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Final Report Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification

VSL-05R5800-1, Rev. 0, 6/27/05

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

Office of River Protection

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Final Report

Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification

prepared by

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for

Duratek, Inc.

and

Bechtel National, Inc.

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Test Exceptions: 24590-HLW-TEF-RT-04-00025, 24590-HLW-TEF-RT-04-00026, 24590-HLW-TEF-RT-04-00028
Test Plan: VSL-04T4800-1, Rev. 0
R&T Focus Area(s): HLW Vitrification, HLW Off-Gas
Test Scoping Statement(s): VH-4, VHO-3, VHO-2, VH-5

Completeness of Testing:

This report describes the results of work and testing specified by the above-listed Test Specification(s), Test Plan(s), and Text Exception(s). The work and any associated testing followed established quality assurance requirements and was conducted as authorized. The descriptions provided in this test report are an accurate account of both the conduct of the work and the data collected. Results required by the Test Plan are reported. Also reported are any unusual or anomalous occurrences that are different from the starting hypotheses. The test results and this report have been reviewed and verified.

I.L. Pegg: _____ **Date:** 6/27/05
VSL Program Director/Principal Investigator

I. Joseph: Innocent Joseph **Date:** 6/27/05
Duratek Sub-Contract Manager

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List of Abbreviations

AA	Atomic Absorption Spectroscopy
ACM	Aspen Custom Modeler
AC-S	Sulfur Impregnated Activated Carbon
ADS	Air Displacement Slurry
AOD	Air Operated Diaphragm
BBI	Best Basis Inventory
CFR	Code of Federal Regulation
CPVC	Chlorinated Polyvinyl Chloride
DCP	Direct Current Plasma Emission Spectroscopy
DF	Decontamination Factor
DM	DuraMelter®
DOE	Department Of Energy
FTIR	Fourier Transform Infrared Spectroscopy
HEME	High-Efficiency Mist Eliminator
HEPA	High-Efficiency Particulate Air Filter
HLW	High Level Waste
i.d.	Inside Diameter
ISE	Ion Selective Electrode
LAW	Low Activity Waste
MS	Microsoft
MT	Metric Ton
ORP	Office of River Protection
PBS	Packed Bed Scrubber
PLC	Programmable Logic Controller
PTFE	Polytetrafluroethylene
QAPjP	Quality Assurance Project Plan for Testing Programs Generating Environmental Regulatory Data
QCGR	Qualified Glass Composition Region
RPP	River Protection Project
RPP-WTP	River Protection Project-Waste Treatment Plant
SBS	Submerged Bed Scrubber
SCR	Selective Catalytic Reduction
TCO	Thermal Catalytic Oxidizer
TDS	Total Dissolved Solids
TFCOUP	Tank Farm Contractor Operation and Utilization Plan
TRU	Transuranic
TSS	Total Suspended Solids
VOC	Volatile Organic Compound
VSL	Vitreous State Laboratory
W.C.	Water Column
WESP	Wet Electrostatic Precipitator
WTP	Waste Treatment Plant
XRF	X-Ray Fluorescence

SUMMARY OF TESTING

A) Objectives

The principal objectives of the DM1200 melter tests were to determine the effects of feed rheology, feed solid content, and bubbler configuration on glass production rate and off-gas system performance while processing the HLW AZ-101 and C-106/AY-102 feed compositions; characterize melter off-gas emissions; characterize the performance of the prototypical off-gas system components, as well as their integrated performance; characterize the feed, glass product, and off-gas effluents; and perform pre- and post test inspections of system components. The specific objectives (including test success criteria) of this testing, along with how each objective was met, are outlined in the following table. Test objectives are numbered from 1 to 14 and success criteria are listed as "a" through "k".

Test Objective	Objective Met?	Discussion Section
1. Define melter testing matrices that provide sufficient coverage of the testing variables defined in Section 6, Test Conditions [6]. The test matrix for each variable is to be provided in the test plan. The test plan shall define each test variable and is to include a discussion of test variable development and basis by which the testing strategy and approach will provide a sufficient technical basis for WTP HLW melter processing constraints. The order in which the testing variables are performed should be done to optimize the testing and take into consideration predecessor activities such as glass formulation support and the maturity of the QGCR boundary definitions.	Yes	See Test Plan [12] and associated Test Exceptions [38, 39, 44].
2. Define the laboratory, small-scale melter (DM10 and DM100) and DM1200 pilot melter testing that are required for each variable defined in Section 6, Test Conditions. The maximum melter scale proposed should be based on the data quality requirements and the scale necessary to achieve that quality of data. (a) When completed, the test results data shall sufficiently define the effects of the test variables on melter throughput attainment and any deleterious processing conditions.	Yes	DM100 and DM1200 testing is described in Sections 3 and 4, respectively. Tables 3.1 and 4.1 provide glass production rate data and summary data for DM100 and DM1200 melter testing.
3. Perform DM10, DM100 and DM1200 melter testing and associated feed handling and off-gas treatment equipment testing. The duration of each campaign or test period shall be sufficient to satisfy the objectives defined in the test plan. (a) When completed, the test results data shall sufficiently define the effects of the test variables on melter throughput attainment and any deleterious processing conditions.	Yes	This report is limited to DM100 and DM1200 testing; no DM10 testing was needed. DM100 data are provided in Tables 3.1-3.4. DM1200 data are provided in Tables 4.1-4.3.

Test Objective	Objective Met?	Discussion Section
4. Continue to assess the HLW bubbler design, operating life, modes of bubbler failure, and if necessary, alternative designs required to achieve a minimum two-month operating life. (b) Document the performance of the HLW bubbler design and placement recommended by the Duratek design staff and recommend alternative design or placement alternatives if deemed to be superior. Provide a mean time to failure estimate of the Inconel-690 bubbler or alternate design if used.	Yes	The recommended bubbler design and placement was employed for these tests as described in Section 1.4.5. Performance with respect to production is provided in Table 4.1. Information on bubbler corrosion and operating lifetimes has been reported separately.
5. For each test, establish and maintain melter throughput rates at the maximum steady state rate. (a) When completed, the test results data shall sufficiently define the effects of the test variables on melter throughput attainment and any deleterious processing conditions.	Yes	Section 3.2 and 4.0 describe attainment of steady state rates and processing conditions for the DM100 and DM1200, respectively.
6. Characterize the melter emissions (particulate, aerosol, and gaseous) under nominal steady-state operating conditions for inorganics and organic compounds. Measurement of organic compounds can be satisfied through the use of Fourier Transform Infra-Red Spectroscopy (FTIR), H_2 and CO monitors. (c) Obtain, report and assess melter emissions (particulate, aerosol, and gaseous) data under nominal steady state operating conditions for each test.	Yes	Section 7.0 provides data and detailed description of melter emissions.
7. Quantify and document the occurrence and associated operating conditions of any melter off-gas volume surging events. (d) Document the occurrence and associated operating conditions of any melter off-gas volume surging events.	Yes	Section 5.0 provides melter pressure data and control air flow rates during testing. Occasional pressure spikes were observed during processing. These transient spikes were typically associated with breakup and rapid incorporation of cold cap sections into the melt.
8. Characterize the performance of the primary off-gas treatment equipment (SBS, WESP and HEME) to remove particulate, aerosol and gas phase emissions under steady state melter conditions. Measurement of organic compounds can be satisfied through the use of FTIR, H_2 and CO monitors. (e) Obtain, report and assess the ability of the primary off-gas treatment equipment (SBS, WESP and HEME) to remove particulate, aerosol and gas phase emissions under steady state melter conditions.	Yes	Section 5.0 provides operational details of off-gas system components. Emissions sampling to quantify unit efficiency was not specified in the Test Plan [12].

Test Objective	Objective Met?	Discussion Section
9. Characterize the performance of the secondary off-gas treatment equipment (SCR, TCO and small-scale silver mordenite column) to treat NO_x and capture iodine emissions under steady state melter conditions. Measurement of organic compounds can be satisfied through the use of FTIR, H_2 and CO monitors. (A sulfur-impregnated activated carbon system is being added and will be similarly characterized.) (g) Measure and document the performance of the secondary off-gas treatment equipment (SCR, TCO and small-scale silver mordenite column) to treat NOx and capture iodine emissions under steady state melter conditions.	Yes	See Sections 5.0 and 7.0. Data are presented for the SCR, TCO, and AC-S. The silver mordenite system was not used during these tests; its performance was reported previously [19]. Nitrogen oxide and volatile organic compound emission rates were not sufficient in the off-gas stream to quantify secondary off-gas treatment performance.
10. Characterize the chemical and physical characteristics of the aqueous streams (feed, SBS, WESP, and caustic scrubber). (f) Measure and document the chemical and physical characteristics of the aqueous streams (feed, SBS, WESP and caustic scrubber).	Yes	Section 2.2 provides detailed feed analysis. Section 5.2 provides detailed off-gas fluid analyses.
11. Obtain the necessary process measurements to provide mass and energy balances throughout the systems, including process monitoring of power, voltage, current, resistance, temperatures, pressures, flow rates, and cooling water and air flows and inlet and outlet temperatures. (h) Document process measurements that provide mass, and energy balances throughout the systems, including process monitoring of power, voltage, current, resistance, temperatures, pressures, flow rates, and cooling water and air flows and inlet and outlet temperatures.	Yes	Data for measured melter parameters are provided in Section 3.0 and data for measured off-gas parameters are in Section 5.0.
12. Document general equipment operations (reliability, availability, maintainability, etc.); especially non-routine equipment failure and replacement activities. (i) Assess and document general equipment operations (reliability, availability, maintainability, etc.), especially non-routine equipment failure and replacement activities.	Yes	Data are presented and discussed in Sections 3.0, and 5.0.
13. Perform pre- and post-test inspections of key equipment and process lines to monitor for solids accumulations and corrosion/erosion of materials, especially ammonium nitrate downstream of the SCR. (j) Document pre- and post-test inspections of key equipment and process lines to monitor for solids accumulations and corrosion/erosion of materials.	Yes	Inspection information for off-gas equipment is provided in Section 5.0. Inspection downstream of the SCR was covered in a previous report [42].

Test Objective	Objective Met?	Discussion Section
14. Operate the melter plenum pressure control using the variable air-injection control method. Assess and document control stability (melter plenum and off-gas system pressure versus time) as a function of instrument controller settings. (k) Document the performance of the melter plenum pressure control using the variable air-injection control method. Document control stability (melter plenum and off-gas system pressure versus time) as a function of instrument controller settings.	Yes	Section 5.0 discusses melter pressure data and control air flow rates during testing.

B) Test Exceptions

Test Exception	Description
24590-HLW-TEF-RT-04-00025	Specified dilutions of adjusted rheology AZ-102 feed
24590-HLW-TEF-RT-04-00026	Specified dilutions and production rates of nominal AZ-102 feed
24590-HLW-TEF-RT-04-00028	Specified riser glass sampling and analysis for high-waste-loading C-106/AY-102 composition.

C) R&T Testing Conditions

Prior to performing the DM1200 tests, three screening tests were performed on the DM100 melter system in order to ensure the success of the larger-scale tests. The tests are described below in the order in which they were conducted:

- AZ-102 composition, nominal rheology (target glass yield = 0.384 kg/kg or 560 g/l): 60 hours at a constant bubbling rate of 9 lpm to compare cold cap limited production rates with previous DM100 AZ-101 results [7] and rates obtained with adjusted-rheology AZ-102 feed. Peristaltic pump used to facilitate observations of cold cap behavior.

- AZ-102 composition, rheology adjusted by NOAH to be more viscous (target glass yield = 0.384 kg/kg or 560 g/l): 47 hours at a constant bubbling of 9 lpm to compare cold cap limited production rates with previous DM100 AZ-101 results [7] and rates obtained with nominal AZ-102 feed. Peristaltic pump used to facilitate observations of cold cap behavior.

- C-106/AY-102, high-waste-loading composition (target glass yield = 0.327 kg/kg or 420 g/l): 106 hours adjusting bubbling to maximize processing rate. Feed introduced into melter by simulated ADS pump system for direct comparison to previous tests.

Based on the successful completion of the DM100 tests, five tests were performed on the DM1200 melter system with HLW AZ-102 and C-106/AY-102 simulants between 6/21/04 and

11/12/04, producing over 21 metric tons of glass. The total testing duration, including the time for water feeding and cold-cap burn-off, was 433 hours, during which over 69 metric tons of feed was processed. A summary of the test conditions and results is provided in Table 4.1. The tests were conducted to determine the effects of feed rheology, feed solids content, waste loading and bubbler configuration on glass production rate as well as off-gas system performance. The tests are summarized below in the order they were conducted:

- Test 1A1: 50 hours processing an adjusted rheology AZ-102 composition (target glass yield = 0.384 kg/kg or 560 g/l). Constant bubbling at 65 lpm from two, single-outlet "J" lance bubblers pointing towards the center and 6" from the floor.

- Test 1A2: 42 hours processing an adjusted rheology AZ-102 composition (target glass yield = 0.347 kg/kg or 480 g/l). Constant bubbling at 65 lpm from two, single-outlet "J" lance bubblers pointing towards the center and 6" from the floor.

