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VSL-00R2590-2, Rev. 0, 08/21/00

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Office of River Protection

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Determination of the Processing Rate of RPP-WTP HLW Simulants Using a DuraMelterJ 1000 Vitrification System

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SECTION 1.0
INTRODUCTION

This report provides data, analysis, and conclusions from a series of tests that were conducted at the Vitreous State Laboratory of The Catholic University of America (VSL) to determine the melter processing rates that are achievable with RPP-WTP HLW simulants. The principal findings were presented earlier in a summary report (VSL-00R2590-1) but the present report provides additional details.

One of the most critical pieces of information in determining the required size of the RPP-WTP HLW melter is the specific glass production rate in terms of the mass of glass that can be produced per unit area of melt surface per unit time. The specific glass production rate together with the waste loading (essentially, the ratio of waste-in to glass-out, which is determined from glass formulation activities) determines the melt area that is needed to achieve a given waste processing rate with due allowance for system availability. As a consequence of the limited amount of relevant information, there exists, for good reasons, a significant disparity between design-base specific glass production rates for the RPP-WTP LAW and HLW conceptual designs (1.0 $MT/m^2/d$ and 0.4 $MT/m^2/d$, respectively); furthermore, small-scale melter tests with HLW simulants that were conducted during Part A indicated typical processing rates with bubbling of around 2.0 $MT/m^2/d$. This range translates into more than a factor of five variation in the resultant surface area of the HLW melter, which is clearly not without significant consequence.

It is clear that an undersized melter is undesirable in that it will not be able to support the required waste processing rates. It is perhaps less obvious that there are potential disadvantages associated with an oversized melter, over and above the increased capital costs. A melt surface that is consistently underutilized will have poor cold cap coverage, which will result in increased volatilization from the melt (which is generally undesirable) and increased plenum temperatures due to increased thermal radiation from the melt surface (which may or may not be desirable but the flexibility to choose may be lost). Increased volatilization is an issue both in terms of the increased challenge to the off-gas system as well as for the ability to effectively close the recycle loops for volatile species that must be immobilized in the glass product, most notably technetium and cesium.

For these reasons, improved information is needed on the specific glass production rates of RPP-WTP HLW streams in DuraMelterJ systems over a range of operating conditions. Unlike the RPP-WTP LAW program, for which a pilot melter system to provide large-scale throughout information is already in operation, there is no comparable HLW activity; the results of the present study are therefore especially important. This information will reduce project risk by reducing the uncertainty associated with the amount of conservatism that may or may not be associated with the baseline RPP-WTP HLW melter sizing decision. In addition, after the submission of the first Test Plan for this work, the RPP-WTP requested revisions to include tests to determine the processing rates that are achievable *without* bubbling, which was driven by the potential advantages of omitting bubblers from the HLW melter design in terms of reduced maintenance. Thus, a further objective of this effort became the determination of whether the basis of design processing rate could be achieved without bubbling.

Ideally, processing rate tests would be conducted on a full-scale RPP-WTP melter system with actual HLW materials, but that is clearly unrealistic during Part B1. As a practical compromise the processing rate determinations were made with HLW simulants on a DuraMelterJ system at as close to full scale as possible and the DM 1000 system at VSL was selected for that purpose. That system has a melt surface area of 1.2 m^2, which corresponds to about one-third scale based on the specific glass processing rate of 0.4 MT/m^2/d assumed in the RPP-WTP HLW conceptual design, but would correspond to larger than full scale if the typical Part A test results of about 2.0 MT/m^2/d were realized. The DM 1000 system was used with the existing off-gas treatment system in order to expedite the collection of this information; while that system is somewhat different from the RPP-WTP conceptual design, that should have no effect on the processing rate measurements. Subsequent tasks supported the later modification of that off-gas system to obtain large-scale system performance information on the baseline off-gas design and those modifications are now complete. Work planned for Part B2 includes similar pilot-scale testing with the prototypical off-gas system.

Three HLW simulant compositions were used in the present tests: the tank AZ-101 waste (the first B2 HLW feed to the RPP-WTP), the 106-C/AY-102 blend (the largest B2 HLW tank), and the HLW composition processed at West Valley. Even though certain differences exist between the RPP-WTP and West Valley HLW compositions and the respective melter designs, West Valley represents the closest relevant full-scale operating experience base. Thus, by conducting tests with a West Valley simulant on the same melter, a direct connection to that experience base can be established to provide additional confidence in the projection of the results obtained with RPP-WTP feeds to full-scale.

This report provides the test data that were collected; analysis and discussion of those data, as well as the principal findings and conclusions from the melter tests; the measured glass production rates for the three compositions for a variety operating conditions; and results from the analysis and characterization of the glass product and the melter exhaust.

1.1 Test Objectives and Overview

The principal objectives of this work were to:

$ Obtain glass production rate data for simulated AZ-101, C-106/AY-102 blend, and West Valley HLW streams combined with pretreatment products and suitable glass forming additives using the DuraMelterJ 1000 vitrification system.

$ Obtain data on the effects of key operating parameters (feed water content and glass bubbling) on glass production rates.

$ Identify possible processing problems such as foaming, secondary phase formation, and poor cold cap characteristics, which may not have been apparent in small-scale melter tests.

Secondary objectives include:

$ Collect data to characterize the melter off-gas emissions.

$ Collect data on product glass composition and product quality.

$ Collect data on mass balance across the melter.

$ Collect operating data with a simulated ADS melter feed system (i.e., intermittent, pulsed flow of feed to the melter).

$ Collect data on post-HEME emissions.

A series of melter system tests were conducted with the primary purpose of determining throughput rates with the HLW simulants over a range of operating conditions. Enough feed was supplied by an outside vendor to produce 10 metric tons (MT) of glass for both the AZ-101 and C-106/AY-102 blend and 7 MT for the West Valley composition. For the purpose of these tests, adequate turnover of the existing glass inventory in the melter to the desired glass composition was taken to be the production of between 2.8 and 3.8 MT of glass. Since the nominal inventory of the DM 1000 is about 2.5 MT, this corresponds to approximately 1.1 to 1.5 melter volumes. While this is less than the 3 melter volumes that is typically used, it was a reasonable compromise, given the expense of these large-scale tests. However, efforts were made to discharge as much of the current glass inventory as possible prior to feeding the next HLW composition to maximize the extent of the compositional turnover. During the turnover period, scoping data with respect to parameters such as feed characteristics, cold-cap stabilization times, effects of melt bubbling and melt temperature, and general system operating characteristics were collected.

1.2 Melter System Description

A schematic diagram of the DuraMelterJ1000 vitrification system that was used for these tests is provided in Figure 1.1; the system is of similar design to the one used for the tests conducted at VSL for Westinghouse Hanford Company in the 1994 Phase I Hanford LLW Melter Vendor Tests. Sampling points (Sx) and data collection points (Dx) are also indicated in that diagram.

1.2.1 Feed System

The feed material for these tests was prepared and controlled according to VSL specifications by a chemical supplier, as detailed in Section 2. Each batch of feed slurry was shipped to VSL in lined 55-gallon drums, which was staged for unloading into the mix tank. A high-torque, variable-speed, drum mixer was used to homogenize the feed in the drums prior to pumping the contents to the mix tank. Water and sugar were added (as needed) at this stage to ensure complete mixing. Both the mix tank and the feed tank are 750-gallon polyethylene tanks with conical bottoms that are fitted with mechanical agitators. Five calibrated load cells directly mounted on the legs of the feed tank are used to measure additions to and removal from the feed tank and are electronically monitored to determine the feed rate to the melter. The requisite amount of feed is pumped to the feed tank from the mix tank and measured amounts of additional water are combined with the feed at this point for the high-water feed tests. The material in the feed tank is constantly recirculated from the feed tank discharge outlet, at the tank bottom, to the tank inlet at the top, which provides additional mixing.

The way in which the feed is introduced into the melter is designed to mimic the operation of an ADS pump, which is the present RPP-WTP baseline. The recirculation loop extends to the top of the melter where feed is diverted from the recirculation loop into the melter through two parallel Teflon-lined feed lines and water-cooled feed tubes. Three computer-operated pinch valves, one on each of the feed lines and one on the recirculation loop, are activated in a timed sequence to introduce feed into the melter at the desired rate. The feed rate is regulated by adjusting the length of each pulse, the time between each pulse, and the pressure applied to the recirculation loop. A compressed air line is attached to each of the feed lines and can be used to automatically clear the feed lines into the melter after each pulse.

1.2.2 Melter System

Capabilities at VSL for melter runs include DuraMelterJ 10, High-Temperature 10, DuraMelterJ 100, and DuraMelterJ 1000 joule-heated ceramic melter systems with processing rates of tens to thousands of kilograms of glass per day. The DuraMelterJ 1000 unit was recently replaced by a DuraMelterJ 1200, which is a one-third scale prototype of the RPP-WTP baseline HLW melter. The smaller systems provide the ability to quickly and economically examine wide ranges of operating conditions, while the larger system is expected to provide more accurate predictions of processing rates and characteristics for the full-scale systems projected for the RPP-WTP.

The DuraMelterJ 1000 is a joule-heated melter with Inconel 690 electrodes and thus has an upper operating temperature of about 1200EC. The footprint of the melter is approximately 6 ft. by 6 ft. with a 2 ft. by 4 ft. air-lift discharge chamber appended to one end; the melter shell is 9 ft. tall. The glass contact refractory is Monofrax K-3 while the plenum area walls are constructed of Monofrax H refractory. The surface of the glass pool is about 42" on a side and the glass depth is nominally 38". The resultant melt volume is approximately 67,000 cubic in. (1100 liters), which represents a glass tank capacity of more than 2.5 metric tons of glass. Each of two opposing walls of the tank has a pair of flat plate electrodes. The bottom electrodes are 12" by 42" and the top electrodes are 10" by 42", giving an electrode area per pair of about 925 sq. in. The plenum space extends about 35" above the melt surface. Under normal operating conditions the melt level would be between about 1-5 inches above the top of the electrodes, but this is adjustable.

The refractories are contained in an inner shell with penetrations for drains and electrode busses. The melter has a bottom drain that can be used to drain the melter completely. There are various ports on the top plate of the melter that will accommodate the feed tubes, thermocouple wells, plenum heaters, bubbler assemblies, and viewing ports.

The power to the melter electrodes (288 kW designed power) is controlled by programmable process controllers. The thermal mass of the DuraMelterJ 1000 is relatively large and the time constants for temperature control of the melt are very long (hours). It is convenient to control the process temperature by configuring the process controller to control power and adjusting the power set-point as needed to maintain the desired operating temperature. Alarms can be set to detect out-of-range temperatures or power in the melter. The top and bottom electrode pairs are powered from separate but same-phase circuits and have independent controllers. It is possible to skew the power supplied to the top or the bottom of the melt pool by adjusting the power to each pair independently. Backup process controllers are installed to be used in case of failure of the main controllers.

1.2.3 Off-Gas System

Since the processing rate information that is the subject of these tests impacts directly on major system sizing decisions, it was decided to use the DM 1000 system with the existing off-gas treatment system (Figure 1.1) in order to expedite the collection of this information. While that system is somewhat different from the RPP-WTP conceptual design, that should have no effect on the processing rate measurements. Subsequent tasks supported the later modification of that off-gas system to obtain large-scale system performance information on the baseline off-gas design.

The exhaust gases from the melter first pass through a film cooler located directly above the melter. Cooling air is injected into the gas stream in the film cooler in such a manner as to minimize the deposition of solids and to maintain a sufficiently high gas velocity (~50 ft/sec) to entrain particulates in the gas stream. The gases exiting from the film cooler pass through a long, straight transition pipe that has gas sampling and measurement ports positioned in accordance with EPA methods. The downstream end of the transition pipe (quencher section) includes water sprays for further cooling of the gas and removal of coarse particulate matter from the transiting gas stream. The liquid then drains into the scrubber sump while the gas passes through the vertical packed-tower scrubber where it contacts a counter-current flow of spray water. The scrub liquors with entrained particulates are collected in the scrubber sump. Liquid is pumped from the sump through a plate-frame heat exchanger to the top of the scrubber tower where it is used as the tower spray liquid. The pH of sump liquid is monitored and maintained mildly to strongly basic by additions of sodium hydroxide solution. Periodically, some of the sump liquid is pumped to a blow-down tank for analysis, evaporation, and ultimate disposal.

The gas exiting from the scrubber next passes through a high-efficiency mist eliminator (HEME) to remove fine soluble particulates from the gas stream. This filtered particulate is then dissolved by an internal water spray that impinges directly on the HEME filter. The spray water is collected in the lower chamber of the HEME and then pumped to the scrubber sump. The exiting gases next pass through an in-line electric resistance heater that reheats the gas to a temperature sufficiently above its dew point to prevent condensation of water vapor in the gas downstream of the heater. The remaining processing of the off-gas stream consists of dry gas filtering. The gas passes through a damper, booster blower, and a heated dilution air source, which serve to further condition the temperature, quantity, and pressure of the gas stream. Further downstream, each of two bag houses, which are piped in parallel and operated alternately, are used to remove fine particulates. The bag house filters are typically pre-coated with a powdered filter aid (usually, diatomaceous earth (DE)). The particulate is captured in the DE and periodically blown down with pulsed air jets. The particulate-DE mixture is collected for sampling and disposal. A HEPA filter provides the final filtration step. The main system blower provides suction on the system sufficient to maintain the desired negative pressure on the melter. The discharge of this blower is to the building stack.

1.3 Quality Assurance

This work was conducted under an NQA-1 based quality assurance program that is in place at VSL. The program has been frequently audited by representatives of GTS Duratek and various DOE sites and contractors over many years and, most recently, by BNFL, Inc. This program is supplemented by a Quality Assurance Project Plan for RPP-WTP-B1 work that is conducted at VSL, which includes the correlation of the VSL QA program with the contractually imposed 10-CFR-831.120.

SECTION 2.0
WASTE SIMULANT, GLASS FORMULATIONS, AND FEED ANALYSIS

2.1 AZ-101 Composition

2.1.1 Waste Simulants

The AZ-101 HLW simulant that was used for these tests is based on waste compositions provided in the Tank Waste Remediation System Operation and Utilization Plan (TWRS-OUP) [1]. The TWRS-OUP provides inventory information on 24 major waste components, which is, for the most part identical to that found in the Best Basis Inventory (BBI) database [2]; the exceptions are mercury, which is omitted in the TWRS-OUP, and strontium, for which the higher of the two values was assumed in this work. The TWRS-OUP, in addition to total inventories, provides the information on the partitioning of those inventories into solid and supernatant fractions that is needed to define waste simulants. The chemical wash factors that are provided in the TWRS-OUP were applied to the solid fractions in defining the AZ-101 simulant. For waste components that are not tracked in the TWRS-OUP or the BBI, data from the HLW Feed Staging Plan [3] based on the recommended number of in-tank sludge washings were used. No radionuclides or noble metals were included and all constituents present at less than 0.05 wt% (waste oxide basis) were omitted. In addition, all of the TOC was assumed to be oxalate and the small amounts of boron, lithium, and zinc were omitted since much greater amounts are present in the glass forming additives.

A total of 32 chemical components are present in the resulting simulant for the washed AZ-101 HLW (Table 2.1). This HLW material must then be blended with the projected products from LAW pretreatment to complete the waste simulant formulation. These pretreatment processes (Cs and Tc removal by ion exchange and Sr/TRU removal by Sr/permanganate precipitation) lead to increases in the amounts of cesium, technetium, sodium, nitrate, strontium, and manganese in the HLW material. The pretreatment products from technetium removal, which contribute technetium, sodium, and nitrate, were neglected in the simulant since the impact on nitrate is relatively small (75 liters of Tc concentrate vs. 3,811 liters of Cs concentrate [4]) and sodium is used as a glass forming additive. The quantities of pretreatment products to be combined with the AZ-101 HLW material were calculated based on References [4] and [5]. In particular, 7.71% of the total Sr/TRU precipitate from pretreatment of Envelope C waste is to be added to AZ-101 waste, which is equivalent to (78 MT x .0771) = 6.01 MT of strontium and (38 MT x .0771) = 2.93 MT of manganese. The strontium precipitate will probably consist of a combination of carbonate and hydroxide. We have assumed that the carbonate is predominant and have included 3 g of carbonate per 100 g of oxides in the simulant (no carbonate is present in the washed HLW material as a consequence of the assumed 100% wash factor for carbonate [1]). The composition of the resulting

AZ-101 simulant mixed with pretreatment products is summarized in Table 2.1.

2.1.2 Glass and Melter Feed Formulations

Glass formulations developed at VSL for the AZ-101 simulant accommodate the recent replacement of iron by manganese for Sr/TRU removal and meet the processing and product quality requirements. The glass composition selected for these tests, HLW98-31, is presented in Table 2.1. On an oxide basis, this glass incorporates 27.0 wt% of Envelope D waste and 3.5 wt% of pretreatment products; the resulting MnO content is 3.03 wt%. Crucible and DuraMelterJ 10 tests have been conducted to determine that this glass meets all processing and performance requirements. The measured viscosity and conductivity at 1150EC are 43 P and 0.41 S/cm, respectively. Heat treatment of HLW98-31 at 950E for 70 hours resulted in 0.26 vol% of spinel while the glass was completely homogeneous after 66 hours at 1050EC. The glass performs considerably better than the DWPF EA glass on the PCT procedure and also shows good TCLP performance: the Cd concentration in the TCLP leachate is 0.067 mg/l, compared to the Universal Treatment Standard (UTS) level of 0.11 mg/l, while all other constituents are below their respective UTS levels by much wider margins.

The additional constituents required to form HLW98-31 glass from the AZ-101 simulant are boron, lithium, sodium, silicon, and zinc. The corresponding chemical additives that are the sources for these elements were selected based upon cost and compatibility with the vitrification process. As an example, lithium hydroxide monohydrate was selected over lithium carbonate to minimize the foaming that is often observed with carbonate-rich feeds and was observed in the supporting DM10 tests (VSL-00R2501-1). The theoretical glass yield of the resulting feed is 0.39 kg of glass per kg of feed, which is equivalent to 0.57 kg of glass per liter of feed based on the estimated density of the feed of 1.47 g/ml (measurements on a similar, but not identical, feed gave a density of 1.33 g/ml). The water content of the feed is about 57% by weight.

Table 2.2 lists the starting materials and amounts required to generate the target AZ-101 simulant and feed. The selected feed vendor, NOAH Technologies Corporation, prepared the feed in batches based on their production capacity of about 4,000 kg per batch. A total of about 26 MT of feed, which resulted in 10 MT of glass, was delivered to VSL for these tests. The formulation was specified by VSL based on chemical assays of the raw materials provided by NOAH, or as necessary, assay samples of those materials performed by VSL. Pre-approval samples of the NOAH feed were analyzed by VSL prior to acceptance for shipment of the corresponding batch.

2.2 C-106/AY-102 Composition

2.2.1 Waste Simulants

The C-106/AY-102 HLW simulant blend used for these tests was based on waste compositions found in the Tank Waste Remediation System Operation and Utilization Plan (TWRS-OUP) [1, 6]. The TWRS-OUP provides inventory information on 24 major waste components which is, for the most part, identical to that found in the Best Basis Inventory (BBI) database [2]. The TWRS-OUP also provides information on the partitioning of the inventories into solid and supernatant fractions that is needed to define HLW simulants. Revision 1 of the Plan [1] partitions the waste in C-106 only and so the information in Revision 0 [6] was used for AY-102. Considerable discrepancies exist between the two revisions on the inventories of aluminum, calcium, fluorine, phosphate, and silicon in AY-102. The solid contents of these components in AY-102 were arrived at by subtracting the liquid fraction found in Revision 0 from the BBI inventories listed in Revision 1. Revision 1 of the TWRS-OUP also provides the wash factors that are to be applied to the solid fractions. For waste components that are not tracked by the BBI, data from the HLW Feed Staging Plan [3] based on the recommended number of in-tank sludge washings were used. Additional data from a sludge washing study conducted on C-106 material [7] were also used. All radionuclides, noble metals (excluding silver), and constituents present at less than 0.05 wt% (waste oxide basis) were omitted. Finally, all of the TOC was assumed to be oxalate and the small amounts of boron, lithium, and zinc were omitted since much greater amounts are present in the glass forming additives.

A total of 33 chemical components are present in the resulting simulants for the washed C-106 and AY-102 sludges. Different blending ratios are found in various data sources and the simulant used in these tests assumed that 85% of the solids in each tank will be retrieved and combined. The resulting waste blend composition, on an oxide basis, is given in Table 2.3. This HLW material must be further blended with products from LAW pretreatment to complete the simulant formulation. These pretreatment processes (Cs and Tc removal by ion exchange and Sr/TRU removal by Sr/permanganate precipitation) lead to increases in the amounts of cesium, technetium, sodium, nitrate, strontium, and manganese in the HLW material. The sodium and technetium pretreatment products from technetium removal were neglected in the simulant since technetium is radioactive and sodium is used as a glass-forming additive.

The assumed quantities of pretreatment products to be combined with the C-106/AY-102 HLW material are different than those found in Reference [4], which preceded the change to a manganese-based pretreatment process. The difference is due primarily to differences in the projected mass of glass to be produced, which in turn is due to the difference in silver concentrations employed in the present case and in Ref. [4]. Since silver can be the constituent that limits waste loading (based on Specification 1), the difference has a major impact on the total amount of glass produced and, therefore, the amount of pretreatment products incorporated. The calculations in

Ref. [4] assumed a total silver inventory of 2,400 kg for C-106/AY-102, based on data from Reference [8]. Other references, however, suggest that the actual amount of silver present is much lower. For example, analyses of washed C-106 sludge found a silver concentration of 1,260 μg/g [7], which is equivalent to a silver inventory of 332 kg in C-106 when it is scaled to the BBI concentration of iron, the most abundant element in the washed solid. Preliminary results from a more recent study suggest an even lower silver concentration of 461 μg/g in the washed C-106 sludge [9]. The concentration of silver in AY-102 is found to be higher but the total amount of solids is only about 15 % of that in C-106 [3]; analytical data on washed AY-102 sludge are not available. Given these discrepancies and the impact of the higher value on the waste loading, we have elected to adopt the inventory information in the HLW Feed Staging Plan [3], which shows a total of 1,603 kg of silver in the C-106/AY-102 sludge. This value is high enough to be quite conservative based on tank sample analytical data but low enough to avoid skewing the entire waste + pretreatment product and glass compositions. This lower assumed silver inventory leads to a projected 666.7 MT of glass (which exceeds the Specification 1 minimum for Al_2O_3+Fe_2O_3+ZrO_2), compared to 876.5 MT of silver-limited glass [4]. The blending ratio of Sr/TRU pretreatment products for C-106/AY-102 was then calculated with the assumption that the products will be distributed on a mass-of-glass basis among the first three B2 tanks (AZ-101, AZ-102, and C-106/AY-102). The calculated ratio for C-106/AY-102 is then 49.19 %, meaning that (78 MT x 0.4919) = 38.37 MT of strontium and (38 MT x 0.4919) = 18.69 MT of manganese from Sr/TRU precipitation will be combined with that waste [5]. In the simulant, the strontium precipitate is assumed to consist of strontium carbonate. The resulting composition of the simulant to be used in these tests, which is the C-106/AY-102 HLW material mixed with pretreatment products, is summarized in Table 2.3. Note, in addition, that the contents of chloride, fluoride, and sulfate, which would otherwise have been somewhat smaller, have been increased to 0.05 wt% for analytical purposes.

2.2.2 Glass and Melter Feed Formulations

Glass formulations have been developed for the C-106/AY-102 simulant that accommodate the recent replacement of iron by manganese for Sr/TRU removal and meet the processing and product quality requirements. The glass composition selected for these tests is identical to HLW98-34 and is given in Table 2.3. On an oxide basis, HLW98-34 incorporates 39.42 wt% of Envelope D waste and 11.58 wt% of pretreatment products; the resulting contents of MnO and SrO are, respectively, 4.44 wt% and 7.35 wt%; the total of Al_2O_3+Fe_2O_3+ZrO_2 is 22.72 wt%, which exceeds the Specification 1 minimum. Crucible tests have been conducted to determine that the HLW98-34 glass meets all processing and performance requirements. The measured viscosity and conductivity at 1150EC are 39.6 P and 0.39 S/cm, respectively. Heat treatment of HLW98-34 at 950EC for 48 hours resulted in 0.70 vol% of spinel. The glass also shows good TCLP and PCT performance:

TCLP leachate concentrations are below the UTS limits and the normalized PCT leach rate of boron after 7 days is 0.05 $g/m^2/d$ (pH of leachate = 9.75), which compares favorably with the SRL-EA reference glass, which has a boron leach rate of 1.25 $g/m^2/d$ (pH of leachate = 11.57).

The additional constituents required to form the target glass from the C-106/AY102 simulant are boron, lithium, sodium, silicon, and zinc. The corresponding chemical additives that are the sources for these elements were selected based upon cost and compatibility with the vitrification process. The theoretical glass yield of the resulting feed is 0.365 kg of glass per kg of feed, which is equivalent to 0.51 kg of glass per liter of feed for an assumed feed density of 1.4 g/ml.

Table 2.4 lists the starting materials and amounts required to generate the target C-106/AY-102 simulant and feed. A total of about 27 MT of feed was made for these tests, which was sufficient to produce 10 MT of glass. The feed material had a measured density of 1.49 g/ml, a pH of 12.92, and a water content of 56.84 wt%. A crucible melt of the feed material at 1150EC yielded 0.372 kg of glass per kg of feed (0.554 kg of glass/liter of feed).

2.3 West Valley Composition

2.3.1 Formulation of Melter Feed

A detailed information package on West Valley feed characteristics, processing rates, and operating conditions was obtained from West Valley Nuclear Services Company, Inc. through the RPP-WTP for this work [10]. The data for "Batch #3," which was used in the West Valley cold commissioning tests, was used to replicate the melter feed for use as the basis for the DM 1000 tests. The preparation of melter feed used at West Valley during their cold commissioning tests consists of several steps. These steps include preparation of the waste simulant and its addition to the Concentrator Feed Makeup Tank (CFMT), characterization of the composite simulant in the CFMT, computer and statistical analyses of the simulant data to determine the glass former composition, preparation and laboratory analyses of the glass former mix, transfer of the glass former mix to the CFMT and analyses of the resulting material, concentration of the CFMT material by evaporation, and addition of sucrose solution as a reductant.

It was impractical to simulate every procedural step in the feed preparation for this work and, instead, the feed formulation began with the simulant and glass former (including chemical shimming) recipes found in the data package [10]; these recipes are shown in Table 2.5. Modifications were then made to the recipes to produce a melter feed with properties that match the characterization data for the West Valley feed. It was found that the required modifications include reduction of water (to simulate the feed evaporation process at West Valley) and addition of additional chemicals (to account for the materials originally present in the CFMT before simulant addition (the Aheel,@ for which a recipe is not available). The extra chemicals necessary to complete the feed batch were inferred by comparing the analytical data with the starting recipes.

Three formulations were defined for the West Valley melter feed. These formulations have essentially the same chemical composition with the major difference being in the choice of starting materials. For example, substitution of sodium hydroxide pellets for aqueous solution is needed to reduce the water content. A test batch of each formulation was prepared by NOAH Technologies and tested at the VSL with respect to physical properties, glass yield, and oxide composition. The final feed formulation selected is listed in Table 2.6. In addition to substituting solid materials for aqueous solution, sodium nitrite in the simulant recipe (see Table 2.5) was replaced by sodium nitrate to avoid NOx emission. It is well known that acidification of nitrite forms nitrous acid, which is unstable toward decomposition to nitric acid and nitrous oxide [11].

Test results showed that the chosen formulation produced a feed (with sucrose added) with a density of 1.40 g/ml, a pH of 3.65, a solid content of 48.5 %, and a glass yield of 302 g/kg of feed (425 g/l), and a nitrate concentration of 15.2 %. These values compare favorably with the West

Valley feed analytical data: density = 1.39 g/ml, pH = 3.8, solid content = 53 %, glass yield = 295 g/kg of feed (410 g/l) and nitrate concentration = 15.13 %. Rheology and settling characteristics were not determined at West Valley [10].

The same vendor that supplied the chemicals used in cold tests to West Valley, NOAH Technologies Corporation, produced the feed according to the formulation provided by VSL (Table 2.6). The specifications for the chemicals used for the major glass components (i.e., those present at greater than 1 wt% on an oxide basis), including particle sizes, were identical to those used at West Valley. Furthermore, the IE-96 zeolite was ground according to specifications provided to NOAH Technologies by West Valley [12]. As seen in Table 2.6, 23.22 MT of feed was produced for 7 MT of glass. The West Valley target glass composition as well as those from the VSL tests and a West Valley cold test [10] are shown in Table 2.7.

2.4 Preapproval Sample Analysis

Prior to the shipment of feed batches produced at NOAH, an aliquot of each feed batch, referred to as a preapproval sample, was shipped by express mail for confirmatory analysis at VSL. These samples were analyzed at VSL for chemical composition, density, water content, and feed to glass conversion factor using VSL standard operating procedures. Not all samples were subjected to all procedures. The chemical composition was determined by first vitrifying a sample of the feed in a platinum/gold crucible at 1150EC, followed by X-ray Fluorescence (XRF) analysis of the powdered glass, by microwave aided acid dissolution of the glass followed by Direct Current Plasma Atomic Emission Spectroscopy (DCP) analysis, or both. Lithium and boron were not determined by XRF and therefore the DCP values were used for normalization purposes, when available, and the target values were used otherwise. The results obtained from analysis of these samples are shown in Tables 2.8 - 2.11.

The purpose of the preapproval samples was to determine whether there was sufficient evidence of deviation from the intended feed characteristics to warrant shimming or rework of the feed batch prior to shipment. Such instances did arise during the earlier DM 10 tests (VSL-00R2501-1, April, 2000) with previous feeds that NOAH prepared for VSL but was not the case during the present tests. It should be noted that in general, the ability to batch a feed (which is based on weight and volume measurements) can be far superior to the ability to reliably sample and analyze the resulting heterogeneous slurry. Thus, there is a real danger of incorrectly responding to sampling and analytical noise and triggering unnecessary and inappropriate shimming or rework if the acceptance limits are too stringent, which can not only push an on-target feed off-target, but can result in considerable cost and schedule implications. Consequently, the burden of proof lies with the sampling and analytical data to convincingly demonstrate that the feed is *not* on target before corrective measures are triggered. The results from the preapproval samples, shown in Tables 2.8 -

2.9, did not indicate that any such corrections would be appropriate. This conclusion was later further substantiated by the results from the melter feed samples and the glass product samples, as discussed below.

2.5 Analysis of Melter Feed Samples

Melter feed samples were also taken and analyzed for most of the tests to confirm physical properties and chemical composition. Sample names, sampling dates, and properties measured for each composition are provided in Tables 2.12 - 2.14. Variable amounts of water were deliberately added to the AZ-101 feed as part of the test matrix and therefore many samples were taken during these tests to verify the water content. Tests 1, 2, 4, 5 and 6 used low-solids feed and the feed samples contained approximately 70% water and yielded about 300 g glass per liter. Samples from the high-solids tests (3, 7, 8) have properties closer to the as-received feed. Minimal dilution was used in the mixing and transfer of the C-106/AY-102 and West Valley feeds, as shown by the similarity between the feed samples and as- received feed data. Since the spread around the average was small, the average values were used in calculating production rates from feed data for the C-106/AY-102 and West Valley tests, whereas the measured values shown in Table 2.12 were used to calculate production rates in the AZ-101 tests.

The chemical compositions of the feed samples were determined by first making a glass from the feed via crucible melt and then dissolving the crushed glass in acid with the aid of a microwave oven and analyzing the resulting solutions by DCP. Data for each of the three compositions is compared to target values in Tables 2.15 - 2.17. As with the preapproval samples, these results generally corroborate the consistency of the feed compositions. The principal exception is the West Valley sample WV1000-F-86A (Table 2.17), which we do not believe to be representative of the actual feed composition since these data are not supported by the preapproval sample results and the contemporaneous melter glass product data (Section 4.1) show no differences in glass discharges during this period (West Valley, Test #3). It is possible that the feed tank was not representatively sampled or the that the one-liter sample was not representatively sub-sampled for the glass crucible melt. Further discussion of glass and feed analysis is provided in Section 4.1.

2.6 Feed Rheology

Samples of the melter feeds that were used for these tests were also subjected to rheological characterization. The results from rheology characterization of a variety of other melter feeds and waste simulants, as well as the effects of a range of test variables, are described in detail in a separate report [13]. Melter feeds were characterized using a Haake RS75 rheometer, which was equipped with either a Z40DIN or a FL22-SZ40 sensor. A typical set of measurements consists of identifying the flow characteristics of the slurry by measuring the shear stress on the slurry at controlled shear rates and temperatures. In these measurements, the shear rates values are preset and are increased stepwise from 0.01 s^{-1} to 200 s^{-1} (70 s^{-1} for FL22-SZ40) with a sufficient delay (typically 15 to 30 seconds) between steps to ensure that shear stress is allowed to fully relax and therefore measured at equilibrium. It should be noted that this approach is somewhat different than the "flow curve" approach that is often used in which the shear rate is ramped up to some maximum value and then ramped back down to produce a hysteresis curve that is dependent on the arbitrarily selected ramp rate. In contrast, the present measurements are equilibrium values of the shear stress at each measured shear rate. The viscosity of the sample as a function of the shear rate is then calculated as the ratio of the shear stress to the shear rate. The yield stress data for the melter feeds were measured using a controlled-stress mode in which the torque on the rotor was slowly increased while the resulting deformation of the fluid was monitored. The discontinuity in the measured deformation-torque curve was identified as the yield stress. It should be noted that this direct measurement of the "true" yield stress can be quite different from the value that is often reported as the yield stress, which is instead obtained simply by extrapolation of the shear stress-shear rate curve to zero shear rate.

Table 2.18 gives a summary of the yield stress data measured for the various melter feeds. As expected, the water content of the feed has a very large effect on the measured yield stress. For example, the as-received AZ-101 feed has a water content of about 55 wt% and a yield stress of 27.8 Pa (26_C), whereas the measured yield stress of a melter feed that has a water content of 72 wt% water is considerably lower at 1.7 Pa (25_C). A similar decrease in yield stress was observed with the West Valley feeds between the as-received feed and the melter feed with sucrose solution added. In contrast, relatively little difference was found among the C-106/AY-102 feeds that were prepared using silica glass former with different average particle sizes but the same water content: nominally -325 mesh SiO_2 was used for Batch 1, -200 mesh for Batch 6, and -80 mesh for Batch 7.

Rheograms for the melter feeds, which show the feed viscosity versus shear rate, are presented in Figures 2.1 to 2.3. The results for the AZ-101 feeds shown in Figure 2.1 span the range of feed water content tested in the AZ-101 melter test (58 - 72 wt%, see Table 2.12). The viscosity of the most dilute AZ-101 feed tested (72 wt% water) is more than an order of magnitude lower than that of the as-received feed (55.5 wt% water): for instance, at a shear rate of 50 s^{-1}, the viscosity of the diluted feed is 0.82 P (25EC) while that of the as-received feed is about 15 P (26EC). Little difference in viscosity was observed on increasing the measurement temperature to 40EC, with the measured values generally within 5% of those found at 25EC.

The acidic as-received feed for the West Valley tests is significantly less viscous than the alkaline AZ-101 as-received feed despite their comparable water contents (51.5 and 55.5 wt%, respectively). However, the as-received West Valley feed has a considerably lower glass yield than the as-received AZ-101 feed (425 g/l and 575 g/l, respectively). After addition of sucrose solution to complete the make up of the West Valley melter feed, the resulting viscosity is further decreased but is comparable to that of the most dilute (72 wt% water, 290 g/l) AZ-101 melter feed (about 1.4 P at 50 s^{-1} and 25EC). For the (alkaline) C-106/AY-102 melter feeds, which had a lower water content and higher glass yield (58 wt% and 494 g/l) than the most dilute AZ-101 feeds, the measured viscosity at 50 s^{-1} ranges from 7 P to 10 P. Different batches of C-106/AY-102 feeds prepared with silica of different nominal particle sizes do not show significantly different viscosity (Figure 2.3), possibly due to the fact that the actual average particle sizes of the silica do not vary greatly, as discussed below.

The particle size distribution of the melter feeds was measured by the feed vendor (NOAH Technologies) using a Microtrac X100 particle analyzer. The analysis technique is based on laser diffraction and covers a range of 0.04 to 700 microns. The measured data for all of the feed batches are presented in Appendix A and Table A-1 provides a summary of the mean particle sizes of the as-received feed slurries. With the exception of West Valley feed batches 3 and 4, it is seen that the distributions are relatively consistent within each melter feed. The differences observed for West Valley feed batches 3 and 4 can be ascribed to the longer contact time allowed for that batch between the iron (III) hydroxide slurry and nitric acid before addition of the other components. Finally, the discernable differences in the particle size distributions among the C-106/AY-102 batches produced using silica of different nominal particle sizes is small and likely insignificant.

SECTION 3.0
MELTER OPERATIONS

3.1 AZ-101 Composition

Eight melter tests were conducted with the AZ-101 simulant on the DM1000 between 9/13/99 and 10/21/99, producing over 6100 kg of glass. Glass bubbling rate, feed water content, and feed sugar content were varied, as shown in the test summary in Table 3.1. A detailed run chronology is provided in Appendix B. The actual test matrix was considerably more complex than envisioned in the Test Plan as a result of problems with the aging DM 1000 melter, complex foaming behavior, and unexpectedly low processing rates without bubbling. The actual test matrix was therefore the result of discussion and resolution of these issues with the RPP-WTP Project as they arose.

Prior to beginning the tests shown in Table 3.1, approximately 3600 kg of glass was produced during the turnover of the melt pool. This was performed in a series of runs between

8/13/99 and 9/10/99. During that time, several problems were addressed and solved prior to the scheduled melter tests. Since the feed system had been reconfigured from solid feed to slurry feed, the feed system was debugged and issues related to feed mixing and transfer were addressed; this included the addition of a larger, high-torque drum mixer to expedite transfer of the feed from the 55-gallon shipping drums into the feed system. It was also determined that a failed weld in the discharge chamber was allowing glass to leak around the pour trough and overflow into the discharge chamber. This was remedied by disassembling the discharge chamber, repairing the welds, increasing the size of the dam, and cutting a hole on the side of the trough to maintain proper flow.

The DM 1000 system has been at temperature for nearly seven years and has been used for testing a wide range of feed compositions, many of which were deliberately challenging the bounds of acceptability. In particular, a number of very high sulfate feeds have been processed in this system. Sulfate corrosion was determined to be the cause of the failure of one of the electrode busses, which occurred during the turnover period. The initial assessment of that problem led to the decision to proceed with the tests with the three remaining powered electrodes, firing only between the bottom electrodes and from the one remaining top electrode to the opposite bottom electrode, which still allowed more than sufficient power for the tests. In view of these findings, a recommendation was made to the RPP-WTP Project to consider replacement of the DM1000 system, given the importance of the large-scale melter testing to the Project. The replacement of the DM1000 by a prototypical pilot-scale HLW melter (the DM1200) has been recently completed. However, based on concerns expressed by the RPP-WTP design group over the unknown effects of the electrode firing pattern on the test results, VSL engineers re-evaluated the possibility for repair of the failed electrode buss on a practical time-scale. A plan was developed that would allow for the repair *without* dropping the melter to room temperature, which would have incurred a significant schedule delay. The repair, which was performed after the second melter test, involved cutting away portions of the outer shell, insulation, inner shell, and refractories around the remaining stub of the electrode buss while force-cooling the area to prevent glass leakage. Sufficient (though challenging) access to the stub was thereby gained to allow two Inconel 690 bars to be welded onto the stub and electrical connection to be re-established by connecting to the two bars; the access hole was then closed.

The rationale for each of the eight tests is summarized below. The details of the tests are provided in Table 3.1 and the cumulative production rates for these tests are compared in Figure 3.1. Displays of both instantaneous and cumulative production rates are provided in Figures 3.2-3.9.

Test 1: Only bottom electrode pair firing; low-solids feed; no bubbling; 62-hour run. No foaming observed and unexpectedly low processing rate obtained (0.15 MT/m^2/day).

Test 2: Three of four electrodes firing; low-solids feed; with bubbling; 49-hour run. Vigorous "cyclical" foaming observed and processing rates increased by about a factor of four. This test showed "cyclical" foaming behavior in which the melt pool first would be quiescent, the cold cap coverage would be complete, and the plenum temperature would be low; the pool would then begin to "bubble" spontaneously and increasingly; the increased agitation then consumes the cold cap and the plenum temperature, power demand, and melt level increase; finally, the foaming subsides and the cold cap gradually reforms before the cycle repeats.

Test 3: All four electrodes firing; high-solids feed; no bubbling; 17-hour run. Vigorous cyclical foaming observed and processing rates were so high than the run had to be terminated due to lack of feed. Feed had been staged on the basis of the Test 1 results with what was assumed to be a comfortable margin. The processing rates with foaming were comparable to the rates with bubbling.

Test 4: Intended to repeat the conditions in Test 1 but with all four electrodes to determine the effect of electrode firing pattern. However, unlike Test 1, vigorous cyclical foaming was observed, which invalidates the comparison. Assessment of the effect of firing patterns was therefore deferred to the West Valley test (see below).

Test 5: Same intention as Test 4 but targeting a duration comparable to that of Test 1, irrespective of foaming. This test showed "cyclical" foaming behavior with a periodicity of about 2-3 hours early on in the test. However, the interval increased during the test and the cyclical foaming behavior eventually ceased. The remainder of the test proceeded with no further foaming. The final steady-state rate (0.16 $MT/m^2/day$) was essentially identical to that measured during Test 1 but the average rate over the test is inflated by the increased rates during the foaming cycles.

Test 6: This test used the same conditions as Test 5 and was intended to determine whether the addition of sugar to the feed would control the foaming but this short test was inconclusive as a result of the unpredictability of the foaming.

Test 7: This test was intended to repeat the foreshortened high-solids test performed in Test 3. All four electrodes firing; high-solids feed; no bubbling; no sugar; 56-hour run. However, unlike Test 3, no foaming was observed. The steady-state rate was about twice that with the lower-solids feed.

Test 8: Same conditions as for Test 7 except with bubbling; 24-hour run. No foaming was observed and the steady-state rate was 0.88 $MT/m^2/day$. The available feed was rationed to obtain 24 hours run time. Since bubbling capabilities were not fully utilized production rates with bubbling could probably be much higher.

A variety of operational measurements were made during these melter tests, many of which are given in Tables 3.2-3.9. Power supplied to the electrodes is compared to plenum temperatures in Figures 3.10-3.17 and glass temperatures in Figures 3.18-3.3.25. The target glass temperature of 1150EC was successfully maintained on average for the majority of the tests, however, temperatures in the bottom of the melt pool were about typically 10 to 20 degrees colder in tests without bubbling (e.g., Test 1 in Figure 3.18). The reverse was observed for the bubbled tests (e.g., Test 8 in Figure 3.25). Average plenum temperatures were typically maintained between 400 and 450EC except for Test 3 (short test ended by first encounter with intense foaming) and Test 8 (test with bubbling and less extensive cold cap in an attempt to extend the available feed), which exhibited average plenum temperatures between 550 and 600EC. The "exposed" (i.e., unsheathed) plenum thermocouple was typically read 10 to 20EC colder than the thermocouple in the thermowell (e.g., Test 5 in Figure 3.14). The temperature within the thermowell is probably elevated due to heat transfer from the glass along the body of the thermowell, therefore the exposed thermocouple provides a more accurate reading of actual plenum temperatures. The average transition line gas temperatures (between film cooler and scrubber) were between 300 and 400EC, depending on the plenum temperature, the amount of added film cooler air, and the temperature of the added film cooler air. The vacuum on the melter was maintained at about one inch of water. Both pairs of electrodes were used except in the first test where only the bottom pair was used and the second test where three of the four electrodes were used. The amount of power supplied to the electrodes depended on the feed rate, water content of the feed, and extent of foaming within the glass. Tests with higher feed rates (e.g., bubbled tests) required more power, however, when normalized to glass production, they also had the lowest power utilization per unit glass produced.

The principal increases in production rates were in response to bubbling (factor of 4 to 6) and increases in feed solids content (factor of 2). Foaming also increased production rates significantly but its occurrence could not be predicted or controlled. However, the foaming action appears to produce similar effects as the bubblers.

It should be noted that the nature of the foaming observed in these tests was quite different to that observed at the GTS Duratek M-Area facility and the LAW Pilot Plant (both of which were effectively controlled by sugar additions), which typically involved smaller bubbles distributed throughout the glass pool, as evidenced by the foamy nature of the glass product under those circumstances, which can lead to massive rise in melt level. In the present tests, only modest rises in melt level were observed and the gas bubbles were very large and apparently confined to the melt surface region, since there were no unusual gas inclusions in the discharged glass.

As discussed above, foaming cycles were observed in Tests 2, 3, 4 and the first half of Test 5. Temperatures and power demand are compared for foaming (Test 3) and non-foaming (Test 7) conditions in Figures 3.12, 3.16, 3.20, and 3.24. Both tests were conducted with high-solids feed and no bubbling. Note that the power demand for Test 3 is on average about twice that of Test 7 and that plenum temperatures are typically at least 100EC higher. Each cycle began with increasing bubble generation in the melt and an increasing melt level followed by a drop in glass temperature. The drop in temperatures requires that the power to the electrodes be increased to compensate, often to well above 200 kW. Any vertical temperature differences in the glass pool disappear as the foaming proceeds (presumably as a result of the improved agitation) and the plenum temperatures drastically increase due to consumption of the cold cap (presumably also as a result of the improved agitation). As discussed earlier on the basis of DM10 tests (VSL-00R2501-1), the sequence of events is thought to be: foaming causes increased agitation, which increases the rate of (endothermic) cold cap consumption, which decreases the melt temperature, which increases the power demand; consumption of the cold-cap causes the plenum temperature to rise while the increase of the melt temperature back to its set-point frequently exacerbates the foaming, bringing the event to a crescendo. As the foam dissipates, the cold cap reforms and the initial quiescent conditions are re-established. The frequency and duration of the foaming events varied widely in the four tests in which it occurred. It should be noted, however, that the impact of foaming was most severe in the tests that were performed without bubbling. It should also be noted that these effects are *not* an artifact caused by oscillations of a poorly tuned temperature controller since the electrode power was controlled *manually* in response to the measured melt pool temperature, as described in Section 1.2.2.

Unfortunately, while the sequence of consequences triggered by the onset of foaming is reasonably well understood, the underlying cause is still unknown. Since the tendency for foaming increased from the turnover into the early tests, it was originally hypothesized that it was a result of reaching some critical level of manganese in the glass, which has been frequently incriminated in foaming in DWPF and WVDP HLW glasses. However, foaming ceased midway through Test 5 and did not recur in the subsequent tests. Clearly, further work is necessary to resolve these questions.

3.2 C-106/AY-102 Composition

Three melter tests were conducted on the DM1000 between 2/1/00 and 2/19/00 with the C-106/AY-102 composition, producing over 6900 kg of glass. This was preceded by the production of almost 3100 kg of glass during the turnover of the melt pool. The primary variable that was evaluated in these tests was the effect of glass bubbling rate, as shown in the test summary in Table 3.10. A detailed run chronology is provided in Appendix B. The production rate was increased from 0.16 MT/m^2/day without bubbling to 1.21 MT/m^2/day with bubbling. It is likely that production rates could have further been increased with further increases in bubbling. The second bubbling test (Test 3) was conducted in response to the low production rate (0.16 MT/m^2/day) observed in the test without bubbling and the goal was to conduct a bubbled melter test for at least the same duration as the unbubbled test for a direct comparison. The bubbling rate was set to obtain a production that would expend the remaining feed in the allotted time. The resulting production rate was a factor of five higher than for the unbubbled test. Cumulative production rate curves for all three tests are compared in Figure 3.26. Instantaneous and cumulative production curves for individual tests are given in Figures 3.27-3.29. Notice that in the bubbled tests, steady-state conditions are achieved after only a few hours, whereas about two days are required when the melt pool is not bubbled. No processing problems such as foaming or secondary phase formation occurred during the C-106/AY-102 tests.

A variety of operational measurements were made during these melter tests, many of which are given in Tables 3.11-3.13. The power supplied to the electrodes is compared to plenum temperatures in Figures 3.30-3.32. The average plenum temperatures increased from about 435EC (Test 2) when the melt was not bubbled to about 550EC at the highest bubbling rate (Test 1). The exposed plenum thermocouple was 20 to 50EC colder than the thermocouple in the thermowell (e.g., Test 3 in Figure 3.32), again probably due to the transfer of heat from the glass to the thermowell. The trend of increasing temperature with increased bubbling was also observed in transition line gas temperatures, with an average of 350EC without bubbling and 450EC at the highest bubbling rate. Both pairs of electrodes were used in all three tests. The amount of power supplied to the electrodes was primarily dependent on the feed rates in these tests. Tests 1 and 3 were bubbled and required more power than Test 2 due to the increase in feed rate. The amount of power utilization per unit glass produced, however, was a factor of 2.6 lower for the high bubbling rate test (3.1 kWhr/kg) than for the no bubbling test (8.0 kWhr/kg). A substantial amount of power is required simply to keep the melter at temperature due to heat loss and therefore the faster glass is produced, the more efficient the process is with respect to power utilization. There was no evidence of silver deposition in the melter (power spikes or electrical shortages) despite the high levels of silver in the feed and, as discussed in Section 4, the Ag_2O in the feed was quantitatively recovered in the glass product.

Five different thermocouples, three in a thermowell on the side of the melter and two in a thermowell at melter center, were located at various depths within the glass pool (see Tables 3.11-3.13). Glass temperatures monitored by side thermocouples are compared to power supplied to the electrodes in Figures 3.33-3.3.35 and glass temperatures monitored by center thermocouples in Figures 3.36-3.38. The electrode power was adjusted to target a glass temperature of 1150EC for the side thermocouple at 12" from the bottom. Temperatures measured at other thermocouples were allowed to vary. The only exception to this approach occurred near the end of the last test as the side thermowell began to fail and the test was completed by simply maintaining the power at the existing level. Temperatures measured in the center of the melt pool were always lower than those measured by the corresponding thermocouples at the side of the melt pool and were usually less than all of the side thermocouples irrespective of height. The only exception was the latter part of Test 2 when the side thermocouple 5" from the bottom was lower for about half the test. As was observed in the AZ-101 tests, temperatures in the bottom of the melt pool were colder in tests without bubbling and the trend was reversed in tests with bubbling tests. This can clearly be seen when comparing Figures 3.36 and 3.38 with 3.37. The thermocouple in the center at 36" from the bottom belies this trend probably due to the proximity to the melt surface. Notice in Figure 3.37 the large drop in temperature at 36" from the bottom at 48 hours run time and the smaller drops at 59 and 77 hours run time. These coincide with one large and two smaller glass discharges placing the thermocouple closer to the glass, cold cap interface.

3.3 West Valley Composition

Three melter tests were conducted on the DM1000 using the West Valley composition between 12/13/99 and 1/5/00 producing over 3800 kg of glass. This was preceded by the production of almost 2800 kg of glass as melt pool turnover. The primary variables evaluated were electrode firing patterns and glass bubbling rate, as shown in the test summary in Table 3.14. A detailed run chronology is provided in Appendix B. Glass production rates were increased by a factor of more than four with bubbling, from 0.3 MT/m^2/day to about 1.3 MT/m^2/day. No processing problems, such as foaming, occurred during the tests with West Valley feeds.

The DM1000 has a relatively deep melt pool and uses two pairs of electrodes. In comparison, the melt pool of the production unit at West Valley and the RPP-WTP baseline design are relatively shallow and have a single bottom electrode on the floor and one pair of electrodes that are relatively close to the glass surface. Thus, the RPP-WTP requested that tests be included to evaluate the effect of electrode configuration on production rate. Consequently, the first two tests were subdivided into three parts to evaluate electrode firing patterns. (The last test was bubbled and required power from both sets of electrodes to maintain the glass temperature at these higher processing rates.) Test 2 was essentially a repeat of Test 1 that was performed to control potential artifacts that were identified during Test 1 as a result of the different plenum temperatures for each firing pattern and to give equal duration to each test segment. In Test 2, the plenum temperature was held constant (after bringing it down to its set-point range at the beginning of segment 1) for all three run segments in order to provide a more equitable comparison of the effect of firing pattern on production rates. Also, each run segment was 24 hours in duration as opposed to the uneven time intervals used in Test 1.

The cumulative production curves for all the tests are compared in Figure 3.39 while instantaneous and cumulative curves for each test are given in Figures 3.40-3.42. The most obvious difference between the tests is the dramatic enhancement of production rate using bubbling. The effect of electrode firing pattern is more difficult to discern. Notice that the second run segment from Test 2 (top electrodes only) reaches steady-state at the same production rate as the first run segment of Test 1 (bottom electrodes only). Overall, these results show little evidence for a significant effect of electrode placement on production rates, particularly compared to the four-fold increase with bubbling.

A variety of operational measurements were made during these melter tests, many of which are given in Tables 3.15-3.21. The power supplied to the electrodes is compared to plenum temperatures in Figures 3.43-3.45. The average thermowell plenum temperatures ranged between 414 and 472EC. The exposed plenum thermocouple was 20 to 30EC colder (e.g., Test 3 in Figure 3.45), again probably due to the transfer of heat from the glass along the thermowell. Also notice in Figures 3.43-3.45 that about 4 hours with bubbling and about 8 hours without bubbling are required to establish a cold cap and for the plenum temperature to reach steady state. It is difficult therefore to compare average plenum temperatures from short test segments at the beginning of tests with averages from latter segments. The goal in Test 2 was to achieve uniform plenum temperatures throughout the tests, which was accomplished for all three test segments only after the cold cap had been developed. The amount of power supplied to the electrodes depended on the feed rate, water content of the feed, and the extent of heat lost from the glass pool. This can be observed on a small scale at the beginning of Test 1 and 2 by the elevated power demand due to higher feed rates used to form a cold cap and the lack of a cold cap to prevent heat from escaping to the exhaust. Power utilization per unit glass produced was lower for the bubbling test (2.7 kWhr/kg) than the tests without bubbling (averaged 4.7 kWhr/kg) by a factor of almost 2.

Five different thermocouples, three in a thermowell at the side of the melt pool and two in a thermowell in the center of the melt pool (Test 2 only), were placed at various depths within the glass pool (see Tables 3.15-3.21). Glass temperatures monitored by side thermocouples are compared to power supplied to the electrodes in Figures 3.46-3.3.48 and glass temperatures monitored by center thermocouples for Test 2 in Figure 3.49. Maintaining constant glass temperatures throughout the pool was made difficult by the various electrode firing patterns used and the introduction of bubbling in Test 3. As was observed in the tests with the other compositions, temperatures decreased towards the bottom of the melt pool in tests without bubbling and the trend was reversed with bubbling tests. This is apparent when comparing Figures 3.46 and 3.47 with 3.48. The drop in temperature near the bottom of the melter was even more pronounced when firing only the top electrodes as can be seen in the last test segment in Figure 3.46 and the middle segment in Figure 3.47. Also, there was a definite rise in the surface temperature of the glass (observe thermocouple 36" from bottom) when only the top electrodes were fired. Temperatures in the center of the melter were lower than those monitored by equivalent thermocouples on the side of the melter when only the bottom electrodes were fired while the reverse was true when only the top electrodes were fired. This is in contrast to the comparable C-106/AY-102 test (Test 2) where the center thermocouples always indicated lower temperatures than the at the side but, unfortunately, the center thermocouples in the C-106/AY-102 test were located at 12" and 36" from the melter bottom as opposed to the 24" and 30" from the melter bottom placement used in the West Valley test, which complicates any comparison.

As discussed above, a detailed information package on West Valley feed characteristics, processing rates, and operating conditions was obtained from West Valley through the RPP-WTP Project for this work. The data for West Valley "Batch #3" that was used in the cold commissioning tests were used to replicate the melter feed for the DM1000 tests. The West Valley data showed that Batch #3 processed at a rate of 70 liters of feed per hour, which produced 25 kg of glass per hour. Since the West Valley melter has a surface area of 2.15 m^2 and the Batch #3 feed had a reported glass yield of 410 g/l, these rates are not quite consistent and correspond to glass production rates of 0.32 and 0.28 MT/m^2/d, respectively. In the tests with the replicated West Valley Batch #3 feed on the DM1000, without bubbling, average rates of 0.29 MT/m^2/d and 0.31 MT/m^2/d were measured for the first (94-hour) and second (72-hour) tests, respectively; these rates are in excellent agreement with the corresponding rates determined at West Valley.

SECTION 4.0
GLASS PRODUCT

Over 26.5 MT of glass was produced in these tests. The glass was discharged into 55-gallon drums, weighed, and sampled. No macroscopic secondary phases or large concentrations of vesicles from foaming were observed in any of the glasses. Glass names, discharge dates, and masses for each of the three melter test series are given in Tables 4.1, 4.2, and 4.3. Samples were taken from the top of each drum and archived. Chemical analyses were performed on most of the samples whereas a more limited number of samples were analyzed for chemical durability, iron redox state, and secondary phases.

The DM1000 melt pool contains approximately 2500 kg of glass and, therefore, 7500 kg of glass production would be required to effect the usual three-melter-volumes turnover so that the glass composition would closely approximate the target composition at the end of the turnover period. Enough feed was available for producing only 10 metric tons each of the AZ-101 and C-106/AY-102 glasses and 7 metric tons of West Valley composition. Shorter turnover periods and longer test periods were agreed upon with the RPP-WTP Project as a more useful means of allocating the fixed amount of feed and run time that was available for these tests. The amount of glass produced during each turnover was 3627 kg for the AZ-101, 3087 kg for the C-106/AY-102, and 2788 kg for the West Valley tests.

4.1 Compositional Analysis

The chemical composition of the sampled glasses was determined by acid dissolution in a microwave oven followed by analysis of the resulting solutions by direct current plasma atomic emission spectroscopy (DCP-AES). Analyzed glass compositions for each of the three melter test series are compared to analyzed feed and target compositions in Tables 4.4, 4.5, and 4.6. Select oxides are plotted against glass production in Figures 4.1- 4.8.

The target composition for the majority of the elements is approached towards the end of testing for each composition. Many oxides were absent in the glass pool prior to feeding a particular formulation that contained that element. Compositional turnover therefore is illustrated by the increase in these elements; examples include: lithium, strontium (Figure 4.2) and cadmium (Figure 4.3) for AZ-101 tests; silver (Figure 4.6) for the C-106/AY-102 tests, and potassium (Figure 4.7) and phosphorus (Figure 4.8) for the West Valley tests. Decreases in elements not in a given feed but present in the melt pool prior to testing such as calcium and magnesium (Figure 4.1) in the AZ-101 tests and potassium and zirconium (Figure 4.5) in the C-106/AY-102 tests are also good indicators of melt pool turnover. Notice all the decreasing and increasing components change very little in concentration after seven or eight metric tons of production, as would be expected based on the melter inventory. This is more difficult to observe for the West Valley tests since less than seven metric tons were produced over the course of the tests.

The analysis of glass samples from the end of each set of tests showed that the melter glasses were closer to the target composition than either the preapproval or feed samples, which reflects the relative ease of sampling and analyzing glass as compared to a heterogeneous slurry. This serves to further corroborate the feed composition and confirms that, with respect to the feed that was used, the glass pool was fully turned over by the end of the testing. Minor exceptions are lithium and strontium for the AZ-101 composition, manganese and strontium for the C-106/AY-102 composition, and potassium for the West Valley composition, which are slightly below their corresponding target values.

The analyzed concentrations of several minor components and heavy metal oxides are plotted against glass production for the AZ-101 and C-106/AY-102 tests in Figures 4.3 and 4.6, respectively. Notice that most of the metals approach either the target value and/or feed composition by the end of the tests, including silver, which has a known tendency for segregation from the glass melt.

4.2 Chemical Durability

Two glasses from each the AZ-101 and C-106/AY-102 tests were subjected to the EPA TCLP leach test (SW-846-1310A). In that procedure, a leachate solution is extracted from crushed glass with a sodium acetate buffer solution for 18 hours at 22EC with constant end-over-end agitation. The leachate concentrations were then measured by direct current plasma atomic emission spectroscopy (DCP-AES). The results are compared to the Universal Treatment Standard (UTS) limits in Table 4.7. The measured leachate concentrations were all lower than the regulatory limits and, for many analytes, one to two orders of magnitude lower than the limits. Cadmium values for the AZ-101 samples, although below the UTS limit, came closest to the limit. Glasses were selected from near the beginning and end of testing a given formulation to bracket the range of compositions during the tests. There were no appreciable differences in the TCLP leach resistance as a result of these compositional changes for the AZ-101 samples. Values for Ag and Zn for samples from the end of the C-106/AY-102 tests were higher than for those from the beginning of the melter tests due to their increasing concentrations in the discharged glasses over the course of the tests (see Table 4.5, Figure 4.5 and Figure 4.6).

Two glasses were subjected to the product consistency test (PCT; ASTM C 1285-94) to evaluate the relative chemical durability of glasses by measuring the concentrations of the chemical species released from crushed glass (75-149 μm) to the test solution (deionized water at 90EC in this case). The ratio of the glass surface area to the solution volume for this test is about 2000 m^{-1}. All tests were conducted in triplicates and in parallel with a standard glass (Savannah River DWPF Environmental Assessment glass, SRL-EA) included in each test set. The leachates were then sampled after seven days. One milliliter of leachate is mixed with 20 ml of 1M HNO_3 and the resulting solution is analyzed by DCP-AES. The results are shown in Table 4.8 and depicted in Figure 4.9. Both glasses show PCT leach resistance far superior to that of the EA glass, with normalized B, Li, Na, and Si concentrations at least an order of magnitude below the corresponding values for the EA glass. The glasses analyzed were sampled after at least 6800 kg of production and therefore should be considered representative of their respective formulations.

4.3 Iron and Manganese Redox State

The iron redox state of glass samples was determined using an AMI MS 1200 Mössbauer spectrometer by examining the locations and intensities of the iron Mössbauer absorptions. The following samples were analyzed: four samples for the AZ-101 tests (three relating to foaming events and one from the added sugar test), one from the end of the West Valley tests, and one from the end of the C-106/AY-102 tests. The test number, sample name, feed and melter conditions, and the iron redox result are given in Table 4.9. All of the samples contained less than 5% divalent iron indicating that the level of reductants was always exceeded by the level of available oxidants. These results do not show any evidence of measurable iron redox changes during the glass foaming events that occurred during some of the AZ-101 tests. The AZ-101 test with sugar (Test 6) was not conclusive due to test brevity (8.7 hours) and a longer test may have resulted in measurable reduced iron. The amount of sugar used in the West Valley tests, about 62 g sucrose per kg feed, was sufficient to ensure that foaming was controlled with this high-nitrate feed without causing over-reduction of the product glass. The molar ratio of sucrose to feed nitrate + nitrite was about 1 to 14. A ratio of 1 to 16 was used in the DM10 C-106/AY-102 nitrated tests and no measurable iron reduction was also observed (VSL-00R2501-2). No reductants were added to the C-106/AY-102 feed during the DM1000 tests and therefore it was expected that the iron would be fully oxidized.

Changes in manganese redox state have been implicated in melt foaming in DWPF and West Valley glasses and are therefore also of interest in the present study. The manganese redox state in these glasses has not yet been directly measured but can be inferred from measurements that were made on glasses of the same composition as the C-106/AY-102 glass that was used in the DM1000 tests if it is assumed that the various redox couples in the melt are in equilibrium. These glasses were produced in crucibles melts and in the DM10 melter tests (VSL-00R2501-2). The measurements were made by synchrotron x-ray absorption spectroscopy performed at Beam Line X23-A2 at the National Synchrotron Light Source at Brookhaven National Laboratory. Mn K-absorption edge spectra were gathered for four Mn valence standards and four glasses, with the results shown in Figure 4.10. The energy of the Mn foil absorption edge is at 6539 eV, which is defined as E_0; this was set to 0 eV for each spectrum. All edge data presented were calibrated to a Mn foil, so that the error of the edge energy is less than 1.0 eV. All data were pre-edge background subtracted and then normalized by scaling the edge step to unity. The absorption edge shifts to higher energy as the absorbing element becomes more oxidized or the valence increases. This is clearly seen in Figure 4.10, where the edge energy systematically increases for the Mn valence standards Mn foil (Mn^0) to MnO_2 (Mn^{+4}). The glasses investigated, HLW98-24, HLW98-02, HLW98-31, (all from crucible melts) and MN-48D (from the C-106/AY-102 DM10 melter tests), contain 0.35, 1.0, 3.0, and 4.4 wt.% MnO_2, respectively. The Mn edges for all of the glasses are similar and are at energies between those for Mn^{++} and Mn^{+3}. The data indicate that the Mn valences for all of these glasses are essentially indistinguishable and the glasses contain a mixture of approximately two thirds Mn^{++} and one third Mn^{+3}. Since iron redox measurements on these glasses by Mössbauer spectroscopy showed the iron to be fully oxidized (less than 5% divalent iron), as was the case for the DM1000 glasses, a similar redox state distribution of manganese is expected in the DM1000 glasses.

4.4 Secondary Phases

Samples of the last glass discharge (AZ2-G-89C, C106-G-100A and WV1000-G-89C) from each of the three compositions was examined microscopically for secondary phases. These samples were obtained from the tops of the 55-gallon drums into which glass was discharged and had, therefore, undergone relatively slow cooling. No secondary phases were observed in the West Valley glass although 25-1000 µm vesicles were common. Small amounts of spinels were observed in the AZ-101 glass totaling less than 0.1 volume percent. The C-106/AY-102 contained up to about 1.6 volume percent spinels as the major phase and a very small volume fraction of at least two different morphologies of a silver metal phase, as discussed below.

The primary concern with the relatively high levels of silver in the C-106/AY-102 waste, and hence, in the corresponding glass, is the possibility of the deposition of silver metal in the melter, which could lead to electrical shorting. However, tests on crucible melts of the glass formulation that was used showed no silver formation on heat treatment at 950EC, indicating that no deposition would be expected in the melter. This expectation was supported by the quantitative recovery of silver in the product glass from the C-106/AY-102 tests on a DM10 melter system (VSL-00R2501-2) and the results from the present tests. The product glass from the DM10 tests was poured into 1-gallon cans and therefore cooled more quickly that the glass in the DM1000 tests. Glass from the DM10 tests contained between 0.1 and 0.6 volume percent secondary phases, most of which were magnetic spinel crystals of 1-10 µm in diameter, with some larger clusters, and no silver phases were observed. In comparison, the more slowly cooled samples from the DM1000 tests contained up to about 1.6 volume percent spinels as the major phase and a very small volume fraction of at least two different morphologies of a silver metal phase. The most commonly observed form of silver was Aglobular bloom areas@ where the silver appeared as radiating spheres of acicular needles, as shown in the optical (Figure 4.11) and SEM (Figure 4.12) micrographs. The gross estimate of volume percent of silver blooms is 0.12 volume percent in the areas in which they were observed, but they were not uniformly distributed. Isolated cavities lined with silver metal were also observed but were rare. A typical spinel crystal can be seen in the top left center of Figure 4.12 as a large arrow-head-shaped crystal. The silver phases were only observed in the brownish "cloudy" portions of the sampled glass, whereas the spinels were observed uniformly in both the clear and cloudy portions of the samples. It is well known that fine dispersions of silver can drastically alter the optical properties of the glass making it appear cloudy even when it is present at very low volume fractions. The amount of cloudy glass estimated from samples taken at the top of the drum was up to about 70%. Based on this number, a gross overall estimate of silver secondary phases in the total discharged glass is about 0.08 volume percent. However, since the relatively slow cooling in the 55-gallon drum is probably responsible for the development of the secondary phases, samples from the center of the drum may contain a higher proportion of secondary phases. Glass samples are also being heat treated according to the expected cooling curves for the RPP-WTP HLW canister. It should be noted that the same glass sample that was analyzed for secondary phases was also subjected to the TCLP test and gave leachate concentrations that were below the UTS limit for all elements, including silver.

4.5 Cold Cap Analysis

In view of the surprisingly low glass production rates that were observed in the absence of bubbling the composition and structure of the cold cap is of interest. Accordingly, a cold cap sample (AZ2-CC-50A) was taken within the last hour of AZ-101 Test 5 to examine transitional phases between the slurry feed and the molten glass. Sampling was accomplished by fashioning a scoop on the end of a rod, which was simply dipped through the cold cap and then withdrawn. The composite sample was mounted for SEM-EDX analysis and then cut and polished with water-free lubricants. Three sub samples were identified as follows: top = 15.5 mm from the glass (Figure 4.13a), middle = 11.5 mm from the glass (Figure 4.13b), and bottom = 2 mm from the glass (Figure 4.13c). The results show no unusual or unexpected features (such as the accumulation of highly refractory layers) that might explain the low melting rates that were observed for this feed. The top sample shows essentially calcined feed wherein the lower melting constituents, such as salts and alkali borates, have begun to melt. The more refractory components, including silica, are still present primarily as angular crystals indicating that relatively little dissolution and melting has taken place at this point. In the middle sample, the angular crystals have become rounded showing the progression of dissolution and melting and by the bottom sample, which includes a significant fraction of glass, the bulk of the particles are relatively spherically shaped. The middle sample also shows evidence of the silica crystals tending to orient with their long axis perpendicular to the melt surface, presumably reflecting the general downward flow of material. Interestingly, all three samples show the presence of high-manganese spinels, which evidently develop very early in the cold cap. However, these phases must subsequently dissolve in the glass melt since the glass product (especially if quenched) is essentially spinel free.

