of the plant. This excess water requires characterization and management through the Building Sump, and increases the volume of wastewater treated by the AWWT plant. The alternative would be to cover the remaining pad area to prevent this waste from being generated.

7.7.4.2 Slurry Tank Heel Removal - Current slurry tank design and operation requires a significant portion of the slurry from each batch to be managed as waste, since the last portion of each batch cannot be fed to the Melter. This requires manual pump out and staging for eventual refeeding, or transfer to the Building Sump Tank (or Plant 8 by portable tank) for discharge as wastewater. This waste generation rate is several hundred pounds of solids and wastewater per batch of feed. At present, the system design and procedures do not accommodate the refeed of tanked or drummed slurry. An alternative would be to redesign the slurry tank system to minimize the heel, and allow refeeding of slurry solids and wastewater.

7.7.4.3 The gem maker required use of large quantities of cooling water mixed with graphite which resulted in a large quantity of waste. This cooling water mixed with the glass product in the waste containers. In future campaigns involving hazardous substances, this may result in the generation of a new (hazardous or mixed) waste stream, requiring additional handling and disposal. The waste disposal facility does not accept waste with free liquids, or hazardous or mixed waste. An alternative would be to redesign to recycle the cooling water, and keep coolant away from the glass product.

7.7.4.4 Contamination control - Slurry or Melter feed pumps can leak or blow seals and spread water and material over a large area. Pumps should be shielded to contain spray, and be placed in separate containment areas to minimize spread of process material. This will become more important for later campaigns that include RCRA materials, or radionuclides.

7.7.5 Miscellaneous

7.7.5.1 Field changes - Changes to the configuration of equipment, or method of operation made in the field can increase the probability of spills and releases due to elimination of environmental oversight and guidance. Field changes, such as rerouting flows, or deviations from procedure or direction must be reviewed by environmental compliance staff and reconcurrence reached prior to implementation.

7.7.5.2 All System Operating Procedures (SOPs) and Systems Operability Test (SOT) procedures that affect environmental areas of the VitPP project (off-gas system, wastewater, material handling, etc.) must be reviewed by environmental compliance staff to ensure environmental requirements, limits, and management methods are addressed in sufficient detail to provide guidance to VitPP operations personnel.

7.7.5.3 VitPP test log entries for environmental events are incomplete.

An example is extended time periods when the EOS was used, but not documented in the log. CERLCA regulatory requirements include release reporting, which rely on accurate documentation.

8.0 VitPP DESIGN DATA NEEDS for Phase II

Data needs and test requirements were identified by the project for development of the VitPP for Phase II testing using silo waste and for design and cost information for a future higher throughput waste vitrification facility. These data needs are planned to be accomplished from the Phase I and Phase II VitPP operating campaigns. The major VitPP systems operation and the test data obtained from Campaign 1 were reviewed from the perspective of providing the identified data needs.

8.1 Feed Preparation System

The Feed Preparation System must be able to mix and homogenize the process slurry and to reliably pump the slurry through both horizontal and vertical piping containing valves and fittings. During Phase I testing, variations were observed in the slurry solids loading during gradual pumped withdrawals from the two slurry tanks (5-TK-29A & B). This nonhomogeneity is believed to be caused by insufficient slurry mixing and solids suspension by the existing slurry tank agitators (5-AG-05A & B). When pumping the slurry, the lack of functioning pressure indicators in the slurry piping has precluded calculation of slurry friction losses and apparent viscosity under actual flow conditions. Providing instrumentation for pump suction and discharge pressures would provide information for adjusting the diaphragm pump motive air supply and discharge pressures to improve operations and reduce wear.

The supplier of the existing slurry tank agitators (Mixmor) indicates that the following data are needed to assess the agitator design:

- Dimensions of process tank and range of operating levels
- Specific gravity of slurry
- Solids content of slurry (percent by weight)
- Particle size distribution
- Density of individual particles (as opposed to the apparent density of a layer of settled solids)
- Slurry viscosity
- Determination of force to overcome settled slurry conditions

Data needed on the flow characteristics and rheology of the slurries were not obtained during Campaign 1. Added instrumentation for the slurry pumps and lines has not been installed.

8.2 Glass Product Handling

Design of upgrade facilities requires information on the temperature and temperature decay with time of the glass product containers. These data could not be obtained during Campaign 1. Specially designed glass product test containers with radial and axial thermowells installed are being considered for future campaigns.

8.3 Furnace Off-gas System

Prior to Campaign 1, it was known that Melter pressure could not be controlled at much lower than -0.5"WC with the Melter full of molten glass. Campaign 1 began on June 16, 1996 with water feed to the Melter, then progressed to a 12 wt% feed benign glass slurry, then to a 40 wt% feed of benign glass slurry on June 27, 1996. By June 28, 1996, it was clear that plugging in the Off-gas system Film Cooler was a serious problem; the Melter could be operated (fed slurry) only 4 to 6 hours before Melter pressure could not be held at -0.5"WC due to the Film Cooler plugging. It was also noticed that the off-gas line downstream of the Film Cooler was steadily increasing in pressure drop. At this time, Film Cooler air flow was about 120 SCFM and total exhaust flow was about 175 SCFM, indicating that Melter in-leakage was about 55 SCFM (all the process tank vents were valved to the "off" position).

The immediate fix was to vacuum out the horizontal section of line just downstream of the Film Cooler and to install a new exhaust fan. The original centrifugal exhaust fan was capable of producing a pressure of -31"WC at 200 SCFM at the fan suction. A new Spencer blower which is capable of producing a pressure of -80"WC at 200 SCFM at the fan suction was installed in its place. This new blower allowed the Melter control pressure to be reduced to -0.75"WC.

The first controlled run after the new blower was installed occurred on July 16, 1996 and July 17, 1996. During the approximately 12 hours of feeding slurry to the Melter at a nominal 1 MT/d glass production rate, the Film Cooler had to be cleaned out three times. However, the off-gas line just downstream of the Film Cooler remained clear. During this run, the Melter pressure varied between -0.6 and -0.8"WC with the off-gas control valve (FCV-250) 100% open much of the time. With total off-gas flow between 220 and 250 SCFM, and Film Cooler air flow between 120 and 150 SCFM, it appears that Melter in-leakage air flow was about 100 SCFM[19].

As a result, it is concluded that the current off-gas system configuration does not provide the Melter pressure to be controlled below about -0.75"WC, even with a lean

[19] A number somewhat less (30 to 80 SCFM) is used when doing heat/energy balance calculations around the Melter. This is because air in-leakage that flows through the Discharge Chamber into the Melter is already preheated (in the Discharge Chamber) and has no effect on the Melter energy balance.

Film Cooler.

Plugging in the throat of the Film Cooler was an impediment to continuous operation. (Subsequent installation of an air lance into the Film Cooler has greatly reduced plugging problems.)

The total pressure drop between the Melter plenum (at -0.7"WC) and the off-gas flow control valve (FCV-250) just upstream of the exhaust fan, at 250 SCFM, total flow is about 40"WC. When feeding the Melter at a 1 equivalent MT glass/day rate, the pressure drop increases to about 55"WC due to increased flow and temperature through the Film Cooler and the line to the Quench Tower. This high frictional pressure drop was not predicted by the design calculations. The cause of this miscalculation appears to be an incorrect accounting of losses in elbows, tees, valves, and entrances/exits for the equipment in the system. The calculation resulted in the specification of a 4" diameter off-gas line which has proved to be inadequate. Also, recent pressure drop calculations allowing for actual line size and routing do not predict pressure drops as high as those observed in the plant. This would seem to indicate significant plugging, plate out, or other problems in the system.

The high Melter in-leakage rate of about 100 SCFM and Film Cooler plugging concerns require the high Film Cooler air rate of about 150 SCFM. This takes up all the off-gas system capacity, leaving none for the tank vents. This high Melter in-leakage rate also cripples the entire off-gas system because attempts to lower the Melter pressure result in even more in-leakage that must be cooled by additional Film Cooler air flow. Since pressure drop rises as the square of the flow, there is no leeway in the existing system to significantly lower Melter pressure. The high in-leakage rate is believed to be due mostly to the large orifice at the glass discharge chamber at the interface with the Gem Machine.

The high velocity in the line to the Quench Tower appears to be keeping it clear, but the high pressure drop observed across the Quench Tower contributes to the problems described in the previous paragraph.

Quench Tower operation is deficient in that water flow is limited to about 16 gpm (vs. design of 40 gpm) believed to be due to scale buildup in the line. Consequently, the air leaving the Quench Tower runs 130 to 140°F (vs. design of 97°F. The water line from the Quench Tower to the system heat exchanger and onto the recycle water tank is also heavily scaled. Even if 40 gpm could be supplied to the Quench Tower, it is doubtful that it could be pumped out of the Quench Tower fast enough.

The Desiccant Tower worked well initially during campaign 1, but the large amounts of moisture to be remove from the off-gas overwhelmed it. Regardless of the final moisture removal system used, most of the moisture should be condensed out of this stream. (Cooling 120°F saturated air down to 50°F condenses out 90% of its moisture.)

It is concluded that replacement of the entire off-gas system and Melter in-leakage interface, which are currently planned for the facility upgrade, should be done at the earliest opportunity. Also, the scaled water lines should be chemically cleaned as soon as possible as is currently planned.

8.4 Maintenance Log keeping

VitPP maintenance activities during Campaign 1 were contained in the Supervisors Shift Turnover Log prepared at the end of each shift. For maintenance work, a FEMP Work Request/Order is prepared (see FEMP Work Request/Order Procedure, MT-0003, 6/28/96) and executed. The work request as written is general and typically does not describe in detail the work or activities performed to complete the work request. Section F of the procedure, Work Process/Package Closeout, provides for recording comments/lessons learned from the activity, however this may be general comments since no guidelines are provided. Completed FEMP Work Request/Order forms are archived and controlled at the document control center.

The present maintenance Log keeping is not adequate for tracking equipment performance, failure modes, diagnostics, and corrective actions in enough detail to provide design data for a future vitrification facility. It is suggested that Log keeping guidelines/procedures be provided for recording information on logs, Log keeping responsible party, and archiving of the logs. The maintenance log should serve as a record for defining equipment maintenance history for both plant and engineering personnel, and it should be recorded and stored in a retrievable manner.

9.0 LESSONS LEARNED

The VitPP has and is undergoing extensive testing of all the operating systems. Design, construction, and operation of the VitPP has provided experiences that can be valuable to others.

These "lessons learned" are contained in Appendix C of this report. The information has been accumulated from "plan of the day" meetings, Total Quality Management (TQM) meetings, and daily operations/testing at the VitPP. Appendix C is sorted by system and area of the VitPP. These items will be reviewed by Fluor Daniel Fernald Engineering, Operations, Project Management, and Testing to ensure all activities are incorporated, documented, and implemented in design and procedures for operation for the VitPP, plant upgrades, and ultimately the final operating facility and program.

Appendix A
Closeout of Systems Operability Test
Glass Campaign 1

VITRIFICATION PILOT PLANT
PHASE 1
CLOSEOUT OF
SYSTEM OPERABILITY TEST PROCEDURE 2504-SU-0034
GLASS CAMPAIGN 1

The following report summarizes the Vitrification Pilot Plant (VITPP) Operability Test Procedure Melter Campaign 1, 2504-SU-0034, Revision 1 in accordance the requirements of ENG-12-6003 Startup and System Operability Test Procedure.

SUMMARY

System operability testing in accordance with revision 1 of the SOT for the VITPP Melter and Gem Machine Systems commenced 6/19/96 and was completed 7/31/96. During Campaign 1, a total of 11 slurry tank batches and one frit batch were fed to the Melter. The Melter's main chamber temperature was maintained at approximately 1250 °C. Both the slurry and frit batches were free of barium and lead compounds. The feed slurries were mixed directly in the slurry tanks, eliminating the need for the Thickener Tank.

Summary data for the 12 batches is provided in the attached "Test Performance Parameters for SOT Campaign 1 at the Vitrification Pilot Plant" data sheets. Some noted highlights from these sheets are as follows:

Weighted Average Melter Temperature:	1250 +/- 20 °C
Total Slurry Fed:	49,734 lbs
Total Glass Produced as Monolith:	21,739 lbs
Total Glass Produced as Gem:	3,452 lbs
Total West Side Chamber Frit:	1,325 lbs
Total East Side Chamber Frit:	575 lbs
Total Center Chamber Frit:	1,862 lbs

The following provides a correlation between the batch and the section of the SOT to which it corresponds:

Batch No.	SOT Section	Description
C1B01	7.2	Initial 20% wt. solids slurry feed, monolith
C1B02	7.2	40% wt. solids, monolith
C1B03	7.4	Glass gem production for 6 hours with addition of center chamber frit for feed.
C1B04	N/A	Bulk discharge during standby/idled modes
C1B05	7.3	1 MT/D slurry feed to melter, monolith
C1B06	*	45% wt. solids, bulk discharge, off-gas upgrades
C1B07	*	46% wt. solids, 1 MT/D bulk discharge
C1B08	7.4	45% wt. solids, continuous gem production
C1B09	7.5	25% wt. solids, Maximum glass production rate
C1B10	7.5	55% wt. solids, Maximum glass production rate
C1B11	7.5	51% wt. solids, Maximum glass production rate
C1B12	7.5	50% wt. solids, Maximum glass production rate
C1B13	7.5	53% wt. solids, Maximum glass production rate

* C1B06 & C1B07 was not associated with any portion of the SOT but was ran during times in which the continuation of the SOT was on hold. C1B06 & C1B07 was used to gain experience with running the melter in an operation status. All data for both batches was recorded in the SOT test log.

Attached is a "Test Performance Parameter" data sheet for each batch ran during campaign I. Each batch data sheet compiles operational data, sampling data, slurry feed/glass production data, etc. that pertaining to each batch.

A total of 17 procedure interim changes and 1 test exception were written that address test changes and exceptions to the SOT methodology and criteria. These changes and exceptions are specifically discussed later herein.

PURPOSE

The systems operability test document "defines and comprises the System Operability (SO) test procedure for Campaign 1 of melter operations" as stated in 2504-SU-0034, Rev. 1. Testing consisted of initial continuous glass production in the melter, establishment of melter temperature and throughput control, synchronization of the operation of the melter and gem machine, and increasing the glass output of the melter to achieve maximum output to define system limits.

PROCEDURE CHANGE NOTICES

A total of 2 Interim Change Procedures (ICP's), ICP 01-96 and ICP 02-96, were written against 2504-SU-0034, Revision 0.

A total of 15 Interim Change Procedures (ICP's), ICP 03-96 through 17-96, were written against 2504-SU-0034, Revision 1.

ICP 1 was prepared to add Melter Feed and Discharge Rate Data Table. This table provides the Shift Test Coordinators an organized location to record key data generated by the SOT.

ICP 2 was prepared to correct an erroneous step reference.

ICP 3 was prepared to include Shift Manager authorization to proceed with the SOT after concurrence on test results from Step 7.1 by FERMCO, Vitreous Sate Laboratory of Catholic University (VSL), and Duratek.

ICP 4 was prepared to change order of ingredients to be added to Slurry Tank B per Duratek direction. The order was changed to avoid clumping/solidification of ingredients in slurry tank.

ICP 5 was prepared to delete step of re-establishing melter idle parameters. This ICP was issued to avoid temperature cycling.

ICP 6 was prepared in response to a suggestion from Duratek and VSL representatives. The ICP was issued to change the feed rate to the melter to 1/4 MT/D for the 20% solids solution. The feed rate at 1/2 MT/D was too great for a 20% solids slurry.

ICP 7 was prepared to correct an erroneous step reference.

ICP 8 was prepared to reflect an agreement between the Operations Manager and VSL representatives that the desired data concerning feed and discharge rates can be obtained in approximately four hours instead of the eight hours specified in the SOT.

ICP 9 was prepared to indicate that initial discharging with FI-007 at 2 SCFH revealed that air flow rates greater than 2 SCFH were not required to produce glass at 80 pounds/hour.

ICP 10 was prepared to delete steps in the SOT that would run the melter at the maximum rate. The steps were deleted as a result of previous sections demonstrating that the Off-gas system could not operate at a slurry feed rate of more than 1 MT/D.

ICP 11 was prepared to change the initial objective of the 24 hour slurry feed Section 7.3. The initial objective of Section 7.3 was changed to establish a cold cap coverage of 60 to 80%. The cold cap allowed operations to maximize feed time and minimize down time related off-gas line clogging. The changes implemented by this ICP allow for slurry feeding of the melter to continue.

PROCEDURE CHANGE NOTICES (cont.)

ICP 12 was prepared to revise Attachments 8 and 9 of the SOT to aid Melter, DCS, and Pad Operators in taking the necessary data. Attachment 10 of the SOT was also added as result of this ICP.

ICP 13 was prepared to change the order of addition of the ingredients on the batch sheets. This was done to support the RWP requirements.

ICP 14 was prepared to change the order of addition of the ingredients on the batch sheets. This was done to help induce usage of the zirconium oxide in the system.

ICP 15 was prepared to maintain a glass stream equivalent to 1-1/4 to 1-1/3 MT/D to the gem cutter/roller to avoid clogging the discharge orifice with glass. ICP 15 was also issued to maintain the melter at standby temperature rather than idle the melter before performing the section.

ICP 16 was prepared to indicate that the normal off-gas equipment was upgraded. The limits of the normal off-gas system, melter feed pump, and air lift were defined with current plant configuration. In addition, using Emergency off-gas system for an extended period of time while feeding slurry to the melter would cause avoidable particulate build up in the Emergency off-gas system.

ICP 17 was prepared to add Test Performance Parameters data sheets for each batch produced during Campaign 1.

TEST EXCEPTIONS

One test exception (TE's) was written against 2504-SU-0034, Revision 1.

TE 1 was prepared to explain that slurry feed rate of 1 metric ton/day (MT/D) for a 8 hour continuous run resulted in build up and eventual clogging of the film cooler in the off-gas system. Additionally, to obtain a 1 MT/D melter output rate, a slurry feed rate of greater than 1 MT/D would be necessary because of material losses to the off-gas system. Film cooler clogging would likewise result. The SOT was suspended and the melter was placed in idle per Operations Managers direction. Reference ICP 16 for resolution to Test Exception 1.

PROBLEMS ENCOUNTERED AND SOLUTIONS IMPLEMENTED

Normal Off-gas System

During early slurry batches of Campaign 1, the Normal Off-gas System frequently required cleaning when Operations personnel attempted to feed slurry to the Melter at rates greater than the 1/2 MT/D. Relatively rapid particulate build up in the Film Cooler Outlet and Transition Line was the primary problem. The frequent cleaning interrupted slurry feeding and strained operations resources.

A successful solution to the problem was the design and installation of an air lance. During later slurry batches of Campaign 1, the Normal Off-Gas System did not trip to the Emergency Off-gas System due to particulate build up and rarely required cleaning between batches.

The trips of the Normal Off-gas system to the Emergency Off-gas system during later slurry batches were often a result of the sudden collapse of a cold cap. This occurrences became less frequent as operations personnel became skilled in working with cold caps.

PROBLEMS ENCOUNTERED AND SOLUTIONS IMPLEMENTED (cont.)

Lube Spray and Gob Cutter Design and Operations

Early efforts to use the gob cutter and roller assembly to make glass gems identified that a heat dissipation problem with the cutter. An exterior cooling system using graphite solution was installed, allowing for the Operations personnel to continue working towards the goals of the SOT. One significant undesired feature of the exterior cooling system is that the excess graphite solution is collected by the drum located under the Emergency Diverter. At the completion of the SOT for Campaign 1, GTS Duratek was continuing to design and test the gob cutter and roller assemblies.

Melter Feed Pump Operations

The Melter Feed Pump seals failed when slurry seeped into the seals. Investigations revealed that the there was insufficient air pressure applied on the seal tank as designed because one of the two valves on the air line was not opened. To avoid this situation in the future, a Design Change Notice (DCN) was generated to add a pressure gauge on the air line to the Melter Feed Pump seal tank. In the field, a catch pan was secured beneath the seals to divert the leaking slurry to a pail. A temporary alteration allowed the mechanical seals to be replaced by a packing gland. this allowed the test to safety continue.

APPLICABLE DOCUMENTS

The following Duratek series of drawings are included in the scope of this test:

CRU4-M-M
CRU4-X-E
CRU4-X-I

A review of the DCN's posted against the VITPP was performed. The following DCN's were identified to have potential impact to the test boundaries. All DCN's listed below were satisfactorily implemented in the field and bounded by this test package.

DCN's 21, 29, 33, 37, 39, 55, 56, 95, 97, 117, 157, 200, 210, 243

Other DCN's initiated subsequent to this test package should be evaluated for impact to system performance and retest requirements.

PROCEDURE ACCEPTANCE

System performance is found to be acceptable according to the criteria specified by 2504-SU-0034, including regard to the satisfactory resolution to the test exception discussed above. The test exception is closed and the SOT is complete.

CONCLUSION

During the performance of the SOT for Campaign 1, Operations personnel proved that the Melter and associated systems can support feeding a slurry with up to 55 weight percent solids. Operations personnel developed the skill of establishing, maintaining, and controlling a 95 percent cold cap with adjustments to the Melter Feed Pump rate, bubbler air flow rate, Melter temperature, and discharge air lift air flow rate and were readily able to exceed the target 1MT/D glass production rate. As a result of the combined efforts and experiences of the Operations personnel, a compilation of preferred operating parameters have been developed to support future campaigns.

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Campaign Number 1	Batch Number C1B01 Formula Benign

Batch Objectives: Perform slurry feeding with a target of 20 % wt solids slurry in support of Section 7.2 of SOT 2504-SU-0034, Rev.1.

Slurry Tank B Initial Weight 3545 lbs (full batch) Final Weight 2275 lbs (heel before flush)	Slurry Fed - 1270 lbs Avg. Rate 133.7 lbs/hr Glass Produced - 395 lbs Avg. Rate 41.6 lbs/hr

Solids in Slurry 15 % wt

Slurry Feed Rate

Maximum	Average
110 RPM	97 RPM
1 L/min	0.80 L/min

Slurry Feed Start (time) 2312 hr on 6/24

Slurry Feed Stop (time) 0844 hr on 6/25

Slurry Feed Duration 9 hr 30 min

Drum ID	Net Weight (lbs)	Form
C1B01D2	395	gem
C1B01D1	142	Bulk

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Slurry Samples

Customer Number	Results
S04B-960624-1721	1.15g/ml & 16.4 wt%
S05-960624-2314	0.939g/ml & 6.5 wt%
S05A-960625-0233	1.128g/ml & 13.3 wt%
S04B-960625-0245	1.18 g/ml * wt%
S05-960625-0915	1.0g/ml & 0.98 wt%
S05-960625-0916	1.0g/ml & 1.1 wt%

* **% solids not analyzed for in sample S04B-960625-0245**

Glass Samples

Customer Number	Results	Drum ID
S10-960624-2249	*	C1B01D2
S10-960725-1701	**	C1B01D1

* **See attached "Laboratory Glass Analysis Results"**

** **See Glass Characteristics (viscosity & conductivity) on next page**

Weighted Avg. Melter Temp. 1256 °C

Weighted Avg. Melter Power 175 KW

Weighted Avg. Melter Current 1707 Amp

Weighted Avg. Melter Voltage 399 Volts

Gem Production

Gem Production Start 0720 hr Stop 0741 hr

Gem Production Duration 21 min

Average Cold Cap Coverage N/A %

Average Cold Cap Thickness N/A in

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Frit Addition			Film Cooler Outlet Temperature	
West Side Chamber	50	lbs	Max.	Avg. w/cold cap
East Side Chamber	25	lbs	1010 °F	923 °F
Center Chamber	0	lbs		

Utility Air Flow Settings			Gem Machine Settings	
Film Cooler Flow Rate	N/A	scfm	Gem Machine Gob Cutter Speed	N/A
Bubbler 1 Flow Rate	6	scfh	Gem Machine Roller Speed	N/A
Bubbler 2 Flow Rate	6	scfh	Gem Machine Conveyor Speed	N/A
Bubbler 3 Flow Rate	6	scfh		
Bubbler 4 Flow Rate	6	scfh		
Air Lift Flow Rate	2~3	scfh		
Trickle Air Flow Rate	1	scfh		

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Glass Characteristics
(as reported by the lab)

Viscosity	36.78 p
Conductivity	366 mS/CM
TCLP Ba	*
TCLP Cr	*
TCLP Pb	*
No. of Phases	1
Gem Size(s)	**
Gem Uniformity	**

* **See attached "Laboratory Glass Analysis Results"**

** **Gem production time was only 21 minutes due to lube spray problems**

Normal Off-Gas Characteristics

Initial DP across HEPA filter	N/A
Maximum DP across HEPA filter	N/A
Final DP across HEPA filter	N/A
Number of changings of HEPA filter	N/A
Initial DP across transition line	N/A
Maximum DP across transition line	N/A
Final DP across transition line	N/A
Initial DP across Film Cooler Outlet	N/A
Maximum DP across Film Cooler Outlet	N/A
Final DP across Film Cooler Outlet	N/A
No. of cleanings of Film Cooler Outlet	N/A

Note: Round sheets (attachment 8 & 10) where not taken due to limited resources

Gem Housing Characteristics

Average Pressure -0.48 " w.c.

Avg. Discharge Temp. 1273° C

Normal Off-Gas Characteristics
(Average During Stable Conditions)

PDIC - 250		FI-250
% Open	Pressure	Flow
64 %	-0.48 " w.c.	180 scfm

Number of Emergency Off-Gas Trips 1

Comments:______________________

Batch Number: 1

Laboratory Glass Analysis Results

	CUSTOMER I.D. S10-960624-2249	S10-960624-2249	CUSTOMER I.D.		CUSTOMER I.D.			
Analyte	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SiO2	46.49	54.12						
B2O3	7.43	8.65						
Li2O	1.80	2.10						
Al2O3	11.82	13.76						
BaO	0.00	0.00						
CaO	12.98	15.11						
Cr2O3	NR	0.00						
CuO	NR	0.00						
Fe2O3	0.19	0.22						
PbO	0.00	0.00						
MgO	0.88	1.02						
Mn3O4	0.00	0.00						
NiO	0.00	0.00						
K2O	0.00	0.00						
V2O5	0.00	0.00						
Na2O	NR	0.00						
ZrO2	4.31	5.02						
	sum (wt%) 85.9	norm sum (wt%) 100	sum (wt%) 0	norm sum (wt%) 0.0	sum (wt%) 0	norm sum (wt%) 0.0		
	multiplier	1.1641443539	multiplier		multiplier			

TCLP Results

ANALYTE	S10-960624-2250 (ug/L)		(ug/L)		(ug/L)		(UG/L)
BARIUM	294						294.00
LEAD	0						0.00
CHROMIUM	39.9						39.90

Density

							(g/mL)
DENSITY (g/mL)							

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Campaign Number 1	Batch Number C1B02 Formula Benign

Batch Objectives: Feed Slurry with approximately 40 % by weight of solids to the Melter and produce glass (bulk discharging) at a minimum rate of 1 MT/D. Section 7.2 of the SOT for Campaign 1.

Slurry Tank B

Initial Weight 7553 lbs
(full batch)

Final Weight 3110 lbs
(heel before flush)

Slurry Fed 4443 lbs Avg. Rate 240 lbs/hr

Glass Produced 1135 lbs Avg. Rate 61lbs/hr

Solids in Slurry 34% wt

Slurry Feed Rate

Maximum	Average
201 RPM	75 RPM
1.75 L/min	0.7 L/min

Slurry Feed Start 1609 hr on 6/26/96
(time)

Slurry Feed Stop 1601 hr on 6/27/96
(time)

Slurry Feed Start 2100 hr on 6/27/96
(time)

Slurry Feed Stop 0326 hr on 6/28/96
(time)

Slurry Feed Duration 30 hr 18 min

Drum ID	Net Weight (lbs)	Form
C1B02D1	707	Bulk
C1B02D02	442	Bulk
C1B02D03	354	Bulk
C1B02D04	550	Bulk
C1B02B05	293	Bulk

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Slurry Samples

Customer Number	Results
S04B-960626-0923	1.25g/ml & 33.6wt%
S04B-960627-1931	1.34g/ml & 44.0 wt%
S04B-960627-1041	1.21g/ml & * wt%
S04B-960627-2105	1.31g/ml & 32.8wt%
S04B-960628-0051	1.31g/ml & 38 wt%
S05A-960626-1616	1.32g/ml & 34.2wt%
S05A-960627-0111	1.24g/ml & 39.5wt%
S05A-960627-1035	1.38g/ml & 39.2wt%
S05A-960627-1036	1.37g/ml & 37.4wt%
S05-960627-1925	1.36g/ml & 44.8 wt%
S05A-960627-2103	1.32g/ml & 31.4wt%
S05A-960628-0107	1.22g/ml & 38 wt%

*** % solids not analyzed for in sample S04B-960627-1041**

Glass Samples

Customer Number	Results	Drum ID
S10-960627-0014	*	C1B02D1
S10-960628-0230	*	C1B02D1
S10-960628-0231	*	C1B02D1
S10-960628-0232	*	C1B02D1
S10-960628-0950	*	C1B02D4
S10-960628-0955	*	C1B02D4
S10-960628-1000	*	C1B02D4
S10-960629-1015	*	C1B02D5
S10-960629-1020	*	C1B02D5
S10-960629-1025	*	C1B02D5
S10-960725-1702	**	C1B02D1

*** See attached "Laboratory Glass Analysis Results"**

**** See Glass Characteristics (viscosity & conductivity) on next page**

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT	
Weighted Avg. Melter Temp. 1253 °C Weighted Avg. Melter Power 164 KW Weighted Avg. Melter Current 1698 Amp Weighted Avg. Melter Voltage 388 Volts	Gem Production Gem Production Start N/A hr Stop N/A hr Gem Production Duration N/A min
Average Cold Cap Coverage N/A %	Average Cold Cap Thickness N/A in
Frit Addition West Side Chamber 75 lbs East Side Chamber 0 lbs Center Chamber 0 lbs	Film Cooler Outlet Temperature Max. 1065 °F Avg. w/cold cap 798 °F
Utility Air Flow Settings Film Cooler Flow Rate 80 ~ 160 scfm Bubbler 1 Flow Rate 6 scfh Bubbler 2 Flow Rate 6 scfh Bubbler 3 Flow Rate 6 scfh Bubbler 4 Flow Rate 6 scfh Air Lift Flow Rate 2 ~ 5 scfh Trickle Air Flow Rate 1 scfh	Gem Machine Settings Gem Machine Gob Cutter Speed N/A Gem Machine Roller Speed N/A Gem Machine Conveyor Speed N/A

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Glass Characteristics
(as reported by the lab)

Viscosity	47.48 p
Conductivity	229 mS/cm
TCLP Ba	•
TCLP Cr	•
TCLP Pb	*
No. of Phases	1
Gem Size(s)	N/A
Gem Uniformity	N/A

- **See attached "Laboratory Glass Analysis Results"**

Normal Off-Gas Characteristics

Initial DP across HEPA filter	N/A
Maximum DP across HEPA filter	N/A
Final DP across HEPA filter	N/A
Number of changings of HEPA filter	0
Initial DP across transition line	N/A
Maximum DP across transition line	N/A
Final DP across transition line	N/A
Initial DP across Film Cooler Outlet	N/A
Maximum DP across Film Cooler Outlet	N/A
Final DP across Film Cooler Outlet	N/A
No. of cleanings of Film Cooler Outlet	12

- **Round sheets (attachment 8 & 10) where not taken due to limited resources**

Gem Housing Characteristics

Average Pressure	-0.4" w.c.
Avg. Discharge Temperature	1275 °C

Normal Off-Gas Characteristics
(Average During Stable Conditions)

PDIC - 250		FI-250
% Open	Pressure	Flow
70%	-0.5 " w.c.	141 scfm

Number of Emergency Off-Gas Trips 3

Comments: ____________________

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000134

Batch Number: 2

Laboratory Glass Analysis Results

	CUSTOMER I.D.		CUSTOMER I.D.		CUSTOMER I.D.			
	S10-960628-0231	S10-960628-0231	S10-960629-1020	S10-960629-1020	S10-960628-0955	S10-960628-0955		
Analyte	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SiO2	46.07	47.93	46.12	47.99	45.11	47.04	45.77	47.65
B2O3	7.80	8.12	8.03	8.36	7.69	8.00	7.84	8.16
Li2O	2.10	2.18	2.62	2.73	2.09	2.17	2.27	2.36
Al2O3	11.23	11.68	10.92	11.36	11.54	12.01	11.23	11.68
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	12.07	12.56	11.34	11.80	12.33	12.83	11.91	12.40
Cr2O3	NR	0.00	NR	0.00	NR	0.00	0.00	0.00
CuO	NR	0.00	NR	0.00	NR	0.00	0.00	0.00
Fe2O3	0.20	0.21	0.17	0.18	0.14	0.15	0.17	0.18
PbO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	1.10	1.14	1.13	1.18	1.08	1.12	1.10	1.15
Mn3O4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.00	0.00	0.00	0.00	0.21	0.22	0.07	0.07
V2O5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na2O	11.23	11.68	11.30	11.76	11.39	11.85	11.31	11.76
ZrO2	4.31	4.48	4.31	4.48	4.31	4.48	4.31	4.48
	sum (wt%) 96.11	norm sum (wt%) 100	sum (wt%) 95.94	norm sum (wt%) 99.8	sum (wt%) 95.89	norm sum (wt%) 99.9		
	multiplier	1.040474456352	multiplier	1.042318115488847	multiplier	1.0428616122641		

TCLP Results

	S10-960628-0232		S10-960628-0950		S10-960629-1015		
ANALYTE	(ug/L)		(ug/L)		(ug/L)		(UG/L)
BARIUM	17.3		309		304		210.10
LEAD	0		0		0		0.00
CHROMIUM	17.5		488		32.2		179.23

Density

	S10-960628-0230		S10-960628-1000		S10-960629-1025		(g/mL)
DENSITY (g/mL)	2.62		1.59		2.6		2.27

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Campaign Number 1	Batch Number C1B03 Formula Frit

Batch Objectives: Produce glass gems as continuously as possible for a minimun of 6 hours in accordance with Section 7.4 of SOT 2504-SU-0034 Rev. 1 for Campaign 1. Frit was added to the melter center chamber to support the activities between July 3rd and July 5th.