- Test 1B: 114 hours processing a nominal rheology, AZ-102 composition (target glass yield = 0.27 kg/kg or 340 g/l). Bubbling adjusted in an attempt to obtain a target production rate of 1050 kg/m^2/day from double-outlet lance bubblers on the melter floor, 8" apart on East and West side, one bubbler outlet 11.3" from feed tube.

- Test 2A: 107 hours processing an adjusted rheology C-106/AY-102 composition (target glass yield = 0.372 kg/kg or 540 g/l). Constant bubbling at 65 lpm from two, single-outlet "J" lance bubblers with outlets located 6" from the bottom of the melter, placed in the corners, and pointed towards the melt pool center.

- Test 2B: 105 hours processing a high-waste-loading C-106/AY-102 composition (target glass yield = 0.263 kg/kg or 340 g/l). Bubbling was adjusted to obtain a production rate of 1050 kg/m^2/day from double-outlet lance bubblers on the melter floor, 8" apart on East and West side, one bubbler outlet 11.3" from feed tube.

The DM1200 HLW Pilot Melter is a Joule-heated melter with Inconel 690 electrodes. The melter shell is water-cooled and incorporates a jack-bolt thermal expansion system. The footprint of the melter is approximately 8 ft by 6.5 ft with a 4 ft by 2.3 ft air-lift discharge chamber appended to one end; the melter shell is almost 8 ft tall. The melt surface area and the melt pool height are approximately 32 percent and 57 percent, respectively, of the corresponding values for the full-scale HLW melter. The discharge riser and trough are full-scale to verify pouring performance. The surface of the glass pool is about 1.2 m^2, and the volume is about 849 liters, corresponding to about 2 metric tonnes. The feed system consists of a mix tank and a feed tank, both of which are 750-gallon polyethylene tanks with conical bottoms that are fitted with mechanical agitators. The feed tank is also fitted with baffles to improve mixing and calibrated load cells that are electronically monitored to determine the feed rate to the melter. The feed is introduced into the melter using an air-displacement-slurry (ADS) pump, which is the present RPP-WTP baseline. Feed from the ADS pump flows into the melter through a prototypic un-cooled feed nozzle that is located above the center of the glass pool. The melter and entire off-gas treatment system are maintained under negative pressure by two Paxton external induced

draft blowers. This negative pressure is necessary to direct the gases from the melter to the prototypical off-gas system. The off-gas treatment system consists of a submerged bed scrubber (SBS); a wet electrostatic precipitator (WESP); a high-efficiency mist eliminator (HEME), a high-efficiency particulate air (HEPA) filter; a thermal catalytic oxidation unit (TCO); a NO_x removal system (SCR); a packed-bed caustic scrubber (PBS); and a second HEME. A sulfur impregnated activated carbon column was installed between the HEPA and the TCO prior to the last test. The second HEME is used to limit entrained particle carryover into the balance of the VSL ventilation system; the PBS and the second HEME are not part of the WTP off-gas train, which effectively ends at the SCR.

The following table outlines the specific testing conditions established in the Test Plan:

R&T Test Condition (from Test Plan [12])	**Status**
Melter	--
Bulk glass temperature target - 1150°C (typically allowed to vary ± 25°C before power input changes are initiated). The bulk glass temperature is taken as the average of the readings from thermocouples located 13, 15.5, and 18 in. from the bottom.	Satisfied. See Table 4.3.
Plenum temperature - 400°C – 450°C (this is a dependent variable whose actual value is the result of cold cap coverage, air inleakage and other conditions).	Values were generally higher than target, as reported in Table 4.3.
Feed rate – as-required to achieve plenum temperature range. This is expected to require a cold cap coverage of 80 to 90% of the glass surface.	Values reported in Tables 4.1.
Melter plenum pressure is controlled by the air injection method described in Section 2.3. The air flow rate will be as required to maintain stable plenum pressure control without exceeding maximum SBS non-condensable gas flow rate. If compatible with melter and SBS operations, an air rate that is based on ~3X the melter condensable rate (essentially the steam rate) would be used to most closely simulate WTP assumptions. The typical control air flow rate on the DM1200 system is about 40 scfm.	Air injection method was used for plenum pressure control. Formation of cold cap mounds and ridges during one of the tests resulted in processing problems and occasional pressure spikes. See discussions in Sections 4.0 and 5.0.
A camera in the inspection view-port will provide for monitoring and recording of solids buildup during the tests.	Satisfied.
Film cooler: No special constraints; typically 70 scfm of air at about 100°C. Air flow to the film cooler will be maintained during idling or, alternatively, the film cooler will be removed. During operations, the film cooler will be washed down with water spray periodically (as directed by the operating procedures, presently every 12 hours).	Typical flow rates for the film cooler were about 70 scfm. The film cooler was periodically rinsed. A new slotted spray wand was tested.

R&T Test Condition (from Test Plan [12])	Status
SBS	--
Tank temperature - 50°C unless condensation downstream requires lowering the temperature. Based on previous test results, a nominal sump temperature of 40°C is expected to be necessary to prevent downstream condensation.	Average SBS water temperatures were about 50°C as reported in Table 5.2. During the last test the sump temperature was allowed to rise to determine the highest possible temperature which could be maintained without downstream condensation.
Liquid level – utilize lower overflow point.	Satisfied.
Condensate purge rate – 100 to 150 gallons per day. This parameter is intended to simulate the expected SBS condensate dissolved and undissolved solids concentrations for the full-scale facility. To achieve this purge rate, a separate water supply is in place to meter make-up water into the SBS, as needed. This average purge rate will be accomplished in blow-downs of about 40 gallons, as needed. The variation in the purge rate should be within about +/- 20 gallons per day.	Average SBS blow-down rates for the tests were as follows: Test 1A: 419 gal/day Test 1B: 585 gal/day Test 2A: 286 gal/day Test 2B: 660 gal/day The specified variation is not relevant across tests involving feeds of vastly disparate water contents, as was the case for the present tests.
All SBS blow-downs will be via the solids removal "square" pick-up wand to help minimize solids accumulation. Accumulation of solids on the bottom of the SBS tank will be assessed after each test. Any solids deposits will be allowed to remain between tests to determine whether the accumulation volume remains static or increases with time.	SBS blow-downs were via the pick-up wand. Infrared inspections of the SBS down-comer were performed. WTP directed the SBS bowl not to be dropped in between tests therefore deposits in the bowl could not be quantified.
Solids sparger lances will be operated on a timer cycle (10 seconds on, 20 seconds off, with lances operated in opposing pairs) throughout the tests.	Satisfied.
No down-comer extension pipe; however, the Project may later direct the installation of an alternative design for testing.	Satisfied.
A camera in the inspection view-port will provide for monitoring and recording of solids buildup in the down-comer pipe during the tests.	Infrared inspections of the SBS down-comer were performed.
WESP	--
Operate at maximum current to achieve maximum voltage without sparking. Based on previous experience this would be about 17 milliamps and 31 - 33 kilovolts.	WESP performance is discussed in Section 5.1.3. Average operating values were: Test 1A: 29.6 kV, 16.7 mA Test 1B: 29.0 kV, 16.7 mA Test 2A: 29.1 kV, 16.8 mA Test 2B: 29.2 kV, 16.7 mA
Inlet water spray – 2 gph ± 0.2 gph.	Satisfied except for a period during Test 1A2 as a result of a drop in building supply water pressure. Data reported in Section 5.1.
As a part of normal operation, the WESP electrodes will be deluged with water from the internal overhead nozzle once a day at the nominal rate of 20 gpm for 2 minutes.	The WESP was deluged daily at a nominal rate of 12 gpm for 3.3 minutes. The spray was turned off immediately before and after deluges. See Section 5.1. The time delays for reinstatement of stable operation are documented in Table 5.4.

R&T Test Condition (from Test Plan [12])	Status
At end of each melter feeding test, inspect WESP internals prior to and after typical wash-down operation.	Discussion and photos provided. See Section 5.1.
--	--
HEME: Operate with 0.2 gph continuous water spray or per manufacturer's recommendations (< 50 mg/acfm of entrained liquid water).	HEME 1 operated with 0.2 gph spray except for a period during Test 1A2 as a result of a drop in building supply water pressure. See Section 5.1.4.
HEPA Pre-heater: Operate to achieve a temperature rise between 10-20°C. Do not exceed a 20°C temperature rise unless condensation in the HEPA housing or downstream of the HEPA or increased pressure drop across the HEPA indicate higher temperatures are required to maintain stable operation.	HEME 1 outlet and HEPA outlet temperatures are reported in Table 5.2. Test average temperature rise value for these tests was about 17°C.
TCO: Bed temperature per the catalyst manufacturer's recommendation and previous test results (approximately 400°C). Based on previous tests, the gas residence time is about 0.16 sec.	TCO and SCR inlet temperatures are reported in Table 5.2. Average TCO inlet temperatures ranged from 404-474°C. Average SCR inlet (TCO bed outlet) temperatures ranged from 397-410°C.
SCR: Bed temperature – per the catalyst manufacturer's recommendation (350-400°C).	Satisfied. SCR inlet and outlet temperatures are reported in Table 5.2.
SCR: Ammonia slip (exit concentration) ≤ 25 ppm, if possible.	Concentrations of nitrogen oxides produced from the HLW were not sufficient to access SCR performance.
All other melter and off-gas treatment system unit operation process and control parameters will be within standard limits and reported in the test summary report.	See Tables 5.1and Table 5.2. No significant deviations from expected limits were observed.

D) Results and Performance Against Objectives

Melter tests were conducted on the DM1200 to determine the effects of feed rheology, feed solids content, and bubbler configuration on glass production rate and off-gas system performance while processing the HLW AZ-101 and C-106/AY-102 feed compositions. Several of these tests were preceded by screening tests on the DM100 melter system. Four tests of 92 to 114 hours in duration were conducted using different feed rheologies, feed solids contents, waste loadings, and bubbler configurations for comparisons to results from previous melter tests. Several of the tests employed adjusted rheology feeds that were intended to provide better representations of the rheological properties of some of the more viscous actual waste samples that have been characterized; the majority of the previous melter testing has been performed with HLW waste simulants that are of somewhat lower viscosity. The test results showed that the rheology-adjusted feeds processed at rates that were four to fifty percent higher than in analogous tests with the less viscous feeds, indicating that the previous test results likely give an accurate to conservative estimate of processing rate. Tests with AZ-102 simulants showed that reduction of the waste solids content to the expected Project minimum value (corresponding to a glass yield of 340 g/L) dramatically reduced the feed processing rate, to the extent that the target glass production rate of 1050 kg/m^2/day could not be achieved. Efforts to achieve the target rate included adjustment of bubbling rates as well as skewing of the total bubbler flow between the bubblers. Significant differences in processing rate were observed as a function of simulant composition for rheology-adjusted feeds and at lower feed solids contents, suggesting that the

previously held conclusion that the processing rates for different HLW simulants are virtually identical may only apply to the four HLW simulants previously tested, which were simulants with high waste solids contents and with lower viscosities.

The optimized bubbler configuration, with double-outlet bubblers in modified locations, resulted in obtaining the target production rate of 1050 kg/m^2/day with the high-waste-loading C-106/AY-102 formulation, despite the high water content of the feed. A production rate of only 900 kg/m^2/day was achieved with the AZ-102 composition at the same waste solids content; however, this rate is a sixty percent increase from previous tests with AZ-101 feed at the same waste solids content using two *single*-outlet bubblers.

The adjusted rheology AZ-102 feed was processed without difficulties with the simulated ADS pump on the DM100 but could not be processed with the actual ADS pump on the DM1200. Observations during attempts to process the feed suggest that the feed was not moving through the pump screen, remaining caked to the outside of the pump in a manner similar to the LAW Sub-Envelope B feeds tested previously. The feed was subsequently diluted from 20% UDS from pretreatment to 17% UDS, after which the feed was processed without incident. No feed system difficulties were encountered with the rheology-adjusted or high-waste-loading C-106/AY-102 feeds. The higher viscosity feeds were easily processed in the DM100 and DM1200 melters, spreading well across the melt surface and forming stable cold caps.

The general performance of the DM1200 melter and off-gas treatment system was good. Design modifications to the internals of the SBS, directed by the Project to address the build-up of solids in the downcomer, were completed and installed prior to the tests. The limited testing performed subsequent to these changes suggests that the build-up of deposits in the downcomer may be less extensive as a result of the modifications. Numerous film cooler blockages requiring mechanical clean-out occurred throughout the tests, particularly during high-bubbling periods with low solids content feed. A slotted spraying wand, fed with air and water, that was inserted into the film cooler region was ineffective at preventing deposits from forming and at removing deposits occluding the film cooler. A sulfur-impregnated carbon bed was installed in between the HEPA filter and the catalyst unit prior to the last test. No problems with the carbon bed were encountered; however, the concentrations of gaseous species such as volatile organics and nitrogen oxides were very low during these tests. Extensive sets of process engineering data were collected during the tests.