SECTION 5.0
MONITORED OFF-GAS EMISSIONS

Melter emissions were monitored on several occasions during these tests and at least once for each different feed composition. Isokinetic samples were taken adapting EPA methods 40 CFR 60 Methods 1A (Sample and velocity traverses for stationary sources with small stacks or ducts), 2A (Direct measurement of gas volume through pipes and small ducts), 4 (Determination of moisture content in stack gases), 5 (Determination of particulate emissions from stationary sources) and 29 (Determination of metal emissions from stationary sources). Impinger solutions, rinses, and filters were also analyzed for halides, sulfur, and in one instance, nitrate and nitrite. The flux of material exiting the melter was calculated from these procedures and compared to the feed flux into the melter to ascertain the potential challenge to future off-gas systems and to complete a mass balance. The results of the sampling and calculations are provided for each composition in Tables 5.1, 5.2, and 5.3. Notice the distinction that is made between constituents sampled as particles and as "gas": the "gaseous" constituents are operationally defined as those species that are scrubbed in the impinger solutions after the air stream has passed through a 0.45 μm heated filter.

Particulate melter emissions were minimal and typically less than 0.2 percent of the feed. A notable exception was the AZ-101, Test 5, in which 0.77 percent of the feed was emitted due to excessive foaming. Minor amounts of most feed components were observed in the particulate emission flux although these seldom exceeded one percent of the feed level for most elements. Observations of gaseous melter emissions were confined to select constituents: boron, selenium, chlorine, fluorine, sulfur, nitrogen oxides, and carbon monoxide. Measurements of nitrogen oxides, carbon monoxide, and sulfur dioxide were made routinely at the end of the off-gas train for local compliance purposes but are not reported here in view of the non-prototypical nature of the off-gas system. Selenium (present only in the AZ-101 feed) was observed in both the particulate and gaseous fractions. Total selenium emissions ranged from 40% to almost 400% of the feed level; in the AZ-101 Test 5, the emissions flux was much greater than the feed flux due to stripping of the glass pool. A similar phenomenon was observed for sulfur, however, the results were difficult to correlate with the test parameters. Boron was also observed in both the particulate and gaseous fraction of the off-gas stream. Although more volatile than most other elements, boron emissions seldom exceeded 1% of the amount fed. Halides, which are also known to be quite volatile, were not present or were present in minute quantities in the feeds and therefore emission fluxes were minimal.

Several factors contributed to the observed differences in melter emissions, which relate to differences in either operating conditions or feed compositions. Increasing glass bubbling rate typically results in increased emissions, as was observed in the C-106/AY-102 melter tests (Table 5.2). The foaming event in AZ-101, Test 5 resulted in the highest melter emissions of any test due to extensive foaming of the glass pool, disappearance of the cold cap, and a sharp rise in plenum temperature; all these factors contribute to increases in melter emissions. Melter emissions increased as the concentration of volatile constituents increased in the feed. The West Valley feed was rich in nitrates, which resulted in higher relative emissions than in comparable tests with other feeds. The elevated emissions with the West Valley composition may be due in part to the high flux of gases such as NO_X leaving the cold cap region and creating local agitation. A similar effect may explain why feeds with higher water contents result in higher relative emissions, as can be seen by comparing AZ-101 Tests 1 and 7.

The particulate filter from Test 5 was examined by SEM to determine particle morphology and provide additional data on chemical composition. This filter was selected because measured emissions were most extensive in this test and to provide insight into the foaming phenomena since it was taken during an extensive foaming event. Particles on the filter typically ranged from 5 - 100 μm with 2-10 μm agglomerates of selenium crystals. There were also a few 50-100 μm particles of quartz. An SEM micrograph showing the typical particle size range is given in Figure 5.1. The major elements present were Na, Se, Al, Si, Cl, Fe and Zn with minor amounts of Ni, Mn, Cd, Cs and S. These observations were generally corroborated by dissolution and analysis of the filters. Selenium and alkali halides are volatile at melter temperatures and therefore the observed abundance of these species is to be expected. The relatively large fraction of large particulates, and particularly silica, suggests considerable feed entrainment in this sample, presumably as a result of the extensive foaming that was occurring.

Emissions were monitored at points other than the melter exit, primarily for regulatory purposes. There were vast increases in the quantities of NO_X and CO gases emitted during the West Valley tests compared to the other tests as a result of the high concentrations of nitric acid and sugar in the West Valley feed. Other data collected show the high efficiency of the off-gas system upstream of the HEME filter outlet (see Table 5.2). At the request of the RPP-WTP, continuous monitoring for H_2 was also performed at the stack during the C-106/AY-102 tests; no H_2 was detected (i.e., < 0.01 vol.%) at any point during the tests.

SECTION 6.0
SUMMARY AND CONCLUSIONS

Figure 6.1 presents a summary of the principal results of this work, which are the measured glass production rates, as compared to the basis-of-design (BOD) rate of 0.4 MT/m^2/day. The tests with West Valley feed provide an important check on the DM1000 throughput rate measurements with respect to scale-up and differences in melter configuration and operating environments. The excellent agreement of the two sets of data indicates that the DM1000 results should be a reliable predictor of full-scale plant behavior.

Production rates with RPP-WTP feeds with bubbling were considerably higher than the Project design basis. These tests clearly show that production rates for all feeds are 4 to 8 times higher when bubbling is used. Smaller but significant increases were achieved by the use of feeds with higher solids content. However, without bubbling, the processing rates were consistently much lower than the Project design basis. These rates are surprisingly low when compared to a variety of other melter feed data. The rates for AZ-101 feeds increased significantly during periods of cyclical melt foaming, which occurred seemingly at random; however, the lower rates prevailed when the foaming subsided. Foaming was not observed during the C-106/AY-102 tests and the production rate obtained without bubbling was even lower than that for the comparable AZ-101 tests (high-solids: 0.16 vs. 0.3 MT/m^2/day). However, with bubbling, there was no difficulty in considerably exceeding the BOD rate. Thus, if the Project elects to pursue the omission of bubblers from the HLW melter design, there is a need to further investigate methods of increasing the processing rates that are achievable without bubblers. Since it is also preferred not to increase the operating temperature, changes in feed characteristics offer the most likely prospects for improvement, although probably not without attendant drawbacks. Such changes would include feed additives, including feed acidification and addition of reductants; changes in glass former characteristics, including particle size and chemical sources (including the possible use of glass frit instead of a mix of chemicals); and changes in glass formulation.

Total particulate emissions from the melter were lowest for C-106/AY-102 feed without bubbling (< 0.01 %); increased with bubbling rate (0.06 to 0.28 %); increased during vigorous foaming episodes (0.77 %); and were higher for the high-nitrate West Valley feed than for comparable RPP-WTP feeds without bubbling (0.17 % vs. < 0.01 to 0.05 %).

SECTION 7.0
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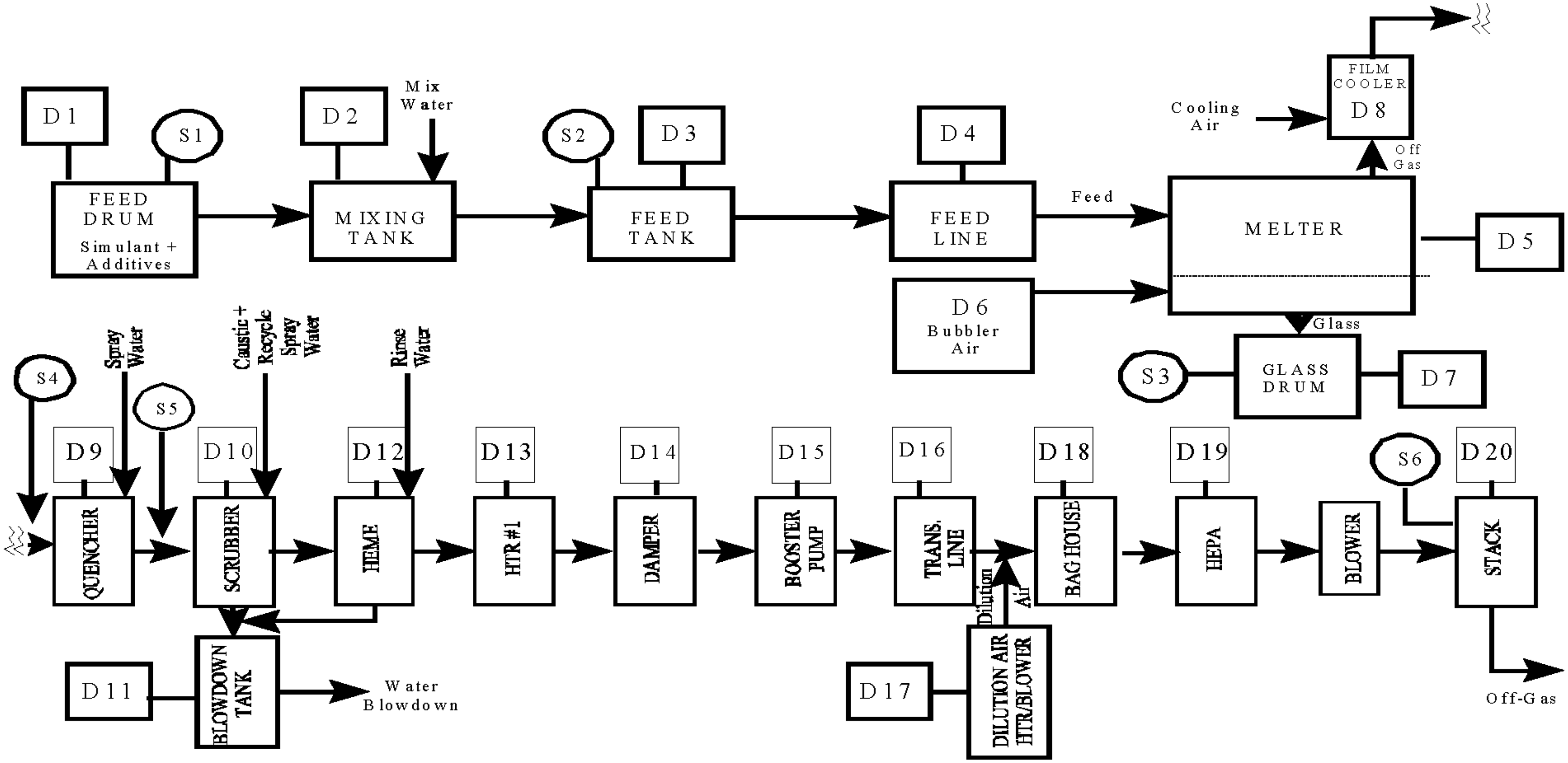

Figure 1.1. Schematic diagram of DuraMelter™ 1000 vitrification system showing sampling points (Sx) and data collection points (Dx).

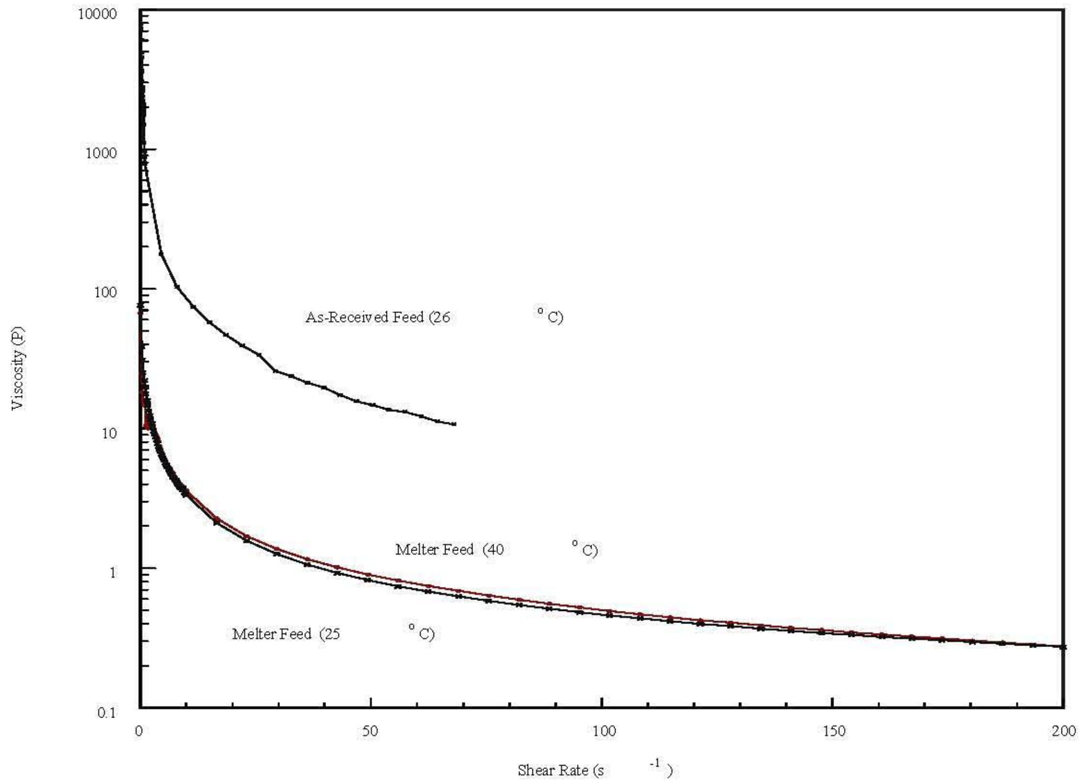

Figure 2.1. Viscosity versus shear rate of the as-received (55.5 wt % water) and the most dilute (72st% water AZ-101 Feeds.

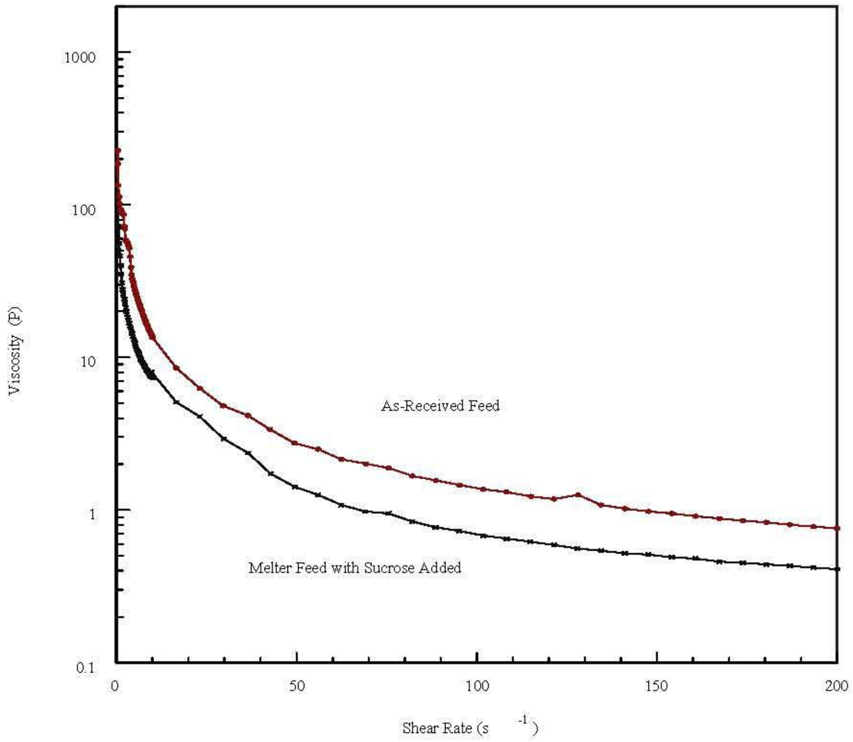

Figure 2.2. Viscosity versus shear rate of the West Valley feeds (25 C)

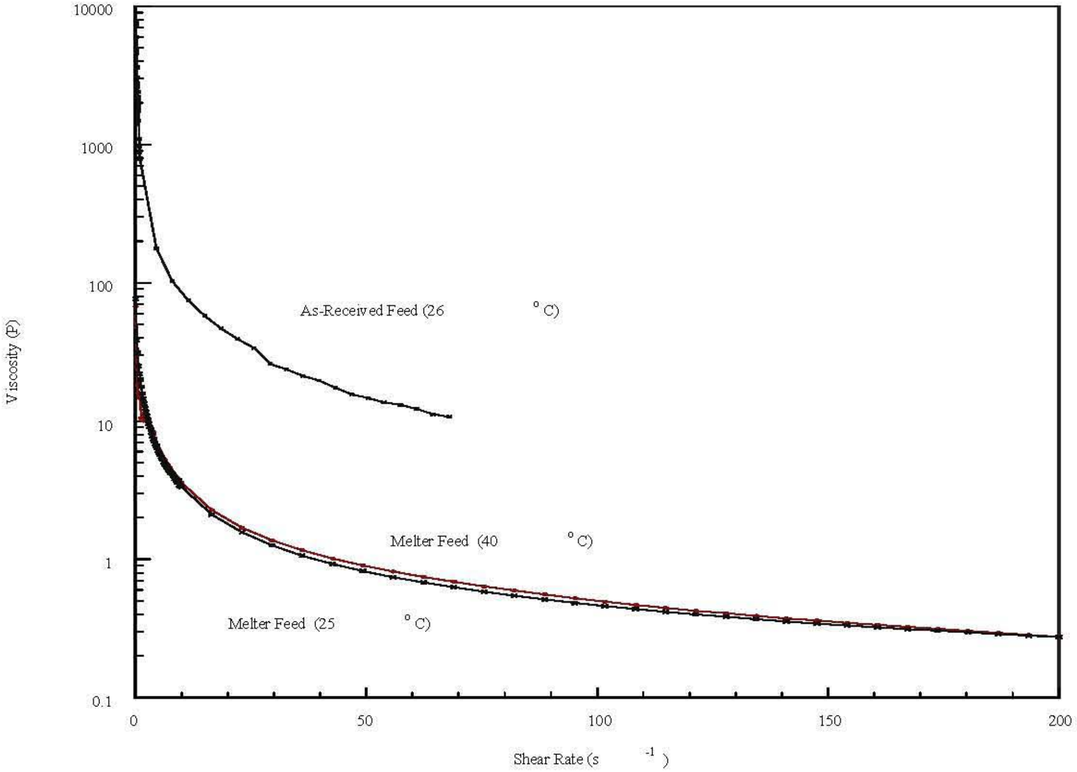

Figure 2.3. Viscosity versus shear rate of the C-106/AY-102 feeds at 25 C(-325 mesh silica was used in glass former for Batch 1, -200 mesh for Batch 6, and –80 mesh for Batch 7.

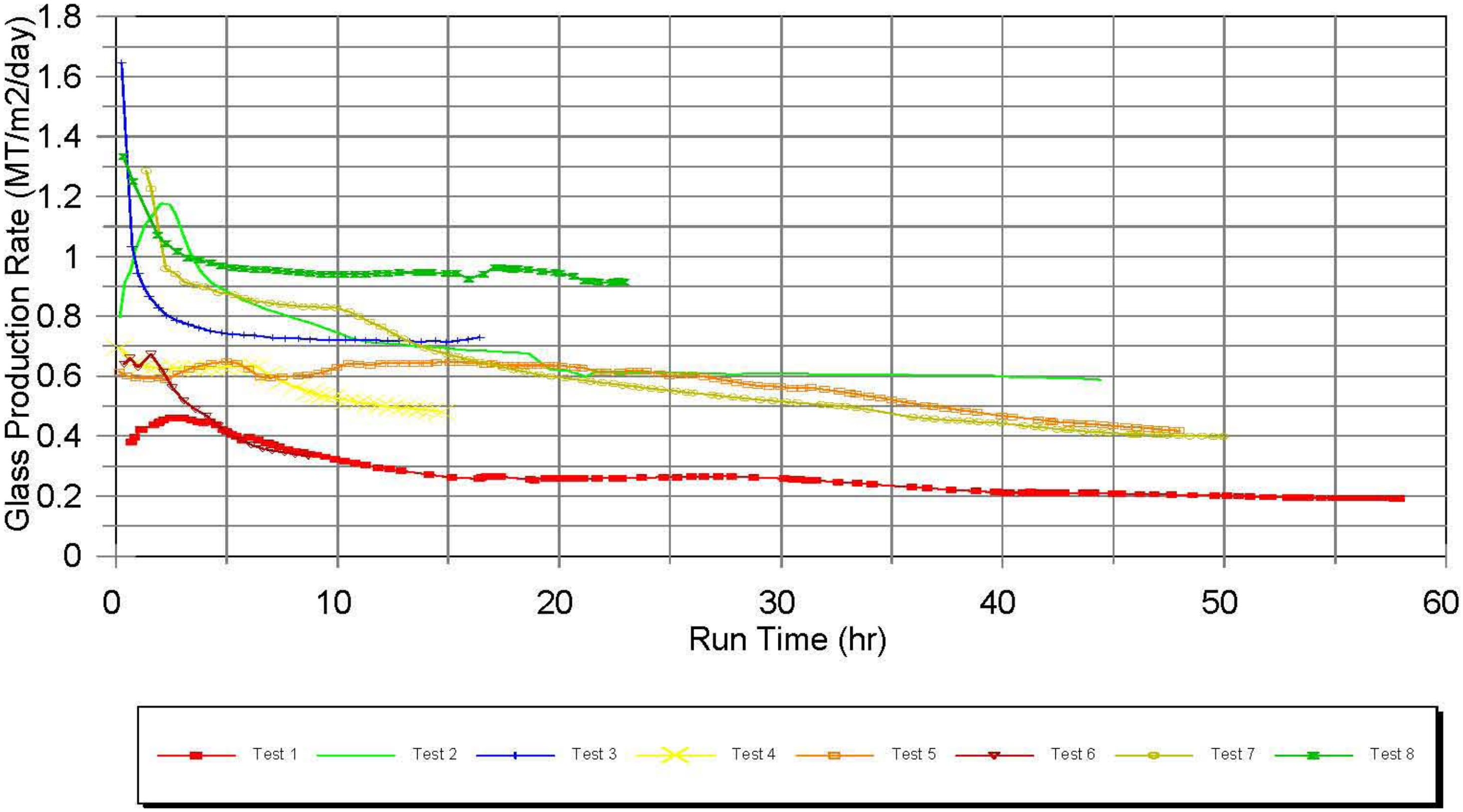

Figure 3.1. Cumulative glass production rates for AZ-101 DM-1000 throughput tests.

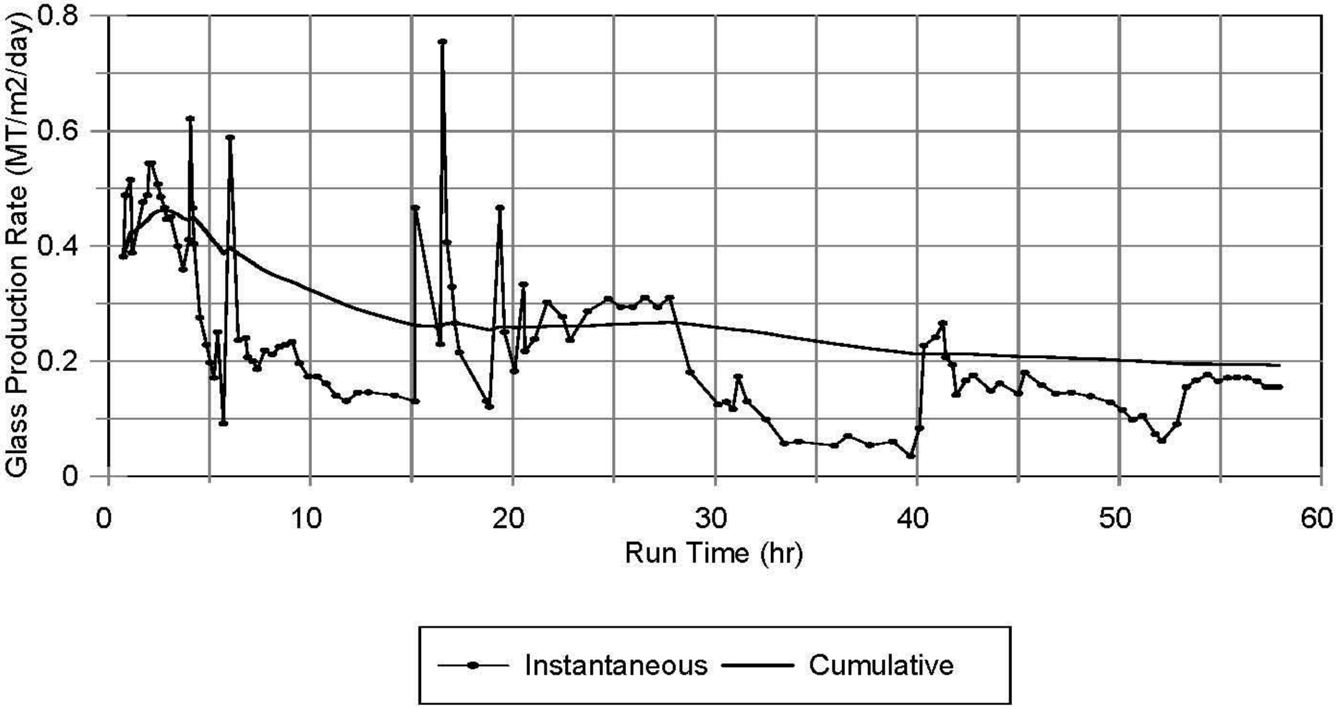

Figure 3.2. Production rates for DM1000 AZ-101 Test #1.

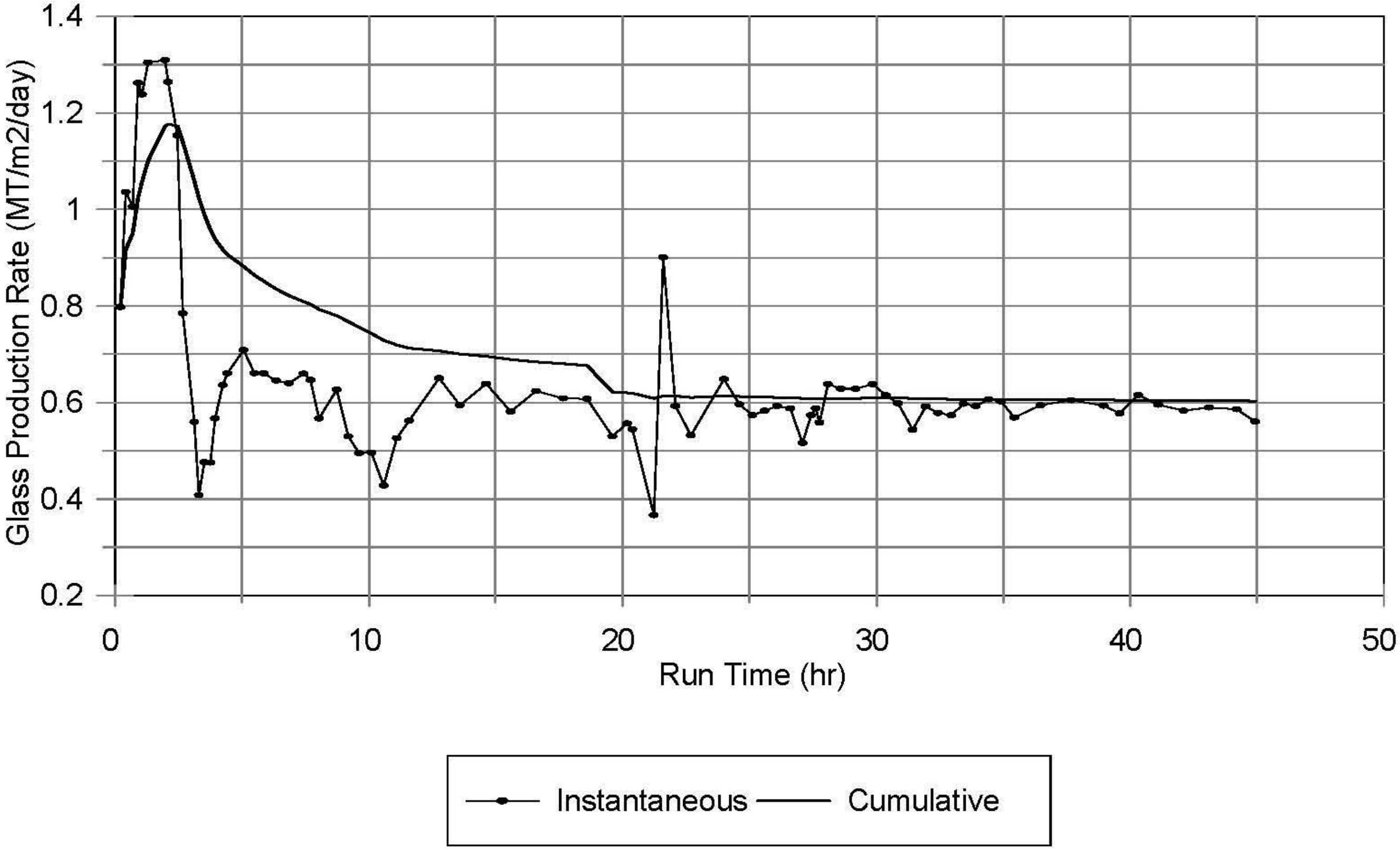

Figure 3.3. Production rates for DM1000, AZ-101 Test #2.

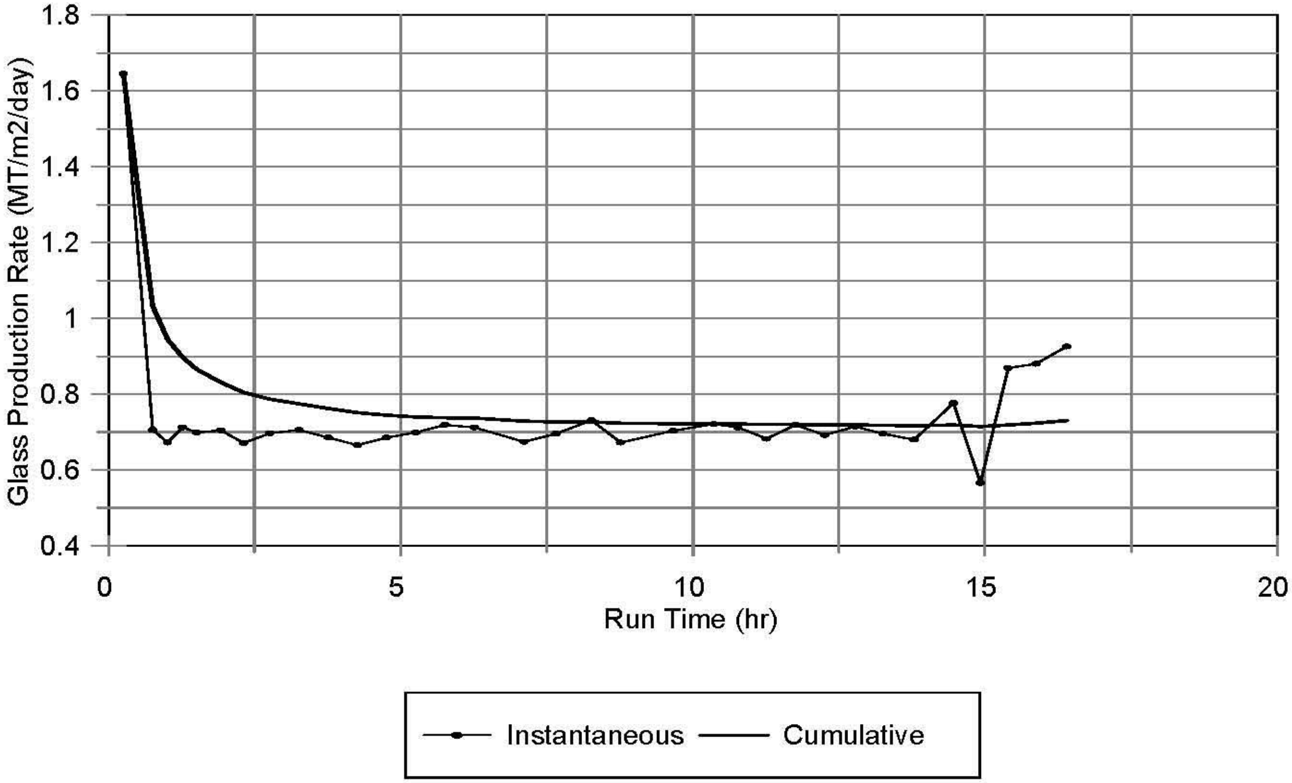

Figure 3.4. Production rates for DM1000 AZ-101, Test 3.

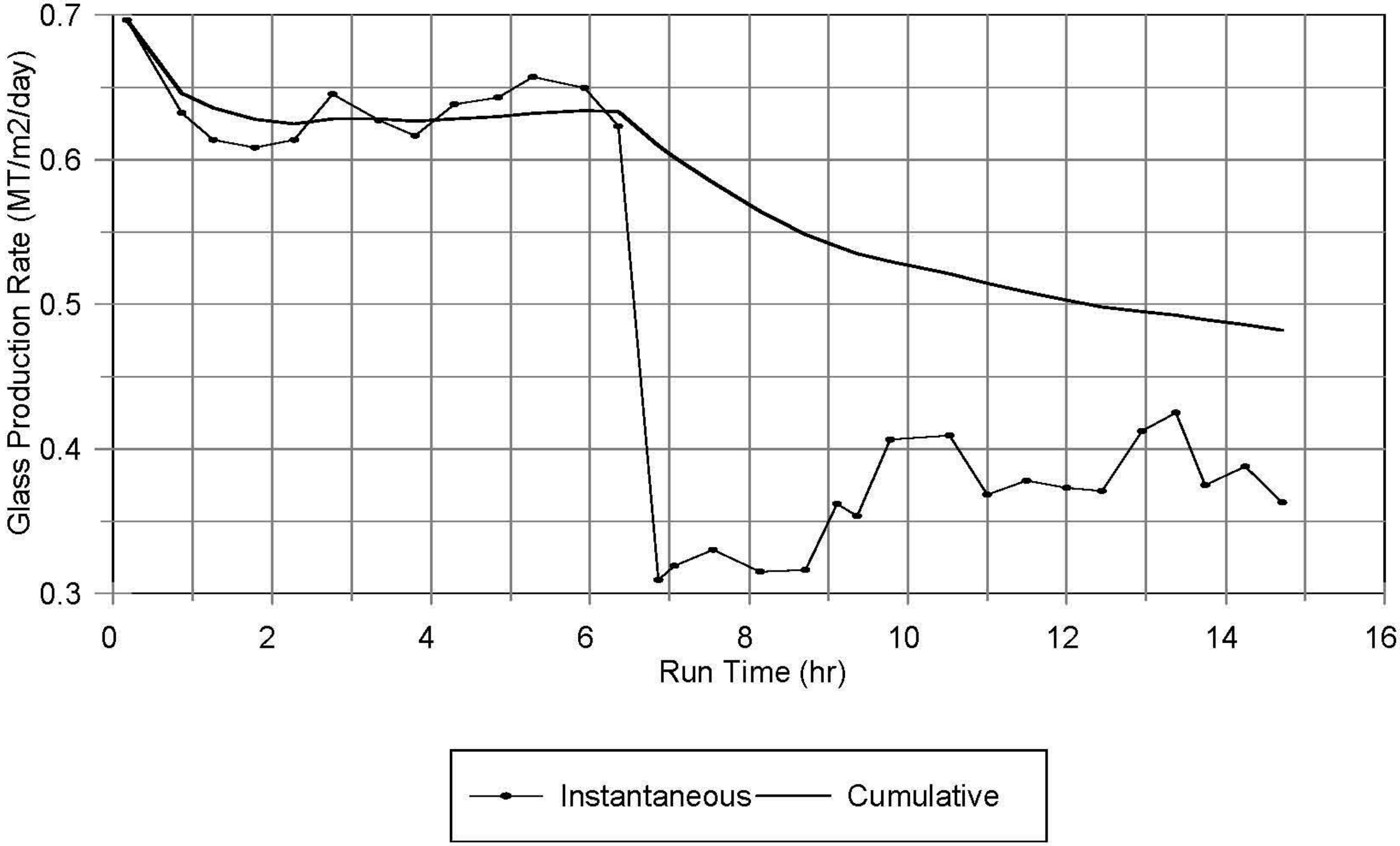

Figure 3.5. Production rates for DM1000, AZ-101, Test 4.

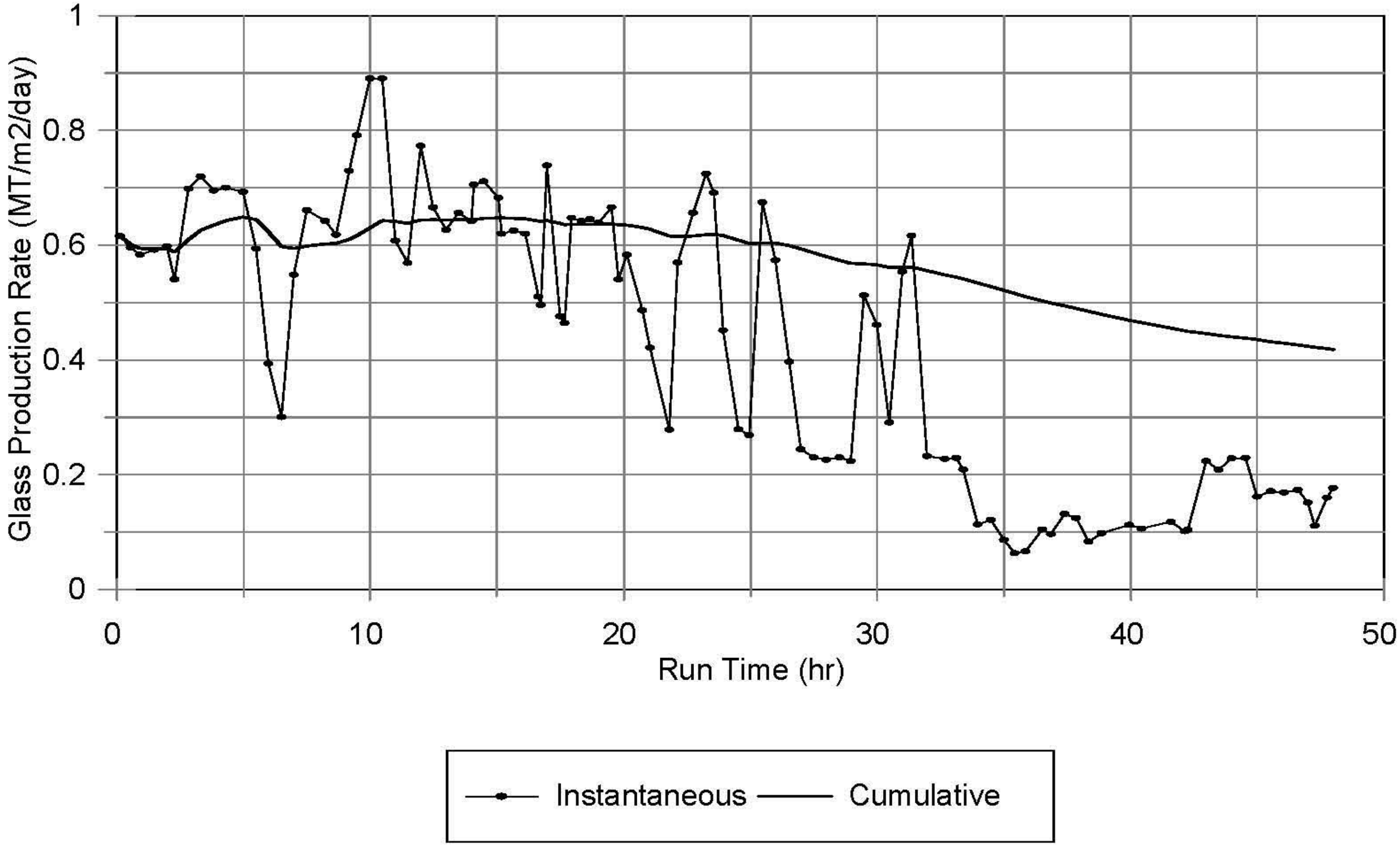

Figure 3.6. Production rates for DM1000, AZ-101 Test 5.

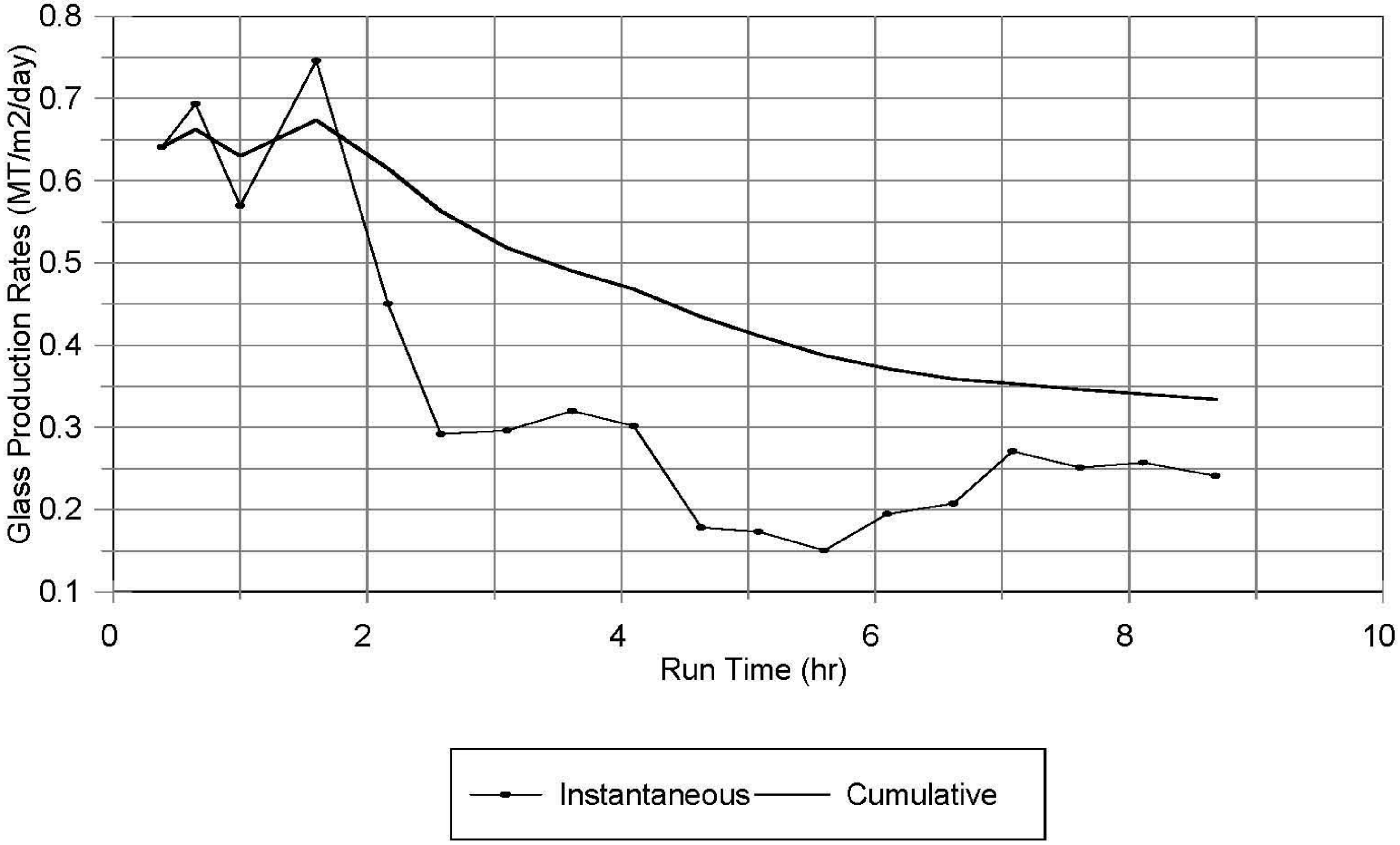

Figure 3.7 Production rates for DM1000 AZ-101 Test 6.

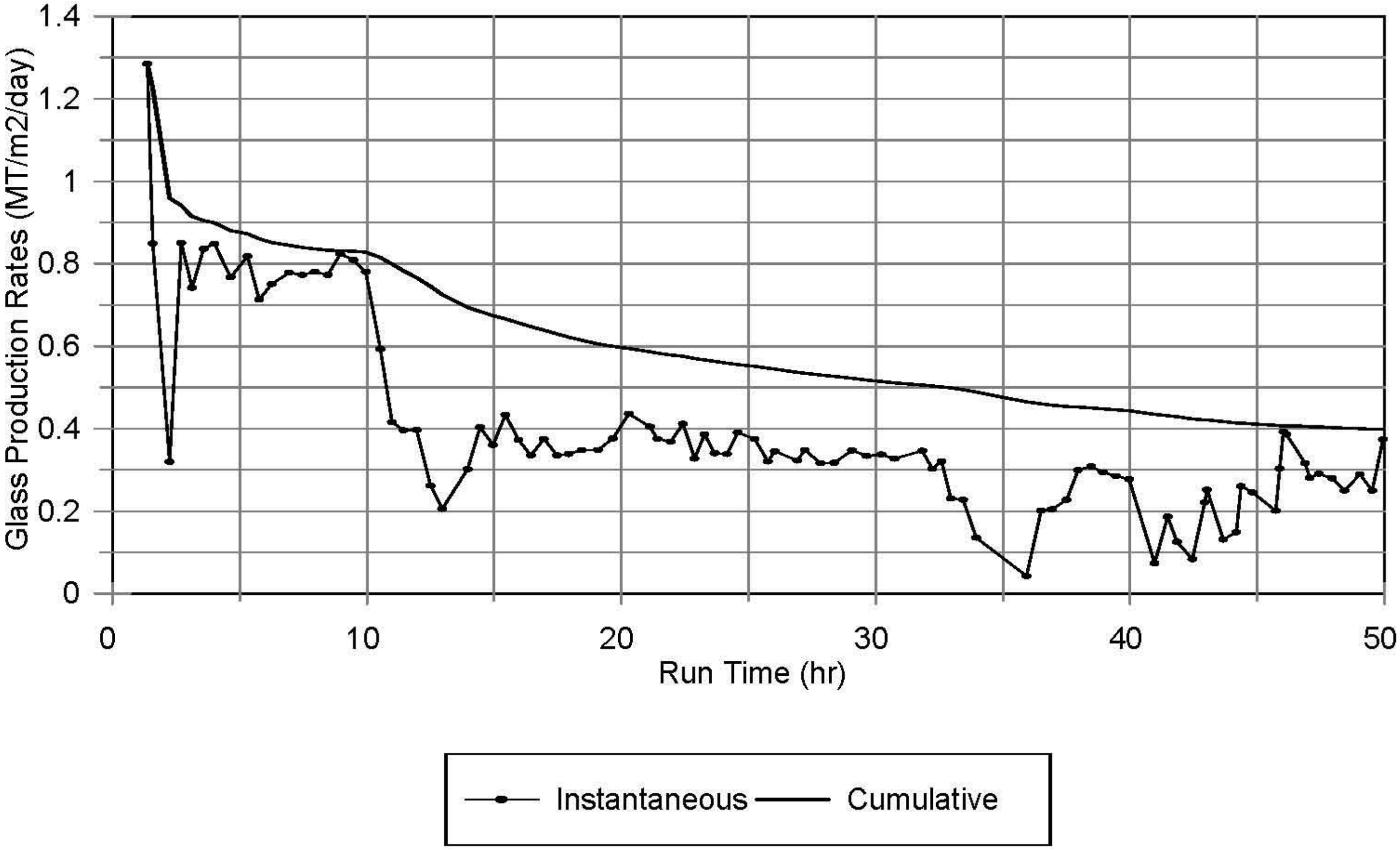

Figure 3.8. Production rates for DM1000 AZ-101, Test 7.

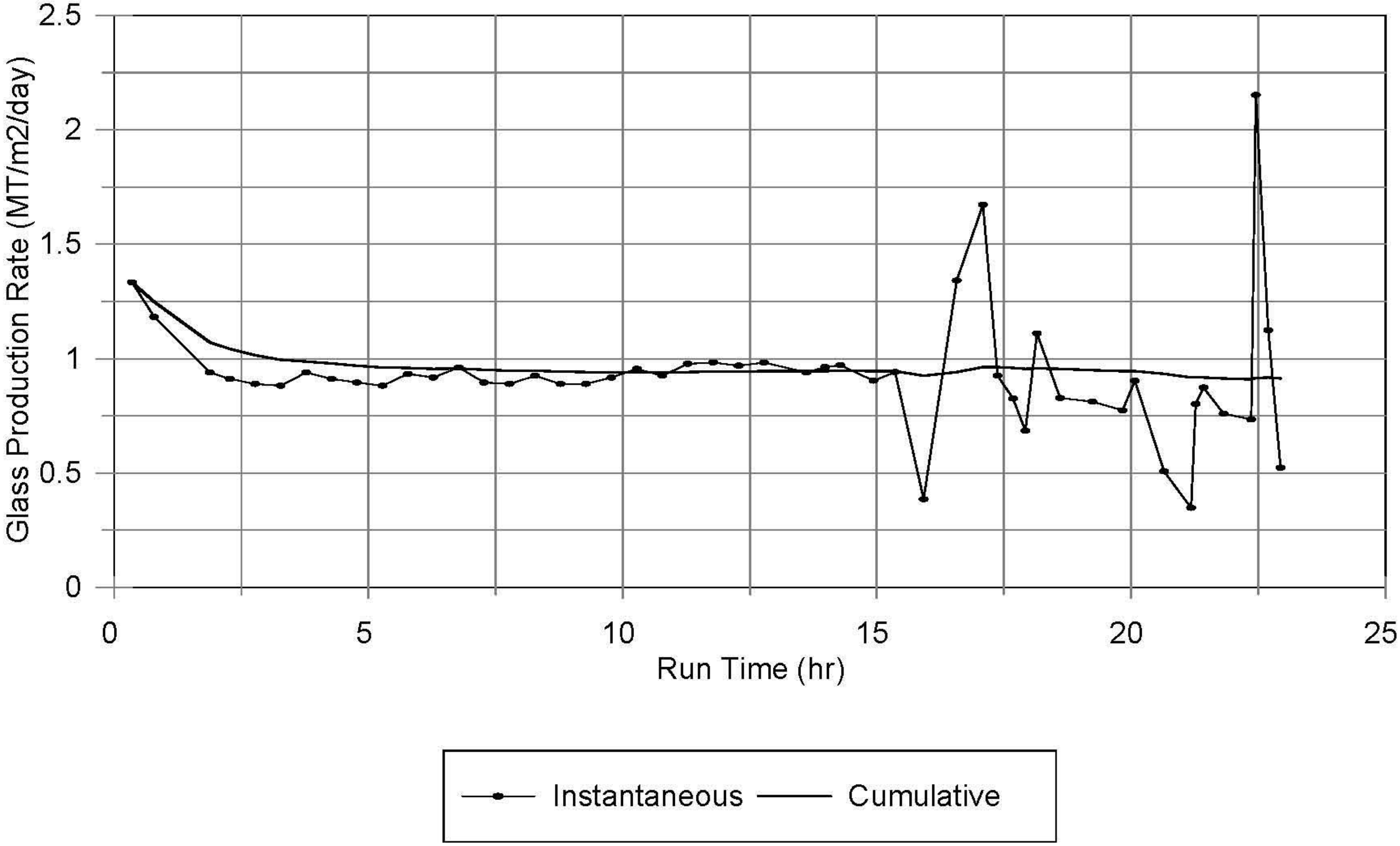

Figure 3.9. Production rates from DM1000 AZ-101 Test 8.

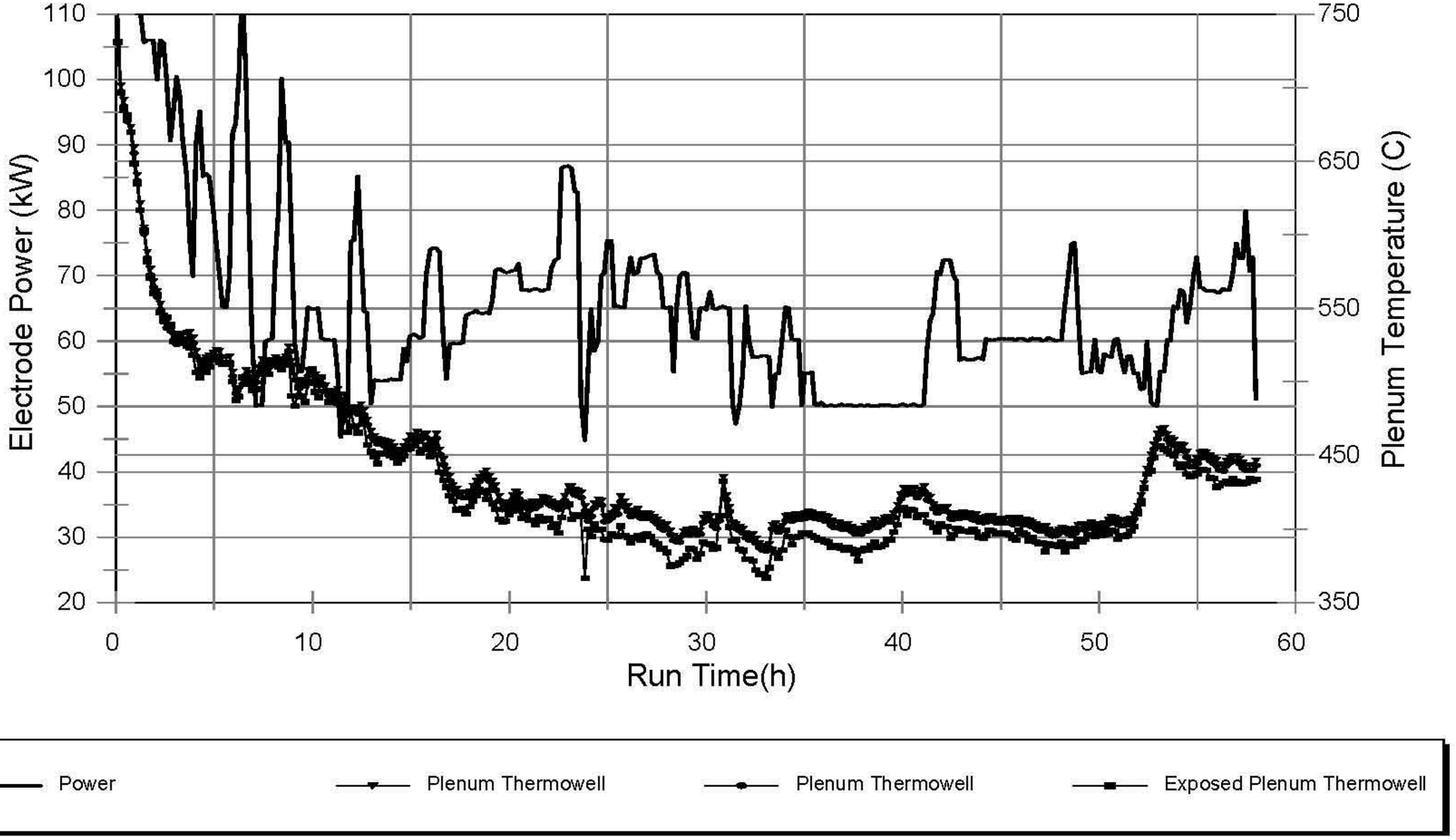

Figure 3.10. Plenum temperature and electrode power for DM1000, AZ-101 Test 1.

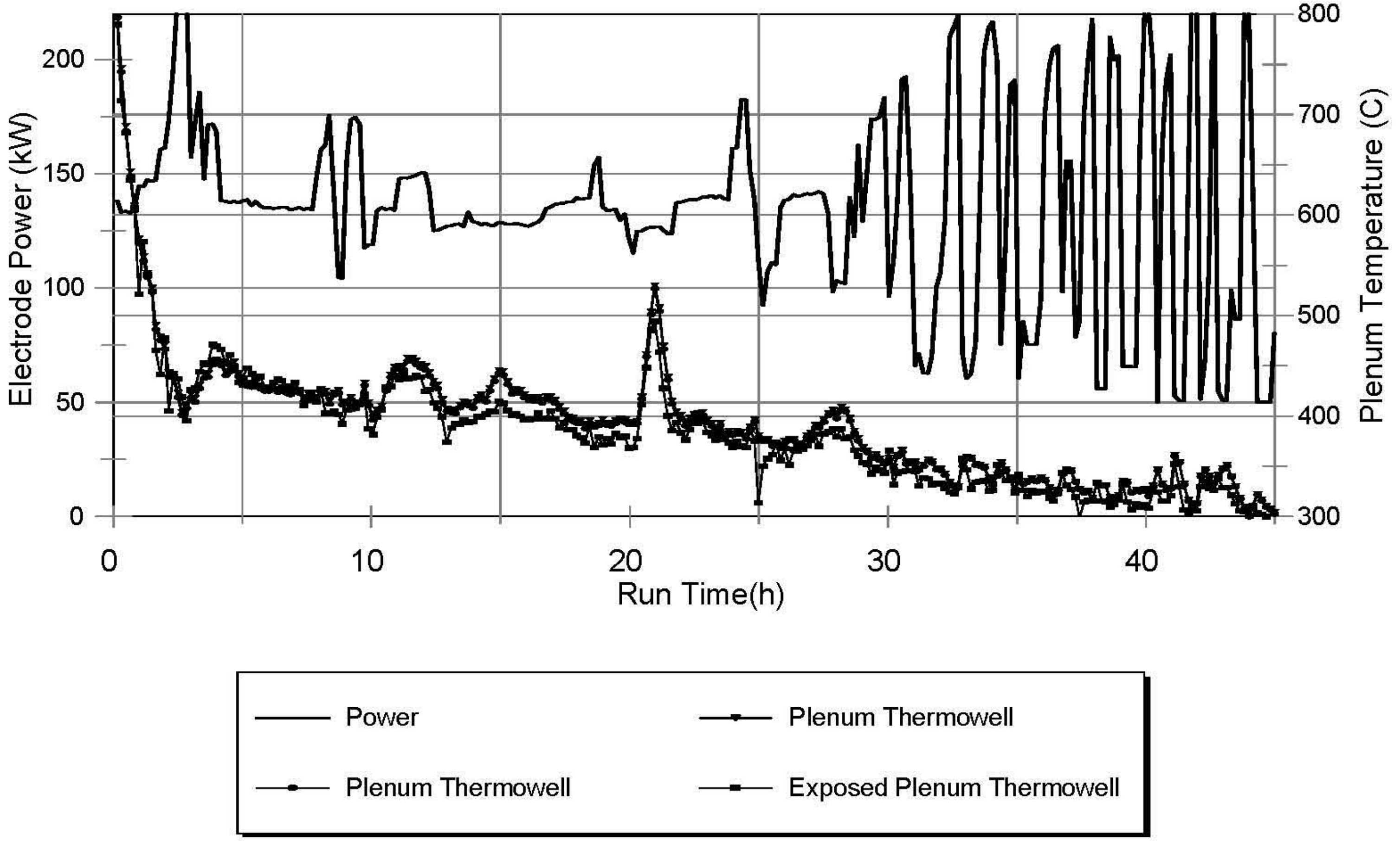

Figure 3.11. Plenum temperature and electrode power for DM1000, AZ-101 Test 2.

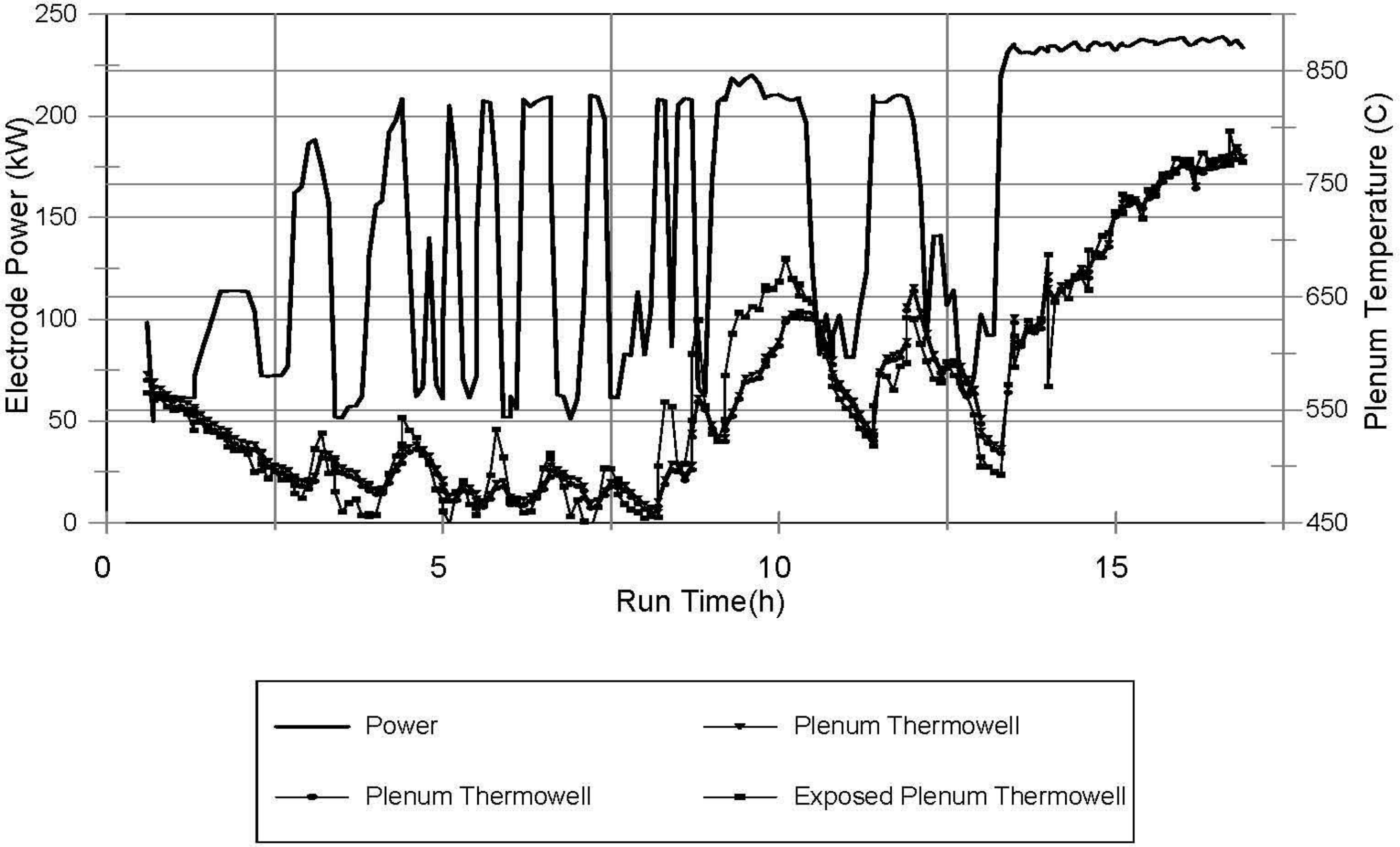

Figure 3.12. Plenum temperature and electrode power for DM1000, AZ-101 Test 3.

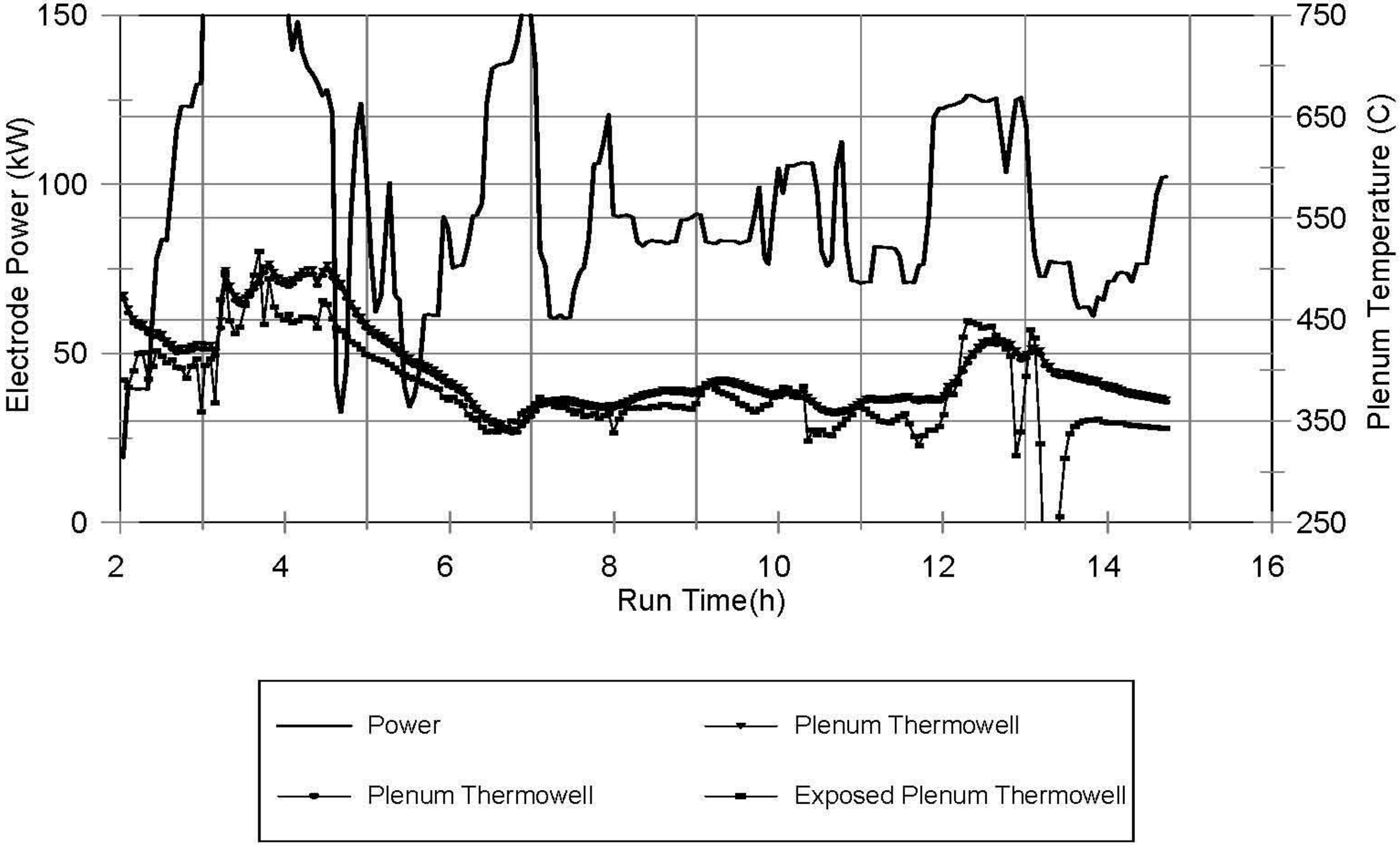

Figure 3.13. Plenum temperature and electrode power for DM1000, AZ-101, Test 4.

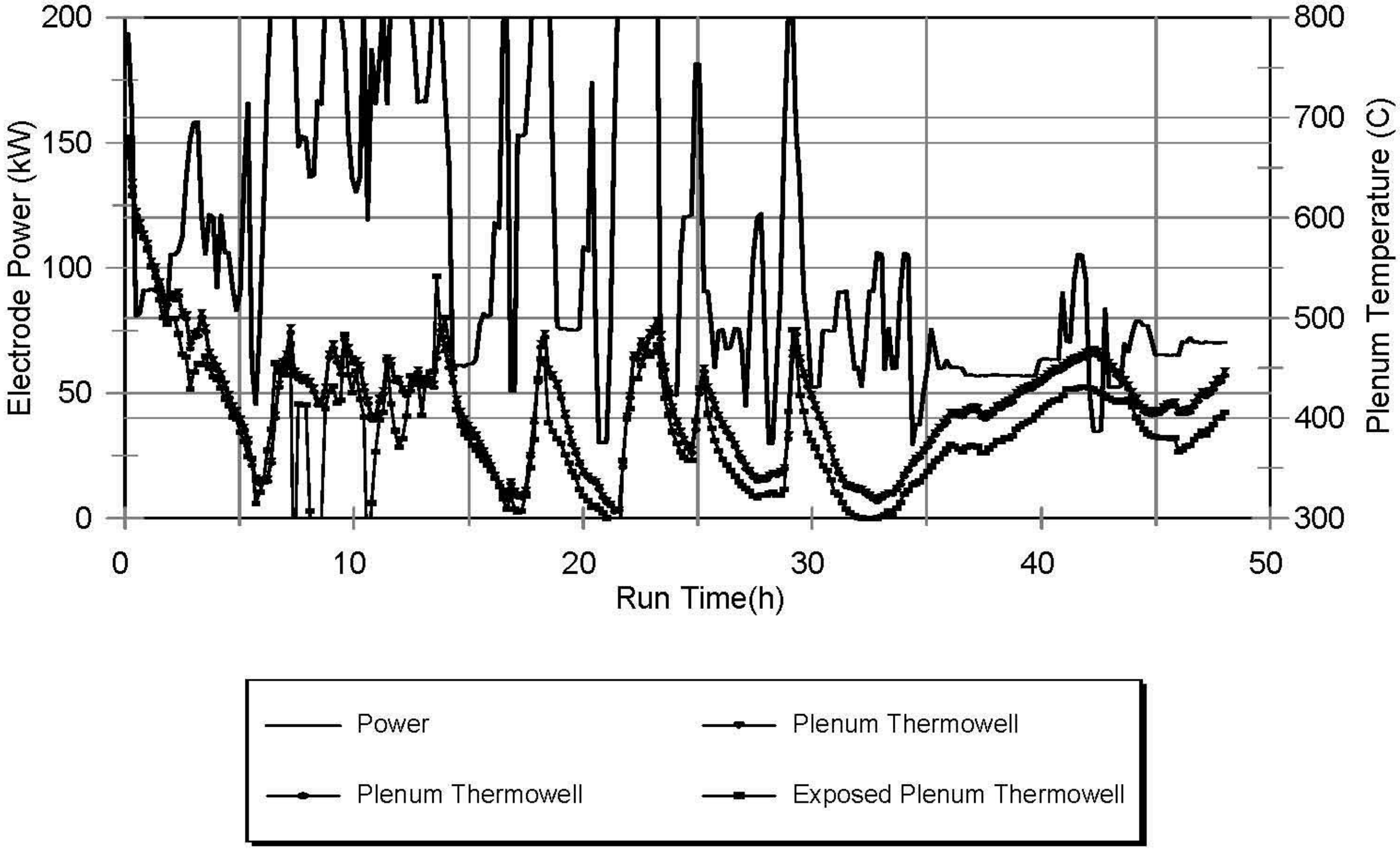

Figure 3.14. Plenum temperature and electrode power for DM1000, AZ-101 Test 5.