Slurry Tank N/A Initial Weight N/A lbs (full batch) Final Weight N/A lbs (heel before flush)	Slurry Fed N/A lbs Glass Produced N/A[a] lbs a - **Currently, the amount of glass produced cannot be measured due to the amount of graphite solution in some of the drums. See item below.**

Solids in Slurry N/A % wt

Loss to Off-Gas N/A % wt
(solids in slurry - glass produced)/solids in slurry

Frit Feed

Frit Feed Start 0545 (time) hr on 7/4/96

Frit Feed Stop 1045 (time) hr on 7/4/96

Frit Feed Start 1530 (time) hr on 7/4/96

Frit Feed Stop 0615 (time) hr on 7/5/96

Frit Feed Duration 19 hr 45 min

Drum ID	Net Weight (lbs)	Form
C1B03D1[a]	529	Bulk
C1B03D2[b]	462	Bulk
C1B03D3	586	Gem
C1B03D4	570	Gem
C1B03D5[a]	335	Bulk
C1B03D6[a]	293	Gem
C1B03D7[a]	266	Bulk

a - These drums contain graphite solution and glass.
b - Drum contains graphite solution only

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Glass Samples

Customer Number	Results	Drum ID
S10-960705-2126	•	C1B03D7
S10-960705-2127	•	C1B03D7
S10-960705-2128	*	C1B03D7
S10-960706-0920	*	C1B03D1
S10-960706-0923	*	C1B03D2
S10-960706-0926	•	C1B03D5
S10-960706-0930	•	C1B03D6
S10-960706-0933	•	C1B03D6
S10-960706-0936	•	

*** See attached "Laboratory Glass Analysis Results"**

Glass Samples

Customer Number	Results	Drum ID
S10-960704-2043	•	C1B03D3
S10-960704-2112	•	C1B03D3
S10-960704-2113	*	C1B03D3
S10-960704-2230	*	C1B03D4
S10-960704-2231	•	C1B03D4
S10-960704-2232	*	C1B03D4
S10-960705-0550	•	C1B03D4
S10-960705-0051	•	C1B03D4
S10-960705-0052	•	C1B03D4
S10-960705-0552	•	C1B03D3
S10-960725-1703	**	C1B03D3

*** See attached "Laboratory Glass Analysis Results"**

**** See Glass Characteristics (viscosity & conductivity) on next page**

Weighted Avg. Melter Temp.	1255	°C
Weighted Avg. Melter Power	130	KW
Weighted Avg. Melter Current	1590	Amp
Weighted Avg. Melter Voltage	82	Volts

Gem Production

Start 1948 hr Stop 2120 hr on 7/4/96

Start 2250 hr on 7/4 Stop 0215 hr on 7/5

Start 0309 hr Stop 0342 hr on 7/5/96

Start 0354 hr Stop 0613 hr on 7/5/96

Gem Production Duration 7 hr 45 min

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT	
Average Cold Cap Coverage N/A %	Average Cold Cap Thickness N/A in
Frit Addition	**Film Cooler Outlet Temperature**
West Side Chamber 125 lbs	Max. 800 °F
East Side Chamber 0 lbs	Avg. w/cold cap 680 °F
Center Chamber 1400 lbs	
Utility Air Flow Settings	**Gem Machine Settings**
Film Cooler Flow Rate N/A scfm	Gem Machine Gob Cutter Speed 10 - 25
Bubbler 1 Flow Rate 6 scfh	Gem Machine Roller Speed 10 - 25
Bubbler 2 Flow Rate 6 scfh	Gem Machine Conveyor Speed 37 - 40
Bubbler 3 Flow Rate 6 scfh	
Bubbler 4 Flow Rate 6 scfh	
Air Lift Flow Rate 3-5 scfh	
Trickle Air Flow Rate 1 scfh	

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Glass Characteristics
(as reported by the lab)

Viscosity	23.12 p
Conductivity	217 mS/cm
TCLP Ba	*
TCLP Cr	*
TCLP Pb	*
No. of Phases	1
Gem Size(s)	1/2" to 1-1/2"
Gem Uniformity	90 %

* **See attached "Laboratory Glass Analysis Results"**

Normal Off-Gas Characteristics

Initial DP across HEPA filter	N/A
Maximum DP across HEPA filter	N/A
Final DP across HEPA filter	N/A
Number of changings of HEPA filter	N/A
Initial DP across transition line	N/A
Maximum DP across transition line	N/A
Final DP across transition line	N/A
Initial DP across Film Cooler Outlet	N/A
Maximum DP across Film Cooler Outlet	N/A
Final DP across Film Cooler Outlet	N/A
No. of cleanings of Film Cooler Outlet	0

* **Round sheets (attachment 8 & 10) where not taken due to limited resources**

Gem Housing Characteristics

Average Pressure -0.16 ~ -0.36_" w.c.

Avg. Discharge Temp. 1290 ° C

Normal Off-Gas Characteristics
(Average During Stable Conditions)

PDIC - 250		FI-250
% Open	Pressure	Flow
63	-0.5 " w.c.	300 scfm

Number of Emergency Off-Gas Trips 0

Comments:

Batch Number: 3

Laboratory Glass Analysis Results

Analyte	CUSTOMER I.D. S10-960704-2043 Result (wt %-abs)	S10-960704-2043 Result (wt %-norm.)	CUSTOMER I.D. S10-960706-0923 Result (wt %-abs)	S10-960706-0923 Result (wt %-norm.)	CUSTOMER I.D. S10-960706-0933 Result (wt %-abs)	S10-960706-0933 Result (wt %-norm.)	CUSTOMER I.D. S10-960704-2231 Result (wt %-abs)	S10-960704-2231 Result (wt %-norm.)	CUSTOMER I.D. S10-960705-0051 Result (wt %-abs)	S10-960705-0051 Result (wt %-norm.)	CUSTOMER I.D. S10-960705-2126 Result (wt %-abs)	S10-960705-2126 Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SiO2	43.89	47.65	43.87	49.04	40.70	47.69	27.74	36.58	45.78	47.52	45.85	49.66	41.31	46.36
B2O3	8.67	9.41	8.71	9.74	7.83	9.17	5.32	7.01	9.19	9.54	9.17	9.93	8.15	9.13
Li2O	2.70	2.93	2.67	2.98	2.86	3.35	1.93	2.54	2.70	2.80	2.32	2.51	2.53	2.85
Al2O3	10.18	11.05	10.05	11.23	8.78	10.29	13.35	17.60	10.38	10.77	10.24	11.09	10.50	12.01
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.13	0.00	0.00	0.00	0.00	0.02	0.02
CaO	10.26	11.14	10.37	11.59	8.53	9.99	10.54	13.90	10.61	11.01	10.98	11.89	10.22	11.59
Cr2O3	NR	0.00	NR	0.00	NR	0.00	NR	0.00	NR	0.00	NR	0.00	0.00	0.00
CuO	NR	0.00	NR	0.00	NR	0.00	NR	0.00	NR	0.00	NR	0.00	0.00	0.00
Fe2O3	0.14	0.15	0.14	0.16	0.16	0.19	0.21	0.28	0.17	0.18	0.13	0.14	0.16	0.18
PbO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.02	0.02
MgO	1.05	1.14	1.04	1.16	1.00	1.17	1.03	1.36	0.98	1.02	0.93	1.01	1.01	1.14
Mn3O4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.00	0.00	0.00	0.00	0.58	0.68	0.41	0.54	0.32	0.33	0.00	0.00	0.22	0.26
V2O5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na2O	10.90	11.83	8.30	9.28	10.60	12.42	10.90	14.37	11.80	12.25	8.40	9.10	10.15	11.54
ZrO2	4.31	4.68	4.31	4.82	4.31	5.05	4.31	5.68	4.31	4.47	4.31	4.67	4.31	4.90
	sum (wt%) 92.1	norm sum (wt%) 100	sum (wt%) 89.46	norm sum (wt%) 100.0	sum (wt%) 85.35	norm sum (wt%) 100.0	sum (wt%) 75.84	norm sum (wt%) 100.0	sum (wt%) 96.34	norm sum (wt%) 100.0	sum (wt%) 92.33	norm sum (wt%) 100.0		
	multiplier	1.085776330076	multiplier	1.1178180192265	multiplier	1.1716461628588	multiplier	1.318565400844	multiplier	1.0379904504879	multiplier	1.083071591032		

TCLP Results

ANALYTE	S10-960704-2112 (ug/L)	S10-960706-0936 (ug/L)	S10-960706-0926 (ug/L)	S10-960704-2230 (ug/L)	S10-960705-0052 (ug/L)	S10-960705-2127 (ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(UG/L)
BARIUM	463	435	36.5	62.7	80.2	74.1							191.92
LEAD	0	0	0	0	0	0							0.00
CHROMIUM	256	0	12.6	15.7	35.6	10							55.02

Density

	S10-960704-2113	S10-960706-0930	S10-960705-0550	S10-960704-2232	S10-960705-2128	S10-960706-0920							(g/mL)
DENSITY (g/mL)	2	1.64	1.6	1.7	1.6	1.64							1.708

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Campaign Number 1

Batch Number C1B05 Formula Benign

Batch Objectives: Feed slurry to the Melter at approximately 1 MT/D continuously while testing newly developed Film Cooler Outlet cleaning device. Work is performed in accordance with Section 7.3.

Slurry Tank B

Initial Weight 7203 lbs
(full batch)

Final Weight 3115 lbs
(heel before flush)

(Note: Remaining slurry used in C1B06.)

Slurry Fed - 4088 lbs Avg. rate 245 lbs/ hr

Glass Produced - 1435 lbs Avg. rate 86 lbs/hr

Solids in Slurry 34% wt

Slurry Feed Rate

Maximum	Average
350 RPM	203 RPM
3.1 L/min	1.8 L/min

Slurry Feed Start - 1830 hr on 7/15/96
(time)
Slurry Feed Stop - 2040 hr on 7/15/96
(time)
Slurry Feed Start - 1205 hr on 7/16/96
(time)
Slurry Feed Stop - 1845 hr on 7/16/96
(time)
Slurry Feed Start - 2025 hr on 7/16/96
(time)
Slurry Feed Stop - 0415 hr on 7/17/96
(time)
Slurry Feed Duration - 16 hr 40 min

Drum ID	Net Weight (lbs)	Form
C1B05D1	899	Bulk
C1B05D4	641	Bulk

Note: The first 112 pounds of glass was from the interim between C1B04 and C1B05.

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Slurry Samples

Customer Number	Results
S04B-960715-0300	1.34g/ml & 34wt%
S04B-960715-1534	1.19g/ml & 40.1wt%
S04B-960715-1815	1.14g/ml & 44.6wt%
S05A-960715-1902	1.34g/ml & 32 wt%
S05A-960715-1903	1.35g/ml & 24 wt%
S05A-960715-1910	1.35g/ml & 34 wt%
S05A-960715-1912	1.34g/ml & 30 wt%
S04B-960715-1821	1.34 g/ml & 33 wt%
S04B-960715-2100	1.34g/ml & 39 wt%

Glass Samples

Customer Number	Results	Drum ID
S10-960716-0930	*	N/A
S10-960725-1705	**	C1B05D1
S10-960715-1215	*	N/A
S10-960715-1210	*	N/A
S10-960715-1205	*	N/A
S10-960715-1200	*	N/A

* See attached "Laboratory Glass Analysis Results"

** See Glass Characteristics (viscosity & conductivity) on next page

N/A Item not available

Weighted Avg. Melter Temp.	1252°C
Weighted Avg. Melter Power	179 KW
Weighted Avg. Melter Current	1742 Amp
Weighted Avg. Melter Voltage	405 Volts

Gem Production

Gem Production Start N/A hr Stop N/A hr

Gem Production Duration N/A min

Average Cold Cap Coverage 70%

Average Cold Cap Thickness 1/2 in

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Frit Addition		Film Cooler Outlet Temperature	
West Side Chamber	0 lbs	Max.	Range w/cold cap
East Side Chamber	0 lbs	920 °F	425 ~ 900 °F
Center Chamber	0 lbs		

Utility Air Flow Settings		Gem Machine Settings	
Film Cooler Flow Rate	120 scfm	Gem Machine Gob Cutter Speed	N/A
Bubbler 1 Flow Rate	6 - 12 scfh	Gem Machine Roller Speed	N/A
Bubbler 2 Flow Rate	6 - 12 scfh	Gem Machine Conveyor Speed	N/A
Bubbler 3 Flow Rate	6 - 12 scfh		
Bubbler 4 Flow Rate	6 - 12 scfh		
Air Lift Flow Rate	1 - 2.8 scfh		
Trickle Air Flow Rate	1 scfh		

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Glass Characteristics
(as reported by the lab)

Viscosity	28.17 p
Conductivity	403 mS/cm
TCLP Ba	•
TCLP Cr	•
TCLP Pb	•
No. of Phases	1
Gem Size(s)	N/A
Gem Uniformity	N/A

• **See attached "Laboratory Glass Analysis Results"**

Normal Off-Gas Characteristics

Initial DP across HEPA filter 0.3" w.c.

Maximum DP across HEPA filter - 0.4" w.c

Final DP across HEPA filter - 0.3" w.c.

Number of changings of HEPA filter - 1

Initial DP across transition line - 11" w.c.

Maximum DP across transition line - 11" w.c.

Final DP across transition line - 7" w.c.

Initial DP across Film Cooler Outlet - off scale

Maximum DP across Film Cooler Outlet - off scale

Final DP across Film Cooler Outlet - off scale

No. of cleanings of Film Cooler Outlet - 6

Gem Housing Characteristics

Average Pressure	-0.57" w.c.
Avg. Discharge Temperature	1149° C

Normal Off-Gas Characteristics
(Average During Stable Conditions)

PDIC - 250		FI-250
% Open	Pressure	Flow
91%	-0.7" w.c.	255 scfm

Number of Emergency Off-Gas Trips 4

Comments: ____________________

Batch Number: 5

Laboratory Glass Analysis Results

Analyte	CUSTOMER I.D. S10-960715-1205 Result (wt %-abs)	S10-960715-1205 Result (wt %-norm.)	CUSTOMER I.D. S10-960715-1215 Result (wt %-abs)	S10-960715-1215 Result (wt %-norm.)	CUSTOMER I.D. Result (wt %-abs)	Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SiO2		0.00		0.00			0.00	0.00
B2O3		0.00		0.00			0.00	0.00
Li2O		0.00		0.00			0.00	0.00
Al2O3		0.00		0.00			0.00	0.00
BaO		0.00		0.00			0.00	0.00
CaO		0.00		0.00			0.00	0.00
Cr2O3		0.00		0.00			0.00	0.00
CuO		0.00		0.00			0.00	0.00
Fe2O3		0.00		0.00			0.00	0.00
PbO		0.00		0.00			0.00	0.00
MgO		0.00		0.00			0.00	0.00
Mn3O4		0.00		0.00			0.00	0.00
NiO		0.00		0.00			0.00	0.00
K2O		0.00		0.00			0.00	0.00
V2O5		0.00		0.00			0.00	0.00
Na2O	12.20	73.89	12.00	100.00			12.10	86.95
ZrO2	4.31	26.11		0.00			2.16	13.05
	sum (wt%) 16.51	norm sum (wt%) 100	sum (wt%) 12	norm sum (wt%) 100.0	sum (wt%) 0	norm sum (wt%) 0.0		
	multiplier	6.056935190793	multiplier	8.333333333333	multiplier	ERR		

TCLP Results

ANALYTE	S10-960715-1205 (ug/L)		S10-960715-1215 (ug/L)		(ug/L)		(ug/L)
BARIUM	358		0				179.00
LEAD	46		49				47.50
CHROMIUM	9.7		19.1				14.40

Density

	S10-960715-1200	S10-960715-1210	S10-960716-0930				(g/mL)
DENSITY (g/mL)	2.6	2.6	2.62				2.61

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Campaign Number 1

Batch Number C1B06 Formula Benign

Batch Objectives: Target wt % solids is 45 %. Feed slurry and maintain stable cold cap with the support of the air lance in the film cooler outlet.

Slurry Tank B

Initial Weight 7337 lbs
(full batch)

Final Weight 47 lbs
(heel before flush)

Slurry Fed 7290 lbs Avg. 317 lbs/hr

Glass Produced 2364 lbs Avg. 103 lbs/hr

Solids in Slurry 35% wt

Slurry Feed Rate

Maximum	Weighted Average
350 RPM	202 RPM
3.1 L/min	1.8 L/min

Slurry Feed Start 2105 hr on July 18th
(time)
Slurry Feed Stop 0410 hr on July 19th
(time)
Slurry Feed Start 1510 hr on July 19th
(time)
Slurry Feed Stop 0705 hr on July 20th
(time)

Slurry Feed Duration 23 hrs 0 min

Drum ID	Net Weight (lbs)	Form
C1B06D1	638	Bulk
C1B06D4	1076	Bulk
C1B06D5	658	Bulk

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Slurry Samples

Customer Number	Results
S05A-960718-2100	1.31 g/ml & 35wt%
S05A-960718-2110	1.32 g/ml & 35.3wt%
S05A-960720-0045	1.19 g/ml & 24 wt%
S05A-960720-0046	1.19 g/ml & 23 wt%
S04B-960718-0215	1.33 g/ml & 40 wt%
S04B-960718-0230	2.63 g/ml & * wt

* % solids not analyzed for in sample S04B-960718-0230

Glass Samples

Customer Number	Results	Drum ID
S10-960719-0525	*	N/A
S10-960719-1405	*	C1B06D1
S10-960720-1630	*	C1B06D5
S10-960720-1645	*	C1B06D5
S10-960719-0925	*	N/A
S10-960719-1240	*	N/A
S10-960720-1330	*	N/A
S10-960720-1345	*	N/A
S10-960725-1706	**	C1B06D4

* See attached "Laboratory Glass Analysis Results"

** See Glass Characteristics (viscosity & conductivity) on next page

N/A Item not available

Weighted Avg. Melter Temp. 1255°C

Weighted Avg. Melter Power 181 KW

Weighted Avg. Melter Current 1592 Amp

Weighted Avg. Melter Voltage 109 Volts

Gem Production

Gem Production Start N/A hr Stop N/A hr

Gem Production Duration N/A min

Average Cold Cap Coverage 86%

Average Cold Cap Thickness 1/2 in

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT	
Frit Addition West Side Chamber 75 lbs East Side Chamber 25 lbs Center Chamber 0 lbs	Film Cooler Outlet Temperature Max. 927 °F Avg. w/cold cap 800 °F
Utility Air Flow Settings Film Cooler Flow Rate 57 scfm Bubbler 1 Flow Rate 6-12 scfh Bubbler 2 Flow Rate 6-12 scfh Bubbler 3 Flow Rate 6-12 scfh Bubbler 4 Flow Rate 6-12 scfh Air Lift Flow Rate 1-3.5 scfh Trickle Air Flow Rate 1.0 scfh	Gem Machine Settings Gem Machine Gob Cutter Speed N/A Gem Machine Roller Speed N/A Gem Machine Conveyor Speed N/A

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT

Glass Characteristics
(as reported by the lab)

Viscosity	95.25 p
Conductivity	336 mS/cm
TCLP Ba	*
TCLP Cr	*
TCLP Pb	*
No. of Phases	1
Gem Size(s)	N/A
Gem Uniformity	N/A

* **TCLP samples were not taken after batch 5 due to the fact that batches 1, 2, 3 & 5 provided sufficient data to prove that the glass passed the TCLP**

Normal Off-Gas Characteristics

Initial DP across HEPA filter 3.9" w.c.

Maximum DP across HEPA filter 4.0" w.c.

Final DP across HEPA filter 0.2" w.c.

Number of changings of HEPA filter 0

Initial DP across transition line 8.0" w.c.

Maximum DP across transition line 14.5" w.c.

Final DP across transition line 5.0" w.c.

Initial DP across Film Cooler Outlet 7.0" w.c.

Maximum DP across Film Cooler Outlet 17" w.c.

Final DP across Film Cooler Outlet 8.0" w.c.

No. of cleanings of Film Cooler Outlet 1

Gem Housing Characteristics

Average Pressure -0.65" w.c.

Avg. Discharge Temperature 1275° F

Normal Off-Gas Characteristics
(Average During Stable Conditions)

PDIC - 250		FI-250
% Open	Pressure	Flow
65%	-0.73" w.c.	245 scfm

Number of Emergency Off-Gas Trips 0

Comments: ______________________________

Batch Number: 6

Laboratory Glass Analysis Results

Analyte	CUSTOMER I.D. S10-960719-1240 Result (wt %-abs)	CUSTOMER I.D. S10-960719-1240 Result (wt %-norm.)	CUSTOMER I.D. S109607201345 Result (wt %-abs)	CUSTOMER I.D. S109607201345 Result (wt %-norm.)	CUSTOMER I.D. S109607201645 Result (wt %-abs)	CUSTOMER I.D. S109607201365 Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SIO2	45.16	45.85	34.75	43.46	30.89	40.92	36.93	43.41
B203	8.71	8.84	7.41	9.27	6.97	9.23	7.70	9.11
Li2O	2.91	2.95	1.15	1.44	1.02	1.35	1.69	1.91
Al2O3	10.50	10.66	9.69	12.12	9.42	12.48	9.87	11.75
BaO	0.06	0.06	0.00	0.00	0.00	0.00	0.02	0.02
CaO	10.74	10.90	11.37	14.22	11.65	15.43	11.25	13.52
CHROMIUM	3.60	3.65	0.06	0.08	0.06	0.08	1.24	1.27
CuO	NR	0.00	NR	0.00	NR	0.00	0.00	0.00
Fe2O3	0.15	0.15	0.10	0.13	0.12	0.16	0.12	0.15
PbO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.94	0.95	0.71	0.89	0.65	0.86	0.77	0.90
Mn3O4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.42	0.43	0.20	0.25	0.00	0.00	0.21	0.23
V2O5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na2O	11.00	11.17	10.20	12.76	10.40	13.78	10.53	12.57
ZrO2	4.31	4.38	4.31	5.39	4.31	5.71	4.31	5.16
	sum (wt%) 98.5	norm sum (wt%) 100	sum (wt%) 79.95	norm sum (wt%) 100.0	sum (wt%) 75.49	norm sum (wt%) 100.0		
	multiplier	1.015228426396	multiplier	1.250781738587	multiplier	1.3246787653994		

TCLP Results

ANALYTE	(ug/L)		(ug/L)		(ug/L)		(UG/L)
BARIUM							
LEAD							
CHROMIUM							

Density

	S10-960719-0925	S10-960719-1405	S10-96-0719-1240	S109607201630	S109607201330		(g/mL)
DENSITY (g/mL)	1.58	1.61	1.58	1.61	1.45		1.566

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Campaign Number 1	Batch Number C1B07 Formula Benign

Batch Objectives: Establish and maintain a cold cap while feeding slurry and producing glass at least 1 MT/D rate.

Slurry Tank A Initial Weight 6245.0 lbs (full batch) Final Weight 347 lbs (heal before flush)	Slurry Fed - 5898 lbs 299 lbs/hr Glass Produced - 2126 lbs 108 lbs/hr

Solids in Slurry 46% wt

Slurry Feed Rate

Maximum	Average
275 RPM	187 RPM
2.45 L/min	1.7 L/min

Slurry Feed Start 1811 hr on 7/21/96

Slurry Feed Stop 1335 hr on 7/22/96

Slurry Feed Duration 19 hr 24 min

Drum ID	Net Weight (lbs)	Form
C1B07D3	960 •	Bulk
C1B07D4	889	Bulk
C1B07D5	415	Bulk

• Approximately 207 pounds of glass from discharge during interim between C1B06 and C1B07.

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Slurry Samples

Customer Number	Results
S04A-960721-1240	1.39 g/ml & 50 wt%
S04A-960721-1243	1.4 g/ml & 42 wt %

Glass Samples

Customer Number	Results	Drum ID
S10-960723-0145	*	C1B07D4
S10-960723-0200	*	C1B07D4
S10-960724-0800	*	C1B07D5
S10-960724-0801	*	C1B07D5
S10-960724-0802	**	C1B07D5
S10-960724-0815	*	C1B07D4
S10-960724-0820	*	C1B07D4
S10-960724-0831	*	C1B07D3
S10-960724-0830	*	C1B07D3

* **See attached "Laboratory Glass Analysis Results"**

** **See Glass Characteristics (viscosity & conductivity) on next page**

Weighted Avg. Melter Temp. 1258°C

Weighted Avg. Melter Power 179 KW

Weighted Avg. Melter Current 1426 Amp

Weighted Avg. Melter Voltage 499 Volts

Gem Production

Gem Production Start Time N/A hr

Gem Production Stop Time N/A hr

Gem Production Duration N/A min

Average Cold Cap Coverage 84%

Average Cold Cap Thickness 2 in

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Frit Addition		Film Cooler Outlet Temperature	
West Side Chamber	25 lbs	Max.	Range w/cold cap
East Side Chamber	50 lbs	1074° F	546-1047° F
Center Chamber	0 lbs		

Utility Air Flow Settings		Gem Machine Settings	
Film Cooler Flow Rate	40 scfm	Gem Machine Gob Cutter Speed	N/A
Bubbler 1 Flow Rate	6-15 scfh	Gem Machine Roller Speed	N/A
Bubbler 2 Flow Rate	6-15 scfh	Gem Machine Conveyor Speed	N/A
Bubbler 3 Flow Rate	6-24 scfh		
Bubbler 4 Flow Rate	6-18 scfh		
Air Lift Flow Rate	0-7 scfh		
Trickle Air Flow Rate	1 scfh		

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Glass Characteristics (as reported by the lab)		Normal Off-Gas Characteristics
Viscosity	47.48 p	Initial DP across HEPA filter - N/A
Conductivity	199 mS/cm	Maximum DP across HEPA filter - N/A
TCLP Ba	*	Final DP across HEPA filter - N/A
TCLP Cr	*	Number of changings of HEPA filter - N/A
TCLP Pb	*	Initial DP across transition line - N/A
No. of Phases	1	Maximum DP across transition line - N/A
Gem Size(s)	N/A	Final DP across transition line - 7.5" w.c.
Gem Uniformity	N/A	Initial DP across Film Cooler Outlet - N/A
		Maximum DP across Film Cooler Outlet - N/A
		Final DP across Film Cooler Outlet - 11.5" w.c.
		No. of cleanings of Film Cooler Outlet - 1

* **TCLP samples were not taken after batch 5 due to the fact that batches 1, 2, 3 & 5 provided sufficient data to prove that the glass passed the TCLP**

* **Round sheets (attachment 8 &10) where not taken due to limited resources**

Gem Housing Characteristics

Average Pressure - 0.6" w.c.

Avg. Discharge Temperature 1273° F

Normal Off-Gas Characteristics (Average During Stable Conditions)

PDIC - 250		FI-250
% Open	Pressure	Flow
54%	-0.76" w.c.	230 scfm

Number of Emergency Off-Gas Trips - 2

Comments: ______________________

Batch Number: 7

Laboratory Glass Analysis Results

	CUSTOMER I.D.		CUSTOMER I.D.		CUSTOMER I.D.		CUSTOMER I.D.			
	S10-960723-0200	S10-960723-0200	S10-960724-0800	S10-960724-0800	S10-960724-0815	S10-960724-0815	S10-960724-0831	S10-960724-0831		
Analyte	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SIO2	41.08	43.89	25.51	36.42	38.26	45.00	8.81	17.73	28.42	35.76
B203	10.60	11.33	5.80	8.28	8.86	10.42	2.09	4.21	6.84	8.56
LI2O	0.71	0.76	1.14	1.63	0.99	1.16	0.79	1.59	0.91	1.29
Al2O3	9.79	10.46	10.11	14.43	9.15	10.76	10.00	20.12	9.76	13.94
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	13.22	14.13	11.53	16.46	11.94	14.04	12.22	24.59	12.23	17.30
CHROMIUM	0.05	0.05	NR	0.00	0.04	0.05	0.06	0.12	0.04	0.06
CuO	NR	0.00	NR	0.00	NR	0.00	NR	0.00	0.00	0.00
Fe2O3	1.30	1.39	0.13	0.19	0.12	0.14	0.12	0.24	0.42	0.49
PbO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	1.10	1.18	0.72	1.03	0.56	0.66	0.69	1.39	0.77	1.06
Mn3O4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.33	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.09
V2O5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na2O	11.10	11.86	10.80	15.42	10.80	12.70	10.60	21.33	10.83	15.33
ZrO2	4.31	4.61	4.31	6.15	4.31	5.07	4.31	8.67	4.31	6.13
	sum (wt%)	norm sum (wt%)	sum (wt%)	norm sum (wt%)	sum (wt%)	norm sum (wt%)	sum (wt%)	norm sum (wt%)		
	93.59	100	70.05	100.0	85.03	100.0	49.69	100.0		
	multiplier	1.068490223314	multiplier	1.427551748751	multiplier	1.1760555098201	multiplier	2.01247735963		

TCLP Results

ANALYTE	(ug/L)								(UG/L)
BARIUM									
LEAD									
CHROMIUM									

Density

	S10-960724-0801	S10-960724-0820	S10-960724-0830	S10-960723-0145					(g/mL)
DENSITY (g/mL)	2.31	2.63	2.6	2.63					2.54

**TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96**

Campaign Number 1	Batch Number C1B08 Formula Benign

Batch Objectives: Perform "continuous" gem forming in accordance with Section 7.4 of SOT for Campaign 1

Slurry Tank B Initial Weight 5577 lbs (full batch) Final Weight 1475 lbs (heal before flush)	Slurry Fed 4102 lbs 310 lb/hr Glass Produced 2153 lbs 162 lb/hr

Solids in Slurry 45% wt

Slurry Feed Rate

Maximum	Weighted Average
350 RPM	195 RPM
3.1 L/min	1.75 L/min

Slurry Feed Start 1100 hr on 7/23/96

Slurry Feed Stop 0015 hr on 7/24/96

Slurry Feed Duration 13.25 hrs

Drum ID	Net Weight (lbs)	Form
C1B08D1	754	Bulk
C1B08D2	257	Bulk
C1B08D3	418	Gem
C1B08D5	714	Gem

TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Slurry Samples

Customer Number	Results
S05A-960723-1135	1.45 g/ml & 45.4 wt%
S05A-960723-1138	1.44 g/ml & 44.5 wt %
S05-960723-1920	1.38 g/ml & 42.6 wt%
S04B-960722-1945	1.46 g/ml & 50.7 wt %
S04B-960722-2000	1.45 g/ml & 63.7 wt %

Glass Samples

Customer Number	Results	Drum ID
S10-960724-0840	*	C1B08D3
S10-960724-0841	*	C1B08D3
S10-960724-0850	*	C1B08D2
S10-960724-0851	*	C1B08D2
S10-960724-0900	*	C1B08D5
S10-960724-0901	*	C1B08D5
S10-960724-0902	**	C1B08D5

* **See attached "Laboratory Glass Analysis Results"**

** **See Glass Characteristics (viscosity & conductivity) on next page**

Utility Air Flow Settings

Film Cooler Flow Rate	40 scfm
Bubbler 1 Flow Rate	8-12 scfh
Bubbler 2 Flow Rate	8-12 scfh
Bubbler 3 Flow Rate	8-12 scfh
Bubbler 4 Flow Rate	8-12 scfh
Air Lift Flow Rate	2-8 scfh
Trickle Air Flow Rate	1 scfh

Gem Machine Settings

Gem Machine Gob Cutter Speed	18-20
Gem Machine Roller Speed	18-20
Gem Machine Conveyor Speed	25-40

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96	
Weighted Avg. Melter Temp. - 1257° C Weighted Avg. Melter Power - 190 KW Weighted Avg. Melter Current - 1503 Amp Weighted Avg. Melter Voltage - 126 Volts	Gem Production Start Time 1155 hr Stop Time 1200 hr Start Time 1230 hr Stop Time 1250 hr Start Time 1300 hr Stop Time 1525 hr Start Time 1615 hr Stop Time 1905 hr Start Time 1953 hr Stop Time 2009 hr Start Time 2026 hr Stop Time 2055 hr Start Time 2100 hr Stop Time 2130 hr Start Time 2138 hr Stop Time 2245 hr Gem Production Duration 8 hr 2 min
Average Cold Cap Coverage 93%	Average Cold Cap Thickness 1-1/2 to 2 in
Frit Addition West Side Chamber 100 lbs East Side Chamber 50 lbs Center Chamber 0 lbs	Film Cooler Outlet Temperature Max. Avg. w/cold cap 1079° F 755° F

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Glass Characteristics
(as reported by the lab)

Viscosity	43.77 p
Conductivity	147 mS/cm
TCLP Ba	*
TCLP Cr	*
TCLP Pb	*
No. of Phases	1
Gem Size(s)	1/2" to 1-1/2"
Gem Uniformity	90%

* **TCLP samples were not taken after batch 5 due to the fact that batches 1, 2, 3 & 5 provided sufficient data to prove that the glass passed the TCLP**

Normal Off-Gas Characteristics

Initial DP across HEPA filter N/A

Maximum DP across HEPA filter N/A

Final DP across HEPA filter N/A

Number of changings of HEPA filter N/A

Initial DP across transition line N/A

Maximum DP across transition line N/A

Final DP across transition line N/A

Initial DP across Film Cooler Outlet N/A

Maximum DP across Film Cooler Outlet N/A

Final DP across Film Cooler Outlet N/A

No. of cleanings of Film Cooler Outlet N/A

* **Round sheets (attachment 8 & 10) where not taken due to limited resources**

Gem Housing Characteristics

Average Pressure -0.56" w.c.

Avg. Discharge Temperature 1214° F

Normal Off-Gas Characteristics
(Average During Stable Conditions)

PDIC - 250		FI-250
% Open	Pressure	Flow
94	-0.67"w.c.	253 scfm

Number of Emergency Off-Gas Trips 1

Comments: A Gem Production Rate of approximately 156 lbs/hour was obtained between the hours of 1230 and 1525.