The glass product was close to the intended composition for all elements except zirconium once the melt inventory was turned over; the absolute deviations for zirconium were small and did not impact the test objectives. After processing the high-waste-loading C-106/AY-102 formulation and idling the melters for various amounts of time, glass samples were taken from the air-lift discharge risers of the DM100 and DM1200 to determine the extent of spinel crystallization in the riser. The samples were analyzed by various microscopic methods. The results indicated that a limited amount of spinels (~0.4 vol%) formed in the DM100 riser after idling whereas no spinels were observed in the DM1200 riser samples. The difference may be due to the much shorter idling duration for the DM1200 samples as a result of the schedule for the subsequent HLW MACT tests, as well as differences in temperature and composition.

Isokinetic particulate samples were taken at the melter outlet for tests using adjusted rheology feed. The purpose of these samples was to determine the effects of changes in feed rheology on melter emissions. Particulate carryover from the melter was comparable to most previous tests conducted at the same melter conditions. The composition of the melter emissions was unchanged by differences in feed rheology. Elemental DF values were determined across the melter and compared to elemental accumulations in off-gas system effluent solutions. Other emissions data collected during the tests included concentrations of various gaseous species throughout the primary off-gas system by FTIR and hydrogen concentrations by gas chromatography at the WESP outlet. The carbon column installed prior to the last test had very little effect on the concentrations of gaseous species in the off gas; however, the concentrations of most species, including nitrogen oxides, were already very low.

The volumes of processing solutions generated in the SBS, WESP, HEME, and PBS were documented during testing and representative samples were subjected to chemical analysis. The SBS solutions were close to neutral pH, due in large part to the lack of acid gases in the exhaust stream. The major dissolved species were halogens, boron, and alkali metals, while the suspended species closely resembled the feed composition. The measured SBS TSS and TDS values were comparable to each other during each test and had concentrations ranging between 3 and 7 g/L. The WESP sump fluid was also in the neutral pH region except during the test with selenium in the feed; as has been observed previously, the selenium concentrated in the WESP solutions, turning them acidic. The WESP solutions contained significant concentrations of dissolved boron, sulfate, and alkali halides, with negligible suspended solids. The WESP was sprayed continuously during these tests and was deluged with 40 gallons of water once daily, resulting in a daily blow-down volume of between 70 and 150 gallons. The 8,583 gallons of liquid that accumulated in the SBS during testing originated from the condensation of water from the melter feed.

E) Quality Requirements

This work was conducted under a quality assurance program that is in place at the VSL that is based on NQA-1 (1989) and NQA-2a (1990) Part 2.7. This program is supplemented by a Quality Assurance Project Plan for RPP-WTP work that is conducted at VSL. Test and procedure requirements by which the testing activities are planned and controlled are also defined in this plan. The program is supported by VSL standard operating procedures that were used for this work. This work was not subject to DOE/RW-0333P or the requirements of the RPP-WTP QAPjP for environmental testing.

F) Simulant Use

This testing used HLW AZ-102 and C-106/AY-102 simulants with a composition described in Section 2.0; this composition was defined in the BNI Test Specification [22]. A second C-106/AY-102 composition was directed for use in the second test with this waste stream [23]. This composition is based on actual waste data [24]. For several tests, the rheology of the

waste simulants was adjusted to approximate rheology targets provided by WTP R&T in order to assess the effects of feed rheology on the test results.

G) Issues

Although the rheology-adjusted feeds processed at or above the rates previously attained with the corresponding less-viscous waste simulants, the observed differences in processing rates for different waste compositions for adjusted rheology feeds and lower solids content feeds challenge the previously held notion that all HLW waste streams can be processed at approximately the same rate under similar conditions.

These and previous tests showed that significant improvements in glass production rates could be achieved by employing modified bubbler configurations. These improvements appear to be sufficient to more than make up for the production rate short-fall brought about by the reduction in the solids content in the feed from pretreatment from 20 wt% to 15 wt% undissolved solids. However, attainment of the target rate was not possible for all simulants after further reduction in solids content. Attempts to achieve the target rate with low solids content feed resulted in unstable melter conditions and frequent blockages of the film cooler.

The modified SBS design appeared to show less tendency for clogging than did the previous design, but longer test durations are needed to confirm this.

Film cooler clogging continued to be a significant operational problem; their frequency appeared to increase with bubbling rate and glass production rate.

Maintaining a cold cap limited feed rate during DM1200 tests is dependent on frequent visual monitoring of conditions in the melter plenum. The planned operation of the WTP melters based on only non-visual data, such as plenum temperature, could lead to either under feeding of the melter resulting in lower than attainable production rates or over feeding of the melter resulting in excessive cold-cap buildup as well as other operational difficulties. Testing under such conditions is therefore recommended to determine whether the required glass production rates can be achieved without the artificial visual data.

SECTION 1.0
INTRODUCTION

The WTP Project has undertaken a "tiered" approach to vitrification development testing involving computer-based glass formulation, glass property-composition models, crucible melts, and continuous melter tests of increasing, more realistic scales. Melter systems ranging from 0.02 to 1.2 m^2 installed at VSL have been used for this purpose, which, in combination with the 3.3 m^2 LAW Pilot Melter at Duratek, Inc. span more than two orders of magnitude in melt surface area. In this way, less-costly small-scale tests can be used to define the most appropriate tests to be conducted at the larger scales in order to extract maximum benefit from the large-scale tests. For HLW vitrification development, a key component in this approach is the one-third scale DuraMelter™ 1200 (DM1200) HLW Pilot Melter system that has been installed at VSL with an integrated prototypical off-gas treatment system. This system replaced the DM1000 system that was used for HLW throughput testing during Part B1 [1]. Both melters have similar melt surface areas (1.2 m^2) but the DM1200 is prototypical of the present WTP HLW melter design whereas the DM1000 was not. In particular, the DM1200 system provides for testing on a vitrification system with the specific train of unit operations that has been selected for both HLW and LAW WTP off-gas treatment [2].

Previous testing with HLW simulants on the DM1000 [1] and DM1200 [3, 4] indicated that while processing rates considerably above the project baseline (0.4 MT/m^2/d) were possible with bubbling, the baseline rate was not achieved in tests performed without bubblers. As a result of this testing, it was concluded and recommended that the current WTP HLW melter design is not capable of achieving the baseline production rate of 1.5 MT/d without the use of bubblers [5]. Testing has shown that the use of bubblers could also provide ORP the "performance enhancement" necessary to achieve the expanded capacity per melter of 3.0 MT/d, which is the present requirement under the so-called "2+2" revised baseline [6]. Following the Project decision to include bubblers in the reference HLW design, DM1200 testing was conducted to determine the processing rates achievable with bubbling for each of the Phase 1 HLW feed compositions [7-10]. In addition, estimates of waste solids content from pretreatment have decreased thereby increasing melter feed water content and placing greater demands on melter feed processing capacity. In response, a series of tests was conducted with the objective of optimizing the HLW bubbler configuration, within the constraints of the existing melter lid design, in order to achieve higher feed processing rates [11].

The data provided in this Final Report address the impacts of HLW melter feed rheology on melter throughput and validation of the simulated HLW melter feeds. The primary purpose of this testing is to further validate/verify the HLW melter simulants that have been used for previous melter testing [3-11] and to support their continued use in developing melter and off-gas related processing information for the Project. The primary simulant property in question is rheology. Simulants and melter feeds used in all previous melter tests were produced by direct addition of chemicals; these feed tend to be less viscous than rheological the upper-bound feeds made from actual wastes. Data provided here compare melter processing for the melter feed used

in all previous DM100 and DM1200 tests (nominal melter feed) with feed adjusted by the feed vendor (NOAH Technologies) to be more viscous, thereby simulating more closely the upper-bounding feed produced from actual waste. This report provides results of tests that are described in the Test Plan for this work [12]. The Test Plan is responsive to one of several test objectives covered in the WTP Test Specification for this work [6]; consequently, only part of the scope described in the Test Specification was addressed in this particular Test Plan [12]. For the purpose of comparison, the tests reported here were performed with AZ-102 and C-106/AY-102 HLW simulants and glass compositions that are essentially the same as those used for recent DM1200 tests [8, 9]. One exception was the use of an alternate, higher-waste-loading C-106/AY-102 glass composition that was used in previous DM100 tests [13] to further evaluate the performance of the optimized bubbler configuration.

1.1 Test Objectives

As listed in the Test Specification for this work [6], the principal objectives of these tests are identified below. Section 6 of the Test Specification ("Test Conditions") [6] describes test "Variability Parameters" in the following nine areas:

(1) *Effect of REDOX on throughput*
(2) *Effect of "troublesome" components on processability and off-gas emissions*
(3) *Assess impact of waste loading or ±15% GFCs variability on processability*
(4) *Evaluate impact of 2+2 compositions and transitions on throughput*
(5) *Simulant vs. precipitated hydroxide recipe methods on melt rate and/or throughput*
(6) *Assess impact of different GFC sources (borax and Na_2CO_3) for B_2O_3 and Na_2O on melt stability and production rate*
(7) *Assess impact of high viscosity glass on melt rate for HLW*
(8) *Assess glass liquidus (T_L) vs. volume percent crystals criterion in terms of production rate or waste throughput*
(9) *System configuration assessments*

The scope of the present tests includes only areas (5) and (9). Other tests that are required to complete the scope with respect to all nine areas either have been described previously or will be addressed in subsequent Test Plans. Area (5) refers to the comparison of simulant and melter feed produced by the direct addition of chemicals (referred to as "nominal" in this report) with more viscous melter feeds that are more representative of the anticipated upper rheological bounds. Higher viscosity melter feed can be produced by the precipitated hydroxide method or by the manipulation of feed additives. In these tests, the more viscous feed (adjusted rheology feed) was generated by NOAH Technologies using a proprietary method of manipulating feed additives.

With respect to the scope of the tests described in this report, the objectives to be achieved under the Test Specification [6] are:

1. Define melter testing matrices that provide sufficient coverage of the testing variables defined in Section 6, Test Conditions [6]. The test matrix for each variable is to be provided in the Test Plan. The Test Plan shall define each test variable and is to include a discussion of

test variable development and basis by which the testing strategy and approach will provide a sufficient technical basis for WTP HLW melter processing constraints. The order in which the testing variables are performed should be done to optimize the testing and take into consideration predecessor activities such as glass formulation support and the maturity of the QGCR boundary definitions.

2. Define the laboratory, small-scale melter (DM10 and DM100) and DM1200 pilot melter testing that are required for each variable defined in Section 6, Test Conditions. The maximum melter scale proposed should be based on the data quality requirements and the scale necessary to achieve that quality of data.
3. Perform DM1200 melter testing and associated feed handling and off-gas treatment equipment testing. The duration of each campaign or test period shall be sufficient to satisfy the objectives defined in the Test Plan.
4. Continue to assess the HLW bubbler design, operating life, modes of bubbler failure, and if necessary, alternative designs required to achieve a minimum two-month operating life.
5. For each test, establish and maintain melter throughput rates at the maximum steady state rate.
6. Characterize the melter emissions (particulate, aerosol, and gaseous) under nominal steady-state operating conditions for inorganics and organic compounds. Measurement of organic compounds can be satisfied through the use of Fourier Transform Infra-Red Spectroscopy (FTIR), H_2 and CO monitors.
7. Quantify and document the occurrence and associated operating conditions of any melter off-gas volume surging events.
8. Characterize the performance of the primary off-gas treatment equipment (SBS, WESP and HEME) to remove particulate, aerosol and gas phase emissions under steady state melter conditions. Measurement of organic compounds can be satisfied through the use of FTIR, H_2 and CO monitors.
9. Characterize the performance of the secondary off-gas treatment equipment (SCR and TCO) to treat NO_x. Measurement of organic compounds can be satisfied through the use of FTIR, H_2 and CO monitors. (A sulfur-impregnated activated carbon system was added and similarly characterized.) (Note: The primary purpose of the carbon system is for mercury control, but the system may also remove organics and halides.)
10. Characterize the chemical and physical characteristics of the aqueous streams (feed, SBS, WESP and caustic scrubber).
11. Obtain the necessary process measurements to provide mass, and energy balances throughout the systems, including process monitoring of power, voltage, current, resistance, temperatures, pressures, flow rates, and cooling water and air flows and inlet and outlet temperatures.
12. Document general equipment operations (reliability, availability, maintainability, etc.); especially non-routine equipment failure and replacement activities.
13. Perform pre- and post-test inspections of key equipment and process lines to monitor for solids accumulations and corrosion/erosion of materials, e.g., film cooler, off-gas jumper, SBS downcomer and tank (sump), WESP internals, post TCO/SCR lines for ammonium nitrate deposits, etc.
14. Operate the melter plenum pressure control using the variable air-injection control method. Assess and document control stability (melter plenum and off-gas system pressure versus time) as a function of instrument controller settings.