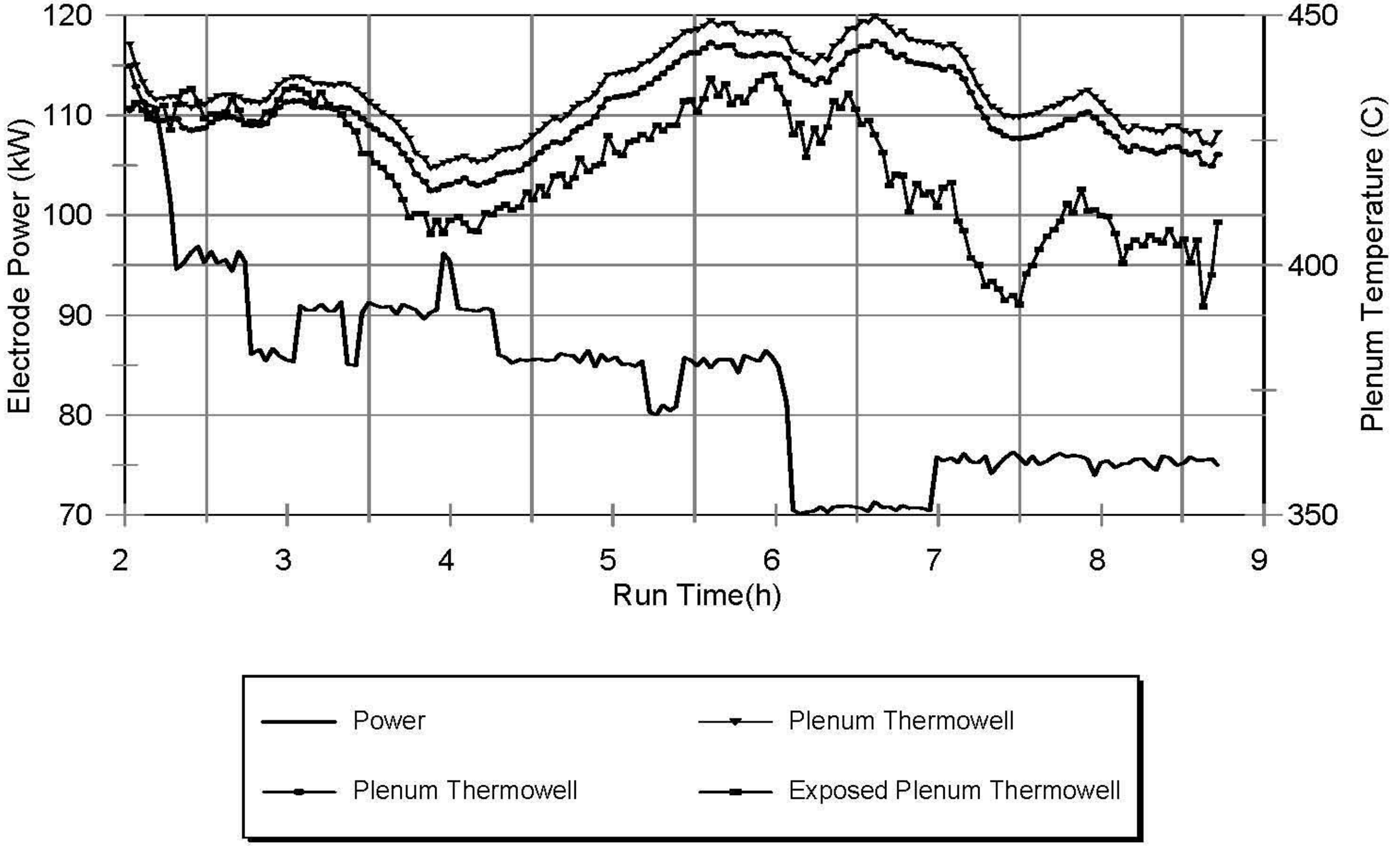

Figure 3.15. Plenum temperature and electrode power for DM100, AZ101 Test 6.

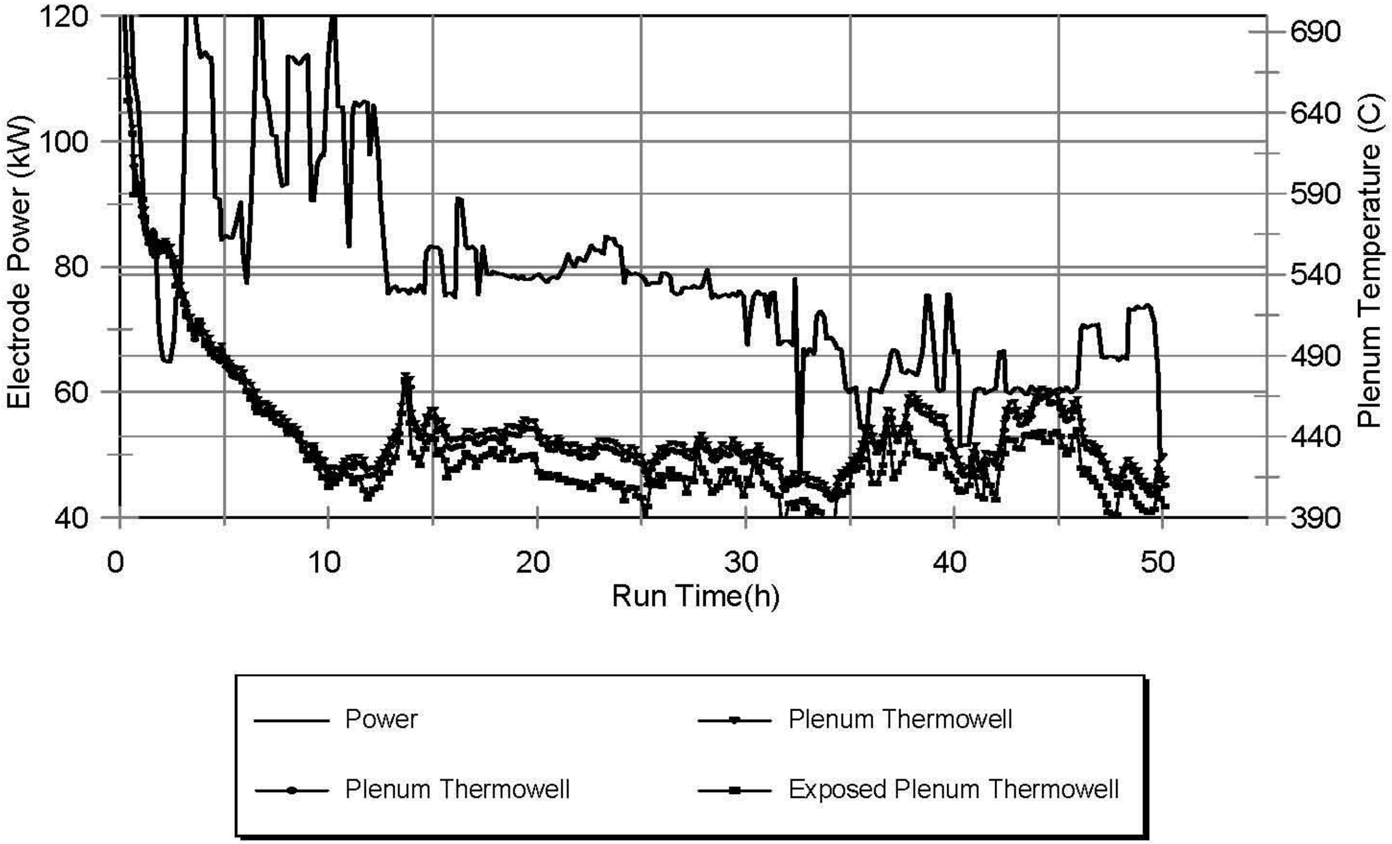

Figure 3.16. Plenum temperature and electrode power for DM1000, AZ101 Test 7.

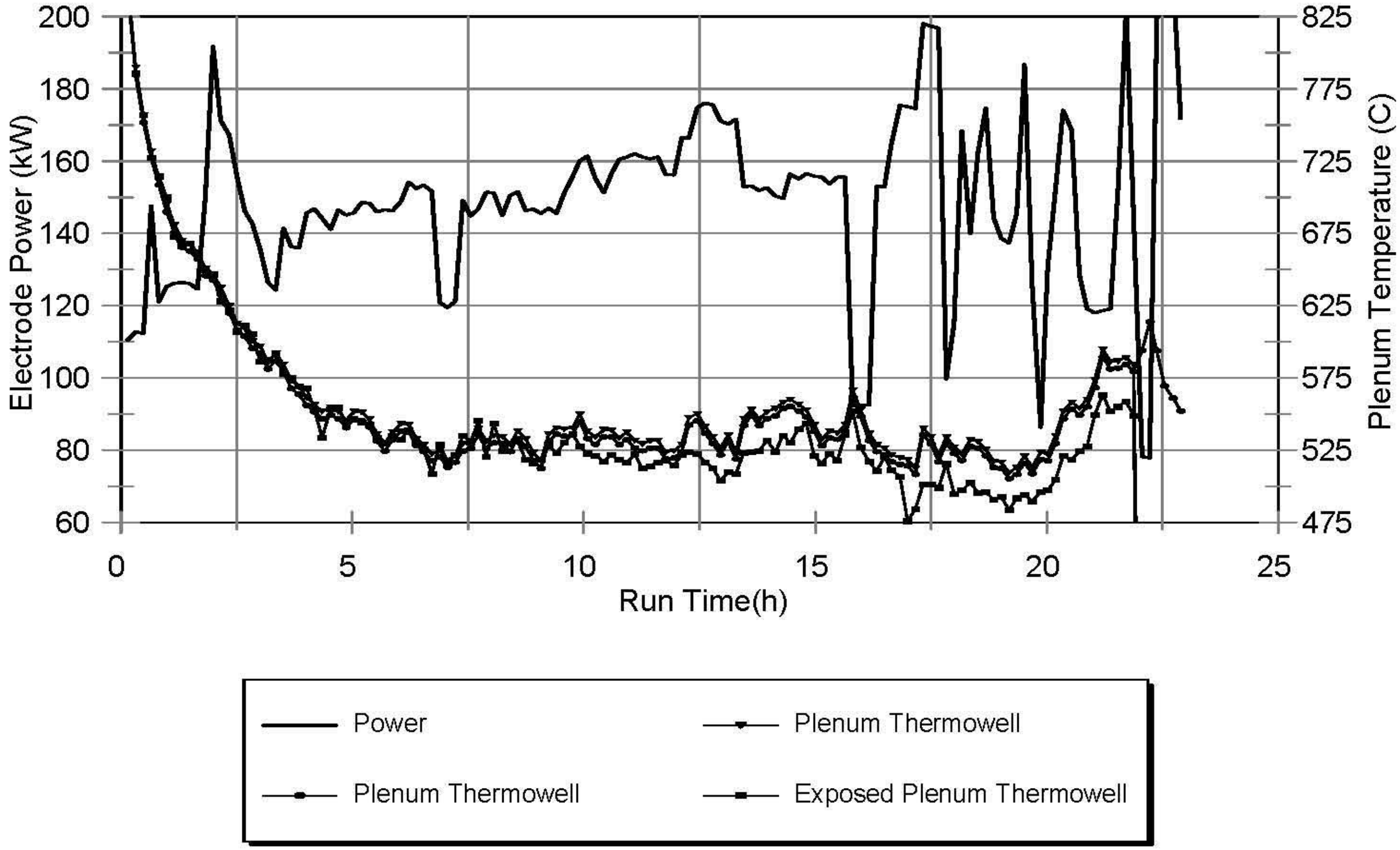

Figure 3.17. Plenum temperature and electrode power for DM1000, AZ101 Test 8.

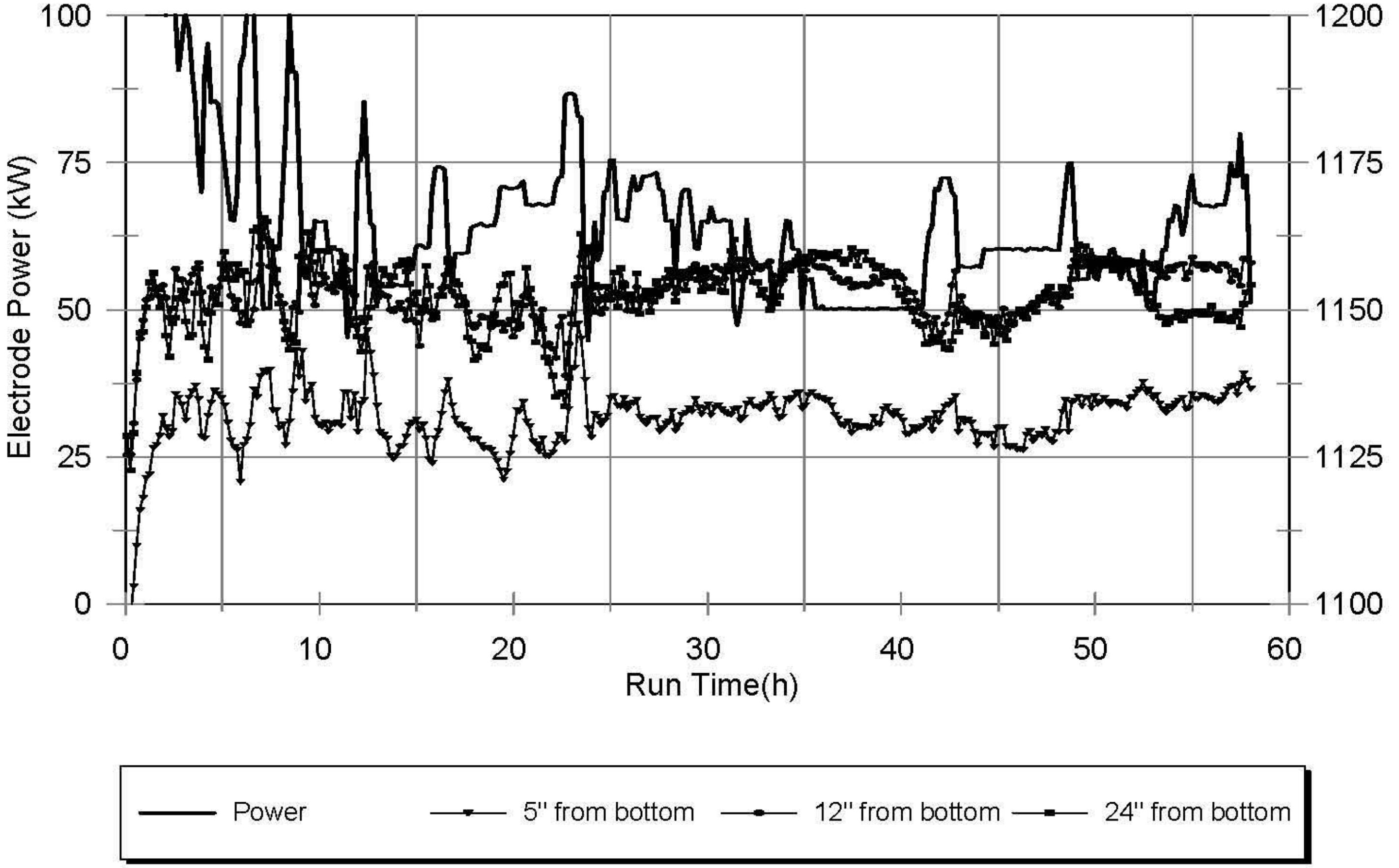

Figure 3.18. Glass temperature and electrode power for DM1000, AZ-101 Test 1.

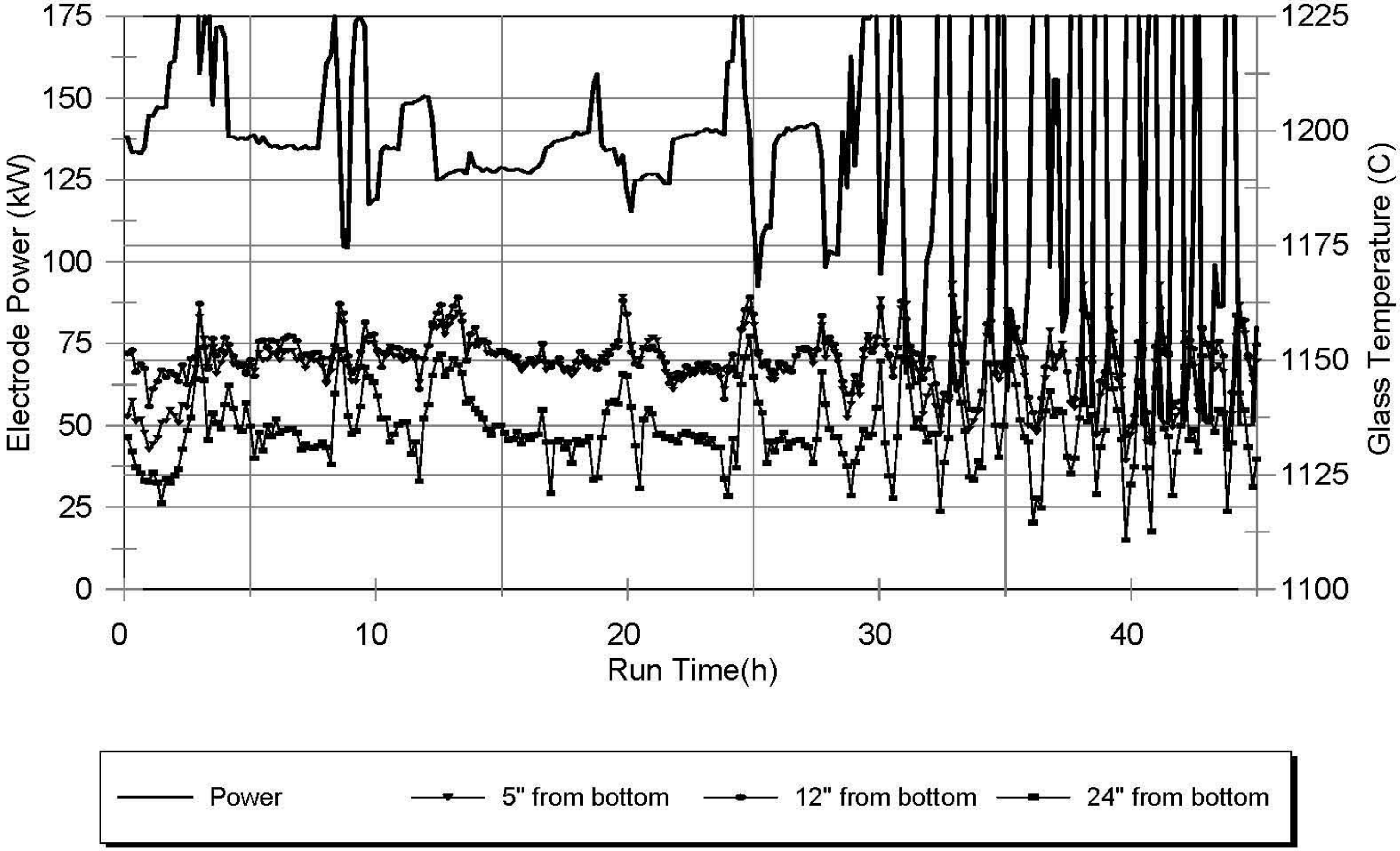

Figure 3.19. Glass temperature and electrode power for DM1000, AZ-101 Test 2.

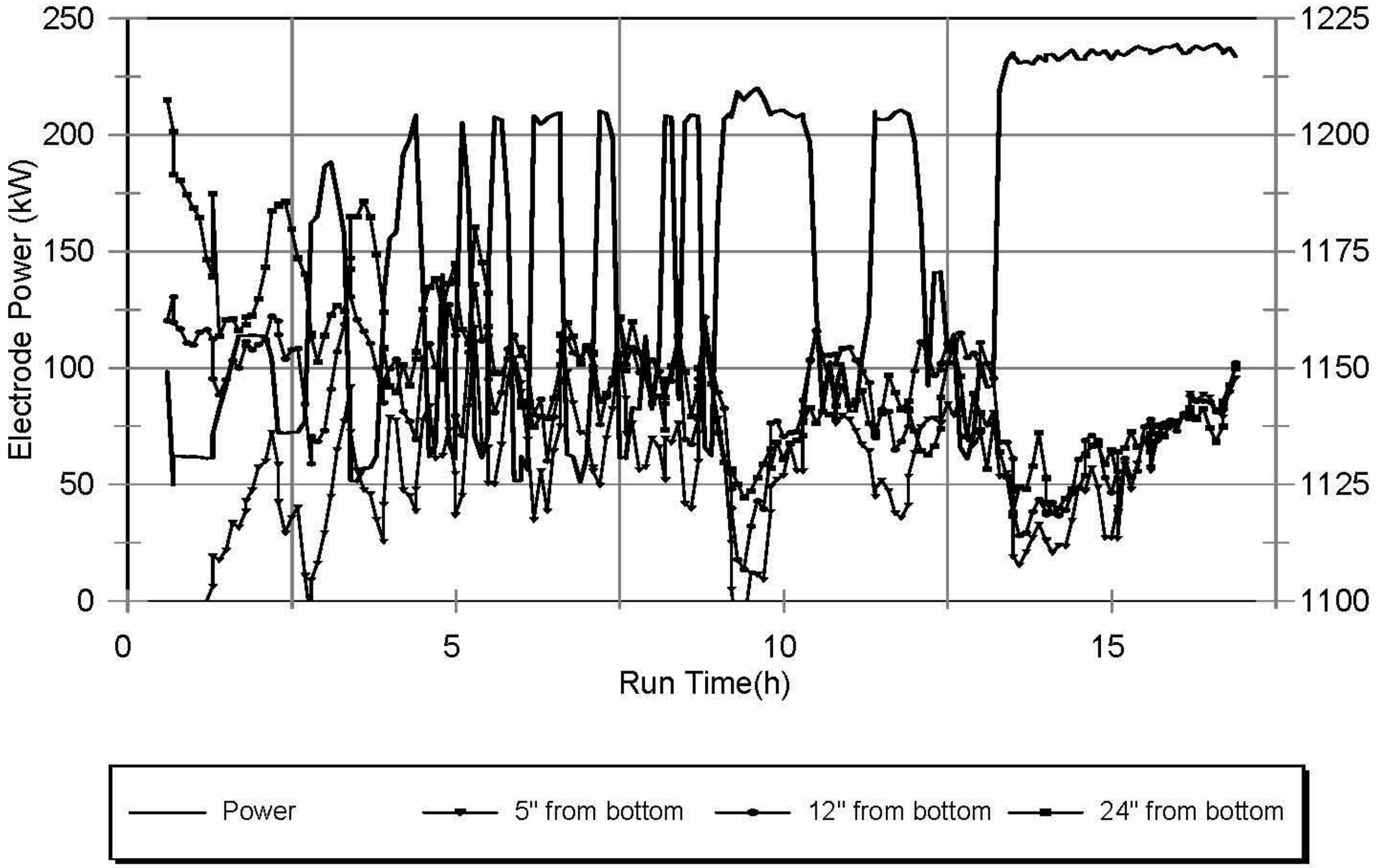

Figure 3.20. Glass temperature and electrode power for DM1000, AZ-101 Test 3.

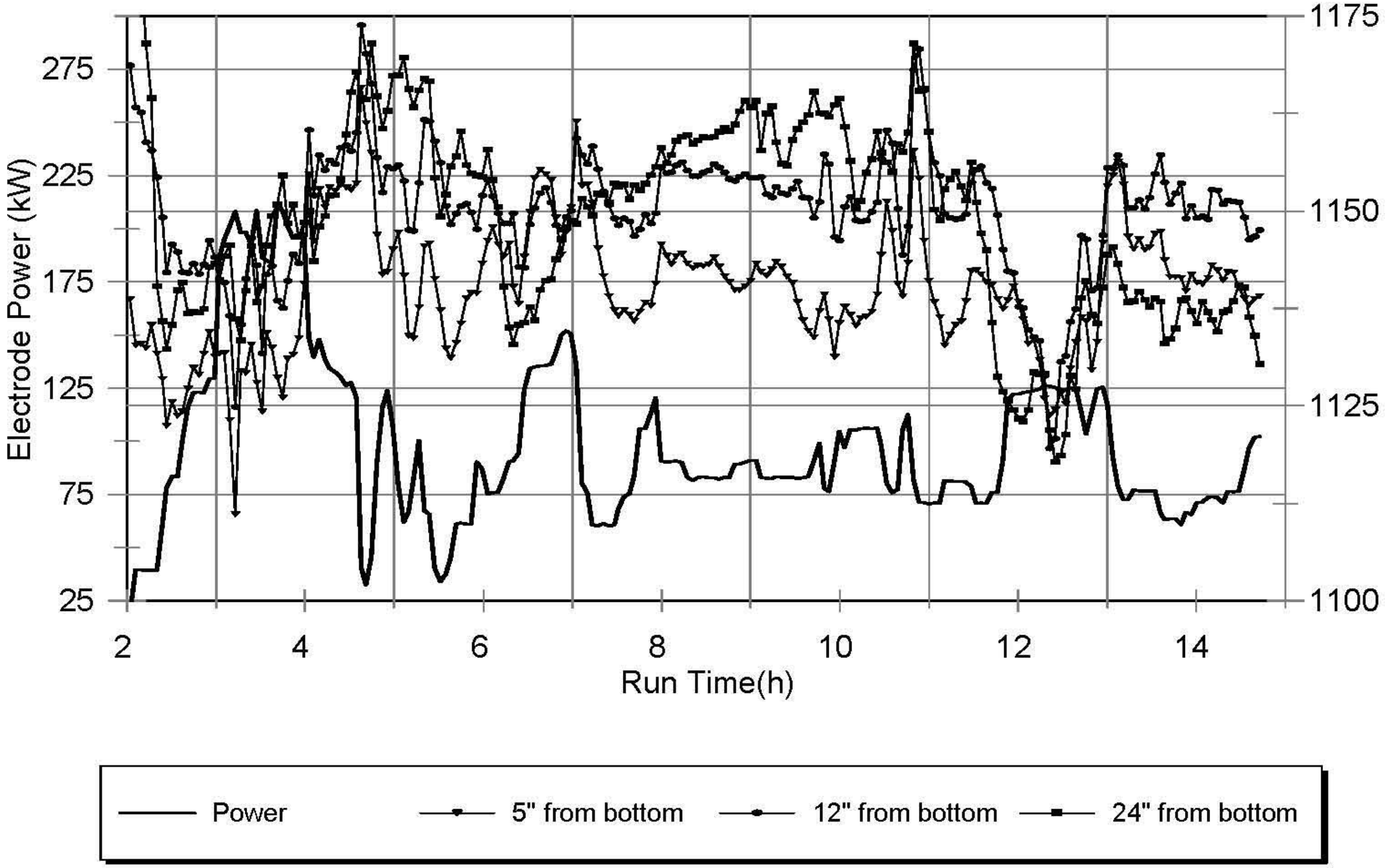

Figure 3.21. Glass temperature and electrode power for DM1000, AZ-101 Test 4.

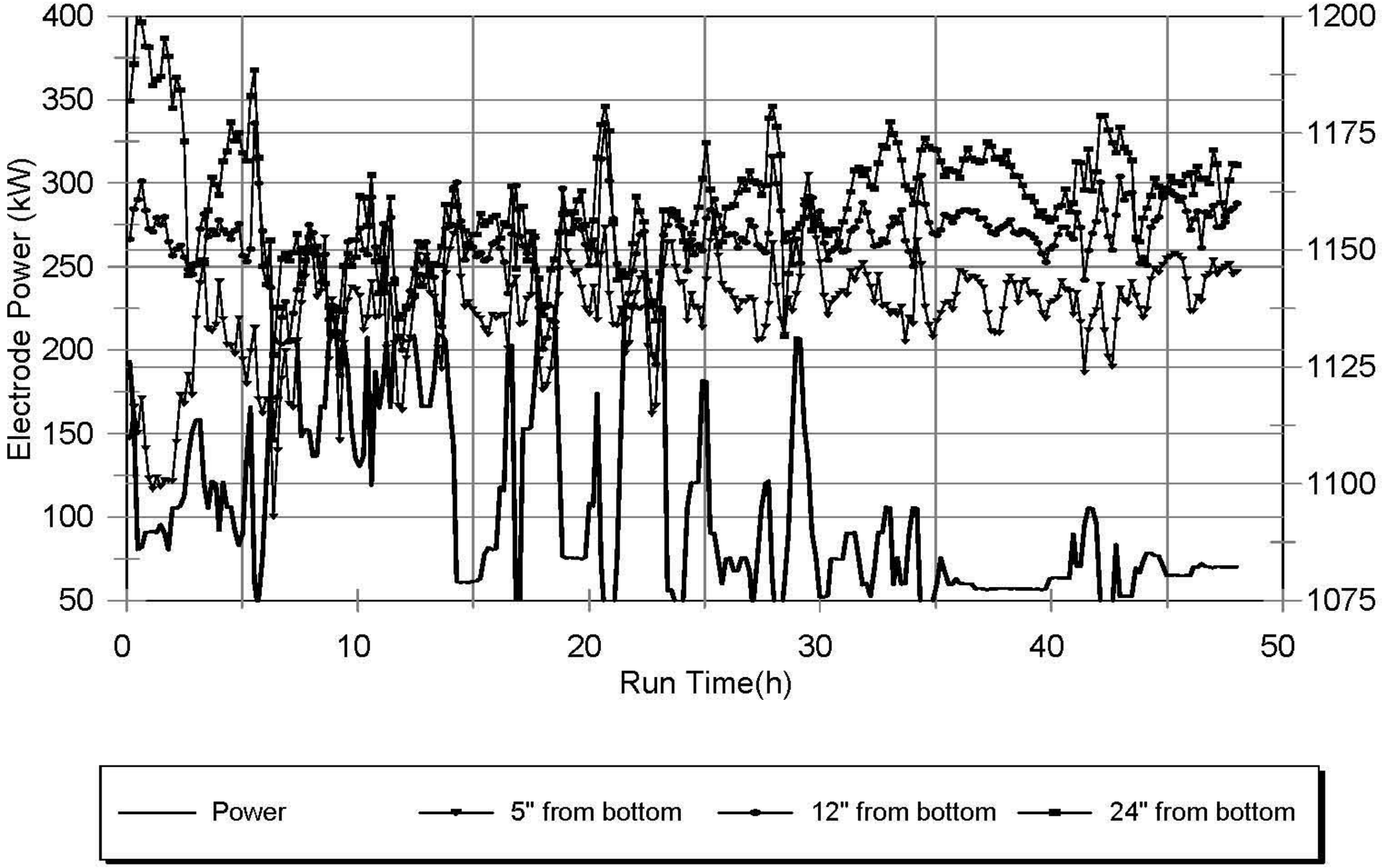

Figure 3.22. Glass temperature and electrode power for DM1000, AZ-101 Test 5.

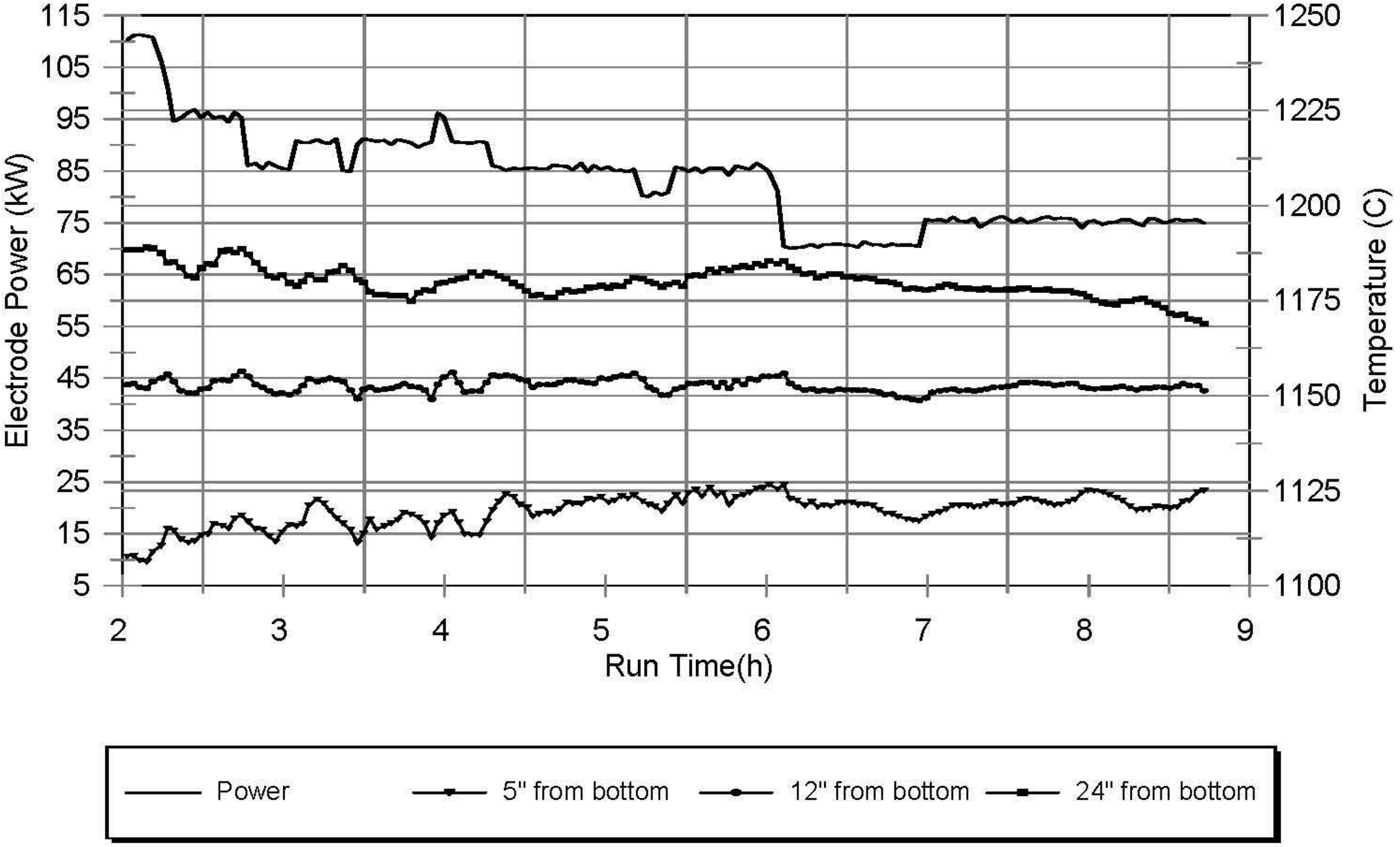

Figure 3.23. Glass temperature and electrode power for DM1000, AZ-101 Test 6.

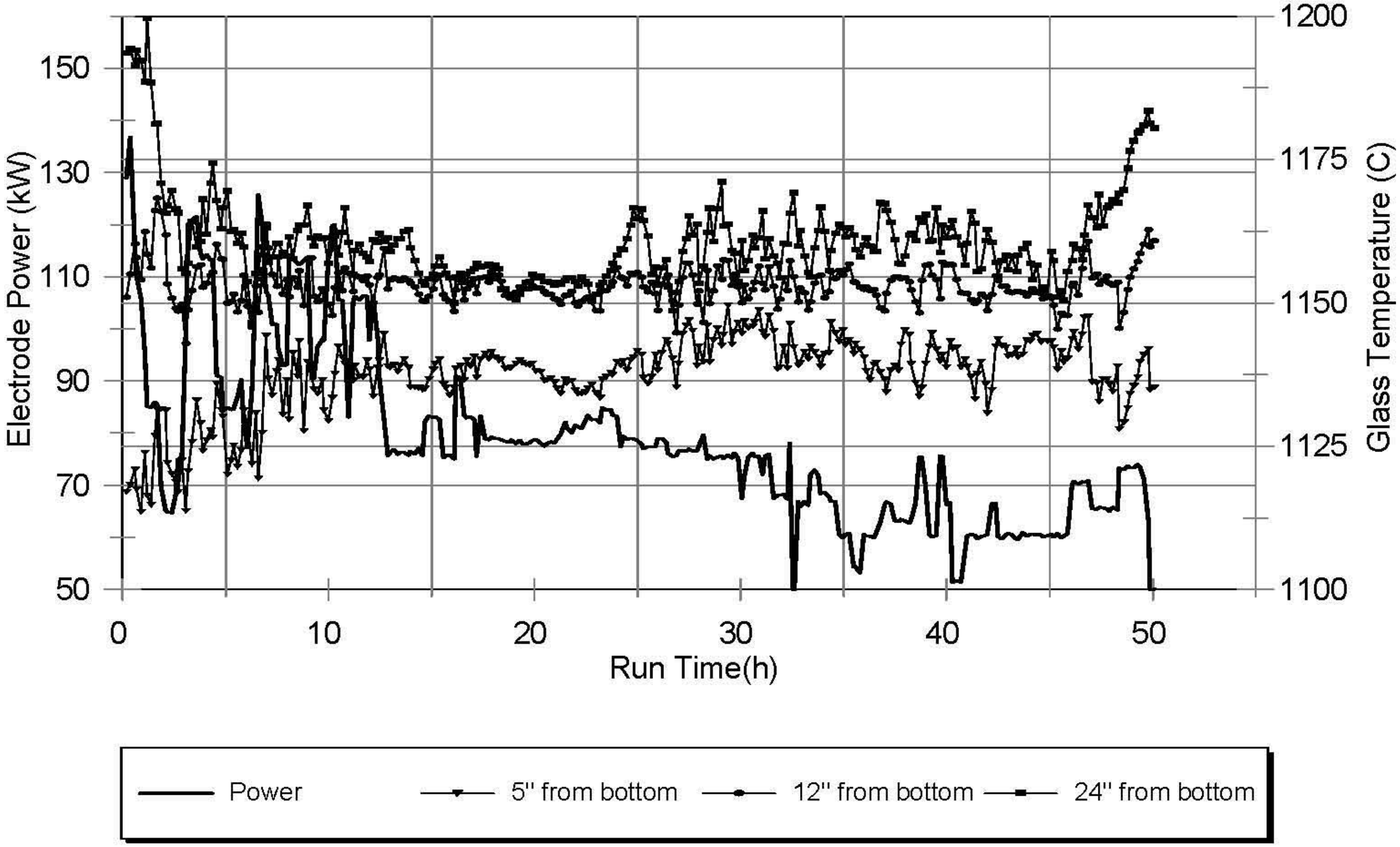

Figure 3.24. Glass temperature and electrode power for DM1000, AZ-101 Test 7.

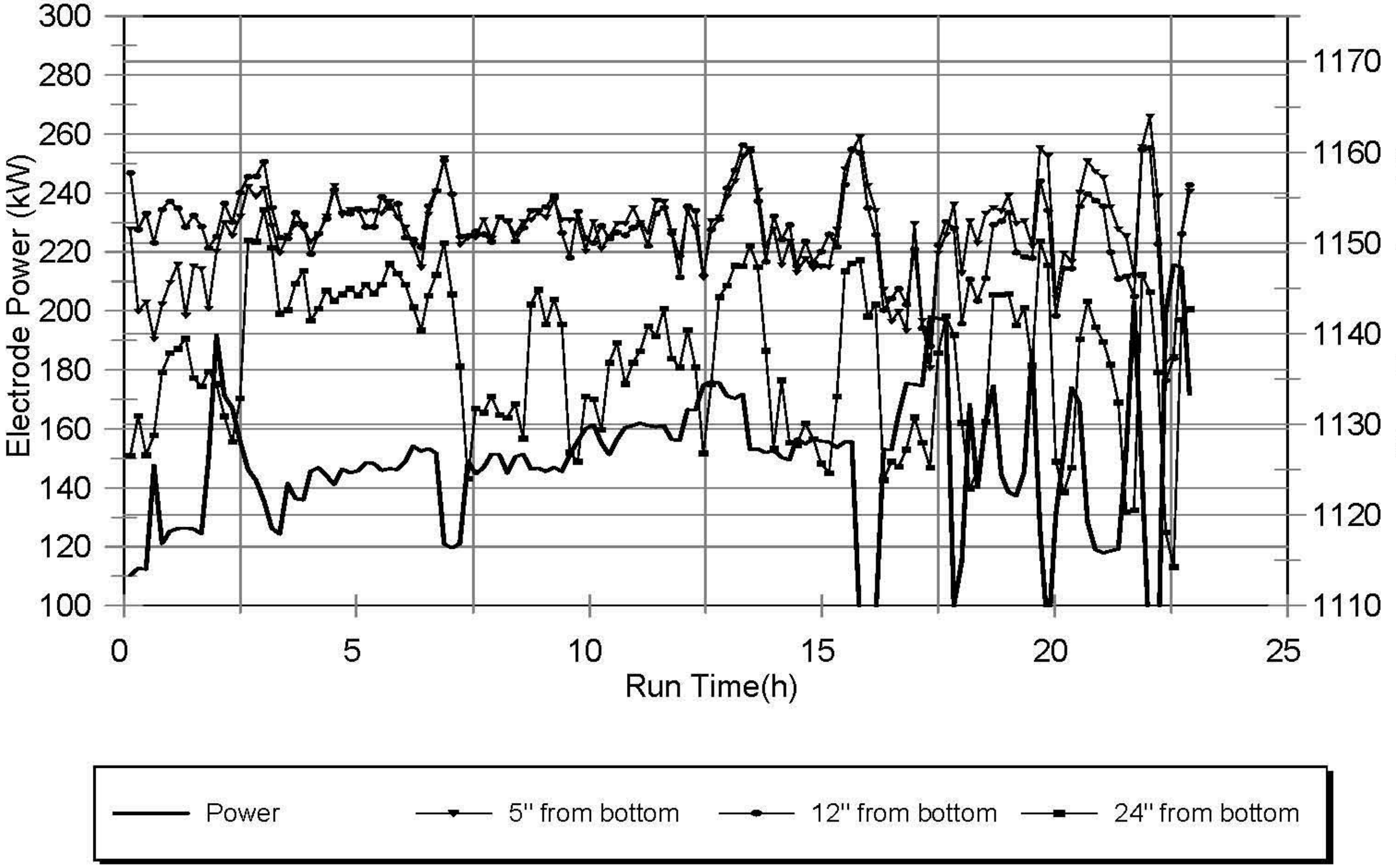

Figure 3.25. Glass temperature and electrode power for DM1000, AZ-101, Test 8.

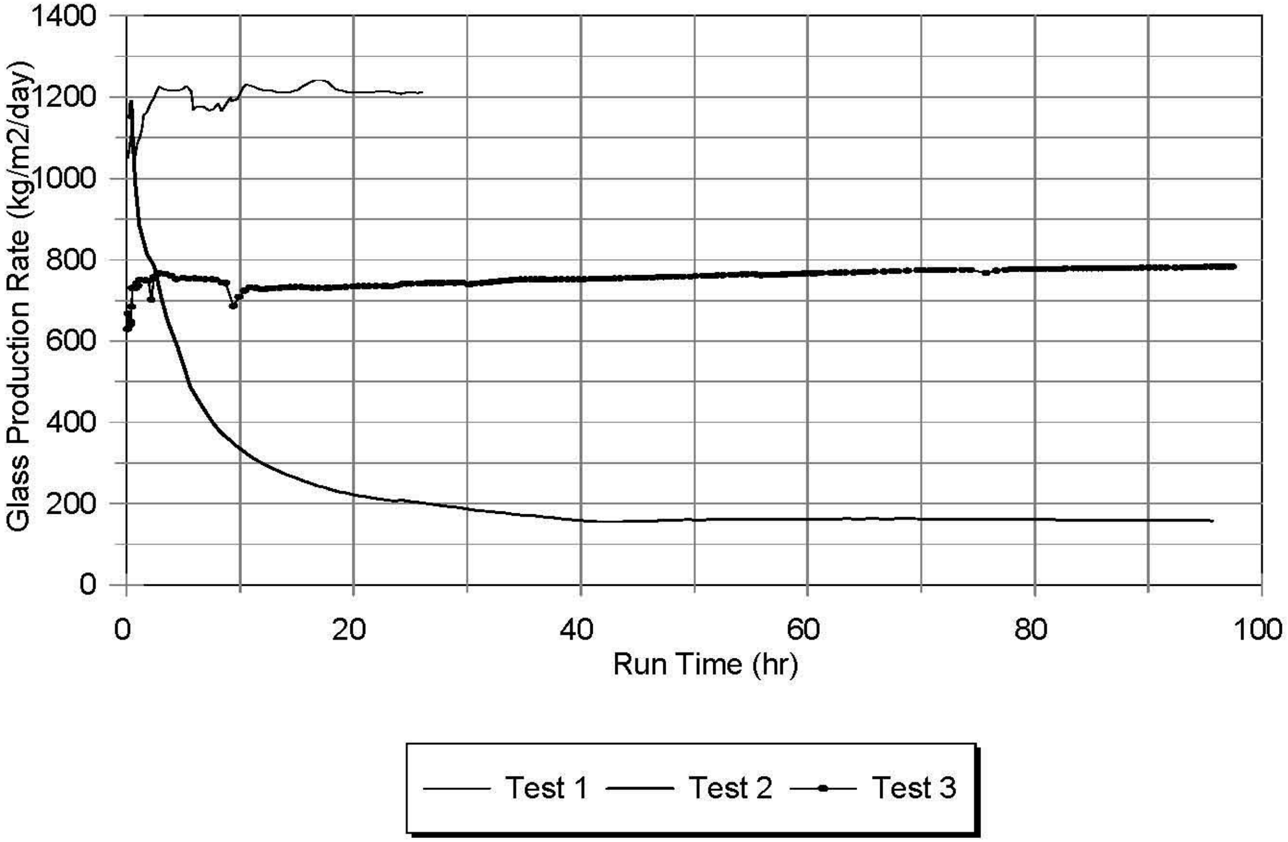

Figure 3.26. Cumulative Glass Production Rates for C106/AY102 DM1000 Throughput Tests.

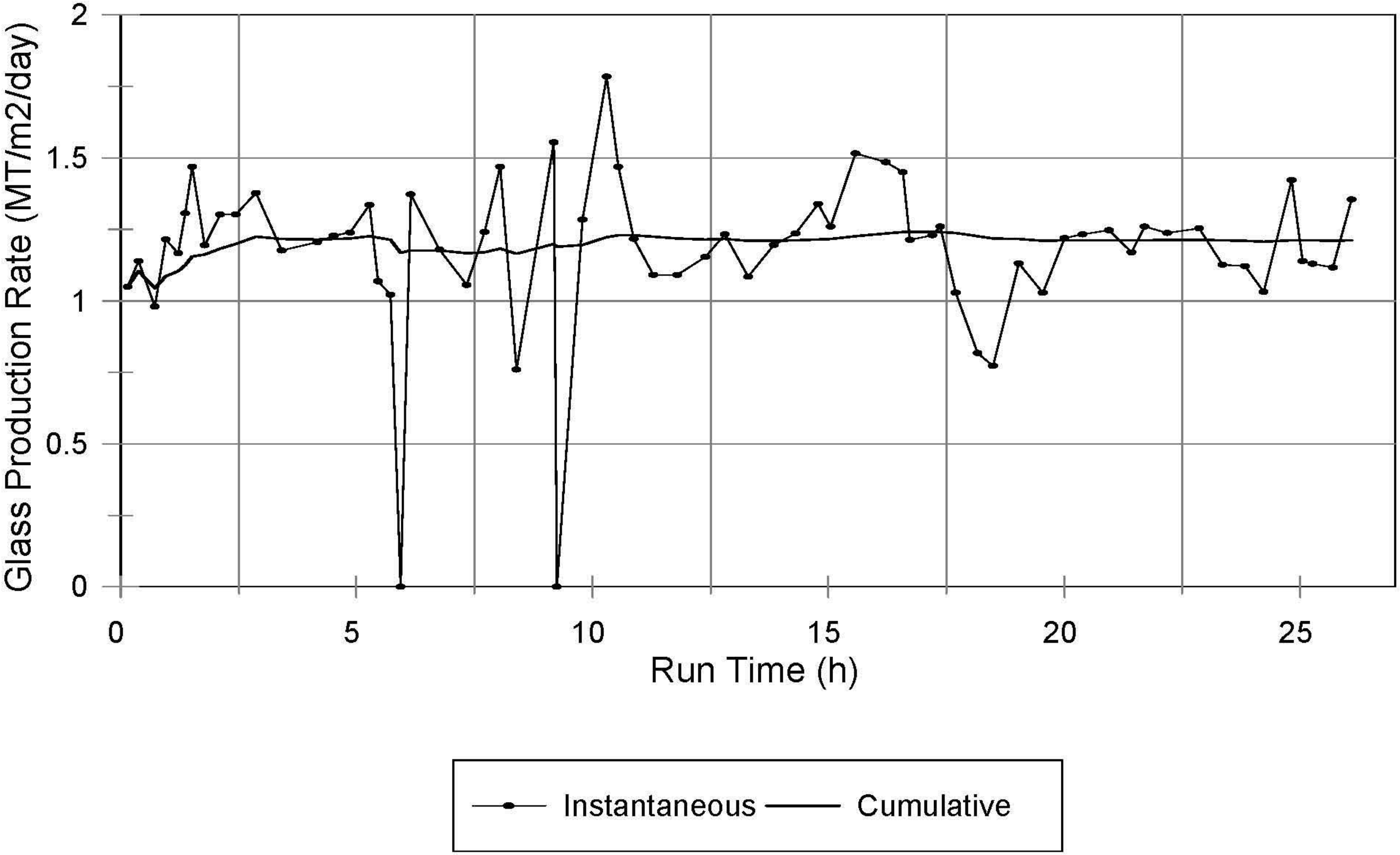

Figure 3.27. Production rates for DM1000, C106/AY102, Test 1.

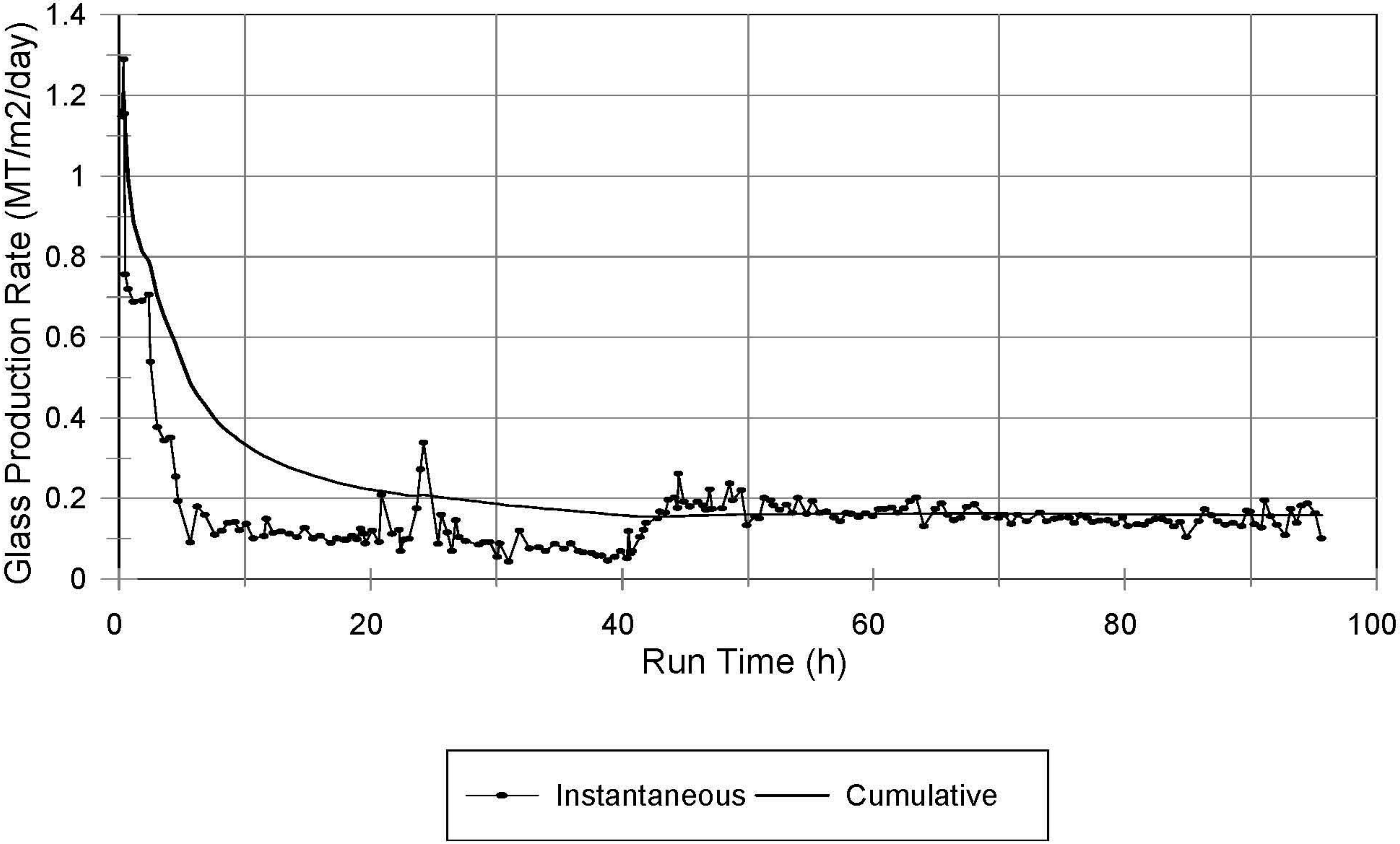

Figure 3.28. Production rates for DM1000, C106/AY102 Test 2.

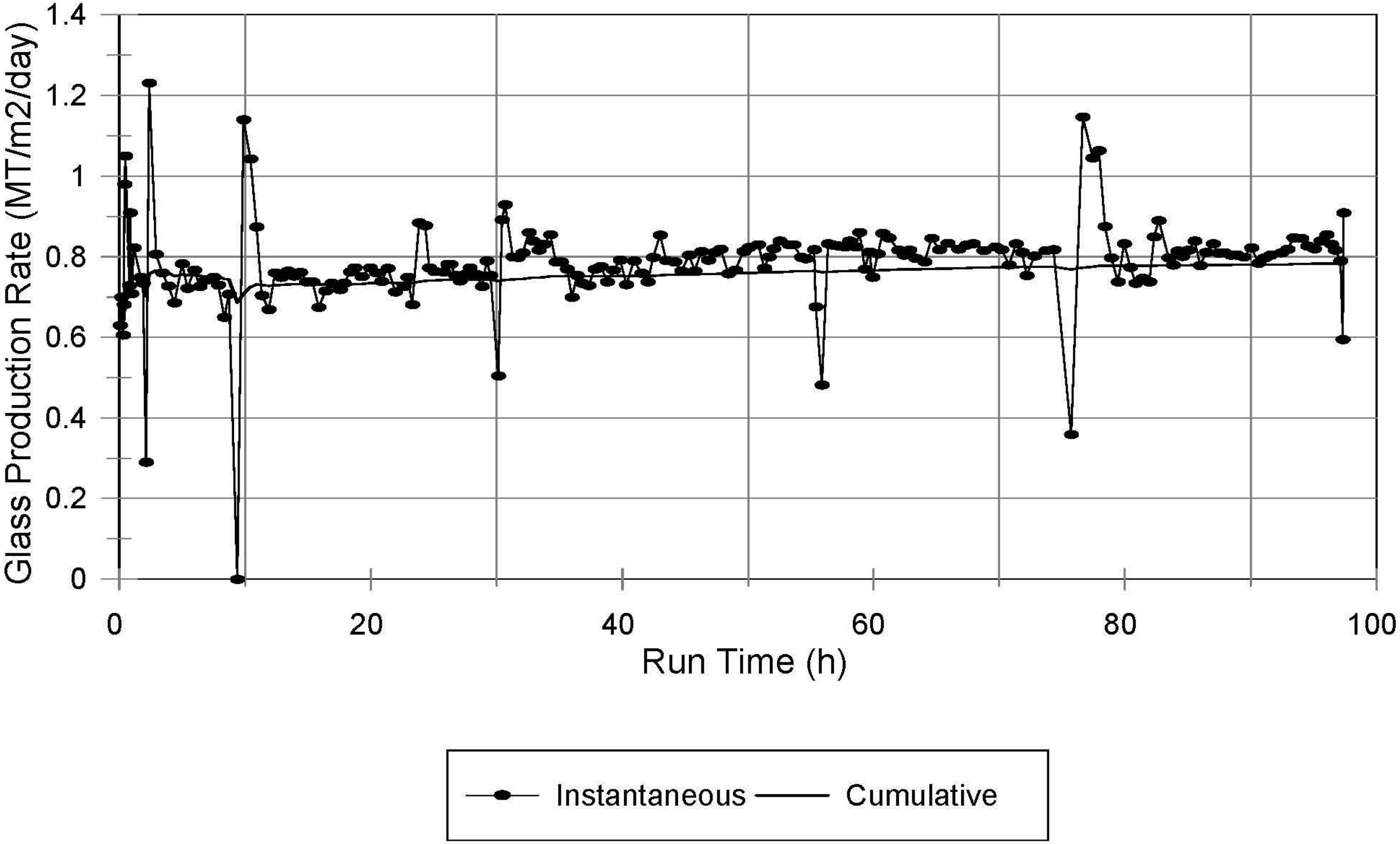

Figure 3.29. Production rates for DM1000, C106/AY102 Test 3.

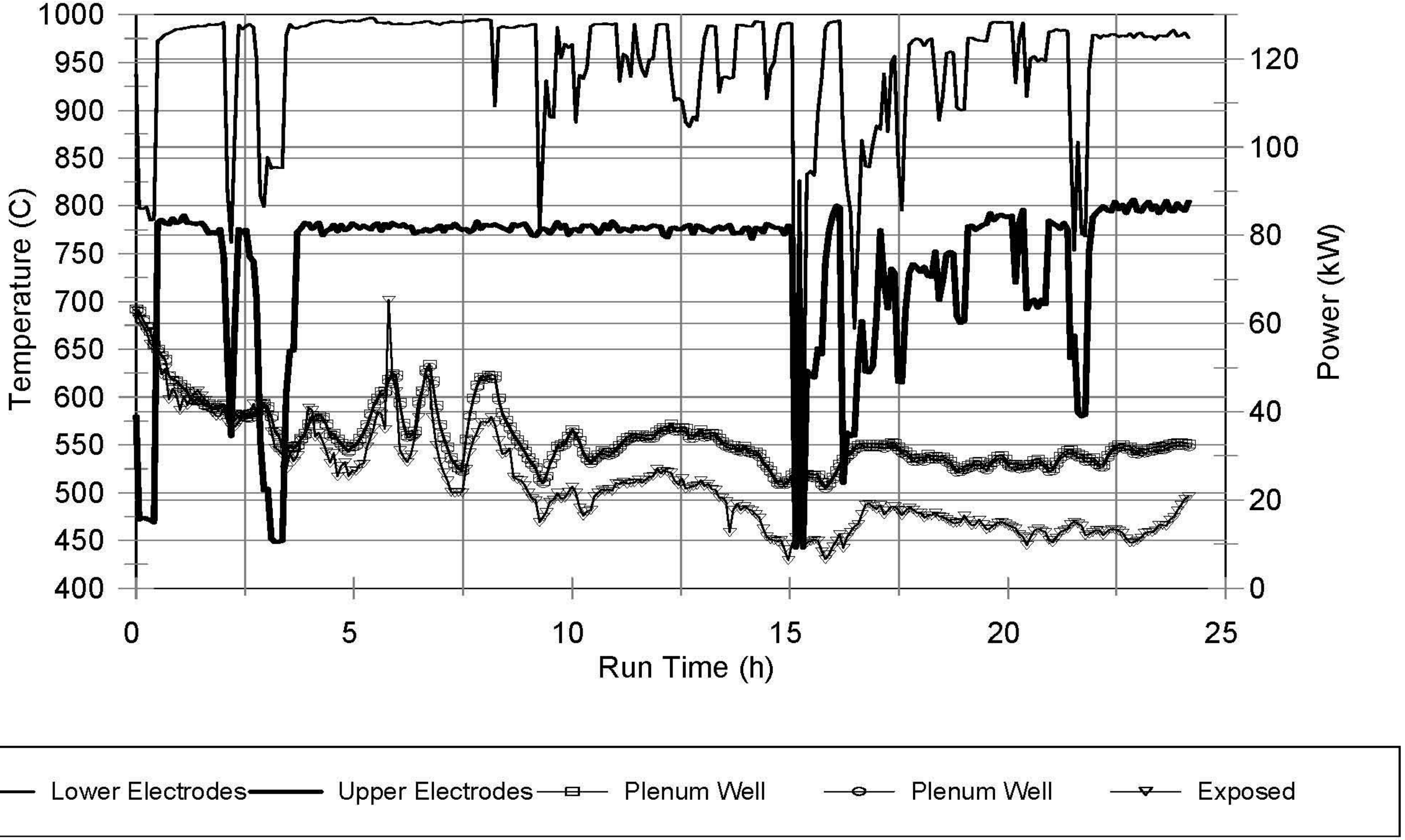

Figure 3.28. Production rates for DM1000, C106/AY102 Test 2.Figure 3.28. Production rates for DM1000, C106/AY102 Test 3

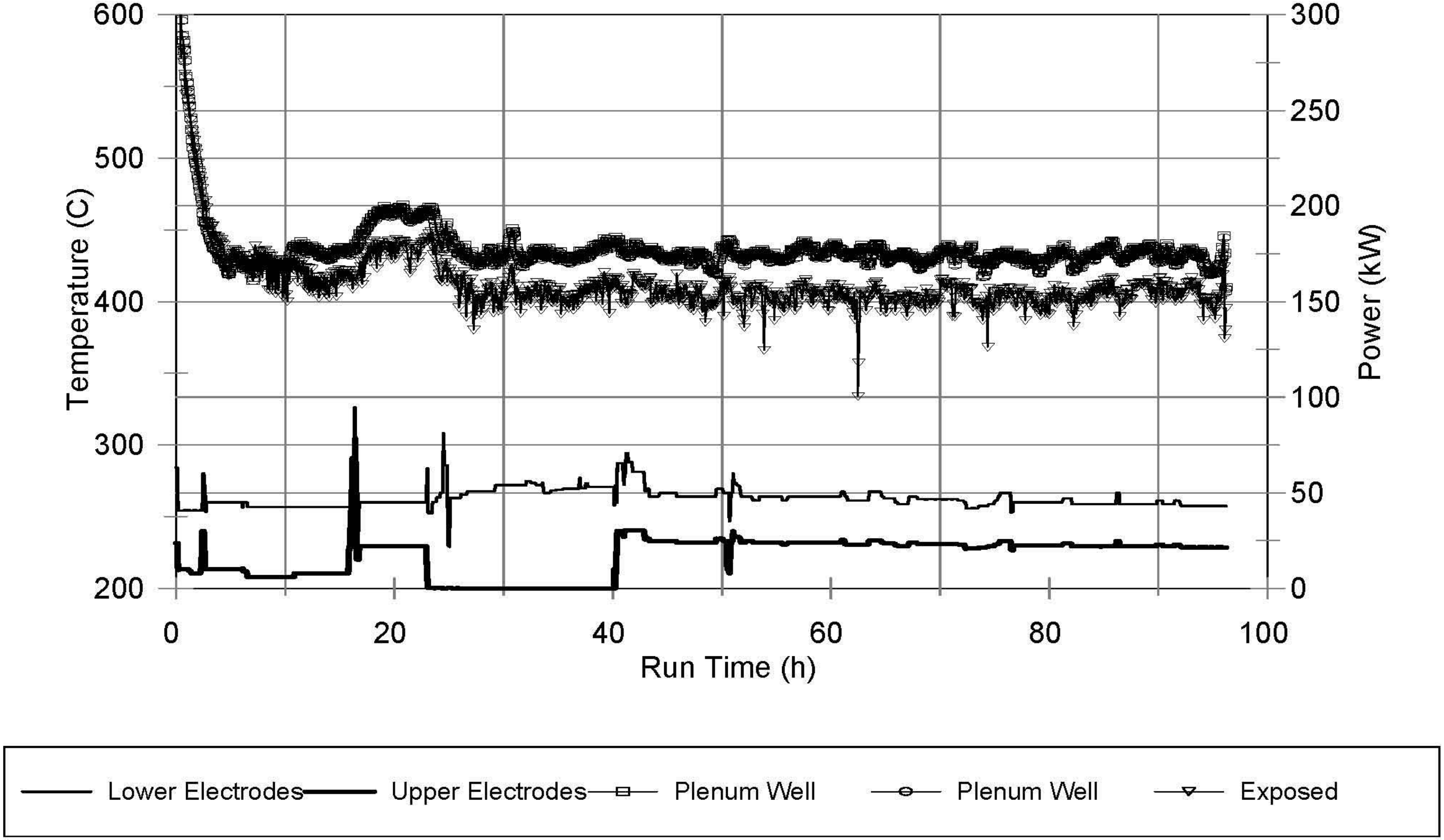

Figure 3.31. Plenum temperatures and electrode power for DM1000, C106/AY102 Test 2

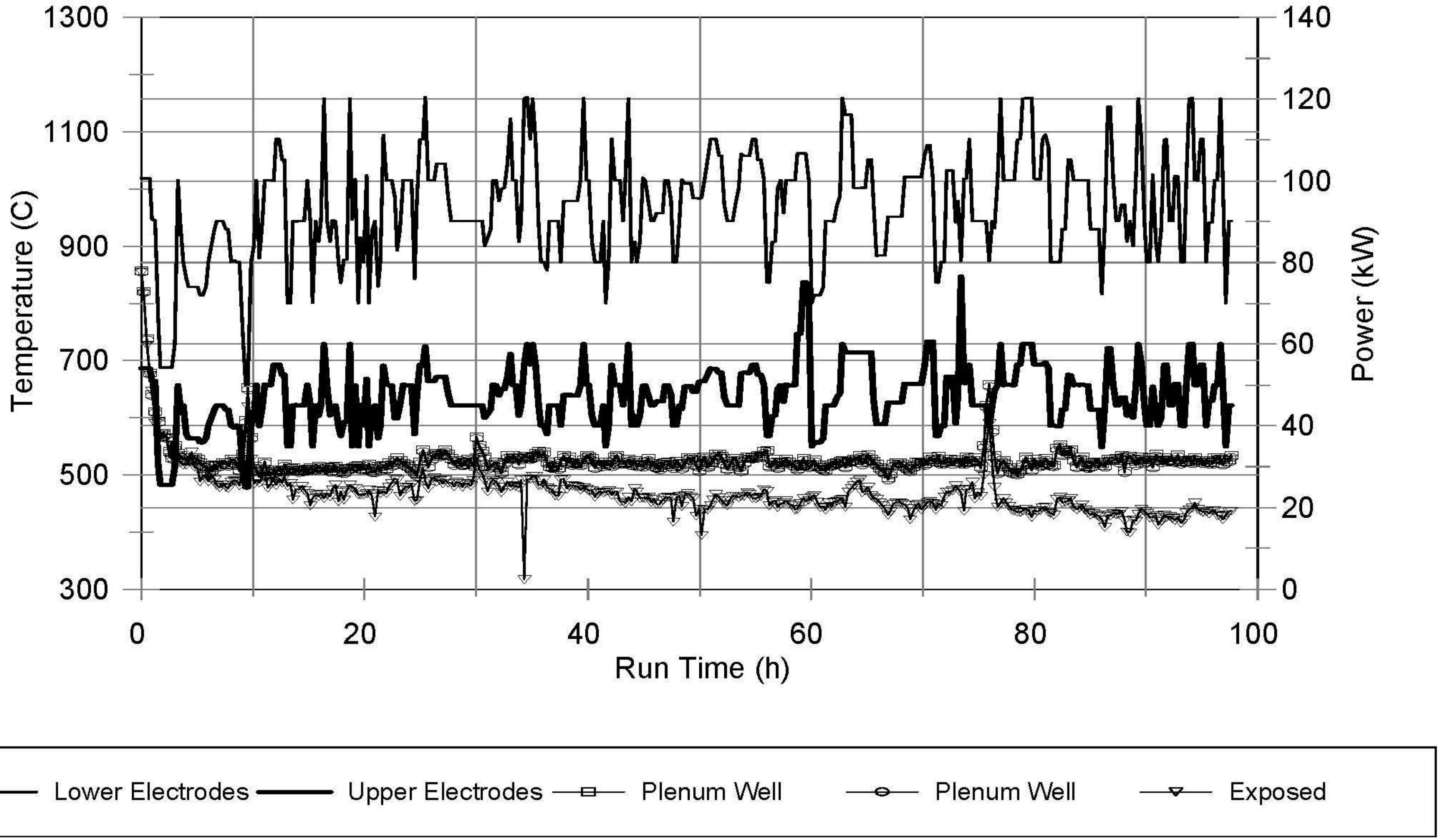

Figure 3.32. Plenum temperatures and electrode power for DM1000, C106/AY102 Test 3