Batch Number: 8

Laboratory Glass Analysis Results

	CUSTOMER I.D.		CUSTOMER I.D.		CUSTOMER I.D.			
	S10-960724-0840	S10-960724-0840	S10-960724-0851	S10-960724-0851	S10-960724-0900	S10-960724-0900		
Analyte	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SIO2	8.99	18.72	2.20	6.57	0.57	1.57	3.92	8.95
B203	2.13	4.44	0.59	1.76	0.34	0.93	1.02	2.38
Li2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al2O3	9.47	19.72	6.80	20.32	8.37	23.01	8.21	21.02
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	11.91	24.80	8.45	25.25	11.16	30.68	10.51	26.91
CHROMIUM	0.04	0.08	0.03	0.09	0.04	0.11	0.04	0.09
CuO	0.00	0.00	NR	0.00	NR	0.00	0.00	0.00
Fe2O3	0.11	0.23	0.00	0.00	0.00	0.00	0.04	0.08
PbO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.56	1.17	0.39	1.17	0.48	1.32	0.48	1.22
Mn3O4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na2O	10.50	21.87	10.70	31.97	11.10	30.52	10.77	28.12
ZrO2	4.31	8.98	4.31	12.88	4.31	11.85	4.31	11.23
	sum (wt%) 48.02	norm sum (wt%) 100	sum (wt%) 33.47	norm sum (wt%) 100.0	sum (wt%) 36.37	norm sum (wt%) 100.0		
	multiplier	2.082465639317	multiplier	2.987750224081	multiplier	2.749518834204		

TCLP Results

ANALYTE	(ug/L)		(ug/L)		(ug/L)		(UG/L)
BARIUM							
LEAD							
CHROMIUM							

Density

	S10-960724-0841	S10-960724-0850	S10-960724-0901				(g/mL)
DENSITY (g/mL)	2.61	2.56	2.62				2.60

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Campaign Number 1	Batch Number 9 Formula: Benign w/150# Na_2CO_3
Batch Objectives: Section 7.5 of SOT for Campaign 1	
Slurry Tank A Initial Weight 7660 lbs (full batch) Final Weight 6165 lbs (heel before flush)	Slurry Fed 1495 lbs 221 lb/hr Glass Produced 200 lbs 30 lb/hr
Solids in Slurry 25% wt Slurry Feed Rate Maximum / Average 200 RPM / 162 RPM 1.8 L/min / 1.45 L/min Slurry Feed Start - 0415 hr on 7/24/96 Slurry Feed Stop - 1100 hr on 7/24/96 Slurry Feed Duration - 6 hrs 45 min	Drum ID / Net Weight (lbs) / Form C1B09D1 / 166 / Bulk C1B09D2 / 80 / Gem C1B09D3 / 63 / Bulk

TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Slurry Samples

Customer Number	Results
S04A-960723-1910	1.23g/ml & 24.02wt%
S04A-960724-0615	1.27g/ml & 24.3wt%
S05A-960724-0630	1.27g/ml & 26.3wt%

Glass Samples

Customer Number	Results	Drum ID

No glass samples taken

Range Melter Temperature - 1262° C

Range Melter Power - 177 KW

Range Melter Current - 1499 Amp

Range Melter Voltage - 117 Volts

Gem Production

Start Time 0430 hr Stop Time 0450 hr

Start Time 0530 hr Stop Time 0615 hr

Gem Production Duration 1 hr 5 min

Average Cold Cap Coverage 85%

Average Cold Cap Thickness 1/2 in

Frit Addition

West Side Chamber 50 lbs

East Side Chamber 25 lbs

Center Chamber 0 lbs

Film Cooler Outlet Temperature

Max.	Avg. w/cold cap
848°F	747°F

**TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96**

Utility Air Flow Settings

Film Cooler Flow Rate	40 scfm
Bubbler 1 Flow Rate	8 - 12 scfh
Bubbler 2 Flow Rate	8 - 12 scfh
Bubbler 3 Flow Rate	8 - 12 scfh
Bubbler 4 Flow Rate	8 - 12 scfh
Air Lift Flow Rate	2 - 7 scfh
Trickle Air Flow Rate	1 scfh

Gem Machine Settings

Gem Machine Gob Cutter Speed	18 rpm
Gem Machine Roller Speed	18 rpm
Gem Machine Conveyor Speed	39 rpm

Glass Characteristics
(as reported by the lab)

Viscosity	*
Conductivity	*
TCLP Ba	**
TCLP Cr	**
TCLP Pb	**
No. of Phases	*
Gem Size(s)	*
Gem Uniformity	*

*** Batch aborted due to glass chemistry problems, no samples taken**

**** TCLP samples were not taken after batch 5 due to the fact that batches 1, 2, 3 & 5 provided sufficient data to prove that the glass passed the TCLP**

Normal Off-Gas Characteristics

Initial DP across HEPA filter	N/A
Maximum DP across HEPA filter	N/A
Final DP across HEPA filter	N/A
Number of changings of HEPA filter	0
Initial DP across transition line	N/A
Maximum DP across transition line	N/A
Final DP across transition line	N/A
Initial DP across Film Cooler Outlet	N/A
Maximum DP across Film Cooler Outlet	N/A
Final DP across Film Cooler Outlet	N/A
No. of cleanings of Film Cooler Outlet	0

*** Batch aborted due to glass chemistry problems, round sheets (attachment 8 & 10) where not taken**

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96	
Gem Housing Characteristics Average Pressure -0.56" w.c. Avg. Discharge Temperature 1300° C	Normal Off-Gas Characteristics (Average During Stable Conditions) PDIC - 250 FI-250 % Open Pressure Flow 65% -0.7" w.c. 327 scfm Number of Emergency Off-Gas Trips - 3

Comments: Aborted batch feed due to low wt % solids.

TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Campaign Number 1	Batch Number C1B10 Formula Benign

Batch Objectives: Establish high and stable feed and production rates to Support Section 7.5 of SOT for Campaign 1.

Slurry Tank A

Initial Weight 5190 lbs
(full batch)

Final Weight 220 lbs
(heel before flush)

Slurry Fed 4970 lbs 382 lbs/hr

Glass Produced 2964 lbs 228 lbs/hr

Final center chamber level lower than initial center chamber level.

Solids in Slurry 55.3% wt

Slurry Feed Rate

Maximum	Average
442 RPM	233.5 RPM
4.0 L/min	2.07 L/min

Slurry Feed Start 1250 hr 7/26/96

Slurry Feed Stop 0145 hr 7/27/96

Slurry Feed Duration 13 hrs

Drum ID	Net Weight (lbs)	Form
*C1B10D1	394 (166)	Bulk
*C1B10D2	358 (80)	Gem
*C1B10D3	220 (63)	Bulk
C1B10D4	673	Bulk
C1B10D6	294	Bulk
C1B10D7	1002	Bulk

* **Contains glass from C1B09. lbs in () indicate amount of glass from C1B09**

TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Slurry Samples

Customer Number	Results
S04A-960724-1915	1.59 g/ml & 55.3 wt %

Glass Samples

Customer Number	Results	Drum ID
S10-960731-2140	*	C1B10D2
S10-960731-2141	*	C1B10D2
S10-960820-1627	**	C1B10D2

* **See attached "Laboratory Glass Analysis Results"**

** **See Glass Characteristics (viscosity & conductivity) on next page**

Weighted Avg. Melter Temp. 1261° C

Weighted Avg. Melter Power 190 KW

Weighted Avg. Melter Current 1537 Amp

Weighted Avg. Melter Voltage 120 Volts

Gem Production

Gem Production Start Time 1330 hr

Gem Production Stop Time 1440 hr

Gem Production Duration 70 min

Average Cold Cap Coverage N/A %

Average Cold Cap Thickness N/A in

Frit Addition

West Side Chamber 75 lbs

East Side Chamber 25 lbs

Center Chamber 0 lbs

Film Cooler Outlet Temperature

Max.	Avg. w/cold cap
1010 °F	788 °F

TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Utility Air Flow Settings		Gem Machine Settings	
Film Cooler Flow Rate	32 scfm	Gem Machine Gob Cutter Speed	18 rpm
Bubbler 1 Flow Rate	15 scfh	Gem Machine Roller Speed	18 rpm
Bubbler 2 Flow Rate	15 scfh	Gem Machine Conveyor Speed	39 rpm
Bubbler 3 Flow Rate	15 scfh		
Bubbler 4 Flow Rate	15 scfh		
Air Lift Flow Rate	3 scfh		
Trickle Air Flow Rate	1 scfh		

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Glass Characteristics
(as reported by the lab)

Viscosity	52.47 p
Conductivity	175 mS/cm
TCLP Ba	*
TCLP Cr	*
TCLP Pb	*
No. of Phases	1
Gem Size(s)	1/2" to 1-1/2"
Gem Uniformity	90%

* TCLP samples were not taken after batch 5 due to the fact that batches 1, 2, 3 & 5 provided sufficient data to prove that the glass passed the TCLP

Normal Off-Gas Characteristics

Initial DP across HEPA filter N/A

Maximum DP across HEPA filter N/A

Final DP across HEPA filter N/A

Number of changings of HEPA filter N/A

Initial DP across transition line N/A

Maximum DP across transition line N/A

Final DP across transition line N/A

Initial DP across Film Cooler Outlet N/A

Maximum DP across Film Cooler Outlet N/A

Final DP across Film Cooler Outlet N/A

No. of cleanings of Film Cooler Outlet N/A

* Round sheets (attachment 8 & 10) where not taken due to limited resources

Gem Housing Characteristics

Average Pressure -0.62" w.c.

Avg. Discharge Temperature 1197° F

Normal Off-Gas Characteristics
(Average During Stable Conditions)

PDIC - 250		FI-250
% Open	Pressure	Flow
46	-0.74" w.c.	196 scfm

Number of Emergency Off-Gas Trips 4

Comments:________________________________

Batch Number: 10

Laboratory Glass Analysis Results

Analyte	CUSTOMER I.D. S10-960731-2140 Result (wt %-abs)	S10-960731-2140 Result (wt %-norm.)	CUSTOMER I.D. Result (wt %-abs)	Result (wt %-norm.)	CUSTOMER I.D. Result (wt %-abs)	Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SiO2	44.80	47.45						
B2O3	11.40	12.07						
Li2O	0.70	0.74						
Al2O3	9.50	10.06						
BaO	0.00	0.00						
CaO	11.50	12.18						
Cr2O3	NR	0.00						
CuO	NR	0.00						
Fe2O3	0.10	0.11						
PbO	0.00	0.00						
MgO	0.80	0.85						
Mn3O4	0.00	0.00						
NiO	0.00	0.00						
K2O	0.80	0.85						
V2O5	0.00	0.00						
Na2O	10.50	11.12						
ZrO2	4.31	4.57						
	sum (wt%) 94.41	norm sum (wt%) 100	sum (wt%) 0	norm sum (wt%) 0.0	sum (wt%) 0	norm sum (wt%) 0.0		
	multiplier	1.059209829467	multiplier		multiplier			

TCLP Results

ANALYTE	(ug/L)		(ug/L)		(ug/L)		(ug/L)
BARIUM							
LEAD							
CHROMIUM							

Density

	S10-960731-2141						(g/mL)
DENSITY (g/mL)	2.63						

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Campaign Number 1	Batch Number 11 Formula Benign w/Boric Acid

Batch Objectives: Perform Section 7.5 of the SOT for Campaign 1

Reach the maximum feed and production rates for the Melter with the current configuration.

Slurry Tank B Initial Weight 5733 lbs (full batch) Final Weight 425 lbs (heel before flush)	Slurry Fed 5308 lbs 425 lbs/hr Glass Produced 1979 lbs 158 lbs/hr

Solids in Slurry 51.2% wt

Slurry Feed Rate

Maximum	Average
325 RPM	265 RPM
2.9 L/min	2.35 L/min

Slurry Feed Start (time) 0207 hr on 7/27/96

Slurry Feed Stop (time) 1429 hr on 7/27/96

Slurry Feed Duration 12 hr 30 min

Drum ID	Net Weight (lbs)	Form
C1B11D1	856	Bulk
C1B11D2	237	Bulk
C1B11D3	118	Gem
C1B11D4	766	Bulk

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Slurry Samples

Customer Number	Results
S04B-960725-2300	1.59 g/ml & 51.2 wt %
S05A-960727-0910	1.52g/ml & 49.3wt%
S05A-960727-0915	1.53g/ml & 50.3wt%

Glass Samples

Customer Number	Results	Drum ID
S10-960727-1545	*	C1B11D1
S10-960727-1546	*	C1B11D1
S10-960731-2222	**	N/A

- * See attached "Laboratory Glass Analysis Results"
- ** See Glass Characteristics (viscosity & conductivity) on next page
- N/A Item not available

Avg. Melter Temp. 1230° C

Avg. Melter Power 130 KW

Avg. Melter Current 1674 Amp

Avg. Melter Voltage 528 Volts

Gem Production

Gem Production Start Time N/A min

Gem Production Stop Time N/A min

Gem Production Duration N/A min

Average Cold Cap Coverage N/A %

Average Cold Cap Thickness N/A in

Frit Addition

West Side Chamber 25 lbs

East Side Chamber 25 lbs

Center Chamber 0 lbs

Film Cooler Outlet Temperature

Max.	Avg. w/cold cap
690° F	664° F

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96	
Utility Air Flow Settings Film Cooler Flow Rate 30 scfm Bubbler 1 Flow Rate 9 scfh Bubbler 2 Flow Rate 9 scfh Bubbler 3 Flow Rate 9 scfh Bubbler 4 Flow rate 9 scfh Air Lift Flow Rate 7 scfh Trickle Air Lift Flow Rate 1 scfh	Gem Machine Settings Gem Machine Gob Cutter Speed N/A Gem Machine Roller Speed N/A Gem Machine Conveyor Speed N/A
Glass Characteristics (as reported by the lab) Viscosity 43.27 p Conductivity 147 mS/cm TCLP Ba * TCLP Cr * TCLP Pb * No. of Phases 1 Gem Size(s) N/A Gem Uniformity N/A * **TCLP samples were not taken after batch 5 due to the fact that batches 1, 2, 3 & 5 provided sufficient data to prove that the glass passed the TCLP**	Normal Off-Gas Characteristics Initial DP across HEPA filter .068 Maximum DP across HEPA filter .138 Final DP across HEPA filter .138 Number of changings of HEPA filter N/A Initial DP across transition line N/A Maximum DP across transition line 7.5 Final DP across transition line 5.5 Initial DP across Film Cooler Outlet N/A Maximum DP across Film Cooler Outlet Off Scale Final DP across Film Cooler Outlet 0 No. of cleanings of Film Cooler Outlet 0

**TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96**

Gem Housing Characteristics	Normal Off-Gas Characteristics (Average During Stable Conditions)
Average Pressure -0.6" w.c.	PDIC - 250 FI-250
Avg. Discharge Temperature 1193° F	% Open Pressure Flow
	43 -0.76"wc 191 scfm
	Number of Emergency Off-Gas Trips 0

Comments:____

Batch Number: 13

Laboratory Glass Analysis Results

Analyte	CUSTOMER I.D. S10-960728-1303 Result (wt %-abs)	S10-960728-1303 Result (wt %-norm.)	CUSTOMER I.D. S10-960729-0330 Result (wt %-abs)	S10-960729-0330 Result (wt %-norm.)	CUSTOMER I.D. S10-960729-0640 Result (wt %-abs)	S10-960729-0640 Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SiO2	42.35	46.05	37.00	43.41	44.49	46.47	41.28	45.31
B203	10.86	11.81	10.90	12.79	10.55	11.02	10.77	11.87
Li2O	0.59	0.64	0.80	0.94	1.06	1.11	0.82	0.89
Al2O3	9.84	10.70	8.90	10.44	9.86	10.30	9.53	10.48
BaO	0.00	0.00	0.00	0.00	0.06	0.06	0.02	0.02
CaO	12.81	13.93	12.20	14.31	12.16	12.70	12.39	13.65
Cr2O3	0.09	0.10	0.08	0.09	0.08	0.08	0.08	0.09
CuO	NR	0.00	NR	0.00	NR	0.00	0.00	0.00
Fe2O3	0.45	0.49	0.40	0.47	0.34	0.36	0.40	0.44
PbO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.43	0.47	0.45	0.53	0.59	0.62	0.49	0.54
Mn3O4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.00	0.00	0.00	0.00	0.12	0.13	0.04	0.04
V2O5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na2O	10.24	11.13	10.20	11.97	12.10	12.64	10.85	11.91
MOLYBDENUM	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.01
ZrO2	4.31	4.69	4.31	5.06	4.31	4.50	4.31	4.75
	sum (wt%) 91.965	norm sum (wt%) 100	sum (wt%) 85.24	norm sum (wt%) 100.0	sum (wt%) 95.74	norm sum (wt%) 100.0		
	multiplier	1.087370195183	multiplier	1.173158141718	multiplier	1.0444955086693		