1.2 Test Overview

The tests were performed with AZ-102 and C-106/AY-102 HLW simulants [8, 9], some of which had been adjusted in order to have feed rheologies comparable to targets provided by WTP R&T based on data from selected actual waste samples. Earlier tests with these two HLW simulants (prior to rheology modification) were conducted at the previous WTP baseline value of 20% undissolved solids from pretreatment [8, 9], which has subsequently been reduced to 15% undissolved solids. Also, the bubbler configuration that was tested previously has since been modified in order to achieve the required throughput at the lower solids content [11]. As a result, testing for each of the two simulant compositions was conducted in two segments: The first segment was performed at the previous feed solids content with adjusted rheology feed and bubbler configuration in order to provide a direct comparison with the results from previous tests [8, 9]; in this way, the effect of the change in feed rheology was determined. The second segment was used to determine the production rate at the current Project baseline feed solids content and bubbler configuration and un-adjusted (nominal) feed rheology. The latter also permits the direct comparison with tests performed using HLW AZ-101 simulants conducted under current baseline conditions [11]. A further aspect of this work was to test a high-waste-loading glass formulation that was developed for the C-106/AY-102 waste simulant. In addition, screening tests were performed on the DM100-BL melter system with the new glass formulation and the adjusted feed rheology prior to performing the DM1200 tests.

The initial DM1200 test segment for each composition featured two single-outlet bubblers located 6" from the melter floor ("original" configuration), whereas the second segment featured two bubblers, each with two outlets about 8" apart, resting on the melter floor ("optimized" configuration). Both bubbler types enter the melter from ports in the corners of the melter lid; however, the single-outlet bubblers point diagonally towards the center, while the double-outlet bubblers are slightly askew to create a prototypical bubbling pattern. Based on the results from earlier tests [7], a total bubbling rate of 65 lpm was used with the single-outlet bubblers. The bubbling rate for the double-outlet bubblers was optimized to achieve a glass production rate of 1050 $kg/m^2/day$. During each test, either the total bubbling rate or the production rate was fixed while either the bubbling rate or feed rate was adjusted to attain the desired near-complete cold cap. Variables that were held constant during each test to the extent possible include melt temperature, plenum temperature, cold cap coverage, the waste simulant composition, and the target glass composition. The feed rate was increased to the point that a constant, essentially complete, cold cap was achieved, which was used as an indicator of a maximized feed rate for each test. All of the data collected were intended for engineering and system design purposes and, therefore, no environmental sampling was performed during these tests.

1.3 Quality Assurance

This work was conducted under a quality assurance program that is in place at the VSL that is based on NQA-1 (1989) and NQA-2a (1990) Part 2.7. This program is supplemented by a Quality Assurance Project Plan for RPP-WTP work [15] that is conducted at VSL. Test and procedure requirements by which the testing activities are planned and controlled are also

defined in this plan. The program is supported by VSL standard operating procedures that were used for this work [16].

This work did not generate data to support waste form qualification activities; nor did it generate data to support environmental regulatory data to support permitting activities. Therefore, this work was not subject to DOE/RW-0333P or the WTP Quality Assurance Project Plan (QAPjP) [17] for environmental and regulatory data.

1.4 Melter System Description

1.4.1 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 (approximately 16 per shipment), which were staged for unloading into the mix tank. Both the mix tank and the feed tank are 750-gallon polyethylene tanks with conical bottoms that are fitted with mechanical agitators; the feed tank is also fitted with baffles to improve mixing. 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 into the feed tank from the mix tank; measured amounts of water are combined by weight with the feed at this point to adjust the concentration of the melter feed. 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 feed is introduced into the melter using an ADS pump, which is the present WTP baseline. The feed transfer line extends from the outlet of the ADS pump in the feed tank to the top of the melter. Feed is introduced into the melter through a prototypic un-cooled feed nozzle that is located above the center of the glass pool. Only one feed tube is used to represent the planned number of feed tubes per unit melt surface area in the full-scale WTP HLW melter. The operation of the ADS pump is controlled from the melter computer control system. The ADS pump works by opening the pump reservoir to the feed tank using a double-acting air cylinder and mechanical link to actuate the poppet. The reservoir is filled with slurry by gravity. After sufficient time is allowed to fill the reservoir (a few seconds), the poppet is toggled to close the reservoir to the tank and open the transfer line. After a two-second delay time, the reservoir is pressurized with air to transfer the slurry (about 1.6 liter/shot) to the melter. This cycle is repeated at the rate required to provide the desired feed rate.

When necessary, a backup system is used to introduce feed into the melter with an air operated diaphragm (AOD) pump system that simulates the pulsed feeding action of an ADS pump. The recirculation loop extends to the top of the melter where feed is diverted from the recirculation loop into the melter through a Teflon-lined feed line and water-cooled feed tube. Two computer-operated pinch valves, one on the feed line 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 line into the melter after each pulse; air at 40 psi is flowed for 3 seconds through the 0.275" i.d. line for this purpose.

1.4.2 Melter System

The DuraMelter™ 1200 (DM1200), which is the HLW Pilot Melter, was used for these tests. Cross-sectional diagrams of the melter illustrating the discharge chamber and electrode configuration are provided in Figures 1.1 and 1.2. The DM1200 is a Joule-heated melter with Inconel 690 electrodes and thus has an upper operating temperature of about 1200°C. The melter shell is water-cooled and incorporates a jack-bolt thermal expansion system. The footprint of the melter is approximately 8 ft. by 6.5 ft. with a 4 ft. by 2.3 ft. air-lift discharge chamber appended to one end; the melter shell is almost 8 ft. tall. The melt surface area and the melt pool height are approximately 32 percent and 57 percent, respectively, of the corresponding values for the full-scale HLW melter. The discharge riser and trough are full-scale to verify pouring performance. Other aspects of the discharge system are also prototypical such as the chamber ventilation scheme. 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 34" by 54" with a glass depth of nominally 25". The resultant melt volume is approximately 45,000 cubic inches (735 liters), which represents a glass tank capacity of more than 1.7 metric tons of glass. However, since the typical operating glass level is closer to 29 inches, the effective glass volume during testing is actually about 849 liters, giving an inventory of about 2.0 metric tons, which is larger than had been previously assumed [18]. The DM1200 is fitted with one pair of electrodes placed high on opposite walls of the melter as well as one bottom electrode. The side electrodes are 11" by 34" giving an electrode area for the pair of about 750 sq. in. Depending on the glass level, the plenum space extends about 33" to 36" above the melt surface, resulting in a plenum volume ranging from about 43 to 46 ft^3.

The single-phase power supply to the melter electrodes (250 kW design power) is derived from the DuraMelter™ 1000 transformers by wiring them in parallel and using a single large silicon controlled rectifier. Current can be passed either from the side electrodes to the bottom electrode or between the two side electrodes only, by rearranging jumpers; only side-to-side operation was used for the present tests. Programmable process controllers are installed and can be used to control temperature or power. The melt temperature is controlled by configuring the process controller to maintain constant 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. Backup process controllers are installed to be used in case of failure of the main controllers. The entire system is supported by a back-up generator that is tripped on in the event of a power outage.

The DM1200 has several other features. The lid refractory is prototypic and also includes a two-piece construction, which simulates the seam needed for the LAW lid that was planned to be fabricated in three pieces. Nozzles are provided for the off-gas film cooler, a standby off-gas port, discharge airlift, along with 11 ports available for top-entering bubblers, start-up heaters and other components as needed. In addition, a bubbler arrangement is installed in the bottom

electrode with the objective of developing permanent bubblers for possible use on future melters. For the present tests, two top-entering bubblers in different configurations were used.

1.4.3 Lance Bubblers

Two types of lance bubblers, placed in two different locations and orientations, were evaluated during these tests for their effect on processing rate. The two types of bubblers used, single-outlet "J" and double-outlet "J", are shown in Figures 1.3 and 1.4, respectively. In many previous tests with HLW simulants [3, 4, 7-11, 19], two single-outlet "J" bubblers was used, located in opposite corners, pointing towards the center, six inches from the melter floor. Figure 1.5 shows a schematic of the prototypical double-outlet bubbler design that was based on the combination of the results from these DM1200 [11] tests and room-temperature tests that were performed in transparent fluid simulating the properties of the glass melt [20]. These bubblers have outlets 8 inches apart and were placed on the melter floor. The orientation of the bubblers in the melter, as shown in Figure 1.6, results in one of the bubbling outlets being 11.3 inches from the feed tube.

1.4.4 Off-Gas System

The melter and entire off-gas treatment system are maintained under negative pressure by two Paxton external induced draft blowers. The two blowers operate in series: the first located upstream of the thermal catalytic oxidizer, and the second located downstream of the packed-bed scrubber. Most of the components of the off-gas system are functionally prototypical. The system, shown schematically in Figure 1.7, consists of a submerged bed scrubber (SBS), a wet electrostatic precipitator (WESP), a high-efficiency mist eliminator (HEME), a high-efficiency particulate air (HEPA) filter, a thermal catalytic oxidation unit (TCO), a NO_x removal system (SCR), a packed-bed caustic scrubber (PBS), and a second HEME. The second HEME is used to limit entrained particle carryover into the balance of the VSL ventilation system. The PBS and the second HEME are not parts of the WTP off-gas train. The DM1200 off-gas system can be functionally divided into four subsystems:

Particulate Removal: Components from the submerged bed scrubber (SBS) through the HEPA remove the particulate matter entrained within the gas stream with an estimated removal efficiency greater than 99.9999% for particles larger than 0.3 μm. In the RPP-WTP facility, this provision serves to segregate the radioactive from the non-radioactive components in the system for maintenance and handling purposes.

VOC Control/Acid Gas: The thermal catalytic oxidation unit is designed to oxidize any hazardous organics that are present in the off-gas stream. This is followed by a SCR to remove NO_x gases and a packed-bed scrubber to remove remaining acidic gases.

Stack System: Both the primary and the emergency/bypass exhaust system with its separate HEPA filter vent into the atmosphere through the building stack.

Liquid Processing: Components such as water spray lines, liquid sampling and water storage tanks, as well as the effluent evaporator, function to sample and process the system liquids for recycle or discharge.

As noted above, with minor exceptions the DM1200 off-gas system processing sequence used for the present tests follows the proposed design for the full-scale WTP HLW installation.

Initial quenching of the melter exhaust gas stream takes place in the film cooler, which is designed to eliminate deposition of solids in the melter off-gas exit. Immediately downstream of the film cooler is the injection point for control air, which is used to regulate slow fluctuations (i.e., occurring in the time scale of several seconds or more) in melter pressure. At the film cooler exit the off-gas stream is in the temperature range of 250 to 350°C and its flow rate is between 100-250 scfm, of which about 10-80 scfm is water vapor. The off-gas is then rapidly quenched by percolation through a submerged packed column in the SBS, which also removes large particulate and many water-soluble species from the gas stream. The piping between the film cooler and SBS has a high superficial gas velocity (~80 ft/s) to minimize particulate deposition. The gas stream leaving the SBS is at a temperature between 40-50°C. Heat is removed from the SBS by means of two banks of internal cooling coils and an external cooling jacket connected in series to a chilled water system. Further mist and particulate removal takes place in the WESP, the HEME, and the HEPA. The TCO and SCR follow the particle removal components and serve to destroy organic compounds and nitrogen oxides. Finally, the PBS provides acid gas removal. Water sprays located in the WESP, the HEMEs, and the PBS drain into their respective collection sumps from which they can be sampled. The system components are fabricated from corrosion resistant materials including AL6XN (SBS and TCO), 316/316L stainless steel, and various plastics (mostly CPVC) at low-temperature locations. There are extensive provisions for sampling of both the gas and the liquid streams throughout the system.

The off-gas system maintains the melter plenum under slightly negative pressure, typically -3 to -5 in. W.C. The plenum pressure is controlled by means of an air injection system that introduces a controlled air flow into the off-gas jumper just downstream of the film cooler. The air is supplied by a blower through a diverter valve. The position of the diverter valve, and therefore the air flow rate, is proportionally controlled by a feedback signal from a melter pressure transducer. Loss of vacuum on the plenum causes the air injection flow rate to decrease, which restores the pressure to the set-point level. Conversely, the control air flow rate increases when the plenum pressure becomes too low.

1.4.5 Modifications to the SBS

Prior to these tests, a modified SBS was placed into service. Details and depictions of these SBS modifications are given in a previous report [11]. A depiction of the new SBS internals with temperature and pressure monitoring points is provided in Figure 1.8. A summary

of the significant modifications to the SBS are as follows:

- The diameter of the bed was increased by 40% to make the superficial flow velocity closer to its prototypical value.
- The water level above the packing was lowered by several inches such that the nominal level is now equal to the prototypical level of 3 inches above the top of the bed packing. This change reduces the pressure drop across the SBS. It also results in a prototypical SBS plenum height (21 inches) from the top of the liquid to the off-gas entry and exit points. The DM1200 SBS plenum volume is, however, smaller than prototypical due to the difference in SBS diameters.
- The overflow nozzle design was changed to the prototypical funnel-like shape.
- The down-comer annular pipe was changed to the prototypical open-ended type.
- An additional ring of the inner cooling coil was added, making a total of two coils in the DM1200 system as compared to three in the WTP SBS. This change improves the heat transfer efficiency enabling the support of higher (water) feed rates to the melter.