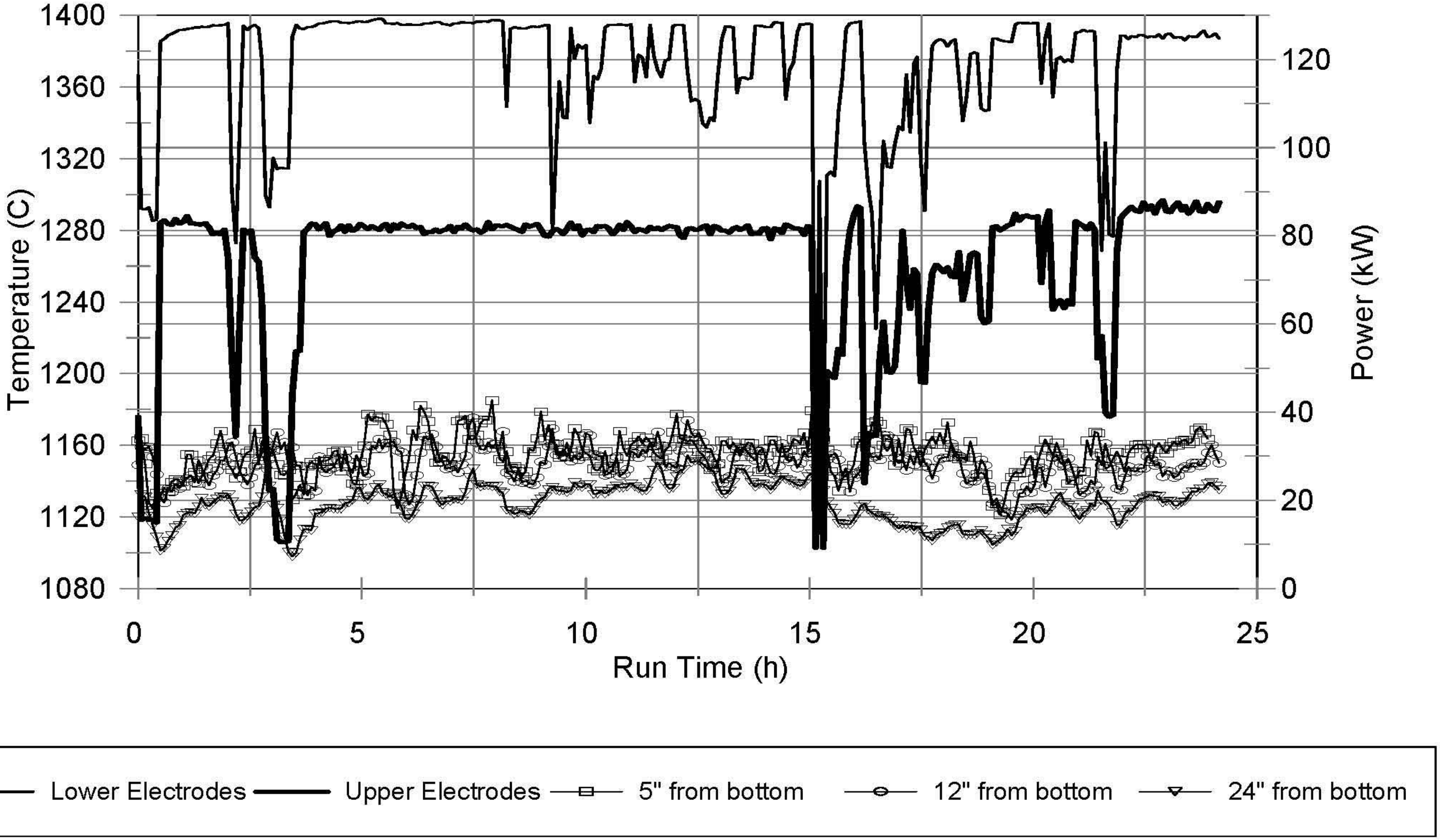

Figure 3.33 Glass temperatures and electrode power for DM1000, C106/AY102 Test 1

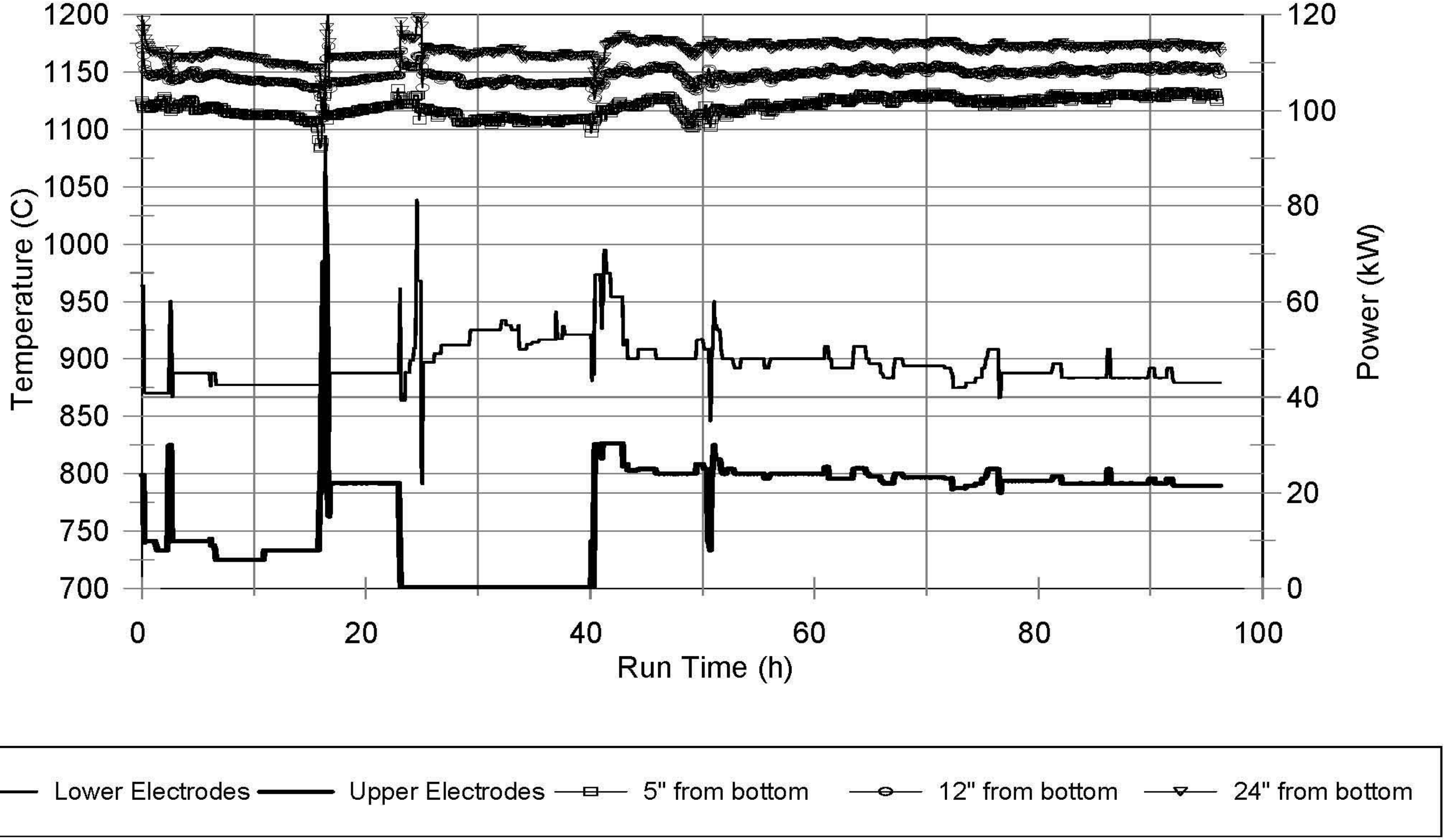

Figure 3.34. Glass temperatures and electrode power for DM1000, C106/AY102 Test 2

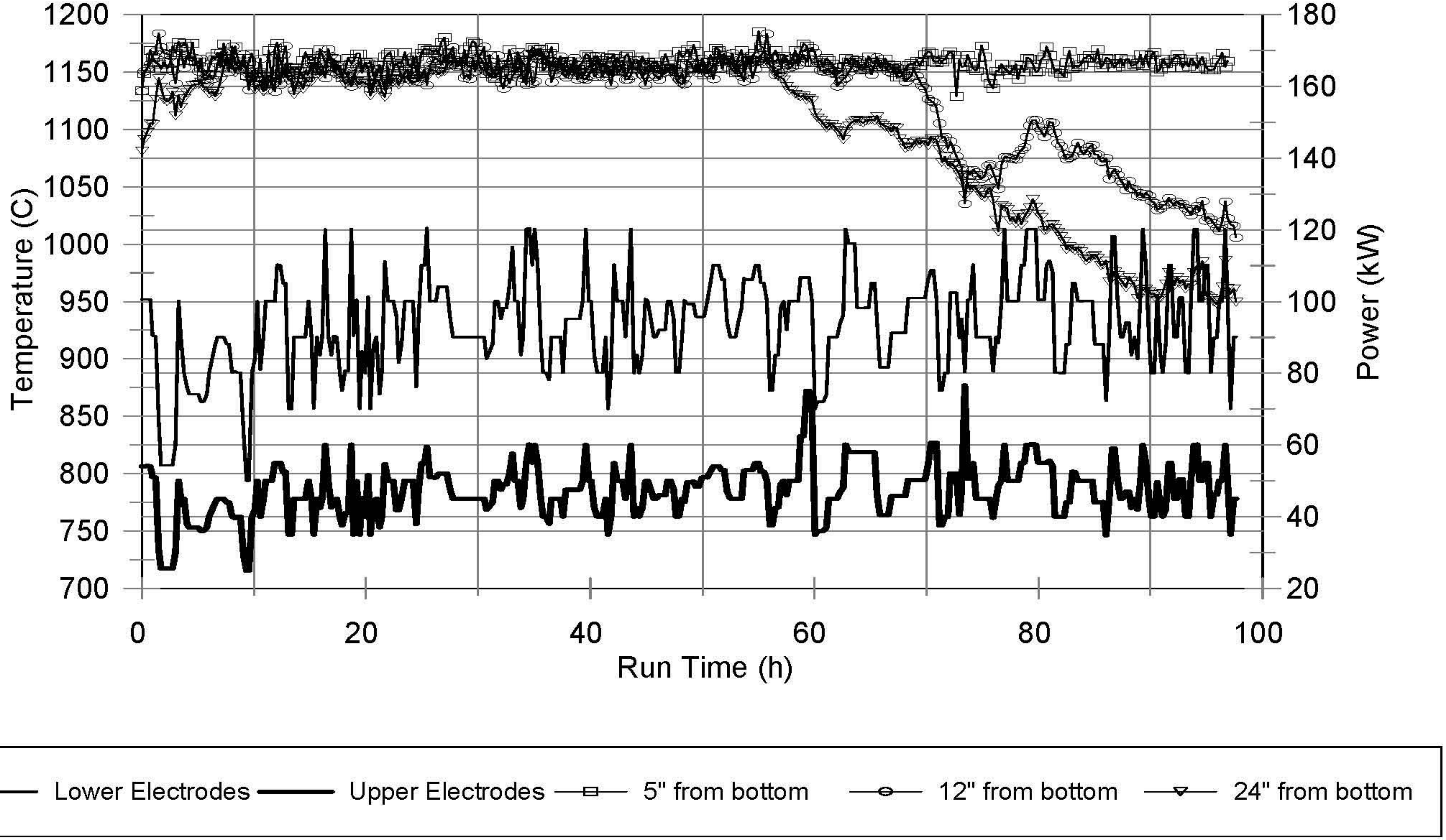

Figure 3.35. Glass temperatures and electrode power for DM1000, C106/AY102 Test 3

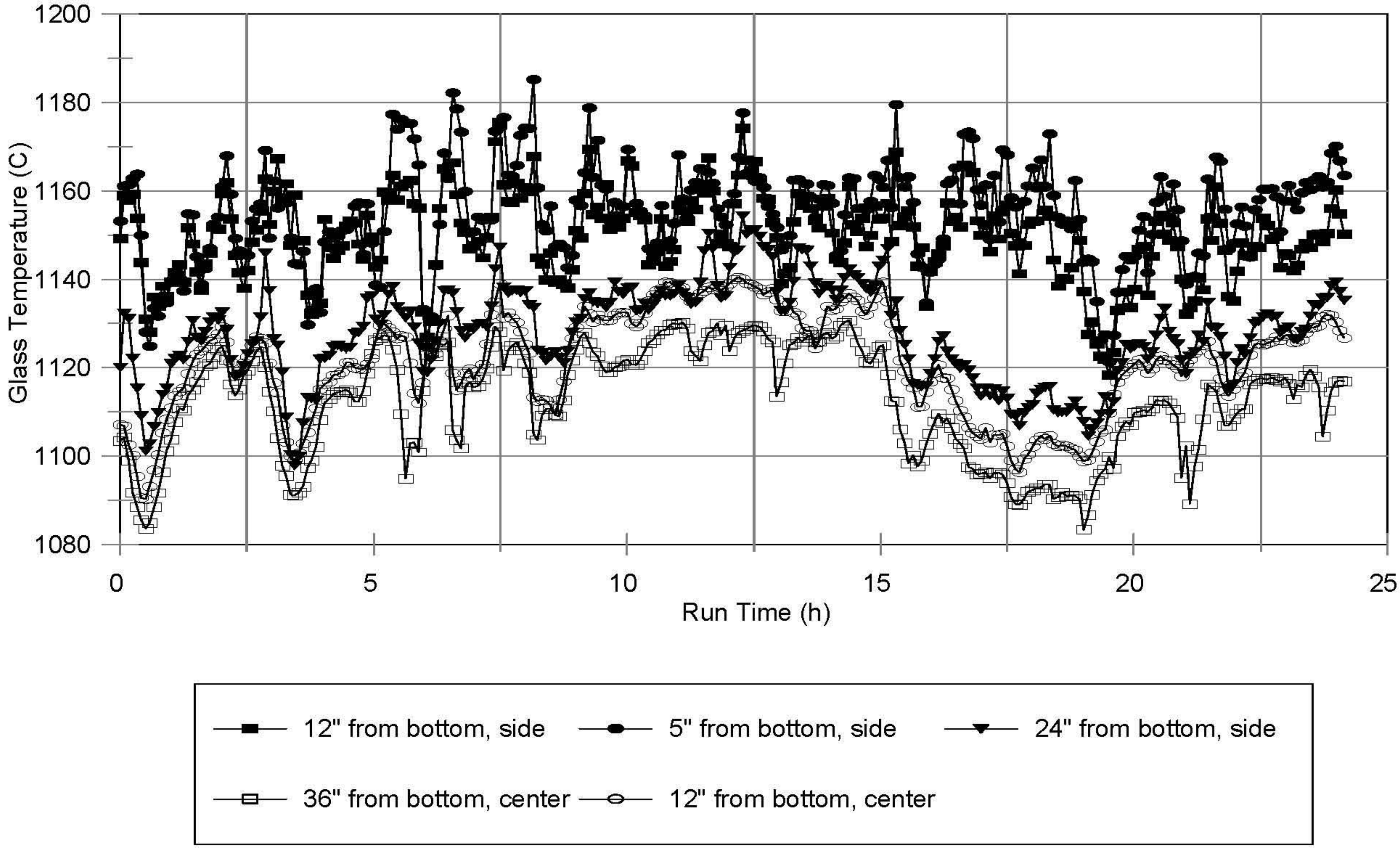

Figure 3.36. Comparison of side and center thermocouples in the glass pool during DM1000, C106/AY102 Test 1

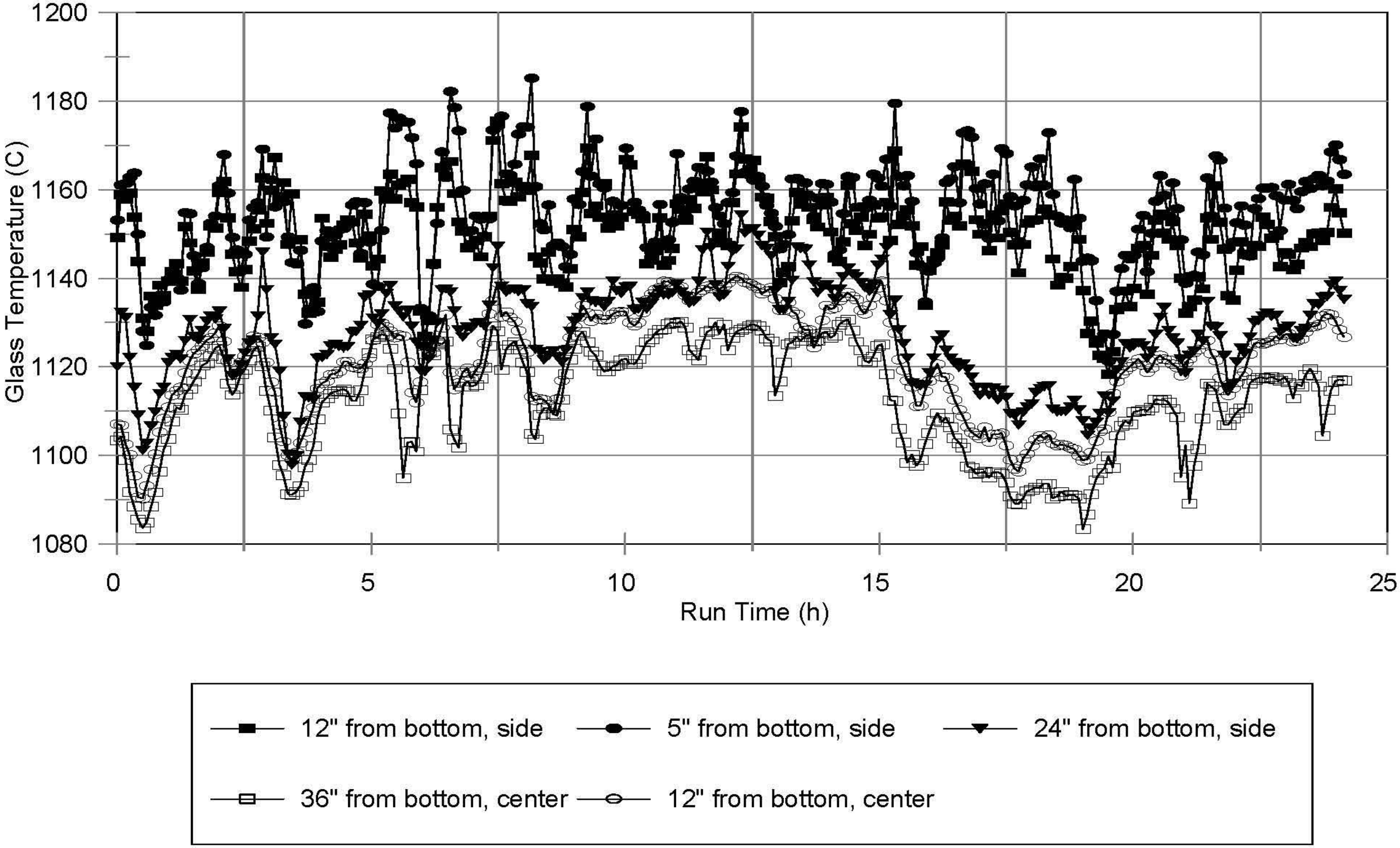

Figure 3.37. Comparison of side and center thermocouples in the glass pool during DM1000, C106/AY102 Test 2

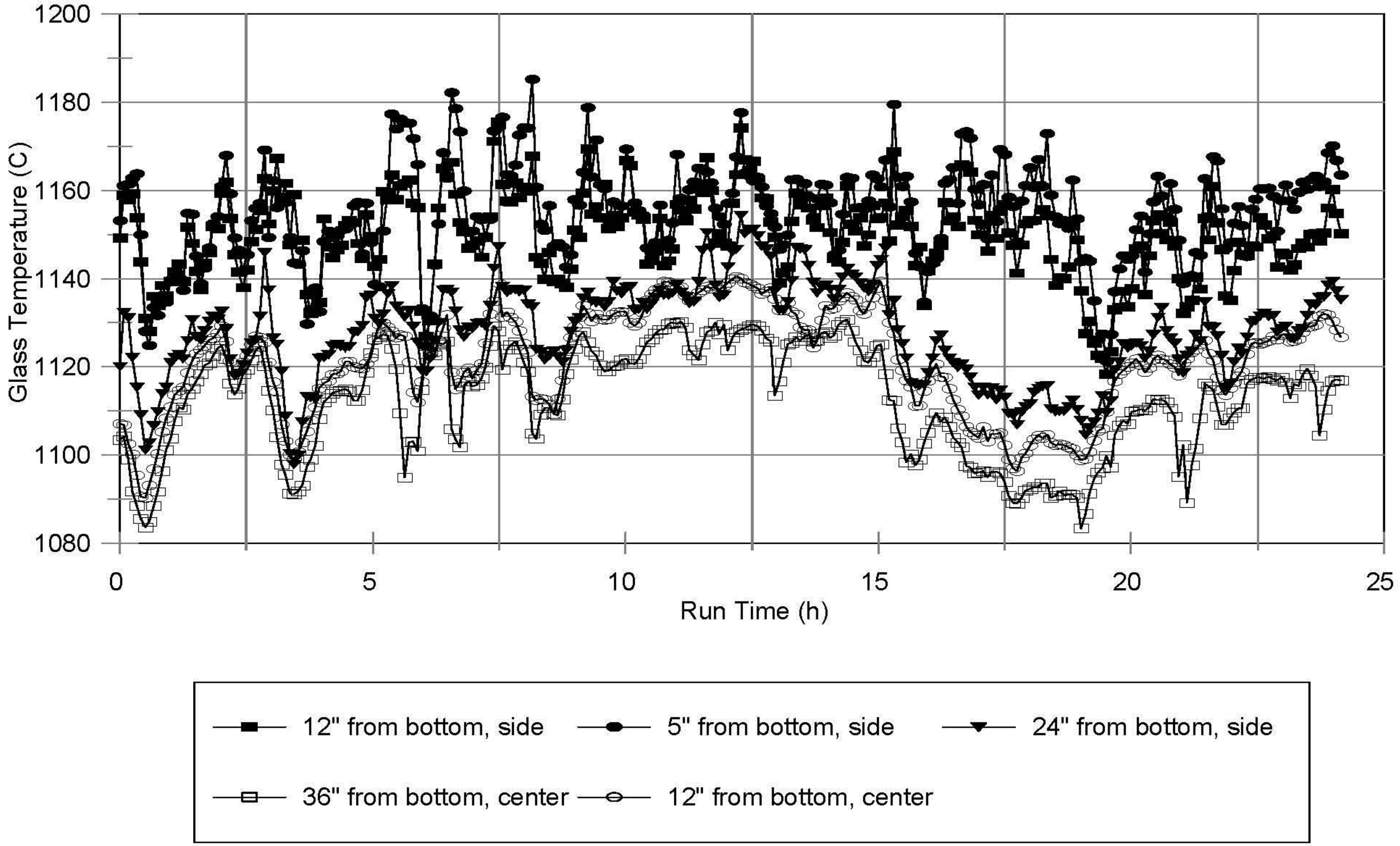

Figure 3.38. Comparison of side and center thermocouples in the glass pool during DM1000, C106/AY102 Test 3

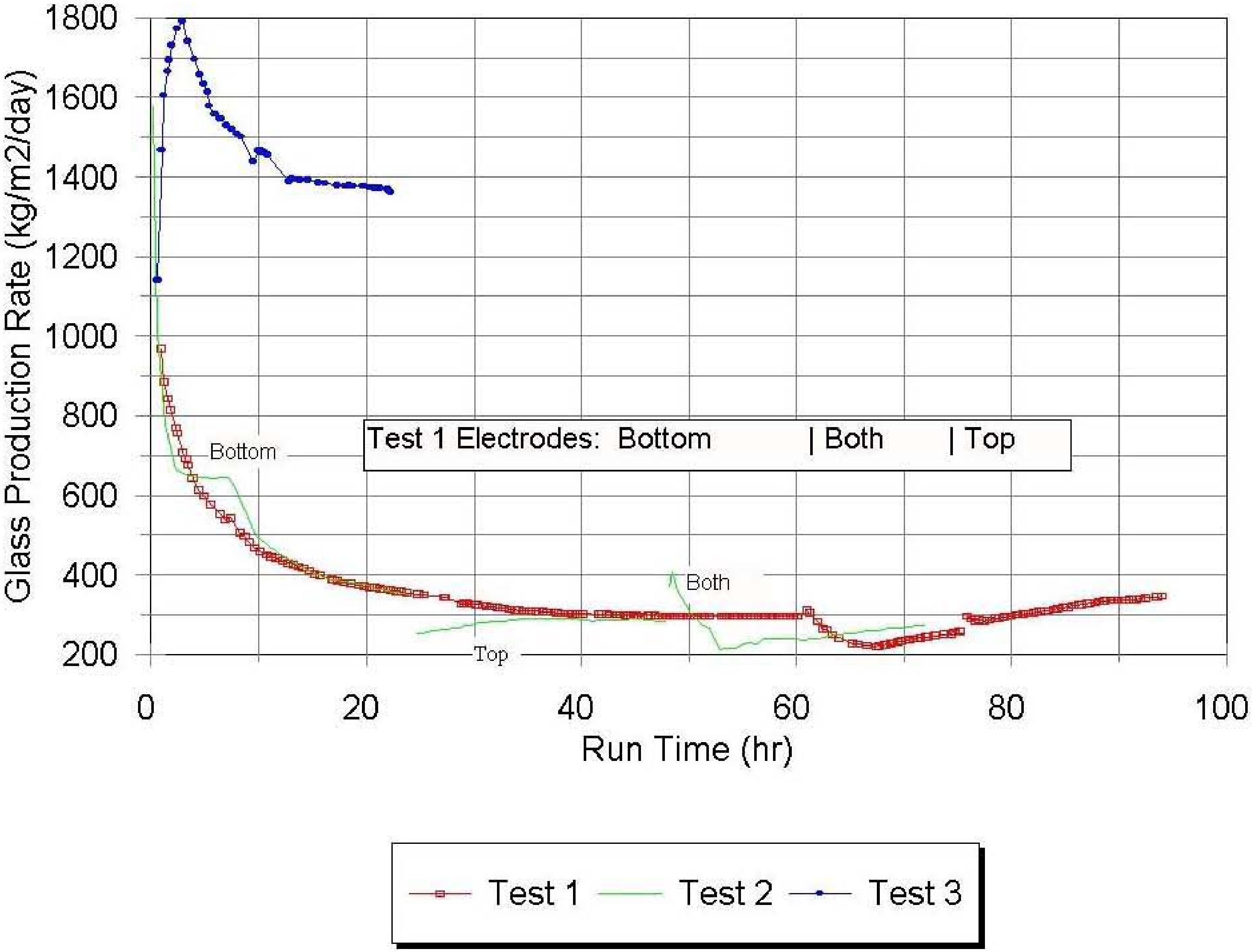

Figure 3.39. Cumulative glass production rates for West Valley DM1000 throughput tests using various electrode combinations.

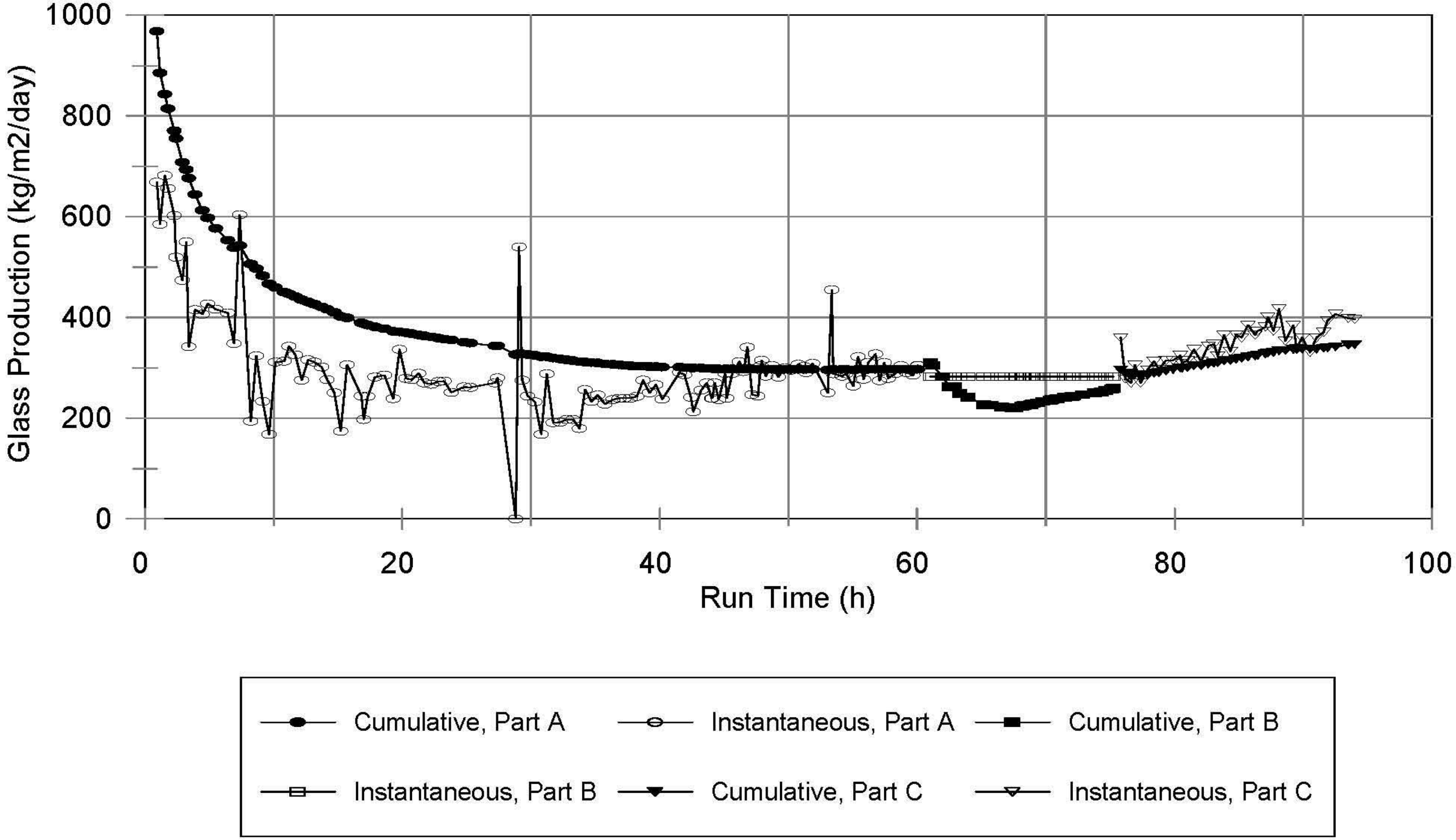

Figure 3.40. Production rates for DM1000 West Valley Test 1.
(Part A = Bottom Electrodes; Part B = Top + Bottom Electrodes; Part C = Top Electrodes.)

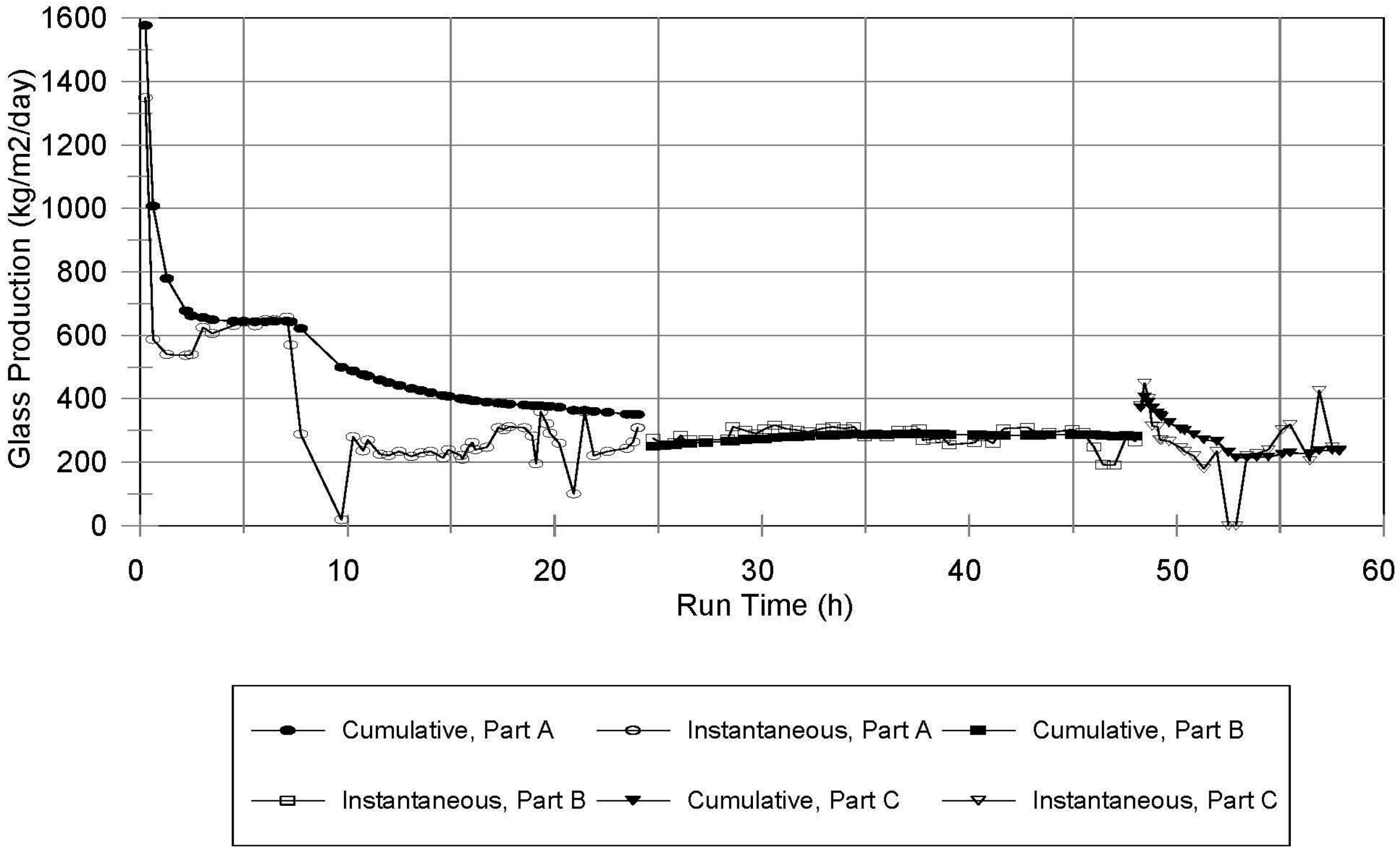

Figure 3.41. Production rates for DM1000 West Valley Test 2
(Part A = Bottom Electrodes; Part B = Top + Bottom Electrodes; Part C = Top Electrodes.)

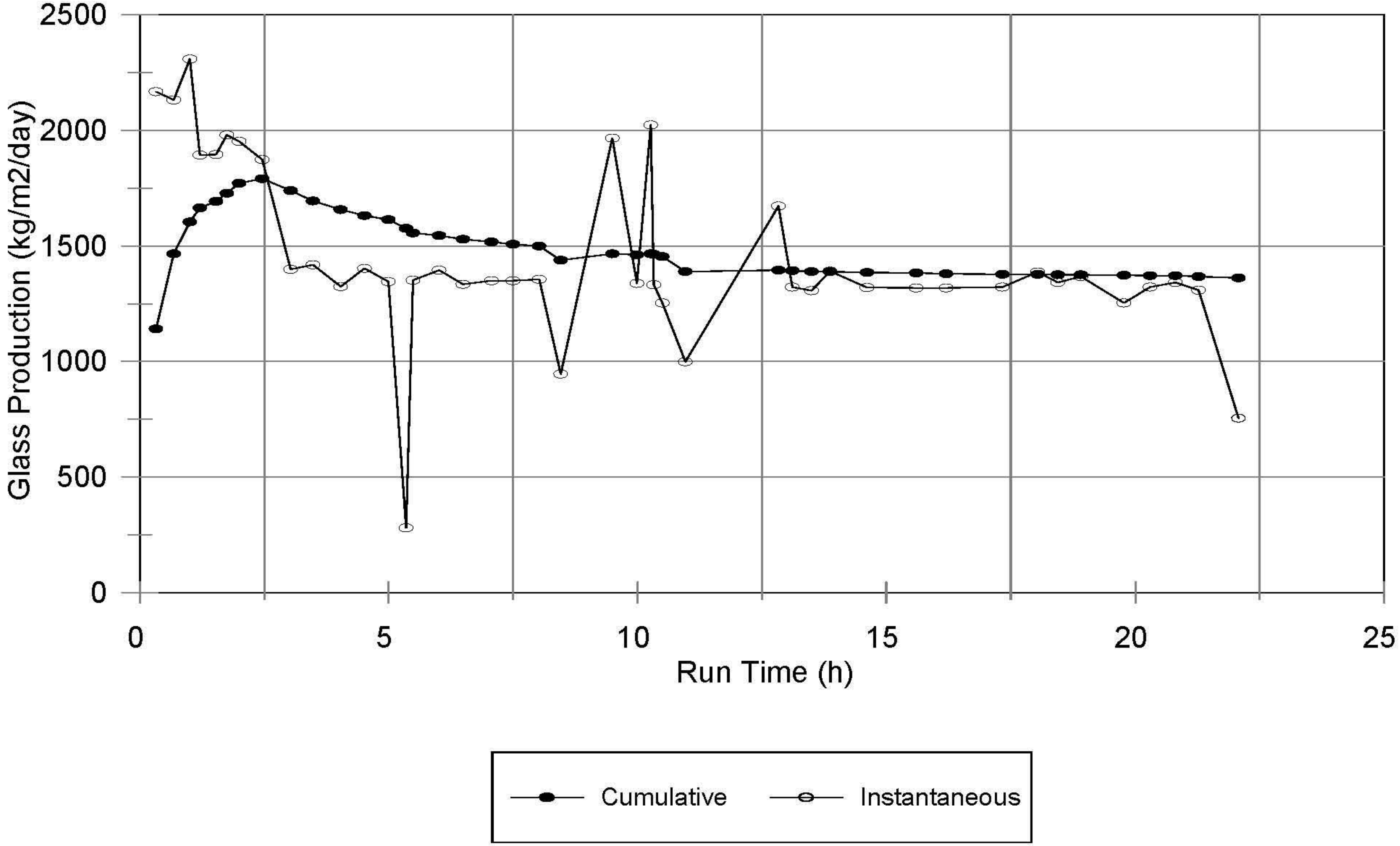

Figure 3.42. Production rates for DM1000, West Valley Test 3.

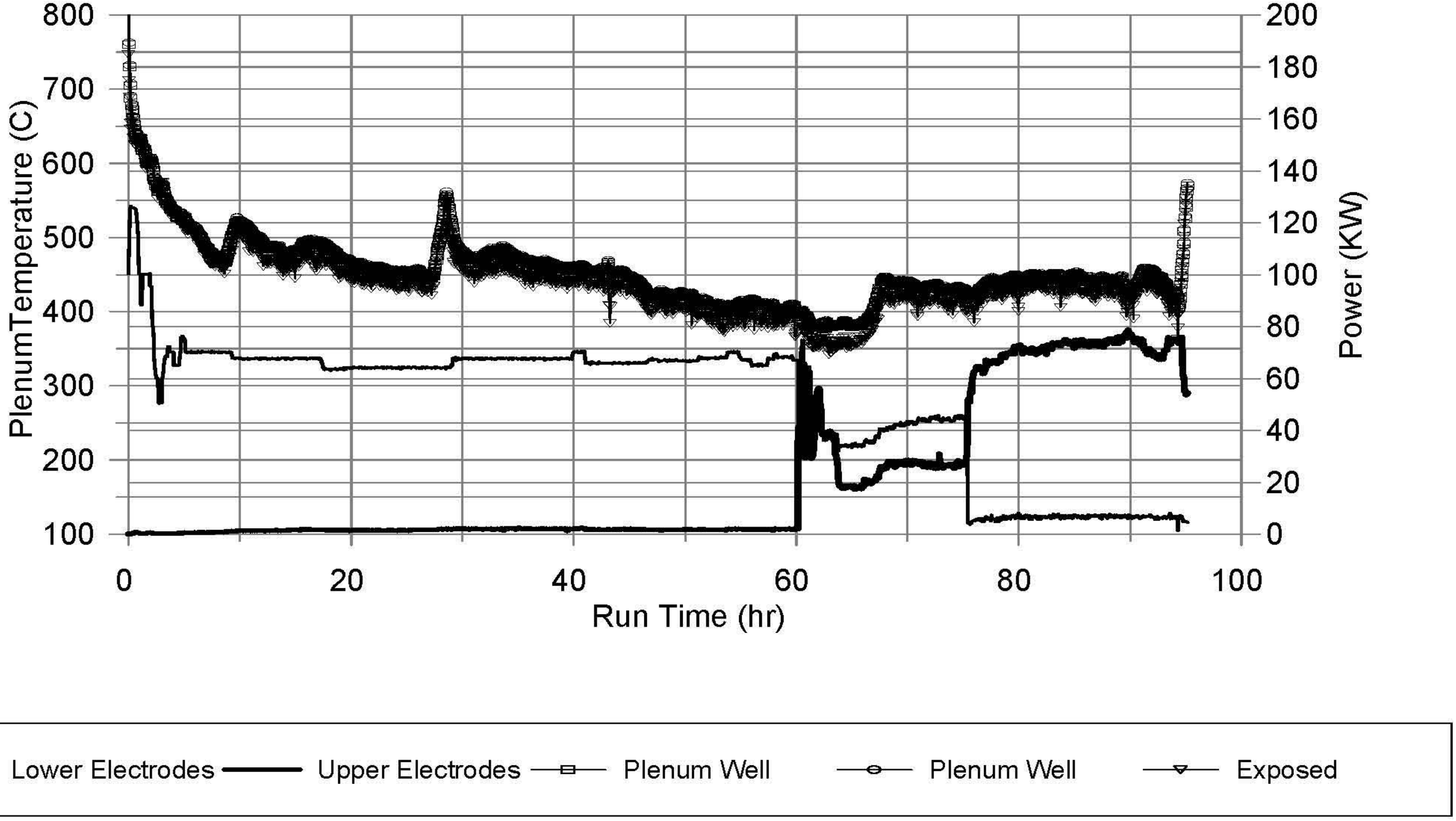

Figure 3.43. Plenum temperature and electrode power for DM1000 West Valley Test 1.

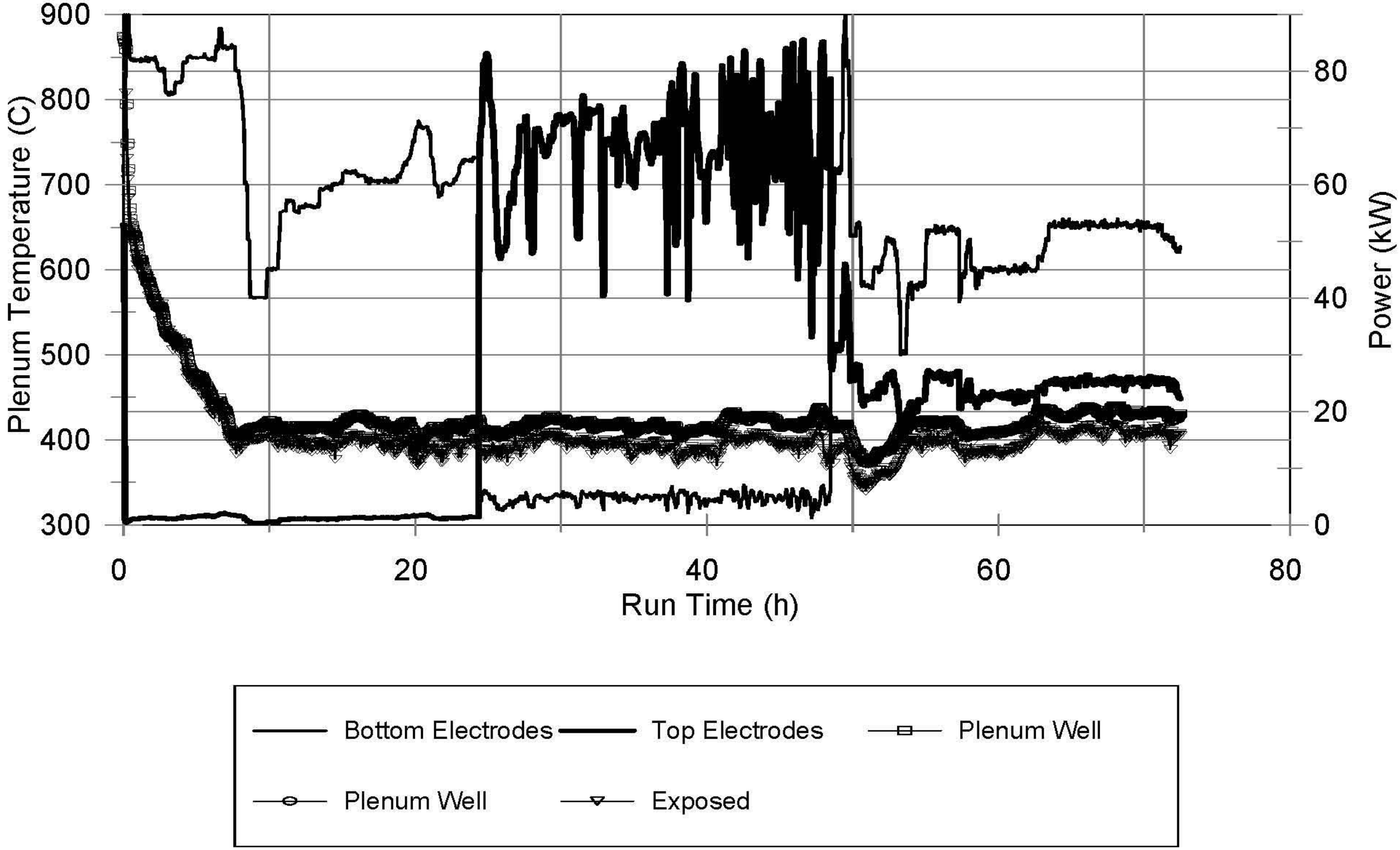

Figure 3.44. Plenum temperature and electrode power for DM1000, West Valley Test 2.

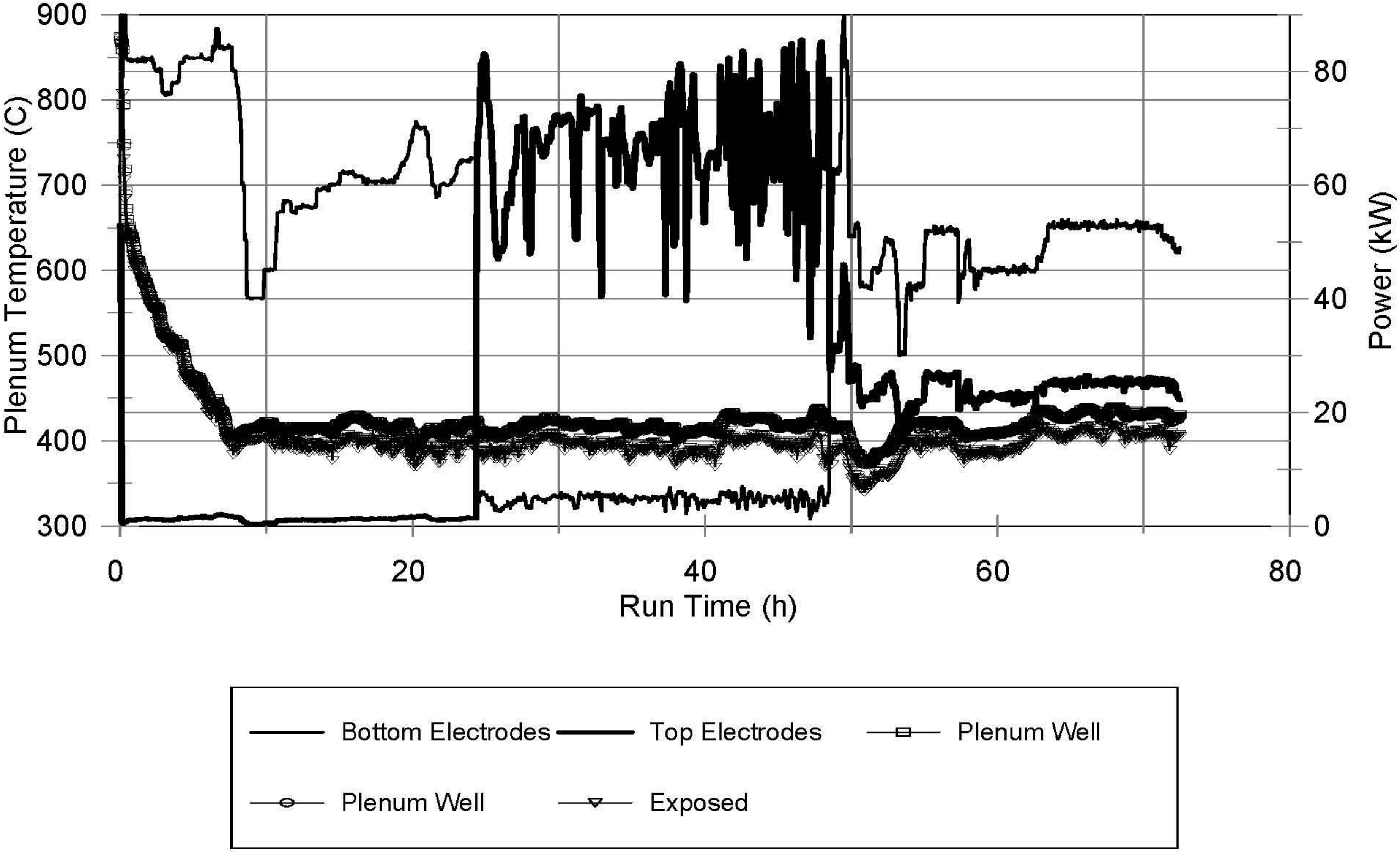

Figure 3.45. Plenum temperature and electrode power for DM1000, West Valley Test 3.

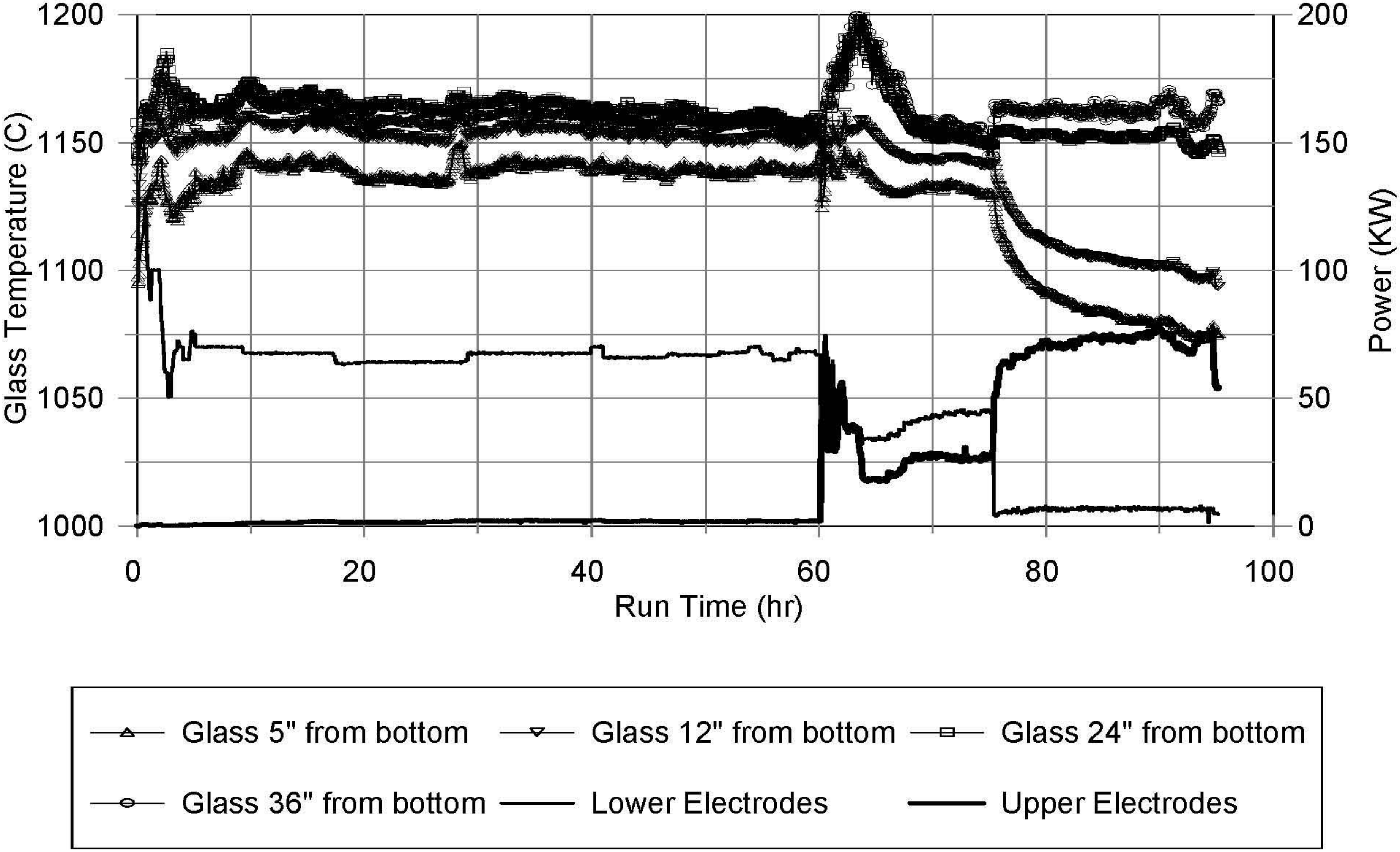

Figure 3.46. Glass temperature and electrode power for DM1000, West Valley Test 1.

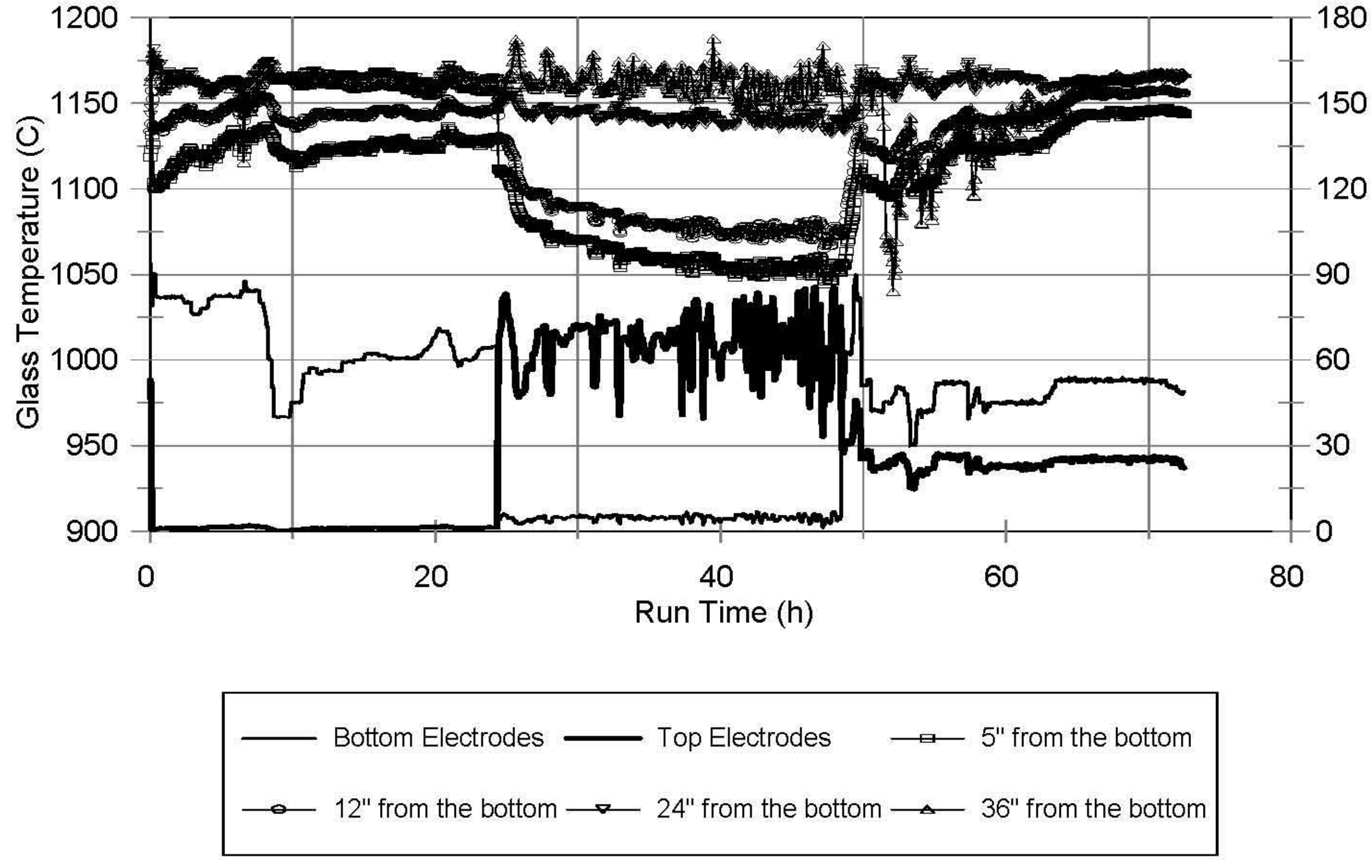

Figure 3.47. Glass temperatures and electrode power for DM1000, West Valley.

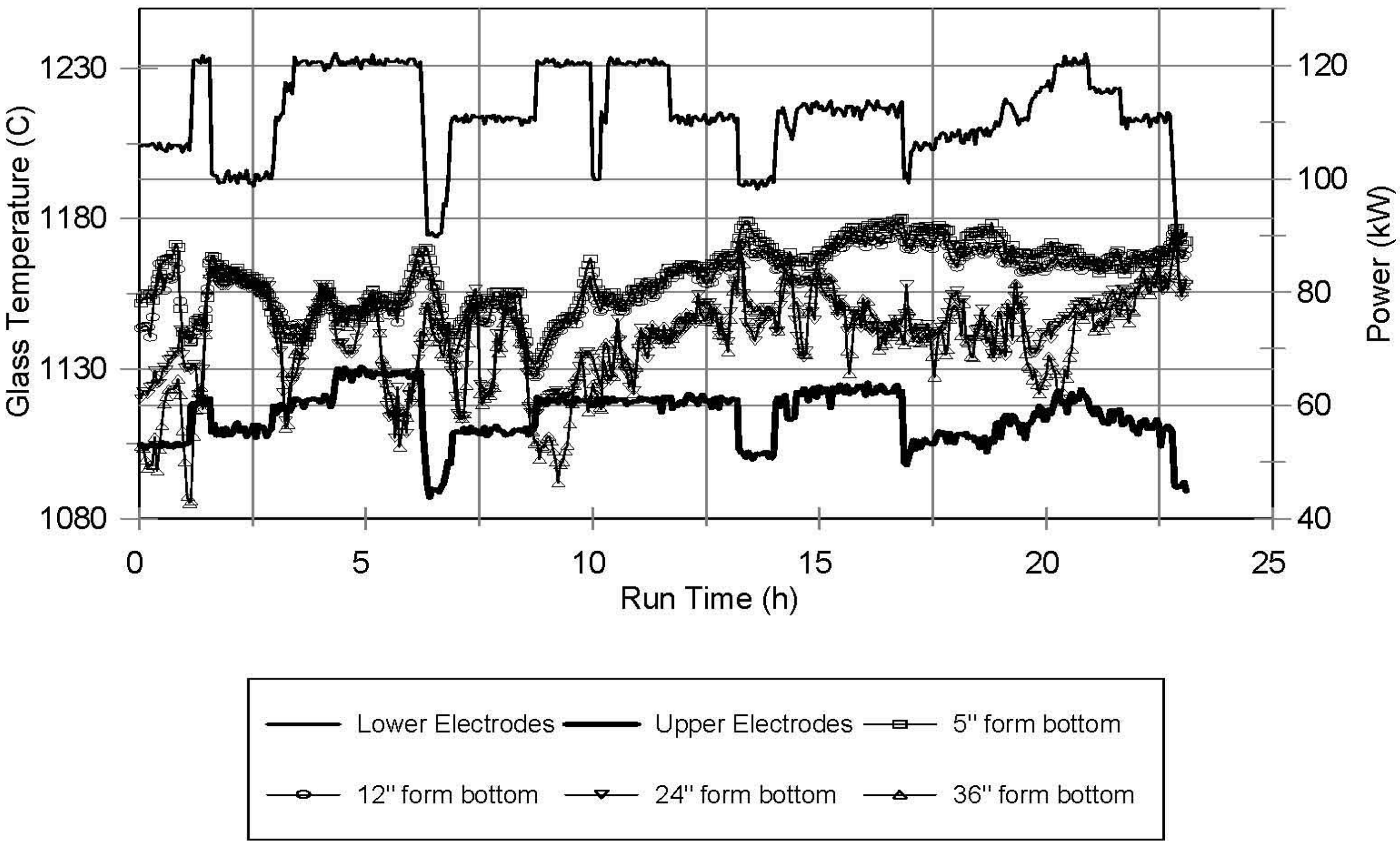

Figure 3.48. Glass temperature and electrode power for DM1000, West Valley Test 3

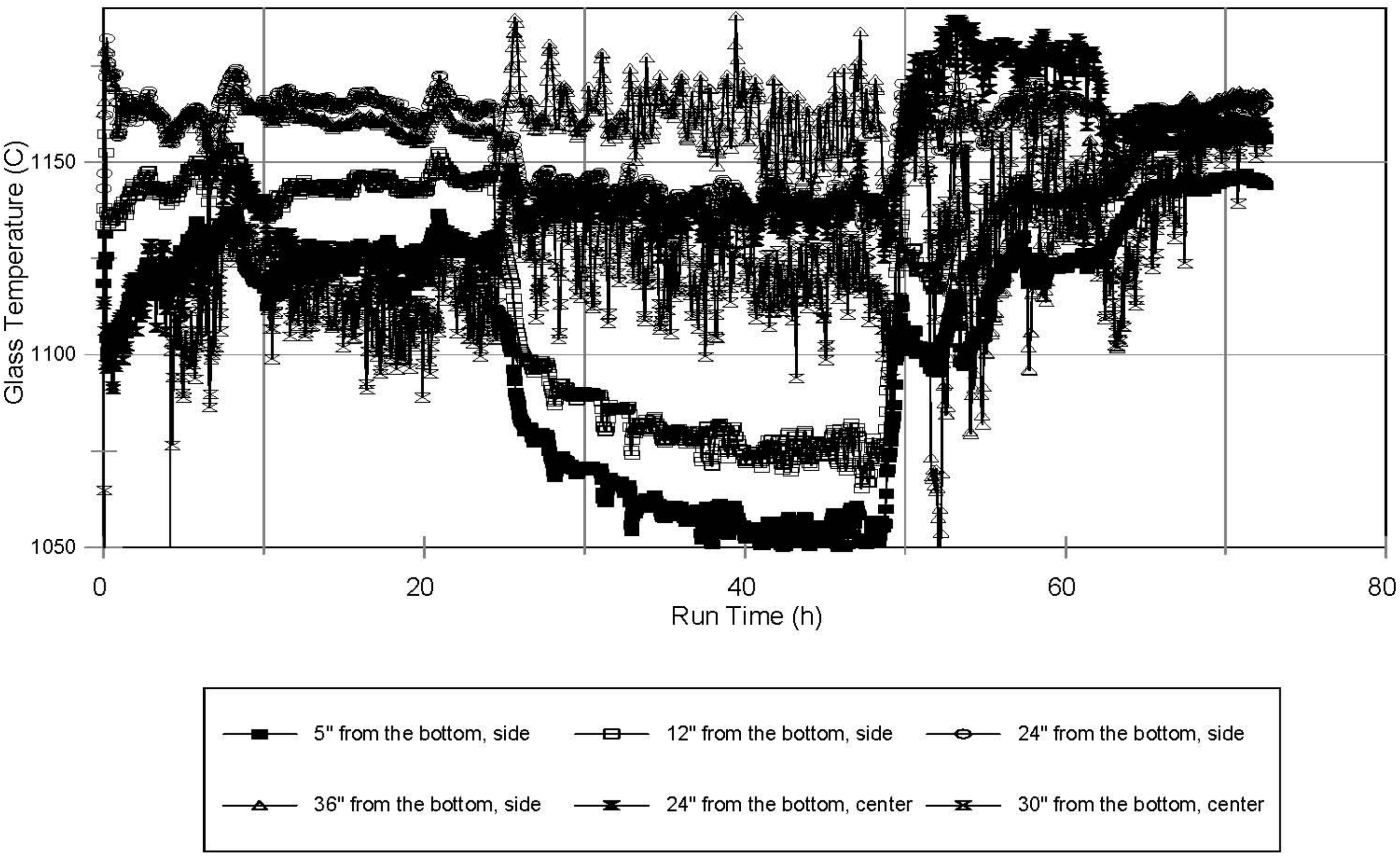

Figure 3.49. Comparision of side and center thermocouples in the glass pool during DM1000, West Valley Test 2.

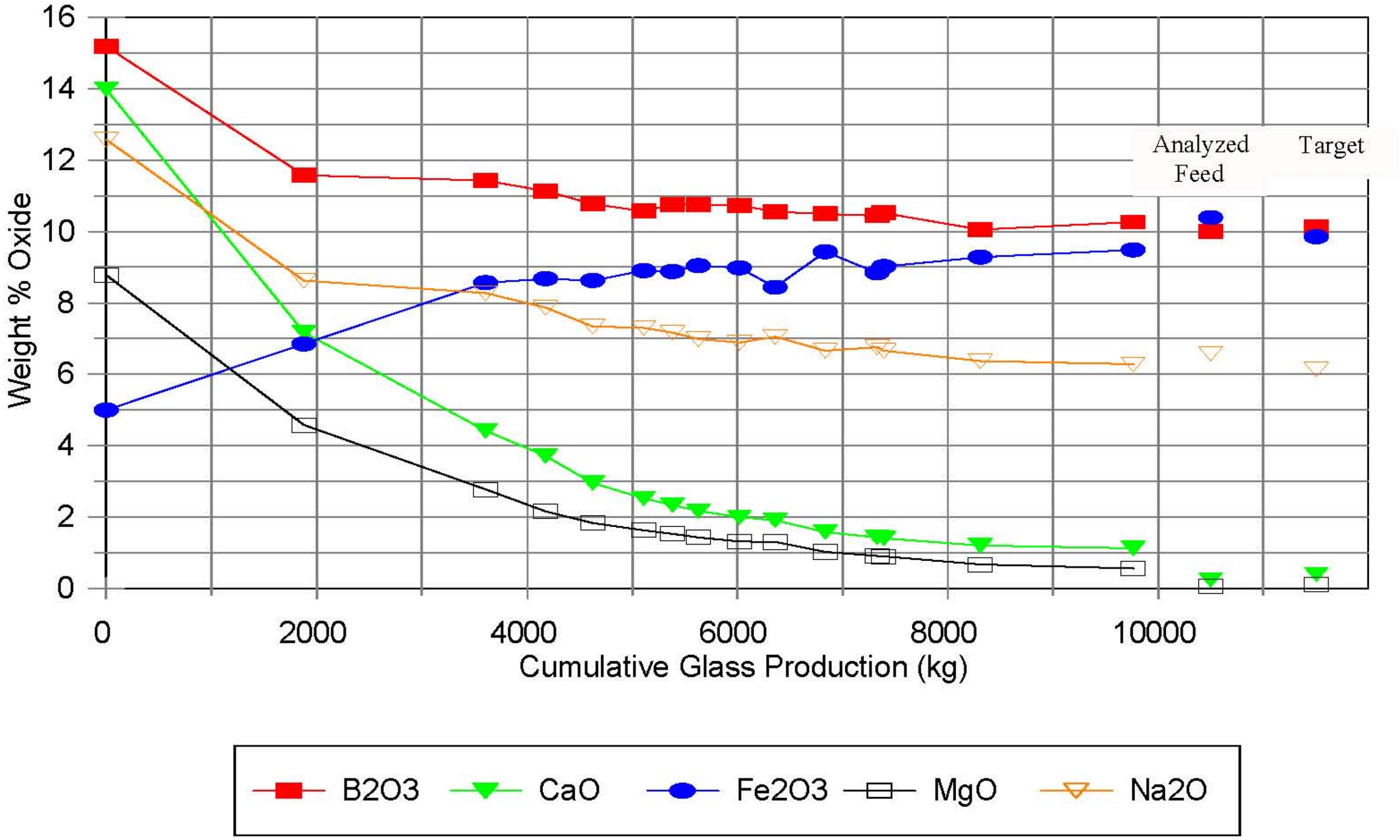

Figure 4.1. Product glass composition for major oxides during AZ-101 Dm1000 tests.