TCLP Results

ANALYTE	(ug/L)		(ug/L)		(ug/L)			(ug/L)
BARIUM								
LEAD								
CHROMIUM								

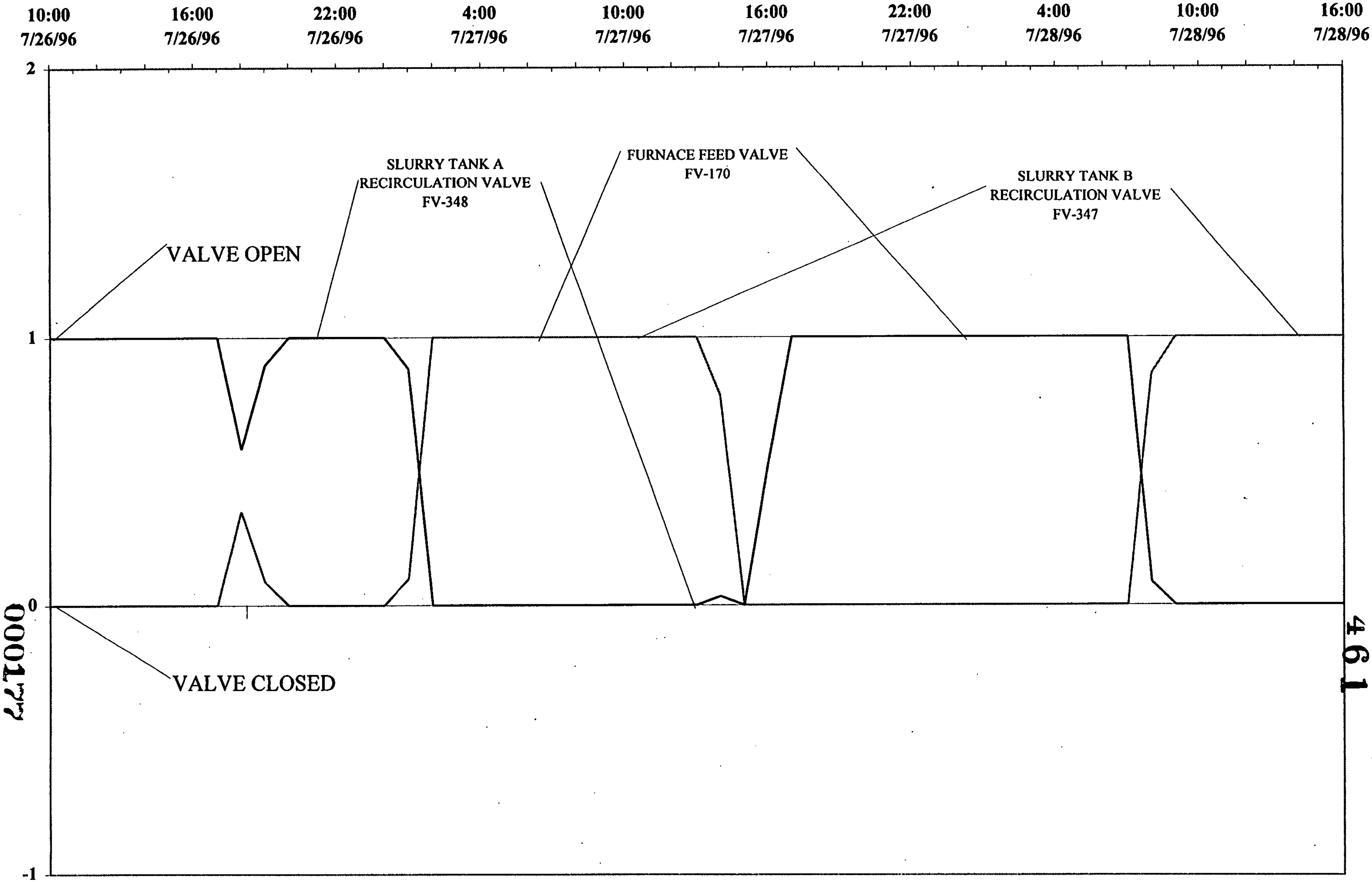
Density

	S10-960728-1300							(g/mL)
DENSITY (g/mL)	2.62							

Appendix B
Snapshot Data

FEED PREPARATION SYSTEM

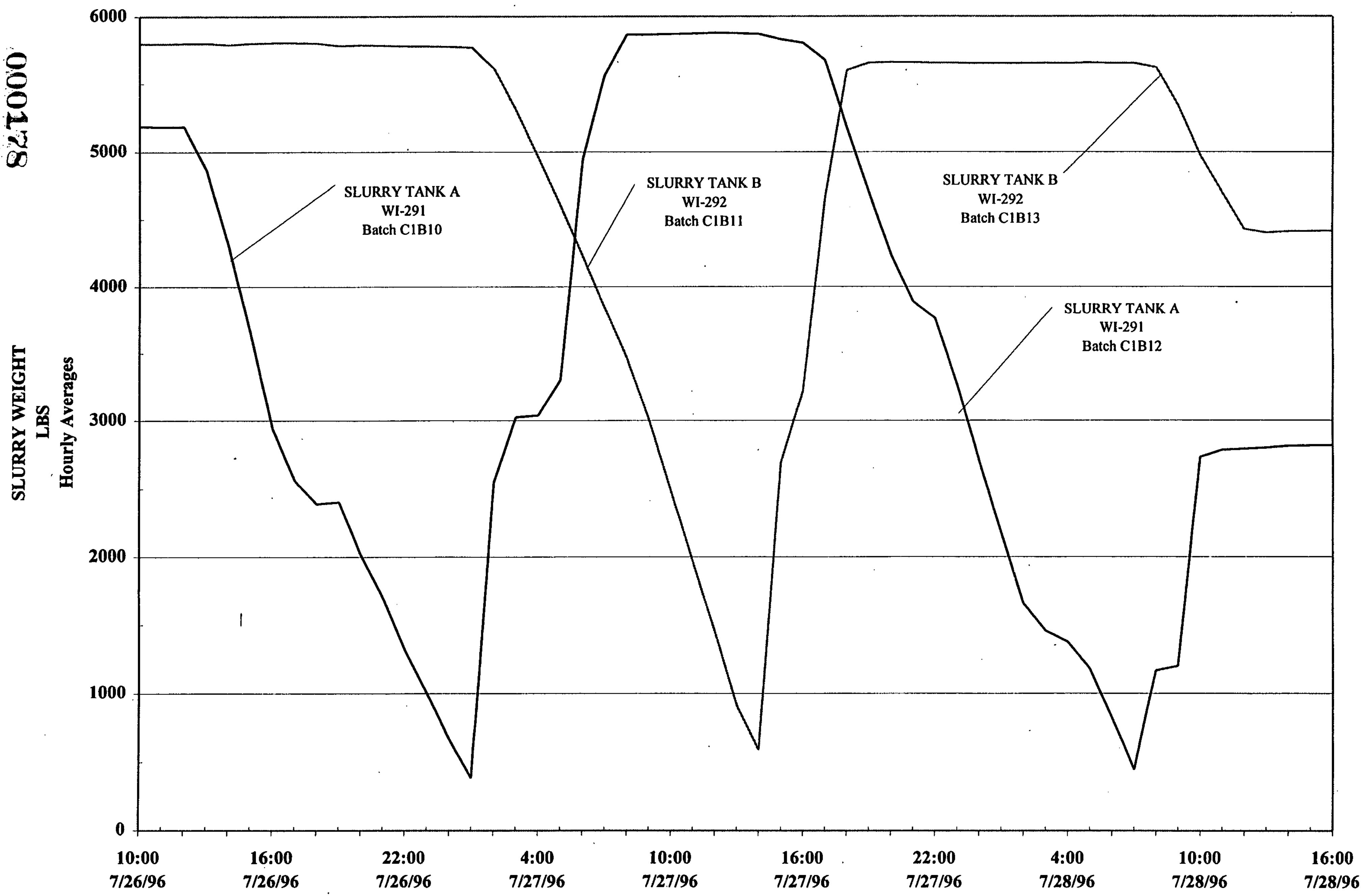
CAMPAIGN 1
FEED PREPARATION SYSTEM



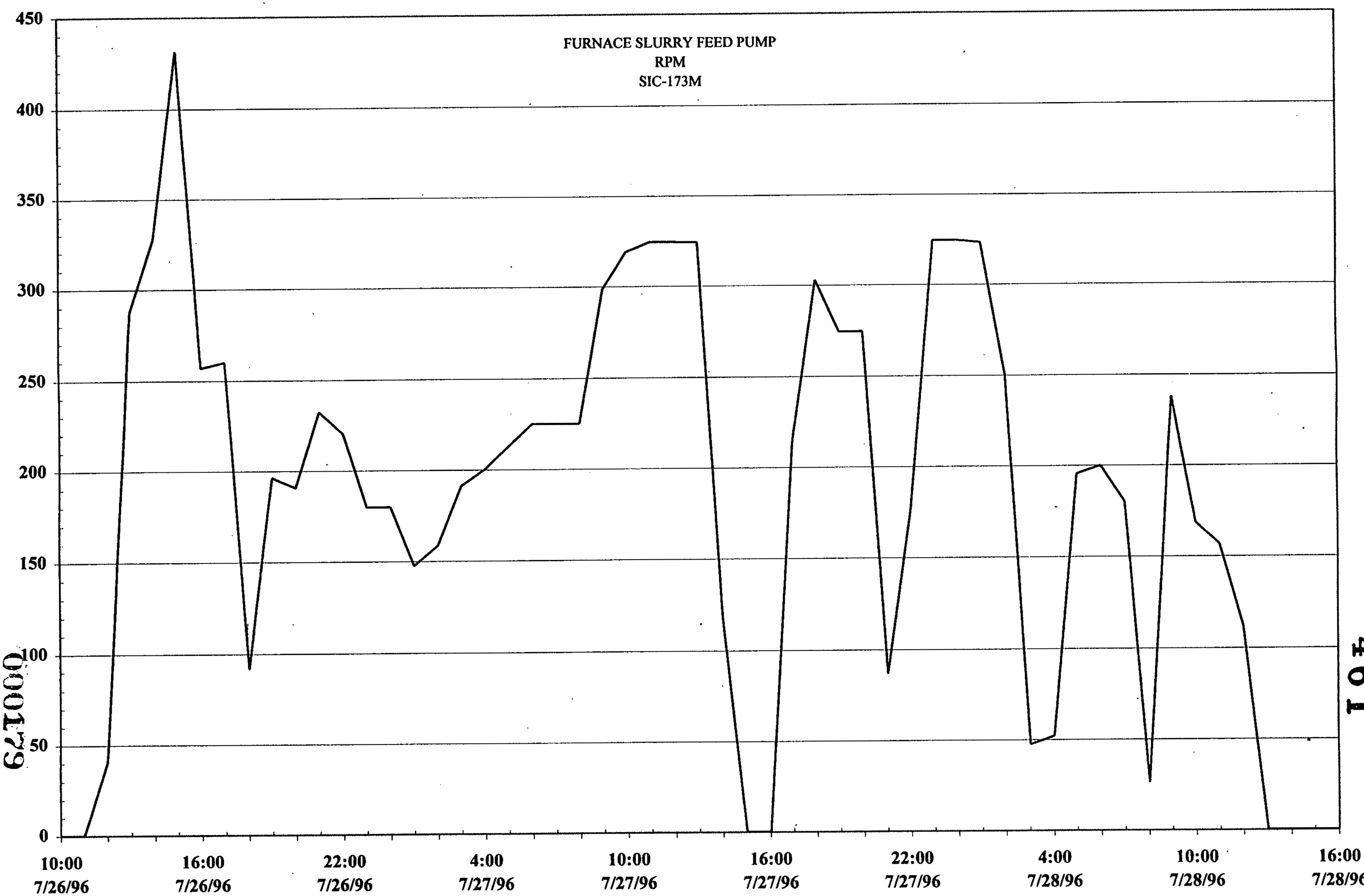
C1_PTF18.XLS Chart 1

VHP 8/27/96

CAMPAIGN 1
FEED PREPARATION SYSTEM



CAMPAIGN 1
FEED PREPARATION SYSTEM



C1_PTF18.XLS Chart 3

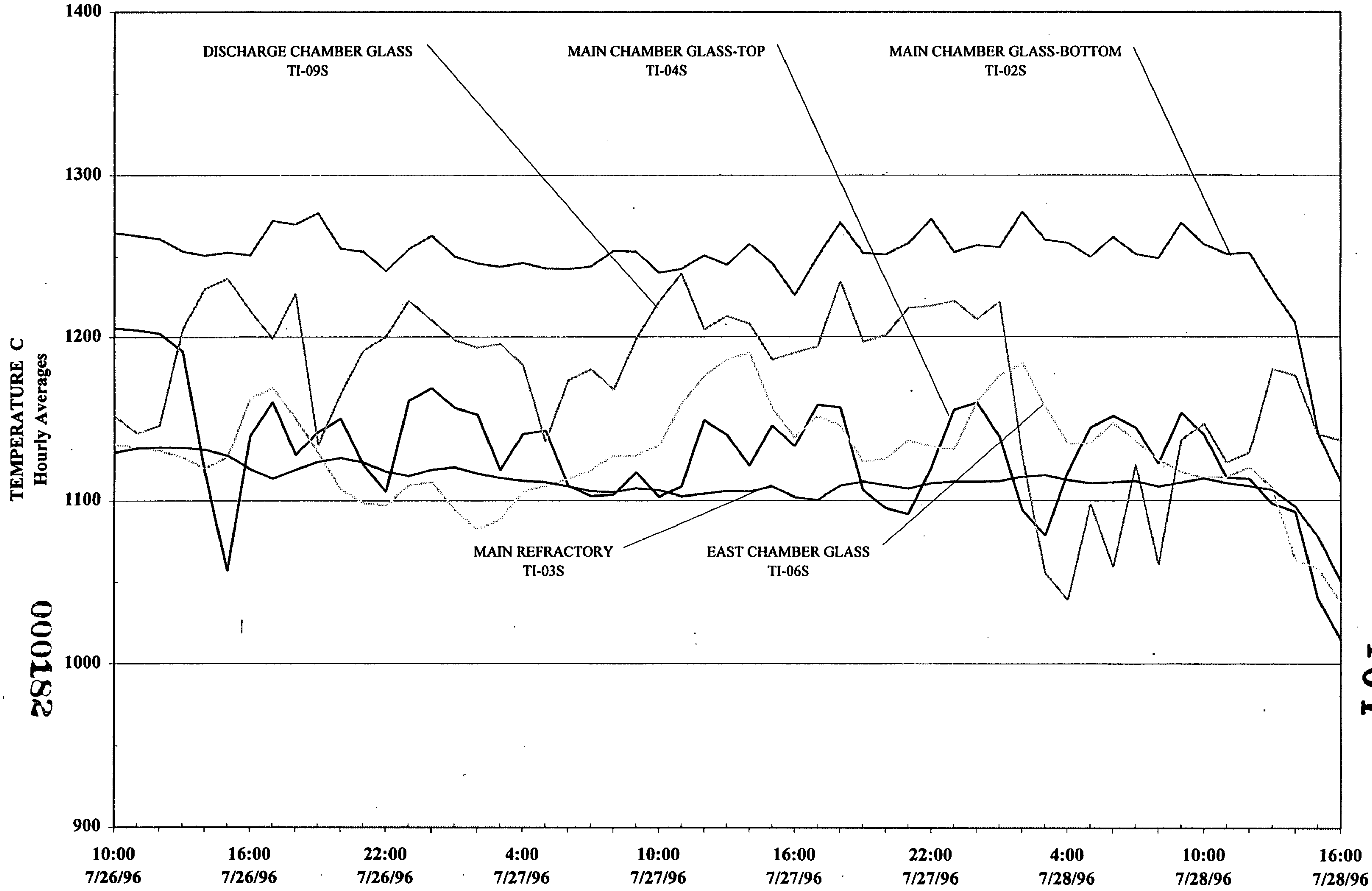
VHP 8/27/96

VITRIFICATION PILOT PLANT FEED PREPARATION SYSTEM												
CAMPAIGN 1												
HOURLY AVERAGES												
READINGS		SLURRY TANK A			SLURRY TANK B			SLURRY	FURNACE	FURNACE	FURNACE	FURNACE
		LEVEL	WEIGHT	SLURRY RECIRC VALVE	LEVEL	WEIGHT	SLURRY RECIRC VALVE	RECIRC FLOW	SLURRY FEED VALVE	SLURRY FEED PUMP RATE	SLURRY FEED SOLIDS *[LABORATORY]*	SLURRY FEED *[CORRECTED FOR % SOLIDS]*
		LI-290	WI-291	FV-348 OPENED = 1	LI-291	WI-292	FV-347 OPENED = 1	FI-170	FV-170 OPENED = 1	SIC-173M		
DATE	HOUR	GAL	LBS	CLOSED = 0	GAL	LBS	CLOSED = 0	GPM	CLOSED = 0	RPM	% SOLIDS	MT GLASS\DAY
7/26/96	10:00	340.77	5185.71	1	418.76	5796.92	0	38.04	0	0.08		
7/26/96	11:00	340.86	5182.33	1	417.63	5794.42	0	38.04	0	0.09		
7/26/96	12:00	339.80	5184.70	1	418.65	5797.20	0	38.01	0	40.63		
7/26/96	13:00	317.01	4864.83	1	419.24	5798.60	0	38.17	1	287.47		
7/26/96	14:00	276.33	4305.83	1	417.98	5788.82	0	38.17	1	327.58		
7/26/96	15:00	260.14	3645.96	1	418.43	5799.08	0	38.10	1	431.29		
7/26/96	16:00	227.09	2941.06	1	418.37	5803.56	0	37.95	1	257.09		
7/26/96	17:00	134.93	2560.39	1	419.04	5803.45	0	38.23	1	260.02		
7/26/96	18:00	125.29	2389.58	1	419.20	5800.46	0	31.27	0	91.49		
7/26/96	19:00	131.49	2404.53	1	422.22	5781.99	0	39.88	1	196.36		
7/26/96	20:00	98.76	2013.75	1	421.84	5786.68	0	42.24	1	190.86		
7/26/96	21:00	71.29	1704.70	1	421.99	5783.22	0	42.72	1	232.44		
7/26/96	22:00	40.98	1319.58	1	421.73	5778.31	0	42.78	1	220.37		
7/26/96	23:00	32.19	1001.10	1	422.44	5776.31	0	42.04	1	179.97		
7/27/96	0:00	23.51	666.82	1	421.24	5773.18	0	39.42	1	180.00		
7/27/96	1:00	6.10	386.75	1	421.54	5767.25	0	31.19	1	147.61		
7/27/96	2:00	236.43	2548.13	0	411.22	5609.50	1	42.56	1	158.64		
7/27/96	3:00	308.16	3025.30	0	387.25	5303.32	1	43.01	1	191.28		
7/27/96	4:00	306.02	3039.32	0	359.57	4956.91	1	43.73	1	200.23		
7/27/96	5:00	321.11	3303.13	0	329.92	4605.63	1	43.62	1	212.67		
7/27/96	6:00	411.25	4946.83	0	299.44	4226.46	1	43.70	1	225.03		
7/27/96	7:00	430.23	5562.92	0	273.09	3842.67	1	43.66	1	225.00		
7/27/96	8:00	436.68	5864.14	0	247.37	3465.00	1	43.46	1	224.98		
7/27/96	9:00	437.99	5865.79	0	249.58	3015.61	1	43.28	1	298.65	49.8	
7/27/96	10:00	439.51	5868.60	0	120.75	2487.84	1	44.21	1	318.96		
7/27/96	11:00	441.34	5870.95	0	92.85	1965.60	1	45.57	1	324.33		
7/27/96	12:00	442.79	5877.58	0	46.55	1453.58	1	45.22	1	324.36		
7/27/96	13:00	443.72	5875.38	0	35.51	913.35	1	43.28	1	324.29		
7/27/96	14:00	442.29	5868.17	0	5.97	585.29	1	24.50	0	118.23		
7/27/96	15:00	438.64	5828.32	0	250.70	2693.88	0	0.00	0	0.19		
7/27/96	16:00	432.56	5801.95	1	287.97	3215.47	0	21.05	0	0.18		
7/27/96	17:00	422.41	5675.99	1	342.76	4668.41	0	42.15	1	214.94		
7/27/96	18:00	384.75	5176.75	1	369.58	5598.04	0	42.63	1	302.87		
7/27/96	19:00	344.41	4700.25	1	371.61	5655.34	0	42.50	1	274.48		
7/27/96	20:00	304.41	4236.61	1	374.16	5660.30	0	42.32	1	274.61		
7/27/96	21:00	279.42	3888.77	1	374.90	5657.59	0	42.00	1	86.68	49.6	
7/27/96	22:00	271.35	3760.38	1	375.32	5653.43	0	42.09	1	177.40	38.5	
7/27/96	23:00	49.78	3267.75	1	375.79	5652.88	0	42.62	1	324.29		
7/28/96	0:00	11.22	2710.00	1	376.76	5649.66	0	42.89	1	324.43		
7/28/96	1:00	0.64	2173.39	1	378.08	5649.70	0	43.27	1	323.12		
7/28/96	2:00	4.24	1663.38	1	378.40	5651.18	0	43.39	1	250.26		
7/28/96	3:00	15.56	1459.50	1	378.33	5653.17	0	44.23	1	47.50		
7/28/96	4:00	49.18	1377.88	1	378.64	5651.99	0	44.47	1	52.18		
7/28/96	5:00	46.99	1184.66	1	378.75	5655.72	0	44.34	1	195.55		
7/28/96	6:00	19.79	821.42	1	380.14	5651.08	0	41.73	1	200.01		
7/28/96	7:00	9.64	446.14	1	379.35	5652.03	0	37.25	1	180.26		
7/28/96	8:00	53.51	1169.14	0	379.81	5618.84	1	40.54	0	26.47		
7/28/96	9:00	58.68	1199.91	0	359.76	5339.87	1	45.02	1	238.20		
7/28/96	10:00	280.31	2731.83	0	330.15	4970.75	1	42.98	1	168.70		
7/28/96	11:00	290.92	2784.03	0	309.64	4701.02	1	42.77	1	156.90	53.8	
7/28/96	12:00	290.09	2791.92	0	292.90	4429.21	1	42.57	1	112.12		
7/28/96	13:00	288.69	2800.00	0	291.63	4400.83	1	42.80	0	0.09		
7/28/96	14:00	289.21	2812.37	0	291.44	4411.19	1	42.82	0	0.08		
7/28/96	15:00	288.07	2815.98	0	291.38	4413.14	1	43.00	0	0.10		
7/28/96	16:00	287.35	2817.03	0	292.20	4415.72	1	43.15	0	0.10		

000180

FURNACE SYSTEM

CAMPAIGN 1
FURNACE SYSTEM



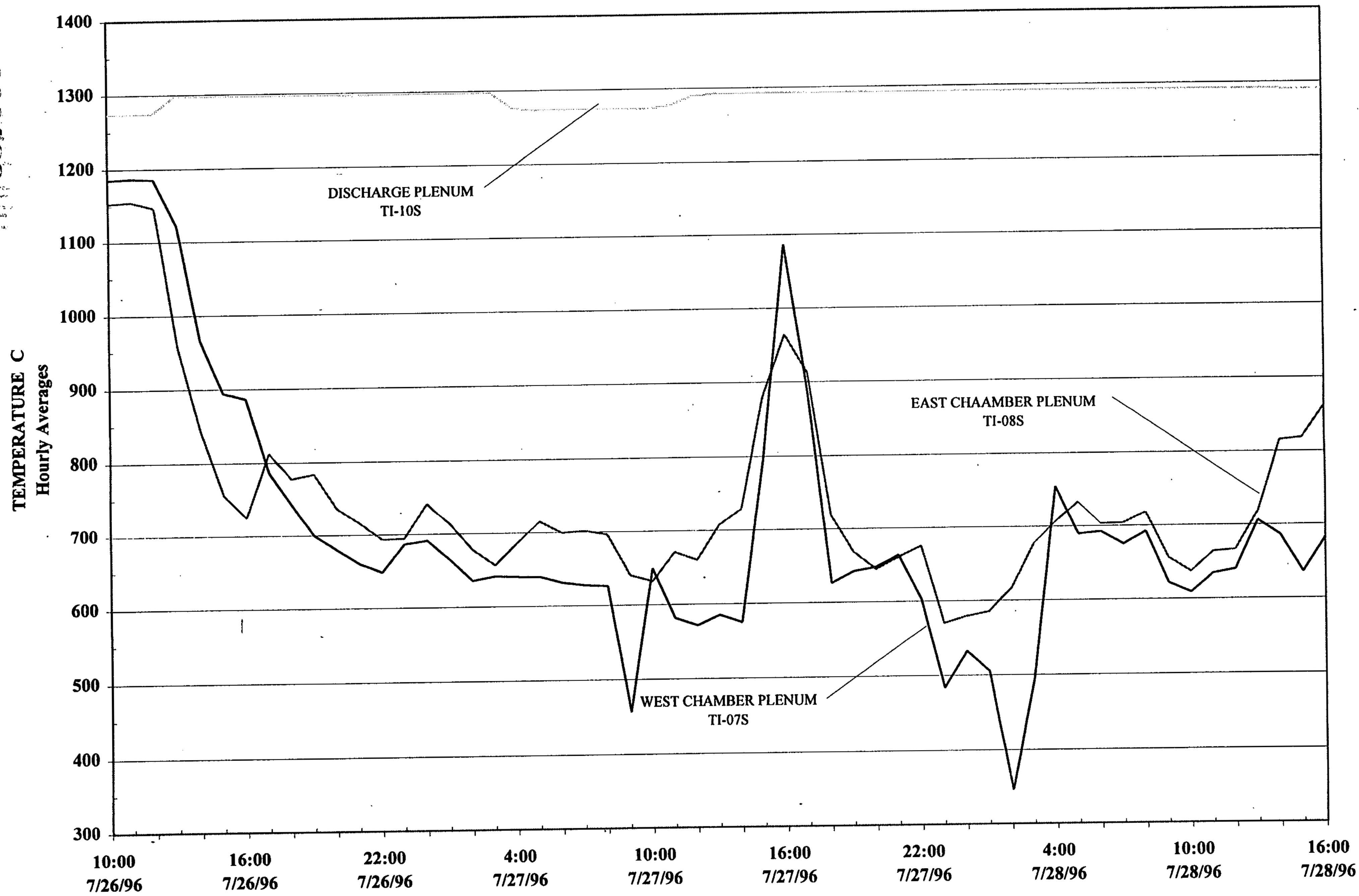
C1_PTF18.XLS Chart 4

VHP 8/27/96

000182

461

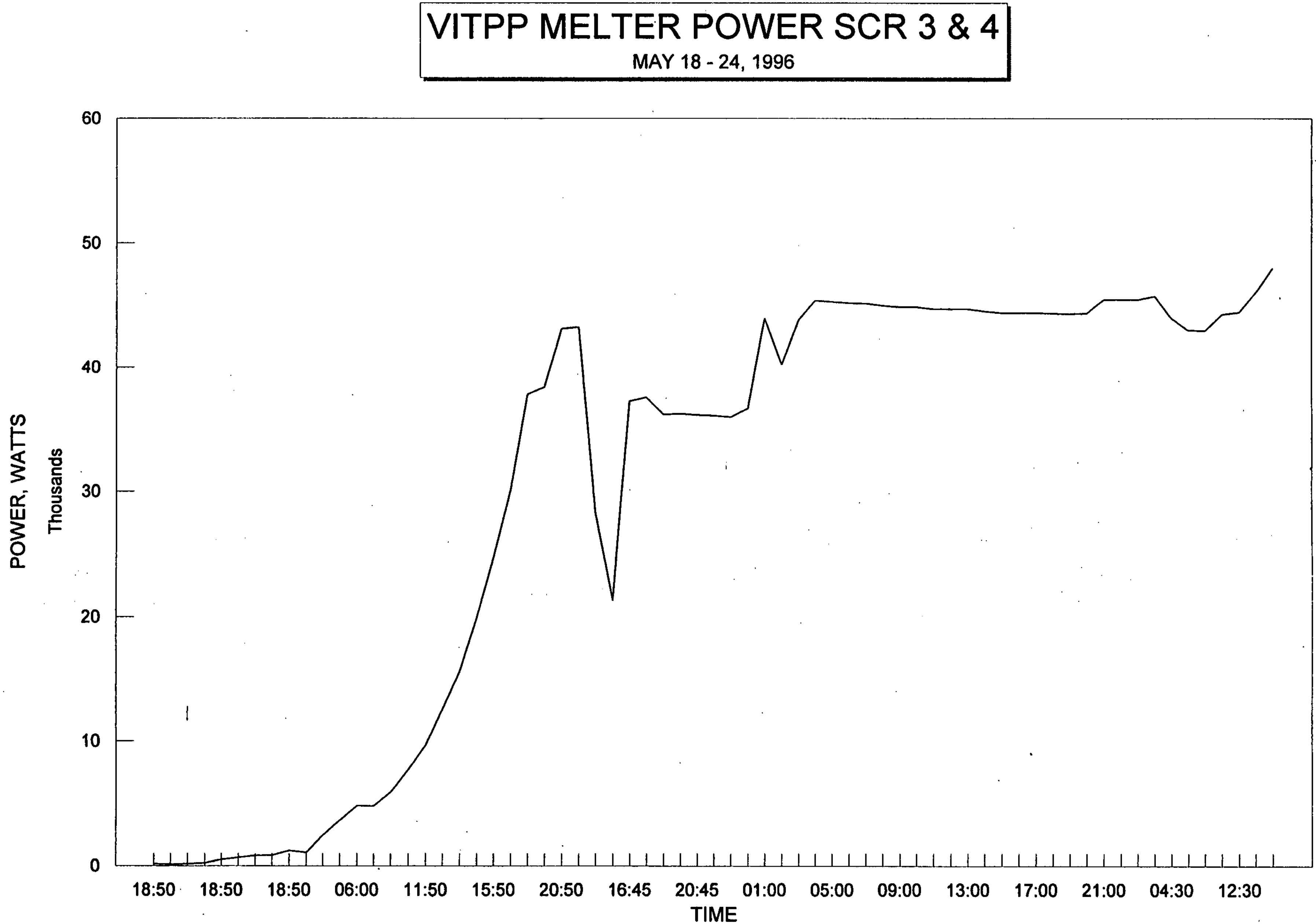
CAMPAIGN 1
FURNACE SYSTEM



000183

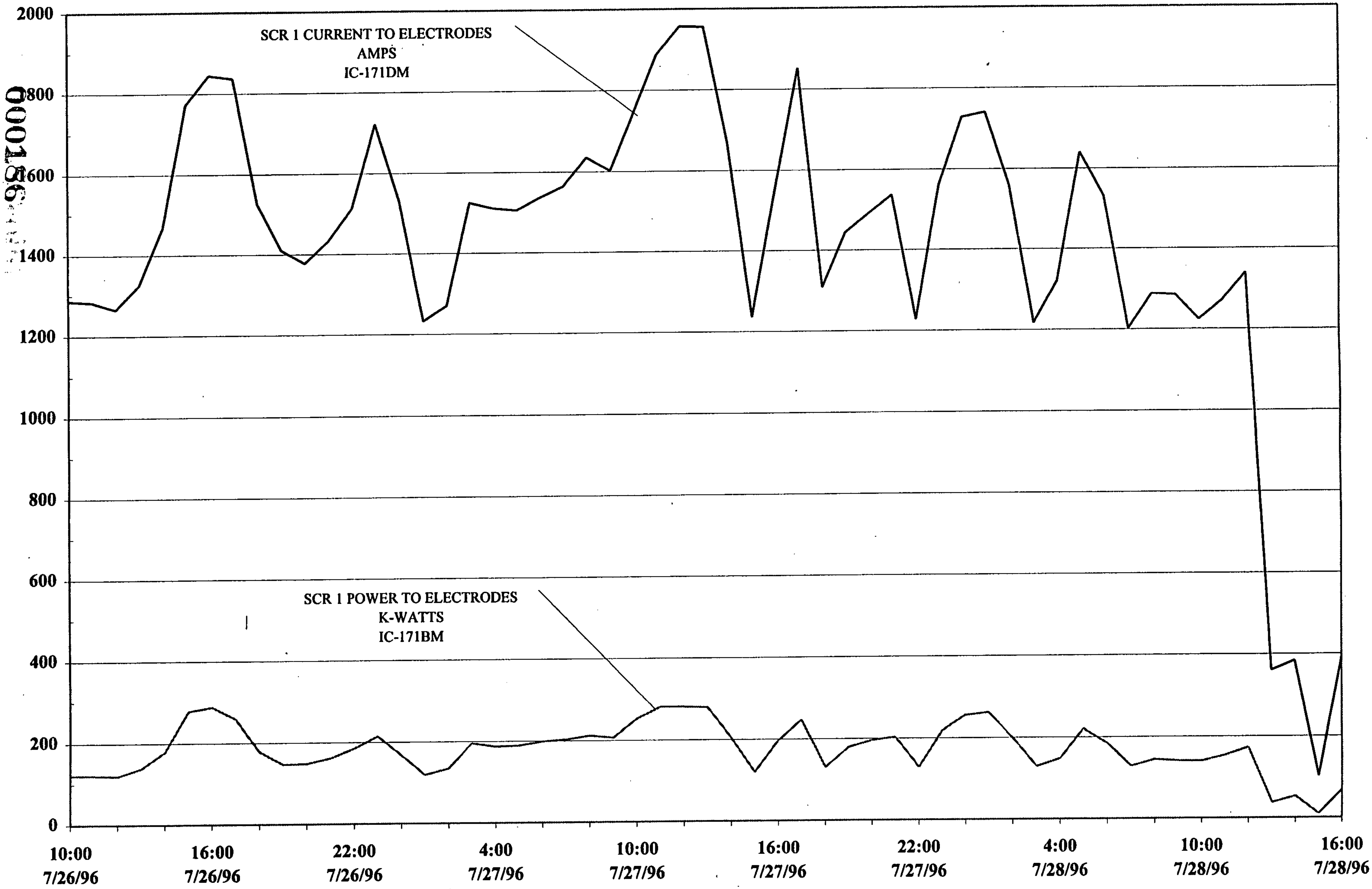
VITRIFICATION PILOT PLANT FURNACE SYSTEM
CAMPAIGN 1
HOURLY AVERAGES

READINGS		MAIN CHAMBER	MAIN CHAMBER	WEST CHAMBER	WEST CHAMBER	EAST CHAMBER	EAST CHAMBER	DISCH CHAMBER	WEST CHAMBER	EAST CHAMBER	DISCH CHAMBER	MAIN
		GLASS TOP	GLASS BOTTOM	GLASS	IR GLASS	GLASS	IR GLASS	GLASS	PLENUM	PLENUM	PLENUM	REFRACTORY
		TI-4S	TI-2S	TI-5S	TI-IRW	TI-6S	TI-IRE	TI-9S	TI-7S	TI-8S	TI-10S	TI-3S
DATE	HOUR	C	C	C	C	C	C	C	C	C	C	C
7/26/96	10:00	1205.57	1264.68	2088.26	2088.26	1134.38	2088.26	1151.65	1185.58	1152.92	1273.36	1129.33
7/26/96	11:00	1204.22	1262.96	2088.26	2088.26	1132.18	2088.26	1141.14	1186.93	1154.72	1273.61	1131.65
7/26/96	12:00	1202.11	1260.99	2088.26	2088.26	1130.32	2088.26	1145.99	1185.97	1146.79	1274.74	1132.37
7/26/96	13:00	1191.21	1253.38	2088.26	2088.26	1126.29	2088.26	1204.65	1121.73	957.79	1298.25	1132.11
7/26/96	14:00	1117.08	1250.75	2088.26	2088.26	1119.43	2088.26	1229.88	965.87	842.08	1298.31	1130.89
7/26/96	15:00	1057.01	1252.76	2088.26	2088.26	1126.40	2088.26	1236.21	894.24	755.94	1297.91	1127.42
7/26/96	16:00	1139.28	1250.90	2088.26	2088.26	1162.18	2088.26	1216.34	886.34	725.35	1297.20	1119.15
7/26/96	17:00	1160.16	1272.04	2088.26	2088.26	1168.83	2088.26	1198.84	786.42	811.93	1297.86	1113.28
7/26/96	18:00	1127.74	1269.95	2088.26	2088.26	1150.08	2088.26	1226.76	742.77	778.07	1297.51	1118.77
7/26/96	19:00	1141.91	1276.78	2088.26	2088.26	1129.16	2088.26	1133.93	699.69	783.82	1297.10	1123.54
7/26/96	20:00	1149.99	1254.82	2088.26	2088.26	1106.87	2088.26	1165.05	679.76	737.06	1297.43	1125.93
7/26/96	21:00	1121.82	1253.25	2088.26	2088.26	1098.75	2088.26	1191.62	660.44	716.50	1295.77	1123.14
7/26/96	22:00	1105.44	1241.08	2088.26	2088.26	1096.92	2088.26	1200.28	648.57	693.61	1297.47	1117.70
7/26/96	23:00	1160.90	1254.68	2088.26	2088.26	1109.27	2088.26	1222.58	686.44	694.42	1297.41	1114.95
7/27/96	0:00	1168.53	1262.84	2078.77	2088.26	1111.41	2088.26	1210.18	691.10	741.65	1297.68	1118.83
7/27/96	1:00	1156.58	1250.09	2088.26	2088.26	1094.55	2088.26	1198.15	664.58	713.94	1297.76	1120.34
7/27/96	2:00	1152.34	1245.70	2088.26	2088.26	1082.39	2088.26	1193.51	635.59	678.01	1297.93	1116.59
7/27/96	3:00	1118.74	1243.77	2088.26	2088.26	1088.82	2088.26	1195.67	641.31	656.46	1297.37	1113.75
7/27/96	4:00	1140.49	1245.98	2088.26	2088.26	1105.32	2088.26	1182.75	640.25	686.12	1276.08	1112.11
7/27/96	5:00	1142.76	1242.82	2088.26	2088.26	1109.25	2088.26	1136.04	639.66	715.29	1273.02	1111.33
7/27/96	6:00	1109.17	1242.32	2088.26	2088.26	1113.02	2088.26	1173.27	631.45	699.24	1273.13	1108.75
7/27/96	7:00	1102.74	1243.89	2088.26	2088.26	1118.57	2088.26	1180.28	627.73	701.70	1273.26	1105.68
7/27/96	8:00	1103.67	1253.66	2088.26	2088.26	1127.32	2088.26	1167.74	626.28	696.55	1273.41	1105.16
7/27/96	9:00	1117.16	1253.16	2088.26	2088.26	1127.55	2088.26	1198.84	457.23	640.66	1273.17	1107.58
7/27/96	10:00	1102.32	1240.02	2088.26	2088.26	1133.36	2088.26	1221.87	649.03	631.62	1273.06	1106.34
7/27/96	11:00	1108.65	1242.42	2088.26	2088.26	1159.16	2088.26	1239.26	581.67	670.93	1277.98	1102.62
7/27/96	12:00	1149.03	1250.86	2088.26	2088.26	1175.90	2088.26	1204.53	571.79	659.74	1289.81	1104.06
7/27/96	13:00	1139.96	1244.78	2088.26	2088.26	1186.31	2088.26	1212.77	585.28	707.17	1292.59	1105.86
7/27/96	14:00	1121.14	1257.83	2088.26	2088.26	1190.46	2088.26	1208.05	574.87	729.30	1292.36	1105.41
7/27/96	15:00	1145.79	1245.82	2088.26	2088.26	1156.43	2088.26	1186.07	797.19	880.35	1292.71	1108.55
7/27/96	16:00	1133.09	1225.73	2088.26	2088.26	1138.46	2088.26	1190.44	1086.17	963.59	1292.91	1102.06
7/27/96	17:00	1158.33	1249.94	2088.26	2088.26	1151.43	2088.26	1194.21	887.46	911.92	1292.72	1100.34
7/27/96	18:00	1156.84	1271.11	2088.26	2088.26	1145.79	2088.26	1234.55	626.15	719.07	1292.22	1109.12
7/27/96	19:00	1106.29	1252.10	2088.26	2088.26	1123.43	2088.26	1197.02	642.13	668.00	1292.58	1111.63
7/27/96	20:00	1095.38	1251.33	2088.26	2088.26	1125.43	2088.26	1200.98	647.33	644.42	1292.50	1109.44
7/27/96	21:00	1091.84	1258.13	2088.26	2088.26	1136.85	2088.26	1217.82	663.14	660.43	1292.28	1107.28
7/27/96	22:00	1120.03	1273.16	2088.26	2088.26	1132.79	2088.26	1219.12	602.37	675.32	1292.57	1110.56
7/27/96	23:00	1155.49	1252.83	2088.26	2088.26	1130.82	2088.26	1222.36	484.12	570.52	1292.62	1111.61
7/28/96	0:00	1159.77	1256.96	2088.26	2088.26	1160.58	2088.26	1210.90	532.23	579.51	1292.56	1111.47
7/28/96	1:00	1138.83	1255.82	2088.26	2088.26	1176.51	2088.26	1221.75	505.76	585.49	1292.62	1111.85
7/28/96	2:00	1094.20	1277.49	2088.26	2088.26	1183.94	2088.26	1127.03	346.13	616.13	1291.72	1114.32
7/28/96	3:00	1078.67	1260.36	2088.26	2088.26	1157.20	2088.26	1055.53	495.95	676.39	1291.48	1115.34
7/28/96	4:00	1117.03	1258.50	2088.26	2088.26	1134.95	2088.26	1039.03	755.03	707.01	1291.38	1112.37
7/28/96	5:00	1144.75	1249.87	2088.26	2088.26	1134.98	2088.26	1098.13	689.46	733.66	1291.50	1110.67
7/28/96	6:00	1151.56	1262.03	2088.26	2088.26	1147.42	2088.26	1059.14	692.26	703.27	1291.47	1111.14
7/28/96	7:00	1144.60	1251.65	2088.26	2088.26	1135.99	2088.26	1121.82	675.18	704.09	1291.39	1111.81
7/28/96	8:00	1122.27	1249.11	2088.26	2088.26	1124.62	2088.26	1060.58	691.98	718.56	1291.55	1108.44
7/28/96	9:00	1153.42	1270.86	2088.26	2088.26	1117.27	2088.26	1137.02	621.94	655.76	1291.47	1111.05
7/28/96	10:00	1140.05	1257.60	2088.26	2088.26	1113.55	2088.26	1146.81	608.71	636.90	1291.45	1113.31
7/28/96	11:00	1113.75	1251.58	2088.26	2088.26	1114.12	2088.26	1122.92	634.46	663.63	1291.45	1110.69
7/28/96	12:00	1113.07	1252.43	2088.26	2088.26	1120.13	2088.26	1129.20	639.93	666.33	1291.45	1108.62
7/28/96	13:00	1097.91	1229.41	2088.26	2088.26	1107.87	2088.26	1180.25	706.18	718.67	1291.44	1106.39
7/28/96	14:00	1093.08	1209.32	2088.26	2088.26	1063.83	2088.26	1176.28	685.92	814.90	1291.40	1096.28
7/28/96	15:00	1039.83	1140.85	2088.26	2088.26	1058.37	2088.26	1140.12	635.41	818.23	1291.04	1077.78
7/28/96	16:00	1014.77	1111.38	2088.26	2088.26	1037.57	2088.26	1136.73	681.34	861.23	1291.05	1050.25



VITPP MELTER POWER SCR 3 & 4
MAY 18 - 24, 1996
POWER, WATTS
Thousands
60
50
40
30
20
10
0
18:50
18:50
18:50
06:00
11:50
15:50
20:50
16:45
20:45
01:00
05:00
09:00
13:00
17:00
21:00
04:30
12:30
TIME

CAMPAIGN 1
FURNACE SYSTEM

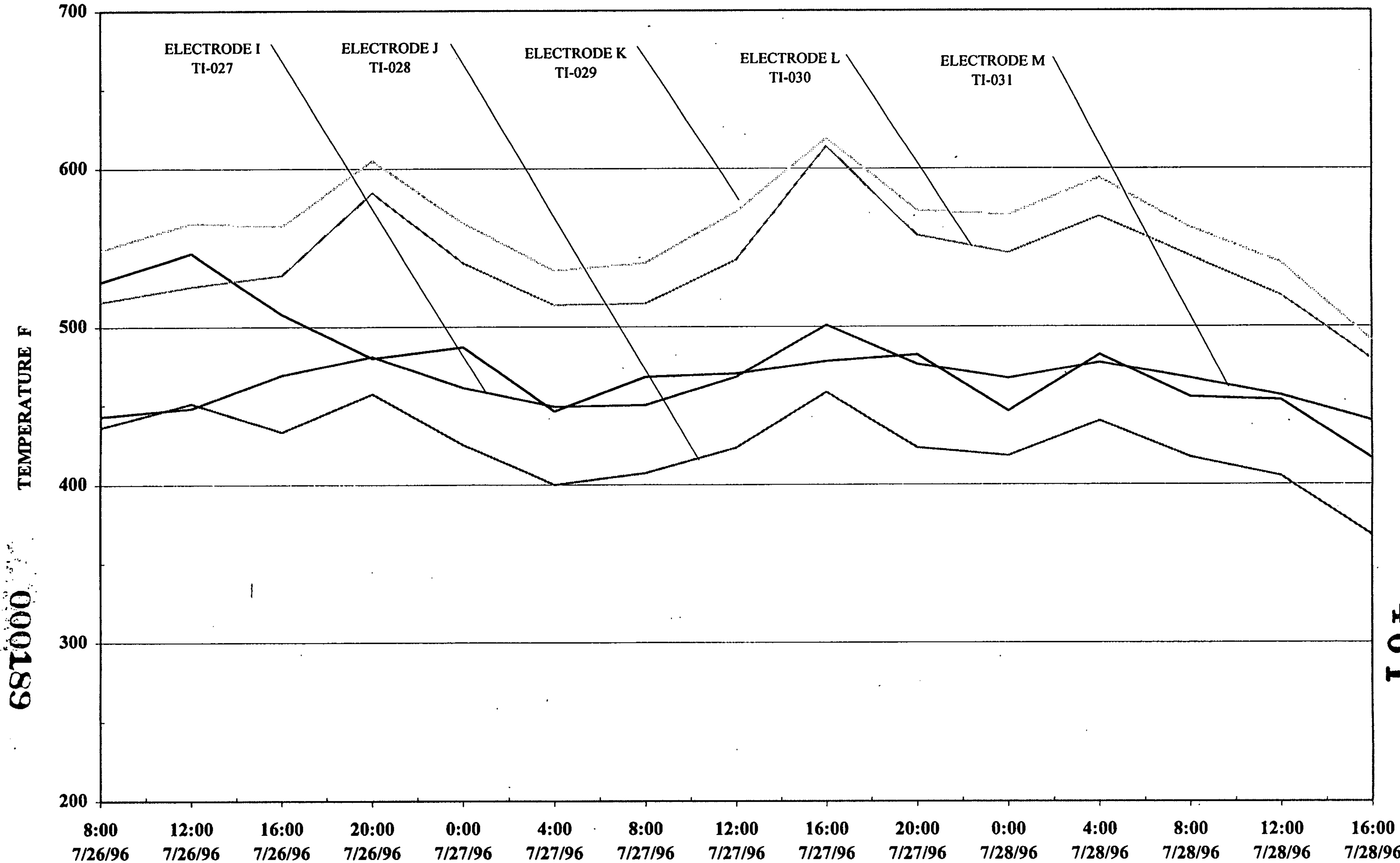


000156

VITRIFICATION PILOT PLANT FURNACE SYSTEM							
CAMPAIGN 1							
		HOURLY AVERAGES					
READINGS		ELECTRODE CURRENT	CURRENT CONTROLLER SET POINT	ELECTRODE VOLTAGE	VOLTAGE CONTROLLER SET POINT	ELECTRODE POWER	POWER CONTROLLER SET POINT
		IIC-171DM	IIC-171DSP	EIC-171CM	EIC-171SP	JIC-171BM	JIC-171BSP
DATE	HOUR	AMPS	AMPS	VOLTS	VOLTS	K-WATTS	K-WATTS
7/26/96	10:00	1286.43	246.00	371.46	454.80	121.85	123.76
7/26/96	11:00	1282.58	246.00	377.23	454.80	121.96	121.96
7/26/96	12:00	1264.68	246.00	378.85	454.80	120.29	120.41
7/26/96	13:00	1324.87	246.00	417.68	454.80	139.25	139.24
7/26/96	14:00	1466.87	246.00	484.08	454.80	179.22	179.37
7/26/96	15:00	1771.70	246.00	614.85	454.80	277.55	276.96
7/26/96	16:00	1844.87	246.00	617.46	454.80	287.59	287.59
7/26/96	17:00	1837.16	246.00	557.13	454.80	258.25	258.17
7/26/96	18:00	1526.00	246.00	463.88	454.80	179.12	179.16
7/26/96	19:00	1410.36	246.00	412.32	454.80	147.17	147.17
7/26/96	20:00	1377.72	246.00	428.42	454.80	148.92	148.97
7/26/96	21:00	1432.30	246.00	449.09	454.80	162.15	162.10
7/26/96	22:00	1513.58	246.00	481.46	454.80	184.93	184.64
7/26/96	23:00	1721.82	246.00	494.51	454.80	214.31	214.05
7/27/96	0:00	1531.60	246.00	431.92	454.80	168.38	168.04
7/27/96	1:00	1231.98	246.00	387.30	454.80	119.78	120.00
7/27/96	2:00	1269.55	246.00	422.08	454.80	134.78	134.88
7/27/96	3:00	1524.93	246.00	507.99	454.80	195.71	195.85
7/27/96	4:00	1511.31	246.00	491.77	454.80	187.18	187.20
7/27/96	5:00	1505.35	246.00	499.16	454.80	189.00	188.96
7/27/96	6:00	1536.88	246.00	512.76	454.80	198.67	198.60
7/27/96	7:00	1564.35	246.00	515.45	454.80	203.05	203.47
7/27/96	8:00	1635.55	246.00	516.34	454.80	212.27	212.03
7/27/96	9:00	1602.61	246.00	514.06	454.80	207.19	207.24
7/27/96	10:00	1744.02	246.00	571.74	454.80	251.63	251.80
7/27/96	11:00	1888.19	246.00	588.32	454.80	280.02	280.14
7/27/96	12:00	1957.63	246.00	568.89	454.80	280.36	280.24
7/27/96	13:00	1956.05	246.00	565.28	454.80	278.38	278.40
7/27/96	14:00	1666.60	246.00	474.11	454.80	204.88	204.32
7/27/96	15:00	1235.56	246.00	385.48	454.80	120.29	120.33
7/27/96	16:00	1551.13	246.00	501.81	454.80	196.48	196.56
7/27/96	17:00	1852.27	246.00	528.77	454.80	245.90	246.58
7/27/96	18:00	1307.93	246.00	391.38	454.80	130.39	129.92
7/27/96	19:00	1443.51	246.00	487.42	454.80	178.94	179.15
7/27/96	20:00	1490.44	246.00	518.11	454.80	195.85	195.74
7/27/96	21:00	1537.11	246.00	523.14	454.80	203.42	203.37
7/27/96	22:00	1226.67	246.00	410.18	454.80	129.29	128.75
7/27/96	23:00	1561.10	246.00	547.18	454.80	217.01	217.16
7/28/96	0:00	1728.69	246.00	582.58	454.80	254.13	254.16
7/28/96	1:00	1740.56	246.00	596.05	454.80	261.48	261.64
7/28/96	2:00	1560.11	246.00	500.96	454.80	199.95	199.92
7/28/96	3:00	1217.05	246.00	420.96	454.80	129.55	129.68
7/28/96	4:00	1320.03	246.00	444.20	454.80	148.20	148.35
7/28/96	5:00	1641.13	246.00	531.90	454.80	220.17	220.39