1.4.6 Installation of Sulfur Impregnated Activated Carbon (AC-S) Bed

Prior to the last test described in this report, a Sulfur Impregnated Activated Carbon (AC-S) Bed was installed immediately upstream of the TCO catalytic unit. A schematic diagram of the AC-S unit is provided in Figure 1.9 and photographs are provided in Figures 1.10 and 1.11. The unit contains 606 lb of granulated, sulfur impregnated activated carbon mixed with an inert mineral material in the ratio of 7:3 by volume; the material is manufactured by Donau Carbon, EU, under the trade name Combisorbon BAT37. Installation piping allows process gases to flow through the reactor or to by-pass it altogether. Both the inlet and the outlet ports are located on the top cover of the reactor. The process flow enters the vessel downwards through the central pipe and then reverses direction at the bottom, flowing upwards through the diffuser plate and the cylindrical carbon bed. The dimensions of the bed conform to its design specifications of 4.0 seconds residence time at the superficial velocity of 35 ft/min and a volumetric flow rate of 250 ft^3/min. Instrumentation includes pressure sensors and thermocouples located at the inlet and the outlet of the reactor and along the carbon bed, as shown in the schematic.

SECTION 2.0
WASTE SIMULANT AND GLASS FORMULATIONS

The AZ-102 and C-106/AY-102 waste data, blending assumptions, and glass formulations that were used for these tests are essentially the same as those used in previous melter tests [8, 9, 19] with only minor changes [21]. The compositions of these HLW simulants were derived and specified in a corresponding BNI Test Specification [22]. A second C-106/AY-102 composition was used in the second test with this waste stream [23]; this composition is based on actual waste data [24] and was used previously in simulant validation tests on the DM100 [13]. This Section summarizes the composition of the AZ-102 simulant together with the changes made as well as the composition of both C-106/AY-102 simulants, associated glass forming chemicals, and glass formulations that were used for melter testing.

2.1 AZ-102 Waste Simulant

Formulation of the AZ-102 waste simulant makes use of inventory data from the TFCOUP [22], calculated data from ACM modeling, and analytical data on Cs- and Tc-removal eluates from LAW pretreatment [25]. The composition of the AZ-102 Envelope D solids is based on the inventory data found in Revision 3A of the TFCOUP [26], as shown in Table 2.1. In addition to updated information, Revision 3A of the COUP also provides information on minor components that were not included in earlier revisions [27] and the Best Basis Inventory (BBI) database (e.g., cadmium). The use of other data sources (e.g., HLW Feed Staging Plan [26]) to supplement the COUP, as was done in previous tests, is therefore no longer necessary. The ACM model calculates the composition of the recycle stream (PWD01), which is then blended with the Envelope D solids based on the expected daily processing rates (i.e., 1.30E+04 lb/day for Envelope D solids and 1.28E+03 lb/day for the recycle stream on a dry solid basis). The resulting material is concentrated and pretreated through caustic leaching/water washing and ultra-filtration to produce the pretreated HLW solids. The separation factors due to caustic leaching and ultra-filtration are given in Table 2.1.

To complete the simulant formulation, the pretreated HLW solids must be blended with wastes from LAW pretreatment. In contrast to the blending scenario used in Part B1 tests, Sr/TRU removal products from pretreatment of Envelope C wastes were omitted from these tests per the Test Specification [22], although the then-current processing schedule suggested that some blending of Sr/TRU products from AN-102 (first Envelope C tank) may occur during the later stages of AZ-102 processing. Analytical data on eluates from Cs- and Tc-removal[1] on an Envelope B sample (AZ-102) [25] provide the compositional bases for the respective feed streams CNP12 and TEP12. The blending proportions are determined by the projected daily processing rate of sodium in the eluates (i.e., 1.71E+01 lb/day for Cs-removal and 3.32E-01 lb/day for Tc-removal). It can be seen in Table 2.1 that waste blending primarily leads to increases of sodium and nitrate in the HLW simulant.

[1] While it is recognized that technetium removal in pretreatment is no longer part of the WTP flow-sheet, this stream is retained in the present simulant in order to permit comparisons to previous test data.

The calculated composition of the blended HLW solids (HLP09b), which is shown in Table 2.1, lists a total of 55 components. A few of the components, however, have been left out of the blended solids in the Test Specification [22] because of unknown separation factors and low concentrations (e.g., Se and Y). In addition, similar to the approach taken during previous testing, radionuclides, noble metals (including silver) and minor components (< 0.02 wt% in glass on an oxide basis) are omitted from the simulant formulation. Another modification is the substitution of neodymium for praseodymium, another rare earth element, to reduce the number of components in the simulant. Cesium is spiked for analytical purposes, at an amount equivalent to 0.05 wt% in the glass product. The resulting HLW simulant formulation consists of 24 components, 20 of which are non-volatile.

As directed by WTP R&T [21], further modifications were made to the simulant composition. These included elimination of fluoride and chloride, but addition of extra carbonate to reach the target amount of 1.145 g per 100 g of waste oxide (as specified by the Test Specification [22]), in contrast with the previous AZ-102 melter tests, which employed simulants with a lower carbonate content. The final simulant composition is listed in Table 2.2.

2.2 AZ-102 Glass and Melter Feed Formulation

With the elimination of Sr/TRU pretreatment products from the HLW simulant, new glass formulations had been developed and tested at VSL to support previous tests; the same glass composition was used for the present tests. The selected glass composition, HLW98-80, is presented in Table 2.2. On an oxide basis, this glass incorporates 23.76 wt% of Envelope D waste and 24.25 wt% of all wastes. These can be compared with the respective values of 26.29 wt% and 33.32 wt% for HLW98-66, the AZ-102 reference glass used in Part B1 [28]. The difference is primarily due to the increased limiting component of Fe_2O_3 in the new HLW simulant and the inclusion of Sr/TRU products in the old simulant. The iron content is increased to such an extent (51.80 wt% in the current simulant) that the reference glass HLW98-80 meets the contract specification by incorporating 12.53 wt% of Fe_2O_3, instead of the >21 wt% of (Al_2O_3+Fe_2O_3+ZrO_2) found in previous testing [28]. The reference glass HLW98-80 was the target glass composition used for previous DM1200 testing [8].

Crucible melts of HLW98-80 have been prepared and tests performed to determine that it meets the necessary processing requirements. The measured viscosity and conductivity at 1150°C are 51 P and 0.36 S/cm, respectively. Heat treatment of HLW98-80 at 950°C for over 70 hours results in < 0.1 vol% of spinel crystals. The target glass formulation for these tests, which is also given in Table 2.2, differs slightly from HLW98-80, with the removal of silver and the addition of small amounts of cesium.

The additional constituents required to form the target test glass from the AZ-102 HLW simulant are boron, lithium, sodium, silicon, and zinc. The corresponding chemical additives that are the sources for these elements are selected based on previous testing and the WTP Project baseline glass forming chemicals. Table 2.3 lists the starting materials and amounts required to produce the target AZ-102 simulant and melter feed. Note that all of the TOC is assumed to be oxalate. For AZ-102, an undissolved solids content of 20 wt% in the feed material from

pretreatment is equivalent to 21.49 wt% total solids, based on the data for actual AZ-102 composite solids [29]. The theoretical glass yield of the resulting melter feed is about 384 g of glass/kg of feed ((520-580) g/l of feed, dependent on feed density).

Once the chemical composition, including water content, of the AZ-102 melter feed was defined, VSL worked with NOAH Technologies Corporation (the supplier of simulant and feed used in previous testing on the DM-100 and DM-1200 melter systems) to produce several batches of the melter feed for rheology and physical properties measurements. These batches of experimental feed had identical chemical compositions and water contents but different viscosities. The data collected on these feeds were then compared with the target, which was specified by WTP R&T based on AZ-102 actual waste data [30]. Rheology test data showed that one of the experimental feeds (formulation NOAH-L4491) closely matched the specified target and it was therefore selected to form the basis for melter feed production for these tests. A comparison of the rheology of NOAH-L4491 with the WTP testing target is given in Figure 2.1. Melter feeds for all of the AZ-102 melter tests were produced by NOAH Technologies Corporation.

2.3 C-106/AY-102 Waste Simulant

As with the AZ-102 feeds, the principal objective of the tests with C-106/AY-102 HLW simulant was to determine the effect of feed rheology on production rate. In order to do this, results were compared to those obtained from past DM-1200 tests with C-106/AY-102 simulants. Consequently, the C-106/AY-102 simulant used in the present tests is compositionally comparable to the previous C-106/AY-102 simulant [9, 19]. Formulation of the C-106/AY-102 waste simulant previously made use of inventory data from the TFCOUP [26], calculated data from ACM modeling, and analytical data on Cs- and Tc-removal eluates[2] from LAW pretreatment [22]. In addition, products from Sr/TRU removal for pretreatment of LAW were also included in the waste blend.

The composition of the C-106/AY-102 Envelope D solids (Stream FRP02) is based on the inventory data found in Revision 3A of the TFCOUP [26]. As seen in Table 2.4, in addition to updated information, Revision 3A of the TFCOUP also provides information on minor components that were not included in earlier revisions [27] and the Best Basis Inventory (BBI) database (e.g., cadmium). The use of other data sources (e.g., HLW Feed Staging Plan [32]) to supplement the TFCOUP, as was done in previous tests, is therefore no longer necessary. The ACM model calculates the composition of the recycle stream (PWD01), which is then blended with the Envelope D solids based on the expected daily processing rates (i.e., 3.79E+04 lb/day for Envelope D solids and 1.31E+03 lb/day for the recycle stream on a dry solid basis). The resulting material is concentrated and pretreated through caustic leaching/water washing and ultra-filtration to produce the pretreated HLW solids. The separation factors due to caustic leaching and ultra-filtration are given in Table 2.4. Note that some of the separation factors are larger than unity (many of which were ignored in derivation of the waste composition, which is

[2] While it is recognized that technetium removal in pretreatment is no longer part of the WTP flow-sheet, this stream is retained in the present simulant in order to permit comparisons to previous test data.

used as-provided [22] in the present work) and that the ACM model predicts mass increases for Fe and Zr after ultra-filtration (75 lb/day and 68 lb/day, respectively) [22].

To complete the simulant formulation, the pretreated HLW solids are blended with wastes from LAW pretreatment. Similar to the blending scenario used in Part B1 tests [32], Sr/TRU removal products from pretreatment of Envelope C wastes were added for these tests, although the amounts of Sr and Mn (449 lb/day and 499 lb/day, respectively) blended are considerably less than those used in earlier tests, which results in lower concentrations of SrO and MnO in the current test glass (e.g., 0.92 wt% vs. 7.35 wt% for SrO) [33]. Analytical data on eluates from Cs- and Tc-removal on an Envelope B sample (AN-102) [34] provided the compositional bases for the respective ACM-model feed streams CNP12 and TEP12 although that was not the case for the SR/TRU stream. The blending proportions are determined by the projected daily processing rate of sodium in the eluates (i.e., 2.02E+01 lb/day for Cs-removal and 9.14E−01 lb/day for Tc-removal). It can be seen in Table 2.4 that waste blending primarily leads to increases of manganese, strontium, sodium, chloride, and nitrate in the HLW simulant.

The calculated composition of the blended HLW solids (HLP09b), which is shown in Table 2.4, lists a total of 55 components. A few of the components, however, were left out of the blended solids in the Test Specification [22] because of missing separation factors, low concentrations and other unspecified reasons (e.g., Be, Co and Mo). In addition, similar to the approach taken in previous melter tests, radionuclides, noble metals (including silver), and minor components (< 0.02 wt% in glass on an oxide basis) are omitted from the simulant formulations. Cesium is spiked for analytical purposes, at an amount equivalent to 0.05 wt% in glass. The resulting HLW simulant formulation, which is given in Table 2.5, consists of 30 components, 26 of which are non-volatile (compared with 33 and 29, respectively, for the previous C-106/AY-102 simulant [33]).

2.4 C-106/AY-102 Glass and Melter Feed Formulation

After definition of composition for the C-106/AY-102 HLW simulant, new glass formulations were developed and tested at VSL to support previous melter tests. The glass composition selected as the basis for those tests, HLW98-86, is presented in Table 2.5. The same glass formulation was used for the present tests. On an oxide basis, this glass has a total waste loading of 27.75 wt%, of which 25.13 wt% is Envelope D waste. These can be compared with the respective values of 51.00 wt% and 39.42 wt% for HLW98-34, the C-106/AY-102 reference glass used in Part B1 [33]. The difference is primarily due to the presence of much more Na_2O in the Part B1 simulant (20.61 wt% vs. 2.11 wt% for the current simulant). The current target glass (HLW98-86) is also different from HLW98-34 in that it meets the contract minimum component limit by incorporating 12.56 wt% of Fe_2O_3 [33], instead of > 21 wt% of (Al_2O_3+Fe_2O_3+ZrO_2).