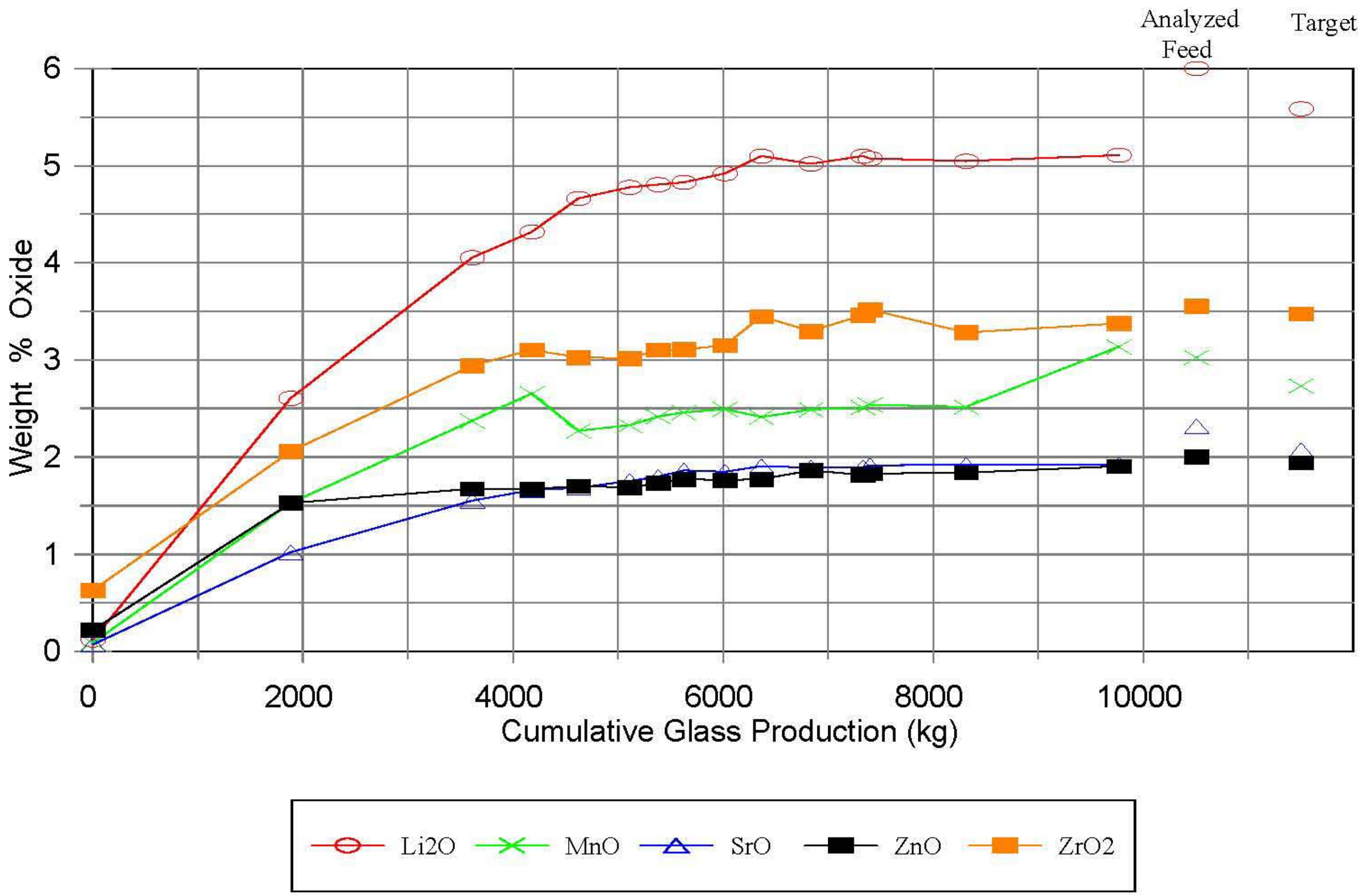

Figure 4.2. Product glass composition during AZ-101 DM1000 tests.

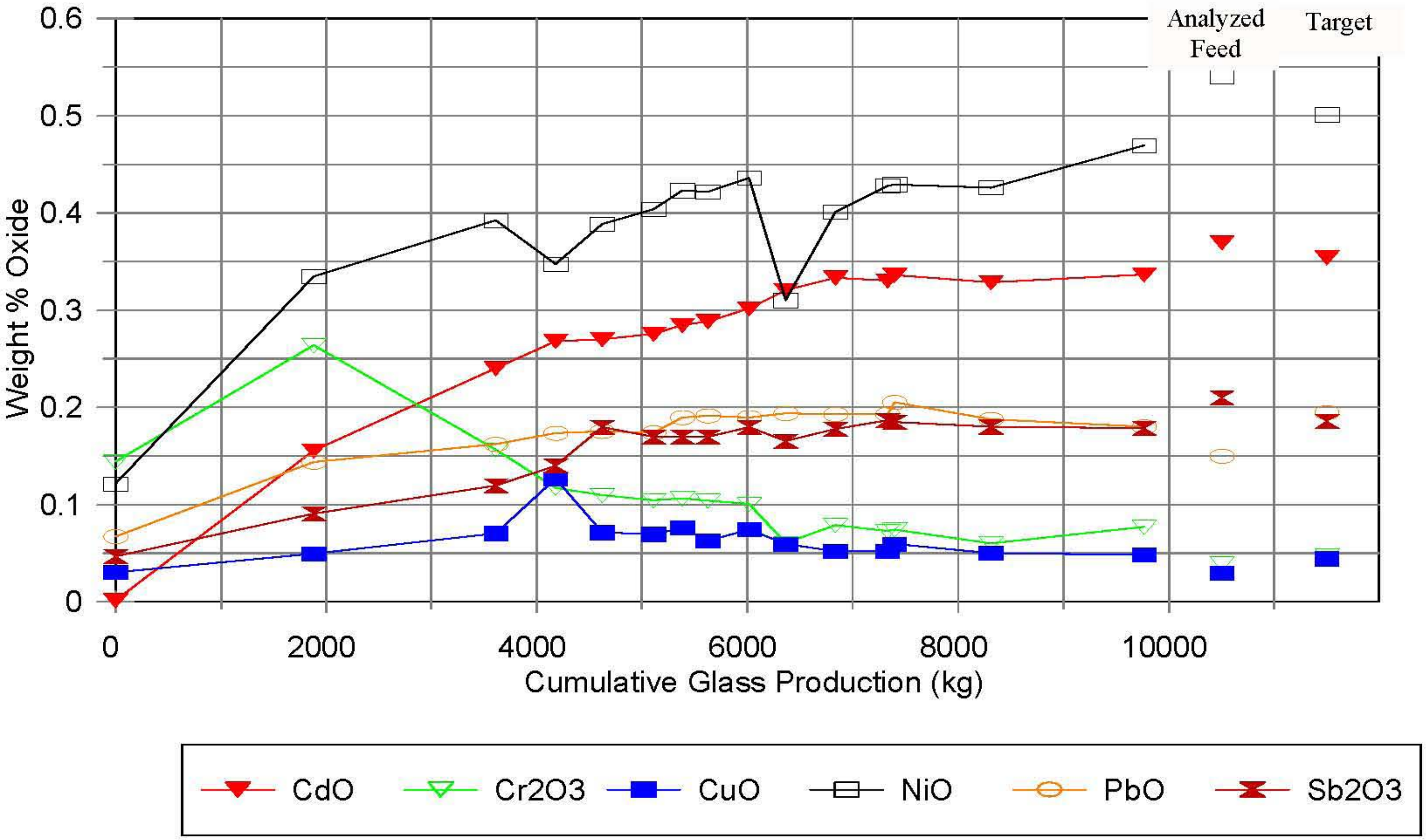

Figure 4.3. Heavy metal oxides in product glass from AZ-101 DM1000 Tests.

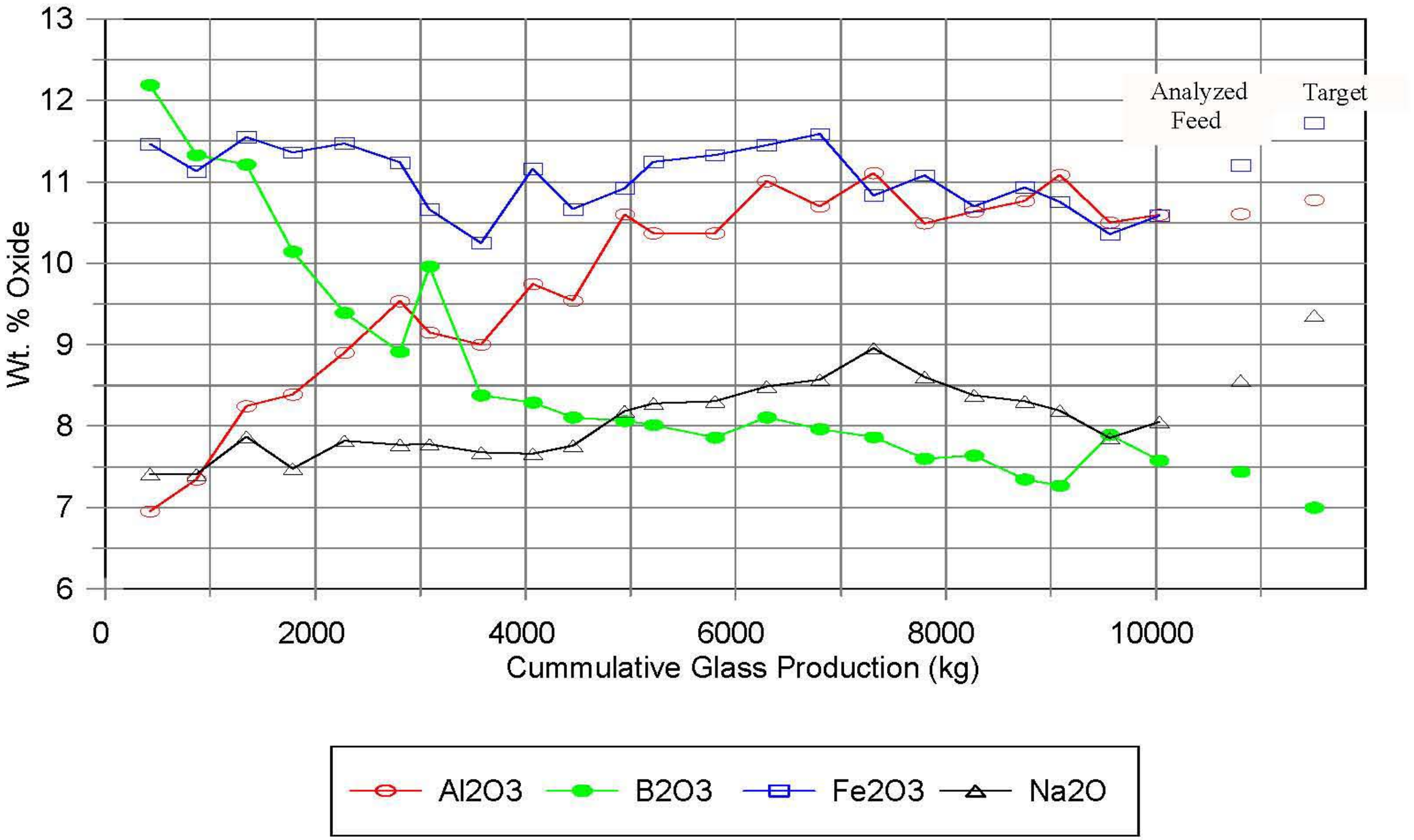

Figure 4.4. Product glass composition for major oxides during C-106/AY-102 DM1000 Tests.

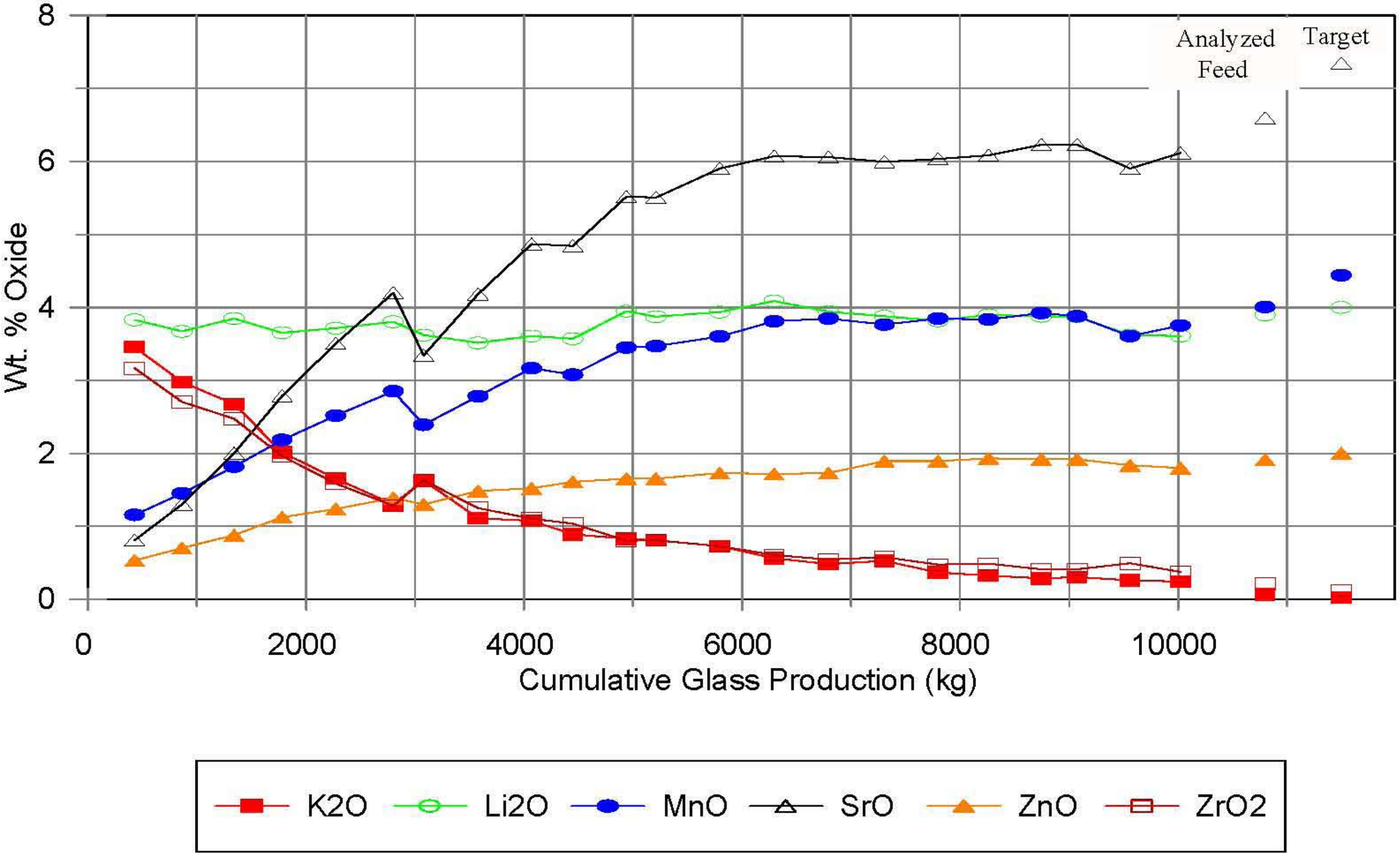

Figure 4.5. Product glass composition during C-106/AY-102 DM1000 tests.

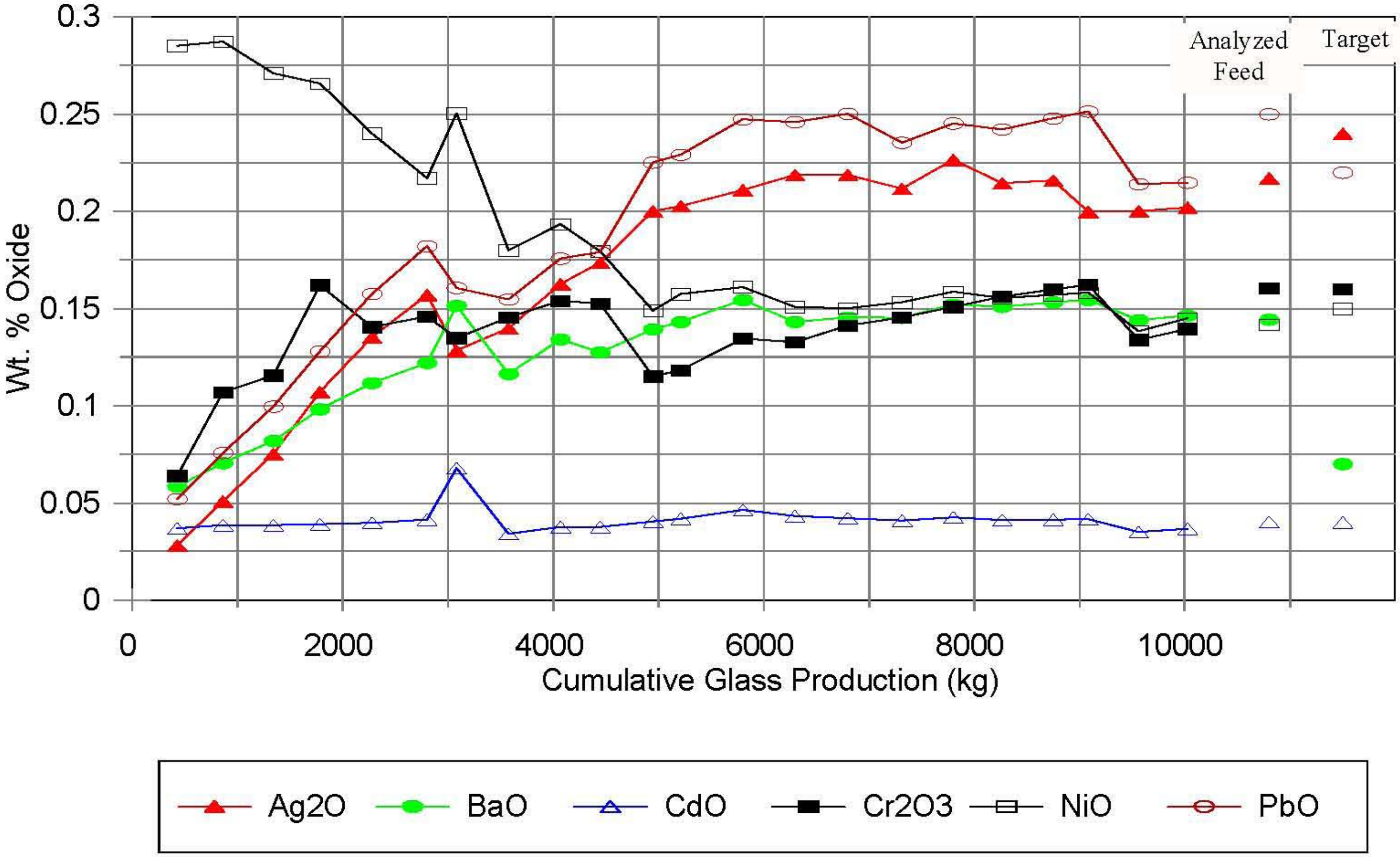

Figure 4.6. RCRA metal oxides in product glass during C-106/AY-102 DM100 tests.

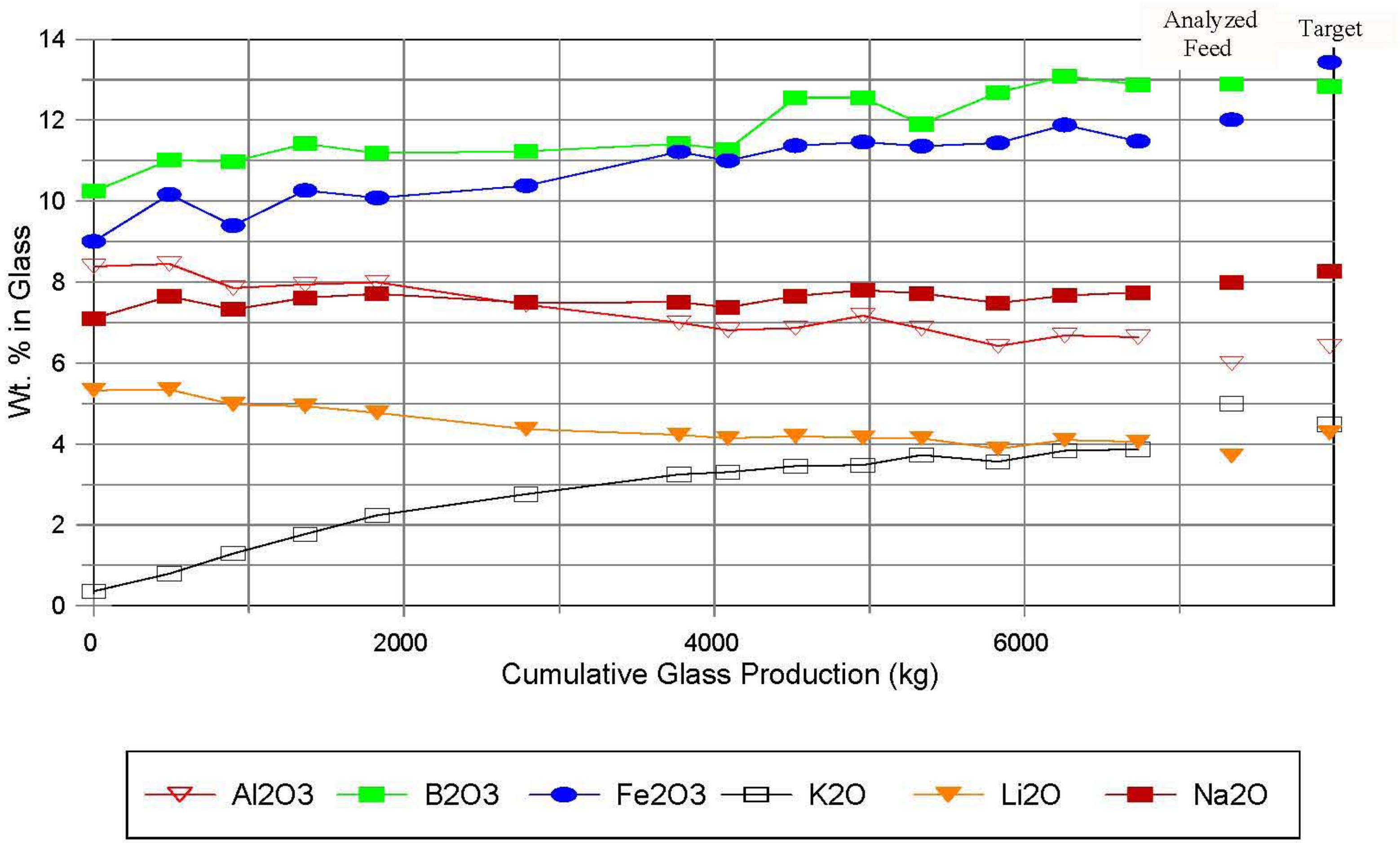

Figure 4.7. Product glass composition for major oxides from West Valley DM1000 tests.

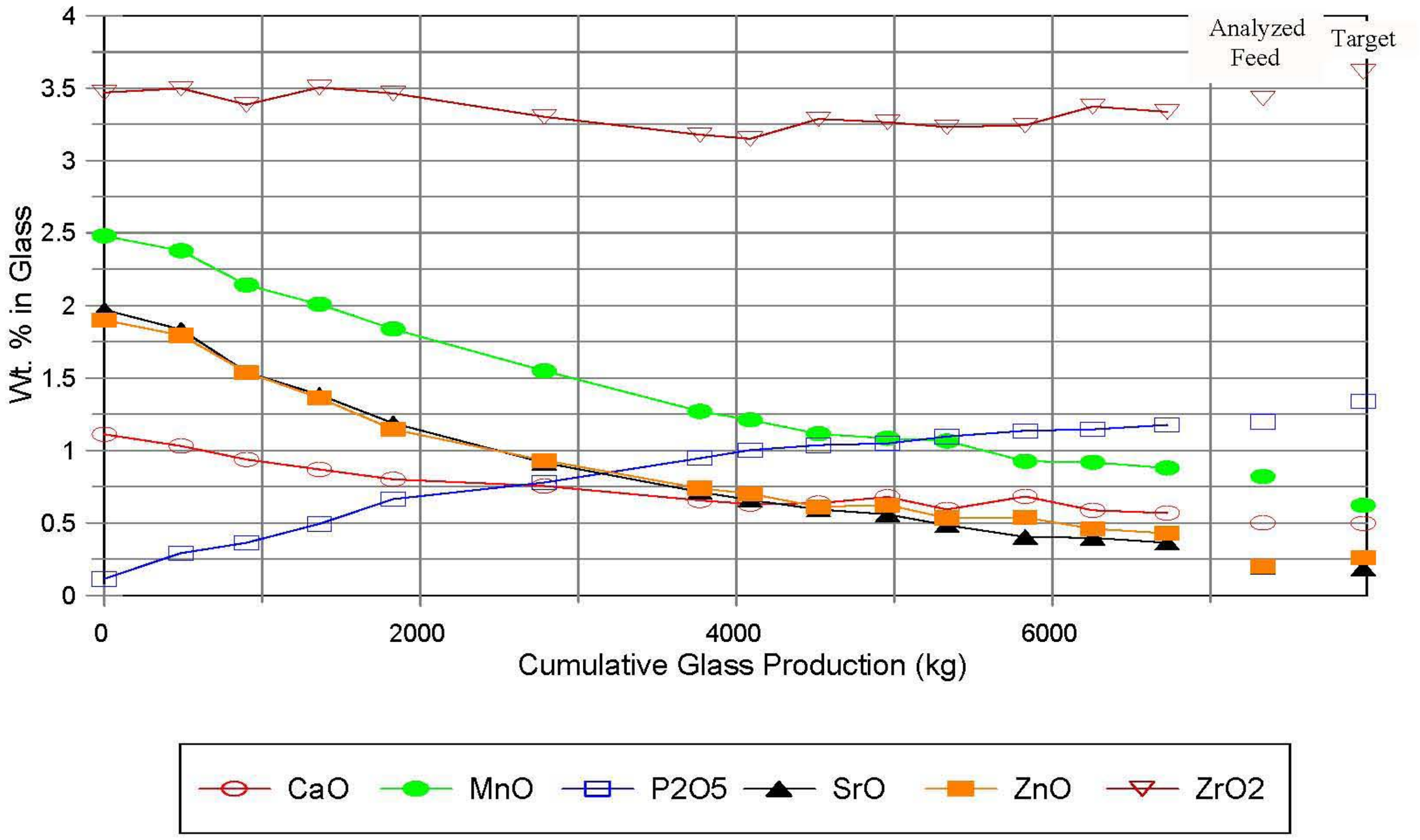

Figure 4.8. Product glass composition from West Valley DM1000 tests.

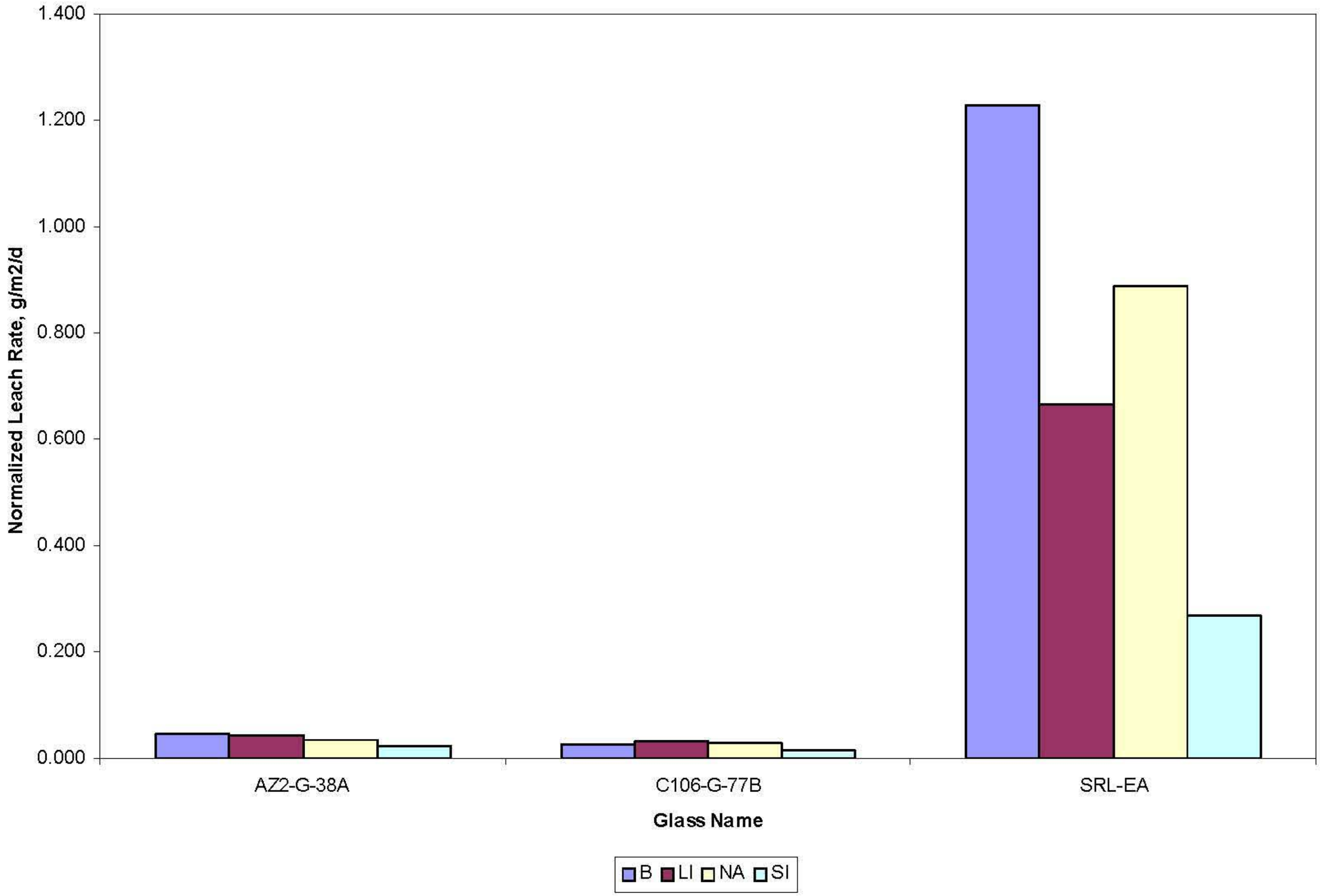

Figure 4.9. Comparison of normalized PCT release for DM1000 melter glasses and DWPF EA benchmark glass

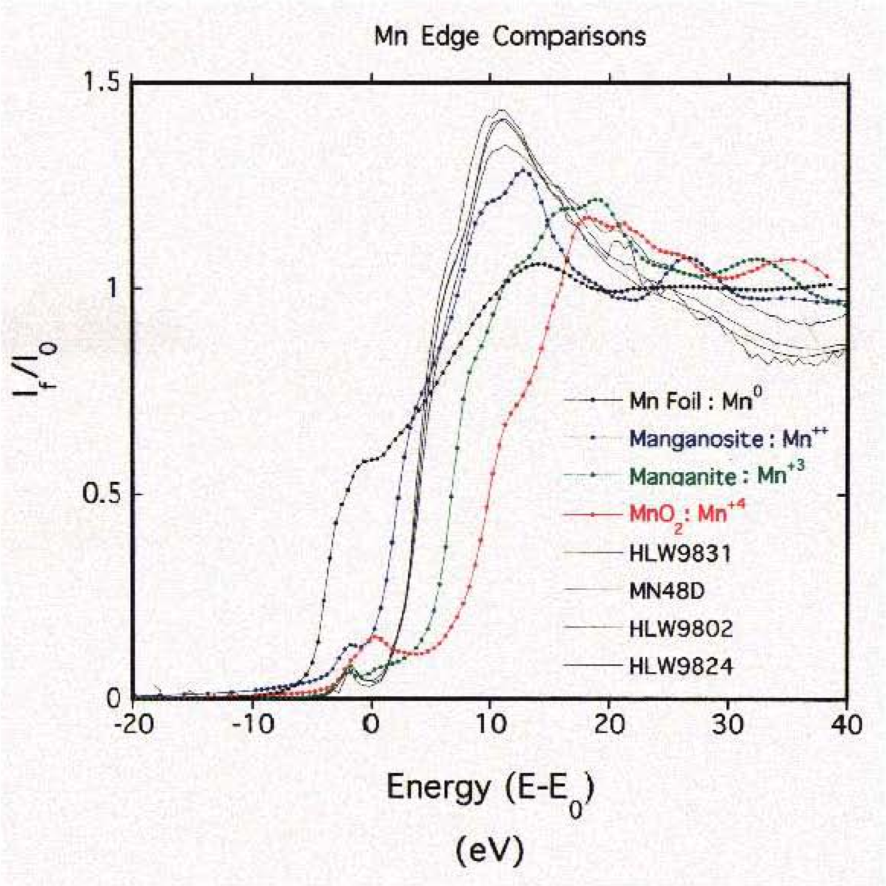

Figure 4.10. Results from synchrotron Mn-edge x-ray absorption spectroscopy on crucible and DM10 melter glasses and Mn redox standards.

Figure 4.11. Optical Micrograph of "Globular Bloom Areas" in Final Discharge (C106-G-100A) from C-106/AY-102 DM1000 Tests.

Figure 4.12. SEM Micrograph of "Globular Bloom Areas" in the final discharge (C106-G-100A) from C-106/AY-102 DM1000 Tests.

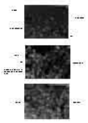

Figure 4.13 SEM micrographs of Cold Cap Sample (AZ2-CC-50A) from DM1000 AZ-101 Test 5.

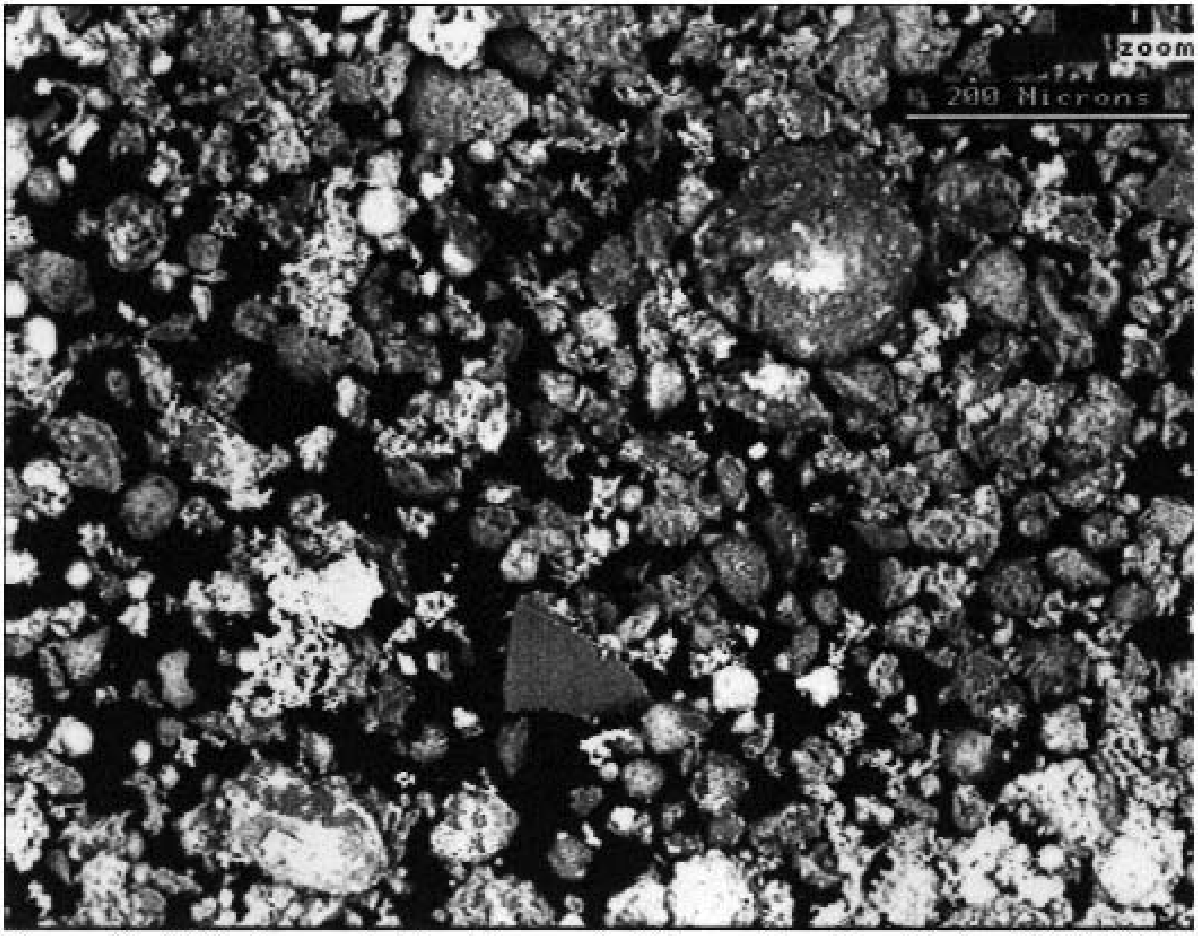

Figure 5.1. SEM micrograph of particles sampled from melter exhaust during DM1000 AZ-101 Test 5. Brightest areas are high in selenium. Much of the rest contains Na, Al, Si, and Fe with small amounts of Cd, Cs, and Zn. Grey angular feature is SiO_2. An occasional high-Cl area is also evident.

Appendix A.

Results from Particle Size Distribution Measurements on West Valley, AZ-101, and C-106/AY-102 Melter Feeds.

TABLE A-1.
Summary of Mean Particle Diameters for Melter Feeds.

Melter Feed	Batch	Mean Diameter (μm) Volume Distribution	Mean Diameter (μm) Number Distribution
AZ-101	1	25.11	0.61
	2	25.05	0.74
	3	24.23	0.75
	4	25.15	0.75
	5	26.34	0.73
	6	25.17	0.72
West Valley	1	34.22	1.22
	2	37.63	0.40
	3	28.43	0.50
	4	3.51	0.58
	5	35.77	0.93
C-106/AY-102*	1	13.20	0.62
	2	10.88	0.65
	3	12.21	0.62
	4	11.27	0.65
	5	13.16	0.69
	6	14.41	0.78
	7	15.00	0.79

*Different silica particle sizes were used: -325 mesh for Batches 1 to 5, -200 mesh for Batch 6 and –80 mesh for Batch 7.

Microtrac Particle Size Analysis: C-106/AY-102

Microtrac Particle Size Analysis:
AZ-101

Microtrac Particle Size Analysis:
West Valley Feed

Appendix B
Run Chronologies

Run Chronology for DM1000 AZ-101 Tests

8-12-99	
10:30	Idling power at Zone 1 (bottom) 30 kW overnight; at Zone 2 (top) 25 kW TC 2 1043EC (top) TC5 1028EC (bottom) TC6 922EC Discharge at 65% TC 15 = 1072EC
10:30	Power in Zone 2 increased to 50 kW
14:20	TC2 1131EC TC5 1106EC TC15 1076EC TC6 1006EC Power set back at 30 kW (z-1) and 25 kw (z-2) Discharge at 60%
	First drum transfer (NOAH-MT1B, CUA #105100) Weight of Feed Tank Content Before Transfer = 29.5 kg (water) Weight of Feed Tank Content After Transfer = 236.0 kg
	About 20 kg of water was used to rinse the drum with the wash transferred to the second drum (NOAH-MT1B, CUA #105096)
	Further rinsing of drum and flushing of transfer lines resulted in Feed Tank reading of 422 kg after partial transfer of the 2nd drum (CUA #105096).
	Transfer stopped due to clogs in pumps. Disassembled pump and lines for cleaning.
	Finished transfer of Drum #2. Weight of Feed Tank Content = 623 kg
	Addition of water for flushing and cleaning. Weight of Feed Tank Content = 675 kg
17:00	Start Recirculation. Feed tank scale reads 656 kg.

17:40	Resumed transfer of feed (NOAH-MT1B, CUA# 105098)
17:55	Stopped transfer. Feed tank scale reads 941 kg
18:03	Flush lines to feed tank 968 kg
18:12	Flush recirculation line 1079 kg (1068 kg with stirrer stopped)
8/13/99	
08:30	Power increased to 50 kW/zone
08:40	Recirculation started. Easily started.
08:50	Main off-gas on.
12:00	Getting ready to feed. Starting mass reading on load cells 1005 kg (recirculation pump is on, agitator is off).
12:07	Started feeding
12:16	Power increased to 60 kW/zone After 10 shots, weight 982 kg
12:37	Melter pressure reduced to 2.8"
12:30	Melter pressure reduced to 2.0" ΔP between feed and no feed −1"
12:42	Density of feed 1.248 kg/l. This feed is composed of : Drums: CUA #105100, 105096, 105098. Plus water. Weight = 1079 kg
13:09	Note on power adjustments: Before feeding Glass Pool 1 temperature (T2) was 1130EC with 50-50 kW. When started feeding, power was raised to 60-60 kW. However, T2 decreased to around 1122EC. Therefore, power is increased to 70-70 kW.
15:28	Power increased to 75-75 kW.
15:24	Discharge (10 minutes). AZ-G-17A
16:28	Feed system restarted.
16:45	Discharge

17:15	Feed system stopped.
18:30	Power was unstable to the voltage tap was lowered from 168 to 112 - current swings were from 300 to 700 amps. Also HEME was not shut off and main off-gas manual valve was not shut off. Power lowered to 30 kW zone 1; 25 kW zone 2; discharge 55%.
8/16/99	
	power to 50 kW each discharge 65% Recirculation started (see notes)
09:32	A sample was taken of HEME blow-down H_2O (>250 ml) AZ-H-21A
09:48	A sample was taken of scrubber sump H_2O (>250 ml) AZ-S-21A
01:00	Feed transfer activities CUA 105099 water addition –25 gallons (approx.) Scale reading 620.5 kg after transfer
11:30	CUA105105 drum was transferred. Approximately 18-20 gallons of water was added. Scale reading after transfer is 912.5 kg.
12:25	Scale reading after transfer 1288.5 kg (30 gal H_2O)
12:20	Started feeding.
12:41	Stopped feeding to change the transformer tap. From 112 v to 168 v. Reason to change tap is the resistance goes up and cannot deliver the current.
	Note: Referring to pp21, scrubber and HEME solutions. After sampling the two, the HEME blow down was pumped to the scrubber sump. Approximately 50-60 gallons of the scrubber sump was then transferred to the blow down tank. Up to now, approximately 100-110 gal. Estimate we have fed approximately 135-140 gallons water so far and have condense about 100-110 gallons.
13:00	Started feeding again
13:10	The fourth can was added. 1493.0 kg. Amount of water added = 28 gallons CUA 10511
	Loop changes on Dimension: Gain on both 2 & 4 were lowered from 12.7 to 6. Reset left uncharged from 10.0. Lowering Gain reduced the oscillation of

	the current at 168 volts.
13:12	Power set at 90 kW/zone
14:07	Plenum temperature too high. (744EC). Feed rate will be increased.
14:16	Feed rate increased 20%.
14:33	Discharge (7 min) AZ-G-29A
14:47	Blew down from the scrubber sump –30-40 gal.
	CUA 105097 added, 1442 kg after transfer; used 33 gallons of water.
15:11	The drum of discharge was taken out. Wt 509.5 kg. Gross including drum
15:14	Started to discharge into the new can. Sparging rate 2 scfh
15:27	Stop discharge Rate of discharge = 12.3 kg/min
	CUA # 105106 1648 kg after transfer; .33 gallons of H_2O added.
15:45	Noticed feed had stopped. Transfer lines from recirculation line to the feed pipes were clogged.
16:02	Stop feeding
16:45	Discharged (20 min) AZ-G-30A
8-17-99	
08:48	Power to the zone increased to 60 kW/each
09:18	1634 kg: initial scale reading of feed tank for 8-17-99
09:19	Started feeding (1634 kg)
10:09	Control center for 1000 kg meter, additional settings: T6:2.0; T7: 1.75; T8:2.0; T9:15; T10:28
10:19	Wt of feed = 1453 kg
10:28	CUA # 1051089 scale reading 1424 kg (initial)
10:34	Stop feeding. Attempt to discharge failed. Reduced power to 80 kW/80 kW.

	T2 = 1112EC
11:26	CUA #105108; wt of feed: 158.5 kg; added 18 gal of H_2O
11:32	CUA # 105104
12:24	Temperature dropping. Power raised to 96/96 kW
13:00	Bubbling rate increased to 18-9-18-9. Melter temperature = 1141EC
14:00	Stopped feeding very large cold cap. Approx. >12" thick.
14:10	Self discharge noticed. Started to discharge AZ-G-36A (50 min)
14:18	Started to feed again. Cycle time 20 sec. Bubbling rate at 10.1, 4.04, 10.1, 5.71
14:20	Feed transfer for CUA # 105173 is initiated.
14:35	Feed tank wt 861 kg
14:50	A sample of sump (scrubber) blow down was taken for metal analysis. AZ-S-37
15:47	Discharge (8 min) AZ-G-37A
16:04	Discharge Drum changed. Gross weight = 430.0 kg (glass + drum) both AZ-G-36, 37A
	Note: The new drum has 171.5 kg of glass in it.
16:57	Transfer from mix to feed tank
17:26	Discharge (13 min) AZ-G-37B
17:40	Stopped feeding.
	1430 kg of feed were fed today in 8 hrs 22 min. This corresponds to 170.9 kg of feed/hr; Average 42.7 kg of glass/hr
8-18-99	
	Scale reading before transfer from mix tank to feed tank. 705.5 kg (without recirculation on)
10:00	Scale reading = 982 kg; about 3-4 min into the transfer.
10:03	Scale reading 1005.5 kg (w/o recirculation on)

10:15	Changed control program. Time between purge and next shot taken out. Sequence is now Shot 1 = Purge 1 while Shot 2 is shooting. Shot 2 purges after and including time of shot 1.
11:30	Started feeding. Initial weight of feed tank with recirculation on. 949 kg
12:49	Sump was blown down (−40-50 gal)
12:52	Cold cap is −100%. Feed rate decreased further to 40 sec = t4 = t8
13:00	Started to discharge at 2 scfh (30 minutes) AZ-G-40A
13:24	Feed wt 543 kg
14:36	Lower the level of blowdown water.
14:50	Feed sample from feed tank was taken. AZ-F-44A
15:20	Discharge (15 min) AZ-G-44A
16:10	Discharge drum was replaced.
	Gross weight = 386.0 kg (glass + drum) Contains: AZ-G-37B, 40A, 44A
16:29	Lowered level of blowdown water
16:56	Melter temperature 1131EC
	Power increased to 100/100 kg
17:08	Melter temperature = 1132EC
	Power increased to 105/105 kW
17:30	Blowdown water sample taken AZ-B-44A
17:35	Discharge (18 min) AZ-G-44B
18:30	Discharge (24 min) AZ-G-44C. Plenum temperature 559EC
18:50	Stopped feeding
8/19/99	
09:12	Main off gas on.
	Note: the recirculation pump had to be primed before start

09:16	Started feeding. Bubbler setting and feed rate the same as yesterday
09:29	631.5 kg, feed scale reading. Additional readings from control center for 1000 kg melter. T6: 1.75, T7: 2, T8: 33.
	1000 wt 1205.5 kg after transfer 592.5 kg before transfer
	Note: At around 09:20 feeding stopped to unclog the transition line (possibly the feed tube). City water was connected to the end of the transition hose and deposits were blown out into the melter. Feeding was resumed at around 09:45.
11:00	Wt 994 kg. Full rate = 211 kg/hr.
11:33	Melter pressurized (large upset)
	Note: it was pressurized two times more since 10 am.
	Note: DP at melter pressurization is more than 10" of water.
11:35	Started discharge 20 minutes. AZ-G-50A
11:35	Blew down scrubber sump.
12:00	Mass 680 kg (feed tank). Feed rate since 10 am = 212.7 kg/hr. Cold cap is greater >95%
12:33	Start discharge @ 3 scfh. AZ-G-50B (14 min) T = 948EC. Cold cap very thin at the back, thick under feed nozzles. ΔP fluctuates, will set up table.
12:50	Tp(#6) = 613EC
13:00	Wt 574.5 (feed tank). Feed rate since 10 am 210.3 kg/hr
13:11	Discharged for 10 minutes. AZ-G-51A
13:41	Large melter pressure upset (fan recover). Purge melter pressure upset is defined as large pressure drift to positives. Normally about 10" H2O drift. Booster fan needs to be activated to recover the negative pressure in the melter. Summary of large upsets today up to now.
14:00	Tm(T-2) = 1164 Reset Power @ 100 kW/100 kg

	Discharge drum was removed. Glass mass = 496 kg AZ-G-44B, 44C, 50A, 50B, 51A
14:03	Large pressure upset
14:06	wt of feed 342.5 kg
14:25	Started to discharge (19 min) AZ-G-52A
14:50	Feed sample from feed tank taken: AZ-F-52A.
15:05	Scrubber blowdown water level reduced.
18:10	Discharge (247.5 kg) AZ-G-52B. 32 minutes
18:25	Cold cap 90% dissolved.
18:30	Cold cap is burned in 1 hour after stop feeding.
18:42	Stop discharge (52-B)
8/20/99	
09:32	Scale reading: 585 kg
09:42	Scale reading after transfer: 900.5 kg
	Low mass flow meters (1-5 L/min) were installed on single bubblers and (4-20 l/min) were installed on double bubblers. The set pt on needle valves were not changed from the settings of past 2 days runs.
11:05	CUA #105149
13:40	Water sample was taken from blow down tank AZ-S-53A (supernatant) and evaporator water which is sitting still for 16 hours. AZ-S-53B
8/23/99	
09:00	It was noticed that the emergency off gas was almost completely clogged. Attempted to dislodge deposits in the pipe by externally impacting it, but not much success. Decided to open up the Emergency Line and clean it.
8/24/99	
	The film cooler pipe was inspected. Heavy deposits were found in the pipe, specifically near the upper end at the turn to the quencher transition pipe. Also observed, fibrous coating over the deposit. (Glass fiber like, light color).

	Samples of deposits and fibrous overcoat (composite) was taken. The deposits at least near the upper end were friable. AZ-FC-55. FC = Film cooler.
	The pH indicator of the scrubber sump showed a reading of 5.7. A solution sample was taken and pH is measured with a calibrated pH meter (rm 35). The pH reading is 2. Approximately 1.5 gallons of a NaOH solution approximately 10% wt was added to the scrubber sump. pH indication by the scrubber panel is 11.6. The actual pH measured by the cal. pH meter is 8.4.
8/25/99	
	Emergency off gas is reinstalled. Discharge can is replaced with a new one. 247.5 kg gross weight. (AZ-G-52B)
10:55	A glass sample from discharge floor drainage is taken. AZ-G-57A.
12:15	Started feeding
13:11	Power increased to 110/110 kW
13:48	Discharge (9 min) AZ-G-57B
14:20	Taps on transformers were changed to increased voltage to 224 V.
14:42	Started to discharge (30 min) AZ-G-57C
14:42	Transferred scrubber water and added NaOH solution to the scrubber
14:59	Breakers had tripped twice since changed to 224 V. Switched to 168 V.
15:59	Discharge (20 min) AZ-G-57D
16:18	Feed sample from feed tank taken AZ-F-57A
16:24	Resistance has increased
17:00	Discharge drum changed. Drum contains: AZ-G-57B, 57C, 57D. Weight = 379 kg.
	pH sensor on the scrubber panel has been calibrated is the range of 7 to 10.
16:27	pH of scrubber water = 7.7
16:36	Plenum temperature T6 > 540EC. Reduce time between feed shots to 25 sec (-5 sec)

16:45	T6= 460EC add 5 sec to 30 sec.
17:15	Bubbling rate increased to 5.5 D, 2.7 S, 5.5 D, 2.7 S. Plenum temperature = 571EC.
17:30	Feed tank sample taken AZ-F-62A
19:42	Clogged feed lines. Test is terminated.
8/26/99	
08:00	It has been found that the melter self-discharged glass.
08:15	Some more glass was air lifted to fill discharge drum. AZ-G-63A
09:45	Drum is changed. Old drum contains: overnight self-discharged AZ-G-63A. Gross weigh = 372.5 kg
01:10	One more discharge to lower glass level. AZ-G-63B. Drum is removed. Gross weight = 220.5 kg. Discharge valve is left open and discharge heater are turned off to cool down chamber.
8/30/99	
	Note: Discharge chamber was removed on 8/27. The trough joint was rewelded. The chamber insulation was relined through 8/28. The chamber was reinstalled and reenergized on 8/28. For more details see the melter repair notebook. Airlift to ground is 6.1 V (measured on 8/30)
	Notes: The agitator shaft in the feed tank was replaced with a new 306 ss shaft.
10:30	Note: The balance of the feed in the mix tank was transferred to the feed on 8/28/99.
	Feed tank: 2107.0 kg (with recirculation pump on).
	A feed sample is taken. AZ-F-64A
11:25	Started to feed.
	Note: Scrubber sump water was drained to be evaporated. A think layer of fine precip. was found at the bottom of the tank. Tank was recirculated before being drained
12:25	pH of the scrubber sump set at 10.3 with NaOH (10% soln.)

12:26	Wt of feed tank 1643. Feed rate 464 kg/hr (very high)
12:29	t4 was increased to 35 sec instead of 25 sec.
14:00	BR on single holes reduced to 1.54 l/min and 1.58 l/min
14:34	Changed valve settings T4 and T8
14:40	Discharge (17 min) AZ-G-71A
14:44	Changed valve settings T4 and T8 each to 15
14:53	Melter went positive.
15:02	Changed bubbler 2 flow to 2.06 and Bubbler 4 flow to 1.93.
15:55	The voltages displayed in computer were confirmed. Zone 1 = 111.4 V and Zone 2 - 125.2 V. This implies that we are not power-limited, but voltage limited.
16:14.	Discharge (64 min) AZ-G-71B.
17:18	Stopped feeding.
17:28	Feed waste transferred from mix to feed tank. From 191.5 kg to 1014.0 kg.
18:06-18:21	The remainder of drums 1-8 is transferred from mix to feed tank. Feed tank reacting: 1041 kg to 3127.0 kg.
18:21	40 gallons of water transferred to mix tank and then transferred to feed tank. Feed tank readings: 3127.0 kg to 3328 kg.
18:33	Restarted feeding with high-water content feed.
18:42	Grab sample taken: AZ-F-72A
18:59	Stopped feeding. Glass melt temp = 1139, 1131.
19:25	Glass melt temperature = 1162, 1154: restarted feeding.
19:49	Scrubber sump level was lowered.
21:00	We were able to achieve steady conditions with the following settings. Bubbler flows: 5.27, 2.09, 5.75, 1.93 Avg. Feed rate = Feed Setting = t1 = 2, t2 = 1.75, t3 = 2.00, t4 = 15.00 (or 20.00)

	Power (set points) Bot = 125, Top = 118 Glass Melts 1159, 1146EC Plenum = 533EC Zone 1 voltage = 88.21 Power = 121.22 Zone 2 voltage = 83.08 Power 117.06
21:07	Plenum = 515EC
21:30	Discharge @ 10 scfh for 90 min. Glass came out of the area near the electrode. Water cooled glass stopped leak.
9/1/99	
	The following samples from the area close to the "leaking" electrodes were taken to be analyzed under XRF spectroscopy: AZ-M-77A (glassy material adhered to insulation) AZ-M-77B (yellow material) AZ-M-77C (metallic material)
9/3/99	
	Glass was found in the discharge chamber mostly on the floor. Discharge exit is full of glass. Power was secured. TC14 992 TC15 979 Before shut down.
10:30	Discharge drum was removed. Wt = 347 kg (gross) AZ-G-71A, 71B Bring total glass drained to 3142 kg
9/7/99	
16:07	CUA 105225, 273.5 kg initial wt. Added 36 gal H_2O
9/8/99	
08:55	Power increased to 50 kW Zone 1 TC 2 1057EC TC 5 1056EC Discharge increased to 70% TC15 985EC
10:00	Plenum heater were turned on TC6 = 511 TC11 = 729

14:30	TC6 = 648 TC11 = 750
15:11	CUA # 105219, 273.5 kg initial wt. 44 gal. H2O added
18:00	Start-up heaters turned off Plenum temperature = 506EC
18:15	Plenum T = 491EC
18:28	Power reduced from 130 kW to 122 w Plenum temperature = 467EC
18:52	Plenum temperature = 467EC Power reduced to 121 kW
19:00	Power reduced to 120 kW
19:52	Though bubbling has been kept as low as possible, one big hole is observed in the cold cap. Thickness of cold cap .4".
22:21	Tglass = 1151EC Power 120 kW
23:06	Stopped feeding
23:50	Cold cap is thin –1" thick
9/9/99	
	Feed tank 2025.5 kg; CUA #105224, 253 kg initial wt CUA # 105165, 253 kg initial wt As we transferred the drum, we progressively added more water. 40 gl = final amount of water added to this drum.
15:30	New air lance was installed in the riser. Bubblers were pulled out
16:33	Feeding started. Shot time 30 sec. TC2 = 1130
20:25	Power reduced from 130 kW to 122 kW. Tglass jumped quickly to 1169EC.
20:28	Tglass = 1171EC Power = 100 kW. Fast feeding (t4 = 30 sec)
22:16	Maximum power at 0.066 Ω is 125 kW with 91 V

23:34	Discharge (20 min) AZ-G-89A. Discharge heater current −180 amps.
24:00	Maximum power at 0.069 Ω is 125 kW with 92.8 V.
01:11	Large amounts of foaming observed. We are able to maintain Tglass at 1155EC with only 70 kW for long periods of time. 6-20 min.
01:42	Discharged (20 min) AZ-G-90A
01:53	For the last 40 min, approx. glass temperature maintained with 85 kW.
03:00	Large amount of foaming is observed. Plenum temperature remains around 400EC. Feed rate is decreased.
07:24	Plenum temperature is slightly creeping up. Reduced time between shots from 450 sec to 420 sec.
08:05	Plenum temperature at 397EC, reduced time between shots to 390 sec.
08:25	Plenum temperature at 399EC, time reduced to 350 sec.
08:31	Plenum temperature at 403EC, time reduced to 300 sec.
08:53	Plenum temperature at 410EC, time reduced to 240 sec
	Plenum temperature at 412EC, time reduced to 210 sec
09:13	Plenum temperature at 415EC, time reduced to 180 sec
09:38	Plenum temperature at 390EC, time at 240 sec
12:02	Plenum temperature at 410EC, time reduced to 180 sec
12:20	pH (scrubber sump) adjusted from 6.5 to 9.5
09:24	Discharge for 38 minutes AZ-G-92A @ 3 scfh
13:52	Discharge for 1 hour. AZ-G-92B @ 3 scfh
14:00	Bubbling started.
14:21	CUA# 105233, 273.5 kg initial wt (includes drums); 253.0 kg net wt. 42.5 gal water added 14
14:22	Bubbler 1 flow 1.90 B same as at 14:00; Bubbler 1 Press 2.23

16:15	Discharge for 41 minutes AZ-G-92C @ 3 scfh
	CUA # 105234 273.5 kg wt of feed and drum. 253.0 kg net wt. 35 gal H2O added
16:39	Stopped feeding
17:50	Discharge for 42 minutes AZ-G-92D @ 3 scfh
18:12	Melter power set at 55 kW
18:36	Bubbler turned down, cold cap almost completely gone. Discharge heater set at 55%
9/13/99	
	Idling over weekend.
10:16	TC2 1141; TC5 1110; TC6 836
	Power 55 kW zone 1
	Glass barrel in the discharge removed includes discharges AZ-G-90A, 92B, 92A, 92C, 92D, 89A Total Mass including drum 491.5 kg -17 kg = 474.5 kg Total glass discharged to date 3616. Kg
14:00	Water flush points and plumbing were done for the feed system Power upgrade is being done. Calibrated thermocouple. VSL # 96A2 is connected to readout #12 which used to be in one of the bubblers before. Length of TC12 allows it to be about 5" from the floor. Therefore TC12 and TC5 both read at the same location at the lower zone.
9/13/99	Test without Bubbling Test #1
	2941.5 kg = starting feed mass
	Recirculation pump on, agitator off.
	Note: Mass of feed in the recirculation line □ 60 kg. Measured before and after the recirculation pump was turned on.
16:48	Started feeding. 30 sec intervals.

	TC6 = 716EC
17:09	VSL 84A3 calibrated thermocouple is connected to TC8 so TC18 and TC2 are in the same position in the glass pool. Approximately 12" from the floor.
17:51	Sample of feed taken from feed tank (AZ-F-97A)
19:08	Tglass = 1156EC, Power 110 kW B 105 kW
20:16	The cold cap is thin and does not cover the entire area; foaming covers great part of the area. Some steam pulses are observed.
20:40	Feed lines were flushed.
20:53	Feed lines flush caused Tp and Tm to drop. Reduced feed rate by increasing T4 T8 to 80 sec.
20:50	2 gallon of NaOH solution added to sump to increase pH from 6.08 to 9.00.
21:18	Discharge (90 min) AZ-G-101A
22:09	Power = 65 kW. T glass = 1155EC
00:06	Cold cap is mostly foam
02:08	Discharge (23 min) AZ-G-101B
03:40	We=ve been operating with the following valve setting : t1 = 2.5; t2 = 2.25; t3 = 2.5; t4 (variable); (small valve from DM10) t5 = 3; t6 = 2.75; t7 = 3 (since 22:00 hrs); t8 (variable)
04:00	Cold cap is complete. Foam layer. Feed rate = 27 kg feed/hr.
04:50	Feed lines were flushed with water
05:24	Discharge (25 min) AZ-G-101C
06:15	Damper of baghouse #1 was partially open. It is closed off. BH #2 Dp dropped to 3.5" from 5.2"
06:40	Feed line was flushed (–2 sec).
07:15	Power increased to 59 kW
9/14/99	
08:20	Noticed valve #1 (feed valve) is not working. Prior to this, line is flushed with

	water and was determined to be clean. We will proceed with changing valve #1 in the mean time feed rate on valve #2 increased. The shot space on valve #2 is set at 75 sec.
08:45	Stopped the feed to replace valve # F-PV-1
09:08	Feeding started @ 60 sec and then 120 sec intervals
	Note: feed line (flexible hose) of valve #1 had a lot of deposit and build up in it which is cleared out.
10:33	Feed lines were flushed, both at the same time for 2-3 seconds.
10:37	Discharge for 40 minutes AZ-G-105A
11:30	Flush feed lines for 3 seconds (both at the same time)
11:45	Noticed one of the feed lines is clogged again. Reduced t4 and t8 to 60 sec. To compensate.
12:00	Lines were rinsed with water (though new injection points)
12:12	t4, t8 120 sec.
12:18	tf, t8 increased to 180 sec
12:52	t4, t8 decreased from 240 to 180 sec.
13:45	Flushed the feed lines.
14:40	Flushed the feed lines (very small volume of water)
15:00	Discharge for 23 minutes. AZ-G-107A
15:30	Flushed the feed line
16:00	Feed sample taken from recirculation line –0.8 liters. AZ-F-107A.
16:54	Readings before flush line: TC6 Exposed: 398; TC1 Well: 412; TC7 Well: 409; 1722.5 kg : scale reading. Shot #149; even shot at line #2.
17:02	TC6: 396EC, TC1-12 413EC, TC7-12 410EC. Did not drop washing lines
20:18	Discharge (15 min) AZ-G-107B
9/15/99	

01:22	A fuse from discharge chamber was replaced. Heater #2
01:24	Plenum temperature = 390EC. (TC1 well thermocouple). Plenum is dark. Time between shots is now t4 = t8 = 800 sec in order to recover a plenum temperature –430EC.
04:50	Plenum temperature has been stable at about 405-410EC for three hours with a feeding rate of 12 kg feed/hr.
04:59	Discharge (30 minutes) AZ-G-108A
05:00	Flushed the line (small quantity of water)
07:40	Glass discharge drum was replaced. Mass of glass = 503.5 kg Gross AZ-G-101A, 101B, 101C, 105A, 107A, 107B, 108A; 486.5 kg net
	Total glass discharged to date 4102.5 kg
12:30	Flushed the line.
14:00	Discharge glass (33 min) AZ-G-113A
15:15	Flushed feed line (small quantity water)
16:28	T4 T8 360 sec.
16:40	Flushed feed line (small quantity water)
20:21	Approx. 1/4 gallon of NaOH solution was added to scrubber sump
9/16/99	
02:43	Stopped feeding
03:00	Discharge glass (10 min) AZ-G-113B
05:03	At TC6 = 552. Cold cap is very thin. There is no foaming over the glass. Only a small fraction of the surface crust is undissolved (dark patches) –5%. The rest of crust is radiating. An infrared thermometer (Omega) was used to record the surface temperature but could not get a reading. The infrared thermometer range is from 900E-3000EC.
	A calibrated Tc (VSL88-72A1) was placed in the glass thermowell. Approximately 36" above the melter floor. Location of this thermocouple should be near the top of the glass. It is hooked up to terminal #24 on the

	panel readout.
05:25	TC24 = 756EC TC6 = 561EC TC5 = 1130EC (5" up) TC2 = 1150EC (12" up) TC9 = 1141EC (24" up)
05:45	The film cooler pipe was inspected through its viewport; it is almost completely clean.
06:00	TC24= 760EC TC6 = 571EC TC1 = 582EC TC7 = 578EC
06:30	TC24- 766EC TC6 = 580EC TC1 = 590EC TC7 = 586EC A very thin layer of crust over the glass pool. Crust judging by radiation is cooler than the interior glass.
07:23	TC24 = 778EC TC6 = 593EC TC1 = 601EC TC7 = 597EC Still cannot get a reading of the surface temperature with the optical pyrometer (less than 900EC)
08:30	TC24 = 787EC TC6 = 607EC TC1 = 614EC TC7 = 611EC Still cannot get a reading of the surface temperature with the optical pyrometer (less than 900EC)
08:40	Turned off the main off-gas. Emergency off-gas. Melter Dp = 0.2"
09:00	TC 24 - 795EC TC6 = 620EC TC1 = 626EC

	TC7 = 623EC
10:00	TC24 = 808EC TC6 = 646EC No major change, still a very thin crust over the top
	Melter is put to idle at 50 kW. Discharge @ 55%
11:30	Remove glass took samples for analysis to determine mass - 100 kg gross B 83 kg net. AZ-G-113A, AZ-G-113B Total glass discharged during run = 569.5 kg Can reinstalled with glass in it. Total glass discharged thus far 4185.5 kg
9/20/99	
	2146.5 kg left in the mix tank due to spilling and foaming over top during weekend. −23 kg of feed spilled over.
9/21/99	
	Approximately 4 kg of feed from the feed tank spilled out overnight. Clamps were added to prevent spilling. Each weighs −2 kg
16:21	Changed bubbling to 5 per hole
16:24	Changed bubbling to 10 per nozzle
16:28	Changed to 50 kW
12:00	2 gal of sodium hydroxide and 20 gal water added to the reagent tank
14:00	Increase in power to maximum set at 130 kW; lid heater zero. Bubbling 10 scfh
14:05	Bubbling reduced temperature. Turned on top electrode
14:24	Reduced bubbling to 5 scfh/nozzle
14:44	Changed bubbling rate to 4 scfh
14:49	Temporary test power adjustment - zone 1 @14:52
15:00	Change bubbling rate to 3 scfh
15:36	Changed zone 1 power setting to 115 kW

15:46	Changed power to 55 kW
16:30	Power set at 70.01 kW
16:41	Power set at 100.00 kW
16:49	Power set @ 90 kW - limit zone 1
17:03	Power set @ 70 kW - limit zone 1
17:10	Power set @ 80 kW - limit zone 1
17:23	Started feeding. Feed samples AZ-F-123A - from feed tube #1 AZ-F-123B from feed tube #2.
18:33	Level of scrubber sump lowered.
18:49	Started up the evaporator.
20:14	Discharge (10 min) AZ-G-123A
22:54	Discharge (10 min) AZ-G-123B
9/22/99	
00:35	Feed lines were washed
01:49	Discharge (16 min) AZ-G-123C
02:15	Scrubber recirculation pump #2 failed.
02:40	Around 2:00 the power consumption decreased significantly due to foaming. Also this caused plenum temperature to decrease.
02:45	Checked scrubber recirculation #2 discharge strainer, was clean.
09:33	Discharge (15 min) AZ-G-129A
05:24	Level is too high in the melter. Started to discharge (26 min) AZ-G-129B. (Approximately rate −15 kg/min @ 5 scfh/br)
05:34	Flushed the lines (feed lines with quencher water)
05:50	Approximate level of glass in the discharge drum ∃ 2/3 feed □ 340 kg
	Notes: During discharge foaming under the cold cap was observed. Consistent with resistivity increase in the top zone (zone 2).

	Bx: at 0543 during discharge R_T = 0.111 ohms P_T = 70 kW V_T = 78.5 volts R_B = 0.082 ohms P_B = 55 kW V_B = 78.5 volts However, the bottom zone resistivity appears to have been dropped slightly.
06:17	Note: Even though the plenum temperature readings are relatively low, the cold cap is probably around 95%. Slight foaming under the cold cap is observed.
06:45	Scrubber sump water was transferred. pH increased from 6.5 to 9.5 by addition of NaOH.
09:20	Sump water was transferred pH = 7.7
09:51	Flushed feed lines with small quantity water.
11:30	Notes: TC plenum readings are all relatively low. However, molten glass can be seen peaking through the cold cap. It appears that the cold cap is not thick. One other observation is that a network of glass fibrous web has formed between the bubbler vertical pipes and thermowell and the plenum walls.
11:50	Sump water is transferred pH raised from 6.5 to 9.6 with NaOH.
12:00	Melter pressure variation is less than 0.2" of water during feeding and non feeding periods.
12:00	Cold cap is –95% or so. Molten glass is visible.
12:15	Discharge (13 min) AZ-G-134A
13:00	Cold cap –95%-98%
13:20	Flushed the feed lines.
13:35	Started to transfer feed from the mix tank to the feed tank. Mass reading before transfer 390.5 kg
13:45	Transfer is over. Mass = 3104.5 kg
13:46	Started to transfer water to clean lines as additional water needed (–35 gallons)
13:47	Finished water transfer and passed air through the transfer line. Final mass = 3258.5 kg.