VITRIFICATION PILOT PLANT FURNACE SYSTEM							
CAMPAIGN 1							
		HOURLY AVERAGES					
READINGS		ELECTRODE CURRENT	CURRENT CONTROLLER SET POINT	ELECTRODE VOLTAGE	VOLTAGE CONTROLLER SET POINT	ELECTRODE POWER	POWER CONTROLLER SET POINT
		IIC-171DM	IIC-171DSP	EIC-171CM	EIC-171SP	JIC-171BM	JIC-171BSP
DATE	HOUR	AMPS	AMPS	VOLTS	VOLTS	K-WATTS	K-WATTS
7/28/96	6:00	1532.40	246.00	476.35	454.80	184.78	185.00
7/28/96	7:00	1202.09	246.00	422.96	454.80	128.76	129.19
7/28/96	8:00	1287.47	246.00	446.37	454.80	144.17	144.00
7/28/96	9:00	1284.67	246.00	436.82	454.80	140.97	140.98
7/28/96	10:00	1223.93	246.00	454.48	454.80	140.16	140.40
7/28/96	11:00	1270.40	246.00	483.24	454.80	154.10	154.25
7/28/96	12:00	1339.10	246.00	491.20	454.80	172.75	172.48
7/28/96	13:00	360.93	246.00	171.40	454.80	37.46	37.52
7/28/96	14:00	383.90	246.00	161.55	454.80	52.88	51.01
7/28/96	15:00	102.36	246.00	85.44	454.80	10.30	9.76
7/28/96	16:00	390.69	246.00	267.19	454.80	67.39	65.04

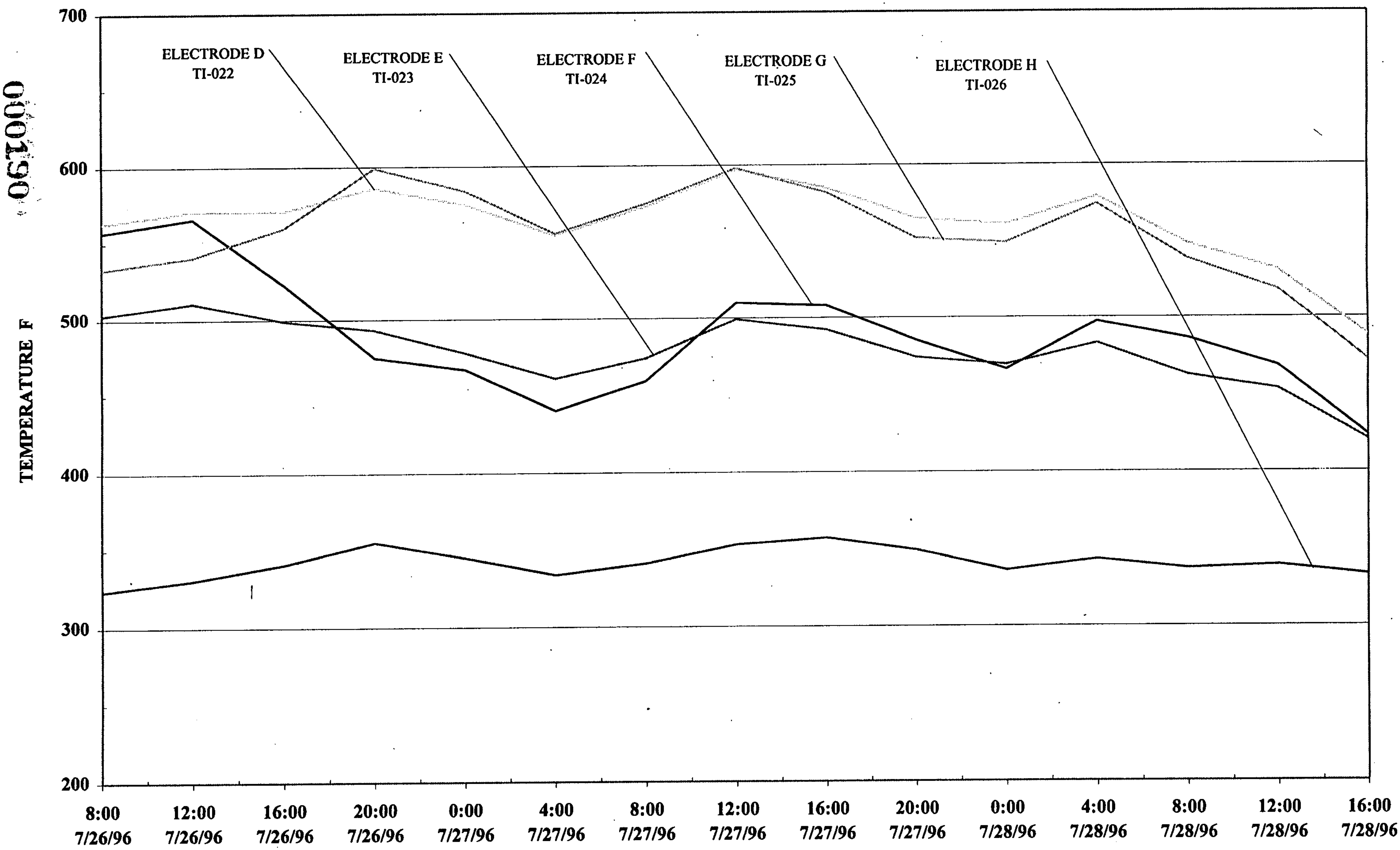
CAMPAIGN 1
FURNACE SYSTEM
WEST ELECTRODE HOLDERS



C1_PTF18.XLS Chart 17

VHP 8/28/96

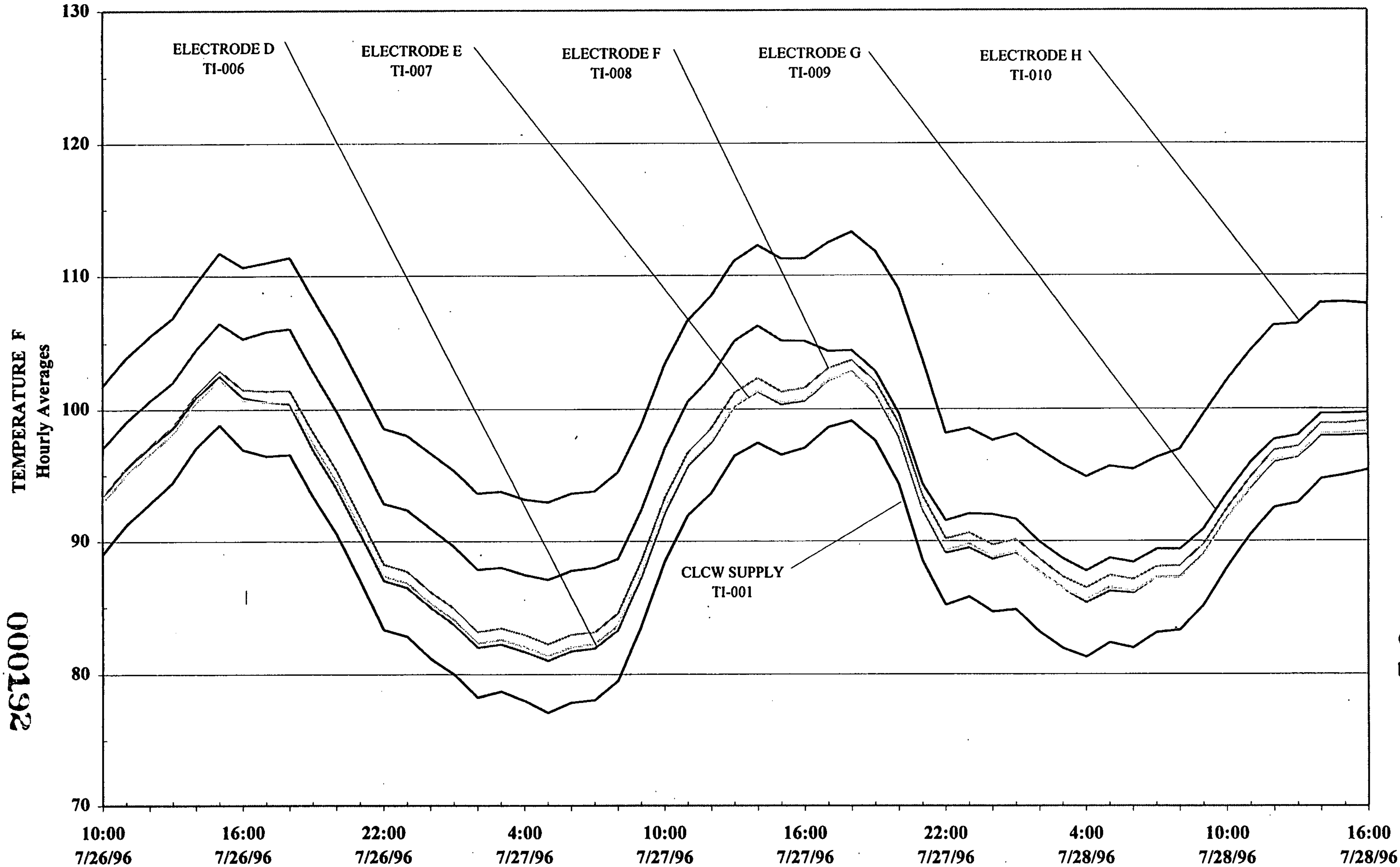
CAMPAIGN 1
FURNACE SYSTEM
EAST ELECTRODE HOLDERS



0001790

VITRIFICATION PILOT PLANT FURNACE SYSTEM											
CAMPAIGN 1											
		HOURLY READINGS ROUNDSHEETS									
READINGS		ELECTRODE HOLDER TEMPERATURES									
		D	E	F	G	H	I	J	K	L	M
		TI-022	TI-023	TI-024	TI-025	TI-026	TI-027	TI-028	TI-029	TI-030	TI-031
DATE	HOUR	F	F	F	F	F	F	F	F	F	F
7/26/96	8:00	557	503	563	533	324	529	436	549	516	443
7/26/96	12:00	566	511	571	541	331	547	451	566	526	448
7/26/96	16:00	523	499	571	560	341	508	433	564	533	469
7/26/96	20:00	475	493	586	599	355	480	457	605	585	481
7/27/96	0:00	467	478	575	584	345	487	425	566	541	461
7/27/96	4:00	440	461	555	556	334	446	400	536	514	449
7/27/96	8:00	459	474	573	575	341	468	407	541	515	450
7/27/96	12:00	510	499	597	598	353	470	423	573	543	468
7/27/96	16:00	508	492	585	582	357	478	458	619	614	501
7/27/96	20:00	485	474	565	552	349	482	423	574	558	476
7/28/96	0:00	466	469	561	549	336	446	418	571	547	467
7/28/96	4:00	497	483	579	574	343	482	440	594	570	477
7/28/96	8:00	486	462	548	538	337	455	417	563	545	467
7/28/96	12:00	468	453	531	518	339	453	405	541	520	456
7/28/96	16:00	423	420	488	472	333	416	368	491	479	440

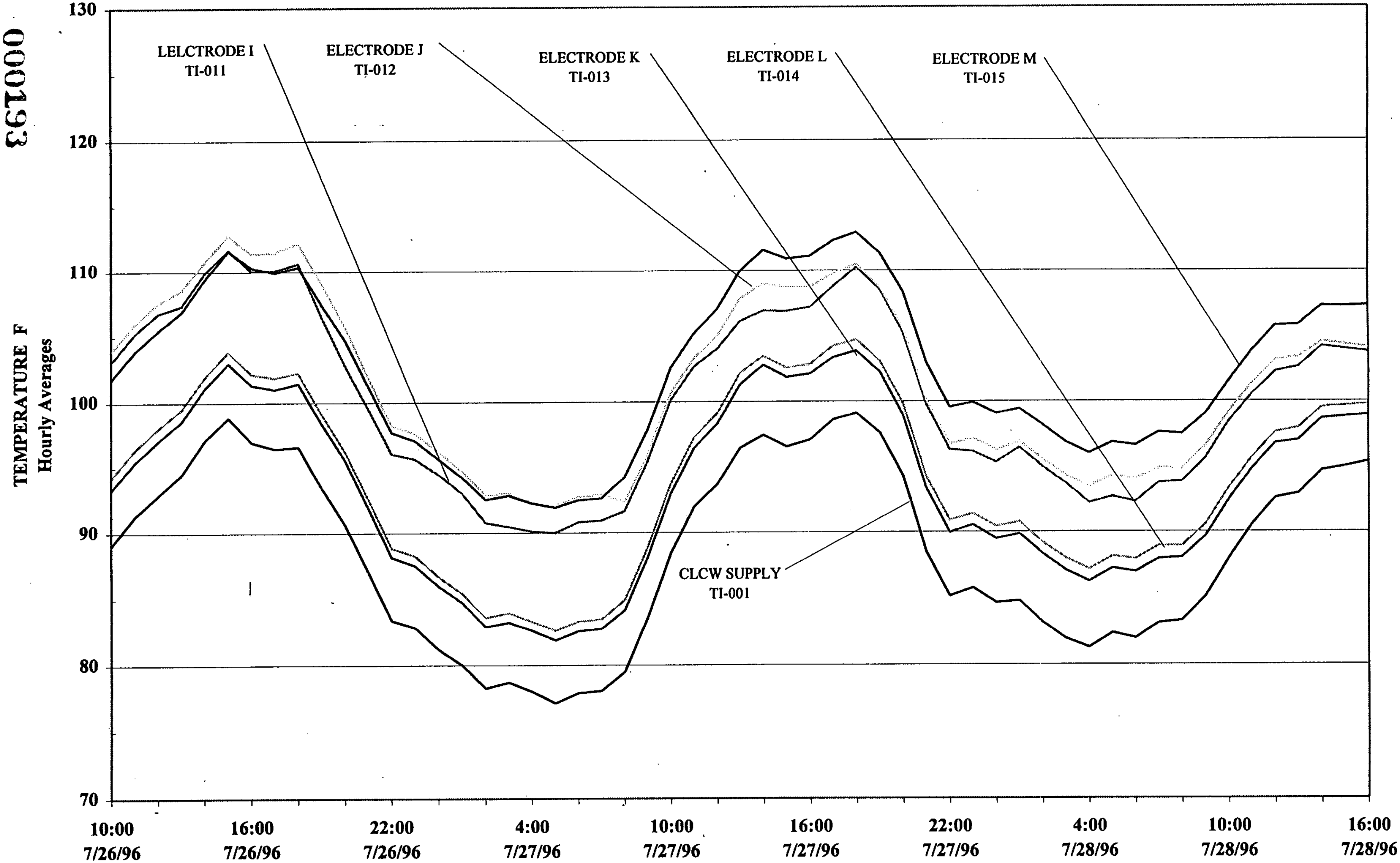
CAMPAIGN 1
FURNACE SYSTEM
EAST ELECTRODE CLCW



VHP 8/27/96

C1_PTF18.XLS Chart 7

CAMPAIGN 1
FURNACE SYSTEM
WEST ELECTRODE CLCW



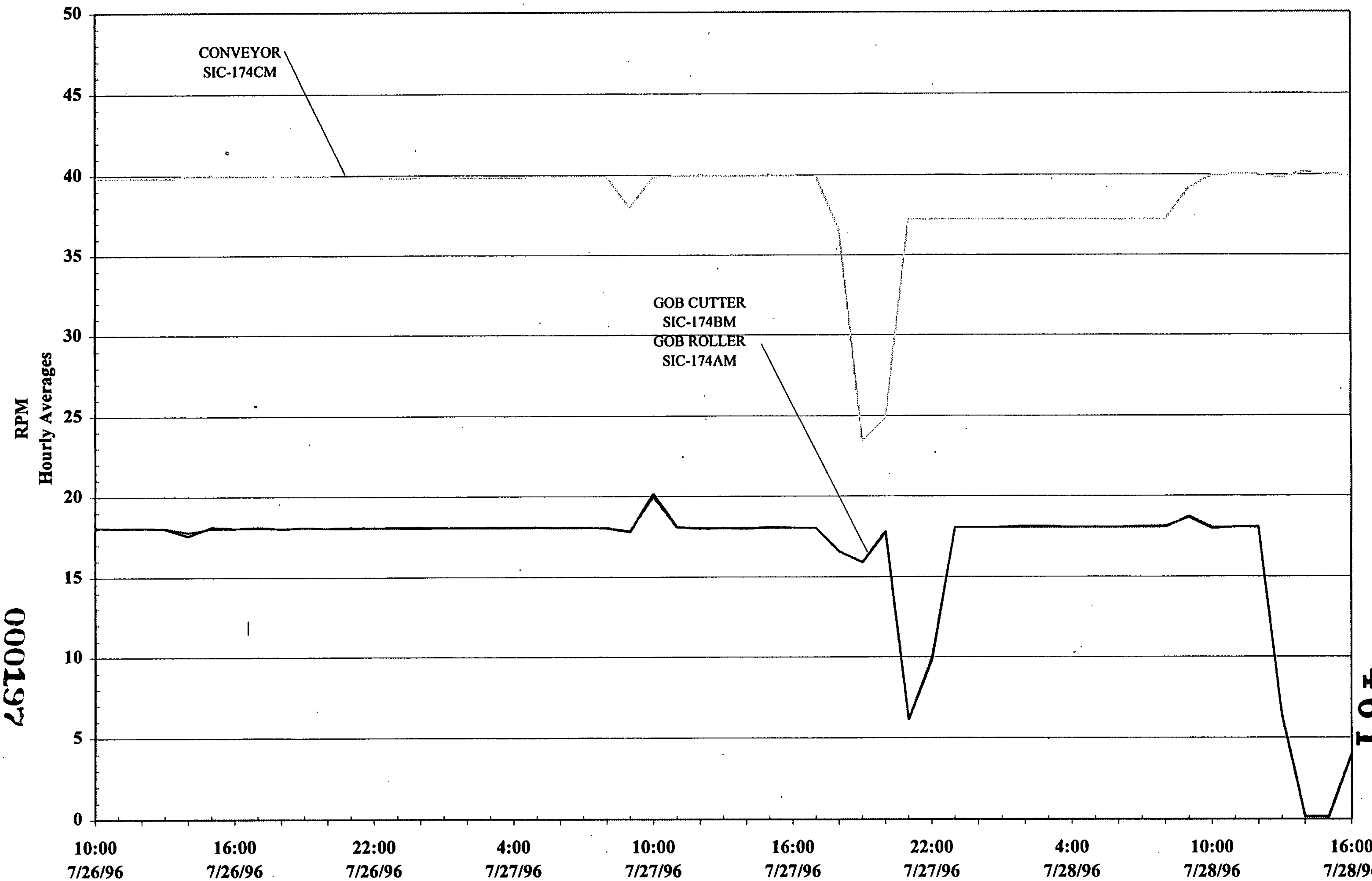
000193

VITRIFICATION PILOT PLANT FURNACE SYSTEM												
CAMPAIGN 1												
HOURLY AVERAGES												
READINGS		ELECTRODE CLOSED LOOP COOLING WATER SYSTEM										
		CLCW	D	E	F	G	H	I	J	K	L	M
		SUPPLY	COOLING WATER RETURN									
		TI-001	TI-006	TI-007	TI-008	TI-009	TI-010	TI-011	TI-012	TI-013	TI-014	TI-015
DATE	HOUR	F	F	F	F	F	F	F	F	F	F	F
7/26/96	10:00	89.04	93.38	92.88	93.37	97.07	101.84	103.07	103.90	94.19	93.26	101.77
7/26/96	11:00	91.25	95.52	95.08	95.57	99.07	103.92	105.24	105.97	96.37	95.39	103.88
7/26/96	12:00	92.84	97.16	96.62	97.22	100.66	105.51	106.79	107.58	98.02	97.04	105.49
7/26/96	13:00	94.45	98.56	98.14	98.69	102.06	106.90	107.39	108.58	99.48	98.53	106.90
7/26/96	14:00	97.09	100.91	100.56	101.16	104.53	109.46	109.91	110.78	101.95	101.10	109.42
7/26/96	15:00	98.82	102.53	102.35	102.93	106.48	111.76	111.65	112.77	103.87	102.97	111.60
7/26/96	16:00	96.93	100.91	100.75	101.51	105.35	110.66	110.06	111.36	102.16	101.34	110.32
7/26/96	17:00	96.44	100.58	100.55	101.40	105.86	111.02	110.09	111.46	101.89	101.01	109.94
7/26/96	18:00	96.57	100.43	100.58	101.45	106.08	111.41	110.61	112.18	102.24	101.44	110.36
7/26/96	19:00	93.43	96.92	97.39	98.28	102.88	108.33	106.51	109.09	99.13	98.37	107.45
7/26/96	20:00	90.61	94.02	94.52	95.41	99.90	105.41	102.81	105.73	96.19	95.53	104.72
7/26/96	21:00	87.04	90.59	90.96	91.84	96.43	102.00	99.50	101.90	92.53	91.86	101.25
7/26/96	22:00	83.36	87.02	87.36	88.26	92.86	98.55	96.02	98.20	88.85	88.16	97.66
7/26/96	23:00	82.83	86.49	86.85	87.73	92.37	97.99	95.62	97.59	88.27	87.52	97.02
7/27/96	0:00	81.19	85.00	85.31	86.18	90.98	96.66	94.44	96.19	86.71	86.00	95.62
7/27/96	1:00	80.01	83.72	84.06	84.92	89.59	95.34	92.99	94.71	85.44	84.75	94.22
7/27/96	2:00	78.27	81.99	82.32	83.19	87.86	93.63	90.75	92.86	83.59	82.89	92.51
7/27/96	3:00	78.71	82.24	82.58	83.45	88.00	93.77	90.45	92.97	83.94	83.22	92.80
7/27/96	4:00	78.02	81.67	82.04	82.95	87.47	93.17	90.10	92.26	83.29	82.60	92.21
7/27/96	5:00	77.13	81.02	81.37	82.25	87.09	92.93	89.99	92.03	82.62	81.87	91.90
7/27/96	6:00	77.89	81.73	82.03	82.97	87.77	93.62	90.78	92.67	83.29	82.56	92.45
7/27/96	7:00	78.06	81.93	82.26	83.15	88.00	93.78	90.91	92.85	83.46	82.72	92.58
7/27/96	8:00	79.49	83.31	83.64	84.56	88.66	95.20	91.61	92.29	84.92	84.14	94.21
7/27/96	9:00	83.59	87.26	87.51	88.51	92.34	98.78	95.44	95.86	88.88	88.14	97.85
7/27/96	10:00	88.43	92.06	92.32	93.23	96.96	103.34	100.13	100.68	93.71	92.95	102.57
7/27/96	11:00	91.93	95.65	95.82	96.68	100.56	106.66	102.67	103.30	97.24	96.43	105.20
7/27/96	12:00	93.62	97.41	97.53	98.51	102.42	108.45	103.99	104.96	99.07	98.27	107.02
7/27/96	13:00	96.43	100.23	100.25	101.24	105.13	111.12	106.13	107.85	102.17	101.32	109.98
7/27/96	14:00	97.42	101.34	101.40	102.34	106.27	112.30	106.92	109.00	103.44	102.77	111.57
7/27/96	15:00	96.51	100.34	100.47	101.31	105.15	111.29	106.88	108.70	102.56	101.86	110.91
7/27/96	16:00	97.04	100.60	100.71	101.60	105.12	111.31	107.19	108.70	102.82	102.09	111.11
7/27/96	17:00	98.60	102.16	102.21	103.06	104.39	112.50	108.76	109.77	104.21	103.35	112.29
7/27/96	18:00	99.09	102.81	102.77	103.68	104.43	113.29	110.24	110.48	104.69	103.83	112.91
7/27/96	19:00	97.57	101.19	101.26	102.06	102.86	111.84	108.51	108.67	103.06	102.22	111.31
7/27/96	20:00	94.28	97.88	98.05	98.91	99.67	108.97	105.20	105.47	99.81	98.93	108.33
7/27/96	21:00	88.49	92.36	92.51	93.39	94.30	103.77	99.76	100.07	94.21	93.31	102.95
7/27/96	22:00	85.17	89.09	89.25	90.16	91.55	98.16	96.28	96.70	90.86	89.94	99.54
7/27/96	23:00	85.79	89.47	89.77	90.61	92.06	98.53	96.13	97.15	91.37	90.52	99.90
7/28/96	0:00	84.65	88.60	88.77	89.69	92.00	97.60	95.30	96.25	90.40	89.47	99.06
7/28/96	1:00	84.82	89.11	89.15	90.12	91.64	98.10	96.44	96.89	90.74	89.85	99.42
7/28/96	2:00	83.15	87.64	87.62	88.61	89.91	96.90	94.97	95.54	89.17	88.34	98.17
7/28/96	3:00	81.93	86.42	86.40	87.28	88.65	95.76	93.67	94.32	88.01	87.11	96.83
7/28/96	4:00	81.26	85.32	85.53	86.46	87.74	94.85	92.16	93.42	87.16	86.27	96.00
7/28/96	5:00	82.35	86.21	86.49	87.39	88.68	95.63	92.64	94.29	88.14	87.25	96.83
7/28/96	6:00	81.96	86.07	86.18	87.09	88.38	95.42	92.25	94.05	87.94	86.98	96.58

VITRIFICATION PILOT PLANT FURNACE SYSTEM												
CAMPAIGN 1												
HOURLY AVERAGES												
READINGS		ELECTRODE CLOSED LOOP COOLING WATER SYSTEM										
		CLCW	D	E	F	G	H	I	J	K	L	M
		SUPPLY	COOLING WATER RETURN									
		TI-001	TI-006	TI-007	TI-008	TI-009	TI-010	TI-011	TI-012	TI-013	TI-014	TI-015
DATE	HOUR	F	F	F	F	F	F	F	F	F	F	F
7/28/96	7:00	83.12	87.23	87.22	88.04	89.35	96.30	93.70	94.85	88.93	87.96	97.61
7/28/96	8:00	83.31	87.27	87.24	88.12	89.35	96.92	93.83	94.81	88.90	88.06	97.49
7/28/96	9:00	85.11	88.96	88.91	89.75	90.90	99.56	95.58	96.54	90.54	89.64	99.00
7/28/96	10:00	87.97	91.69	91.66	92.46	93.57	102.14	98.40	99.16	93.26	92.37	101.53
7/28/96	11:00	90.50	94.03	94.10	94.82	95.93	104.38	100.52	101.34	95.63	94.75	103.82
7/28/96	12:00	92.51	95.97	96.06	96.83	97.64	106.29	102.23	103.09	97.57	96.74	105.74
7/28/96	13:00	92.86	96.31	96.37	97.10	97.97	106.40	102.60	103.35	97.91	96.97	105.81
7/28/96	14:00	94.65	97.91	98.05	98.87	99.60	107.92	104.16	104.52	99.52	98.64	107.24
7/28/96	15:00	94.95	97.93	98.11	98.88	99.61	107.98	103.94	104.30	99.63	98.79	107.22
7/28/96	16:00	95.34	98.01	98.26	99.03	99.67	107.84	103.74	104.08	99.75	98.93	107.30

GEM MACHINE SYSTEM

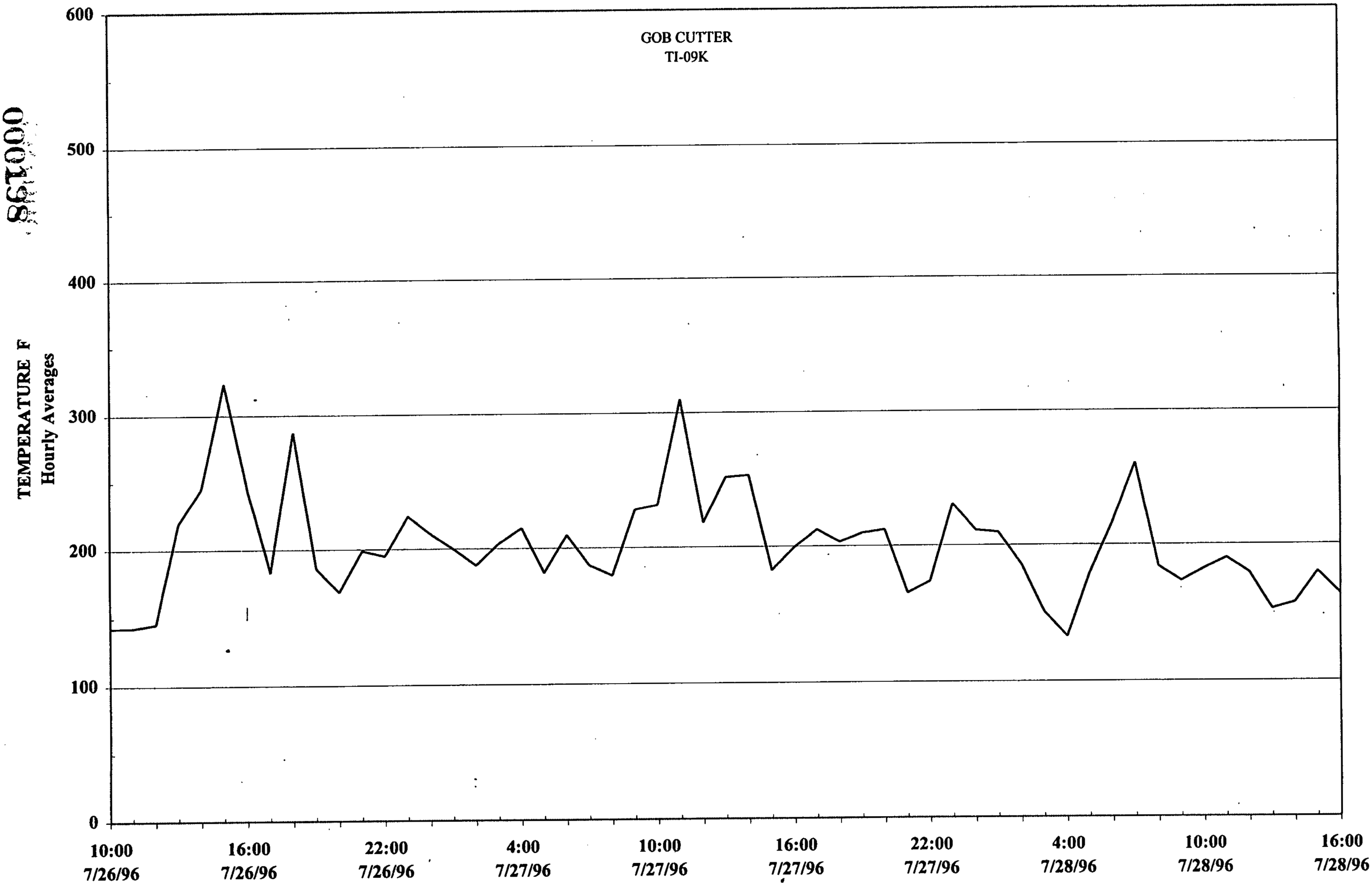
CAMPAIGN 1
GEM MACHINE SYSTEM



C1_PTF18.XLS Chart 10

VHP 8/27/96

CAMPAIGN 1
GEM MACHINE SYSTEM



VHP 8/27/96

VITRIFICATION PILOT PLANT GEM MACHINE SYSTEM									
CAMPAIGN 1									
		HOURLY READINGS ROUNDSHEETS							
READINGS		CONVEYOR HEAD TEMP	CONVEYOR TAIL TEMP	GEM HOPPER TEMP	BULK HOPPER #1 TEMP	BULK HOPPER #2 TEMP	GEM ENCLOSURE BOTTOM TEMP	GEM ENCLOSURE TOP TEMP	ENCLOSURE EXPANSION JOINT TEMP
DATE	HOUR	F	F	F	F	F	F	F	F
7/26/96	8:00	76	79	77	83	79	107	107	111
7/26/96	12:00	80	82	81	93	82	110	110	114
7/26/96	16:00	91	93	131	504	194	190	220	245
7/26/96	20:00	85	89	85	127	190	127	130	132
7/27/96	0:00	82	89	86	160	344	121	130	141
7/27/96	4:00	80	86	79	121	262	132	132	137
7/27/96	8:00	81	111	78	132	281	141	142	144
7/27/96	12:00	91	110	119	230	300	156	159	163
7/27/96	16:00	89	94	97	148	139	132	136	139
7/27/96	20:00	91	96	106	150	548	201	203	202
7/28/96	0:00	88	116	86	166	838	213	215	224
7/28/96	4:00	83	85	86	142	176	160	170	180
7/28/96	8:00	84	99	84	150	92	177	186	194
7/28/96	12:00	90	197	89	162	401	222	239	247
7/28/96	16:00	111	140	84	92	139	166	182	231

Batch Number: 11

Laboratory Glass Analysis Results

	CUSTOMER I.D. S109607271546	S109607271546	CUSTOMER I.D.		CUSTOMER I.D.			
Analyte	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Result (wt %-abs)	Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SiO2	42.40	45.19						
B2O3	10.31	10.99						
Li2O	0.81	0.86						
Al2O3	10.35	11.03						
BaO	0.00	0.00						
CaO	12.88	13.73						
Cr2O3	0.11	0.12						
CuO	NR	0.00						
Fe2O3	0.54	0.58						
PbO	0.00	0.00						
MgO	0.51	0.54						
Mn3O4	0.00	0.00						
NiO	0.00	0.00						
K2O	0.00	0.00						
V2O5	0.00	0.00						
Na2O	11.60	12.36						
ZrO2	4.31	4.59						
	sum (wt%) 93.82	norm sum (wt%) 100	sum (wt%) 0	norm sum (wt%) 0.0	sum (wt%) 0	norm sum (wt%) 0.0		
	multiplier	1.065870816457	multiplier		multiplier			

TCLP Results

ANALYTE	(ug/L)		(ug/L)		(ug/L)		(ug/L)
BARIUM							
LEAD							
CHROMIUM							

Density

	S109607271545						(g/mL)
DENSITY (g/mL)	2.63						

TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Campaign Number 1	Batch Number C1B12 Formula Benign

Batch Objectives: High Feed / Production Rate Batch w/ maximum feed rate.