Crucible melts of HLW98-86 and related formulations have been prepared and tests performed to determine that the target glass meets the necessary processing requirements. Heat treatment at 950°C for over 70 hours of HLW98-86 results in a homogeneous dark brown glass that is free of secondary phases. The viscosity and electrical conductivity measured for HLW98-86AG, which has the same composition as HLW98-86 except with Ag_2O excluded, are

44 P and 0.36 S/cm, respectively, at 1150°C. Finally, the normalized PCT leach rates of HLW98-86 are (in g/(m^2-day)) 0.058, 0.047, 0.046 and 0.028, respectively for B, Li, Na and Si; these values can be compared with those for the reference glass (SRL-EA): 1.17, 0.71, 0.80 and 0.27. The target glass formulation for previous DM-1200 tests with C-106/AY-102 simulant [9, 19], which is also given in Table 2.5, differs slightly from HLW98-86, with the removal of silver and the addition of small amounts of cesium.

The additional constituents required to form the target test glass from the C-106/AY-102 HLW simulant are aluminum, boron, lithium, sodium, silicon, and zinc. The chemicals that are the sources for the glass-forming additives were selected based on previous testing and with direction of the WTP Project. Table 2.6 lists the starting materials and amounts required to produce the target C-106/AY-102 simulant and melter feed. Note that all of the TOC is assumed to be oxalate and that only 4.36 (g/100 g waste oxide) of carbonate is present in the simulant, instead of the required 4.65 (g/100 g waste oxide). This small discrepancy in carbonate is not expected impact the tests since much greater amounts are present in the glass forming additives. The undissolved solids in the *simulant* is assumed to be 20 wt%, which is equivalent to 21.49 wt% total solids, based on the data from AZ-102 testing [8]. The theoretical glass yield of the resulting feed is 372 g of glass/kg of feed (about (485-550) g/l of feed, dependent on feed density).

Experimental simulants and melter feeds with different viscosities were prepared using the compositions discussed above. These feeds were subjected to rheological characterization and the data were compared to the target specified by WTP R&T. After the rheology target of the C-106/AY-102 melter feed was defined by the WTP Project, NOAH Technologies was requested to prepare a series of test samples using identical feed formulation and water content. The test samples were received and rheologically characterized at VSL; the results are depicted in Figure 2.2. Test sample L4515 was selected as the basis for feed production based on its similarity in measured rheology to the target. The melter feed was produced at NOAH Technologies in four batches, and a 3 kg-sample from each batch was sent to VSL for characterization before shipment of the feed. As seen in the Figure 2.2, the "up-curve" rheogram of the sample from the first batch shows good agreement with the target and test sample L4515 but considerable deviations are seen for the subsequent three batches. By comparison, the "down-curve" rheograms of all four batches are more comparable and show relatively good match with the test sample.

2.5 High Waste Loading C-106/AY-102 Waste Simulant

The second C-106/AY-102 HLW simulant that was used in the current tests is based on the analytical data for actual wastes, which were previously provided by the WTP Project for developing HLW glass formulations to support vitrification testing of actual C-106/AY-102 waste [24]. This section describes the actual waste data and the derivation of the HLW simulant.

Samples of C-106/AY-102 actual waste solids were shipped to Savannah River National Laboratory (SRNL) where they were combined and the composite sample analyzed. Washing and caustic leaching were the HLW pretreatments performed before analysis. Table 2.7 lists the

analyzed composition of the C-106/AY-102 waste in terms of non-volatile oxides, as approved and provided by the WTP Project [23, 35]. Table 2.7 also lists the analyzed composition of the cesium eluate (average of six sets of data) from LAW pretreatment of AW-101 waste [36], which needs to be blended with the C-106/AY-102 solids to give the HLW simulant. The blending ratio was determined from the WTP dynamic process flow-sheet model (G2), with the mass ratio of ^{137}Cs in the AW-101 eluate to iron in the C-106/AY-102 sludge equal to 2.09×10^{-5} [35]. This blending ratio corresponds to a mass ratio of AW-101 oxides to C-106/AY-102 oxides of about 5.9×10^{-4}. The blended composition is given in Table 2.7. As can be seen, the AW-101 cesium ion-exchange eluate is composed essentially of a solution of sodium (nitrate) and boron, together with smaller amounts of other alkalis and selected metal ions, including barium, cerium, copper, nickel, and tin. The blended waste composition is very similar to that of the C-106/AY-102 waste, primarily because of the low blending ratio.

The blended waste in Table 2.7 contains 32 non-volatile components and is modified to give the HLW waste simulant for the current tests. The modifications are made to keep the number of components at a manageable level and include: i) omitting the minor components (i.e., components that make up < 0.05 wt% in glass, which corresponds to about 0.12 wt% in waste, on an oxide basis); ii) omitting silver, which was not included in earlier C-106/AY-102 melter tests; and iii) substituting sodium for potassium, lanthanum for gadolinium, and zirconium for uranium (to eliminate the use of radioactive materials). Renormalization after these modifications results in the HLW waste simulant (in terms of non-volatile oxide), the composition of which is given in Table 2.7.

To complete the formulation of the HLW waste simulant, non-volatile components need to be defined. No analytical data on the actual wastes were provided since they did not affect glass formulations [24, 34]. Consequently, concentrations of carbonate, nitrate, nitrite, and total organic carbon (TOC) from previous C-106/AY-102 melter tests are adopted [9, 19]. The complete HLW waste simulant is listed in Table 2.8.

2.6 High Waste Loading C-106/AY-102 Glass and Melter Feed Formulation

After definition of the composition of the blended C-106/AY-102 waste, new glass formulations were developed and tested at VSL to support actual waste testing [24]. The glass composition selected as the basis to vitrify actual C-106/AY-102 waste, HLW04-09, is presented in Table 2.8. The same glass formulation, with modifications including those made in defining the simulant described above, was used for the present tests. On an oxide basis, HLW04-09 has a total waste loading of 37.10 wt%, practically all of which is Envelope D waste (37.08 wt%). These can be compared with the respective values of 51.00 wt% and 39.42 wt% for HLW98-34, the C-106/AY-102 reference glass used in Part B1 [33]. The difference is primarily due to the presence of much more Na_2O in the Part B1 simulant (20.61 wt% vs. 2.11 wt% for the current simulant). The current target glass (HLW09-04) is also different from HLW98-34 in that it meets the contract minimum component limit by incorporating 14.01 wt% of Fe_2O_3, instead of > 21 wt% of (Al_2O_3+Fe_2O_3+ZrO_2) [33].

Crucible melts of HLW04-09 and related formulations have been prepared and tests performed to determine that the target glass meets the necessary processing and performance requirements [24]. Heat treatment of HLW04-09 using the HLW canister-centerline-cooling temperature profile results in a homogeneous dark brown glass that contains only 0.1 vol% of spinel crystals. In addition, heat treatment of HLW04-07, which has a composition very similar to HLW04-09, at 950°C for 70 hours results in about 0.2 vol% of spinel crystals. The viscosity measured for HLW04-07 is 45 P at 1150°C. Finally, the normalized PCT leach rates of HLW04-09 are (in g/(m^2-day)) 0.039, 0.043, 0.040 and 0.024, respectively for B, Li, Na and Si; these values can be compared with those for the reference glass (SRL-EA): 1.17, 0.71, 0.80 and 0.27. The target glass formulation to be used for the present tests, as given in Table 2.8, is very similar to HLW04-09 and has a total waste loading of 36.80 wt%.

The additional constituents required to form the target test glass from the HLW simulant are boron, lithium, sodium, silicon, and zinc (see Table 2.8). They were added in the same proportions as those used in HLW04-09, with the exception of zinc, which was added at 1.00 wt%, with respect to glass (oxide basis), compared to 0.70 wt% in HLW04-09 [24]. The raw materials that are the sources for the glass forming additives were selected based on previous testing and with direction of the WTP Project. Table 2.9 lists the starting materials and amounts required to produce the target C-106/AY-102 simulant and melter feed. Note that all of the TOC is assumed to be oxalate. The undissolved solids concentration in the *simulant* is assumed to be 20 wt%, which is equivalent to 21.49 wt% total solids, based on the data from AZ-102 testing [8]. The theoretical glass yield of the resulting C-106/AY-102 feed is 327 g of glass/kg of feed (about (415-480) g/l of feed, depending on feed density)[3].

These melter feeds were produced by NOAH Technologies Corporation, the supplier of simulant and feed samples used in previous testing on the DM1200 melter system.

2.7 Analysis of Feed Samples

2.7.1 General Properties

Feed samples were analyzed from each distinct feed tank charging, or at least once per day of operation, to confirm the chemical composition and physical properties. Sample names, sampling dates, and measured properties are provided for DM100 and DM1200 feed samples in Table 2.10. Data from samples with the same target composition and water contents [8, 9, 19, 37] are provided for comparison. All samples were taken from the feed line immediately upstream of the entrance point to the melter. The test average measured glass yields for AZ-102 feeds at 20% Undissolved Solids from pretreatment (UDS) were all very similar to each other and were within one percent of the target glass yield of 384 g glass per kg of feed. The adjusted-rheology feed at 20% UDS could not be pumped by the prototypical ADS to pump and therefore the feed was diluted in the middle of Test 1A to 17% UDS [39]. Feed dilution resulted in uninterrupted processing with the ADS pump and an about 11 percent decrease in glass yield.

[3] Note that for a given solids content in the feed from pretreatment, the water content in the *melter* feed increases as the waste loading is increased. Consequently, the high-waste-loading C-106/AY-102 melter feed has a higher water content and lower glass yield than its lower-waste-loading predecessor (at the same solids content from pretreatment).

Nominal AZ-102 feed was diluted for Test 1B targeting 340 g glass per liter of feed simulating the lowest waste solids content expected at WTP [39]. Measured glass yields for the more viscous C-106/AY-102 feed were within about five percent of samples from previous tests using nominal C-106/AY-102 feed. The high-waste-loading C-106/AY-102 feed was diluted to 15% UDS [23] which resulted in a measured glass yield of only 272 g glass per kg feed (348 g/L). The measured glass yields were all close to target values therefore target glass yields were used for calculating glass production rates. For each feed type and target solids content, all measured parameters including glass conversion ratio, water content, density, and pH, fall within narrow ranges, confirming the relative consistency of the melter feed. As intended, feed designed to be more viscous otherwise had the same physical properties as the nominal feed of the same composition. All measured parameters were also very similar to those for previous tests conducted with the same feeds at the same solids contents. The expected differences in measured feed properties were observed as a consequence of the intended changes in feed solids content: feed water content was lower, feed pH was slightly higher, and feed density was higher at the higher feed solids content.

2.7.2 Rheology

Samples of the melter feeds that were used for these tests were also subjected to rheological characterization. The results from rheological 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 [40]. 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 rate 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. 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. All of the measurements in this work were made at 25°C; previous work [40], which examined a range of temperatures, showed a relatively weak effect of temperature.

Rheograms for feed with AZ-102 and C-106/AY-102 simulants showing feed viscosity versus shear rate are given in Figures 2.3 and 2.4 and shear stress versus shear rate in Figures 2.5 and 2.6. Included in the figure for comparison are rheology targets and data from previously reported [8, 9, 19] feed samples of the same composition and solids content. Measured values for viscosity at selected shear rates and the yield stress values are shown in Table 2.11. The rheological properties for AZ-102 samples follow the expected trends: rheology of the as-received adjusted-rheology AZ-102 feed is close to the target, dilution with water results in a viscosity decrease proportional to the amount of dilution, the nominal feed at 20% UDS is considerably less viscous than the adjusted-rheology feeds, and the nominal feed diluted to the minimum project feed solids content is considerably less viscous than the other AZ-102 feeds. The feed with C-106/AY-102 simulants follow a similar trend, although the melter feed samples are less viscous than the target but are similar to the measured "down curve" shown for test samples in Figure 2.2. The measured rheological properties for adjusted-rheology feed are very

similar to the adjusted-rheology feed used in a separate DM100 test with C-106/AY-102 simulants [13]. Also, the adjusted-rheology C-106/AY-102 feed used in Test 2A is considerably more viscous than the nominal C-106/AY-102 used previously [9, 19], the high-waste-loading C-106/AY-102 feed used in these tests, and is of about the same viscosity as the adjusted-rheology feed used in Test 1A2.