	Note: Mass of water and left over feed in the transfer line = 154 kg
13:55	Noticed both feed lines are clogged. Stopped the feed system. Proceeded by cleaning (water pressure) the teflon transfer lines (source of clog)
14:20	Started feeding.
14:40	Transferred sump water
15:10	Discharge can was removed, replaced with a new one. Gross wt = 546.0 kg AZ-G-123A, 123B, 123C, 129A, 129B, 134A, 113A, 113B
	Net glass from this test to date = 446 kg
16:52	Feed sample taken AZ-F-135A
17:00	Discharge (5 min) AZ-G-135A @ 6 scfm
19:03	Discharge (5 min) @ 5 scfm AZ-G-135B
20:38	Feed lines were flushed.
21:32	Discharge (5 min) AZ-G-135C
21:40	Scrubber sump level was lowered
21:45	NaOH solution (−2 gallon) added to scrubber sump
23:33	Discharge (5 min) AZ-G-135D
9/23/99	
00:50	Feed lines were flushed.
01:32	Discharge (5 min) AZ-G-138A
03:34	Discharge (5 min) AZ-G-138B
03:40	Scrubber sump level was lowered
03:43	NaOH solution (−1/4 gallon) added to scrubber sump.
04:34	Feed lines were flushed.
05:00	Power fluctuation from about 60 kW to about 200 kW (+3 electrodes) difficult to maintain the temperature.

05:34	Discharge for 6 min. AZ-G-138C
	Glass level is relatively low and about 95% cold cap with molten glass bubbling.
06:15	Notes: At 0528 total power to the melter was −176 kW. After discharge (approximately 15-20 min), noticed a sudden rise in temperature of glass and plenum. After inspecting the melt, foaming was confirmed. To lower the temperature, power had to be cut down to as low as 80 kW (TC2 = 1161, TC5 1154). During the foaming episode, glass temperature at the bottom of melt (e.g., TC5) reaches or exceeds the temperature of the middle (e.g., TC2), indicating extensive foaming within the bulk of the glass pool. Normally TC5 is 6-10EC lower than TC2). After foaming subsided (around 06:10), a rough estimate of the difference in glass level before and after foaming is about 8"-10".
06:42	Sump water was transferred. pH adjusted to 9.
07:20	Foaming has happened again, same process consistent with 06:15 notes. Power shift: from −210 kW to −60 kW.
07:30	Discharge drum was removed.
	Gross wt. = 499.0 kg AZ-G-135A, 135B, 135C, 135D, 138A, 138B, 138C, net wt = 482 kg. Total in test to date 928 kg.
	Note: missed by one kg to get the target 500 kg. Glass level = 7" from the drum rim.
07:45	Flushed feed tubes with H2O
07:52	Temperature dropping below 1140EC to TC-2. Raising power to 200 kW; not having much effect.
08:00	kW @ 210 temp beginning to rise.
08:03	Lowered kW to 200 to slow rise in glass temperature. Temperature stabilizing @ 1145EC, will gradually increase power.
08:08	Temperature @ 1147EC and foam level in melter has dropped to about 5" with corresponding plenum temperature drop.

08:20	Melt pool began foaming cycle again with corresponding temperature power fluctuating.
08:25	Turned off zone 2 power, temperature stabilizing. 1162EC and beginning to lower.
09:00	Temperature/foaming cycle beginning again.
09:10	Discharged for 5 min. AZ-G-142A.
09:15	Blowing down scrubber sump.
09:25	Power @ 225 kW and temperature is still dropping.
09:35	Raised power gradually until temperature began to rise again. Power settings @ 235 kW
09:40	Glass raised by foam around 6". Power reduced to control temperature.
10:20	Foaming again.
	Notes: It appears that the foaming cycle repeats itself every hour or so. Foaming sequence: temperature starts to drop below 1150EC (say TC2); no foaming at this point; increase power to keep the temperature from falling; power to >210 kW; glass temperature starts to come back up from say 1130-1140B1150EC; foams; power is decreased since temperature is going back up; power to as low as 50 kW; foam subsides.
10:45	Flushed feed tubes
10:55	Temperature beginning to drop; cycle resuming.
11:14	Discharging glass for 5 min. AZ-G-142B
11:45	Under no foaming conditions cold cap closes and plenum temperature drops.
13:00	Discharging glass for 5 min AZ-G-143A
13:05	Cold cap closing. Energizing Zone 2 electrode.
13:40	Blew down scrubber as much as possible. All blowdown tanks are full.
13:30	De-energized zone 2 electrode and reduced zone 1 to 50 kW
14:24	Stopped feeding. Final wt = 221 kg

14:40	Feed lines were flushed with small quantity of water. Recirculation line was flushed out.
15:00	Sump water was transferred. Monitor the cold cap burn.
16:00	No foaming is observed
16:20	The extent of the cold cap is about 40-50%. It is relatively thin, about several inches. The thickness varies and there are some spots visible through the viewport that look chunky (thicker than several inches). There are fibrous deposits over the plenum walls (above the melt level) bubbler pipes, so on. They appear to be melting or softening and falling down into the glass pool.
17:15	Cold cap still there. Plenum deposits are clearing out. CC = 30-40%
18:10	There is only hot cap over a small fraction of the molten glass pool.
18:30	The very small molten crust still is lingering over the tip. TC6 = 685EC TC1 = 708EC TC7 = 703EC Most all of the plenum deposits have cleared out.
	End of the run. Total run time is approximately 49 hours. At approximately 4 hours cold cap burn time. The average feed rate was about 120.3 kg/hr.
18:30	Discharge for 5 min. AZ-G-145A
18:45	Off-gas is secured. BR = 3 scfh Idling power = 50 kW
9/24/99	
	Glass can removed and weighed. Gross 292.5 - 17 = 275.5 kg NET AZ-G-142A, 143A, 145A Total poured for test 1203.5 kg
9/29/99	
15:30	Feed transfer
	Feed tank wt. 261 kg

	Before transfer
	After transfer 2123.5 kg After addition of water 2150.5 kg Only about 4 gallons of water was added to rinse the recirculation line
	Feed tank during 2087.0 kg Recirculation operation
16:10	Started feeding
17:03	Feed lines were rinsed
17:13	Power Bottom: 60 kW ; top: 0 kW T_{BOT} = 1094EC; T_{TOP} = 1159EC
17:59	Discharge (5 min) AZ2-G-7A Plenum temps = 517EC - 528EC - 523EC (before) Plenum temps = 513EC - 526EC - 520EC (after)
19:04	Feed lines were flushed.
19:19	The top of the melt is mostly foam.
19:37	Discharge (5 min) AZ2-G-7B @5 SCFH
19:45	Power = 50 kW bottom; 0 kW top. Glass temps: TC9-84 - 1196EC TC2-12 = 1160EC (top) TC5-5=1122EC (bottom)
21:00	Feed lines were flushed
21:24	Discharge (5 min) AZ2-G-14A
23:25	Discharge (5 min) AZ2-G-14B
23:28	Feed lines were flushed
9/30/99	
00:11	Scrubber sump water level was lowered.
00:53	Discharge (5 min) AZ2-G-14C
01:58	Feed lines were flushed.

02:00	Discharge drum was replaced. Net weight - 538 kg Includes 292.5 kg (weight of previous discharges + drum, see VSL-751-99, p. 145) Glass weight (from this test) = 245.5 kg Discharges: AZ2-G-7a, B, and AZ2-G-14A, B, C
02:09	Discharge (10 min) AZ2-G-14D
02:22	The plenum has been much hotter than planned for the run –635EC. However, did not increase feed rate because: (1) There is a lot of foam in melter and concern foam may cause melter to overflow (2) The production of foam consumes a great deal of power. Using the maximum power available –205 kW could not maintain melt temperature at 1150EC T2 went down to 1120EC now it is at 1142EC.
03:04	Foaming has receded considerably and glass level is much lower due to last discharge. Glass temperature can be controlled with 100 kW (bottom electrodes).
03:49	Discharge (5 min) AZ2-G-15A
04:11	Feed lines were flushed.
04:12	Scrubber sump water level was lowered
04:45	–1/4 gallon of NaOH solution added to scrubber sump.
05:10	Cold cap is approximately 80% and at 20% foam
05:30	Power demand is up
05:35	Very extensive foaming in the melt. Level has risen a lot (at least 10"-15" above its previous level). A sudden rise in plenum temperature is indicative of foaming.
05:35	Discharge (5 min) AZ2-G-16A
05:45	When glass foams, cold cap is almost completely dissolved and melt get covered with a hot layer of foam. From time to time, a violent boil off is observed at the melt surface where the feed is dropped. The boil off which looks very much like bubbling and consumes the feed very rapidly.

06:10	Flushed feed lines
06f:15	Melt level has dropped and melt surface has darkened except where gas bubbles are releasing. Temps are: T/C 2 = 1119EC, T/C 5 = 1105EC, Plenum = 643EC.
06:20	Feed sample is taken AZ2-F-16A
07:02	Discharge (10 min) AZ2-6-16B
07:02	Lots of foam, level is high
07:05	Scrubber sump water was transferred.
08:15	Flushed feed tubes
08:56	Feed was transferred from the mixing tank to the feed tank.
	Mass before transfer 261.5 kg @ 0843 Mass after transfer 434.0 kg @ 0844 Approx. 2.5 gallons of water was used to flush the transfer line
09:00	Feed lines are clogged up. Stopped Feeding.
09:30	Removed feed lines and cleaned hoses. Installed hoses and flushed system.
13:00	65 gallons required to make the 487 kg in feed tank. For mix tank 885.5 kg (3.5 drums) - 172.5 transfer @ 9am = 713 kg feed on 2.8 drums @ 41 gallons added H2O per drum - 115 gallons needed - 8 were already added 103 gallons required for mix tank Total for both is 173 gallons
14:05	Glass can removed 409 kg ; gross - 17 kg can = 392 kg net. AZ2-G-14D, 15A, 16A; total for test - 637.5 kg
9/30/99	Test #4 High Water Zero Bubbling
14:15	Started feeding
15:17	Transferred water from scrubber
15:30	Feed sample is taken (grab sample) AZ2-F-20A
15:45	Description of cold cap: −50% foam layer; −50% solids
17:15	Feed lines were flushed.

17:40	Scrubber sump water level lowered.
18:27	Discharge (5 min) AZ2-G-20A @ 5 scfh
19:00	Beginning to control temperature by using top electrode as our major power supplier.
19:05	It was decided not to follow strategy stated @ 1900.
19:57	Discharge (5 min) AZ2-G-20B @ 5 scfh
20:00	The manner we have been trying to control glass temperature is maintaining the following ratio constant: top electrode power/total power is about 0.33.
20:09	Feed lines were flushed.
20:30	Scrubber sump water level was lowered
22:10	Feed lines were flushed.
22:30	Discharge (5 min) AZ2-G-20C @ 5 scfh
23:15	There are many broken holes in cold cap Tp = 381EC
10/1/99	
00:12	Feed lines were flushed.
01:00	From 14:15 (9/30/99) to 01:00 (10/1/99), the temperature controlling strategy is that described @ 22:00 (9/30/99). From 01:00 (10/1/99) on, the top electrodes are shut down, and all power is now delivered through bottom electrodes.
01:01	The time between shots, t4, is set at 100 sec for this part of the experiment because it was found (from 14:15 to 01:00) that the most stable conditions for the cold cap were attained for t4 at, or close to, this value.
02:01	Discharge (5 min) @ 5 SCFH AZ2-G-24A.
02:40	About 1/4 gallon of NaOH solution added to scrubber sump.
02:58	Feed lines were flushed.
03:25	Discharge (5 min) @ 5 scfh AZ2-G-24B
03:45	Note on cold cap: During this experiment, the amount and nature of the cold

	cap changed constantly. However, it was observed that, in any case, it was a thin and "flexible" layer being easily deformed by the underlying melt movements.
04:20	Scrubber sump water level was lowered.
04:25	Discharge (5 min) AZ2-G-26A
04:58	Feeding stopped on 04:58. All recirculation and feed lines flushed.
06:30	Plenum temperature reading: TC6 = 395EC; TC1 = 416EC; TC7 = 412EC. Power: 35 kW.
07:02	Plenum temperature readings: TC6 - 394EC; TC1 = 419EC; TC7 = 414EC; Power 35 kW
07:30	Plenum temperature readings: TC6 = 404EC; TC1 = 430EC; TC7 = 425EC; Power 80 kW
08:00	Plenum temperature readings: TC6 = 412EC; TC1 = 437EC; TC7 = 433EC; Power 37 kW
08:30	Plenum temperature readings: TC6 = 423EC; TC1 = 446EC; TC7 = 441EC; Power 45 kW
09:05	Plenum temperature readings: TC6 = 437EC; TC1 = 457EC; TC7 = 452EC; Power 45 kW
09:34	Plenum temperature readings: TC6 = 443EC; TC1 = 464EC; TC7 = 460EC; Power 45 kW
09:43	Energizing lid heaters to assist in burning off remaining cold cap and foam. Current cold cap composition: 90% foam, 10% solids.
10:00	Plenum temperature readings: TC6 - 464EC; TC1 = 478EC; TC7 = 474EC; Power 45 kW
10:13	Cold cap solids dissolved, remaining cap is foam composition. Current plenum temperatures TC6 = 479EC; TC1 = 493EC; TC7 = 489EC. Run is considered complete and I am completing shut down checklist.
12:50	Observed melt surface has unusual appearance of "moon" surface type air bubbles.
13:05	Shut down checklist complete. See notes and checklist for variations.

10/5/99	
14:30	Discharge can was replaced. Mass (gross) 350.0 kg Glass weight = 343 kg Glasses included AZ2-G-20A, B, C - 24A, B, - 26A.
10/5/99 - Test #5	
15:00	Feed mass = 3288.5 kg with recirculation and agitator off, but the 2" valve at the tank bottom closed.
15:15	Feed mass = 3233.5 kg Recirculation on, agitator off. Bottom valve open.
16:00	Started the run.
16:30	Notes: At the beginning of the run, as the cold cap formed, the glass pool temperature near the top (i.e., TC9 at 24: above the floor) starts to climb up rapidly and in this case reached a value of about 1200EC. To control the temperature, the power to zone 2 (top) had to be secured to bring the temperature down. The melt temperature near the bottom stays around 1110EC.
18:15	Feed lines were flushed.
18:17	Cold cap is constituted mainly of foam, and plenum temperatures remain relatively high. Therefore, feed rate is increased. t4 is decreased from 55 to 45 seconds.
18:34	Discharge (5 min) AZ2-G-30A
19:16	Scrubber sump water level lowered
20:00	Discharge (5 min) AZ2-G-30B
20:12	Feed lines were flushed.
21:33	Discharge (6 min) AZ2-G-30C
21:58	Scrubber sump water level was lowered.
22:17	Foaming event occurs. Glass temperature = 1125EC Plenum: 379EC-345EC-342EC Power: 125/80 kW

	Plenum temperature rose while glass temperature decreased.
23:05	Power: 125/80 kW Glass temperature = 1131EC Plenum: 449EC-469EC-464EC Level has risen about 10" 1/3 of area is hot. Red foam, 2/3 cold cap.
23:17	Discharge (5 min) AZ2-G-35A
23:29	Scrubber sump water level was lowered.
23:50	Feed lines were flushed.
10/6/99	
00:05	Feed sample taken (from feed tank). AZ2-F-35A.
00:32	The right half of the melt is significantly higher than the left half and "foaming" molten glass flows downward. This lasted for about 5 min.
00:52	Discharge (7 min) AZ2-G-35B.
01:15	Scrubber sump water level was lowered.
02:02	Discharge (5 min) AZ2-G-36A
02:18	Feed lines were flushed.
02:45	Scrubber sump water level was lowered.
03:34	Discharge (5 min) AZ2-G-36B.
04:22	Feed lines were flushed.
04:35	Scrubber sump water level was lowered.
04:50	Glass level (or foam level) is high, almost to the lower tip of the bag shot. The cold cap looks thin and is mobile (moves up and down).
05:00	Discharge 10 min. AZ2-G-36C
05:15	Notes: At an average feed rate of 133 kg/hr over13 hours, we have made about 430 kg of glass (0.25 yield glass to feed). At the end of discharge (05:00) glass level in the discharge can indicates an approximate mass of about 400 kg + (around 24" high). However, the foam layer (foamed cap) or glass level is

	approximately 15∀2(3) inches above the starting glass level. At a starting depth of about 38", the glass pool is expanded by about 30%. Correction expansion is about 40%.
05:45	Extensive foaming is happening. Level is higher than before, approximately 8-10". Bed expansion: 65%.
05:48	Glass level dropped suddenly by about 10-15" as foaming appeared to be subsiding. It looks like boil off and degassing. Higher foamingBhigher power demand.
06:22	Feed lines flushed.
06:24	After lowering power @ 06:20 due to temperature reaching 1174EC, temperature has dropped to 1164EC and cold cap has broken with foam/glass level dropping 8-10".
06:35	Discharging glass for 5 min. AZ2-G-38A.
07:10	Even though the plenum temperatures are low, glass (and some foam) is seen around the edges (at contact refractories/glass interface)
07:25	Discharge can was removed. Gross weight = 490 kg AZ2-G-30A, 30B, 30C, 35A, 35B, 36A, 36B, 36C, 38A
07:59	Discharging glass for 5 min. AZ2-g-39A
08:25	Flushed feed lines.
08:30	Onset of foaming. Happens relatively quickly.
08:45	Cold cap opened up. Level has not risen too much yet.
08:52	Transferred scrubber water.
09:15	Cold cap is almost closed in @09:00 the feed rate was reduced because plenum temperature was dropping. Since then the plenum temperature came back up.
09:32	Onset of foaming.
09:35	Discharge glass for 8 minutes. AZ2-G-39B
09:40	Changed feed rate from 65 seconds to 50 seconds. Temperature in glass immediately dropping. Increased power to 125/90 kW temperature. Still

	dropping, glass beginning to foam. Plenum @ 362EC.
09:50	Cold cap breaking up, glass rising with foam.
09:55	Plenum temperature continuing to rise, glass temperature dropping. Changed feed rate from 50 seconds to 45 seconds. Power is 125 /100 kW. Plenum 436EC.
10:03	Transferring feed from mixing tank to feed tank. Feed tank beginning level 871.5 kg. Feed tank ending level 2031.0 kg. Feed tank after flushing 2230.0 kg. Feed tank after water added 2676.0 kg. Elapsed time during transfer 19 minutes.
10:23	Flushed feed lines.
10:45	Discharging glass for 5 minutes. AZ2-G-42A.
11:10	Transferred scrubber water. Note: Evaporator is out of service and only have room for about 75 gallons in scrubber blowdown tanks remaining. Will use drums for temporary storage.
12:19	Discharging glass for 7 min. AZ2-6-42B.
12:23	Flushed feed lines.
12:27	Raised scrubber pH from 6.10 to 8.50
12:35	Cold cap 100% temperature rising up to 1184EC before beginning to lower. Power has been lowered to 30 kW on bottom only. Plenum is 311EC. Feed rate is 65 sec.
12:45	Changed feed rate to 75 sec. Plenum temperature continuing to drop (307EC). Glass temperature 1174EC.
12:55	Changed feed rate to 80 seconds. Plenum temperature 304EC. Glass temperature 1162EC. Cold cap 100%.
13:03	Feed rate changed to 120 second, due to plenum temperature continuing to drop.
13:12	Plenum reaches a low point of 287EC before reversing and raising temperature.
13:23	Plenum temperature stopped rise and began lowering again (currently 251EC) glass temperature 1147EC. Power @ 110/69 kW.

14:23	Discharging glass for 8 minutes. AZ2-G-42C.
15:00	We are filming the foaming sequence in the melter as both computer and video since about 2 hours ago.
15:08	Flushed feed tubes.
16:30	Discharge glass for 10 minutes. AZ2-G-44A.
17:15	Scrubber sump water level was lowered.
17:25	Feed lines were flushed.
17:30	NaOH solution (– 2 gallon) added to scrubber sump.
17:57	Calculation of feed transferred to feed tank during period 09:57-10:22 hrs. 883.0 kg to 2671 kg. Feed rate @ 9:57 –133 kg-feed/hr. 55 kg feed during this period. 1843 kg were transferred.
18:17	Discharge (5 min) AZ2-G-44B.
19:35	Feed sample from "feed tank" was taken. AZ2-F-44A.
20:05	Feed lines were flushed.
10/7/99	
00:22	Feed lines were flushed.
00:25	Discharge (5 minutes) AZ2-G-45A.
00:34	Cold cap consists of a thick crust that is beginning to present some motion.
01:32	Scrubber sump water level was lowered.
02:30	Feed lines were flushed.
05:17	Feed lines flushed.
05:36	Discharging glass for 7 min. AZ2-G-45B.
06:24	Flushed feed tubes again due to 8 kg/hr drop in feed rate during last 2 hr.
07:20	Discharge can was removed, replaced with a new one. Gross wt. 508.5 kg. Filled to 4 2" from top. Includes: AZ2-G-39A, 39B, 42A, 42B, 42C, 45A, 45B.

09:00	Switched power to the top electrodes. 70 kW.
10:57	Flushed feed tubes.
09:30	Switched power back to both electrodes due to high temperature on contact of top electrode.
10:54	Molten glass can be seen under the cold cap indicating that the cold cap thickness should not be large. About 50-60% of the cold cap is foamy (which should not be called cold cap).
13:08	Discharge for 7 min. AZ2-G-50A.
13:54	Flushed feed tubes.
15:05	A sample of the cold cap was taken. AZ2-CC-50A. A port in the top was opened, a homemade scoop was used to dig into the cold cap, into the surface of the melt and pull the composite sample out.
16:00	Stopped feeding.
17:00	Glass pool: TC2- 1157; TC5-1146; TC9-1161; Plenum: TC6-448; TC1-477; TC7-472
17:05	Cold cap looks to be 20% and foamy.
19:07	Foaming surface with small spots of dark materials.
20:13	Foam looks brighter and thinner. Damper was closed slightly to reduce melter pressure from 1.0 to 0.5 H_2O.
20:18	Big bubbles are gone and a "fine" foaming is observed.
21:00	Foam looks very much the same since around 20:00 hours.
21:24.	No further changes are observed on the nature of the foaming surface (same as described @ 20:18). Besides that, the increase of plenum temperature is beginning to slow down.
21:30	Preparing to shut down system
21:45	Finished shutting down the system. Recorded on checklist.
22:05	No changes observed on the foaming surface.
10/11/99	

11:00	Can removed from discharge and weighed @ 84 kg - 17 kg for drum = 67 kg net. Glass name AZ2-G-50A. Glass sampled (–300 g) and can replaced.
14:10	105310 CUA # - sugar 13.0 kg weighed out for addition.
10/11/99, Run #6/High Water Sugar Test	
14:24	Started feeding.
14:51	Feed lines were flushed.
15:24	t2 was increased from 1.5 to 2.0 seconds because the shot were around 1.8 kg/shot.
15:30	Discharge T - 897 (cold) closed. Blue discharge valve to test leaks.
16:00	Plenum is almost completely dark.
16:20	Discharge (5 min) AZ2-G-54A
16:40	Off-gas computer (Keith=s) is 4 minutes slower than melter data acquisition computer.
17:17	Feed lines were flushed.
17:16	Scrubber sump water level was lowered.
20:08	Feed lines were flushed.
21:03	Feed lines were flushed.
21:29	Recirculation speed was increased. 1/4 turn on air valve.
22:38	Scrubber sump water level was lowered.
22:55	Discharge (9 min) AZ2-G-54B
23:05	Stopped feeding.
10/12/99	
01:18	System shut down.
01:25	Light foam. Very little dark spots. Quiet surface.
	Glass discharge can removed Mass - 143 kg, net - 126 kg

	67 kg (from last test) = 59 kg AZ2-G-54A, 54B from test.
15:15	Transfer of feed tank to final weight 74.5 kg. Liquid transferred into drums. 1 full drum + −50 kg of the high H2O 15 g sugar/liter was removed.
10/13/99	
	NOAHF11 Batch #3 (CUA #) feed material was removed for viscosity measurement after stirring for 30 minutes with MX-5TV. Sample removed directly from drum. Temperature of feed = 26EC.
10/13/99	Test #7: High solids, no bubbling
09:52	No foam in the glass pool before the start.
10:02	Started feeding. Initial scale reading: 1085.5 kg
11:25	Started to transfer feed from the mix tank to the feed tank.
11:34	844 kg starting mass. 2828 kg after transfer.
11:37	2876 kg after H_2O rinse.
12:05	One feed line is clogged.
12:13	Flushed feed lines, commenced feeding.
12:30	Feed sample is taken. AZ2-F-64A.
12:45	Cold cap seems to be leveling out, no foaming yet.
13:30	Discharge 8 minutes AZ2-G-64A.
13:22	Increased the pumping speed in the recirculation line slightly.
13:55	No foaming. However, the glass under the cold cap appears to contain bubbles.
14:03	Increased time on feed pump to 75 seconds.
14:47	No foaming. Same observation as 13:55.
15:09	Starting discharge of glass.
15:17	Stopped discharging.
15:20	Flushed feed tubes.

16:15	No foaming observed as of this time.
16:18	Transferred scrubber H2O to holding tanks.
16:30	Cold cap is about 98% (approximately) and is mobile. No apparent foaming is visible. However power demand is on the rise.
16:52	Discharge. AZ2-G-65A.
17:15	Remove glass from discharge. Gross mass - 498.0 kg. Net - 481.0 kg. Includes AZ2-G-50A, 54A, 54B, 64A, 65A.
17:36	Feed lines were flushed.
	Calculation of feed transferred from mixing to feed tank during the period 11:25-11:38. The feed rate (estimated) from 12:18 to 12:45 (@ t4 = 60 s) was 115.6 kg/hr Feed transferred = 2878 kg - 844 kg + 115.6 kg x 13/60 = 2059 kg
18:31	Almost 100% cold cap, but there are some holes through which bubbles emerge. The cold cap does not remain still.
19:29	Feed lines were flushed.
20:06	Discharge (5 min) AZ2-G-66A.
20:06	Scrubber sump water level was lowered.
20:13	The cold cap holes through which bubbles come out have increased.
21:35	Feed lines were flushed.
21:55	Cold cap is closing. Only 2 holes visible where there used to be –4-6 holes. Will further decrease feed rate at 22:00 to 240 second intervals.
22:50	Cold cap is further closing. Only 1 small hole visible. Plenum t is increasing with t4 - 240 sec.
10/14/99	
00:10	Between –23:10 to 23:50 feeding was stopped to clean feed lines.
00:26	Discharge (5 min) AZ2-G-66B
00:33	There is a fractured cold cap on top of a foamy surface. Four bubbling holes can be observed.

01:03	Feed lines were flushed.
01:15	Scrubber sump water level was lowered.
01:20	2 gallons approximately of NaOH added to scrubber sump.
01:40	Plenum getting darker. Only two bubbling holes are observed. t4 increased from 150 to 180 s.
01:58	Feed lines were flushed.
02:57	Feed lines were flushed.
10/14/99 Test #7	
03:12	Scrubber sump water level was lowered.
03:14	1/4 gallon of NaOH solution added to scrubber sump.
03:57	Feed lines were flushed.
04:19	Discharge (5 min) AZ2-G-70A.
04:54	Feed lines were flushed.
05:15	Notes: The flow characteristic of the feed over the cold cap is poor. Initially it piles up and then gets digested. The melt surface is not totally dark (unmelted feed materials), part of it especially near the walls is semi-melted (dark red color). Molten glass perks up through several holes in the cold cap. No foaming is apparent.
05:54	Feed lines were flushed.
06:43	It was noticed that Tc1 (plenum temperature readout) and film cooler outlet temperature read out are the same. After further inspection, there is not any film cooler temperature read out. Quencher inlet temperature, however, is confirmed and is valid. Correction will be made when the run is over.
06:54	Feed lines were flushed.
07:54	Feed lines were flushed.
08:41	Discharge 8 minutes. AZ2-G-71A.
08:55	Feed lines were flushed.

10:00	Feed lines were flushed.
10:40	Still no foaming. Cold cap is 98% with 1 small hole bubbling through.
11:15	Flushed feed lines.
11:45	Flushed feed lines.
13:10	Feed tubes flushed.
13:23	Discharge 8 minutes. AZ2-G-71B.
13:32	Video recorder is on at 30 minutes to the end.
14:30	Flushed feed tubes.
15:15	There appears to be some slight foaming under the cold cap. Tc2 = 1156EC, Tc5 = 1148EC, Tc9 = 1162EC. However there is not a big surge in power demand unlike foaming events in the previous runs.
15:30	Back to normal, no foaming, small holes incold cap.
16:18	Discharge 8 minutes. AZ2-G-71C.
16:24	Flushed feed tubes.
16:40	Gross wt. 522.0 kg. Net 505.0 kg. Test production to date: 843.0 kg. AZ2-G-66A, 66B, 70A, 71A, 71B, 71C.
16:57	Increased time of feed pups to 200 sec.
16:58	Cold cap @ 100%.
17:40	Stopped feeding for about 15 minutes to clean clogged feed line. Feed lines flushed.
18:25	Feed lines were flushed.
19:02	Feed lines were flushed.
20:03	Feed lines were flushed.
22:36	Feed line 1 was flushed.
23:00	Scrubber sump water level was lowered.
23:04	Feed lines were flushed.

23:27	Discharged (5 min) AZ2-G-75A.
23:28	At 20:04 feeding was stopped to increase T (Plenum) when Tc1 > 440EC start feeding t4 = 180 sec. Temp (Tc1) dropped: 180 sec too short.
23:45	Feed lines were flushed.
10/15/99	
00:50	Feed lines were flushed.
01:10	The cold cap Ablock@ only covers part of the melter. Away from the feed parts, one has Ared@ foam. In the boundary between the dark and the Alight@ cold cap one has active foaming with hot glass flowing up.
02:06	Feed lines were flushed.
02:08	Stopped momentarily to increase plenum temperature.
03:57	Feed lines were flushed.
05:00	Notes: The holes in the cold cap are gone part of the cold cap is semi-fused., meaning it is more like a still hot cap. The semi-fused hot cap is mostly at the walls. The center of the cap is pretty dark.
05:40	Few holes in the cold cap have been generated.
06:19	Feed lines were flushed.
06:55	Feed appears to be aerated because the level is low and feed is thick. Kg/shot has been reduced to less than 2 kg/shot.
07:54	Feed lines were flushed.
09:24	Scrubber water transferred. pH adjusted.
09:35	Feed lines were flushed.
09:38	Discharge. 8 minutes. AZ2-G-78A.
10:30	Flushed feed tubes.
11:37	A minor foaming even has happened. It reversed itself relatively quickly.
11:38	Decreased feed shot time from 220 to 150 seconds.

12:01		Stopped feeding.
12:10		Rinsed the recirculation line. Fed small volume of water through pinch valve into the melter.
		Mass of feed 488.5 kg after recirculation line was clean from feed.
13:00	Cold Cap Burn Notes	Only few small openings in the cold cap..
14:00		Fewer openings than 13:00. Looks like foamy under the cold cap.
15:00		Cold cap has turned into a foam cap. Slightly red and foamy.
15:30		Cold cap is foamy, getting hotter.
16:00		Power is increased to 75 kW (from around 50 kW) to maintain the glass temperature. Foam layer is still on.
17:00		Layer of foam over the top.
17:30		Foam layer over the top.
17:45		At this plenum temperature, melter can be fed at the high feed rate for Test #7.
		End of run
20:11		Thin foam layer
21:17		No foam. Glass surface is clean from foam.
16:32		Discharge for 11 minutes. AZ2-G-78B.
15:15		Main off gas off.
10/20/99		
14:30		Glass can removed. Gross Mass 293 kg. AZ2-G-75A, 78A, 78B. Net mass - 276 kg.
15:00		Added to 2945 kg high solids feed was – 250 kg feed with 15 g/liter hence @ 1.2 kg/liter feed density the combined feed contains 0.9 g sugar/kg
10/20/99, Test #8 - High Solids, Bubbling		
		Initial mass 3306 kg (stirrer off)
16:13		Started feed 16:13

16:40	t4 changed to 55 sec from approximately 45 sec. 180+ kg/hr of feed.
17:10	NaOH solution (1/4 gallon) added to scrubber sump.
17:17	Feed lines were flushed.
18:28	Feed lines were flushed. Scrubber sump water level was lowered. NaOH solution added to scrubber sump (−1/4 gallon).
19:35	Feed lines were flushed.
20:07	Discharge (5 min) AZ2-G-84A
20:34	Feed lines were flushed. NaOH solution (−2 gallon) added to scrubber sump.
20:40	Bubbling rate increased from 20-10-20-10 to 30-1530-15.
20:44	Bubbling broke cold cap along the bubbler. Plenum temperature starts to increase.
21:03	Plenum temperature stable for the last 30 min.
21:10	Scrubber sump water level was lowered.
21:33	Feed lines were flushed.
21:48	NaOH solution (−2 gallon) added to scrubber sump.
22:04	Discharge (5 min) AZ2-G-85A.
22:33	Feed lines were flushed.
22:39	Plenum temperature drop −40EC past the hour because feed line is flushed at 30+ after each hour. The cold cap is broken with multiple holes. Over last hour cycle system (melter power, Tp, Tm, etc.) is very stable.
22:40	Scrubber sump water level was lowered.
10/21/99	
00:05	Feed lines were flushed.
00:35	Discharge (5 min) AZ2-G-85B.
01:12	Scrubber sump water level was lowered.

01:13	Bubbling rate increased to 40-20-40-20
01:22	NaOH solution (−2 gallons) added to scrubber sump.
01:35	Feed lines were flushed.
02:08	Bubbling rate decreased to 30-15-30-15.
02:19	Bubbling rate increased to 35-17.5-35-17.5.
02:33	Bubbling rate increased to 40-20-40-20.
02:37	Discharge (5 minutes) AZ2-G-86A.
03:15	Feed lines were flushed.
03:36	Scrubber sump water level was lowered. NaOH solution (3/4 gallon) added to scrubber sump.
04:15	Bubbling rate increased to 50-25-50-25
04:33	Feed lines were flushed.
04:38	Bubbling rate decreased to 40-20-40-20
04:47	Discharge (5 min) AZ2-G-86B.
05:10	Bubbling rate 50-25-50-25
05:19	Discharge 4 min. (Can is almost full.) AZ2-G-86C.
	Note: The level is too high and glass being discharged appears slightly foamy. Bubbling rate 40-20-40-20.
05:25	Taking video of the glass and cold cap. Time on the film 36:44.
06:00	Discharge can was replaced. AZ2-G-84A, 85A, 85B, 86A, 86B, 86C. Gross weight 527.5 kg. Net 510.5 kg.
06:10	Sump water was transferred.
06:19	Feed lines were flushed.
06:27	Discharge 5 minutes. AZ2-G-88A.
08:06	Switched to a new feed control screen because the previous control screed was accidently switched off.

08:20	Discharge 8 minutes. AZ2-G-88B.
08:25	Bubbling rate 40-20-40-20
08:45	Feed lines were flushed.
08:47	Transferred water from scrubber sump. Adjusted pH.
09:42	After rechecking the valve (feed valve) opening times, noticed that the tm is set at 15 sec instead of 1.5 sec. It was corrected.
09:46	Discharge 7 minutes. AZ2-G-88C.
	Discharge glass is being discharged, appears to be slightly foamy (gas bubbles can be seen in the glass stream).
10:05	Cold cap is about 95% coverage. Glass under appears to be slightly foamy, but stable. Resistance of zone 2 (top) is slightly higher than before (0.091 compared to –0.085 ohms).
10:15	Feed lines were flushed.
10:20	Glass in the melter does not look as foamy. Cold cap is 90-95%.
10:41	Sump water was transferred.
11:04	Discharge 7 minutes. AZ2-6-89A.
11:05	Sump water transferred, pH adjusted.
12:15	Recording of the cold cap @ 1:44 of tape time.
13:10	Noticed one feed line is clogged. Stopped feeding.
13:20	Cleaned the line. Started feeding.
13:49	Discharge 7 minutes. AZ2-G-89B.
13:52	Feed sample taken from feed tank. AZ2-F-89.
14:20	Noticed the feed lines are clogged. Stopped feeding.
14:50	Both lines cleaned out. Start feeding.
15:00	Bubbling rate has not been changed. 40-20-40-20 scfh.
	Lost signal from Tc6 and Tc1.

15:07	Discharge can removed prior to the last discharge. AZ2-G-89C. Gross weight: 511.5 kg. Net: 494.5 kg. AZ2-G-88A, 88B, 88C, 89A, 89B.
15:08	Discharge for 12 minutes. AZ2-G-89C.
15:12	Stopped the run. Feed lines are both clogged again. Feed level too low. Large clumps clogging up the feed tubes.
15:40	Tc7: 628EC, computer read out. Bubbling rate: 40-20-40-20. Tc6: 611EC, panel read out. Tc1: 637EC panel readout.
15:50	Tc7: 660EC. Bubbling rate: 40-20-40-20. Tc6: 662EC. Tc1: 667EC. Cold cap has dissolved. Only a thin layer of foam on the top.
16:15	Tc7: 692EC. Zero cold cap. Thin layer of foam over the top. Same bubbling rate. Tc6: 685EC. Tc1: 700EC.
	Note: AZ2-G-89C is in the discharge can attached currently to the discharge chamber.
	Notes concerning the end of the run: The feed lines were clogging frequently, as a result, the melter could not be fed at a rate of −130 kg/hr, which appeared to be stable under the conditions that the system was operating. As a result of frequent line clogging, it was decided to terminate the run, despite having about 430 kg of feed in the feed tank.
16:35	Main off-gas turned off.
16:40	Tc7: 753, Tc6: 753, Tc1: 758/ Bubbling rate 40-20-40-20.
	Foam has all gone.
16:40	Bubbling rate was adjusted to minimum.
10/22/99	
08:45	Cleaned pinch valves and lines.
	Discharge drum was removed and weighed.
	Gross weight = 185.5 kg. AZ2-G-89C. Net: 168.5 kg. Total glass made during Run #8: 1224.5 kg.

Run Chronology for DM1000 West Valley Tests

12/6/99	
	Recipe for West Valley feed requires the addition of 61.64 g sugar/kg feed. Most drums have a net mass of 247 kg hence 15.225 kg sugar per drum. Also 43.69 g water are required per kg feed or 10.79 kg per drum; this will be taken into account during the transfer.
12/6/99, West Valley Turnover	
11:00	Mass of feed (watered down waste AZ-101) Before recirculation = 407 kg After recirculation = 358 kg
11:04	Started to feed
11:10	Stopped, quencher inlet appears to be clogged. Upon examination of the film cooler and the quencher inlet, quencher inlet is relatively clear, but film cooler has large build-up all around it. The build up was removed as much as possible.
11:35	Started feeding again. Bubbling rate 20, 40, 20, 40 SCFH.
12:21	Mass 207.0 kg Transferred 1st tank (drum) of feed to the feed tank.
12:30	1156 kg total mass in the feed tank after transfer of three drums.
12:45	Discharged for 7 minutes. WV1000-G-106A.
13:26	Discharged for 10 minutes. WV1000-G-106B.
15:23	Bubbling rate reduced to 20-10-20-10.
15:40	Bubbling rate reduced to 12-6-12-6.
17:45	22.7 kg of sugar were added to feed tank. Approximately 31 g/kg extra over 61.64 g/kg.
19:45	Recirculation line was flushed.
20:30	System shut down.
12/7/99	

09:26	Started to feed.
09:42	Discharged for 7 minutes. WV1000-G-114A.
10:25	Transferred feed weight before transfer 329.5 kg. CUA 105306.
10:30	Feed mass after transfer 136.0 kg. Added 31 kg of sugar to feed tank (extra 31 g per 1 kg of feed)
11:31	20-10-20-10 bubbling rate.
11:36	Discharged for 10 minutes. WV1000-G-114B.
12:30	Read high carbon monoxide,−1500-1800 ppm on ENERAC installed post off-gas system.
12:35	Combustion can clearly be seen over the cold cap through opening into the glass.
12:25	Transfer feed out before transfer 1002.5 kg. Feed mass after transfer 3345.0
12:26	Discharged for 11 minutes. WV1000-G-114C.
12:30	ENERAC check.
12/7/99	
13:45	To lower CO, the plenum temperature was raised to about 730EC. The feed rate was lowered also from t_4 = 45 sec to t_4 = 60 sec. The plenum temperature was raised by increasing the bubbling rate from 60 SCFH to 120 SCFH. The average CO dropped from 1500 ppm to about 150 ppm −10 x drop.
14:04	Carbon monoxide is down to zero. T6 = 756, T1 - 756, T7 = 753.
	To examine the CO temperature dependency, the plenum temperature will be decreased (same feed rate).
	Remove/replace discharge can. Total mass 506.5 gross. WV1000-G-117A. WV1000-G-106A, 106B, 114A, 114B, 114C, 117AB506.5 kg gross.
14:05	Adjust bubbler rate- 18-10-20-10.
14:13	Approximate feed ratio: t4 = 45 sec6FR = 190-195 kg/hr. t4 = 90 sec 6 FR = 105-110 kg/hr; t4 = 40 sec 6 FR = 220-230 kg/hr.

14:20	CO = 43, NO = 720 T6 = 710, T1 = 716, T7 = 713 CO = 130, NO = 800 T6 = 700, T1 = 701, T7 = 702
15:07	Started discharging glass
15:18	Secured discharge. Discharged for 11 minutes. WV1000-G-117B
15:35	Changed feed shots from 45 sec to 40 sec.
17:15	Started discharging glass. WV1000-G-118A. Discharged for 7 minutes.
19:25	Started discharging glass. WV 1000-G-118B. Discharged for 7 minutes.
19:32	Secured air lift.
19:35	The gauges M-G-10 and M-G-11 read -2" of water yet at each feed cycle the melter went positive. M-G-14 went positive while MG-10 and 11 were negative. Turned the fan on all the time and often the valve all the way. ΔP high in film cooler t1G1 –6", MG13 – 3". Scrubber S1G1 9". MG-10, 11 -5" or more. M-G-14 cycle -2" to -2@. Pressure in melter is now permanently negative. Looked into film cooler; it needs cleaning. It seems to be insulation that is clogging film cooler. The large flow through off-gas increases NO emissions, NO_2 off-scale. CO decreases.
20:11	Secured feed wt 1900 kg. After empty feed line 1949.5 kg.
12/8/99	
05:30	Discharge drum was changed. Mass = 428.00 kg, WV1000-G-117B, 118A, 118B.
05:15	Main off-gas on.
	Note: NO = 12 ppm, NO_2 - 22 ppm before fan was turned on. CO = 0 and SO_2 = 0 ppm Film cooler dilution on @ 2000 FPM and 280EC. Feed mass 1949.5 kg before recirculation (Note: 1972 kg with agitator on). Mass with recirculation on 1877.5 kg.
05:45	Started to feed. T4 = 40 sec.

05:53	NO = 806 ppm, T6 = 840EC; NO_2 = over, T1 = 859EC; CO = 0 ppm, T2 = 856EC.
06:35	NO_2 920 ppm, TC6 - 236EC, CO = 70 ppm, T1 = 742EC, T7 = 740EC. BR = 10, 20, 10 20.
07:13	Changed bubbling rate 50-24-50-28
07:53	Discharge 26 min. WV1000-G-120A.
08:10	Feed rate changed TC2 = 1131E. P1 = 127.4 kW . Before @ t4 - 30 sec 6 TC5 1135EC Pz2 = 85.6. Max. power allowed. BR before change 50-25-50-25, SCFH TB - 150 SCFH. Feed rate changed because of high NOx release. Cold cap before change = 80% system very stable.
09:45	Discharge 10 min. WV1000-G-122A.
09:55	Under the present conditions the system is highly stable. Feed rate = 180-190 kg/hr TC2 and TC5 6 −1160EC BR = 24, 40, 24, 40 SCFH TC6 = 781EC Zone 1 Power 105 kW TC1 = 792EC Zone 2 Power 70 kW TC7 = 789EC CO = 0 ppm NO = 737 ppm NO_2 = over SO_2 = No reading
11:34	Discharged glass for 10 minutes. WV1000-G-122B
12:20	Film cooler is almost completely clogged. Feeding was stopped in order to clean the film cooler.
13:00	Discharged glass for 7 minutes. WV1000-G-122C.
14:00	System maintenance. 1) Scrubber column mist eliminator was back washed with city water for about 1 minute. 2) Quencher entrance was cleaned from heavy build up deposits. The deposits were knocked back to the scrubber sump. 3) Build up deposits were scraped off the film cooler pipe. Could not be

	removed completely, semi-viscous glassy materials. 4) Emergency exhaust clean out port was opened and the entrance was cleaned. 5) Baghouse No. 2 is opened. Interior is very rusty (new rust) indicating acid gas corrosion.
14:35	Acid gas concentrations during cold cap burnout (near the end). NO = 10 ppm NO_2 - 110 ppm SO_2 = 25 ppm
14:53	Remove/replace drum. Mass 480.0 kg. WV1000-G-120A, 122A, 122B, 122C.
16:00	After changing bags, pressure base lines: 1) Film cooler –2500 FPM. Temperature outlet @ 260EC. 2) Melter Dp=s @ the film cooler M-G-10 6 1.4"; @ the emergency location M-G-14 6 1.0" 3) Film cooler diff. pressure. T1-G-1 = 2.4". 4) Scrubber column –3.2" (S1-G-1) 5) Main ISO. Damper B1-G-4 (17") 6) Booster blower 6 on. 7) Baghouse #2 total pressure = 2.2" (DP) HEPA = 1.4" (DP) 8) HEME = 2.0" (DP)
16:30	Feed transfer batch #2. Before transfer 379.5 kg. After transfer 2909.5 kg; recirculation is operational. About 5 gallons of water was used to clean the transfer line.
18:50	Discharged for 7 minutes. WV1000-G-128A.
10:21	Discharged for 10 minutes. WV1000-G-128B.
12/8/99	
21:40	Increased bubbler to 1 to 50 SCFH, 2 to 25 SCFH, 3 to 50 SCFH Plenum temperature T6 = 511EC T1 = 537EC T7 = 534EC Tp is rather low and dropping. The increase in bubbling is to obtain a constant plenum temperature.

22:06	Discharged for 6 minutes. WV1000-G-132A.
23:35	Film cooler was cleaned.
12/9/99	
00:02	Discharged for 10 minutes. WV1000-G-132B.
01:40	Glass drum was replaced. WV1000-G-128A, 128B, 132A, 132B. Gross weight 481.0 kg.
01:20	Discharged for 20 minutes. WV1000-G-132C.
04:54	Discharged for 5 minutes WV1000-G-132D
05:09	Feed transfer. Before transfer 230 kg.
05:18	After transfer with 4 gallons of water to wash the line = 1670 kg. Amount of feed transferred = 1470 kg.
05:35	Scrubber column was back washed with city water for about a minute.
05:43	Feed lines were flushed.
06:15	Discharged for 9 minutes. WV1000-G-134A.
06:34	Proceed to clean the film cooler. Feeding stopped. TC6 is bad (exposed plenum TC)
06:50	Feeding started at t4 = 20 sec.
07:22	Discharged for 4 minutes. WV1000-G-134B.
	Notes: Related to system clean up @ 06:34. The film cooler was relatively clean, but rodded to remove deposits. Noticed the liquid lock again in the off-gas. Concluded that the liquid must be collected in the HEME which can not be drained because of the high vac in the HEME. The off-gas was switched to the emergency and pres. diff. across HEME dropped to zero. Approx. 50-60 gallons of condensate was discharged from the HEME. Need to install a pump for HEME discharge. After HEME discharge, all the system pressure (off-gas) went back to normal.

	Reason for clogging the bags: HEME is over filled with condensate and therefore moisture gets into the baghouse.
08:10	To keep the plenum temperature below 550EC (–500E) at t4 = 60 sec. had to bring down the bubbling rate to –10-20-10-20 SCFH
08:45	New TC6 (exposed plenum) installed.
08:50	Discharge can was removed. Mass = 534.5 kg gross includes: WV1000-G-132C, 132D, 134A, 134B
09:00	A 3@ AOD pump was installed for HEME waste water discharge.
08:55	Bubbling rate is adjusted at 12-24-12-24 SCFH. TC6 =464EC, TC1 = 500E, TC7 = 496EC
10:05	Discharged for 7 minutes. WV1000-G-135A.
11:15	System very stable. CC = +95%
12:17	Discharged for 7 minutes. WV1000-G-135B.
	Transferring feed from mix tank to feed tank.
13:34	Mass in feed tank 484 kg. Recirculation is on
13:38	After transfer 1006.5 kg. Approximately 4 gallons of water used to rinse the transfer line.
	Feed transferred = 531.0 kg
14:44	Discharged for 8 minutes. WV1000-G-139A.
16:44	Discharged for 10 minutes. WV1000-G-139B.
18:18	Discharged for 7 minutes. WV1000-G-139C.
18:41	Stopped feeding.
18:53	Feed lines were flushed.
12/13/99	
12:00	Remove/replace discharge can. Mass=460.0

	WV1000-G-135A, 135B, 139A, 139B, 139C.
	Feed weight before transfer = 287.0 kg, weight after transfer = 3069.0 kg
12:40	Mass of feed in the feed tank with recirculation on = 3005 kg
12:48	Start feeding 6 Test conditions. Zero bubbling, lower electrode firing, –100% cold cap.
15:36	Discharged for 5 minutes. WV1000-G-142A.
16:05	Feed sample WV1000-F-142A.
16:11	Additional water was transferred. Mass before addition 2620.0 kg After addition 2738.0 kg Net water added = 118.0 kg
19:00	Neutralizing HEME solution original pH = 1.5. Small 1 lt experiment showed that about 20% solution with 2 (50% NaOH) + 2 water @ 10% was still acidic at 20% was basic. Will attempt to add 25% NaOH solution at different ratios. Also small experiment showed no gas evolution, no heat. Added 4 gallons 25% NaOH to melter. 25 gallon solution. Added 2 lt of neutralized AHEME@ (pH 14) to 2 lt of scrubber solution in the hood no off-gas. Used Aneutralized@ heme solution in evaporator, no fumes.
20:22	Discharged for 8 minutes. WV1000-G-147A.
21:30	Could not hold temperature @ t4 = 190 sec. R - 52 kg/h o0f feed. T1= 469EC dropped below 470EC. Decided to heat Tp to 520EC. Region set t4 = 300 sec.
12/14/99	
00:25	The cold cap emitted red radiation; it looked cracked. The area near the feed pipe was darker.
03:00	Increased the time t4 to 250 sec. TC1 is below 480EC. TC1 should increase at a rate of 25EC/hr.
04:12	Discharged for 7 minutes. WV1000-G-148A.
05:25	Feed lines were rinsed.

05:28	Cold cap is slightly opening up. T1 = 496EC. T7 = 493EC and appears to be thin relatively.
08:00	Cold cap is in 100%, but it does not appear to be too thick. Spots of molten glass intermittently show up through the cold cap (very small spots).
08:19	Discharged for 6 minutes. WV1000-G-11A.
09:08	TC1 = 465EC. TC7 = 462EC. Almost same condition, as recorded @ 08:00, −100% cold cap, but relatively thin, spots show up from time to time.
10:33	TC1 = 461EC. TC7 = 458EC. Cold cap −100%, molten spots are still visible from time to time less frequent than 08:00, but they are still there, indicating that the cold cap is not thick.
12:38	TC1 = 456EC TC7 = 453EC. The melter temperatures and other conditions appear to be very stable. Cold cap = 100%. Same observation as at 10:33.
13:45	Transition line flows 450EF, ΔP-0.5 in H_2O (std pitot tube).
13:53	Discharge. 7 minutes. WV1000-G-11B.
17:25	Inspected scrubber tower, no visible problems. Noticed, buttoned up and pressure was @ 7". Started feeding @ 215 seconds.
22:25	Discharge. 7 minutes. WV1000-G-11C
12/15/99	
02:15	@22:35 t4 was set to 250 sec. TC1 = 490, t4 dropped -9.5EC/hr to 24:03. @ TC1 = 476, t4 dropped - 3.7EC/hr to 01:41 @ TC1 = 470-468 t4 remains constant. Obtained a feed rate of 40 kg/hr (feed). The day melter had t4 - 215 sec the temperature dropped ΔT/Δt decreased at T was reduced to about 450EC. The experiment was terminated because of off-gas problems. Thus, setting t4 to 225 sec @ −02:30 to see if a higher −10% feed rate will exist @ a lower plenum temperature.
04:10	Discharged for 6 minutes. WV1000-G-18A.
04:42	As the feed rate increased the glass melter temperature T2 decreased from

	1159 to 1152EC. Power to bottom electrodes increased from 67.5 kW to 70.0 kW.
05:00	Cold cap conditions are similar to the description given @10:33. TC1 = 461EC, t4 is set at 215 sec. TC7 = 458EC.
	Remove/replace discharge can. WV1000-G-11A, 11B, 11C, 18A. Gross weight = 541.0 kg.
05:30	Flushed scrubber column from top.
07:35	Stopped feeding to clean the check valve on the feed line, which was clogged.
07:50	Started again, feed lines were flushed.
08:51	Discharged for 7 minutes. WV1000-G-16A.
09:30	Feed lines are flushed, per shot delivery had stopped to 2.1 kg/shot.
09:36	Mass before transfer 895.5 kg Net transfer is 1731.5 kg.
09:50	After transfer 2708.0 kg (includes water)
	Approximate mass of water added = 81 kg.
	Note: water addition also rinsed the feed residue from the transfer line, so actual mass of water may be less.
09:55	Total mass added = 1823 kg.
10:54	Cold cap is −100%, however, a very small opening from time to time in the cold cap indicates that the cap is not very thick.
11:10	Notes: The scrubber column appears to be blocked which restricts the flow of gas. The restriction (possibly film) can be broken by shutting off the sprayer pump for −1 minute and restarting it. The gas flow through the column without the liquid down flow seems to break the film barrier. This process was carried out at −06:00 and 11:00 today. Corrective action: spray flow was reduced.
11:20	T1 = 427EC T7 = 424EC Cold cap is 100% and no spot can be observed in the cold cap (molten glass spot) cold cap is thickening?

13:18	Feed lines were flushed.
14:24	Discharge. 7 minutes. WV1000-6-22A.
16:50	Cold cap = 100%.
17:59	Feed lines were flushed.
18:76	Discharge. 6 minutes. WV1000-G-22B.
20:06	Feed lines were flushed.
22:38	Discharge glass. 7 minutes. WV1000-G-22C.
22:42	Flushed feed tubes.
12/16/99	
00:40	Flushed feed tubes.
00:57	Upper electrodes turned on.
02:14	Feed lines were flushed.
02:54	Discharged for 5 minutes. WV1000-G-22D
05:17	Feed lines were flushed
07:20	Feed lines were flushed.
08:24	Discharged for 7 minutes. WV1000-G-22E
09:22	Feed lines were flushed.
11:38	Feed lines were flushed.
12/16/99	
08:35	Notes: Zone 2 Power 26 kW top. Zone 1 power 40 kW bottom.
	Will try to balance the power to maintain a temperature of about 1145EC @ 12" above the floor (i.e., TC2) At this time the cold cap is −100% with some small openings where molten glass can be seen indicating a relatively thin cold cap.
10:30	Try balancing the power between two pairs of electrodes to minimize the temperature variations from top to the bottom of the glass pool.

12:27	Discharge. 6 minutes. WV1000-G-28A.
13:34	Feed lines were flushed.
15:00	Note: The feeding rate is very stable and so is the plenum temperature. The power also appears to be very stable and almost constant. Cold cap is 100%.
15:30	Discharged glass for 5 minutes. WV1000-G-29A.
16:00	Getting ready to switch off the bottom electrodes and run only on top electrodes.
16:03	Took feed sample: WV1000-F-29
16:10	Bottom electrodes were switched off.
17:20	The temperature in the melter appears to be stable. Plenum temperature also appears to be stable.
17:24	Glass drum was replaced: WV1000-G-16A;-18A;-22A,B,C,D,E;-28A;-29A.
18:27	Feed lines were flushed.
19:27	Discharged glass for 7 minutes. WV1000-G-33A.
20:42	Flushed feed tubes.
22:47	Feed lines were flushed.
23:26	Discharged glass for 6 minutes. WV1000-G-33B.
12/17/99	
01:37	Feed lines were flushed.
03:22	Discharged for 7 minutes. WV1000-G-33C.
03:38	Feed lines were flushed.
06:04	Flushed feed lines.
07:44	Discharged for 13 minutes. WV1000-G-33D.
12:24	Cold cap is almost completely dissolved (melted), only minor dark speckles can be seen over the surface. Also glass is occasionally bubbling (only few spots) from under the film layer over the top.

12/20/99	
08:30	Clean off film cooler.
10:30	Remove/replace discharge drum. WV1000-G-33A, B, C, and D. Gross weight = 333.5. Transfer to feed tank. Mass before transfer: 302.0 kg; mass after transfer 3020.0 kg; net transfer 2718.0 kg. Add H_2O-target 120 kg. Final 3158.5 kg.
13:00	A second thermowell was installed in the melter at the position of a bubbler near the center of the glass pool. Three thermocouples were installed in the thermowell.
	Test: Bottom electrodes only, zero bubbling
13:45	Started to feed. t4=30 sec.
15:00	There is a large temperature gradient horizontally from center to the electrodes. The largest gradient is near the top of the glass pool (about 200-750E) and gets better near the bottom. This may indicate heat flux convection circulating upward at the electrodes and downward near the center. The control parameters for this run are: TC24 (36" above the floor) around 1160-1165EC; plenum temperature TC1 around 420∀10EC.
17:14	Discharged for 7 minutes. WV1000-G-48A.
17:40	Adjusted TC8 depth by inserting 6" into thermowell.
17:55	Flushed feed lines.
19:45	Plenum dark.
19:58	Discharged glass for 10 minutes. WV1000-G-48B.
20:17	Flushed feed lines.
21:38	Plenum temperature too low. TC1=405. Stopped feeding.
23:30	Restarted feeding t4 = 280 sec.
12/21/99	
01:10	Flushed feed lines.
03:22	The cold cap glows with red cracks: looking from the top, the edges have more cracks than the middle.

04:13	Discharged for 8 minutes. WV1000-G-52A.
06:30	Flushed feed lines.
08:00	Notes about cold cap: The cold cap coverage is –100%. Around the perimeter, next to the walls, the cap is relatively thin, showing a faint glow. TC1 = 418-420EC. The instantaneous and average feed rates are about 50 kg/hr. Around the perimeter, next to the walls, the cold cap is relatively thin, showing a faint glow. At this point the melter conditions appear to be very stable.
08:16	Discharged for 7 minutes. WV1000-G-52B.
09:13	Flushed feed lines.
11:22	Discharged for 6 minutes. WV1000-G-52C.
11:50	The difference between temperature at 36" elevation has decreased since this morning. Also, glass temperature at 24" level has been slightly higher than 36" level at the electrode side. Added a new constraint on the test, to not exceed 1165EC at 24" level. Previous constraints are: TC1 is kept between 410EC and 430EC.
12:43	Discharged for 11 minutes. WV1000-G-52D.
13:15	The power appears to be relatively fixed around 64 kW. At the present the throughput is about 40 kg/hr. As a result the power consumption at this rate is about 1.6 kW/kg of feed.
13:47	End of test.
13:49	Transfer feed. Mass before transfer 1684.0 kg. Recirculation on feeding is on.
14:04	Mass after transfer 3381 kg. Lines are washed with 4 gallons of water.
	Mass transferred = 1708 kg.
Test: Upper Electrodes #2	
14:05	Test begins. Power set at 70 kW. Same control parameters as previous test.
14:10	Notes: Temperature of the upper electrode buss (left) was 160EC before was powered.

14:15	Change/replace discharge can. WV1000-G-48A,B; 52A, B, C, D. Gross wt = 451.0 kg.
15:00	There is a strong indication that the temperature of glass near the center and top are rising by firing top electrodes only.
16:23	Discharged for 7 minutes. WV1000-G-54A.
17:42	Flushed feed lines.
21:55	Discharged for 12 minutes. WV1000-G-54B.
22:17	Flushed feed lines.
12/22/99	
01:52	Discharged for 7 minutes. WV1000-G-54C.
03:30	Flushed feed lines.
06:25	Discharged for 12 minutes. WV1000-G-54D. Plenum temperature rose after discharge.
07:20	Notes: Plenum temperature is sensitive to the glass level in the melter. After discharging glass, plenum temperature normally rises, which then allows higher feed rates. Thus, we need to discharge glass relatively frequently, i.e., every 2 hours.
07:36	Flushed feed lines.
08:27	Discharged for 5 minutes. WV1000-G-63A.
10:27	Discharged for 5 minutes. WV1000-G-63B.
10:28	Flushed feed lines.
11:20	TC24 changes with time relatively rapidly and requires almost full time attention as a part of control power to the electrodes.
12:25	Remove/replace discharge can.
12:30	Suspect there might be foaming cycles in the melt that cause such a wide variation in power and temperature. The melt resistance shows peaks that may be partly associated with manual power control events. This possible foaming event requires further investigation.

12:32	Discharged for 6 minutes. WV1000-G-63C.
12:39	Flushed feed lines.
13:00	Noticed the feed rate has dropped from its previous value. After checking out the feed system, found that the air pressure to the AOD pump had dropped. The feeding interval, t4 was shortened to compensate for the drop.
14:07	Stopped the upper electrode test.
	Notes: toward the end of run, air comp. in the building was noticed that is not working properly. As a result t4 was reduced to compensate for the lower amount of feed/shot.
	Test All Electrodes - 2
14:08	Test begun. Test parameters same as previous test.
15:00	Discharged for 5 minutes. WV1000-G-68A.
	Large amount of power is being used, i.e., 90 kW (zone 1), and 45 kW (zone 2) to raise the temperature of glass at TC-24 to 1160EC. Trying to balance the power to minimize crosstalk between the electrodes, normally based on our previous runs to 2:1 (zone1:zone 2).
15:15	In the case of all electrodes TC9-24 normally stays higher than TC4-36 by 5-10EC. Therefore we put the 1160-1165EC limit on either one of these two.
16:40	TC12-5 (center 15 24") seems to be reading the highest, but think we should use either TC9 or TC24 as the limiting thermocouple.
16:55	Discharged for 16 minutes. WV1000-G-68B.
21:12	Discharged for 6 minutes. WV1000-G-68C.
12/23/99	
04:20	Production rate increased from –40 kg/hr to 48 kg/hr. It is related to high Tp = TC1 > 420EC or high glass level in melter.
07:51	Flushed feed lines.
08:43	Cleaning around computer accidently shut computer off. Computer was off for 5 minutes before it was restored. 3 shots were added to make up for lost time.

09:26	Flushed feed lines.
09:35	Discharged for 7 minutes. WV1000-G-77A.
11:55	Flushed feed lines.
14:08	End of all electrode runs.
15:00	Feed system was cleaned. Cold cap is almost gone. Plenum temperature rises relatively fast.
15:75	Discharged for 8 minutes. WV1000-G-77B.
16:25	All cold cap is practically gone. Only a small fraction of black speckles over the melt surface.
17:02	End of run.
1/4/00	
12:00	Transfer feed to feed tank. Final tank mass 3177.0 kg
13:45	Remove can from discharge. Gross weight = 393 kg. Includes WV1000-G-68A, 68B, 68C, 77A, 77B New can installed.
16:00	Load cell readout was reset to 3178 kg. Impact is unclear.
17:00	Start run #4 with West Valley feed. Main off gas on. Scale reading 3113 kg (w/recirc on).
19:10	Discharge for 5 minutes (WV1000-G-79A).
20:06	Discharge for 3 minutes WV1000-G-79B.
20:25	System is stable at this feed rate. t_4 = 35 sec. Power –180 kW. Feed rate = 320 kg/hr = 96.7 kg glass/h.
22:08	Discharge for 5 minutes WV1000-79C.
22:15	Flushed feed lines.
22:51	Clean film cooler.
23:20	Discharge for 7 minutes. WV1000-G-79D.

1/5/00	
24:00	A lot of material accumulated in film cooler to mitigate problem increase flow of RGB to 2.2 x 1000 ft.
01:21	Discharge for 5 minutes. WV1000-G-79E.
01:30	Flushed feed tubes.
02:32	Cleaned both film cooler and transition line.
02:48	Looking down transition line could see additional deposits too far to reach.
04:07	Flushed feed lines.
05:00	Discharge drum was removed. Self-discharging prior to the removal. Mass 509.5 kg. WV1000-G-79-ABCDE
05:10	Discharge 30 minutes. WV1000-G-84A.
05:20	276 kg before transfer. Start to transfer.
05:26	2340 kg after transfer.
	Total transferred –2180 kg.
05:59	Stopped feeding to clean the deposits in the film cooler and transition pipes.
06:20	Started feeding at t_4 = 40 sec.
07:37	Discharge for 8 minutes. WV1000-6-86A.
09:47	Discharge for 6 minutes. WV1000-6-96B.
11:12	Remove/replace discharge can: WV1000-6-84A, 96 A & B, Mass = 448.0 kg.
11:41	Flushed feed lines.
11:50	Discharge for 4 minutes. WV1000-G-86C.
12:24	Discharge for 9 minutes. WV1000-G-86D
12:49	Feed sample taken WV1000-F-86A.
13:41	Discharge for 16 minutes WV1000-6-86E.
14:37	Discharge for 9 minutes WV1000-G-86F.

15:00	Connect thermocouples that were not connected.
15:57	Discharge for 7 minutes.
16:05	Stopped feeding due to the low level in the feed tank.
16:40	TC1 = 515EC TC7 = 511EC TC6 = 481EC
17:00	Removed/replaced discharge drum. WV1000-G-86C,D,E,F. 489.0 kg
17:50	Flushed feed lines.
18:05	Performing shut down of off-gas system.

Run Chronology for DM1000 C-106?AY-102 Tests

1/17/00	
11:00	Transfer feed from mix to feed tanks. Initial feed tank mass 100.5 kg. Transfer to 250.0 kg stopped. Rinsed line with H2O. New mass 294.5 kg, start again to 2560 kg. Wash line with 5 gallon H2O, final 2602.5 kg.
1/18/00	C106 Turnover
13:44	Remove thermocouple TC6 exposed and replaced with calibrated VSL ID 11300 B8; VSL log 750-99 p 36
23:20	Summary of foaming. Around 1400 hours after feeding about 10 kg of feed (2410.5 kg, final scale reading), the test was aborted due to excessive foaming. The melt level raised to close the viewport level. Plenum temperature was about 500EC at that time. By keeping the melt temperature to about 1170EC, the level of the foaming melt was gradually lowered. At 22:45 hours, the melt level was low, a fine thin foam layer was observed on top of the melt. The system was shut down at this time because it was considered that the melter has achieve normal operating conditions.
1/19/00	
10:00	Adjust bubbling rate 10-5-10-5 to 30-15-30-15
10:15	Flushed feed lines

11:15	Flushed feed lines.
11:43	Feed transferred 2072 kg.
11:48	Transfer is over: 3011.0 kg net transfer = 957 kg
1/19/00	C106 Turnover
08:47	Started feeding
10:38	Foaming is observed.
10:41	Discharge for 5 minutes C106-G-102A
12:12	Discharge for 7 minutes C106-G-102B.
12:16	Bubbling rate increased to 20,40,20, 40 SCFH Previous settings were at 15,30,15,30 Reason: plenum temperature is dropping and we want to maintain the feed rate if we can.
12:30	BR is further increased to 25,50,25,50 scfh
12:44	Discharge for 10 minutes. C106-G-102C
13:13	Flushed feed lines.
13:33	Started self-discharge. C106-G-102D. Discharge for 7 minutes.
14:24	Remove replace discharge can. C106-G-102 ABCD. Glass density = 2.3 kg; mass = 446 kg.
1/19/00	
14:29	Extensive foaming self-discharging (approximately 45 mins)
16:40	Bubbling rate increase to 20-10-20-10.
16:45	Heaters are on
16:50	Bubbling rate increased to 40-20-40-20
17:03	Bubbling rate increased
18:13	Bubbling rate increased to 80-40-80-40
18:28	Discharge for 10 minutes. C106-G-103A
18:42	Bubbling rate reduced to 60-30-60-30.
18:43	Resumed feeding.

20:42	Attempted to flush feed tubes. After repeated switching and Atapping@ the left side feed tube flushed. Repeated attempts on right side were unsuccessful.
21:00	Discharge glass for 7 minutes. C106-G-103B.
21:46	Discharge for 10 minutes. C106-G-104A.
22:19	Bubbling rate reduced to 50-25-50-25. Maximum power cannot maintain temperature. Also, feed rate reduced because thick cold cap is forming.
22:25	Feed line 1 was flushed. Failed to flush feed line 2.
23:24	Discharge for 10 minutes. C106-G-104B.
23:30	Stopped feeding.
23:50	From the last 4.5 hours, it seems that bubbling rate must be at most 60-30-60-30 because of power limitation. At this bubbling, t_4 = 75 sec. seems to be a little too fast. t_4 = 100 sec may be too slow. Perhaps an adequate value would be t_4 = 85 sec.
1/20/00	
00:05	Isolated big chunks of cold cap floating over the melt.
00:36	Discharge can was replaced. C106-G-103A,B, 106A,B. Gross weight = 457.0 kg.
01:20	Cold cap gone.
08:40	Remove feed line and flushed. Remove check value and clean also. Cleaned feed tube.
09:30	Feed transferred. Mass transfer = 1284 kg.
10:04	Start feeding T_4 = 90 sec.
12:35	Notes: Bubbler is set at 25,50,25,50 scfh. Previous setting 20,40,20,40. By keeping the cold cap open (60-80%) it appears that the foaming may be controlled. It is not extensive. The plenum temperature is around 670EC. Glass production rate is about 900 kg/m^2 d.
12:48	Discharge for 10 minutes. C106-G-105A.
13:00	BR had to be increased to keep Tp □ 670EC to 30,60,30,60 scfh
13:15	Flushed the feed lines.
14:34	Discharge for 9 minutes. C106-G-105B.