Slurry Tank A Initial Weight 5785 lbs (full batch) Final Weight 300 lbs (heel before flush)	Slurry Fed 5485 lbs 374 lb/hr Glass Produced 2341 lbs 160 lb/hr

Solids in Slurry 50.8% wt

Slurry Feed Rate

Maximum	Average
325 RPM	229 RPM
2.9 L/min	2.0 L/min

Slurry Feed Start 1715 hr on 7/27

Slurry Feed Stop 0755 hr on 7/28

Slurry Feed Duration 14 hr 40 min

Drum ID	Net Weight (lbs)	Form
C1B12D1	921	Bulk
C1B12D2	397	Bulk
C1B12D4	1012	Bulk

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Slurry Samples

Customer Number	Results
S04A-960727-1305	1.4 g/ml & 50.8wt%
S04A-960727-1300	1.46 g/ml & * wt%
S04A-960727-1305	1.4 g/ml & 50.8 wt%
S05A-960727-2055	1.51g/ml & 49.6wt%

* % solids not analyzed for in sample S04A-960727-1300

Glass Samples

Customer Number	Results	Drum ID
S10-960728-1301	*	C1B12D2
S10-960728-1300	*	C1B12D2
S10-960728-1303	*	C1B12D2
S10-960729-1700	*	C1B12D4
S10-960729-1708	**	C1B12D1

* See attached "Laboratory Glass Analysis Results"

** See Glass Characteristics (viscosity & conductivity) on next page

Range Melter Temp. 1263° C

Range Melter Power 190 KW

Avg. Melter Current 1424 Amp

Avg. Melter Voltage 123 Volts

Gem Production

Gem Production Start Time N/A min

Gem Production Stop Time N/A min

Gem Production Duration N/A min

Average Cold Cap Coverage 97 %

Average Cold Cap Thickness 3-6_in

Frit Addition

West Side Chamber 75 lbs

East Side Chamber 50 lbs

Center Chamber 0 lbs

Film Cooler Outlet Temperature

Max.	Range w/cold cap
950° F	682° F

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Glass Characteristics (as reported by the lab)		Normal Off-Gas Characteristics
Viscosity	43.3 p	Initial DP across HEPA filter -0.1
Conductivity	142 mS/cm	Maximum DP across HEPA filter -0.1
TCLP Ba	*	Final DP across HEPA filter -0.1
TCLP Cr	•	Number of changings of HEPA filter N/A
TCLP Pb	•	Initial DP across transition line 0.0
No. of Phases	1	Maximum DP across transition line 9.0
Gem Size(s)	N/A	Final DP across transition line 7.0
Gem Uniformity	N/A	Initial DP across Film Cooler Outlet 0
		Maximum DP across Film Cooler Outlet 13
		Final DP across Film Cooler Outlet N/A
		No. of cleanings of Film Cooler Outlet 0

** **TCLP samples were not taken after batch 5 due to the fact that batches 1, 2, 3 & 5 provided sufficient data to prove that the glass passed the TCLP**

Gem Housing Characteristics

Average Pressure	-0.62" w.c.
Avg. Discharge Temperature	1161° F

Normal Off-Gas Characteristics (Average During Stable Conditions)

PDIC - 250		FI-250
% Open	Pressure	Flow
47	-0.75" w.c.	215 scfm

Number of Emergency Off-Gas Trips 3

Comments:______________________________

Batch Number: 12

Laboratory Glass Analysis Results

Analyte	CUSTOMER I.D. S10-960728-1301 Result (wt %-abs)	S10-960728-1301 Result (wt %-norm.)	CUSTOMER I.D. S10-960728-1303 Result (wt %-abs)	S10-960728-1303 Result (wt %-norm.)	CUSTOMER I.D. S10-960729-1700 Result (wt %-abs)	S10-960729-1700 Result (wt %-norm.)	CUSTOMER I.D. S10-960729-1708 Result (wt %-abs)	S10-960729-1708 Result (wt %-norm.)	Average (wt %-abs)	Average (wt %-norm.)
SiO2	41.67	46.29	42.35	46.05	40.42	43.44	42.28	44.53	41.68	45.08
B2O3	11.28	12.53	10.86	11.81	11.58	12.45	11.78	12.41	11.38	12.30
Li2O	0.50	0.56	0.59	0.64	0.46	0.49	0.61	0.64	0.54	0.58
Al2O3	9.78	10.86	9.84	10.70	10.09	10.84	10.30	10.85	10.00	10.81
BaO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	13.00	14.44	12.81	13.93	13.72	14.75	13.91	14.65	13.36	14.44
CHROMIUM	0.11	0.12	0.09	0.10	NR	0.00	NR	0.00	0.05	0.06
CuO	NR	0.00	NR	0.00	NR	0.00	NR	0.00	0.00	0.00
Fe2O3	0.63	0.70	0.45	0.49	0.42	0.45	0.35	0.37	0.46	0.50
PbO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MgO	0.49	0.54	0.43	0.47	0.54	0.58	0.50	0.53	0.49	0.53
Mn3O4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V2O5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na2O	8.25	9.16	10.24	11.13	11.50	12.36	10.90	11.48	10.22	11.04
ZrO2	4.31	4.79	4.31	4.69	4.31	4.63	4.31	4.54	4.31	4.66
	sum (wt%) 90.02	norm sum (wt%) 100	sum (wt%) 91.965	norm sum (wt%) 100.0	sum (wt%) 93.04	norm sum (wt%) 100.0	sum (wt%) 94.94	norm sum (wt%) 100.0		
	multiplier	1.110864252388	multiplier	1.087370195183	multiplier	1.0748065348237	multiplier	1.053296819044		

TCLP Results

ANALYTE	(ug/L)		(ug/L)		(ug/L)				(ug/L)
BARIUM									
LEAD									
CHROMIUM									

Density

	S10-960728-1300		S10-960729-1700		S10-960729-1708				(g/mL)
DENSITY (g/mL)	2.62		2.6		2.62				2.61

000204

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Campaign Number 1

Batch Number C1B13 Formula Benign

Batch Objectives: Feed 50 % wt slurry at a steady, high feed rate (325 RPM) in support of Section 7.5 of SOT 2504-SU-0034, Rev. 1

Slurry Tank B

Initial Weight 5620 lbs
(full batch)

Final Weight 232 lbs
(heel before flush)

Slurry Fed 5388lbs Avg. Rate 348 lbs/hr

Glass Produced 3169lbs Avg Rate 205lbs/hr

Solids in Slurry 53.9% wt

Slurry Feed Rate

Maximum	Average
350 RPM	196 RPM
3.1 L/min	1.75 L/min

Slurry Feed Start 0850 Hours on 7/28

Slurry Feed Stop 1240 Hours on 7/28

Slurry Feed Start 1930 Hours on 7/30

Slurry Feed Stop 0710 Hours on 7/31

Slurry Feed Duration 15 hrs 30 min

Drum ID	Net Weight (lbs)	Form
C1B13D1	1065	Bulk
C1B13D2	440	Bulk
C1B13D4	808	Bulk
C1B13D5	876	Bulk

TEST PERFORMANCE PARAMETERS FOR
SOT CAMPAIGN 1 AT
THE VITRIFICATION PILOT PLANT
2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Slurry Samples

Customer Number	Results
S04B-960727-2041	55.7 wt% & 1.61 g/ml
S05B-960728-1100	1.56 g/ml & 53 wt %
S05B-960728-1101	1.60 g/ml & 54.7 wt%
S04B6-960730-1145	1.58g/ml & 55.2 wt%

Glass Samples

Customer Number	Results	Drum ID
S10-960728-1300	*	C1B13D3
S10-960728-1303	*	C1B13D3
S10-960729-0330	*	C1B13D3
S10-960729-0640	**	C1B13D3

* **See attached "Laboratory Glass Analysis Results"**

** **See Glass Characteristics (viscosity & conductivity) on next page**

Range Melter Temperature 1259-1279 °C

Weighted Avg. Melter Power 170 KW

Range Melter Current 1014 Amp

Range Melter Voltage 97 Volts

Gem Production

Gem Production Start Time 0910 hr on 7/28

Gem Production Stop Time 0928 hr on 7/28

Gem Production Duration 18 min

Average Cold Cap Coverage 90%

Average Cold Cap Thickness 4 in

Frit Addition

West Side Chamber 250 lbs

East Side Chamber 75 lbs

Center Chamber 212.5 lbs

Film Cooler Outlet Temperature

Max.	Avg. w/cold cap
690° F	640° F

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96

Utility Air Flow Settings

Film Cooler Flow Rate	29 scfm
Bubbler 1 Flow Rate	6 ~ 10.5 scfh
Bubbler 2 Flow Rate	6 ~ 10.5 scfh
Bubbler 3 Flow Rate	6 ~ 10.5 scfh
Bubbler 4 Flow Rate	6 ~ 10.5 scfh
Air Lift Flow Rate	3.5 ~ 5 scfh
Trickle Air Flow Rate	1 scfh

Gem Machine Settings

Gem Machine Gob Cutter Speed	18 rpm
Gem Machine Roller Speed	18 rpm
Gem Machine Conveyor Speed	32 rpm

Glass Characteristics
(as reported by the lab)

Viscosity	34.71 p
Conductivity	143 mS/cm
TCLP Ba	*
TCLP Cr	*
TCLP Pb	*
No. of Phases	1
Gem Size(s)	1/2" to 1-1/2"
Gem Uniformity	90%

**** TCLP samples were not taken after batch 5 due to the fact that batches 1, 2, 3 & 5 provided sufficient data to prove that the glass passed the TCLP**

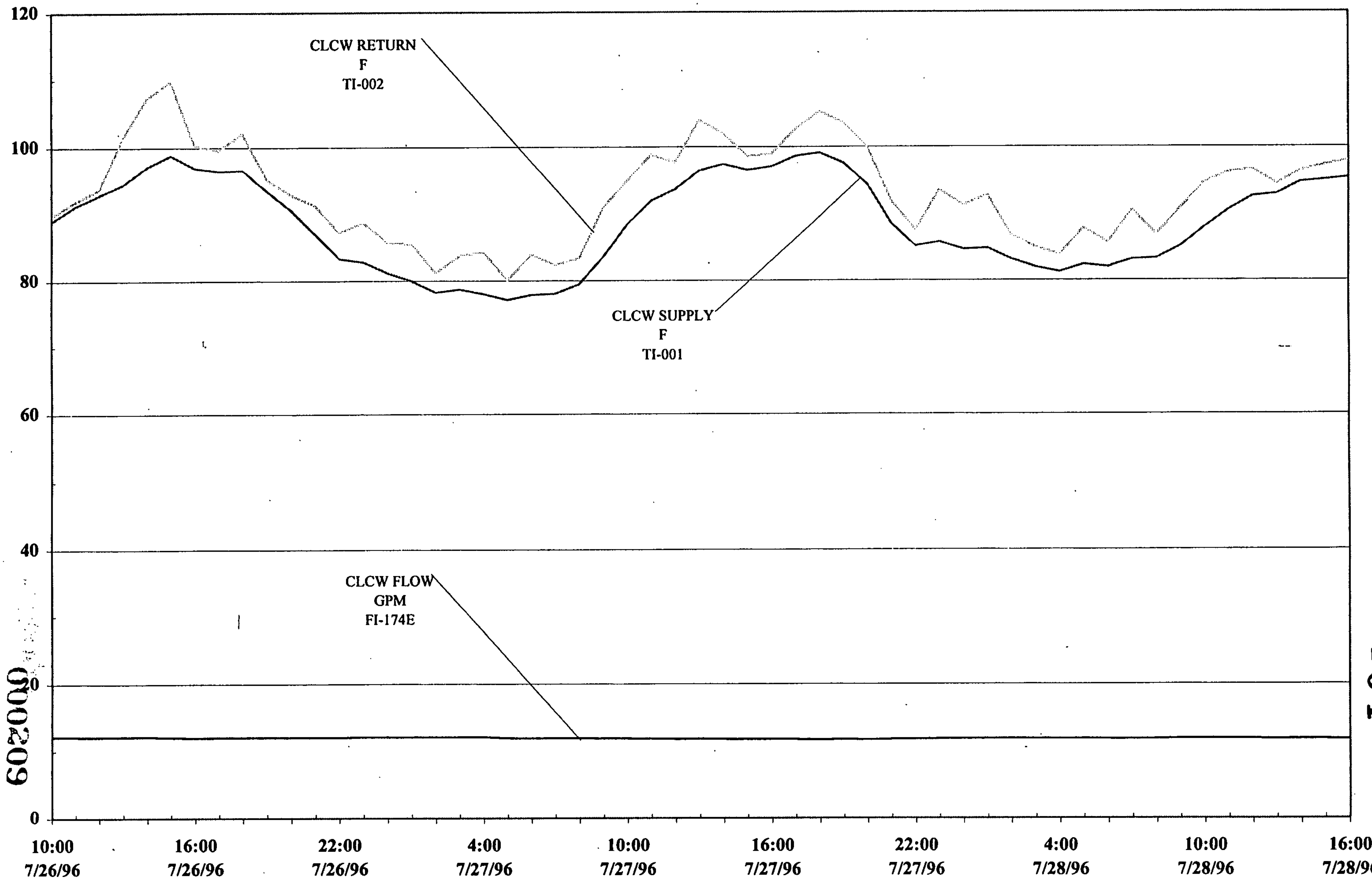
Normal Off-Gas Characteristics

Initial DP across HEPA filter	0.2
Maximum DP across HEPA filter	0.2
Final DP across HEPA filter	0.2
Number of changings of HEPA filter	1
Initial DP across transition line	N/A
Maximum DP across transition line	10
Final DP across transition line	4.5
Initial DP across Film Cooler Outlet	N/A
Maximum DP across Film Cooler Outlet	7
Final DP across Film Cooler Outlet	10
No. of cleanings of Film Cooler Outlet	0

TEST PERFORMANCE PARAMETERS FOR SOT CAMPAIGN 1 AT THE VITRIFICATION PILOT PLANT 2504-SU-0034, REV. 1 ATTACHMENT 11, ICP 17-96	
Gem Housing Characteristics Average Pressure -0.51" w.c. Avg. Discharge Temperature 1294° F	Normal Off-Gas Characteristics (Average During Stable Conditions) PDIC - 250 FI-250 % Open Pressure Flow 53 -0.75 217 scfm Number of Emergency Off-Gas Trips 1

Comments: __The feeding of this batch was discontinued due to viscosity of the glass._______

CAMPAIGN 1
GEM MACHINE



C1_PTF18.XLS Chart 12

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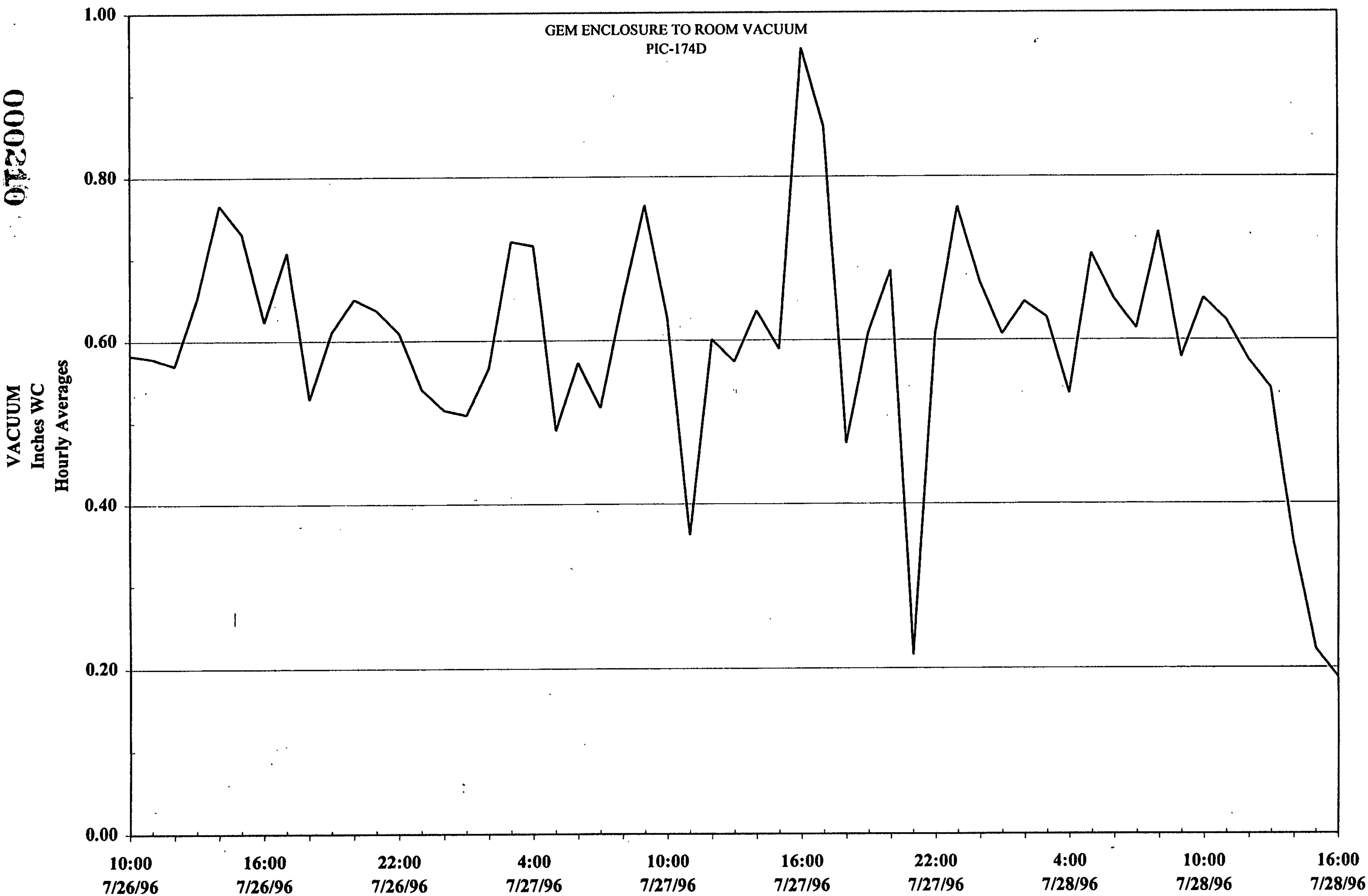
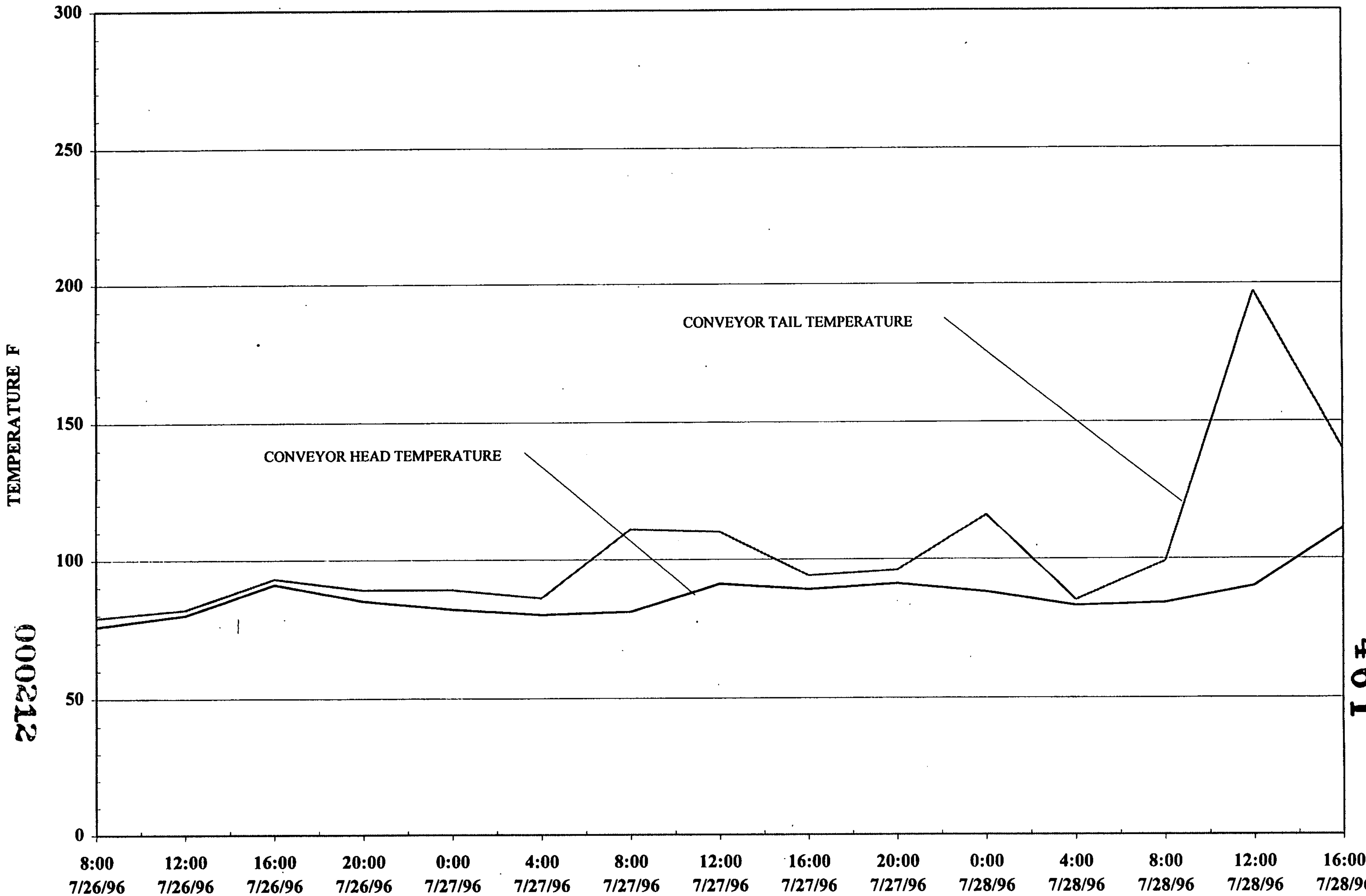
CAMPAIGN 1
GEM MACHINE SYSTEM



000210

VITRIFICATION PILOT PLANT GEM MACHINE SYSTEM										
CAMPAIGN 1										
		HOURLY AVERAGES								
READINGS		GEM	GOB	GOB	GOB	CONVEYOR	GEM	CLCW	CLCW	CLCW
		HOPPER	CUTTER	CUTTER	ROLLER	SPEED	ENCLOSURE	DIVERTERS	DIVERTERS	DIVERTERS
							TO ROOM	& CONVEYOR	& CONVEYOR	& CONVEYOR
							VACUUM	SUPPLY	SUPPLY	RETURN
		TI-3K	TI-9K	SIC-174BM	SIC-174AM	SIC-174CM	PIC-174D	FI-174E	TI-001	TI-002
DATE	HOUR	F	F	RPM	RPM	RPM	In WC	GPM	F	F
7/26/96	10:00	76.34	142.72	18.09	18.10	39.86	0.58	12.18	89.04	89.76
7/26/96	11:00	77.16	143.09	18.06	18.07	39.82	0.58	12.18	91.25	91.91
7/26/96	12:00	78.37	145.69	18.08	18.08	39.87	0.57	12.16	92.84	93.68
7/26/96	13:00	179.90	219.23	18.03	18.06	39.83	0.65	12.18	94.45	101.43
7/26/96	14:00	261.19	245.26	17.58	17.79	39.99	0.77	12.21	97.09	107.28
7/26/96	15:00	109.69	323.23	18.12	18.04	40.01	0.73	12.11	98.82	109.77
7/26/96	16:00	117.78	244.67	18.06	18.05	39.97	0.62	12.07	96.93	100.27
7/26/96	17:00	90.84	183.21	18.11	18.06	39.99	0.71	12.09	96.44	99.54
7/26/96	18:00	87.16	287.03	18.03	18.04	39.99	0.53	12.08	96.57	102.07
7/26/96	19:00	84.22	185.91	18.09	18.09	39.95	0.61	12.13	93.43	95.14
7/26/96	20:00	81.99	168.56	18.05	18.06	39.95	0.65	12.09	90.61	92.85
7/26/96	21:00	80.48	198.79	18.09	18.04	39.93	0.64	12.09	87.04	91.30
7/26/96	22:00	79.67	194.86	18.08	18.09	39.90	0.61	12.09	83.36	87.27
7/26/96	23:00	111.57	224.17	18.10	18.05	39.85	0.54	12.13	82.83	88.78
7/27/96	0:00	92.60	211.02	18.10	18.04	39.89	0.52	12.15	81.19	85.76
7/27/96	1:00	78.36	199.86	18.08	18.07	39.90	0.51	12.11	80.01	85.58
7/27/96	2:00	78.64	187.68	18.07	18.07	39.87	0.57	12.12	78.27	81.19
7/27/96	3:00	76.90	203.56	18.09	18.05	39.85	0.72	12.14	78.71	83.77
7/27/96	4:00	77.56	214.88	18.08	18.07	39.86	0.72	12.13	78.02	84.29
7/27/96	5:00	78.77	181.94	18.10	18.08	39.92	0.49	11.97	77.13	80.07
7/27/96	6:00	75.88	209.48	18.07	18.06	39.92	0.57	11.94	77.89	83.96
7/27/96	7:00	75.64	187.06	18.09	18.06	39.92	0.52	11.95	78.06	82.37
7/27/96	8:00	75.56	179.63	18.04	18.06	39.91	0.65	11.99	79.49	83.39
7/27/96	9:00	92.75	227.99	17.80	17.85	37.95	0.77	11.92	83.59	90.94
7/27/96	10:00	165.65	231.50	20.14	19.96	39.88	0.63	11.92	88.43	94.90
7/27/96	11:00	134.80	309.67	18.11	18.09	39.96	0.36	11.87	91.93	98.79
7/27/96	12:00	115.77	217.87	18.02	18.05	40.00	0.60	11.81	93.62	97.72
7/27/96	13:00	110.55	251.80	18.04	18.03	39.98	0.57	11.86	96.43	103.93
7/27/96	14:00	102.58	253.22	18.01	18.05	39.97	0.64	11.82	97.42	101.91
7/27/96	15:00	97.04	182.55	18.09	18.04	40.00	0.59	11.79	96.51	98.61
7/27/96	16:00	88.94	199.30	18.05	18.06	39.95	0.96	11.81	97.04	98.95
7/27/96	17:00	87.00	212.34	18.05	18.05	39.94	0.86	11.77	98.60	102.56
7/27/96	18:00	93.28	203.02	16.57	16.55	36.59	0.47	11.73	99.09	105.21
7/27/96	19:00	111.63	209.60	15.90	15.92	23.45	0.61	11.78	97.57	103.51
7/27/96	20:00	105.70	211.97	17.77	17.85	24.82	0.69	11.73	94.28	99.92
7/27/96	21:00	100.74	165.41	6.14	6.16	37.22	0.22	11.80	88.49	91.80
7/27/96	22:00	112.89	173.87	9.83	9.95	37.21	0.61	11.83	85.17	87.58
7/27/96	23:00	109.11	230.81	18.07	18.07	37.26	0.76	11.86	85.79	93.49
7/28/96	0:00	84.08	211.15	18.07	18.07	37.20	0.67	11.87	84.65	91.23
7/28/96	1:00	92.59	209.50	18.08	18.07	37.21	0.61	11.87	84.82	92.74
7/28/96	2:00	86.07	185.80	18.13	18.06	37.19	0.65	11.93	83.15	86.79
7/28/96	3:00	84.17	150.98	18.13	18.05	37.22	0.63	11.86	81.93	84.94
7/28/96	4:00	85.14	132.68	18.07	18.07	37.22	0.54	11.85	81.26	83.85
7/28/96	5:00	84.30	179.21	18.08	18.06	37.22	0.71	11.87	82.35	87.83
7/28/96	6:00	81.42	216.59	18.07	18.06	37.19	0.65	11.86	81.96	85.69
7/28/96	7:00	81.41	260.80	18.13	18.07	37.25	0.61	11.83	83.12	90.54
7/28/96	8:00	81.34	183.88	18.12	18.05	37.19	0.73	11.86	83.31	86.87
7/28/96	9:00	130.95	173.31	18.68	18.73	39.13	0.58	11.93	85.11	90.78
7/28/96	10:00	100.55	182.05	17.99	18.06	39.94	0.65	11.92	87.97	94.63
7/28/96	11:00	88.22	190.02	18.07	18.06	40.02	0.63	11.93	90.50	96.14
7/28/96	12:00	83.86	179.07	18.10	18.05	40.01	0.58	11.88	92.51	96.55
7/28/96	13:00	83.21	152.66	6.42	6.45	39.84	0.54	11.80	92.86	94.40
7/28/96	14:00	82.10	157.26	0.14	0.20	40.15	0.35	11.84	94.65	96.33
7/28/96	15:00	82.03	179.84	0.14	0.20	40.04	0.22	11.81	94.95	97.22
7/28/96	16:00	81.45	163.44	4.00	4.05	39.97	0.19	11.80	95.34	97.98

CAMPAIGN 1
GEM MACHINE SYSTEM



C1_PTF18.XLS Chart 15

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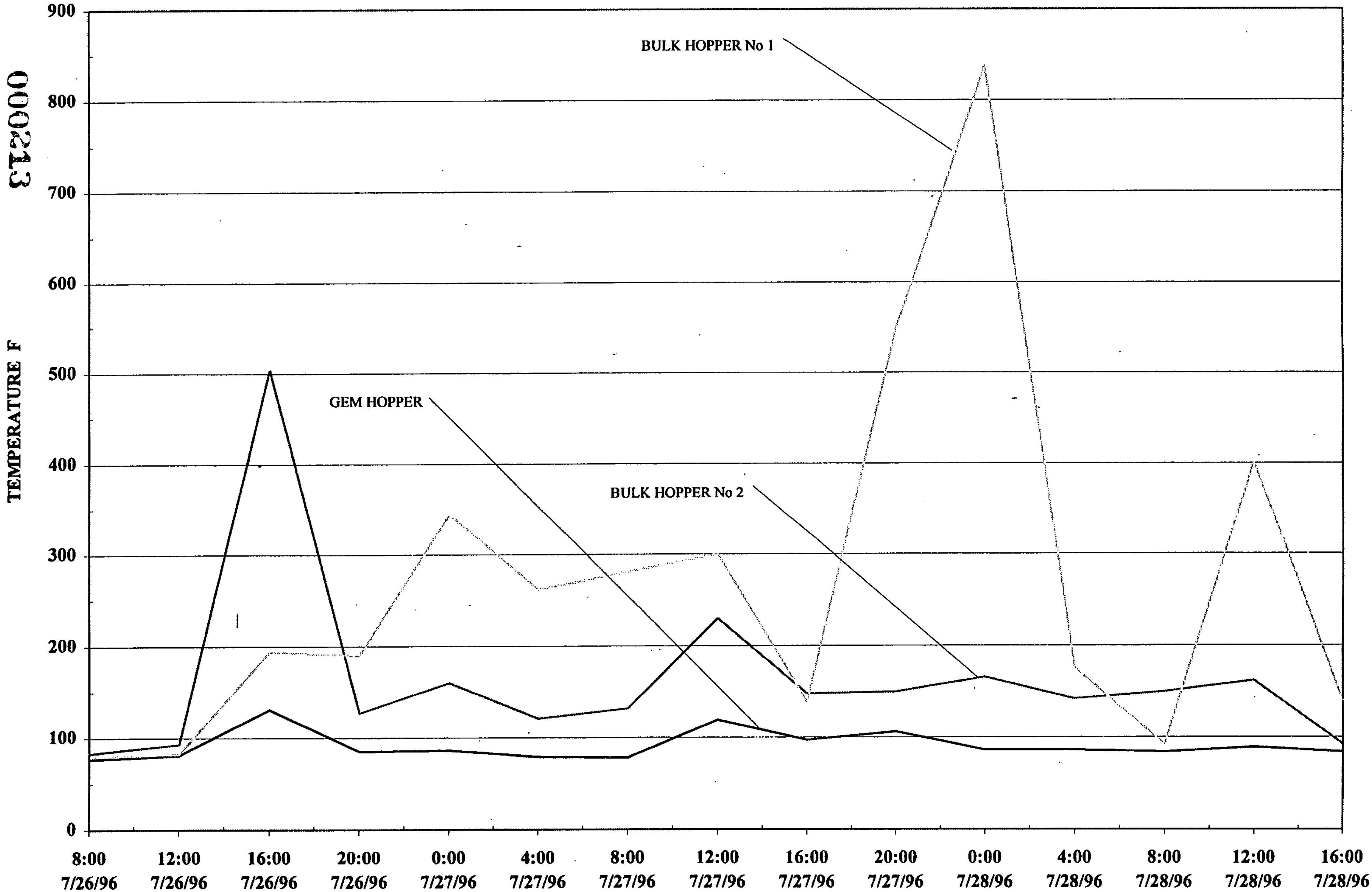
CAMPAIGN 1
GEM MACHINE SYSTEM