2.7.3 Chemical Composition

Feed samples collected during these tests were subjected to chemical analysis using x-ray fluorescence (XRF). The chemical compositions of the feed samples from the tests were determined by first making a glass from the feed samples via crucible melt. The glass was subsequently crushed and analyzed directly by XRF. Target values for boron and lithium oxide were used for normalizing the XRF data since they were not determined by XRF. The data are compared to the target compositions in Table 2.12. The compositional analysis results can be discussed by dividing the elements into four categories: major elements with measured oxide concentrations greater than 3%, intermediate elements with measured oxide concentrations between 1 and 3%, minor elements with target concentrations less than 1%, and contaminants that are not in the target composition. The major elements constitute the bulk of the glass and, therefore, largely determine its properties. The average measured concentration for all the major elements (Al, Fe, Na, and Si, as well as Mn for C-106/AY-102) were within 10 percent of the target composition. Two elements are in the intermediate concentration range for each of the formulations: zinc in each formulation, zirconium in the AZ-102 formulation, magnesium in the nominal C-106/AY-102 formulation, and manganese in the high-waste-loading C-106/AY-102 formulation. Magnesium and manganese deviations from target were less than three and six percent, respectively. Zinc in two of the three formulations was within 10% of their respective target values. Zirconium was about twenty-five percent above its target for all three formulations, even in formulations with target oxide concentrations as low as 0.26 wt%. This surplus observed in the feed samples was also observed in glass discharge samples as well as in previous HLW tests [9, 10, 12, 17] for both feed samples and product glasses. The uniform relative excess suggests that the purity of the zirconium used by NOAH may have been somewhat higher than was assumed. The absolute deviations for zirconium and in the one instance for zinc were less than half a weight percent and therefore the effect on the glass properties is expected to be inconsequential with respect to meeting the test objectives. The feed recipes were not adjusted to correct for the deviations in zirconium and zinc since the intent of the present tests was comparison of results from previous tests with the same feed that also had these deviations. No deviations greater than ten percent were observed for either major or intermediate oxides in samples from the high-waste-loading C-106/AY-102 formulation, in agreement with DM100 sample results with the same composition [13]. The large number of minor elements (Ba, Ca, Cd, Cl, Cs, Cu, I, K, La, Mg, Mn, Nd, P, Pb, S, Sb, Se, Sn, Sr, Ti, and Zr, depending on the formulation) are all contributed by the simulated waste or spiked into the feed at low levels. Deviations were not calculated for these oxides due to the high volatility of many of the constituents and the uncertainty associated with deviation calculations on very low concentrations. Common elements such as calcium, magnesium, and potassium, which are typical impurities in bulk chemicals, are over-represented when the constituent is a minor component. Elements not included in some of the glass formulations but detected at low levels in

the feed as impurities were potassium, titanium, and sulfur; small amounts of these common elements are present in additive sources. An excess in titanium oxide has been observed in previous studies [7-9, 11, 19, 41-43], suggesting that titanium is a common contaminant in the source chemicals.

SECTION 3.0
DM100 OPERATIONS

The DM100-BL vitrification system has served extensively as a screening tool for subsequent tests on the DM1200 HLW pilot melter [7, 9, and 10]. Factors such as new HLW glass formulations, different glass forming additive sources, and feed nitration were successfully tested on the smaller melter prior to use on the DM1200 in order to ensure the success of the more costly larger-scale tests [41]. A similar tiered approach has also been employed with the combination of the DM100-WV and the LAW Pilot Melter in Columbia for LAW testing. In the present work, the feed that had been adjusted to be considerably more viscous and the high-waste-loading C-106/AY-102 formulation had not been tested previously in a melter and, therefore, DM100 tests were conducted to identify any issues with the feed or glass prior to embarking on the DM1200 tests. This section presents a description of the DM100-BL system, glass product analysis, and screening level process data from the DM100 tests.

3.1 Melter System Description

3.1.1 Feed System

The melter feed is introduced in batches into a feed container that is mounted on a load cell for weight monitoring. The feed is stirred with a variable speed mixer and is constantly recirculated. The recirculation loop extends to the top of the melter where feed is diverted through a peristaltic pump into the melter. The feed rate is regulated by adjusting the peristaltic pump and the pressure applied to the recirculation loop. An alternate method can be used that is designed to mimic the operation of an ADS pump; both methods were used in the present work, as specified in Section 3.2. In the ADS method, two mechanical computer-operated pinch valves, one on the feed line 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 the feed line and can be used to automatically clear the feed line into the melter after each pulse. In both methods, the mixed feed enters the melter through a Teflon-lined, water-cooled, vertical feed tube.

3.1.2 Melter System

The DM100-BL unit is a ceramic refractory-lined melter fitted with a total of five electrodes: two pairs of opposing Inconel 690 plate electrodes as well as a bottom electrode. Power can be supplied in either three-phase or single-phase configurations. All of the tests in the present work were performed with the upper and lower electrodes on each side connected together and powered by a single-phase supply; the bottom electrode was not powered. Melt pool agitation is achieved by either a removable lance entering from the top of the melter or a permanent bubbler installed through the bottom electrode; only the lance bubbler was used for the present tests. The glass product is removed from the melter by means of an airlift discharge system. The melter has a melt surface area of 0.108 m^2 and a variable glass inventory of about

120 kg, when only the bottom pair of electrodes is used and between 180 and 200 kg when both pairs of electrodes are used. In these tests both pairs of electrodes were used.

3.1.3 Off-Gas System

For operational simplicity, the DM 100s are equipped with dry off-gas treatment systems involving gas filtration operations only. Exhaust gases leave the melter plenum through a film cooler device that minimizes the formation of solid deposits. The film-cooler air has constant flow rate and its temperature is thermostatically controlled. Consequently, the exhaust gases passing through the transition line (between the melter and the first filtration device) can be sampled at constant temperature and airflow rate. The geometry of the transition line conforms to the requirements of the 40-CFR-60 air sampling techniques. Immediately downstream of the transition line are cyclonic filters equipped with internal coarse filter elements followed by conventional pre-filters and HEPA filters. The temperature of the cyclonic filters and the HEPAs are held above 100°C to prevent moisture condensation. For each melter, the entire train of gas filtration operations is duplicated and each train is used alternately. An induced draft fan completes the system.

3.2 Melter Testing

The DM100 tests were conducted between 3/15/04 and 7/23/04, producing over 1.2 metric tons of glass. A summary of the test conditions and results is provided in Table 3.1. The total test duration, including the time for water feeding was 214.6 hours. The tests were conducted to screen the effects of feed rheology, feed solids content, and waste loading on feed and glass product behavior prior to conducting tests on the larger DM1200. The tests are described below in the order in which they were conducted:

- AZ-102 composition, nominal rheology (target glass yield = 0.384 kg/kg or 560 g/l): 60 hours at a constant bubbling rate of 9 lpm to compare cold cap limited production rates with previous DM100 AZ-101 results [7] and rates obtained with adjusted-rheology AZ-102 feed. Peristaltic pump used to facilitate observations of cold cap behavior.

- AZ-102 composition, rheology adjusted by NOAH to be more viscous (target glass yield = 0.384 kg/kg or 560 g/l): 47 hours at a constant bubbling of 9 lpm to compare cold cap limited production rates with previous DM100 AZ-101 results [7] and rates obtained with nominal AZ-102 feed. Peristaltic pump used to facilitate observations of cold cap behavior.

- C-106/AY-102, high-waste-loading composition (target glass yield = 0.327 kg/kg or 420 g/l): 106 hours adjusting bubbling to maximize processing rate. Feed introduced into melter by simulated ADS pump system for direct comparison to previous tests.

No processing problems such as foaming were encountered during the tests other than occasional dried feed bridging from the walls across the melt pool. This is much more of an issue

in smaller melters and, therefore, was not projected to be a problem with the larger DM1200. The feed tube was rodded out about once a day during the test with adjusted-rheology AZ-102 feed and at twice that frequency during the other two tests. Cleaning of the feed tube in this manner is common during DM100 tests as a result of feed drying on the feed tube tip. The adjusted-rheology AZ-102 formed the most fluid, uniform cold cap with the least amount of bridging. The measured glass production rates are depicted in Figures 3.1.a and 3.1.b as one-hour moving averages. After a day of feeding nominal AZ-102 feed, a rate of about 1300 kg/m^2/day was held for approximately one day before the rate was reduced to about 1200 kg/m^2/day in response to excessive accumulations of dried feed in the plenum. After switching to the adjusted-rheology AZ-102 feed, the production rate increased to about 1400 kg/m^2/day and was sustained for the last 40 hours of the test. The steady-state rates obtained in these tests bracket the 1300 kg/m^2/day rate obtained with the same amount bubbling while processing AZ-101 feed [7]. The average production rate obtained with the high-waste-loading C-106/AY-102 feed was very similar to that for the adjusted-rheology AZ-102 feed, even though the bubbling rate used was higher. This can be attributed to the higher water content of the feed, although differences in feed composition and rheology may also have contributed to the need for more melt pool agitation.

A variety of operational measurements were recorded during these tests, the most important of which are glass temperature (Figures 3.2.a and 3.2.b), electrode power (Figures 3.2.a and 3.2.b), plenum temperature (Figures 3.3.a and 3.3.b), and glass bubbling rate (Figures 3.4.a and 3.4.b). The test-average glass temperature for the entire glass pool approximated the target glass temperature of 1150°C. Adjusting power to achieve this temperature was a balance between the bottom and top halves of the melt pool with the upper portion of the melt pool being 25-50°C cooler. Plenum temperatures varied over a greater range (300 - 550°C) during the test with C-106/AY-102 feed due to the changes in bubbling over the course of the test. Plenum temperatures varied over the smallest range (500 - 575°C) during the test with adjusted-rheology AZ-102 feed as result of the more stable cold cap that was produced. The exposed thermocouple often read significantly higher than the thermocouple in the thermowell due to its proximity to an opening in the cold cap. Electrode power consumption was highest for the C-106/AY-102 test due to higher glass production rate and feed water content; power usage varied significantly during this test as a result of the frequent changes in bubbling rate. After the cold cap was established in the AZ-102 tests, the bubbling rate was relatively constant at that target of 9 lpm whereas bubbling varied mostly between 8 and 18 lpm during the test with C-106/AY-102 feed.

3.3 Glass Product Analysis

Over 1230 kg of glass product was discharged from the melter through an airlift system into 5-gallon pails. The discharged product glass was sampled from each pail by removing sufficient glass from the top for total inorganic analysis. Product glass masses, discharge date, and the analyses performed are listed in Table 3.2.

Glass samples were crushed and analyzed directly by XRF. The target value for the boron and lithium oxide concentrations were used for normalizing the XRF data since boron and

lithium were not determined by XRF. Analyzed compositions for discharged glass samples are provided in Table 3.3. There was good agreement with the target composition for the majority of oxides and, in particular, for the major oxides, as described for feed samples in Section 2.7.3. The only oxide in the two glass formulations with a target concentration greater than one weight percent and a deviation greater than ten percent was zirconium in the AZ-102 formulation. This surplus of close to thirty percent has been observed in previous tests with this composition [8, 37] suggesting that the zirconium source chemicals are of a higher purity than was assumed. The absolute zirconium difference is only about half a percent and therefore is not anticipated to have an impact on glass quality or processing properties. Titanium, potassium, and chromium were observed in the glass at very low levels, even though they are not included in the feed recipe.

Compositional trends from the XRF data are plotted for selected elements in Figures 3.5-3.8. The same AZ-102 formulation used in these tests was also used in preceding DM100 tests [37] and therefore little compositional change was observed at the beginning of these tests. The graphs illustrate two trends as the melt pool transitions from the AZ-102 to the C-106/AY-102 composition: systematic decreases due to a lower concentration in the C-106/AY-102 formulation (e.g. Al, Zn, and Zr in Figure 3.6 and La in Figure 3.7), or systematic increases due to a higher concentration in the C-106/AY-102 formulation (e.g., Fe and Na in Figure 3.5, Mn in Figure 3.6, Ca and Pb in Figure 3.7, Cr and S in Figure 3.8). Silicon, which comprises almost half of both glass compositions, changes very little during the tests.

3.4 Discharge Riser Glass

Per a WTP Test Exception [44], several glass samples were taken from the DM100 riser over an extended period of time after the melter test to determine if the high-waste-loading C-106/AY-102 formulation was prone to excessive spinel crystallization at idling temperatures. A list of all the samples taken, date of sampling, location of sampling, method of sampling, and analytical results are provided in Table 3.4. A diagram of the DM100 riser, annotated with a detailed temperature profile, is given in Figure 3.9. Samples were taken from the melt pool and riser by extending a metal rod to the bottom and subsequently removing the cooled glass from the rod. Even though the rod is extended to the bottom for each sample, the glass adhering to the rod may originate from anywhere between the glass surface to the bottom of the riser. The temperature gradient from the surface to the riser bottom is 858 to 920°C, with the hottest portion at the level between the two electrode pairs. Glass at the bottom of the riser was sampled by suction through a tube (sample: BLK-O-41A). Another type of sample (sample: BLK-D-41A) was collected by taking glass from the air-lift pipe, which is removed to enable dip sampling. Samples were taken throughout the week after the high-waste-loading tests and three to five months after processing a very similar C-106/AY-102 formulation [13]. Analysis of samples was done with both optical and scanning electrode microscopy. The quantification of crystalline phases was done by SEM on sectioned and polished samples.

The results of the sample analysis indicate that, as would be expected based on the crucible melt heat treatment data, spinels can form at the lower riser idling temperatures of 858 to 920°C but not at the higher melt pool idling temperatures of 1007 to 1070°C. Over the course

of four to seven days after the test, several dip samples contained spinel crystals at about 0.4 volume percent, as depicted in Figures 3.10 – 3.14. The chemical composition of the crystals determined during SEM microscopy by EDS is consistent with high-chromium spinels that also contain lesser amounts of manganese and nickel. No secondary phases were observed in contemporaneous samples taken from the melt pool. Samples taken about three months after processing the same high-waste-loading C-106/AY-102 formulation followed by processing the equivalent of about one turnover of feed using SIPP simulant [13] yielded a range of results. Thin layers of spinels were observed on glass removed from the riser air-lift pipe, as shown in Figure 3.15. No crystalline phases were observed on riser dip samples taken about two and half months later. A suction sample taken from the very bottom of the riser at the same time as these two dip samples had a few isolated spinel crystals, as shown in Figure 3.16, however, the amount of observed crystallization was significantly less than that observed after the initial high-waste-loading test. Since it was confirmed that the idling temperatures after the two tests were the same, the reason for disparate extent of crystallization can be attributed only to differences in idling time and glass composition. The crystallization never impeded the discharge of glass.