15:15	Flushed feed lines.
16:16	Feed lines were flushed.
16:17	Discharged for 10 minutes C106-G-110A
16:33	Discharged for 5 minutes C106-G-110B.
17:05	Feed lines were flushed.
17:50	The melter is using all the power available –200 kW ∀ 5 kW with a bubbling rate 60,30,60,30 scfh. The plenum temperature TC1 is high –660EC. Indicating that bubbling <30.
18:03	Feed lines were flushed.
18:25	Attempted to discharge. No glass came into drum. Tried to clear entrance by closing and opening gate; gate closed and would not open. Stopped feeding. Discharging lowered bubbling to 10,20,10,20. Lowered power to 80 kW/40 kW.
18:40	Power 40 kW; 20 kW.
1/21/00	
08:30	Glass level in the melter is down to the top electrodes. East side top electrode profile can be seen which is bowed out by –10".
	Discharge gate valve is removed.
09:30	Remove/replace discharge can. C106-G-105-A,B;110-A,B. Mass = 493.5 kg.
10:00	Up to this point, mass of glass discharged since the start of C-106 campaign: 1396.5 kg. However mass of glass produced via feeding is approximately 907 kg. There was a small quantity of glass at the very beginning which is not accounted for. Mass of glass from the melt inventory is 490 kg.
10:30	2199 kg feed, start feeding.
11:02	Notes: Bubblers are set at 18,32,18,32. (Previous setting 10,20,10,20).
12:11	Flushed feed lines.
12:19	Adjust bubbler rate 60,30,60,30.
12:28	Adjust bubbler rate 55,25,55,25
13:30	Single lance bubbler has been set at 4 scfh since the start of the run. The bubbler keeps the corner of the glass pool (southeast) clean from build up which is very important in reducing the bridging of the cold cap.

13:35	Discharge for 10 minutes. C106-G-115A.
13:40	Notes: In order to prevent extensive foaming and consequent self-discharge, the cold cap cannot be increased to above 50-60%. As a result the plenum temperature would not drop to low values of typical 450-500EC range. It appears that a plenum temperature in the range of 650-700EC is suitable under the partial cold cap coverage. The extent of the cold cap is controlled by feed rate and bubbling rate. For a target feed rate, BR is used to control Tp. Feeding above 120-130 kg/hr appears to cause extensive foaming and auto discharge.
14:14	Flushed feed tubes.
14:26	Increased bubbling to 60,30,60,30
15:01	Increased bubbling to 65,30,65,30
15:22	Discharge (10 minutes with 3 scfh) C106-G-116A.
16:13	Discharge (11 minutes with 6 scfh) C106-G-116B.
16:25	Flushed feed tubes.
17:20	Feed system flushed. Feed tube #1 flushed. Check valve was clogged. Equipment was disassembled and cleaned. Works now.
17:40	Film cooler cleaned, horizontally and vertically.
19:25	Cold cap is gone.
20:10	Replaced HEPA on baghouse #2. Apparent cause of failure is moisture. Filter was Adripping@ H2O.
1/24/00	
09:20	Total mass transferred 985 kg
09:45	Start feeding t4 90 sec.
09:59	Discharge for 15 minutes. C106-G-117A.
10:13	Flushed feed lines.
10:36	Increased bubbling rate to 50,25,50,25
10:54	Increased bubbling rate to 60,30,60,30
11:20	Flushed feed lines.
13:00	Added 50 lb sugar to feed tank that contained –2100 kg feed. Sugar CUA#105464

13:15	Flushed feed lines.
14:00	Discharge for 5 minutes. C106-G-117B
15:05	Discharge for 5 minutes. C106-G-117C.
15:15	Changed bubbling rate 65-32-65-32
15:15	Flushed the feed lines.
16:03	Discharged for 5 minutes C106-G-121A.
16:10	Flushed feed lines. Note: feed tube #1 check valve is clogged and will not flushed.
17:04	Discharged for 5 minutes. C106-G-121B.
17:10	Flushed feed tubes. F.T. #1 is now unclogged.
17:27	Bubbling increased 100,50,100 50.
18:00	Discharge for 10 minutes C106-G-121C.
18:12	Flushed feed tubes.
19:10	Stopped feeding because discharge gate would not open after drums were changed. C106-G-117A,B,C, 121A,B,C. Mass = 457.0 kg.
19:38	Discharge (12 minutes). C106-G-123A.
19:55	Feed tubes were flushed.
20:20	Changed to B1-G-1, B2-G-2. Reduced dilution air at heater. Bubbling 50,100,50,100 scfh. Note: max power and max bubbling.
20:45	The cold cap has mostly been burned. The level of melter is much lower (foam must have gone).
21:07	Flushed feed lines.
21:35	Feeding slowed. Feed tank had 1016 kg ; most of feed was on sides and very little in middle. Stop feeding. Transferred to 1648 kg. Again mix tank was not mixed.
22:00	Added 6.77 kg sugar to feed tank CUA #105463
1/25/00	
00:00	The feed tank has been mixed and is being recirculated. Prepare to feed rinse feed tubes. Increase power 125/80
00:25	TC5 has low reading in computer and high reading in controls.

00:50	The melt temperature was low. Reduced bubbling rate to 80,40,80,40. Power staged at 125/80 kW. Melter level low cold cap thin: no foam.
01:40	Bubbler hot cap is in decrease holes rather than line. Level low: no foam.
02:35	Discharge for 5 minutes. C106-G-124A.
03:50	Plenum temperature TC1 < 480EC. Increase bubbling to 80,40,80,40. Feed in the mix tank is too thick to pump. Add 42 gallons of water to mobilize feed.
04:20	Discharge for 10 minutes. C106-G-125A.
04:30	Feed pump shots are – 20 kg/shot; feed lines are washed. Feed Tank depressed in middle. Need to transfer more feed to feed tank.
05:10	Stop feeding to use feed pump to clear mix tank drain. Weight 41.0 kg
06:25	Discharged for 10 minutes. C106-G-125B.
07:10	Remove/replace discharge drum. C106-G-123A,124A,125A,B. Mass = 509.0 kg.
07:30	Flushed feed lines.
07:42	Shift changeover problems due to snow storm; suggested that feeding be stopped and to burn the cold cap and go to emergency.
07:45	Flushed feed lines and feed tubes.
10:14	Cold cap is starting to break up.
11:30	Transfer feed. Feed transferred 967.0 kg. No recirculation and lines flushed.
13:10	Shut down off gas system.
1/27/00	
11:00	Cleaned feed line, tubes, water line, replaced air lines. Cleaned valves.
11:58	Start feeding. Feed mas during recirculation: 2992.0 kg
12:30	50 lb bag sugar added to feed tank. CUA #105461.
12:40	Flushed feed tubes.
14:10	Flushed feed tubes.
14:55	Flushed feed tubes.
15:20	Discharge for 10 minutes. C-106-G-131A.
15:45	Discharge for 6 minutes. C-106-G-131B.

16:00	Baghouses switched. Dp across baghouse #2. Bags had reached −9".
16:35	Feed lines were flushed.
16:55	Baghouses switched back.
17:79	Discharge for 6 minutes. C-106-G-131C.
17:52	Flushed feed lines.
18:38	Flushed feed lines.
19:05	Flushed feed lines.
19:23	Discharge for 6 minutes. C106-G-131D.
19:30	Feed starts flowing into air purge lines (blue tubes).
19:58	To avoid high pressure on purge lines, pump pressure increased slightly.
20:20	Flushing feed tubes.
21:03	Flushing feed tubes.
21:26	Discharge for 6 minutes. C106-G-132A.
21:48	Flushed feed tubes.
21:49	Feed to melter is very Awatery@ looking. Cold cap is softening. Inspection of feed tank with level of 1700 kg shows 8" of solids exposed at tank wall with water agitating in the middle.
21:52	Reduced bubbling to 50/30/50/30 due to power. Unable to maintain temperature.
22:39	Bubbling rate reduced to 40/20/40/20 due to low melt temperature. −1130EC with maximum power.
23:00	Baghouses switched.
23:17	Flushed feed lines.
23:30	Recirculation line clogged. Stopped feeding.
23:55	Baghouses switched back.
1/28/00	
00:22	Discharge for 6 minutes. C106-G-134A.
00:39	Flushed feed lines.
01:14	Bubbling rate increased to 80/40/80/40.

02:21	Flushed feed lines.
01:49	Flushed feed lines.
02:32	Flushed feed lines.
03:07	Discharged for 7 minutes. C106-G-134B.
03:34	Flushed feed lines.
04:16	Stopped feeding due to melter level too high and no key to the trailer to get a new discharge drum. Working on cutting the lock.
04:32	Commenced feeding.
04:33	Remove/replace discharge drum. C106-G-131-A,B,C,D; 132-A; 134-A&B. Mass = 542.5
04:53	Discharge for 10 minutes. C106-G-134-C.
05:08	Flushed feed lines.
06:05	Stopped feeding. No longer able to feed the melter due to feed tank build-up. Feed tank @ 648 kg
06:15	Flushed feed lines. Feed tank @ 665 kg.
07:49	Discharge can is just below the 1st ring.
15:00	Notes: After mobilizing the feed residue in the feed tank and clearing the feed lines from numerous clogs. The main building compressor was noticed to be off (low line pressure). The back-up compressor cannot produce air volume and pressure needed to operate the feed system. As a result the system is shut down.
1/31/00	
12:05	Start running. Weight after recirculation start was 735.5 kg.
14:10	Flushed the feed lines.
14:10	Bubbling rate = 25/50/25/50
14:20	Notes: Feed spreading characteristics (flow over cold cap) has improved a great deal over low water equivalent C-106.
16:22	Stopped feeding.
18:20	Discharged for 10 minutes. C1060-G-139A.
2/2/00	

11:69	Glass sample taken. C106-G-139A.
12:45	Remove/replace discharge can. C106-G-139A. Mass = 300.5 kg. Feed mass before transfer 59.5 kg Feed mass after transfer 1586.0 kg Feed mass transferred 1526.5 kg Feed mass after recirculation 1547.0 kg
13:12	Start feeding. Bubbling rate 50/25/50/25
14:00	Flushed feed lines.
14:45	Bubbling rate 30/60/30/60
15:10	Discharge for 20 minutes. C106-G-140A.
16:07	Feed lines were flushed.
17:11	Discharge for 20 minutes. C106-G-140B.
17:15	Feed lines were flushed.
19:32	Discharged for 20 minutes. C106-G-140C.
20:10	Feed lines were flushed.
20:30-21:00	Had to increase bubbling from 60/30/60/30 to 100/50/100/50 in 5 scfh steps to keep melter Tc5 from going up to 1175. This caused high melter pressure had to increase melter negative pressure to 2" H2O in order to prevent emergency off-gas from coming on.
21:00	Reducing bubbling to 80/40/80/40.
21:06	Reduce bubbling 40/20/40/20.
21:40	Increased bubbling 60/30/60/30.
21:29	Stopped feeding. Increased bubbling 100/50/100/50.
22:27	Take feed sample after transfer. C106-G-144A.
22:05	Replaced discharge can. C106-G-140 A,B,C, and 144A. Mass = 510.5 kg.
23:10	Discharged for 11 minutes. C106-G-144B.
23:20	Flushed feed tube #1, Tube #2. Check valve is clogged.
23:32	Discharged for 9 minutes. C106-G-144C.
2/2/00	

00:35	Flushed feed tube #1, #2 still clogged.
00:38	Discharged for 20 minutes. C106-G-146A.
01:54	Flushed bath feed tubes.
02:18	Discharged for 7 minutes. C106-G-146B.
03:26	Flushed feed tubes.
04:00	Discharged for 8 minutes. C106-G-146C.
04:35	Flushed feed tubes.
04:42	Replaced discharge drum. C106-G-144B,C; 146A,B,C. Mass = 507.5 kg.
05:38	Discharged for 22 minutes. C106-G-146D.
05:52	flushed feed tubes.
06:38	Bubbling rate from 60/30/60/30 to 70/30/70/30.
07:00	Bubbling rate from 70/30/70/30 to 60/30/60/30.
07:10	Flushed feed tubes.
07:42	Discharged for 5 minutes. C106-G-146E.
07:49	Bubbling set to 65/35/65/35.
08:14	Flushed feed tubes.
09:39	Flushed feed tubes.
10:26	Discharged for 7 minutes. C106-G-148A.
10:30	Notes: Have the dilution air to the film cooler off during this run. The film cooler appears to be OK (not many deposits, accumulation on the wall). Certainly not worse than what it was with heated dilution air in the previous runs. However, for gas sampling, more air flow is required through the system. Therefore during sampling, the film cooler dilution air is turned back on.
11:30	Flushed feed tubes.
12:04	Discharged for 6 minutes. C106-G-148B.
12:56	Flushed feed tubes.
13:16	Discharged for 11 minutes. C106-G-148C.
13:24	Started feeding at t4 = 40 sec.

15:10	A feed sample was taken. C-106-F-9A.
15:17	Feeding stopped. Final mass 134.0 kg. Cold cap burn out.
17:00	Cold cap is gone.
2/7/00 - C-106 No Bubbling	
14:30	Remove/replace discharge. C106-6-15A. Mass 396.0 kg
14:50	Feed sample taken. C106-F-15A. Starting wt 1398.5 kg.
16:22	Start feeding @ 16.22. t4 = 60 sec.
18:15	Flushed feed tubes.
18:50	Discharge (5 min w 2 scfh) C106-G-15A. 100 kg of glass was discharged, indicating that air flowmeter may not be accurate.
19:47	Sample scrubber blowdown. C106-SL-15A.
20:58	Flushed feed tubes.
21:06	Stopped feeding due to TC 7 temp dropping below 420EC.
21:10	Discharge (5 min @ 2 scfh) = 50 kg of glass. C106-G-15B.
21:12	Lowered temperature for TC1 = 419EC.
21:36	Recovered TC1 = 430EC. Start feed @ t4 = 400 sec. Collected HEME liquid sample. C1-6-HL-15A.
23:15	Flushed feed lines.
2/8/00	
01:10	Flushed feed lines.
02:05	Flushed feed lines.
03:50	Collected HEME liquid sample C106-HL-15B.
03:40	Flushed feed lines.
04:50	Flushed feed lines.
05:50	Flushed feed lines.
06:40	Discharged for 5 minutes.
06:55	Flushed feed lines.

07:28	Took scrubber sample. C106-SL-24A.
07:52	Flushed feed lines.
08:45	Notes: Cold cap is relatively thin, yet is about 100% coverage.
08:52	Discharge (11 minutes) C106-G-24A.
09:10	Looking at the temperature profiles, there appears to be almost no convection heat in the melt.
09:20	Feed lines were flushed.
09:26	Took heme sample. C106-HL-25A.
10:59	Flushed feed lines.
11:56	Flushed feed lines.
13:12	Flushed feed lines.
14:43	Flushed feed lines.
14:48	Feed transfer. Mass before = 721.0 kg.
14:50	Transfer feed 723 kg transferred bring total feed mass to 1444.0 kg.
15:21	Switched off upper electrodes.
15:28	Discharged 12 min @ 2 scfh. C106-G-28A.
17:00	Feed line #1, cleaned and reassembled. Both feed lines flushed.
18:05	Flushed feed lines.
19:06	Feed line #1 (close to viewport) is partially clogged (seems prior to the pinch valve). Shots size –0.5 kg.
19:30	Flushed feed lines.
19:58	Change T1, T2, T3 due to falling plenum temperature and drastic drop in temperature after large shot.
20:35	Discharging glass in attempt to raise plenum temperature. 8 minutes. C106-G-28B. (. 50 kg discharged).
21:15	Heme liquid sample. C106-HL-28A.
21:25	Flushed feed lines.
22:28	Flushed feed tubes.
22:41	Stopped feeding due to clogged feed lines.

23:10	Feed lines cleaned, recommenced feeding.
23:15	Observations made during feed line cleaning. 1. Pinch valve was not clogged or deformed. 2. Downstream of pinch valve thru braided hose was 99% clogged with Asolid@ mud that would not wash out. It had to be scraped. There was a pinhole opening that allowed flushed water to flow.
2/9/00	
00:42	Flushed feed lines.
01:44	Flushed feed lines.
02:46	Flushed feed lines.
03:50	Flushed feed lines.
04:50	Flushed feed lines.
05:06	Took HEME sample. C106-HL-30A.
05:50	Flushed feed lines.
06:50	Flushed feed lines.
07:59	Flushed feed lines.
08:30	Bottom electrode firing was changed to all electrode firing.
08:45	After switch, power demand went up to maintain temperatures, i.e., from a total of 43 kW to 95 kW.
09:30	Flushed feed lines.
09:38	Discharge for 34 minutes (C106-G-33A) @ 2 scfh.
10:44	Flushed feed lines.
11:50	Flushed feed lines.
12:08	Scrubber sample taken. C106-SL-33A.
13:13	Flushed feed lines.
14:23	Remove/replace discharge can. C106-G-25 A& B, 24A, 28 A&B, 33A. Mass - 513 kg.
14:38	HEME sample taken. C106-HL-33A.
14:40	Flushed feed lines.

15:43	Discharge @ 2 scfh for 2 hr, 16 min. C106-G-33B.
16:21	Feed lines flushed feed connectors (next to pinch valves) cleaned.
17:30	Flushed feed lines.
18:30	Flushed feed lines.
19:18	Flushed feed lines.
20:18	Flushed feed lines.
21:03	Cleaned out feed line #2 and flushed both feed lines.
22:04	Flushed feed lines.
22:10	Scrubber sample taken. C106-SL-35A.
23:05	Flushed feed lines.
02/10/00	
00:08	Flushed feed lines.
00:16	Discharge (7 minutes) C106-G-37A.
00:30	Collected HEME sample. C106-HL-37A.
01:02	Flushed feed lines.
02:04	Flushed feed lines.
02:51	Flushed feed lines.
03:41	Flushed feed lines.
04:21	Flushed feed lines.
05:10	Flushed feed lines.
06:00	Discharged for 5 minutes @ 2 scfh. C106-G-37B.
06:08	Flushed feed lines.
07:15	Flushed feed lines.
07:56	Discharge (6 minutes). C106-G-37C.
08:22	Flushed feed lines.
09:45	Flushed feed lines.
10:42	Flushed feed lines.

10:43	Removed/replaced discharge can. C106-G-33B, 37A, B, C,. Mass = 288.5 kg.
11:54	Flushed feed lines.
13:10	Flushed feed lines. Clean line 2 to pinch valve.
15:25	Cleaned and flushed line #1.
16:35	Flushed feed lines.
17:10	Clean flushing water duct of feed line #2. Feed lines were flushed.
2/10/00	
17:25	HEME sample taken. C106-HL-40A.
18:10	Flushed feed lines.
18:34	Feed sample taken. C106-F-40A. From shot #135.
18:50	After shot #137 and before #138. 246.5 kg of feed (2 gal of flushing water included were transferred to feed tank.)
18:58	Flushed feed lines.
19:29	Discharge (6 minutes) C106-G-40A.
19:45	Flushed feed lines.
19:28	Flushed feed lines.
21:16	Flushed feed lines.
22:03	Flushed feed lines.
22:38	Cleaned piping and hose on feed line #1.
23:12	Flushed feed lines.
02/11/00	
00:10	Flushed feed lines.
00:55	Flushed feed lines.
01:41	Flushed feed lines.
01:51	Collected scrubber sample. C106-SL-45A.
02:21	Piping on lines #1 and #2 were cleaned. Feed lines were flushed.
03:10	Flushed feed lines.

04:15	Flushed feed lines.
05:00	Discharged for 5 minutes. C106-G-45A.
05:15	Flushed feed lines.
06:23	Flushed feed lines.
07:20	Flushed feed lines.
07:57	Took HEME sample C106-HL-45A.
08:22	Flushed feed lines.
09:15	Flushed feed lines.
09:50	Cleaned lines in 1 and 2 up to check valve and then flushed lines.
10:55	Flushed feed lines.
11:42	Discharge for 5 minutes. C106-G-45B. C106-G-40A, 45A, B. Gross wt. 100.5 kg.
12:15	Flushed feed lines.
14:10	wt/shot –1.3 kg increase t2 from 2.05 6 3.0 sec.
16:30	Stopped feeding.
17:25	Feed valves cleaned and feed lines flushed.
21:22	Samples heme liquid. C106-HL-45B.
2/14/00	
07:56	Total transferred 3,091.5 kg.
11:00	The bubblers are installed.
13:44	Discharge can was dropped, weighed 100.5 kg and then reinstalled.
13:49	Evaporator floats are sticking.
	Start of Bubbler Test. #2 100 hr-test.
14:01	2324 kg starting mass.
14:03	Started the run.
15:26	Flushed feed lines.
16:00	Scrubber sample was taken. C106-SL-54A.

16:35	Flushed feed lines.
16:43	Stopped feeding to clean feed lines.
17:00	Feed lines were cleaned.
17:03	Re-started feeding.
17:19	Bubbling rate increased to 40-20-40-20
17:20	Discharge (15 minutes). C106-G-54A.
18:08	Flushed feed lines.
18:30	Bubbling rate increased to 50-25-50-25
18:40	Scrubber sample taken. C106-SL-54A.
18:41	Bubbling rate decreased to 40-20-40-20.
18:42	Stopped feeding due to remainder of feed not being shipped.
18:50	195 kg of feed transferred.
19:25	Collected heme sample. (C106-HL-54A.)
2/15/00	Start of 100 hr run, 2nd part.
14:30	Scale reading with recirculation on 1987 kg.
14:35	Started to feed. BR 10-5-10-5 scfh
16:35	Stopped feed to clean the purge line.
16:45	Started the feed. Check valve was cleaned up.
16:40	Collected scrubber sample C106-SL-58A.
17:05	Increased bubbling 40-20-40-20
17:20	Decreased bubbler 30-15-30-15
17:33	Discharged for 12 minutes. C106-G-58A.
17:37	Flushed feed lines.
18:15	Collected scrubber sample. C106-SL-58B.
19:32	Flushed feed lines.
19:53	Discharged for 10 minutes. C106-G-58B.
20:00	Collected HEME sample. C106-HL-58A.

20:30	Collected scrubber sample. C106-SL-58C.
20:35	Changed out discharged drum C106-G-59A, 58A,B. Mass 518 kg.
21:00	Flushed feed lines.
22:00	Flushed feed lines.
22:33	Discharge 12 minutes. C106-G-58C.
23:00	Collected scrubber sample. C106-SL-58D.
2/16/00	
00:01	Cleaned and flushed feed lines.
00:32	Increased bubbling to 40-20-40-20.
01:02	Increased bubbling to 50-25-50-25.
01:05	Flushed feed lines.
01:06	Discharge (8 minutes) C106-G-60A.
01:20	Obtained scrubber sample C106-SL-60A.
01:32	Reduced bubbling 30-15-30-15.
01:35	Obtained heme sample. C106-HL-60A.
01:40	Increased bubbling to 40-20-40-20.
02:06	Flushed feed lines.
02:53	Flushed feed lines.
03:20	Reduced bubbling. 30-15-30-15
03:27	Increased bubbling 36-18-36-18.
03:30	Obtained scrubber sample. C106-SL-60B.
03:43	Discharged for 10 minutes. C106-G-60B.
04:07	Flushed feed lines.
05:05	Flushed feed lines.
05:32	Reduced bubbling. 30-15-30-15
05:45	Sample scrubber. C106-SL-60C.
2/16/00 C106 Bubbling.	

06:00	Flushed feed lines.
06:30	Discharged for 7 minutes. C106-G-64A.
06:46	Flushed feed lines.
07:12	Collected heme sample. C106-HL-64A.
07:25	Replaced discharge drum. C106-G-58C, 60A,B, 64A. Mass - 513.5 kg.
07:42	Flushed feed lines.
07:55	Increased bubbling to 36/18/36/18
08:35	Bubbling rate - 40-20-40-20 scfh.
09:20	Flushed feed lines.
09:52	Took scrubber sample. C106-SL-64A.
10:50	Discharge glass for 10 minutes. C106-G-64B.
10:58	Flushed feed lines.
11:45	Transfer feed.
11:48	Finished transfer 1484 kg.
11:53	After cleaning the line with water = 1502 kg. Approx. 2 2 gallons of water used.
12:05	Flushed feed lines.
12:10	Took scrubber sample C106-SL-66A.
12:55	Flushed feed lines.
13:59	Flushed feed lines.
14:04	Obtained scrubber sample. C106-SL-66B.
15:00	Discharged for 15 minutes. C106-G-66A.
15:05	Flushed feed lines.
15:15	Increased bubbling to 50-25-50-25
15:43	Decreased bubbling to 50-20-40-20.
16:03	Scrubber sample was taken. C106-SL-68A.
16:10	HEME sample was taken C106-HL-68A.

16:20	Flushed feed lines.
17:20	Flushed feed lines.
17:44	Bubbling rate reduced to 36-18-36-18.
18:06	Discharged for 8 minutes. C106-G-68A.
18:40	Scrubber sample was taken. C106-SL-68B.
19:10	Flushed feed lines.
19:30	Bubbling rate: 38-19-38-19
19:56	Flushed feed lines.
20:07	Stopped to transfer.
20:20	2592 kg of feed were transferred from mixing to feed tank, includes 2.5 gal of flushing water.
20:25	Flushed feed lines.
21:27	Bubbling rate: 40-20-40-20
21:20	Scrubber sample was taken. C106-SL-68C.
21:30	flushed feed lines.
21:35	discharged for 10 minutes C106-G-68B.
22:30	flushed feed lines.
22:55	No more NaOH solution will be added in order to observe how the pH decreases with time. Last time NaOH solution was added was at 2210 hrs. (pH = 8.1).
22:56	Drum was replaced. Gross wt = 519 kg. C106-G-64B, 66A, 68A,B
23:25	Flushed feed lines.
23:29	Scrubber sample was taken C106-SL-70A.
23:35	Collected HEME sample. C106-HL-70A.
24:00	Discharge (5 minutes). C106-G-70A.
2/17/00	
00:12	Flushed feed lines.
01:03	Flushed feed lines.

01:07	Obtained feed sample C106-F-70A.
01:41	Scrubber sample was taken. C106-SL-70B.
01:50	Bubbling rate: 38-14-38-19.
02:00	Feed line flushed.
02:44	Discharged for 6 minutes. C106-G-70B.
02:55	Cleaned and flushed feed tubes.
03:05	Bubbling rate 36-11-36-18
03:30	Flushed feed lines.
04:04	Raised bubbling 40-20-40-20
04:10	Collected scrubber sample. C106-SL-72A.
04:22	Flushed feed lines.
05:20	Flushed feed lines.
05:30	Discharged for 5 minutes. (C106-G-72A)
06:08	Flushed feed lines.
06:20	Collected scrubber sample. C106-SL-72B.
06:30	Collected heme sample. C106-HL-72A.
07:02	Cleaned and flushed feed lines.
08:05	Flushed feed lines.
09:05	flushed feed lines.
09:06	Obtained sample. C106-SL-72C.
09:51	Discharge (6 minutes) C106-6-72B.
10:30	Note: Single bubbler #2 was getting clogged overnight. This morning the flow had dropped to less than 10 scfh @ 30 psi or so. The inlet pressure was raised to – 50 psi form –20 psi. Bubbler opened up after about 2 hours being set at –50 psi.
10:44	Obtained scrubber sample. C106-SL-74A.
11:29	Flushed feed lines.
12:30	Flushed feed lines.

12:39	Obtained scrubber sample. C106-SL-74B.
13:03	Discharge (9 minutes). C106-G-74A.
13:30	Flushed feed lines.
14:26	Removed/replaced discharge can. C106-G-70A, B; 72A, B. Gross wt. 529 kg.
14:33	Obtained scrubber sample. C106-SL-74C.
14:36	Discharge (13 minutes). C106-G-74A.
15:36	Flushed feed line.
15:45	Bubbling rate 58-2-58-2 scfh
16:00	Scrubber sample was taken. C106-SL-75A Heme sample was taken C106-HL-75A.
16:18	Bubbling rate 65,2,65,2
16:20	Flushed feed lines.
16:30	Bubbling rate back to normal.
17:09	Discharged for 13 minutes. C106-G-75B.
17:25	Flushed feed lines.
18:05	Flushed feed lines.
18:17	Bubbling rate set at: 34-3-34-17
18:50	Flushed feed lines.
19:00	Scrubber sample was taken. C106-SL-77A.
20:00	flushed feed line.
20:39	Discharged for 7 minutes. C106-G-77A.
20:43	Flushed feed lines.
21:25	Flushed feed lines.
21:29	Scrubber sample taken. C106-SL-77B.
22:01	Stopped to transfer. Wt 275.0 kg.
22:11	Transferred 2300 kg of feed.
22:27	Flushed feed lines

22:50	Bubbling set 45-0-45-25
23:18	Flushed feed lines.
23:45	Sampled scrubber. C106-SL-77C.
23:49	Discharged for 5 minutes. C106-G-77B.
2/18/00	
00:15	Cleaned and flushed feed lines.
00:50	Discharge drum replaced. Gross wt = 505 kg. C106-G-75A,B, C106-G-77A,B.
01:00	Feed sample was taken. C106-F-83A.
01:09	Flushed feed lines.
01:18	Bubbling rate: 50-0-50-30.
01:42	Bubbling rate = 40-0-40-20
01:50	Scrubber sample was taken. C106-SL-83A.
01:58	Flushed feed lines.
02:10	HEME sample collected. C106-HL-83A.
02:15	Discharge for 5 minutes. C106-G-83A.
02:25	Increased bubbling 45-0-45-25
02:44	Flushed feed lines.
03:22	Increased bubbling rate to 50-0-50-25.
03:29	Flushed feed lines.
03:40	Note: observed during scrubber blowdowns that pH of H2O using pH strip is not corresponding to digital readout. Readout is . 6.8 and test shows . 8pH.
03:43	Bubbling rate 55-0-55-25.
03:48	Raised bubbling 60-0-60-30
04:10	Collected scrubber sample. C106-SL-83B.
04:15	Flushed feed lines.
05:00	Flushed feed lines.
05:02	Discharge (5 minutes) C106-G-83B.

06:30	Flushed feed lines.
06:35	Scrubber sample was taken. C106-SL-84A.
07:20	Discharge for 15 minutes. C106-G-84A.
07:40	flushed feed lines.
09:10	Flushed feed lines.
10:05	Scrubber sample was taken. C106-SL-84B.
10:20	Flushed feed lines.
10:20	Discharged for 10 minutes. C106-G-84B.
11:40	HEME sample was taken. C106-HL-84A.
12:15	Flushed feed lines.
12:25	Started to discharge for 10 minutes. C106-G-85A.
12:40	Notes: There is no apparent difference in the melting rate and cold cap formation of C-106 med-silica (-220 mesh) and previous C-106 fine-silica (-325 mesh). Observation is that the med silica feed batch is less clumpy than the fine silica batch and easier to homogenize and pump. However, this observation can be subjective to age and temperature.
13:28	Flushed feed lines.
13:25	Obtained scrubber sample. C106-SL-85A.
14:30	Flushed the feed lines.
15:00	Removed/replaced discharge drum. C106-G-83 A,B, 84A,B, 85A. Gross weight 483.5 kg.
15:28	Flushed feed lines
15:42	Discharged (10 minutes) C106-G-86A.
15:50	Obtained scrubber sample C106-SL-86A.
16:48	Flushed feed lines.
17:47	Transferred 2350.5 kg of feed from mix tank to feed tank.
18:15	Discharge (10 minutes) C106-G-86B
18:45	Obtained HEME sample. C106-HL-86A.
18:50	Obtained scrubber sample. C106-SL-86B.

19:12	Increased bubbling 50/0/50/20
19:20	Lowered bubbling 40/0/40/20
20:35	Discharge for 10 minutes. C106-G-86C
21:44	Lowered bubbling. 30/0/30/15
21:50	Obtained scrubber sample. C106-SL-86C.
22:05	Raised bubbling. 46/0/46/23
22:10	Flushed feed lines.
22:36	Discharge for 8 minutes. C106-G-86D.
23:00	Flushed feed lines. Replaced air hose.
23:26	Reduced bubbling. 32/0/32/16
23:50	Collected sample. C106-SL-90A.
2/19/00	
00:02	Flushed feed lines.
00:15	Replaced discharge drum. C106-G-86A,B,C,D. Mass = 505.0 kg
00:32	Bubbling rate = 40-0-40-20
00:52	Flushed feed lines.
01:35	Collected heme sample. C106-HL-90A.
01:50	Flushed feed lines. #2 is clogged at check valve.
02:00	Collected scrubber sample. C106-SL-90B.
02:02	Discharge for 5 minutes. C106-G-90A.
02:11	Flushed feed line #2.
02:46	Flushed feed lines.
03:42	Flushed feed lines.
04:03	Collected scrubber sample. C106-SL-90C.
04:34	Discharge for 4 minutes. C106-G-90B
04:37	Flushed feed lines.
05:30	Flushed feed lines.

06:08	Scrubber sample. C106-SL-90D.
06:27	Flushed feed lines.
07:01	Discharge (5 minutes) C106-G-92A.
07:23	Flushed feed lines and replaced air line.
08:24	Flushed feed line.
09:00	Obtained scrubber sample. C106-SL-92A.
09:50	Flushed feed lines.
10:07	Heme sample obtained. C106-HL-92A.
11:23	Remove/replace discharge can. C106-G-90A,B, 92A. Gross mass 344.5 kg.
11:45	Flushed feed lines.
11:47	Obtained scrubber sample. C106-SL-95A.
12:00	A feed sample was taken. C106-F-95A.
12:00	Note: notes @1240 in regard to feed also apply to coarse grain silica feed (present) which is -80 mesh. If anything, the present feed appears to be more fluid. No feed clogging has been observed.
12:40	Flushed feed lines.
12:59	Discharge for 10 minutes. C106-G-A.
13:59	Obtained scrubber sample. C106-SL-95B.
14:22	Flushed feed lines.
16:00	Amount of feed after recirculation line was emptied 129.5 kg. Cold cap burnout.
16:20	Checked the film cooler pipe, it looked clean without many deposits.
16:51	Shut down off gas system
2/21/00	
08:55	Start discharge (34 minutes) C106-G-97A.

Table 2.1.
Composition Summary of AZ-101 Waste, LAW Pretreatment Products, AZ-101 Simulant Plus Pretreatment Products, Glass Additives, and HLW98-31 Glass.

	AZ-101 Envelope D Waste	**Pretreatment Products (as wt%of total AZ-101 oxides)**	**AZ-101 Simulant (Envelope D + Pretreatment Products)**	**Additives (as wt% of glass)**	**HLW98-31 Glass Composition**
Al_2O_3	27.41%		24.27%		7.40%
As_2O_3	0.15%		0.13%		0.04%
B_2O_3				10.00%	10.00%
BaO	0.16%		0.14%		0.04%
CaO	0.91%		0.81%		0.25%
CdO	1.38%		1.22%		0.37%
CeO_2	0.31%		0.27%		0.08%
Cl	0.03%		0.02%		0.01%
Cr_2O_3	0.16%		0.14%		0.04%
Cs_2O	0.01%	0.3%	0.27%		0.08%
CuO	0.10%		0.09%		0.03%
F	0.14%		0.12%		0.04%
Fe_2O_3	38.49%		34.08%		10.39%
K_2O	0.63%		0.55%		0.17%
La_2O_3	1.20%		1.06%		0.32%
Li_2O				6.00%	6.00%
MgO	0.24%		0.21%		0.06%
MnO	7.76%	3.5%	9.94%		3.03%
Na_2O	1.46%	0.8%	1.96%	6.00%	6.59%
NiO	1.99%		1.76%		0.54%
P_2O_5	0.47%		0.42%		0.13%
PbO	0.56%		0.50%		0.15%
SO_3	0.93%		0.82%		0.25%

Sb_2O_5	0.78%		0.69%		0.21%
SeO_2	0.55%		0.49%		0.15%
SiO_2	0.08%		0.07%	45.51%	45.53%
SrO	0.16%	8.6%	7.60%		2.32%
TeO_2	0.53%		0.47%		0.14%
TiO_2	0.23%		0.21%		0.06%
ZnO				2.00%	2.00%
ZrO_2	13.19%		11.68%		3.56%
TOTAL	100%	13.16%	100%	69.61%	100%
Total Oxides (kg)	82,997	10,920	93,917	214,108	308,025
Volatiles, g/100 g oxides					
CO_3	0.00	4.96*	3.00		
NO_2	1.08		0.95		
NO_3	0.61	1.63	1.97		
TOC	1.50		1.32		

* If all Sr in pretreatment is precipitated as $SrCO_3$

Table 2.2.
Composition of Melter Feed Simulant to Produce 10 Metric Tons of HLW98-31 Glass from AZ-101 Waste Plus Pretreatment Products.

AZ-101+ Pretreatment Products		Glass-Forming Additives	
Starting Materials	**Target Weight, kg**	**Starting Materials**	**Target Weight, kg**
$Al(OH)_3$	1131.6		
Na_2HAsO_4	7.5		
$Ba(OH)_2*8H_2O$	8.7		
$CaCO_3$	44.1		
CdO	37.2		
$Ce(OH)_4$	10.1		
$Cr_2O_3*1.5H_2O$	5.2		
CsOH (50% Solution)	17.5		
$CuSO_4*5H_2O$	8.8		
NaF	8.4		
$Fe(OH)_3$ Slurry	10553.5		
KNO_3	36.3		
$La(OH)_3*3H_2O$	48.5		
Li_2CO_3		Li_2CO_3*	53.1
		$LiOH*H_2O$	1624.0
$(MgCO_3)_4(Mg(OH)_2*5H_2O)$	15.1		
MnO_2	371.5		
NaOH (50% Solution)	12.8		
		$Na_2B_4O_7*10H_2O$	2738.7
$Ni(NO_3)_2*6H_2O$			
$Ni(OH)_2$	66.7		
$FePO_4$ (80%)	33.8		

$PbCO_3*Pb(OH)_2$	17.3		
Na_2SO_4	39.4		
Sb_2O_5	21.1		
SeO_2	14.9		
SiO_2	2.2	SiO_2	4551.8
$Sr(NO_3)_2$	57.3		
$Sr(OH)_2*8H_2O$	522.2		
TeO_2	14.2		
TiO_2	6.3		
ZnO		ZnO	200.0
$ZrOOH(CO_3)_{0.5}$ (50%)	570.9		
Zr(OH)4 (50%)	330.8		
KCl	1.5		
Na_2CO_3		Na_2CO_3	264.3
$NaNO_2$	63.6		
$NaNO_3$			
$C_2H_2O_4*2H_2O$	208.1		
		H_2O	1897.6
TOTAL	14,287.2	TOTAL	11,329.5
		FEED TOTAL	25,616.7

*Carbonate in the Li_2CO_3 additive will originate from pretreatment products; replace by equivalent amount of $LiOH*H_2O$ for the actual waste.

Table 2.3.
Compositions Summary of C-106/AY-102 Waste Blend, LAW Pretreatment Products, C-106/AY-102 Simulant Plus Pretreatment Products, Glass Additives, and Target Glass.

	C-106/AY-012 Envelope D Waste	**Pretreatment Products (as wt% of total waste oxides)**	**Adjustment to Envelope D Waste**	**C-106/AY-102 Simulant (Envelope D + Pretreatment**	**Additives (as wt% of glass)**	**Target Glass Composition (HLW98-34)**
Ag_2O	0.60%			0.46%		0.24%
Al_2O_3	27.33%			21.13%		10.78%
B_2O_3					7.00%	7.00%
BaO	0.17%			0.13%		0.07%
Bi_2O_3	0.00%		-0.00%	0.00%		
CaO	1.81%			1.40%		0.71%
CdO	0.11%			0.09%		0.04%
CeO_2	0.08%			0.06%		0.03%
Cl	0.00%		0.0005	0.05%		0.03%
Cr_2O_3	0.41%			0.32%		0.16%
Cs_2O	0.01%	0.25%		0.20%		0.10%
CuO	0.04%		-0.04%			
F	0.04%		+0.01%	0.05%		0.02%
Fe_2O_3	29.74%			22.99%		11.73%
HgO	0.01%		-0.01%			
K_2O	0.07%			0.05%		0.03%
La_2O_3	0.28%			0.22%		0.11%
Li_2O					4.00%	4.00%
MgO	0.56%			0.43%		0.22%
MnO	1.36%	9.89%		8.70%		4.44%
Na_2O	20.61%	0.61%		16.40%	1.00%	9.36%
NiO	0.39%			0.30%		0.15%
P_2O_5	0.38%			0.30%		0.15%
PbO	0.55%			0.42%		0.22%
PdO	0.01%		-0.01%			
SO_3	0.02%		+0.03%	0.05%		0.02%
SiO_2	14.93%			11.55%	35.00%	40.89%
SrO	0.05%	18.59%		14.41%		7.35%
TiO_2	0.10%			0.08%		0.04%
ZnO	0.04%		-0.04%		2.00%	2.00%
ZrO_2	0.29%			0.23%		0.12%
TOTAL	100 %			100 %	49 %	100 %
Total Oxides (kg)	244,056	71,603	-1,291	314,368	301,946	616,314
Volatiles (g/100 g oxides)						
CO_3	0.004	26273 kg		8.326		
NO_2	0.003			0.002		
NO_3	0.00	3230 kg		1.023		
TOC	1.62			1.253		

Table 2.4.
Chemical Compositions of the C-106/AY-102 Simulant (Plus Pretreatment Products) and the Corresponding Feed.

C-106/AY102 + Pretreatment Products		Glass Forming Additives	
Starting Materials	**Target Weight (kg)**	**Starting Materials**	**Target Weight (kg)**
Ag_2O	24		
$Al(OH)_3$	1648	H_3BO_3	844
$Ba(OH)_2*8H_2O$	13		
$CaCO_3$	128		
CdO	4		
$Ce(OH)_4$	4		
$Cr_2 O_3*1.5H_2O$	19		
CsOH (50% Solution)	22		
NaF	6		
$Fe(OH)_3$ Slurry	11893		
KNO_3	6		
$La(OH)_3*3H_2O$	17		
		$LiOH*H_2O$	1124
$4MgCO_3*Mg(OH)_2*5H_2 O$	53		
MnO_2	543		
NaOH (50% Solution)	2068		
		$Na_2B_4O_7*10H_2$	615
$Ni(OH)_2$	19		
$FePO_4$	32		
$PbCO_3*Pb(OH)_2$	25		
Na_2SO_4	5		
SiO_2	589	SiO_2	3500
$Sr(OH)_2*8H_2O$	471		
$SrCO_3$	785		
TiO_2	4		
ZnO		ZnO	200
$Zr(OH)_4$	17		
NaCl	4		
Na_2CO_3			
$NaNO_2$	0		
$NaNO_3$	67		
$C_2H_2O_4*2H_2O$	336		
H_2O	2256		
TOTAL	21054	TOTAL	6283
		FEED TOTAL	**27337**

Table 2.5.
Chemical Compositions of West Valley Simulant and Glass Former Mix. (For 6.46 MT of Glass).

Starting Materials	**Weight in Simulant (kg)**	**Weight in Glass Former (kg)**
H_2O	2388.1	1864.00
$Al(OH)_3$	86.5	247.93
$CaCO_3$	19.5	3.95
$Ce(OH)_4$	20.5	
$CsOH\cdot H_2O$	5.1	
$Fe(OH)_3$ Slurry	6374.4	
KOH (45 % solution)	565.8	191.79
$Mg(OH)_2$	3.4	60.90
MnO_2	37.7	13.47
NaH_2PO_4	63.9	37.13
$NaNO_2$	192.8	
NaOH (50% solution)	244.8	
Na_2SO_4	18.2	
$Na_2SiO_3\cdot 5H_2O$	20.4	
Nd_2O_3	10.0	
$Ni(OH)_2$	16.9	
SiO_2	161.2	1770.69
$Sr(OH)_2$	10.2	
TiO_2	19.7	26.43
Zeolite IE-96	771.6	
ZnO	10.4	
$ZrO(NO_3)_2\cdot 2H_2O$ (42.5% solution)	565.1	409.01
Concentrated HNO_3		2684.00
B_2O_3		350.70
$LiOH\cdot H_2O$		571.86

$Na_2B_4O_7 \cdot xH_2O$		841.38
P-1200 Antifoam		40.20

Table 2.6.
Chemical Composition of the West Valley Melter Feed to Produce 7 MT of Glass.

Starting Materials	Target Weight (kg)*	Weight %
Concentrated HNO_3	3871.54	16.67 %
$Al(OH)_3$	412.34	1.78 %
B_2O_3	446.73	1.92 %
$Na_2B_4O_7 \cdot xH_2O$ (x . 7.7)	1076.75	4.64 %
$CaCO_3$	25.04	0.11 %
$Ce(OH)_4$	22.29	0.10 %
$CsOHXH_2O$	5.49	0.02 %
$Fe(OH)_3$ Slurry	8290.55	35.70 %
KOH	408.99	1.76 %
$LiOH \cdot H_2O$	774.45	3.34 %
$Mg(OH)_2$	78.43	0.34 %
MnO_2	67.63	0.29 %
NaOH	158.33	0.68 %
NaH_2PO_4	143.09	0.62 %
Na_2SO_4	34.12	0.15 %
$NaNO_3$	255.75	1.10 %
$Na_2SiO_3 \cdot 5H_2O$	21.97	0.09 %
Nd_2O_3	10.77	0.05 %
$Ni(OH)_2$	21.34	0.09 %
SiO_2	2324.13	10.01 %
$Sr(OH)_2 \cdot 8H_2O$	24.55	0.11 %
TiO_2	54.33	0.23 %
ZnO	14.17	0.06 %
$ZrO(NO_3)_2 \cdot 2H_2O^{\#}$	1221.37	5.25 %
Zeolite IE-96	1201.28	5.17 %
Antifoam P-1200	43.29	0.19 %
Sucrose	1294.99	5.58 %
Deionized Water	918.00	3.95 %
TOTAL	23221.71	100.00%

* All target weights have been adjusted for assay/purity of materials

$^{\#}$ As 42.5 % solution in 20% HNO_3

Table 2.7.
Compositions of West Valley Target Glass, VSL Test Glass, and West Valley Cold Test Glass.

Oxide	West Valley Target Glass (wt %)	VSL Test Glass (wt %)	West Valley Cold Test Glass(wt %)
Al_2O_3	6.00 %	6.25 %	6.05 %
B_2O_3	12.90 %	11.98 %	13.06 %
BaO	0.00 %	0.05 %	0.01 %
CaO	0.50 %	0.48 %	0.39 %
Ce_2O_3	0.31 %	N. M.*	0.20 %
Cr_2O_3	0.05 %	0.01 %	0.01 %
Cs_2O	0.00 %		
CuO	0.00 %	N. M.	0.00 %
Fe_2O_3	12.02 %	11.90 %	12.36 %
K_2O	5.00 %	4.86 %	5.16 %
La_2O_3	0.00 %		
Li_2O	3.71 %	3.76 %	3.74 %
MgO	0.89 %	0.95 %	0.93 %
MnO	0.82 %	0.78 %	0.81 %
MoO_3	0.00 %		
Na_2O	8.00 %	7.80 %	7.94 %
Nd_2O_3	0.14 %	N. M.	0.12 %
NiO	0.25 %	0.22 %	0.25 %
P_2O_5	1.20 %	1.22 %	1.13 %
Pr_6O_{11}	0.00 %		
SO_3	0.23 %	N. M.	0.34 %
SiO_2	43.27 %	42.60 %	42.87 %
SrO	0.20 %	0.16 %	0.15 %
ThO_2	0.00 %		
TiO_2	0.80 %	0.84 %	0.77 %
UO_3	0.00 %		
ZnO	0.20 %	0.25 %	0.20 %
ZrO_2	3.43 %	3.26 %	3.50 %
TOTAL	99.92 %	97.37 %	99.99 %

* N. M. = Not Measured

Table 2.8.
Physical Properties of As-Received, Preapproval Samples.

		Water (wt%)	Density (g/ml)	Glass Yield (g/kg feed)	pH
C106/ AY102	NOAHF13 Test	56.8	1.49	373	12.92
	NF13MT1A	58.5	1.49	363	13.19
	NF13MT2A	56.4	1.47	382	13.08
	NF13MT3C	59.1	1.46	361	13.11
	NF13MT4A	57.9	1.43	364	13.05
	NF13MT5A	58.9	1.48	343	12.68
	NF13MT6A	57.8	1.42	352	12.89
	NF13MT7A	60.9	1.43	338	13.01
	Average	**58.3**	**1.46**	**359**	
AZ101	NOAH-MT1A		1.47	391	
	NOAH-MT2A			398	
	NOAH-MT3A			388	
	NOAH-MT4A			390	
	NOAH-MT5A			382	
	NOAH-MT6A			391	
	Average			**390**	
West Valley	Test	48.5	1.40	302	3.65
	NOAH-WV3MT1	48.3	1.40	320	3.13
	WV3MT1 (Sugared)		1.40		2.99
	NOAH-WV3MT2	55.1	1.37		2.77
	Average	**50.7**	**1.39**		**3.14**

Table 2.9.
Chemical Analysis of AZ-101 Preapproval Samples.

NOAHMT	1A		2A		3A		4A		5A	6A		Average		Target
	DCP	XRF	DCP	XRF	DCP	XRF	DCP	XRF	DCP	DCP	XRF	DCP	XRF	
Al_2O_3	7.67	7.81	7.97	8.18	8.15	8.48	7.60	7.69	7.59	7.79	8.74	7.80	8.18	7.4
As_2O_3	0.03	0.05	0.05	0.03	0.05	0.04	0.05	0.04	0.07	0.05	0.03	0.05	0.04	0.04
B_2O_3	9.98	9.98	10.09	10.09	10.39	10.39	10.15	10.15	10.39	9.92	9.92	10.15	10.11	10
BaO	0.07	0.00	0.08	0.00	0.06	0.00	0.06	0.00	0.05	0.06	0.00	0.06	0.00	0.04
CaO	0.39	0.38	0.59	0.44	0.37	0.39	0.37	0.37	0.38	0.43	0.45	0.42	0.41	0.25
CdO	0.35	0.57	0.35	0.54	0.35	0.34	0.34	0.56	0.34	0.34	0.34	0.35	0.47	0.37
Cl	NA	0.06	NA	0.05	NA	0.05	NA	0.05	NA	NA	0.04	NA	0.05	0.01
Cr_2O_3	0.05	0.05	0.05	0.04	0.05	0.04	0.05	0.04	0.05	0.05	0.05	0.05	0.04	0.04
Cs_2O	NA	0.09	NA	0.08	NA	0.05	NA	0.08	NA	NA	0.04	NA	0.07	0.08
CuO	0.04	0.24	0.04	0.03	0.05	0.05	0.04	0.02	0.05	0.05	0.04	0.05	0.08	0.03
Fe_2O_3	9.77	11.27	10.11	10.97	9.85	10.12	10.28	11.27	10.13	9.46	10.45	9.93	10.82	10.39
K_2O	0.21	0.17	0.25	0.17	0.22	0.23	0.20	0.15	0.20	0.25	0.23	0.22	0.19	0.17
Li_2O	5.45	5.45	5.31	5.31	6.11	6.11	5.69	5.69	5.74	5.69	5.69	5.67	5.65	6
MgO	0.12	0.08	0.27	0.07	0.09	0.00	0.11	0.03	0.10	0.11	0.07	0.13	0.05	0.06
MnO	2.82	3.15	2.75	2.95	2.80	2.72	2.77	2.98	3.29	2.80	2.94	2.87	2.95	3.03
Na_2O	6.09	5.41	5.99	5.25	6.61	6.26	6.23	5.52	6.45	6.39	6.93	6.29	5.87	6.59
NiO	0.50	0.57	0.49	0.55	0.52	0.51	0.49	0.57	0.49	0.53	0.53	0.50	0.55	0.54
P_2O_5	0.21	0.14	0.32	0.22	0.21	0.15	0.20	0.13	0.18	0.22	0.14	0.22	0.16	0.13
PbO	0.20	0.15	0.21	0.14	0.19	0.11	0.20	0.15	0.20	0.20	0.12	0.20	0.13	0.15
Sb_2O_3	0.20	0.23	0.18	0.22	0.18	0.14	0.18	0.24	0.19	0.20	0.14	0.19	0.19	0.21
SeO_2	0.04	0.04	0.03	0.03	0.03	0.03	0.01	0.01	0.01	0.04	0.02	0.03	0.03	0.15
SiO_2	42.83	44.41	42.81	45.03	43.14	45.97	45.09	44.42	44.37	42.49	45.11	43.46	44.99	45.53
SO_3	NA	0.39	NA	0.36	NA	0.34	NA	0.28	NA	NA	0.34	NA	0.34	0.25
SrO	2.08	2.48	2.13	2.35	2.16	1.83	2.21	2.49	2.12	2.29	1.92	2.17	2.21	2.32
TeO_2	0.13	0.19	0.12	0.17	0.12	0.11	0.10	0.14	0.11	0.15	0.10	0.12	0.14	0.14
TiO2	0.10	0.12	0.11	0.12	0.10	0.13	0.12	0.15	0.12	0.13	0.16	0.12	0.14	0.06
ZnO	1.91	2.02	1.88	2.00	2.00	1.79	1.99	2.06	1.99	1.96	1.84	1.96	1.94	2
ZrO_2	3.61	4.17	3.56	3.99	3.69	3.05	3.65	4.14	3.65	3.52	3.06	3.61	3.68	3.56
SUM	94.83	99.67	95.74	99.38	97.47	99.43	98.19	99.42	98.30	95.14	99.44	96.61	99.47	99.54

NA - Not Analyzed

Table 2.10.
Chemical Analysis of C-106/AY-102 Preapproval Samples.

	XRF Analysis									DCP Analysis	Target
NF13MT	1A	2A	3B	3C	4A	5A	6A	7A	Average	NOAHF13*	
Ag_2O	0.34	0.27	0.27	0.26	0.21	0.27	0.22	0.30	0.27	NA	0.24
Al_2O_3	10.7	11.1	11.2	11.4	12.2	12.3	12.0	11.8	11.64	10.90	10.78
B_2O_3	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	6.79	7
BaO	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.07
CaO	0.87	0.84	0.91	0.89	0.86	0.88	0.83	0.89	0.87	0.95	0.71
CdO	0.07	0.05	0.05	0.05	0.04	0.04	0.05	0.06	0.06	0.04	0.04
Cr_2O_3	0.15	0.14	0.14	0.15	0.14	0.14	0.14	0.14	0.14	0.16	0.16
Fe_2O_3	11.8	12.3	12.1	12.6	10.7	10.5	11.1	12.1	11.69	12.98	11.73
K_2O	0.04	0.18	0.05	0.19	0.09	0.08	0.10	0.07	0.10	0.08	0.03
Li_2O	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.85	4
MgO	0.20	0.33	0.12	0.19	0.23	0.14	0.15	0.10	0.18	0.28	0.22
MnO	4.16	4.08	4.37	4.16	3.82	4.02	3.89	4.16	4.08	3.88	4.44
Na_2O	8.95	9.07	8.42	8.37	9.93	9.24	9.48	8.12	8.95	10.03	9.36
NiO	0.15	0.14	0.16	0.14	0.13	0.14	0.13	0.14	0.14	0.14	0.15
P_2O_5	0.19	0.16	0.18	0.17	0.14	0.15	0.14	0.18	0.16	0.16	0.15
SiO_2	40.45	39.90	40.63	40.62	41.89	41.45	42.04	40.74	40.96	39.32	40.89
SO_3	0.18	0.18	0.05	0.16	0.12	0.14	0.12	0.17	0.14	NA	0.02
SrO	7.54	7.07	7.21	6.66	5.71	6.74	5.82	7.09	6.73	6.68	7.35
TiO_2	0.07	0.13	0.08	0.11	0.15	0.14	0.16	0.13	0.12	0.07	0.04
ZnO	2.01	1.97	2.05	1.91	1.73	1.82	1.83	1.94	1.91	1.84	2
ZrO_2	0.17	0.15	0.16	0.14	0.12	0.14	0.12	0.15	0.14	0.21	0.12
SUM	98.87	98.92	99.01	99.02	99.10	99.08	99.18	98.99	99.02	98.43	99.50

NA - Not Analyzed

* - Silver was not included in this formulation and therefore no silver analysis was performed.

Table 2.11.
Chemical Analysis of West Valley Preapproval Samples.

	NOAHWV		WV3MT1		WV3MT2		Average		Target
	DCP	XRF	DCP	XRF	DCP	XRF	DCP	XRF	
Al_2O_3	6.25	6.77	6.03	6.49	6.18	6.37	6.15	6.54	6.00
B_2O_3	11.98	11.98	11.25	11.25	11.54	11.54	11.59	11.59	12.90
BaO	0.05	0.00	0.05	0.00	0.05	0.00	0.05	0.00	0.00
CaO	0.48	0.51	0.42	0.46	0.44	0.46	0.45	0.48	0.50
Cr_2O_3	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.05
Fe_2O_3	11.90	11.58	11.72	12.32	11.83	12.73	11.82	12.21	12.02
K_2O	4.86	5.24	4.17	4.97	4.28	4.77	4.44	4.99	5.00
Li_2O	3.76	3.76	3.55	3.55	3.79	3.79	3.70	3.70	3.71
MgO	0.95	0.79	0.94	0.77	0.96	0.69	0.95	0.75	0.89
MnO	0.78	0.72	0.82	0.77	0.74	0.72	0.78	0.74	0.82
Na_2O	7.80	7.87	7.00	7.81	7.61	7.32	7.47	7.67	8.00
NiO	0.22	0.22	0.43	0.44	0.25	0.27	0.30	0.31	0.25
P_2O_5	1.22	1.21	1.18	1.18	1.25	1.19	1.22	1.19	1.20
SiO_2	40.79	44.59	41.77	44.60	41.93	44.43	41.50	44.54	43.27
SrO	0.15	0.11	0.16	0.12	0.15	0.13	0.15	0.12	0.20
TiO_2	0.84	1.00	0.86	1.01	0.91	1.10	0.87	1.04	0.80
ZnO	0.25	0.20	0.21	0.20	0.21	0.19	0.22	0.20	0.20
ZrO_2	3.26	2.60	3.23	2.58	3.51	3.22	3.33	2.80	3.43
SUM	95.55	99.15	93.80	98.52	95.64	98.92	95.00	98.86	99.24

Table 2.12.
Measured Properties of Feed Samples From AZ-101 Melter Tests.

TEST	Sampling Date	Sample Name	Measured Wt. % Water	Density (g/ml)	Glass Yield (kg/kg)	Glass Yield (g/l)
As Received Feed			55.53	1.47	0.391	575.3
TURNOVER	8/18/99	AZ-F-44A	NA	1.34	NA	NA
	8/19/99	AZ-F-52A	63.31	1.44	NA	NA
	8/25/99	AZ-F-57A	62.91	1.34	NA	NA
	8/25/99	AZ-F-62A	62.84	1.34	NA	NA
	8/30/99	AZ-F-64A	63.59	1.35	NA	NA
	8/30/99	AZ-F-72A	71.85	NA	NA	NA
1	9/13/99	AZ-F-97A	70.05	1.29	0.258	333.2
2	9/22/99	AZ-F-123A	70.13	1.26	0.258	325.2
	9/22/99	AZ-F-123B	NA	1.22	NA	NA
	9/22/99	AZ-F-135A	71.97	1.20	0.239	286.8
3	9/30/99	AZ2-F-16A	60.47	1.37	0.330	451.5
4	9/30/99	AZ2-F-20A	71.07	1.21	0.246	297.7
5	10/6/99	AZ2-F-35A	71.79	1.20	0.245	293.5
	10/6/99	AZ2-F-44A	71.31	1.19	0.240	286.0
7	10/13/99	AZ2-F-64A	57.61	1.43	0.369	528.1
8	10/21/99	AZ2-F-89A	58.31	1.41	0.365	514.5

NA - Not Analyzed
Note: Water content and hence, glass yield, were deliberately varied during these tests.

Table 2.13.
Measured Properties of Feed Samples From C-106/AY-102 Melter Tests.

TEST	Sampling Date	Sample Name	Wt% Water	Density (kg/l)	Glass Yield (kg/kg)	Glass Yield (g/l)
As Received Feed*			58.9	1.44	0.349	503
1	2/1/00	C106-F-144A	59.4	1.44	0.344	495
	2/2/00	C106-F-9A	58.0	1.34	0.350	469
2	2/7/00	C106-F-15A	58.1	1.44	0.340	490
	2/10/00	C106-F-40A	57.8	1.43	0.327	468
3	2/17/00	C106-F-70A	57.1	1.46	0.353	515
	2/18/00	C106-F-83A	57.7	1.45	0.356	516
	2/19/00	C106-F-95A	58.1	1.43	0.349	499
Average			58.1	1.43	0.346	494
Standard Deviation			0.7	0.03	0.009	17

* - average value determined for 3 preapproval samples.

Table 2.14.
Measured Properties of Feed Samples from West Valley Melter Tests.

TEST	Sampling Date	Feed Sample Name	Wt% Water	Density (g/ml)	Glass Yield (kg/kg)	Glass Yield (g/l)
As Received Feed			51.5	1.40	0.302	425
1	12/13/00	WV1000-F-142A	46.6	1.39	0.300	417
1	12/16/00	WV1000-F-29A	56.8	1.37	0.290	397
3	1/5/00	WV1000-F-86A	60.4	1.39	0.320	445
Average			53.8	1.39	0.303	420
Standard Deviation			5.2	0.01	0.011	20

Table 2.15.
Analyzed Composition of AZ-101 Melter Feed Samples.
(Wt% Oxide)

	97A	123A	135A	2-16A	2-20A	2-35A	2-44A	2-64A	2-89A	Average	Target
Test #	1	2	2	3	4	5	5	7	8		
Al_2O_3	7.49	7.40	7.19	7.92	7.61	7.34	7.99	7.83	8.06	7.65	7.4
As_2O_3	0.03	0.03	0.03	0.04	0.04	0.03	0.04	0.02	0.05	0.03	0.04
B_2O_3	10.21	9.98	9.87	10.31	9.42	10.05	10.78	10.24	10.29	10.13	10
BaO	0.06	0.06	0.06	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.04
CaO	0.42	0.41	0.38	0.38	0.42	0.38	0.39	0.37	0.48	0.40	0.25
CdO	0.33	0.37	0.36	0.37	0.36	0.34	0.35	0.36	0.35	0.35	0.37
Cr_2O_3	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
CuO	0.05	0.04	0.04	0.05	0.05	0.04	0.05	0.05	0.04	0.04	0.03
Fe_2O_3	9.74	9.78	9.43	9.85	9.61	9.79	10.61	9.98	9.83	9.85	10.39
K_2O	0.21	0.23	0.21	0.22	0.21	0.22	0.22	0.20	0.20	0.21	0.17
Li_2O	5.49	5.51	5.29	5.81	5.33	5.44	5.90	5.66	5.86	5.59	6
MgO	0.12	0.11	0.10	0.10	0.10	0.11	0.10	0.10	0.14	0.11	0.06
MnO	2.72	2.71	2.64	2.81	2.67	2.60	2.78	2.78	2.88	2.73	3.03
Na_2O	5.90	6.05	5.70	6.44	5.95	6.07	6.34	6.29	6.53	6.14	6.59
NiO	0.51	0.51	0.50	0.51	0.50	0.49	0.51	0.50	0.48	0.50	0.54
P_2O_5	0.17	0.19	0.16	0.18	0.17	0.17	0.20	0.21	0.34	0.20	0.13
PbO	0.20	0.19	0.19	0.20	0.20	0.20	0.20	0.19	0.19	0.20	0.15
Sb_2O_3	0.20	0.18	0.18	0.18	0.19	0.18	0.19	0.20	0.19	0.19	0.21
SeO_2	0.03	0.02	0.03	0.03	0.04	0.04	0.03	0.02	0.00	0.03	0.15
SiO_2	42.66	42.27	42.10	43.35	42.58	42.76	42.81	43.72	43.59	42.87	45.53
SrO	2.01	2.07	1.96	2.14	2.06	1.99	2.17	2.13	2.13	2.07	2.32
TeO_2	NA	0.09	0.11	0.12	0.10	0.09	0.08	0.10	0.10	0.09	0.14
TiO_2	0.12	0.12	0.12	0.13	0.12	0.12	0.12	0.10	0.12	0.12	0.06
ZnO	1.96	1.98	1.90	1.96	1.87	1.92	2.01	1.97	1.97	1.95	2
ZrO_2	3.45	3.42	3.32	3.56	3.39	3.39	3.60	3.51	3.66	3.48	3.56
Sum	94.12	93.77	91.92	96.75	93.08	93.88	97.56	96.62	97.58	95.03	99.20

Table 2.16.
Analyzed Composition of C106/AY-102 Melter Feed Samples.
(Wt% Oxide)

Test #	1		2		3				
C106-F	144A	9A	15A	40A	70A	83A	95A	Average	Target
Ag_2O	0.22	0.23	0.21	0.23	0.19	0.23	0.21	0.22	0.24
Al_2O_3	10.81	11.08	10.79	10.22	10.40	10.15	10.81	10.61	10.78
B_2O_3	7.28	7.21	7.57	7.54	7.59	7.35	7.54	7.44	7
BaO	0.14	0.15	0.14	0.14	0.14	0.15	0.16	0.14	0.07
CaO	0.87	0.86	0.94	0.85	0.95	1.04	1.12	0.94	0.71
CdO	0.04	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.04
Cr_2O_3	0.16	0.16	0.16	0.22	0.12	0.15	0.16	0.16	0.16
Fe_2O_3	11.63	12.06	11.46	10.78	10.13	11.28	11.14	11.21	11.73
K_2O	0.08	0.09	0.07	0.06	0.06	0.06	0.07	0.07	0.03
Li_2O	3.81	3.86	3.98	3.93	4.02	3.85	3.84	3.90	4
MgO	0.27	0.27	0.31	0.26	0.32	0.34	0.38	0.31	0.22
MnO	3.92	4.00	4.12	3.97	4.09	4.09	3.85	4.01	4.44
Na_2O	8.33	8.24	8.80	9.43	8.81	8.28	8.06	8.56	9.36
NiO	0.14	0.15	0.15	0.14	0.13	0.14	0.14	0.14	0.15
P_2O_5	0.21	0.20	0.20	0.51	0.31	0.25	0.17	0.26	0.15
PbO	0.26	0.27	0.27	0.25	0.23	0.24	0.23	0.25	0.22
SiO_2	39.14	39.46	40.21	37.98	40.28	39.57	39.12	39.39	40.89
SrO	6.40	6.58	6.74	6.63	6.77	6.66	6.39	6.60	7.35
TiO_2	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.04
ZnO	1.85	1.89	1.98	1.83	1.96	1.95	1.93	1.91	2
ZrO_2	0.19	0.17	0.20	0.16	0.23	0.24	0.28	0.21	0.12
	95.81	97.03	98.41	95.24	96.85	96.12	95.71	96.62	99.70

Table 2.17.
Analyzed Composition of West Valley Melter Feed Samples.
(Wt % Oxide)

	F-142A	F-29A	F-86A*	Average	Target
Test #	1	1	3		
Al_2O_3	6.35	6.27	6.60	6.41	6.00
B_2O_3	12.63	11.96	13.95	12.84	12.90
BaO	0.05	0.05	0.05	0.05	0.00
CaO	0.43	0.49	0.57	0.50	0.50
Cr_2O_3	0.00	0.01	0.01	0.01	0.05
Fe_2O_3	11.71	13.75	14.86	13.44	12.02
K_2O	4.41	4.37	4.70	4.49	5.00
Li_2O	3.96	4.06	4.82	4.28	3.71
MgO	0.86	0.96	1.19	1.01	0.89
MnO	0.68	0.73	0.45	0.62	0.82
Na_2O	7.82	7.96	9.03	8.27	8.00
NiO	0.24	0.27	0.30	0.27	0.25
P_2O_5	1.13	1.32	1.57	1.34	1.20
SiO_2	40.17	40.18	31.30	37.22	43.27
SrO	0.18	0.18	0.20	0.19	0.20
TiO_2	0.83	0.91	1.00	0.91	0.80
ZnO	0.23	0.27	0.28	0.26	0.20
ZrO_2	3.38	3.33	4.13	3.61	3.43
Sum	95.08	97.08	95.02	95.73	99.24

*Note: This feed sample was evidently unrepresentative since the composition is inconsistent with the results from the preapproved samples and the product glass, which show the feed to be on target.

Table 2.18.
Summary of Yield Stress Data on Melter Feeds.

	Temperature (°C)	Yield Stress (Pa)
AZ-101 As-Received Feed	26	27.8
AZ-101 Feed (72 wt% Water)	10	2.0
	25	1.7
	40	0.4
West Valley As-Received Feed	10	32.0
	25	35.0
	40	25.0
West Valley Feed (with Sucrose Solution)	10	7.3
	25	4.5
	40	3.3
C-106/AY-102 Feed (As-Received Batch 1)	25	65.0
	40	45.0
	50	40.0
C-106/AY-102 Feed (As-Received Batch 6)	25	70.0
	40	70.0
C-106/AY-102 Feed (As-Received Batch 7)	25	70.0
	40	65.0

Table 3.1.
Summary of Results from DuraMelter 1000 AZ-101 Throughput Tests.