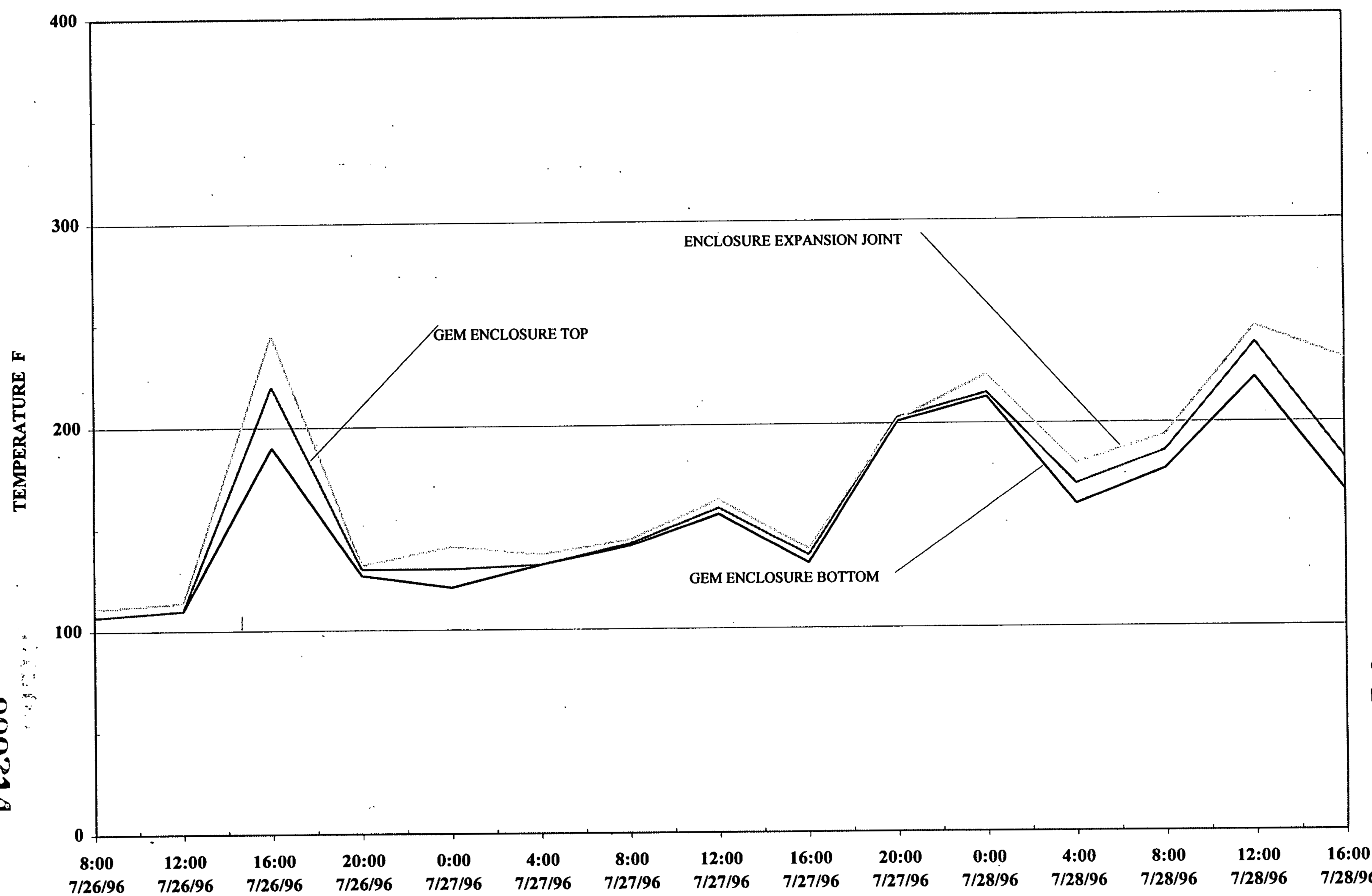


000213

C1_PTE18.XLS Chart 9

VHP 8/28/96

CAMPAIGN 1
GEM MACHINE SYSTEM



C1_PTF18.XLS Chart 14

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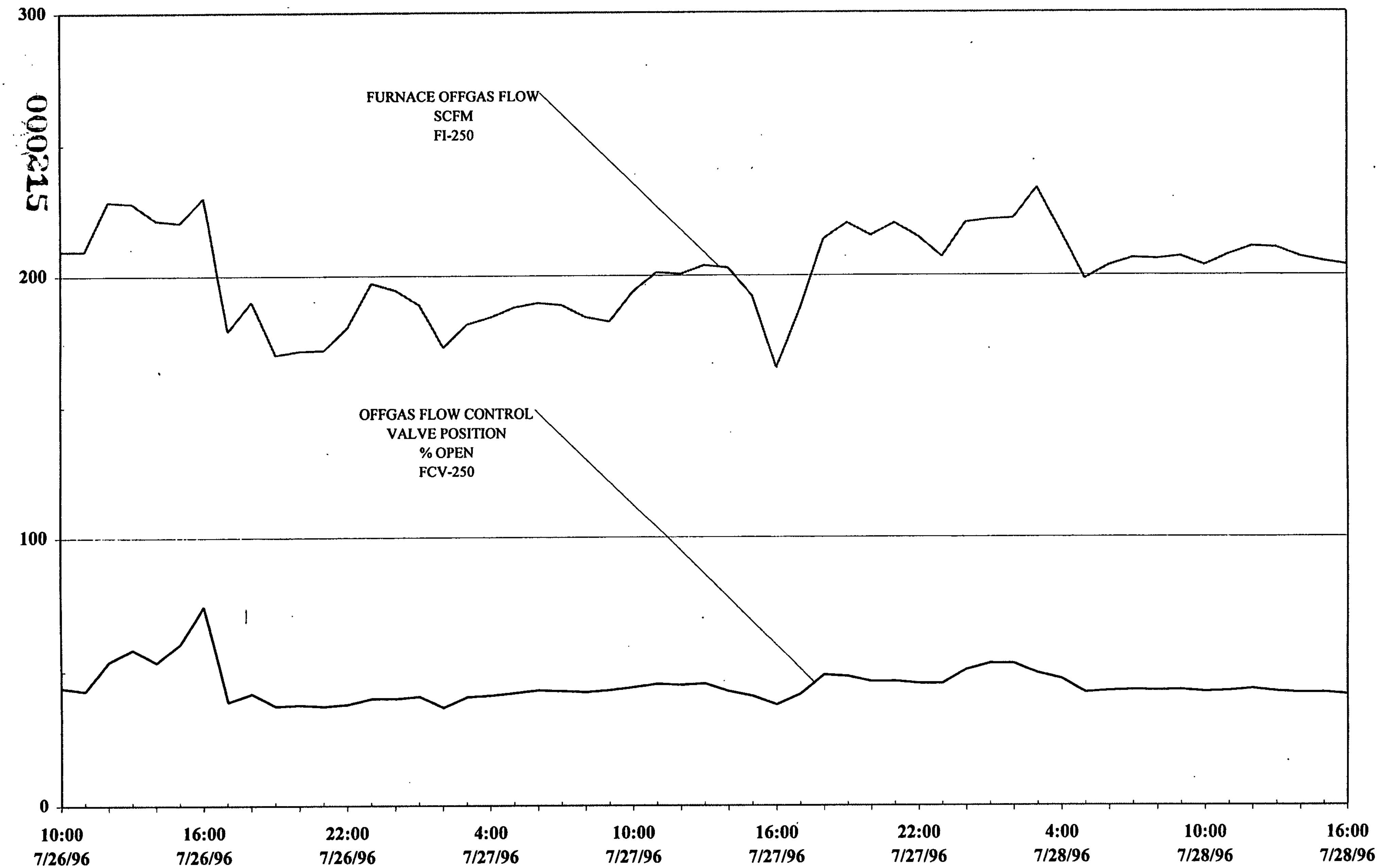
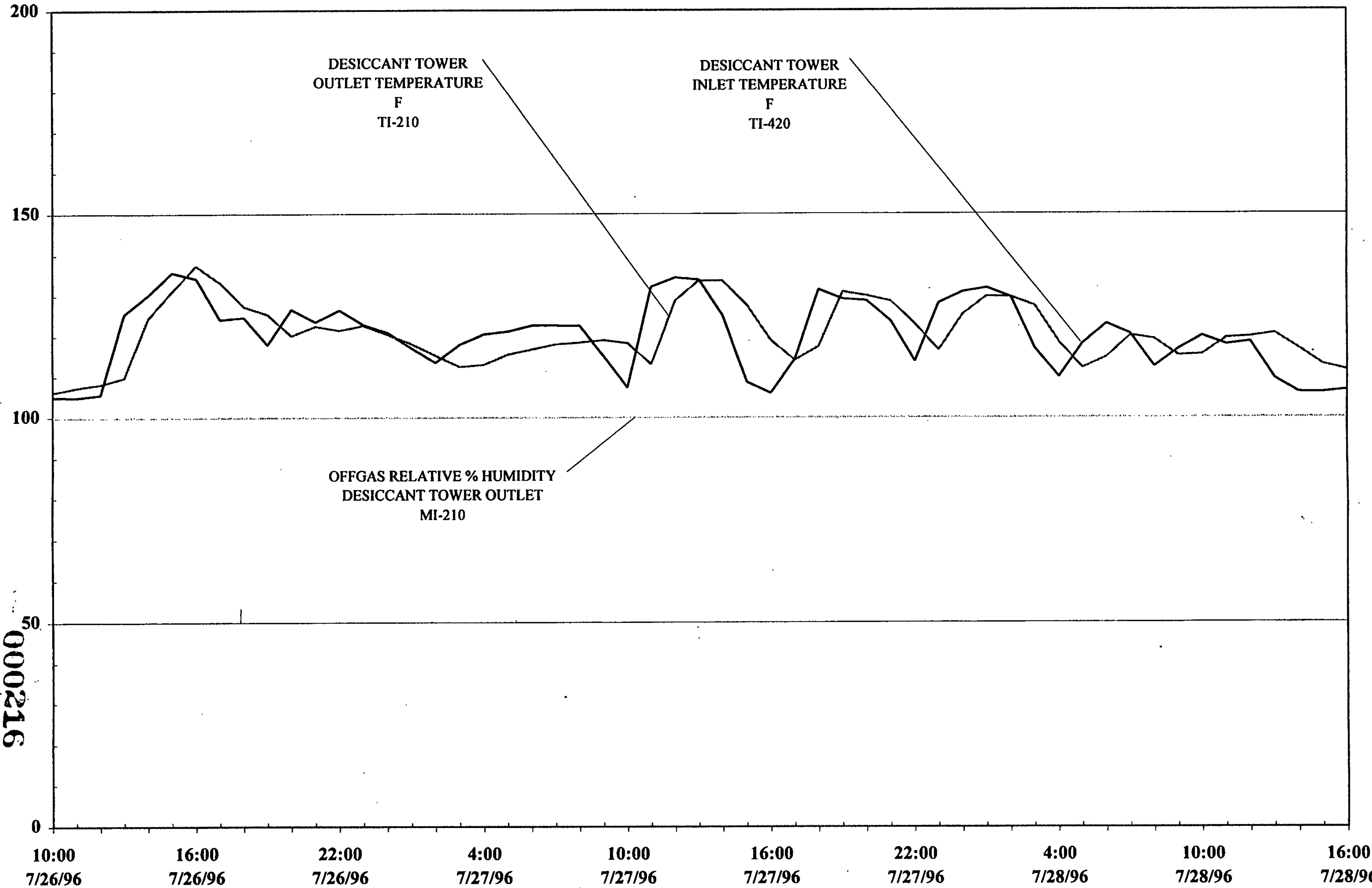
CAMPAIGN 1
FURNACE OFFGAS SYSTEM



000215

CAMPAIGN 1
FURNACE OFFGAS SYSTEM



C1_PTF18.XLS Chart 25

VHP 8/28/96

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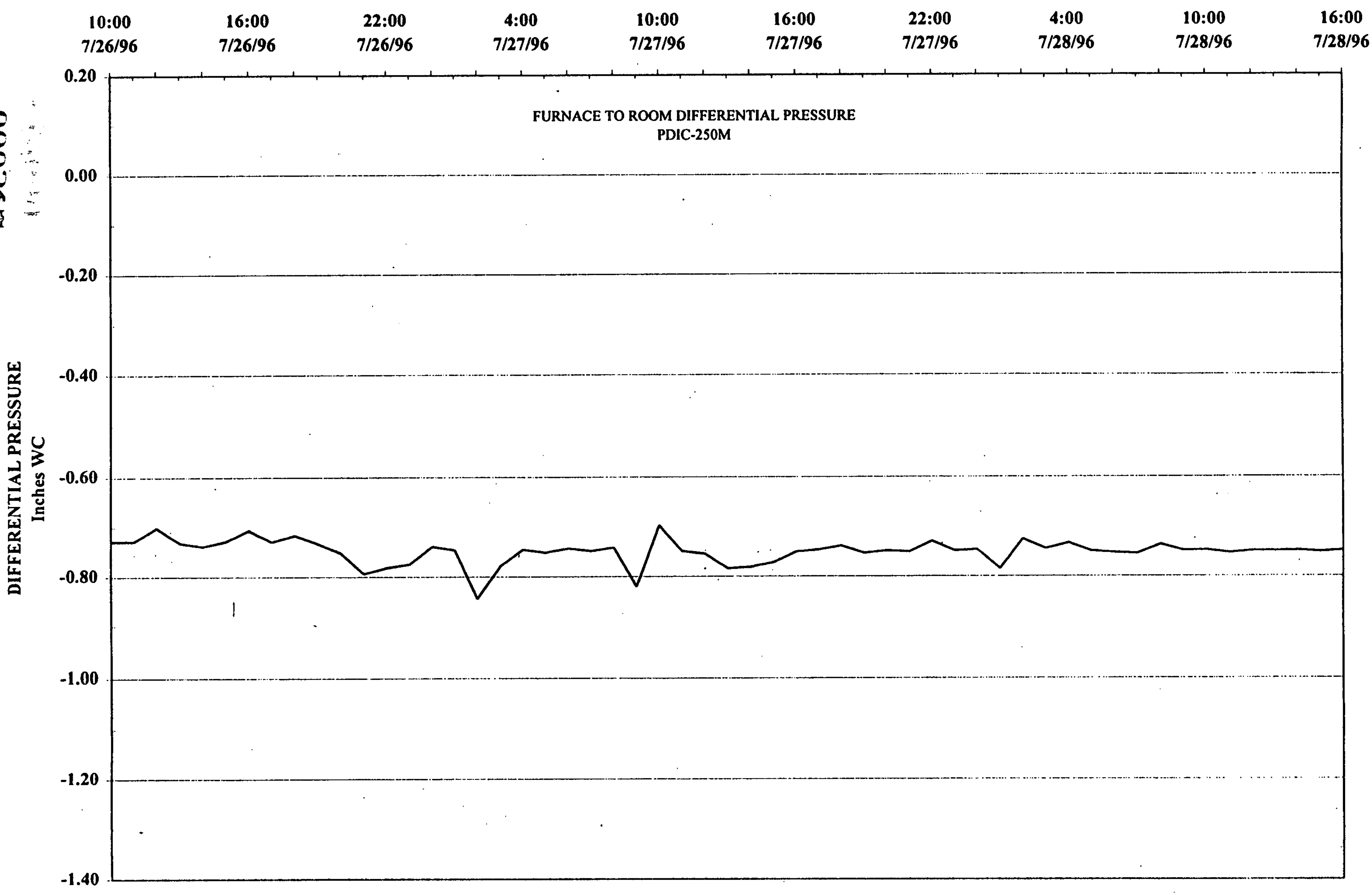
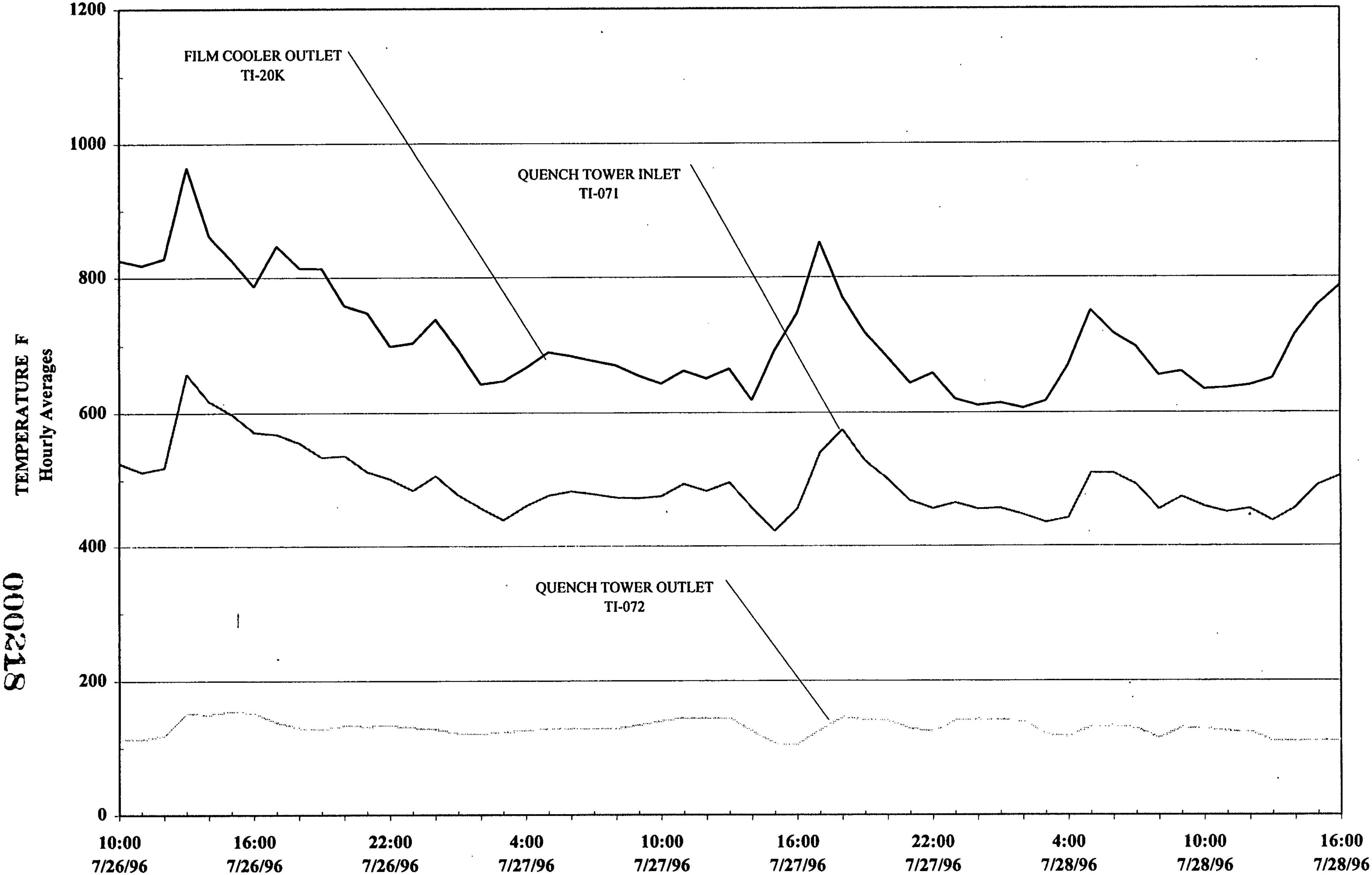
000216

CAMPAIGN 1
FURNACE OFFGAS SYSTEM



000217

CAMPAIGN 1
FURNACE OFFGAS SYSTEM



C1_PTF18.XLS Chart 24

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FURNACE OFF-GAS SYSTEM

VITRIFICATION PILOT PLANT FURNACE OFFGAS SYSTEM

CAMPAIGN 1

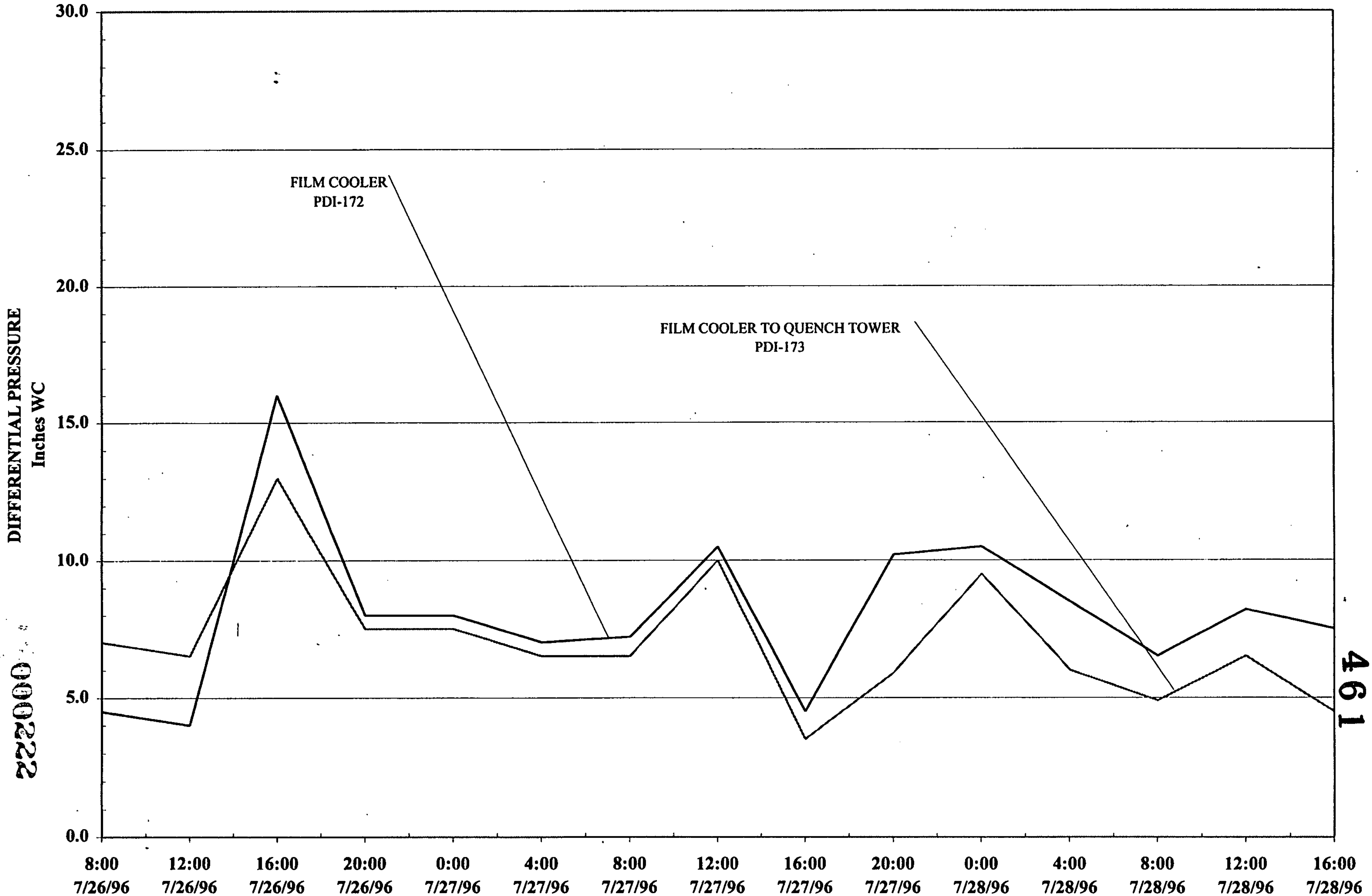
HOURLY AVERAGES

READINGS		FURNACE TO ROOM DIFF PRESS	FILM COOLER OFFGAS OUTLET	QUENCH TOWER OFFGAS INLET	QUENCH TOWER OFFGAS OUTLET	DESICCANT TOWER OFFGAS INLET	DESICCANT TOWER OFFGAS OUTLET	DESICCANT TOWER RELATIVE HUMIDITY OFFGAS OUTLET	CARBON BEDS DIFF PRESS	HEPA FILTERS DIFF PRESS	OFFGAS FLOW CONTROL VALVE POSITION	FLOW TO STACK	TOTAL STACK FLOW
		PDIC-250M	TI-20K	TI-071	TI-072	TI-420	TI-210	MI-210	PDI-190	PDI-480	FCV-250	FI-250	FI-251
DATE	HOUR	In WC	F	F	F	F	F	% RH	In WC	In WC	% OPEN	SCFM	SCFM
7/26/96	10:00	-0.728	826.06	525.19	113.06	104.97	106.19	99.95	NOT IN	-0.100	44.09	209.41	9168.50
7/26/96	11:00	-0.728	818.60	512.31	112.71	104.87	107.30	99.95	SERVICE	-0.100	42.97	209.32	9116.58
7/26/96	12:00	-0.701	828.49	519.00	118.76	105.51	108.17	99.95		-0.100	53.62	228.39	9105.51
7/26/96	13:00	-0.731	964.76	658.31	151.49	125.43	109.78	99.95		-0.100	58.11	227.86	8853.86
7/26/96	14:00	-0.738	861.88	617.25	150.24	130.21	124.41	99.95		-0.100	53.43	221.15	8559.12
7/26/96	15:00	-0.728	826.28	597.71	155.49	135.79	131.17	99.96		-0.100	60.26	220.29	8205.75
7/26/96	16:00	-0.706	787.12	571.11	151.60	134.31	137.43	99.95		-0.100	74.46	229.82	7876.36
7/26/96	17:00	-0.729	847.12	567.85	138.35	124.13	133.26	99.96		-0.100	38.85	178.90	8292.59
7/26/96	18:00	-0.716	814.66	554.89	129.70	124.70	127.32	99.96		-0.100	41.88	190.15	8271.75
7/26/96	19:00	-0.733	813.52	534.12	127.92	117.98	125.42	99.96		-0.100	37.29	170.06	8401.36
7/26/96	20:00	-0.752	758.08	536.30	133.21	126.64	120.15	99.95		-0.100	37.73	171.55	8582.07
7/26/96	21:00	-0.794	747.83	512.38	132.19	123.56	122.51	99.95		-0.094	37.22	171.80	8653.14
7/26/96	22:00	-0.782	699.05	501.34	133.36	126.44	121.51	99.95		-0.092	38.00	180.51	8707.12
7/26/96	23:00	-0.775	703.63	484.37	130.10	122.82	122.67	99.95		-0.096	40.01	197.16	8701.53
7/27/96	0:00	-0.739	738.38	506.24	127.92	120.93	120.47	99.94		-0.100	40.05	194.60	8678.73
7/27/96	1:00	-0.746	694.08	477.58	121.61	117.17	118.18	99.94		-0.100	40.76	188.97	8668.50
7/27/96	2:00	-0.846	643.13	457.31	121.22	113.55	115.29	99.94		-0.073	36.72	172.86	8930.58
7/27/96	3:00	-0.779	647.72	439.47	123.50	118.00	112.43	99.94		-0.096	40.66	181.53	9010.86
7/27/96	4:00	-0.745	667.23	460.46	126.25	120.49	112.97	99.94		-0.100	41.15	184.20	9024.15
7/27/96	5:00	-0.751	690.31	476.45	127.91	121.24	115.53	99.94		-0.100	42.00	188.06	9004.00
7/27/96	6:00	-0.743	684.53	482.65	129.71	122.70	116.81	99.94		-0.100	43.04	189.71	8909.33
7/27/96	7:00	-0.748	677.27	478.40	129.28	122.67	118.07	99.94		-0.100	42.71	188.89	8844.15
7/27/96	8:00	-0.741	670.92	473.20	128.90	122.63	118.49	99.95		-0.100	42.30	184.20	8975.91
7/27/96	9:00	-0.821	655.49	472.26	134.22	115.09	119.06	99.94		-0.092	43.06	182.50	8819.04
7/27/96	10:00	-0.697	643.62	475.01	140.12	107.27	118.36	99.95		-0.095	44.10	193.91	8679.49
7/27/96	11:00	-0.749	662.61	493.75	145.20	132.16	113.02	99.95		-0.100	45.38	201.13	8569.66
7/27/96	12:00	-0.754	651.16	483.03	144.59	134.46	128.72	99.95		-0.098	44.95	200.49	8376.67
7/27/96	13:00	-0.784	665.61	495.99	144.49	133.90	133.73	99.95		-0.093	45.45	203.76	8269.92
7/27/96	14:00	-0.781	618.60	457.29	124.70	125.02	133.65	99.96		-0.100	42.53	202.85	8222.33
7/27/96	15:00	-0.772	692.20	422.45	106.48	108.63	127.64	99.96		-0.100	40.82	192.29	8333.02
7/27/96	16:00	-0.750	746.32	455.94	105.44	105.82	118.97	99.96		-0.100	37.66	164.79	8293.98
7/27/96	17:00	-0.746	852.14	540.01	127.05	114.21	114.07	99.96		-0.100	41.48	187.19	8327.76
7/27/96	18:00	-0.738	770.80	573.86	146.04	131.43	117.41	99.96		-0.100	48.56	213.76	8280.33
7/27/96	19:00	-0.753	718.35	528.28	142.17	129.09	130.89	99.96		-0.100	47.99	219.93	8035.51
7/27/96	20:00	-0.748	682.37	501.06	140.27	128.66	129.92	99.96		-0.100	46.06	215.06	8134.58
7/27/96	21:00	-0.750	643.92	468.07	128.68	123.58	128.52	99.96		-0.100	46.20	219.83	8316.14
7/27/96	22:00	-0.729	658.59	456.08	124.42	113.73	122.93	99.95		-0.100	45.47	214.50	8565.85
7/27/96	23:00	-0.748	620.28	464.60	140.60	128.08	116.49	99.95		-0.100	45.38	206.89	8590.42
7/28/96	0:00	-0.746	610.42	455.54	143.02	130.86	125.26	99.94		-0.100	50.43	220.03	8587.03
7/28/96	1:00	-0.785	613.82	456.98	142.04	131.81	129.75	99.95		-0.096	52.69	221.22	8433.90

7/28/96	2:00	-0.725	606.34	447.03	139.32	129.56	129.61	99.95		-0.096	52.61	221.67	8399.83
7/28/96	3:00	-0.744	616.80	435.41	120.13	116.96	127.42	99.94		-0.100	49.06	233.28	8594.00
7/28/96	4:00	-0.733	670.40	442.25	116.56	109.78	118.54	99.94		-0.100	47.00	216.13	8706.86
7/28/96	5:00	-0.749	751.10	510.00	132.14	118.12	112.01	99.94		-0.100	42.03	198.62	8681.95
7/28/96	6:00	-0.752	717.52	509.51	132.61	122.98	114.81	99.95		-0.100	42.58	203.46	8660.42
7/28/96	7:00	-0.754	697.61	492.60	129.09	120.52	120.14	99.94		-0.100	42.91	206.41	8504.49
7/28/96	8:00	-0.736	655.93	454.93	114.06	112.41	119.28	99.95		-0.100	42.81	206.02	8703.97
7/28/96	9:00	-0.748	661.38	473.41	129.88	116.78	115.19	99.95		-0.100	42.95	206.99	8682.76
7/28/96	10:00	-0.747	634.70	459.20	128.15	120.05	115.49	99.95		-0.100	42.20	203.61	8443.33
7/28/96	11:00	-0.753	636.71	450.74	124.82	117.90	119.54	99.95		-0.100	42.53	207.54	8359.15
7/28/96	12:00	-0.749	640.90	455.78	124.35	118.60	119.82	99.95		-0.100	43.30	210.73	8407.08
7/28/96	13:00	-0.749	650.79	437.43	109.84	109.47	120.69	99.96		-0.100	42.28	210.31	8521.75
7/28/96	14:00	-0.748	715.24	456.49	108.96	105.99	116.97	99.96		-0.100	41.74	206.84	8539.75
7/28/96	15:00	-0.751	757.91	491.57	110.45	105.96	112.92	99.96		-0.100	41.82	205.06	8552.03
7/28/96	16:00	-0.748	787.17	505.35	111.11	106.53	111.53	99.96		-0.100	41.09	203.63	8530.93

000221

CAMPAIGN 1
FURNACE OFFGAS SYSTEM



C1_PTF18.XLS Chart 18

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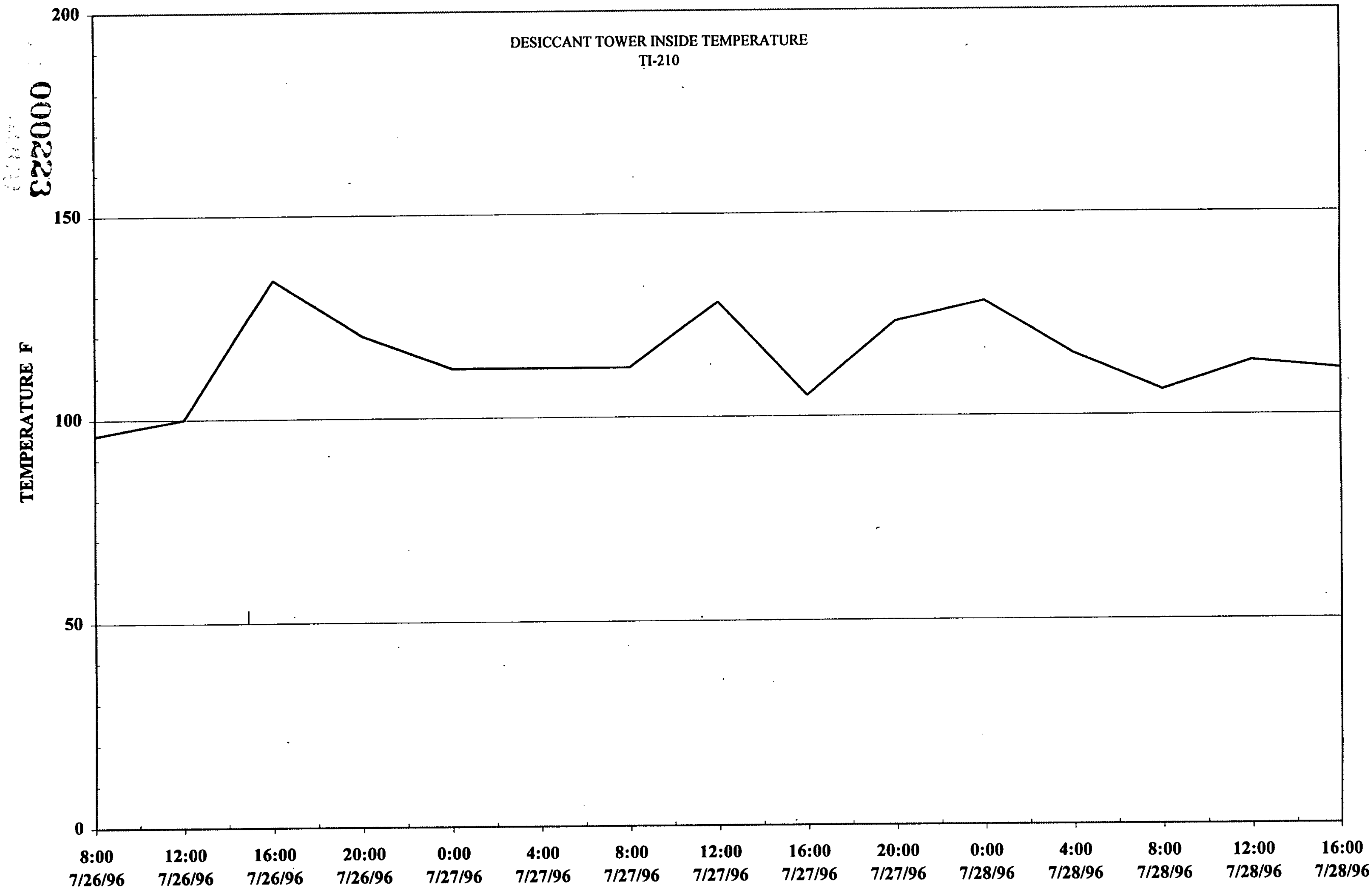
000222