Test #		1	2	3	4	5	6	7	8
Time	Feed Start	9/13/99 16:48	9/21/99 17:23	9/29/99 16:10	9/30/99 14:15	10/5/99 16:00	10/11/99 14:24	10/13/99 09:58	10/20/99 16:13
	Feed End	9/16/99 02:43	9/23/99 1 4:24	9/30/99 09:00	10/1/99 04:58	10/7/99 16:00	10/11/99 23:05	10/15/99 12:00	10/21/99 15:12
	Interval	57.9 hr	45.0 hr	16.8 hr	14.7 hr	48.0 hr	8.7 hr	50.0 hr	23.0 hr
Cold cap burn		4.1 hr	4.0 hr	0 hr	5.2 hr	5.5 hr	2.3 hr	5.8 hr	1.0 hr
Total		62.0 hr	49.0 hr	16.8	19.9 hr	53.5 hr	11.0 hr	55.8	24.0 hr
Bubbling		NO	YES	NO	NO	NO	NO	NO	YES
Observed Vigorous Foaming		NO	YES	YES	YES	YES	NO	NO	NO
Feed	Used	2162 kg	5657 kg	1816 kg	1445 kg	4130 kg	596 kg	1863 kg	2875 kg
	Glass yield	333.2 g/l	325.2 g/l 286.8 g/l	451.5 g/l	297.7 g/l	293.5 g/l 286.0 g/l	286.0$^{\#}$ g/l	528.1 g/l	515 g/l
	Sugar	NO	NO	NO	NO	NO	15 g/l	NO	1 g/l
	Avg. Rate	34.9 kg/hr	115.4 kg/hr	108.1 kg/hr	72.6 kg/hr	77.2 kg/hr	54.2 kg/hr	33.4 kg/hr	119.8 kg/hr
	St.St. Rate	30 kg/hr	125 kg/hr	105 kg/hr$^{@}$	75 kg/hr$^{@}$	33 kg/hr$^{@}$	50 kg/hr$^{@}$	40 kg/hr	120 kg/hr
Glass Produced	Poured	569.5 kg	1203.5 kg	637.5 kg	343.0 kg	1031.5 kg	59.0 kg	1136.0 kg	1173.5 kg
	Avg. Rate$^{\$}$	0.18 MT/ m^2/day	0.49 MT/ m^2/day	0.75 MT/ m^2/day	0.34 MT/ m^2/day	0.39 MT/ m^2/day	0.11 MT/ m^2/day	0.41 MT/ m^2/day	0.98 MT/ m^2/day
	Avg. Rate*	0.18MT/ m^2/day	0.57 MT/ m^2/day	0.71 MT/ m^2/day	0.35 MT/ m^2/day	0.38 MT/ m^2/day	0.26 MT/ m^2/day	0.26 MT/ m^2/day	0.87 MT/ m^2/day
	St.St. Rate*	0.15MT/ m^2/day	0.60 MT/ m^2/day	0.69 MT/ m^2/day	0.37 MT/ m^2/day	0.16 MT/ m^2/day	0.24 MT/ m^2/day	0.30MT/ m^2/day	0.88 MT/ m^2/day
	Avg. Power Use	7.3 kW.hr/ kg glass	4.5 kW.hr/ kg glass	3.9 kW.hr/ kg glass	5.7 kW.hr/ kg glass	5.4 kW.hr/ kg glass	6.4 kW.hr/ kg glass	5.8 kW.hr/ kg glass	3.4 kW.hr/ kg glass

$ - Rates calculated from glass poured.

*- Rates calculated from feed data.

- Assumes the 15 g sugar/ liter added does not change density.

@ - Steady state was probably not attained due to run brevity or foaming.

Table 3.2.
Operational Measurements for DM1000, AZ-101 Test 1.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1 (EC)	1041	908	1101	1041
Discharge Chamber 2 (EC)	1004	881	1064	1004
Melter Pressure (inches, H_2O)	-0.96	-0.11	-3.38	-0.97
Transition Line Entrance (EC)	307	269	513	300
Plenum Thermowell (EC)	451	388	791	425
Glass (12" from bottom, EC)	1153	1119	1165	1154
Glass (5" from bottom, EC)	1132	1090	1150	1132
Exposed Plenum Thermocouple (EC)	439	361	795	411
Redundant Plenum Thermowell (EC)	447	385	788	422
Glass (24" from bottom, EC)	1152	1118	1168	1152
Current (Amps)	1007	15	1369	984
Bottom Electrode Power (kW)	66	10	128	61
Voltage (V)	64	1	104	62
Current(Amps)	0	0	0	0
Top Electrode Power (kW)	0	0	0	0
Voltage (V)	0	0	0	0
Cumulative Power (kW)	66	10	128	61

Table 3.3.
Operational Measurements for DM1000, AZ-101 Test 2.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1 (EC)	1031	800	1098	1042
Discharge Chamber 2 (EC)	997	767	1061	1007
Melter Pressure (inches H_2O)	-1.12	-0.11	-4.55	-1.10
Transition Line Entrance (EC)	318	243	618	314
Plenum Thermowell (EC)	412	301	895	400
Glass (5" from bottom, EC)	1150	1118	1166	1151
Glass (12" from bottom, EC)	1151	1128	1166	1151
Glass (5" from bottom, EC)*	1149	1125	1170	1149
Exposed Plenum Thermocouple (EC)	399	171	886	384
Well Plenum Thermowell* (EC)	410	299	892	397
Glass (12" from bottom, EC)	1152	1128	1168	1152
Glass (24" from bottom, EC)	1132	1073	1157	1133
Current (Amps)	1011	6	1522	996
Bottom Electrode Power (kW)	81	4	128	79
Voltage (V)	80	1	110	82
Current (Amps)	577	0	1466	707
Top Electrode Power (kW)	48	0	124	56
Voltage (V)	77	0	111	82
Cumulative Power (kW)	129	5	244	135

*Redundant

Table 3.4.
Operational Measurements for DM1000, AZ-101 Test 3.

	Avg.	Min.	Max.	Median
Discharge Chamber 1 (EC)	1035	990	1103	1034
Discharge Chamber 2 (EC)	998	954	1064	997
Melter Pressure (inches H_2O)	-1.02	-0.51	-0.69	-0.96
Transition Line Entrance (EC)	421	342	571	415
Plenum Thermowell (EC)	591	460	799	570
Glass (5" from bottom, EC)	1130	1095	1161	1132
Glass (12" from bottom, EC)	1148	1107	1174	1150
Glass (5" from bottom, EC)*	1131	1090	1171	1133
Exposed Plenum Thermocouple (EC)	589	394	807	569
Well Plenum Thermowell*	587	455	795	565
Glass (12" from bottom, EC)	1149	1107	1177	1152
Glass (24" from bottom, EC)	1151	1059	1208	1149
Current (Amps)	1166	556	1518	1196
Bottom Electrode Power (kW)	95	41	129	102
Voltage (V)	80	34	107	81
Current (Amps)	486	0	1260	441
Bottom Electrode Power (kW)	45	0	115	21
Voltage (V)	65	21	110	63
Glass (36" from bottom, EC)	1108	971	1181	1115
Cumulative Power (kW)	140	49	241	127

*Redundant

Table 3.5.
Operational Measurements for DM1000, AZ-101 Test 4.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1(EC)	1032	964	1082	1040
Discharge Chamber 2 (EC)	995	928	1042	1003
Melter Pressure (inches H_2O)	-1.30	-0.82	-4.60	-1.18
Transition Line Entrance (EC)	312	270	486	297
Plenum Thermowell (EC)	404	342	507	387
Glass (5" from bottom, EC)	1139	1112	1163	1139
Glass (12" from bottom, EC)	1150	1118	1175	1151
Glass (5" from bottom*, EC)	1140	1111	1167	1140
Exposed Plenum Thermocouple (EC)	379	155	562	367
Well Plenum Thermowell* (EC)	400	338	503	383
Glass (12" from bottom, EC)	1152	1119	1177	1153
Glass (24" from bottom, EC)	1149	1118	1190	1151
Current (Amps)	1079	420	1500	1049
Bottom Electrode Power (kW)	75	19	129	70
Voltage (V)	67	29	98	64
Current (Amps)	407	0	1319	521
Top Electrode Power (kW)	24	0	98	25
Voltage (V)	52	17	93	51
Glass (36" from bottom, EC)	1100	819	1165	1104
Cumulative Power (kW)	99	19	215	87

*Redundant

Table 3.6.
Operational Measurements for DM1000, AZ-101 Test 5.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1(EC)	1028	945	1122	1029
Discharge Chamber 2 (EC)	990	909	1080	991
Melter Pressure (inches H_2O)	-1.17	0	-5.13	-1.03
Transition Line Entrance (EC)	310	233	510	308
Plenum Thermowell (EC)	429	307	760	426
Glass (5" from bottom, EC)	1139	1095	1167	1141
Glass (12" from bottom, EC)	1153	1108	1182	1154
Glass (5" from bottom*,EC)	1138	1092	1172	1140
Exposed Plenum Thermocouple (EC)	401	142	760	392
Well Plenum Thermowell* (EC)	425	306	756	422
Glass (12" from bottom, EC)	1155	1109	1185	1156
Glass (24" from bottom, EC)	1161	1127	1203	1161
Current (Amps)	995	2	1488	921
Bottom Electrode Power (kW)	67	0	129	51
Voltage (V)	64	0	101	56
Current (Amps)	614	0	1541	554
Top Electrode Power (kW)	36	0	105	25
Voltage (V)	56	0	103	49
Glass (36" from bottom, EC)	969	491	1178	972
Cumulative Power (kW)	103	2	229	76

*Redundant

Table 3.7.
Operational Measurements for DM1000, AZ-101 Test 6.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1 (EC)	985	928	1032	996
Discharge Chamber 2 (EC)	946	877	992	958
Melter Pressure (inches H_2O)	-1.39	-0.25	-2.86	-1.40
Transition Line Entrance (EC)	326	309	346	324
Plenum Thermowell (EC)	435	419	450	434
Glass (5" from bottom, EC)	1119	1110	1127	1120
Glass (12" from bottom, EC)	1153	1149	1157	1153
Glass (5" from bottom*, EC)	1120	1106	1128	1121
Exposed Plenum Thermocouple (EC)	420	391	442	420
Well Plenum Thermowell* (EC)	431	415	445	430
Glass (12" from bottom, EC)	1157	1152	1161	1157
Glass (24" from bottom, EC)	1180	1170	1189	1180
Current (Amps)	1027	888	1295	1017
Bottom Electrode Power (kW)	60	50	86	60
Voltage (V)	59	48	71	59
Current (Amps)	571	443	782	571
Top Electrode Power (kW)	23	19	28	25
Voltage (V)	47	39	55	47
Glass (36" from bottom, EC)	1007	880	1102	1011
Cumulative Power (kW)	83	69	112	85

*Redundant

Table 3.8.
Operational Measurements for DM1000, AZ-101 Test 7.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1 (EC)	1023	880	1133	1033
Discharge Chamber 2 (EC)	985	843	1090	994
Transition Line Entrance (EC)	322	204	338	321
Glass (5" from bottom, EC)	1135	1113	1149	1136
Glass (12" from bottom, EC)	1153	1142	1171	1153
Glass (5" from bottom*, EC)	1138	1112	1152	1139
Exposed Plenum Thermocouple (EC)	436	310	755	421
Well Plenum Thermowell* (EC)	448	398	772	434
Glass (12" from bottom, EC)	1155	1144	1175	1155
Glass (24" from bottom, EC)	1161	1146	1200	1160
Current (Amps)	930	643	1396	919
Bottom Electrode Power (kW)	52	29	91	50
Voltage (V)	55	40	78	55
Current (Amps)	563	189	1012	562
Top Electrode Power (kW)	24	8	55	25
Voltage (V)	47	31	63	47
Glass (36" from bottom, EC)	1076	702	1159	1077
Cumulative Power (kW)	76	45	138	76

*Redundant

Table 3.9.
Operational Measurements for DM1000, AZ-101 Test 8.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1(EC)	932	39	1047	967
Discharge Chamber 2 (EC)	896	39	1008	930
Melter Pressure (inches H_2O)	-1.58	-0.99	-3.24	-1.53
Transition Line Entrance (EC)	417	32	647	417
Plenum Thermowell (EC)	540	36	949	539
Glass (5" from bottom, EC)	1149	1132	1165	1149
Glass (12" from bottom, EC)	1151	1133	1173	1152
Glass (5" from bottom*, EC)	1151	1132	1171	1152
Exposed Plenum Thermocouple (EC)	526	35	945	525
Well Plenum Thermowell* (EC)	558	504	947	536
Glass (12" from bottom, EC)	1151	1132	1171	1151
Glass (24" from bottom, EC)	1137	1111	1155	1138
Current (Amps)	1196	788	1457	1195
Bottom Electrodes Power (kW)	93	58	126	92
Voltage (V)	77	53	94	77
Current (Amps)	855	228	1273	889
Top Electrode Power (kW)	56	8	93	60
Voltage (V)	69	34	94	69
Glass (36" from bottom, EC)	1110	843	1160	1133
Cumulative Power (kW)	148	77	218	151

*Redundant

Table 3.10
Summary of Results from DuraMelter 1000 C-106/AY-102 Throughput Tests.

Test #		1	2	3
Time	Feed Start	2/1/00 1312	2/7/00 1622	2/15/00 1435
	Feed End	2/2/00 1517	2/11/00 1623	2/19/00 1600
	Interval	26.1 hr	96.0 hr	97.4 hr
Cold cap burn		1.7 hr	5.0 hr	0.5 hr
Bubbling Rate		130-205 l/min	0 l/min	90-100 l/min
Feed	Used	4480 kg	1888 kg	10902 kg
	Avg. Rate	172 kg/hr	22 kg/hr	111 kg/hr
	St.St. Rate	173 kg/hr	23 kg/hr	112 kg/hr
GlassProduced	Poured	1363.0	850.0	4729.5
	Avg. Rate	0.98 MT/ m^2/day	0.17 MT/ m^2/day	0.97 MT/ m^2/day
	Avg. Rate*	1.25 MT/ m^2/day	0.16 MT/ m^2/day	0.81 MT/ m^2/day
	St.St. Rate*	1.25 MT/ m^2/day	0.16 MT/ m^2/day	0.85 MT/ m^2/day
	Avg. Power Use	3.1 kW.hr/ kg glass	8.0 kW.hr/ kg glass	3.5 kW.hr/ kg glass

*- Rates calculated from feed data.

Table 3.11.
Operational Measurements for DM1000, C-106/AY-102 Test # 1.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1(EC)	1061	1031	1090	1060
Discharge Chamber 2 (EC)	1028	914	1077	1031
Transition Line Entrance (EC)	457	371	547	456
Glass (5" from bottom, side,EC)	1155	1121	1185	1156
Glass (12" from bottom, side, EC)	1150	1118	1176	1150
Glass (12" from bottom, center, EC)	1121	1090	1141	1123
Glass (24" from bottom, side, EC)	1128	1098	1154	1129
Glass (36" from bottom, center, EC)	1113	1083	1131	1115
Plenum Thermowell (EC)	559	508	692	551
Redundant Plenum Thermowell (EC)	556	505	692	548
Exposed Plenum (EC)	511	430	702	500
Bottom Electrode Current (A)	1257	37	1375	1287
Bottom Electrode Power (kW)	119	16	129	126
Bottom Electrode Voltage (V)	94	12	107	97
Top Electrode Current (A)	919	277	1292	971
Top Electrode Power (kW)	74	9	88	82
Top Electrode Voltage (V)	85	20	97	88

Table 3.12.
Operational Measurements for DM1000, C-106/AY-102 Test # 2.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1(EC)	1035	999	1062	1035
Discharge Chamber 2 (EC)	988	863	1039	989
Transition Line Entrance (EC)	352	331	544	349
Glass (5" from bottom, side,EC)	1121	1084	1150	1121
Glass (12" from bottom, side, EC)	1148	1110	1174	1149
Glass (12" from bottom, center, EC)	1126	1091	1147	1136
Glass (24" from bottom, side, EC)	1170	1135	1209	1172
Glass (36" from bottom, center, EC)	1068	904	1141	1078
Plenum Thermowell (EC)	438	408	770	434
Redundant Plenum Thermowell (EC)	437	407	768	433
Exposed Plenum (EC)	414	334	771	408
Bottom Electrode Current (A)	849	602	1175	841
Bottom Electrode Power (kW)	47	22	95	46
Bottom Electrode Voltage (V)	56	36	83	55
Top Electrode Current (A)	408	0	939	530
Top Electrode Power (kW)	17	0	68	22
Top Electrode Voltage (V)	43	20	75	45

Table 3.13.
Operational Measurements for DM1000, C-106/AY-102 Test # 3.

	AVG	MIN	MAX	MEDIAN
Discharge Chamber 1(EC)	1036	493	1087	1038
Discharge Chamber 2 (EC)	971	744	1044	978
Transition Line Entrance (EC)	434	409	577	431
Glass (5" from bottom, side, EC)	1159	1129	1185	1159
Glass (12" from bottom, side, EC)	1128	1006	1184	1148
Glass (12" from bottom, center, EC)	1111	1071	1144	1111
Glass (24" from bottom, side, EC)	1101	948	1170	1139
Glass (24" from bottom, center, EC)	1104	1069	1138	1104
Plenum Thermowell (EC)	528	495	857	523
Redundant Plenum Thermowell (EC)	525	492	855	520
Exposed Plenum (EC)	469	318	855	463
Bottom Electrode Current (A)	1168	838	1357	1168
Bottom Electrode Power (kW)	94	50	121	94
Bottom Electrode Voltage (V)	81	59	95	81
Top Electrode Current (A)	742	323	993	741
Top Electrode Power (kW)	47	25	77	47
Top Electrode Voltage (V)	69	40	82	70

Table 3.14.
Summary of Results from DuraMelter 1000 West Valley Throughput Tests.

Test #		1				2				3
		A	B	C	TOTAL	A	B	C	TOTAL	
Time	Feed Start	12/13/99 1248	12/16/99 0057	12/16/99 1610		12/20/99 1349	12/21/99 1400	12/22/99 1408		1/4/00 1745
	Feed End	12/16/99 0057	12/16/99 1609	12/17/99 1059		12/21/99 1359	12/22/99 1407	12/23/99 1408		1/5/00 1605
	Inter-val	60.2 hr	15.2 hr	18.8 hr	94.2 hr	24.2 hr	24.1 hr	24.0 hr	72.3 hr	22.3 hr
Cold cap burn		NA	NA	NA	1.5 hr	NA	NA	NA	2.2 hr	2.0 hr
Electrode Pairs		Bottom	Both	Top		Bottom	Top	Both		Both
Bubbling		NO	NO	NO	NO	NO	NO	NO	NO	YES
Feed	Used	2834 kg	638 kg	1028 kg	4500 kg	1408 kg	1132 kg	1087 kg	3626 kg	5070 kg
	Avg. Rate	47 kg/hr	42 kg/hr	55 kg/hr	47 kg/hr	58 kg/hr	47 kg/hr	45 kg/hr	49 kg/hr	209 kg/hr
	St.St. Rate	45 kg/hr	51 kg/hr	63 kg/hr	ND	40 kg/hr	49 kg/hr	49 kg/hr	ND	220 kg/hr
Glass Produced	Pour-ed	ND	ND	ND	1301 kg	317 kg	434 kg	376 kg	1127 kg	1396 kg
	Avg. Rate[$]	ND	ND	ND	0.28 MT/ m^2/day	0.26 MT/ m^2/day	0.36 MT/ m^2/day	0.31 MT/ m^2/day	0.31 MT/ m^2/day	1.16 MT/ m^2/day
	Avg. Rate[*]	0.29 MT/ m^2/day	0.26 MT/ m^2/day	0.33 MT/ m^2/day	0.29 MT/ m^2/day	0.36 MT/ m^2/day	0.29 MT/ m^2/day	0.28 MT/ m^2/day	0.31 MT/ m^2/day	1.27 MT/ m^2/day
	St.St. Rate[*]	0.27 MT/ m^2/day	0.31 MT/ m^2/day	0.38 MT/ m^2/day	ND	0.24 MT/ m^2/day	0.30 MT/ m^2/day	0.30 MT/ m^2/day	ND	1.32 MT/ m^2/day
	Avg. Power Use	4.5 kW.hr/ kg glass	5.5 kW.hr/ kg glass	4.3 kW.hr/ kg glass	ND	4.1 kW.hr/ kg glass	4.6 kW.hr/ kg glass	5.3 kW.hr/ kg glass	ND	2.7 kW.hr/ kg glass

[$] - Rates calculated from glass poured.

[*]- Rates calculated from feed data, glass yield = 420 g/liter; density = 1.39 g/ml

Table 3.15.
Operational Measurements for DM1000, West Valley Test 1 (Part A, Bottom Electrodes).

	AVG	MIN	MAX	MEDIAN
Plenum Thermowell (EC)	472	398	867	467
Exposed Plenum Thermocouple (EC)	454	367	841	446
Redundant Plenum Thermowell (EC)	470	397	865	464
Glass (5" from bottom, side, EC)	1138	1095	1150	1140
Glass (5" from bottom, side, EC)	1131	1091	1139	1132
Glass (12" from bottom, side, EC)	1154	1125	1163	1153
Glass (12" from bottom, side, EC)	1154	1125	1163	1153
Glass (24" from bottom, EC)	1163	1143	1185	1164
Glass (36" from bottom, EC)	1159	1144	1179	1159
Bottom Electrode Current (A)	1046	0.0	1376	1041
Bottom Electrode Power (kW)	68.4	0.0	126	67.5
Bottom Electrode Voltage (V)	64.5	55.2	94.8	63.9
Top Electrode Current (A)	0.10	0.03	1.15	0.04
Top Electrode Power (kW)	1.69	0.11	2.61	1.83
Top Electrode Voltage (V)	35.4	30.9	52.7	35.0

Table 3.16.
Operational Measurements for DM1000, West Valley Test 1 (Part B, Top + Bottom Electrodes).

	AVG	MIN	MAX	MEDIAN
Plenum Thermowell (EC)	414	380	447	427
Exposed Plenum Thermocouple (EC)	391	342	430	402
Redundant Plenum Thermowell (EC)	412	378	444	424
Glass (5" from bottom, side, EC)	1135	1124	1149	1133
Glass (5" from bottom, side, EC)	1129	1118	1144	1128
Glass (12" from bottom, side, EC)	1147	1135	1161	1144
Glass (12" from bottom, side, EC)	1147	1135	1162	1144
Glass (24" from bottom, EC)	1164	1145	1200	1156
Glass (36" from bottom, EC)	1167	1144	1203	1160
Bottom Electrode Current (A)	751	534	1022	739
Bottom Electrode Power (kW)	43.0	32.1	74.9	42.5
Bottom Electrode Voltage (V)	56.8	46.6	81.2	57.3
Top Electrode Current (A)	579	0.0	1037	559
Top Electrode Power (kW)	28.2	2.0	62.7	27.0
Top Electrode Voltage (V)	49.7	34.8	77.6	50.3

Table 3.17.
Operational Measurements for DM1000, West Valley Test 1 (Part C, Top Electrodes).

	AVG	MIN	MAX	MEDIAN
Plenum Thermowell (EC)	443	420	460	444
Exposed Plenum Thermocouple (EC)	425	385	445	427
Redundant Plenum Thermowell (EC)	441	418	457	442
Glass (5" from bottom, side, EC)	1088	1073	1131	1084
Glass (5" from bottom, side, EC)	1087	1073	1127	1084
Glass (12" from bottom, side, EC)	1107	1094	1143	1104
Glass (12" from bottom, side, EC)	1108	1096	1143	1105
Glass (24" from bottom, EC)	1152	1145	1156	1152
Glass (36" from bottom, EC)	1162	1145	1171	1162
Bottom Electrode Current (A)	4.60	2.02	789	2.52
Bottom Electrode Power (kW)	6.77	3.78	48.0	6.79
Bottom Electrode Voltage (V)	38.5	29.8	62.2	38.8
Top Electrode Current (A)	1125	599	1246	1134
Top Electrode Power (kW)	71.1	30.1	78.9	72.2
Top Electrode Voltage (V)	63.2	50.7	68.8	63.7

Table 3.18.
Operational Measurements for DM1000, West Valley Test 2 (Part A, Bottom Electrodes).

	AVG	MIN	MAX	MEDIAN
Plenum Thermowell (EC)	450	394	860	420
Exposed Plenum Thermocouple (EC)	432	370	808	400
Redundant Plenum Thermowell (EC)	447	391	858	417
Glass (5" from bottom, side, EC)	1124	1100	1137	1125
Glass (12" from bottom, side, EC)	1144	1134	1154	1144
Glass (24" from bottom, side, EC)	1165	1152	1182	1165
Glass (24" from bottom, center, EC)	1125	1091	1148	1125
Glass (30" from bottom, center, EC)	1113	1076	1137	1113
Glass (36" from bottom, side, EC)	1161	1116	1180	1161
Bottom Electrode Current (A)	1017	790	1195	993
Bottom Electrode Power (kW)	66.4	40	90.4	62.3
Bottom Electrode Voltage (V)	64.1	48.6	77.7	62.8
Top Electrode Current (A)	0.05	0.04	0.31	0.04
Top Electrode Power (kW)	1.25	0.34	2.12	1.25
Top Electrode Voltage (V)	35.2	26.5	42.5	34.5

Table 3.19.
Operational Measurements for DM1000, West Valley Test 2 (Part B, Top Electrodes).

	AVG	MIN	MAX	MEDIAN
Plenum Thermowell (EC)	419	403	439	419
Exposed Plenum Thermocouple (EC)	394	369	420	395
Redundant Plenum Thermowell (EC)	417	401	437	417
Glass (5" from bottom, side, EC)	1064	1045	1129	1060
Glass (12" from bottom, side, EC)	1084	1065	1146	1080
Glass (24" from bottom, side, EC)	1142	1132	1162	1142
Glass (24" from bottom, center, EC)	1138	1122	1154	1138
Glass (30" from bottom, center, EC)	1125	1094	1149	1125
Glass (36" from bottom, side, EC)	1162	1141	1188	1162
Bottom Electrode Current (A)	6.4	1.8	1003	2.6
Bottom Electrode Power (kW)	5	1.2	64.7	4.9
Bottom Electrode Voltage (V)	39.2	11.8	63.5	39.4
Top Electrode Current (A)	1047	0	1226	1062
Top Electrode Power (kW)	66.3	1.4	85.7	67.8
Top Electrode Voltage (V)	63.1	18.5	73.6	63.9

Table 3.20.
Operational Measurements for DM1000, West Valley Test 2 (Part C, Top + Bottom Electrodes).

	AVG	MIN	MAX	MEDIAN
Plenum Thermowell (EC)	419	374	441	422
Exposed Plenum Thermocouple (EC)	394	340	420	399
Redundant Plenum Thermowell (EC)	418	372	438	420
Glass (5" from bottom, side, EC)	1124	1055	1147	1125
Glass (12" from bottom, side, EC)	1140	1075	1158	1141
Glass (24" from bottom, side, EC)	1162	1133	1176	1164
Glass (24" from bottom, center, EC)	1166	1125	1187	1164
Glass (30" from bottom, center, EC)	1141	1084	1171	1145
Glass (36" from bottom, side, EC)	1141	1040	1169	1147
Bottom Electrode Current (A)	812	2.5	1112	819
Bottom Electrode Power (kW)	49.6	6	90	50.9
Bottom Electrode Voltage (V)	61.1	43.6	90.5	61.4
Top Electrode Current (A)	528	393	1132	524
Top Electrode Power (kW)	24.9	14.7	78.8	25
Top Electrode Voltage (V)	51.4	39.1	75.7	51.4

Table 3.21.
Operational Measurements for DM1000, West Valley Test 3.

	AVG	MIN	MAX	MEDIAN
Plenum Thermowell (EC)	460	407	917	447
Exposed Plenum Thermocouple (EC)	422	273	914	397
Redundant Plenum Thermowell (EC)	456	404	917	443
Glass (5" from bottom, EC)	1162	1131	1180	1164
Glass (12" from bottom, EC)	1159	1127	1177	1162
Glass (24" from bottom, EC)	1143	1107	1176	1144
Glass (36" from bottom, EC)	1141	1085	1174	1144
Bottom Electrode Current (A)	1219	1023	1349	1227
Bottom Electrode Power (kW)	112	88.9	122	111
Bottom Electrode Voltage (V)	92.6	77.8	104	91.5
Top Electrode Current (A)	804	652	940	810
Top Electrode Power (kW)	58.4	43.8	66.8	59.6
Top Electrode Voltage (V)	79	65.1	89.2	78.8

Table 4.1.
Glass Discharges from AZ-101 DM1000 Throughput Tests.

	Discharge Date	Glass Name	Measured Mass (kg)	Overall Cumulative Mass (kg)	Mass per Test (kg)
Turn-over	8/13/99	AZ-G-17A	392.5	392.5	3626.5
	8/16/99	AZ-G-29A			
	8/16/99	AZ-G-30A	413.0	805.5	
	8/17/99	AZ-G-36A			
	8/17/99	AZ-G-37A			
	8/17/99	AZ-G-37B	369.0	1191.5	
	8/18/99	AZ-G-40A			
	8/18/99	AZ-G-44A			
	8/18/99	AZ-G-44B	479.0	1670.5	
	8/18/99	AZ-G-44C			
	8/19/99	AZ-G-50A			
	8/19/99	AZ-G-50B			
	8/19/99	AZ-G-51A			
	8/19/99	AZ-G-52A	230.5	1901.0	
	8/19/99	AZ-G-52B			
	8/25/99	AZ-G-57B	362.0	2263.0	
	8/25/99	AZ-G-57C			
	8/25/99	AZ-G-57D			
	8/26/99	AZ-G-63A	355.5	2618.5	
	8/26/99	AZ-G-63B	203.5	2822.0	
	8/30/99	AZ-G-71A	330.0	3152.0	
	8/30/99	AZ-G-71B			
	9/9/99	AZ-G-89A	474.5	3626.5	
	9/10/99	AZ-G-90A			
	9/10/99	AZ-G-92A			
	9/10/99	AZ-G-92B			
	9/10/99	AZ-G-92C			

	9/10/99	AZ-G-92D			
TEST #1	9/13/99	AZ-G-101A	486.5	4096.0	569.5
	9/13/99	AZ-G-101B			
	9/13/99	AZ-G-101C			
	9/14/99	AZ-G-105A			
	9/14/99	AZ-G-107A			
	9/14/99	AZ-G-107B			
	9/15/99	AZ-G-108A			
	9/15/99	AZ-G-113A	83.0	4179.0	
	9/15/99	AZ-G-113B			
TEST #2	9/22/99	AZ-G-123A	446.0	4625.0	1203.5
	9/22/99	AZ-G-123B			
	9/22/99	AZ-G-123C			
	9/22/99	AZ-G-129A			
	9/22/99	AZ-G-134A			
	9/22/99	AZ-G-135A	482.0	5107.0	
	9/22/99	AZ-G-135B			
	9/22/99	AZ-G-135C			
	9/22/99	AZ-G-135D			
	9/23/99	AZ-G-138A			
	9/23/99	AZ-G-138B			
	9/23/99	AZ-G-138C			
	9/23/99	AZ-G-142A	275.5	5382.5	
	9/23/99	AZ-G-143A			
	9/23/99	AZ-G-145A			

Test #3	9/29/99	AZ2-G-7A	245.5	5628.0	637.5
	9/29/99	AZ2-G-7B			
	9/29/99	AZ2-G-14A			
	9/29/99	AZ2-G-14B			
	9/30/99	AZ2-G-14C			
	9/30/99	AZ2-G-14D	392.0	6020.0	
	9/30/99	AZ2-G-15A			
	9/30/99	AZ2-G-16A			

Table 4.1, continued.

	Discharge Date	Glass Name	Measured Mass (kg)	Overall Cumulative Mass (kg)	Mass per Test (kg)
Test# 4	9/30/99	AZ2-G-20A	343.0	6363.0	343.0
	9/30/99	AZ2-G-20B			
	9/30/99	AZ2-G-20C			
	10/1/99	AZ2-G-24A			
	10/1/99	AZ2-G-24B			
	10/1/99	AZ2-G-26A			
Test# 5	10/5/99	AZ2-G-30A	473.0	6836.0	1031.5
	10/5/99	AZ2-G-30B			
	10/5/99	AZ2-G-30C			
	10/5/99	AZ2-G-35A			
	10/6/99	AZ2-G-35B			
	10/6/99	AZ2-G-36A			
	10/6/99	AZ2-G-36B			
	10/6/99	AZ2-G-36C			
	10/6/99	AZ2-G-38A			
	10/6/99	AZ2-G-39A	491.5	7327.5	
	10/6/99	AZ2-G-39B			
	10/6/99	AZ2-G-42A			
	10/6/99	AZ2-G-42B			
	10/6/99	AZ2-G-42C			
	10/6/99	AZ2-G-44A			
	10/6/99	AZ2-G-44B			
	10/7/99	AZ2-G-45A			
	10/7/99	AZ2-G-45B			
	10/7/99	AZ2-G-50A	67.0	7394.5	
6	10/11/99	AZ2-G-54A	59.0	7453.5	59.0

	10/11/99	AZ2-G-54B			
TEST 7	10/13/99	AZ2-G-64A	355.0	7808.5	1136.0
	10/13/99	AZ2-G-65A			
	10/14/99	AZ2-G-66A	505.0	8313.5	
	10/14/99	AZ2-G-66B			
	10/14/99	AZ2-G-70A			
	10/14/99	AZ2-G-71A			
	10/14/99	AZ2-G-71B			
	10/14/99	AZ2-G-71C			
	10/14/99	AZ2-G-75A	276.0	8589.5	
	10/15/99	AZ2-G-78A			
	10/15/99	AZ2-G-78B			
TEST 8	10/20/99	AZ2-G-84A	510.5	9100.0	1173.5
	10/20/99	AZ2-G-85A			
	10/21/99	AZ2-G-85B			
	10/21/99	AZ2-G-86A			
	10/21/99	AZ2-G-86B			
	10/21/99	AZ2-G-86C			
	10/21/99	AZ2-G-88A	494.5	9594.5	
	10/21/99	AZ2-G-88B			
	10/21/99	AZ2-G-88C			
	10/21/99	AZ2-G-89A			
	10/21/99	AZ2-G-89B			
	10/21/99	AZ2-G-89C	168.5	9763.0	

Table 4.2.
Glass Discharges During C-106/AY-102 DM1000 Throughput Tests.

	Discharge Date	Glass Name	Measured Mass (kg)	Overall Cumulative Mass (kg)	Mass per Test (kg)
TURNOVER	1/19/00	C106-G-102A	429.0	429.0	3086.5
	1/19/00	C106-G-102B			
	1/19/00	C106-G-102C			
	1/19/00	C106-G-102D			
	1/19/00	C106-G-103A	440.0	869.0	
	1/19/00	C106-G-103B			
	1/19/00	C106-G-104A			
	1/19/00	C106-G-104B			
	1/20/00	C106-G-105A	476.5	1345.5	
	1/20/00	C106-G-105B			
	1/20/00	C106-G-110A			
	1/20/00	C106-G-110B			
	1/21/00	C106-G-115A	440.0	1785.5	
	1/21/00	C106-G-116A			
	1/21/00	C106-G-116B			
	1/24/00	C106-G-117A			
	1/24/00	C106-G-117B			
	1/24/00	C106-G-117C			
	1/24/00	C106-G-121A			
	1/24/00	C106-G-121B			
	1/24/00	C106-G-121C			
	1/24/00	C106-G-123A	492.0	2277.5	

	1/25/00	C106-G-124A			
	1/25/00	C106-G-125A			
	1/25/00	C106-G-125B			
	1/27/00	C106-G-131A	525.5	2803.0	
	1/27/00	C106-G-131B			
	1/27/00	C106-G-131C			
	1/27/00	C106-G-131D			
	1/27/00	C106-G-132A			
	1/28/00	C106-G-134A			
	1/28/00	C106-G-134B			
	1/28/00	C106-G-134C	283.5	3086.5	
	1/31/00	C106-G-139A			
TEST 1	2/1/00	C106-G-140A	493.5	3580.0	1363.0
	2/1/00	C106-G-140B			
	2/1/00	C106-G-140C			
	2/1/00	C106-G-144A			
	2/1/00	C106-G-144B	490.5	4070.5	
	2/1/00	C106-G-144C			
	2/2/00	C106-G-146A			
	2/2/00	C106-G-146B			
	2/2/00	C106-G-146C			
	2/2/00	C106-G-146D	379.0	4449.5	
	2/2/00	C106-G-146E			
	2/2/00	C106-G-148A			
	2/2/00	C106-G-148B			
	2/2/00	C106-G-148C			

Table 4.2, continued.

	Discharge Date	Glass Name	Measured Mass (kg)	Overall Cumulative Mass (kg)	Mass per Test (kg)
TEST 2	2/7/00	C106-G-15A	496.0	4945.5	850.0
	2/7/00	C106-G-15B			
	2/8/00	C106-G-24A			
	2/8/00	C106-G-28A			
	2/8/00	C106-G-28B			
	2/9/00	C106-G-33A			
	2/9/00	C106-G-33B	271.0	5216.5	
	2/10/00	C106-G-37A			
	2/10/00	C106-G-37B			
	2/10/00	C106-G-37C			
	2/10/00	C106-G-40A	83.5	5300.0	
	2/11/00	C106-G-45A			
	2/11/00	C106-G-45B			
TEST 3	2/14/00	C106-G-54A	501.0	5801.0	4729.5
	2/15/00	C106-G-58A			
	2/15/00	C106-G-58B			
	2/15/00	C106-G-58C	495.5	6296.5	
	2/16/00	C106-G-60A			
	2/16/00	C106-G-60B			
	2/16/00	C106-G-64A			
	2/16/00	C106-G-64B	502.0	6798.5	
	2/16/00	C106-G-66A			
	2/16/00	C106-G-68A			

	2/16/00	C106-G-68B			
	2/16/00	C106-G-70A	512.0	7310.5	
	2/17/00	C106-G-70B			
	2/17/00	C106-G-72A			
	2/17/00	C106-G-72B			
	2/17/00	C106-G-74A			
	2/17/00	C106-G-75A	488.0	7798.5	
	2/17/00	C106-G-75B			
	2/17/00	C106-G-77A			
	2/17/00	C106-G-77B			
	2/18/00	C106-G-83A	466.5	8265.0	
	2/18/00	C106-G-83B			
	2/18/00	C106-G-84A			
	2/18/00	C106-G-84B			
	2/18/00	C106-G-85A			
	2/18/00	C106-G-86A	488.0	8753.0	
	2/18/00	C106-G-86B			
	2/18/00	C106-G-86C			
	2/18/00	C106-G-86D			
	2/19/00	C106-G-90A	327.5	9080.5	
	2/19/00	C106-G-90B			
	2/19/00	C106-G-92A			
	2/19/00	C106-G-95A	482.0	9562.5	
	2/19/00	C106-G-96A			
	2/21/00	C106-G-97A			
	2/21/00	C106-G-97B	467.0	10029.5	
	2/21/00	C106-G-100A			

Table 4.3.
Glass Discharges From West Valley DM1000 Throughput Tests.

	Discharge Date	Glass Name	Measured Mass (kg)	Overall Cumulative Mass (kg)	Mass per Test (kg)
Turn-over	12/6/99	WV1000-G-106A	489.5	489.5	2788.0
	12/6/99	WV1000-G-106B			
	12/7/99	WV1000-G-114A			
	12/7/99	WV1000-G-114B			
	12/7/99	WV1000-G-114C			
	12/7/99	WV1000-G-117A			
	12/7/99	WV1000-G-117B	411.0	900.5	
	12/7/99	WV1000-G-118A			
	12/7/99	WV1000-G-118B			
	12/8/99	WV1000-G-120A	463.0	1363.5	
	12/8/99	WV1000-G-122A			
	12/8/99	WV1000-G-122B			
	12/8/99	WV1000-G-122C			
	12/8/99	WV1000-G-128A	464.0	1827.5	
	12/8/99	WV1000-G-128B			
	12/8/99	WV1000-G-132A			
	12/9/99	WV1000-G-132B			
	12/9/99	WV1000-G-132C	517.5	2345.0	
	12/9/99	WV1000-G-132D			
	12/9/99	WV1000-G-134A			
	12/9/99	WV1000-G-134B			
	12/9/99	WV1000-G-135A	443.0	2788.0	
	12/9/99	WV1000-G-135B			
	12/9/99	WV1000-G-139A			

	12/9/99	WV1000-G-139B			
	12/9/99	WV1000-G-139C			
TEST #1	12/13/99	WV1000-G-142A	524.0	3313.0	1300.5
	12/13/99	WV1000-G-147A			
	12/14/99	WV1000-G-148A			
	12/14/99	WV1000-G-11A			
	12/14/99	WV1000-G-11B			
	12/14/99	WV1000-G-11C			
	12/15/99	WV1000-G-18A			
	12/15/99	WV1000-G-16A	460.0	3773.0	
	12/15/99	WV1000-G-22A			
	12/15/99	WV1000-G-22B			
	12/15/99	WV1000-G-22C			
	12/16/99	WV1000-G-22D			
	12/16/99	WV1000-G-22E			
	12/16/99	WV1000-G-28A			
	12/16/99	WV1000-G-29A			
	12/16/99	WV1000-G-33A	316.5	4089.5	
	12/16/99	WV1000-G-33B			
	12/17/99	WV1000-G-33C			
	12/17/99	WV1000-G-33D			
TEST #2	12/20/99	WV1000-G-48A	434.0	4523.5	1245.0
	12/20/99	WV1000-G-48B			
	12/21/99	WV1000-G-52A			
	12/21/99	WV1000-G-52B			

	12/21/99	WV1000-G-52C			
	12/21/99	WV1000-G-52D			
	12/21/99	WV1000-G-54A	435.0	4958.5	
	12/21/99	WV1000-G-54B			
	12/21/99	WV1000-G-54C			
	12/22/99	WV1000-G-63A			
	12/22/99	WV1000-G-63B			
	12/22/99	WV1000-G-63C			
	12/22/99	WV1000-G-68A	376.0	5334.5	
	12/22/99	WV1000-G-68B			
	12/22/99	WV1000-G-68C			
	12/22/99	WV1000-G-77A			
	12/22/99	WV1000-G-77B			

Table 4.3, continued.

	Discharge Date	Glass Name	Measured Mass (kg)	Overall Cumulative Mass (kg)	Mass per Test (kg)
TEST 3	1/4/00	WV1000-G-79A	492.5	5827.0	1395.5
	1/4/00	WV1000-G-79B			
	1/4/00	WV1000-G-79C			
	1/4/00	WV1000-G-79D			
	1/5/00	WV1000-G-79E			
	1/5/00	WV1000-G-84A	431.0	6258.0	
	1/5/00	WV1000-G-86A			
	1/5/00	WV1000-G-86B			
	1/5/00	WV1000-G-86C	472.0	6730.0	
	1/5/00	WV1000-G-86D			
	1/5/00	WV1000-G-86E			
	1/5/00	WV1000-G-86F			

Table 4.4.
Composition of Glass Produced During DM1000 AZ-101 Tests.
(Wt% Oxide)

		52B	92D	113B	134A	138C	145A	2-14C	2-16A	2-26A	2-38A	2-45B	2-50A	2-71C	2-89C	Target	Analyzed Feed
Test #		Turnover		1	2			3		4	5			7	8		
Glass poured (kg)	0	1884	3610	4179	4625	5107	5383	5628	6020	6363	6836	7328	7395	8314	9763		
Al_2O_3	7.28	7.90	8.59	8.34	8.43	8.47	8.34	8.17	8.08	8.51	8.03	8.13	8.08	7.59	7.72	7.4	7.99
As_2O_3	0.03	0.03	0.04	0.01	0.03	0.03	0.04	0.03	0.03	0.05	0.03	0.03	0.04	0.05	0.05	0.04	0.04
B_2O_3	15.19	11.58	11.43	11.14	10.77	10.57	10.76	10.76	10.74	10.56	10.49	10.45	10.52	10.06	10.27	10	10.78
BaO	0.06	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.06	0.04	0.06
CaO	13.99	7.18	4.41	3.71	2.95	2.53	2.34	2.17	1.99	1.91	1.59	1.43	1.40	1.21	1.13	0.25	0.39
CdO	0.00	0.16	0.24	0.27	0.27	0.28	0.28	0.29	0.30	0.32	0.33	0.33	0.34	0.33	0.34	0.37	0.35
Cr_2O_3	0.14	0.26	0.16	0.12	0.11	0.10	0.11	0.10	0.10	0.06	0.08	0.07	0.07	0.06	0.08	0.04	0.05
CuO	0.03	0.05	0.07	0.13	0.07	0.07	0.08	0.06	0.07	0.06	0.05	0.05	0.06	0.05	0.05	0.03	0.05
Fe_2O_3	5.00	6.85	8.57	8.67	8.63	8.91	8.89	9.05	8.98	8.44	9.44	8.84	9.02	9.29	9.48	10.39	10.61
K_2O	0.87	0.63	0.41	0.37	0.34	0.31	0.31	0.31	0.30	0.33	0.28	0.32	0.29	0.25	0.26	0.17	0.22
Li_2O	0.12	2.61	4.05	4.32	4.67	4.78	4.80	4.83	4.92	5.10	5.02	5.10	5.08	5.05	5.11	6	5.90
MgO	8.78	4.58	2.78	2.16	1.84	1.63	1.54	1.43	1.32	1.30	1.03	0.92	0.90	0.67	0.57	0.06	0.10
MnO	0.09	1.53	2.38	2.65	2.27	2.33	2.42	2.46	2.50	2.41	2.49	2.51	2.54	2.52	3.14	3.03	2.78
Na_2O	12.57	8.63	8.28	7.87	7.35	7.30	7.16	6.99	6.89	7.05	6.66	6.76	6.66	6.38	6.29	6.59	6.34
NiO	0.12	0.34	0.39	0.35	0.39	0.40	0.42	0.42	0.44	0.31	0.40	0.43	0.43	0.43	0.47	0.54	0.51
P_2O_5	0.13	0.23	0.16	0.11	0.26	0.29	0.22	0.19	0.19	0.19	0.21	0.19	0.16	0.22	0.23	0.13	0.20
PbO	0.07	0.14	0.16	0.17	0.18	0.17	0.19	0.19	0.19	0.19	0.19	0.19	0.21	0.19	0.18	0.15	0.20
Sb_2O_3	0.05	0.09	0.12	0.14	0.18	0.17	0.17	0.17	0.18	0.17	0.18	0.19	0.18	0.18	0.18	0.21	0.19
SeO_2	0.02	0.03	0.01	0.03	0.05	0.02	0.01	0.05	0.03	0.00	0.04	0.03	0.02	0.05	0.02	0.15	0.03
SiO_2	29.89	36.65	41.08	42.45	40.31	41.01	40.69	41.66	41.02	41.59	42.26	41.08	42.00	42.39	43.27	45.53	42.81

SrO	0.08	1.02	1.55	1.66	1.68	1.76	1.80	1.87	1.85	1.91	1.89	1.90	1.92	1.92	1.93	2.32	2.17
TeO_2	0.01	0.08	NA	NA	NA	NA	NA	NA	NA	NA	0.12	NA	NA	0.15	0.12	0.14	0.08
TiO_2	0.43	0.30	0.21	0.18	0.21	0.17	0.16	0.16	0.15	0.16	0.15	0.16	0.15	0.13	0.14	0.06	0.12
ZnO	0.22	1.53	1.68	1.67	1.70	1.69	1.73	1.78	1.77	1.78	1.87	1.82	1.83	1.84	1.91	2	2.01
ZrO_2	0.63	2.06	2.94	3.10	3.03	3.02	3.10	3.11	3.15	3.45	3.30	3.46	3.52	3.28	3.38	3.56	3.60
SUM	95.80	94.53	99.80	99.71	95.78	96.07	95.65	96.30	95.25	95.93	96.18	94.46	95.50	94.33	96.37	99.20	97.56

NA - Not Analyzed

Table 4.5.
Composition of Glass Produced During DM1000 C-106/AY-102 Tests (wt% oxide)

Glass Poured (kg)	102D	106B	110B	121C	125B	134B	139A	144A	146C	148C	2-33A	2-37C	2-58B	2-64A	2-68B	2-72B	2-77B	2-85A	2-86D	2-92A	2-97A	2-100A	Target	Analyzed Feed
	429	869	1345	1786	2278	2803	3087	3580	4071	4450	4946	5217	5801	6297	6799	7311	7799	8265	8753	9081	9563	10030		
Ag_2O	0.03	0.05	0.08	0.11	0.14	0.16	0.13	0.14	0.16	0.17	0.20	0.20	0.21	0.22	0.22	0.21	0.23	0.21	0.22	0.20	0.20	0.20	0.24	0.22
Al_2O_3	6.96	7.35	8.25	8.39	8.90	9.54	9.15	9.00	9.75	9.55	10.60	10.37	10.37	11.01	10.70	11.11	10.49	10.64	10.77	11.09	10.51	10.60	10.78	10.61
B_2O_3	12.19	11.33	11.21	10.15	9.39	8.91	9.96	8.38	8.29	8.11	8.07	8.02	7.86	8.11	7.96	7.87	7.60	7.64	7.35	7.27	7.89	7.58	7	7.44
BaO	0.06	0.07	0.08	0.10	0.11	0.12	0.15	0.12	0.13	0.13	0.14	0.14	0.15	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.15	0.07	0.14
CaO	0.64	0.74	0.81	0.84	0.84	0.85	1.00	1.20	0.91	1.13	0.94	0.95	1.00	0.93	0.94	1.05	0.98	1.07	0.99	0.99	1.21	0.94	0.71	0.94
CdO	0.04	0.04	0.04	0.04	0.04	0.04	0.07	0.03	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Cr_2O_3	0.06	0.11	0.12	0.16	0.14	0.15	0.13	0.15	0.15	0.15	0.12	0.12	0.13	0.13	0.14	0.15	0.15	0.16	0.16	0.16	0.13	0.14	0.16	0.16
Fe_2O_3	11.47	11.13	11.55	11.37	11.47	11.24	10.66	10.25	11.17	10.67	10.92	11.25	11.33	11.45	11.59	10.83	11.08	10.70	10.93	10.76	10.36	10.59	11.73	11.21
K_2O	3.46	2.98	2.68	2.02	1.66	1.30	1.63	1.11	1.07	0.89	0.83	0.81	0.73	0.57	0.48	0.53	0.37	0.32	0.29	0.31	0.26	0.25	0.03	0.07
Li_2O	3.83	3.67	3.85	3.65	3.72	3.80	3.62	3.51	3.61	3.57	3.95	3.87	3.94	4.09	3.95	3.88	3.82	3.90	3.88	3.87	3.62	3.61	4	3.90
MgO	0.98	0.95	0.89	0.87	0.72	0.68	0.80	0.65	0.52	0.59	0.47	0.48	0.44	0.42	0.40	0.46	0.39	0.41	0.37	0.37	0.48	0.36	0.22	0.31
MnO	1.16	1.45	1.82	2.18	2.52	2.85	2.39	2.79	3.17	3.08	3.45	3.47	3.60	3.81	3.85	3.77	3.85	3.84	3.92	3.88	3.61	3.76	4.44	4.01
Na_2O	7.41	7.41	7.87	7.48	7.82	7.77	7.78	7.68	7.66	7.76	8.19	8.28	8.31	8.49	8.57	8.96	8.61	8.38	8.31	8.19	7.86	8.05	9.36	8.56
NiO	0.29	0.29	0.27	0.27	0.24	0.22	0.25	0.18	0.19	0.18	0.15	0.16	0.16	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.14	0.15	0.15	0.14
P_2O_5	1.06	0.97	0.88	0.74	0.67	0.52	0.61	0.48	0.51	0.41	0.35	0.35	0.37	0.26	0.30	0.29	0.34	0.27	0.31	0.26	0.33	0.30	0.15	0.26
PbO	0.05	0.08	0.10	0.13	0.16	0.18	0.16	0.15	0.18	0.18	0.23	0.23	0.25	0.25	0.25	0.24	0.25	0.24	0.25	0.25	0.21	0.21	0.22	0.25
SiO_2	40.75	39.69	40.27	39.68	39.90	39.87	39.46	38.49	40.00	40.25	39.56	40.51	40.87	40.52	40.89	40.55	40.61	39.62	39.21	39.35	40.13	39.42	40.89	39.39
SrO	0.81	1.30	2.00	2.79	3.51	4.20	3.34	4.18	4.87	4.85	5.52	5.50	5.91	6.08	6.06	6.00	6.04	6.09	6.23	6.23	5.91	6.12	7.35	6.60
TiO_2	0.78	0.69	0.62	0.53	0.41	0.33	0.41	0.24	0.24	0.20	0.19	0.19	0.17	0.15	0.13	0.13	0.12	0.11	0.10	0.11	0.10	0.10	0.04	0.07
ZnO	0.53	0.70	0.88	1.13	1.24	1.39	1.30	1.48	1.52	1.61	1.66	1.65	1.73	1.72	1.73	1.89	1.89	1.93	1.92	1.92	1.84	1.80	2	1.91
ZrO_2	3.17	2.71	2.47	1.96	1.59	1.28	1.63	1.25	1.11	1.04	0.81	0.81	0.73	0.61	0.55	0.58	0.47	0.49	0.41	0.41	0.50	0.37	0.12	0.21
Total	95.73	93.71	96.74	94.57	95.18	95.41	94.66	91.47	95.23	94.55	96.37	97.42	98.32	99.14	99.07	98.82	97.64	96.37	95.97	95.99	95.45	94.72	99.70	96.62

Table 4.6.
Composition of Glass Produced During DM1000 West Valley Tests.
(wt% oxide)

	95B	117A	118B	122C	132B	139C	29A	33D	52D	63C	77B	79E	86B	86F	Target	Analyzed Feed
Glass Poured (kg)	0	490	901	1364	1828	2788	3773	4090	4524	4959	5335	5827	6258	6730		
Al_2O_3	8.39	8.46	7.86	7.95	8.00	7.44	7.00	6.81	6.86	7.17	6.86	6.43	6.69	6.65	6.00	6.41
B_2O_3	10.24	11.02	10.99	11.42	11.19	11.23	11.42	11.28	12.57	12.56	11.91	12.69	13.09	12.88	12.90	12.84
BaO	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.05
CaO	1.11	1.03	0.94	0.87	0.80	0.76	0.66	0.63	0.64	0.68	0.59	0.68	0.59	0.57	0.50	0.50
Cr_2O_3	0.07	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.05	0.04	0.05	0.05	0.01
Fe_2O_3	9.01	10.17	9.40	10.27	10.08	10.39	11.22	11.01	11.37	11.47	11.36	11.45	11.89	11.49	12.02	13.44
K_2O	0.36	0.80	1.30	1.78	2.24	2.76	3.25	3.31	3.46	3.48	3.73	3.57	3.84	3.88	5.00	4.49
Li_2O	5.33	5.34	4.98	4.94	4.78	4.37	4.23	4.15	4.20	4.15	4.14	3.88	4.10	4.06	3.71	4.28
MgO	0.63	0.65	0.69	0.72	0.76	0.83	0.88	0.88	0.90	0.93	0.92	0.97	0.95	0.96	0.89	1.01
MnO	2.48	2.38	2.14	2.01	1.84	1.55	1.27	1.21	1.11	1.09	1.07	0.93	0.92	0.88	0.82	0.62
Na_2O	7.11	7.66	7.32	7.62	7.71	7.50	7.51	7.39	7.66	7.81	7.73	7.49	7.68	7.75	8.00	8.27
NiO	0.38	0.36	0.39	0.39	0.38	0.35	0.33	0.31	0.30	0.30	0.28	0.27	0.29	0.28	0.25	0.27
P_2O_5	0.12	0.29	0.36	0.49	0.67	0.78	0.95	1.00	1.04	1.05	1.10	1.14	1.15	1.18	1.20	1.34
SiO_2	43.85	42.28	41.83	42.99	42.42	42.44	42.33	41.80	42.06	43.41	42.30	40.93	41.07	39.52	43.27	37.22
SrO	1.97	1.84	1.54	1.39	1.19	0.92	0.72	0.66	0.60	0.56	0.48	0.40	0.40	0.37	0.20	0.19
TiO_2	0.14	0.20	0.30	0.37	0.45	0.56	0.67	0.68	0.71	0.72	0.75	0.74	0.78	0.79	0.80	0.91
ZnO	1.90	1.79	1.54	1.36	1.15	0.93	0.74	0.70	0.61	0.63	0.54	0.54	0.46	0.43	0.20	0.26
ZrO_2	3.47	3.50	3.39	3.51	3.47	3.30	3.18	3.15	3.29	3.27	3.23	3.24	3.37	3.34	3.43	3.61
Total	96.63	97.89	95.09	98.18	97.24	96.22	96.43	95.07	97.47	99.36	97.06	95.44	97.37	95.11	99.24	95.72

Table 4.7.
TCLP Results for AZ-101 and C-106/AY-102 Glasses.
(mg/l)

	Sample ID	**Ag**	**As**	**Ba**	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Sb**	**Se**	**Tl**	**Zn**
	UTS Limit	**0.14**	**5.00**	**21.00**	**0.11**	**0.60**		**11.00**	**0.75**	**1.15**	**5.70**	**0.20**	**4.30**
AZ-101	AZ-G-92D	<0.01	<0.05	0.04	0.10	0.01	0.09	0.12	0.05	0.04	<0.05	<0.04	0.63
	AZ2-G-45B	<0.01	<0.05	0.02	0.08	<0.01	0.02	0.08	0.03	<0.04	<0.05	<0.04	0.40
C-106/AY-102	C106-G-102D	<0.01	<0.05	0.02	0.01	<0.01	NA	0.04	<0.02	NA	<0.05	NA	0.12
	C106-G-100A	0.10	0.08	0.05	0.01	<0.01	NA	0.01	0.06	NA	<0.05	NA	0.47
	Detection Limits	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.04	0.05	0.04	<0.01

NA - Not Applicable, not present in formulation.

Table 4.8.
PCT Results for AZ-101, C-106/AY-102 and the DWPF EA Benchmark Glass (SRL-EA).

OXIDE%	AZ2-G-38A	C106-G-77B	SRL-EA
B	10.49	7.6	11.2
Li	5.02	3.82	4.26
Na	6.66	8.61	16.8
Si	42.26	40.61	48.7
PCT, ppm			
B	20.2	8.00	598
Li	13.8	7.87	184
Na	23.6	26.2	1546
Si	60.4	38.6	856
Normalized con.g/L			
	AZ2-G-38A	C106-G-77B	SRL-EA
B	0.619	0.339	17.2
Li	0.590	0.443	9.30
Na	0.477	0.410	12.4
Si	0.306	0.203	3.76
Normalized Leach Rate,g/m^2/d			
	AZ2-G-38A	C106-G-77B	SRL-EA
B	0.044	0.024	1.228
Li	0.042	0.032	0.664
Na	0.034	0.029	0.886
Si	0.022	0.015	0.269

Table 4.9.
Mössbauer Analysis of DM1000 Product Glasses

Test	Sample	Conditions	Result
AZ-101, Test 3	AZ2-G-14C	During Foaming	$< 5\%$ Fe^{++}
AZ-101, Test 3	AZ2-G-16A	During Foaming	$< 5\%$ Fe^{++}
AZ-101, Test 4	AZ2-G-26A	During Foaming	$< 5\%$ Fe^{++}
AZ-101, Test 6	AZ2-G-54B	Added Sugar	$< 5\%$ Fe^{++}
WV, Test 3	WV1000-G-86F	Final discharge, Added Sugar	$< 5\%$ Fe^{++}
C-106/AY-102, Test 3	C106-G-100A	Final discharge	$< 5\%$ Fe^{++}

Table 5.1.
Melter Emissions During AZ-101 DuraMelter 1000 Throughput Tests.

Test #		Test 1			Test 2			Test 5			Test 7		
Conditions		Low Solids, No Bubbling, No Foaming			Low Solids, Moderate Bubbling, No Foaming			Low Solids, No Bubbling, Vigorous Foaming[&]			High Solids, No Bubbling, No Foaming		
Average Glass Production Rate		0.18 MT/m^2/day			0.57 MT/m^2/day			0.38 MT/m^2/day			0.26 MT/m^2/day		
Stack Flow Rate		147 dscf/min			132 dscf/min			133 dscf/min			169 dscf/min		
Air Volume Sampled		32.318 dscf			32.270 dscf			31.898 dscf			40.917 dscf		
Moisture		18.9 %			28.6 %			38.3 %			11.0 %		
Fluxes (mg/min)		Feed*	Emitted	%	Feed	Emitted	%	Feed	Emitted	%	Feed	Emitted	%
Particle Emissions @	Solid	150 x 10^3	152	0.10	604 x 10^3	362	0.06	157 x 10^3	1203	0.77	283 x 10^3	147	0.05
	As	39	0.1	0.14	130	0.4	0.30	41	1.8	4.43	74	0.4	0.51
	B	4034	1.7	0.04	13319	6.8	0.05	4165	37.6	0.90	7614	3.2	0.04
	Ba	47	0.1	0.13	154	0.2	0.16	48	0.8	1.58	88	0.1	0.13
	Cd	421	0.7	0.18	1390	2.0	0.15	435	6.1	1.41	795	0.7	0.08

	Cl	13	< 2.0	<15.0	43	< 2.0	< 5.0	13	3.0	23.10	25	< 2.0	< 8.0
	Cr	36	1.1	3.07	117	2.7	2.29	37	3.2	8.69	67	0.2	0.37
	Cu	31	0.0	0.12	103	0.0	0.05	32	0.4	1.32	59	0.0	0.03
	Fe	9445	8.0	0.08	31180	13.3	0.04	9750	90.8	0.93	17824	8.0	0.05
	K	183	1.5	0.84	606	7.0	1.15	189	35.2	18.61	346	1.9	0.54
	Li	3623	4.1	0.11	11962	34.5	0.29	3740	35.5	0.95	6838	2.5	0.04
	Mn	3051	0.8	0.03	10071	32.9	0.33	3149	86.5	2.75	5757	3.8	0.07
	Ni	552	0.3	0.05	1821	0.9	0.05	569	1.3	0.23	1041	0.2	0.02
	Pb	181	0.4	0.21	598	0.6	0.10	187	1.4	0.74	342	0.2	0.05
	Sb	206	0.2	0.07	678	0.6	0.09	212	1.4	0.66	388	0.3	0.07
	Se	139	25.2	18.19	458	86.1	18.79	143	258.9	180.76	262	26.4	10.07
	Sr	2550	1.5	0.06	8419	3.0	0.04	2633	18.8	0.71	4813	1.5	0.03
	Tl	70	0.0	<0.01	230	0.1	0.05	72	0.6	0.87	132	0.1	0.04
	Zn	2089	1.9	0.09	6896	3.4	0.05	2156	18.6	0.86	3942	1.6	0.04
	Zr	3426	1.4	0.04	11311	1.7	0.02	3537	20.8	0.59	6466	1.1	0.02
Gaseous[#] Emissions	B	4034	30.4	0.75	13319	82.2	0.62	4165	151.6	3.64	7614	13.2	0.17

	Se	139	33.6	24.17	458	29.3	6.40	143	274.3	191.80	262	35.2	13.40
	S	130	92.1	70.85	429	100.9	23.51	134	67.1	50.11	245	35.7	14.57

& - Sample taken during vigorous foaming event.

* - Feed fluxes based on steady state rates.

\# - Constituents passing through a 0.45 µm filter and scrubbed in impinger solutions.

@ - Al, Si, Ca, Mg, Na and P were not included due to high concentrations in blank filter.

Table 5.2.
Melter Emissions During C-106/AY-102 DuraMelter 1000 Throughput Tests.

Test #		1			2			3					
Bubbling Rate		130-205 scfh			0 scfh			90-100 scfh					
Average Glass Production Rate		1.25 MT/m^2/day			0.16 MT/m^2/day			0.81 MT/m^2/day					
Sample Type		Melter Exhaust			Melter Exhaust			Melter Exhaust			HEME Exhaust		
Sampling Interval		2/2/00 1045-1148			2/10/00 1345-1445			2/16/00 1435-1525			2/18/00 1315-1956		
Stack Flow Rate		271 dscfm			175 dscfm			143 dscfm			155 dscfm		
Air Volume Sampled		37.30 dscf			54.28 dscf			38.34 dscf			222.37 dscf		
Moisture		5.9 %			0.7 %			27.8 %			2.4 %		
Fluxes (mg/min)		Feed*	Emitted	%	Feed	Emitted	%	Feed	Emitted	%	Feed	Emitted	%
Particle Emissions	Solid	1264 x 10^3	3527	0.28	162 x 10^3	7.00	<0.01	863 x 10^3	972	0.11	863 x 10^3	7.7	<0.01
	Ag	2327	3.43	0.15	298	0.02	0.01	1508	2.41	0.16	1508	0.18	0.01
	Al	59449	38.12	0.06	7609	0.05	<0.01	38523	10.51	0.03	38523	<0.01	<0.01
	B	22629	21.64	0.10	2897	0.04	<0.01	14664	28.51	0.19	14664	0.20	<0.01
	Ba	653	1.23	0.19	84	<0.01	<0.01	423	1.26	0.30	423	0.01	<0.01
	Ca	5287	3.73	0.07	677	0.06	0.01	3426	1.32	0.04	3426	0.20	0.01
	Cd	365	2.34	0.64	47	0.03	0.05	236	14.51	6.15	236	0.14	0.06
	Cl	312	7.66	2.46	40	< 1.5	< 3.7	202	< 1.5	< 0.7	202	< 0.3	< 0.2
	Cr	1140	2.06	0.18	146	0.06	0.04	739	1.35	0.18	739	0.01	<0.01
	Fe	85439	158.90	0.19	10936	0.16	<0.01	55365	64.03	0.12	55365	<0.01	<0.01
	K	259	1.96	0.76	33	<0.01	<0.01	168	8.80	5.24	168	0.14	0.08
	Li	19355	36.29	0.19	2477	0.05	<0.01	12542	21.56	0.17	12542	0.08	<0.01
	Mg	1382	0.92	0.07	177	0.01	0.01	895	0.32	0.04	895	<0.01	<0.01
	Mn	35819	47.65	0.13	4585	0.02	<0.01	23210	13.57	0.06	23210	<0.01	<0.01
	Na	72339	124.86	0.17	9259	0.12	<0.01	46875	97.09	0.21	46875	0.97	<0.01

	Ni	1228	1.90	0.15	157	0.03	0.02	796	0.67	0.08	796	<0.01	<0.01
	P	682	0.13	0.02	87	0.44	0.51	442	0.63	0.14	442	0.25	0.06
	Pb	2127	4.09	0.19	272	<0.01	<0.01	1379	4.78	0.35	1379	0.03	<0.01
	S	83	9.86	11.9	11	<0.01	<0.01	54	20.80	38.5	54	0.38	0.70
	Sr	64740	103.93	0.16	8287	0.03	<0.01	41952	44.36	0.11	41952	<0.01	<0.01
	Ti	250	0.20	0.08	32	<0.01	<0.01	162	0.22	0.14	162	<0.01	<0.01
	Zn	16737	29.93	0.18	2142	0.01	<0.01	10846	14.75	0.14	10846	0.03	<0.01
	Zr	925	2.83	0.31	118	0.06	0.05	600	0.73	0.12	600	<0.01	<0.01
Gaseous[#] Emissions	B	22629	21.5	0.10	2897	<0.1	<0.05	14664	76.00	0.5	14664	<0.1	<0.01
	Cl	312	10.2	3.26	40	<0.1	<0.36	202	31.10	15.3	202	<0.1	<0.05
	F	208	8.8	4.22	27	<0.1	<0.53	135	192.00	30.4	135	<0.1	<0.07
	S	83	9.0	10.8	11	<0.1	<1.43	54		519	54	<0.1	<0.19

* - Feed fluxes based on steady state rates.

\# - Constituents passing through a 0.45 μm filter and scrubbed in impinger solutions.

Table 5.3.
Melter Emissions During West Valley DuraMelter 1000 Throughput Test 2. (No Bubbling, 0.3 MT glass/m^2/day)

Sampling Date		36515		
Sampling Interval		1338 - 1438		
Air Sample Volume		56.747 dscf		
Air Flow Rate		143 dscfm		
% Moisture		11.1		
Fluxes (mg/min)		Feed	Emissions	%
Gaseous Emissions #	B	10009	82.1	0.8
	Cl	Not in formulation	5.3	NA
	F	Not in formulation	4.2	NA
	NO_x	69680	15909	22.8
	S	210	6.9	3.3
Particulate Emissions	Solids	370767	643.50	0.17
	Al	7941	3.80	0.05
	B	10009	39.72	0.40
	Ca	893	< 0.01	< 0.01

	Cr	86	0.07	0.08
	Fe	21012	46.44	0.22
	K	10377	31.38	0.30
	Li	4308	11.98	0.28
	Mg	1342	2.01	0.15
	Mn	1588	1.03	0.06
	Na	14839	42.78	0.29
	Ni	491	1.02	0.21
	P	1310	3.02	0.23
	S	210	< 1.6	< 0.76
	Sr	423	0.93	0.22
	Ti	1199	0.67	0.06
	Zn	402	1.00	0.25
	Zr	6348	15.19	0.24

- Calculated from impinger solutions (1 M NaOH followed by 10% H_2O_2/ 5% HNO_3) that are preceded by a 0.45 µm heated filter. NOx is not efficiently removed in impingers and therefore reported gas values may under represent actual fluxes.