CAMPAIGN 1
FURNACE OFFGAS SYSTEM



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VHP 8/28/96

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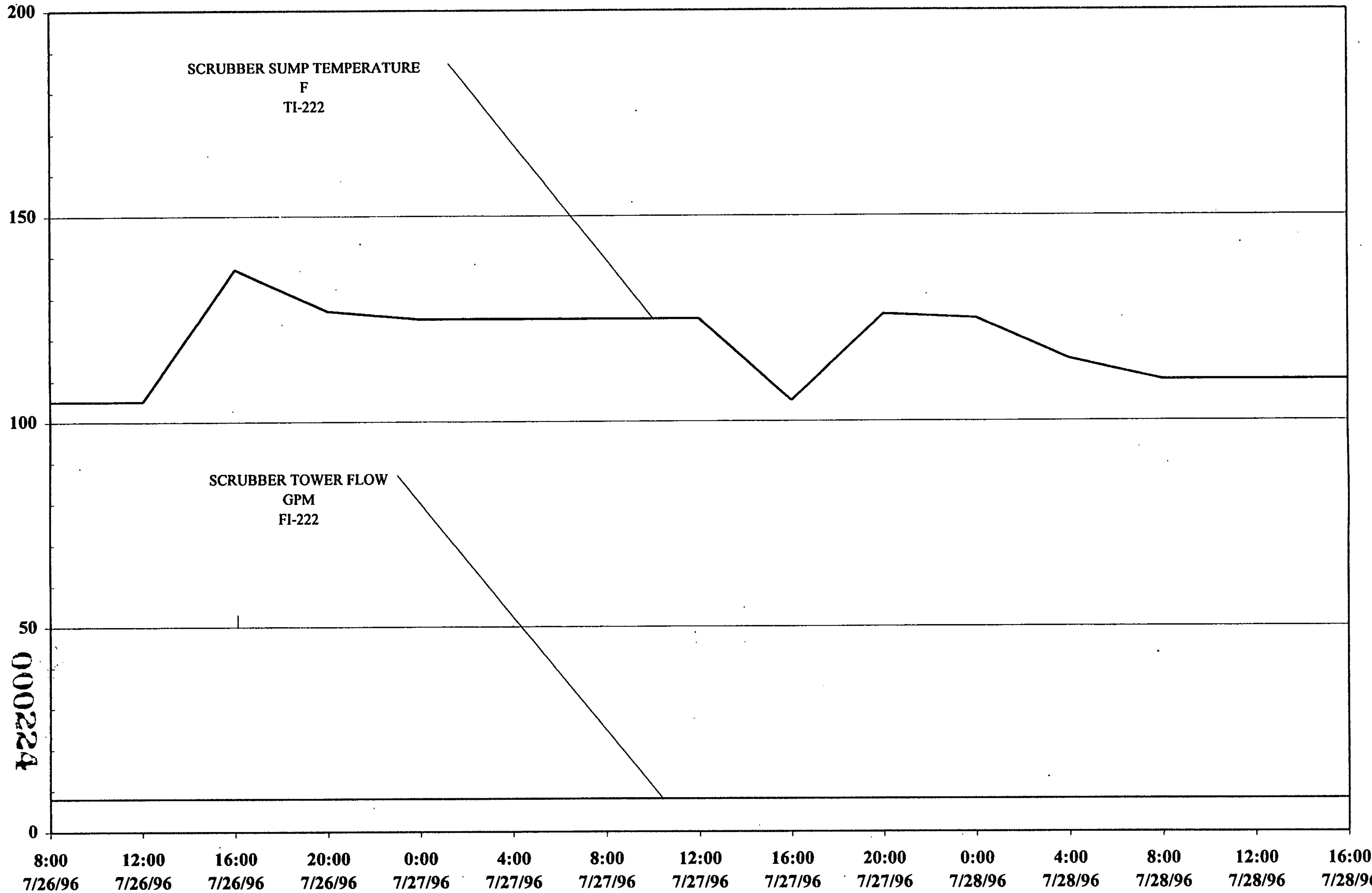

File Chart 20

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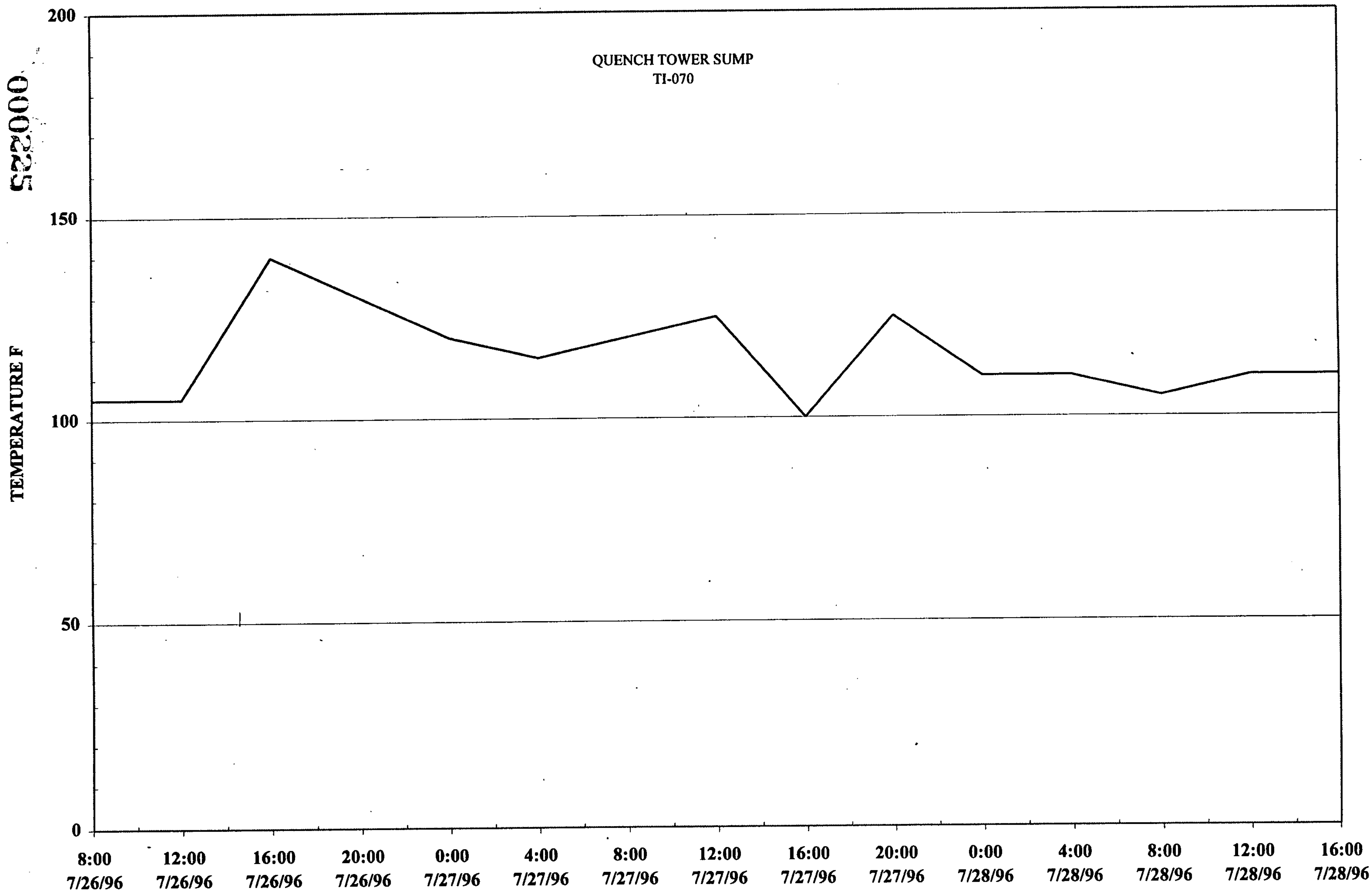
CAMPAIGN 1
FURNACE OFFGAS SYSTEM



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VITRIFICATION PILOT PLANT FURNACE OFFGAS SYSTEM									
CAMPAIGN 1									
		ROUNDSHEET DATA							
READINGS		FILM COOLER DIFF PRESS	FILM COOLER TO QT DIFF PRESS	QUENCH TOWER SUMP TEMP	SCRUBBER TOWER VACUUM	SCRUBBER SUMP TEMP	SCRUBBER TOWER FLOW	DESICCANT TOWER INTERNAL TEMP	DESICCANT TOWER VACUUM
		PDI-172	PDI-173	TI-070	PI-222	TI-222	FI-222	TI-210	PI-210
DATE	HOUR	In WC	In WC	F	In WC	F	GPM	F	In WC
7/26/96	8:00	4.5	7.0	105	INSTRUMENT	105	8	96	INSTRUMENT
7/26/96	12:00	4.0	6.5	105	OFF SCALE	105	8	100	OUT OF
7/26/96	16:00	16.0	13.0	140		137	8	134	SERVICE
7/26/96	20:00	8.0	7.5	130		127	8	120	
7/27/96	0:00	8.0	7.5	120		125	8	112	
7/27/96	4:00	7.0	6.5	115		125	8	112	
7/27/96	8:00	7.2	6.5	120		125	8	112	
7/27/96	12:00	10.5	10.0	125		125	8	128	
7/27/96	16:00	4.5	3.5	100		105	8	105	
7/27/96	20:00	10.2	5.9	125		126	8	123	
7/28/96	0:00	10.5	9.5	110		125	8	128	
7/28/96	4:00	8.5	6.0	110		115	8	115	
7/28/96	8:00	6.5	4.9	105		110	8	106	
7/28/96	12:00	8.2	6.5	110		110	8	113	
7/28/96	16:00	7.5	4.5	110		110	8	111	

Appendix C
Vitrification Pilot Plant (VitPP) - LESSONS LEARNED

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Design Criteria	Building	177	Weather delays and equipment destroyed as a result of not having adequate protection from elements. No building around the water systems (pad). Temporary structure added. Additional cost of heating facility during winter, and heat tracing and insulating lines would more than justify a bilding and HVAC system.
Design Criteria	Control Systems	8	Use logic diagrams from pilot plant Foxboro to extent feasible.
Design Criteria	Control Systems	22	Involve fire protection personnel early in design to assure acceptable deployment and fire protection instrumentation.
Design Criteria	Control Systems	43	Define deliverables for documentation of control system software
Design Criteria	Control Systems	51	Include training simulator in plant control system.
Design Criteria	Control Systems	66	Design for proper integration of thermocouples and other instrumentation into any local panels and DCS.
Design Criteria	Control Systems	83	Develop DCS/PLC architecture early.
Design Criteria	Control Systems	84	Develop functional logic diagrams, for process programmers to work from for configuration control and for basis for program verification/validation later.
Design Criteria	Control Systems	85	Develop an instrument list that can be used by project personnel through local network but with built-in security for changes.
Design Criteria	Control Systems	86	Buy electronic/instruments that are magnetic/high frequency noise free, including instrument cabling. Route instrument cabling away from SCRs, VFDs, etc.
Design Criteria	Control Systems	91	Consider purchase of smart transmitters with any purchase of new control system (can check remotely).
Design Criteria	Control Systems	180	Need additional instrumentation for complete data for future design. DCN initiated.
Design Execution	Control Systems	107	Systems Engineering or A/E select instrument set points and alarm points; implement in initial calibrations.
Design Execution	Control Systems	181	Grounding problems on DACS. Brought in additional outside contractor to help resolve problem. Need ensure that qualified personnell are avaible to suppport data system installation and maintaince.
Design Execution	Cooling Water	207	Cooling water originally contained antifreeze...This also contained small amounts of chlorides that could lead to corrosion problems. This was removed during Campaign 1.
Operation	Cooling Water	160	Water quality of cooling systems must be controlled to strick specifications

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Design Criteria	Electrical	5	Define requirements for grounding of melter, other systems as early as is appropriate. (Title I?)
Design Criteria	Electrical	55	Settle on requirements for emergency power early, and size emergency generator generously.
Design Criteria	Electrical	56	Provide normal power bypass to UPS for maintenance work on UPS.
Design Criteria	Electrical	74	Establish single line diagram early. Size power transformer with spare capacity. Use computerized calculation for load, short circuit, voltage drop and relay coordination. Establish tray and conduit routing envelope early, to avert layout interferences and signal interferences.
Design Criteria	Electrical	75	Generate standard design formats for drawings like layout, ladder diagram, connection wiring diagram, termination, cable conduit/tray routing, functional logic diagrams, grounding, lightning protection, etc.
Design Criteria	Electrical	76	Generate a electrical system description (SD) early. This SD and the design criteria will enable a smooth start in design with no guesswork.
Design Criteria	Electrical	77	Buy standard electrical equipment, do not custom build. Do not generate connection wiring diagrams; let the panel, switchgear or equipment vendor generate them based on ladder diagrams. Try to force vendors to match decided-upon wiring format for ease of checking. Do not accept catalog cuts from vendors, to maintain configuration control of documents.
Design Criteria	Electrical	79	Design grounding system properly, for installation with your foundation and footing works. Make calculation, and separate instrument grounding from power grounding. Define lightning protection requirements early. Place all these in design criteria.
Design Criteria	Electrical	81	Try to get the electric substation as close to the facility being built as close as you can, even inside the building if possible. Get load centers/MCC close to the loads. Cabling will be less and tray/conduit layout will be more manageable.
Design Criteria	Equipment	102	Specify removable insulation on pumps, valves and other equipment, as there are no insulators on FEMP maintenance staff.
Design Criteria	Feed Preparation	26	On any tanks on which load cells are used, isolate the tank physically from piping and instrumentation (flex connectors, etc.).
Design Criteria	Feed Preparation	97	Route slurry lines as directly as possible; use large radius bends instead of elbows.

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Design Criteria	Feed Preparation	145	Lines Plugging with slurry/ Line flushing has been improved however, lines are not designed for slurry transfer.
Design Criteria	Feed Preparation	146	Erosion of ball valves/ replaced selected valves with pinch valves or better ball valves
Design Criteria	Feed Preparation	147	Slurry tank agitation is poor. Material settling out in tank. Are doing off-site agitation testing to determine best agitation method.
Design Criteria	Feed Preparation	148	Dry additive system plugging. Heavy materials plug lines, moisture gets in and help causes plugging. Lines must be kept dry
Design Criteria	Feed Preparation	193	Use proven technology to handle slurry: use gravity- take conservative actions to declog and rinse piping. Locate the slurry pump in dedicated rooms. Install equipment that needs periodic maintaince in a lower RAD area.
Design Execution	Feed Preparation	144	Damage to pump diaphragms due to material selection, other problems/ parts made of new materials have been installed: Little improvement in life.
Operation	Feed Preparation	189	Start ASAP the simulation tests of the whole retrieval system
Operation	Feed Preparation	202	Slurry system has poor agitation. Agitator only reaches about two/thirds of the material in the slurry tanks. Pump recirculation is weak. However it is the only agitation when level is below the agitator. Need variable speed on agitation
Design Criteria	Gem Maker	152	Gem maker cutter needs to have water cooling... not just air cooling. need to improve seal on water cooled cutter system
Design Criteria	Gem Maker	153	maker uses excessive lubrication/water spray. Fills drum with water solution
A/E Scope of Work	General	24	FERMCO and A/E use same numbering system for DCNs.
A/E Scope of Work	General	188	Consider areas of uncertainty- Facility layout and Capacity and performance of ancillary systems
A/E Scope of Work	General	190	Incorporate "lessons learned" in the VITPP Upgrade.
A/E Scope of Work	General	195	Some functions could be shared between VITPP and Production facility: Waste water treatment, laboratory, utilities, and gem cooling/handling.
A/E Scope of Work	General	197	Have a clean separation between pilot plant and production plant operations
A/E Scope of Work	General	199	Upfront investments (safety, RAM) and planning will reduce long term costs.

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Construction	General	12	Fully define requirements for construction acceptance testing and turnover package contents in specifications (wiring checks, tests of motors, line flushing, hydrostatic testing, data sheets, submittals, QA checks, etc.). Include correction of deficiencies in subcontractor scope, estimate.
Construction	General	59	Require redlines from subcontractor upon completion of work.
Construction	General	62	Handle and stockpile soil, concrete, debris and other materials per EW-0006. Plan during design with Soil Remediation Project personnel.
Construction	General	70	Develop detailed, comprehensive inspection test plan during Title II. Involve Inspection Services personnel.
Construction	General	120	During construction, cover or plug open equipment nozzles, unconnected pipe and similar openings to prevent entry of rainwater or foreign materials.
Construction	General	122	Implement control of superseded and cancelled documents to ensure that only legible, properly marked current revisions of documents are used.
Design Criteria	General	3	Use engineered controls to minimize likelihood of contamination and radiation exposure of plant and personnel.
Design Criteria	General	4	Include high point vents and low point drains in all piping systems.
Design Criteria	General	15	Avoid putting flow meters in high points of piping systems.
Design Criteria	General	20	Specify valves to accept plant standard locks. Also, specify all process valves to avoid problems observed with VITPP manual valves (difficulty in operating valves).
Design Criteria	General	23	Do not vent tanks directly to atmosphere - use vacuum breakers or other appropriate pressure protection.
Design Criteria	General	28	Allow adequate space within and adjacent to plot for emergency egress, maintenance, operation and other foot traffic and for possible future expansion.
Design Criteria	General	34	Follow plant labeling standard (ED-12-4016) and all other applicable plant procedures (engineering, RSO, safety and others).
Design Criteria	General	38	Fix plant design capacity as early as possible to minimize later changes and rework.

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Design Criteria	General	39	Thoroughly define process and functional requirements, rest of design basis as early as possible (i.e., what facility must do) and obtain widespread agreement, then design the facility itself.
Design Criteria	General	40	Include requirements for cold and hot operational testing in facility design criteria.
Design Criteria	General	42	Avoid ratcheting effects of midstream changes in internal procedures or other requirements.
Design Criteria	General	54	Use double-valve isolation as appropriate for maintenance of equipment.
Design Criteria	General	58	Provide adequate lighting for maintenance and operation (3 to 5 footcandles).
Design Criteria	General	61	Design and construct systems for phased turnover and testing.
Design Criteria	General	67	Include provisions to facilitate maintenance of equipment, such as hoists, work platforms, etc. (note pilot plant gem maker maintenance).
Design Criteria	General	72	Establish exact design criteria for calculation requirements, sizing equipment, type of equipment, tray/conduit loading, codes and standards, etc.
Design Criteria	General	78	Establish number of sets of documents needed from vendors and list of recipients at site.
Design Criteria	General	80	Equipment specification has to be exacting, no open-ended statements. Try to buy standard equipment and off-the-shelf items (avoid custom designs) where feasible.
Design Criteria	General	82	Develop P&IDs early. Agree on the format and detail of control/monitoring representation in the PIDs. There should only be one set of PIDs and one format. Tagging of equipment/instrument should be established early to avoid costs of retagging.
Design Criteria	General	88	For sampling, use double valve arrangement, sampling cell or glovebox, or other improved system.
Design Criteria	General	103	Obtain list of prohibited products, compounds, etc., from Industrial Hygiene, and require use of approved products for cements, solvents, cleaners and other construction uses.
Design Criteria	General	119	For any outdoor equipment with containment curbs, provide means for pumping out rainwat and adequate anchoring to prevent floating.
Design Criteria	General	186	Contamination control- install SS drip trays under all pumps Paint all areas of possible contamination, to enable better clean-up
Design Criteria	General	187	Control radiation similar to production plant use shielding for sample taking and where operators are normally working.
Design Criteria	General	191	Use quick connectors for decoupling and refitting on key equipment

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Design Criteria	General	192	Have redundancy on key process equipment
Design Criteria	General	203	Provide CLEAN water supply to any mechanical seals for pumps...and proper method for supplying clean water to seals.
Design Execution	General	2	Prepare standard specifications in advance for common items such as pumps, motors, valves, instruments, HEPA filters.
Design Execution	General	9	When design is frozen, set up in advance system for tracking and analyzing root causes of DCNs. Set up categories and system for tracking and controlling costs of each DCN.
Design Execution	General	60	Before preparing Design Change Notices, concerned personnel in FERMCO engineering, construction and startup and A/E project management and design disciplines should discuss the problem and possible solutions (hold an alignment session) and spend time in the field as necessary to make sure that the solution is right.
Design Execution	General	65	Define requirements for review and checking of vendor drawings, calculations and other media as part of procurement specifications.
Design Execution	General	95	Have A/E redline drawings in the field, not the construction subcontractor.
Design Execution	General	98	Require A/E to provide lists with quality levels, inspection, other appropriate information - equipment, valves, instruments, lines, wall penetrations, other.
Design Execution	General	99	Obtain block of CMMS numbers for valves, other items before issuing numbers in design, and use CMMS numbers from design through operation to eliminate renumbering.
Design Execution	General	100	Show flanges, unions, other fittings on P&IDs.
Design Execution	General	101	Show pipe hangers on initial construction issue of piping drawings. Use typical details where appropriate.
Design Execution	General	104	As-build P&IDs, other drawings as appropriate, including equipment and other items actually installed.
Design Execution	General	106	Fully integrate various disciplines' space requirements into three-dimensional model to eliminate interferences and space allocation conflicts.
Design Execution	General	112	Visit M-Area, other melters as appropriate to obtain lessons learned and other information.
Design Execution	General	114	Implement configuration management from the inception of the project.

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Design Execution	General	115	Carry out performance grading on all structures, systems and components during Title I, in conjunction with preparation of P&IDs, hazard analysis, and hazard categorization. Document grading rationale thoroughly and obtain Technical Review Board approval. Incorporate performance grades into specifications.
Design Execution	General	118	Modify DCN forms and procedure to include performance grade, project engineering technical evaluation, and approval by Technical Review Board chair. Design engineer and project engineer should review in parallel, and DCN should be walked through the TRB during review cycle.
Design Execution	General	123	Personnel reviewing plant operating data should hold frequent discussions with operations personnel for full understanding of operational changes, test results and other considerations.
Design Execution	General	179	Access to some equipment and valves/instruments inadequate for operation and maintaince. Added stairs and platforms, relocated some equipment.
Operation	General	105	During SO testing, startup and operation, involve Engineering and Maintenance in any consideration of changes to or replacement of equipment, valves or piping.
Operation	General	198	Prove equipment with cold running. Go HOT only when you are ready.(It's expensive and time consuming when your not)
Procurement	General	1	Require construction subcontractors to submit operation and maintenance manuals on equipment they purchase during construction.
Procurement	General	11	Specify desired equipment and "or equal" salient features tightly enough to assure likelihood of getting desired item.
Procurement	General	68	Plan major procurements well in advance to phase design and construction properly and to provide vendor design for interface early in detailed design.
Procurement	General	113	Engineer responsible for design of any system should review related procurement packages.
Procurement	General	183	Ensure that when a RFP goes out that acceptable Construction Acceptance Testing requirements are included, and that Startup Turnover and Testing approves requirements.
Procurement	General	184	Define the specifications for pipe flushing. In the SPECS.
Project Management	General	17	Plan for adequate resources at FERMCO and at A/E for Title III.
Project Management	General	18	Do plastic block model on general plant layout to allow for good review of layout, proximities, operability, etc.

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Project Management	General	25	Avoid the inclusion of used equipment in the design (for example, lab trailer, pumps, stack monitors, HEPA filters and associated problems during pilot plant construction and startup).
Project Management	General	35	Thoroughly spell out all vendor requirements in specifications - deliverables, documentation (O&M manual, cut sheets), interfaces with A/E, with rest of plant and other vendors, compliance with site procedures, in-plant test procedures by vendor, spares, supplies, chemicals. A/E integrate and check vendor packages.
Project Management	General	36	Make goals of project and facility clear from the outset to all personnel and organizations involved.
Project Management	General	37	Carry out decisions and design in logical order to reduce unnecessary rework.
Project Management	General	41	Involve appropriate groups and subject matter experts from definition of design requirements on, and allow time for thorough reviews on their part. Include construction, procurement, operations, maintenance, safety and others.
Project Management	General	52	Do not split up design work - have all design done by one agency.
Project Management	General	69	Provide ample office trailer space as needed for various project personnel (construction, engineering, training, startup, etc.)
Project Management	General	93	To the extent feasible, arrange for the same engineers to do systems engineering and design, write and perform systems operability tests, start up the facility, and operate the plant.
Project Management	General	94	Institute system for transfer of information from systems operability testing and other VITPP activities to future design work.
Project Management	General	109	Design and construct plant with readiness review in mind. Functional area managers document how the plant and their activities meet specified requirements, company procedures.
Project Management	General	116	All project documents must be maintained in a single central project file, whether originated by FERMCO, A/E, vendor, construction subcontractor or other.
Project Management	General	124	The project manager should require all functional area managers to conduct readiness preparation in their areas. The project manager also needs to support training and other work by the functional area managers to learn what is needed for RA or ORR and to prepare for it.

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Project Management	General	125	The ORR plan of action should be prepared early in the project. The ORR plan of action should define who is responsible for the various areas of readiness preparation (generally the functional area managers).
Project Management	General	126	The various functional areas should review other areas' preparations for ORR to avoid gaps and inconsistencies.
Project Management	General	127	The functional areas' preparation for readiness review should be built into the master schedule.
Project Management	General	128	Readiness reports from UNH, thorium overpack, other sites and VITPP RA should be reviewed as part of the planning and execution of future VITPP ORR.
Project Management	General	129	Self-assessments by FEMP personnel not on VITPP should be conducted to make sure that the systems put into place just before RA are functioning as intended and to otherwise prepare for VITPP ORR.
Project Management	General	196	Have good characterization of site residues
Safety	General	194	Layout of facility should consider personnel path to avoid exposure, contamination, and risk.
Startup	General	21	Define during construction methods for documenting and resolving problems found by personnel from any functional area during startup and SO testing.
Startup	General	44	Define need and responsibility (Maintenance vs. construction subcontractor) for instrument calibration during Title II. Make sure requirements for documentation of any calibration are clear to subcontractor.
Design Criteria	HEPA Filters	32	Include DOP testing ports on all HEPAs. Set up to FEMP plant standards for hookup of test equipment. Include provisions for access to HEPAs by test personnel and equipment. Involve plant HEPA filtration personnel early.
Design Criteria	HVAC	14	Set up Silo 3 transfer system HEPA with DOP testing provisions, proper radiation shielding, appropriate prefilter, etc.
Design Criteria	HVAC	63	Design for proper ventilation of rooms with UPS or other batteries.
Design Criteria	Melter	10	Provide current monitor on each electrode.
Design Criteria	Melter	19	Avoid use of refractory ceramic fiber where feasible due to inhalation safety concerns.

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Design Criteria	Melter	33	Provide means for safely adding cold frit to melter (all chambers, if more than one) for testing and other purposes.
Design Criteria	Melter	53	Avoid the use of high maintenance items such as the electrode turning requirements on the pilot plant melter.
Design Criteria	Melter	108	Properly size electrode cooling water lines.
Design Criteria	Melter	150	Use of air supply for bubblers is crucial to operation. Add secondary/emergency air supplies for bubblers
Design Criteria	Melter	151	Pour spout air inleakage/discharge plugging. Need redesign on pour spout to minimize inleakage.
Design Criteria	Melter	154	Film cooler is plugging at entry point. Installed air lance is helpful...but, needs additional work.
Design Criteria	Melter	156	All bottom drains failed. Started leaking water into melter and below on floor. Need better design
Design Criteria	Melter	157	Melter does an auto discharge of glass. This causes plugging of discharge outlet.
Design Criteria	Melter	165	Premature failure of lid heaters
Design Criteria	Melter	168	Level detector consumed in melt pool
Design Criteria	Melter	204	Ensure that any new design of melters are designed so that we do not have continious auto discharge such as we have experienced with our melter.
Design Execution	Melter	111	Schedule project so that preliminary melter design is provided in time for design of off-gas, utility and other systems. Carefully define equipment interfaces and lines of communication between melter vendor, other vendors, and rest of project.
Design Execution	Melter	158	E- walls leak glass through them. Causes substantial increase in use of side chamber frit to maintain level and conductivity of side chambers.
Design Execution	Melter	161	Cooling wter lines to melter was to small. Changed to larger lines
Design Execution	Melter	162	Side chamber frit feeder inoperable.
Design Execution	Melter	163	side drain on melter, non operable. Also, A/E, Engineering forgot to install method for discharge of glass.

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Design Execution	Melter	164	Failure of Thermowells on melter. need resolution
Design Execution	Melter	166	Premature failure of I. R. detectors on side chambers
Design Execution	Melter	169	Air bubbler # 1 inoperable.
Maintenance	Melter	155	Monyo melter feed pumpcontinually fails. Seals do not hold up/ and pump is insufficient to supply melter feed at required rates.
Operation	Melter	149	development of cold cap on glass melt reduces quanity of solids to the off-gas system
Procurement	Melter	13	Include significant weight for past performance on deliverables, etc., in technical evaluation of melter vendors.
Procurement	Melter	50	Require vendor of melter and other major equipment assemble equipment off-site as much as possible. Also, require vendors to provide critical spares with equipment, or at least as part of contract.
Startup	Melter	205	Ensure that during initial startup of amy new melter, that you fully understand the thermal heat stresses to be encountered during initial heat up.
Design Criteria	Off-Gas System	29	Auxiliary / emergency off-gas system needs to match primary in design and capabilities unless justified otherwise.
Design Criteria	Off-Gas System	30	Do not use deliquescent dryer as primary means of moisture removal from off-gas. If one is used for final moisture removal, provide means for charging desiccant as appropriate for usage rate.
Design Criteria	Off-Gas System	45	Design off-gas system for control of melter pressure, not system flow.
Design Criteria	Off-Gas System	46	Place quench tower a very few feet away from the melter. Include provisions for mechanical cleaning.
Design Criteria	Off-Gas System	47	Avoid the use of a deliquescent dryer, especially as the only means of moisture removal. Consider the use of refrigeration or other means of moisture removal.
Design Criteria	Off-Gas System	49	Separate melter off-gas handling from vessel vents as appropriate. Also, use two blowers on off-gas system(s).
Design Criteria	Off-Gas System	92	Protect carbon beds from heating due to sunlight. Include roof, insulation, cooling or other.
Design Criteria	Off-Gas System	171	Rapid consumption of disiccant, possibly building up in lines. Wetting of HEPA's. Replacing of prefilters on almost daily basis. Heat tape not entirely sucessful. Need long term fix,
Design Criteria	Off-Gas System	172	Inability to DOP test filters while system on line. Need to add piping to add capability.

VIT Pilot Plant - Lessons Learned

Area	Subarea	Number	Description
Design Criteria	Off-Gas System	173	inability of off-gas system to provide desired melter vacuum. Added additional blower, limited by duct/pipe size. Inleakage higher than anticipated
Design Criteria	Off-Gas System	174	scrubber pump failures because of.seals.(multiple)
Design Execution	Off-Gas System	110	Involve melter vendor in design of off-gas system - design system, provide or review system basis and design requirements.
Design Execution	Off-Gas System	175	Quench tower has not been as effective as required. Plugging of spray nozzles. Replaced plugged spray nozzles.
Design Execution	Off-Gas System	176	Very lengthy and torturous off-gas routing, increased potential for plugging. Needto locate quench tower near melter.
Design Criteria	Piping	57	Design manually operated valves for easy access (location, chain or extension operators, etc.)
Design Criteria	Utilities	6	Include utility drops / hose hookup stations at appropriate points in facility.
Design Criteria	Utilities	7	Pipe air directly to permanent usage points such as seal pots on pumps and others.
Design Criteria	Utilities	16	Make sure that utility supplies are adequate, with plenty of allowance for expansion. (Note problems with process water to VITPP.) Consider in-house supplies for air or others if plant systems will need to be taken out of service.
Design Criteria	Utilities	64	Develop requirements for heat tracing early in project and implement consistently.
Design Criteria	Utilities	121	Include nitrogen purge for diesel fuel tanks or other means to prevent moisture accumulation, oxidation, and possible fuel contamination.
Design Criteria	Vendor Packages	31	Require vendors to number their equipment, valves, lines, instrumentation, etc., consistently with plant numbering standards. Provide blocks of numbers from project system for vendors to use.

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