3.5 DM100 Test Summary

The DM100 tests were conducted in order to screen for possible melter operational or feed processing issues prior to DM1200 testing since the adjusted-rheology AZ-102 formulation and the high-waste-loading C-106/AY-102 simulant and glass composition had not been tested previously in a melter. No processing problems such as foaming were encountered during the test other than occasional dried feed bridging from the walls across the melt pool. This is much more of an issue in smaller melters and, therefore, was not projected to be a problem with the larger DM1200. The adjusted-rheology AZ-102 feed spread well over the glass surface producing a marginally better cold cap than the less viscous feed. Even though spinels were observed in glass riser samples subsequent to the high-waste-loading C-106/AY-102 test, the concentrations were not sufficient to impede glass discharge.

Results from glass analysis using XRF indicated good agreement with the target composition for the majority of oxides and, in particular, for the major oxides after the melter pool had experienced three complete turnovers (540 - 600 kg of glass produced).

Consequently, the successful DM100 test results supported proceeding to the subsequent DM1200 testing.

SECTION 4.0
DM1200 OPERATIONS

Five tests with the HLW AZ-102 and C-106/AY-102 simulants were conducted between 6/21/04 and 11/12/04, producing over 21 metric tons of glass. The total testing duration, including the time for water feeding and cold-cap burn-off, was 433 hours, during which over 69 metric tons of feed was processed. A summary of the test conditions and results is provided in Table 4.1. The tests were conducted to determine the effects of feed rheology, feed solids content, waste loading, and bubbler configuration on glass production rate as well as off-gas system performance. The tests are summarized below in the order they were conducted:

- Test 1A1: 50 hours processing an adjusted rheology AZ-102 composition (target glass yield = 0.384 kg/kg or 560 g/l). Constant bubbling at 65 lpm from two, single-outlet "J" lance bubblers pointing towards the center and 6" from the floor.

- Test 1A2: 42 hours processing an adjusted rheology AZ-102 composition (target glass yield = 0.347 kg/kg or 480 g/l). Constant bubbling at 65 lpm from two, single-outlet "J" lance bubblers pointing towards the center and 6" from the floor.

- Test 1B: 114 hours processing a nominal rheology, AZ-102 composition (target glass yield = 0.27 kg/kg or 340 g/l, which was provided as corresponding to the expected Project minimum solids content). Bubbling adjusted in an attempt to obtain a target production rate of 1050 kg/m^2/day from double-outlet lance bubblers on the melter floor, 8" apart on East and West side, one bubbler outlet 11.3" from feed tube.

- Test 2A: 107 hours processing an adjusted rheology C-106/AY-102 composition (target glass yield = 0.372 kg/kg or 540 g/l). Constant bubbling at 65 lpm from two, single-outlet "J" lance bubblers with outlets located 6" from the bottom of the melter, placed in the corners, and pointed towards the melt pool center.

- Test 2B: 105 hours processing a high-waste-loading C-106/AY-102 composition (target glass yield = 0.263 kg/kg or 340 g/l). Bubbling was adjusted to obtain a production rate of 1050 kg/m^2/day from double-outlet lance bubblers on the melter floor, 8" apart on East and West side, one bubbler outlet 11.3" from feed tube.

Immediately prior to these tests, a series of tests using HLW AZ-101 simulants was conducted to evaluate the effects of bubbler configuration on glass production rate [11]. The change in melt pool composition from the HLW AZ-101 to the HLW AZ-102 composition was not expected to impact the objectives of the tests and therefore no turnover was conducted.

The tests employed a prototypical ADS feed system, a single feed tube in the center of the melter, a nominal glass temperature of 1150°C for all tests, and a side-to-side electrode firing pattern. In each test, the cold-cap-limited production rate was determined by visual observations

of the cold cap and confirmed by the plenum temperature. The ADS feed system performed well in all tests except for the first (adjusted-rheology AZ-102 feed). Despite increasing the pump line air pressure to the maximum value of 55 psi, manipulating the pump dwell time, and repeated line flushes, only small quantities of strained liquid were moved through the pump and, ultimately, the pump was not able to move any material. It is likely that solids could not be moved through the screen and were caked on the outer portion of the pump in a manner analogous to the attempt to process the LAW Sub-Envelope B1 feed [42]. The backup AOD feed system was used to process this viscous feed for about two days without incident. After discussions of this finding with WTP R&T, the AZ-102 feed was diluted from 20 to 17 percent UDS [38] and feeding was reinitiated with the ADS system. Feeding was conducted successfully for another two days using the ADS pump with no processing problems. The AOD pump was again used for the last few hours of the AZ-102 tests to minimize the heel remaining in the feed tank.

Feeding was interrupted several times during Test 1B and once or twice in the other tests for 1- to 10-minute intervals to remove blockages from the film cooler (see Section 5.1). The majority of the deposits were readily removed by running a rod down through the film cooler. These feeding hiatuses, those required to change between the AOD and ADS feed systems, and those required for diluting or changing feed, did not compromise the objective of determining a steady production rate for any of the test segments. The viscous feed used in Tests 1A and 2A formed easily managed cold caps without excessive mounds or ridges that would prevent free flow of the aqueous feed slurry. Production rates were 4 to 50% higher in tests with the more viscous feed than the analogous tests conducted previously with less viscous feed [8, 9]. It is likely that the higher production rates at the same melter conditions and bubbling rate resulted by utilizing more of the melter surface area as a result of improved feed spreading. Conditions were not as favorable while processing the nominal AZ-102 feed diluted to the projected minimum solids content. The target feed rate of 1050 kg/m^2/day could not be achieved and a feed stoppage of one hour was required in the middle of the test to allow the portions of the cold cap to diminish and become incorporated into the glass melt. Efforts to achieve the target rate included adjustment of bubbling rates as well as skewing of the total bubbler flow between the bubblers.

The effects of feed rheology, feed water content, simulant composition, and bubbler configuration on glass production rates are illustrated in Figures 4.1.a – 4.1.c. The results from the first test illustrate the effect of feed water content on processing rate: the production rate dropped from 1350 to 1150 to 900 kg/m^2/day as the melter feed glass yield dropped from 560 g/l to 480 g/l to 340 g/l. The effect is more pronounced when considering that lowest of these rates was obtained with double-outlet bubblers and an optimized bubbling rate, whereas the higher production rates were obtained with feed at the higher solids contents and but with single-outlet bubblers at a fixed bubbling flow rate of 65 lpm. A previous test with AZ-101 simulants at the lower solids content feed but with single-outlet bubblers at a fixed bubbler flow rate of 65 lpm achieved a steady state rate of only 550 kg/m^2/day [7] suggesting that the optimized bubbler configuration is responsible for a sixty four percent production rate enhancement to 900 kg/m^2/day. Also, at the same solids content and with the optimized bubbler configuration, the high-waste-loading C-106/AY-102 feed was processed at the target rate of 1050 kg/m^2/day, illustrating the effectiveness of the new bubblers as well as the differences in rate possible with

different simulant compositions. Comparison of tests conducted at the same melter conditions with the same feed composition show a 27 to 50 percent increase in production rate (1350 and 1150 vs. 900 kg/m^2/day [8]) for the more viscous feed when processing AZ-102 simulants. The rate enhancement with more viscous feed was only four percent (1010 vs. 970 kg/m^2/day [9]) when processing C-106/AY-102 simulants, further illustrating the differences in achievable production rates for different chemical compositions. These results are in contrast to previous tests with four different HLW simulants (without rheology adjustment) that showed little difference in achievable production rates as a function of chemical composition [7-11]. Compositional effects on production may be increased by factors that affect the way feed spreads over the melt surface such as feed water content, feed rheology, and bubbling configuration. The results from these tests with rheology-adjusted feeds suggest that tests performed with the nominal (non-rheology-adjusted) feeds are conservative; the adjusted rheology feeds yield production rates at least as high as those previously obtained with the nominal feeds. Once steady-state rates were established for each condition tested, production rates varied within less than ten percent of the steady-state value.

A variety of operational measurements recorded during these tests, including temperatures throughout the melter system, are given in Table 4.2. The target glass temperature of 1150°C was successfully maintained for most of the glass pool during each test, as illustrated in Figures 4.2.a -4.2.c. One exception was near the surface (27" from the floor) in some of the tests where temperatures were lower due to the thermocouples being in or near the cold cap. Another exception was in Tests 1B and 2B with low solids content feed when the melter was at or near power (or current) limits during attempts to maximize production rates with the double-outlet bubblers, resulting in glass temperatures as much as thirty degrees below target. Notice in Figure 4.2.a that the glass temperatures return to 1150°C at 172 hours run time, which corresponds to an hour hiatus in feeding followed by a reduction in feed rate. Aside from this excursion, bulk glass temperatures were relatively constant throughout the glass pool. Plenum temperatures, given in Figure 4.3.a - 4.3.c, spanned a larger range during the testing, 400 to 900°C, than the 450 to 550°C target given in the Test Plan. The majority of values over 600°C were from the beginning of each test as the cold cap was being formed or during attempts to maximize production rates with low solids content feed. The plenum temperature profiles also give an indication of the uniformity and completeness of the cold cap; temperatures for all thermocouples were close together with little variation over time, suggesting a uniform and stable cold cap (e.g., Test 1A), whereas highly variable plenum temperature readings would suggest an unstable cold cap (e.g., Test 1B). The consistency of the thermowell and exposed readings along with visual observations of the cold cap indicate the 100°C separation between the two sets of readings is due to the close proximity of the exposed thermocouple to a small opening in the cold cap near a bubbler outlet.

The east and west side electrode temperatures varied over the narrow range of 1060 – 1166°C after the cold cap was established, and typically varied by no more than 20°C from the mean during each test, as shown in Figures 4.4.a - 4.4.c. An exception was Test 1B during attempts to maximize production rates with low solids content feed when electrode temperatures reflected the changes in electrode power. The bottom electrode, which was not powered in these tests, was 30 – 110°C lower than the west electrode. The difference between temperatures

decreased with increasing bubbling as the melt pool was better mixed. The discharge chamber and riser temperatures were largely maintained above 950°C throughout the tests. (The riser thermocouple is located about 4 inches above the bottom of the riser pipe, which is about 7.5 inches above the melter floor.) Gas temperatures after the film-cooler were 140 - 280°C lower than the plenum temperature as a result of film-cooler and control-air dilution. The film cooler was cleaned by a water spray every 12 hours during most of the testing, resulting in a short-duration reduction to about 75°C in the film cooler outlet temperature.

Conditions in the glass pool are illustrated for electrical properties in Figures 4.5.a – 4.5.c, level and density in Figures 4.6.a – 4.6.c, and bubbling in Figures 4.7.a – 4.7.c. Power supplied to the electrodes was relatively constant once the cold was established in all tests except Test 1B where bubbling was frequently manipulated in an attempt to maximize the production rate with the low solids content feed. The maximum amount of power supplied to the electrodes was 249 kW during Test 1B; however, loss of glass temperature and poor cold cap conditions resulted in power, bubbling rate, and therefore production rate being reduced. In Test 2B while processing feed of the same solids content but of a different chemical composition, electrode power was sustained for the majority of the test at about 210 kW with only a modest decrease in glass temperature. Glass resistance varied as a function of glass pool bubbling, electrode power and, to a lesser extent, glass composition, during the tests. Changes in bubbling and supplied power in Test 1B are reflected in changes in glass resistance. Bubbling rate and power supplied to the electrodes are relatively constant in the other three tests, which are mirrored in the glass resistance profiles. The test average glass resistance for the AZ-102 composition was 0.01 ohm lower than for the C-106/AY-102 composition processed under the same melter conditions, suggesting a compositional effect. Glass pool density varied between 2.17 and 2.44 g/cc during these tests and experienced little change over the course of each test due to the constant bubbling rates. An exception is Test 1B where bubbling was more frequently manipulated. Glass pool level varied during Test 1B, increasing from the nominal 33 inches due to the formation of large ridges in the cold cap. Target total bubbling rates of 65 lpm for Tests 1A and 2A were successfully maintained after the formation of the cold cap. Using the double-outlet bubblers, total lance bubbling rates of 65 and 90 lpm were required for steady-state production with low solids content AZ-102 feed and high-waste-loading C-106/AY-102 feed, respectively.

It is worth noting that visual observation of the DM1200 melt pool is a key operational aspect of current DM1200 testing. In Test 1B feeding was stopped based on visual observations of cold cap ridges and mounds. Non-visual data such as plenum temperature would not have identified the extent of the cold-cap buildup. In fact, high plenum temperatures can result from a high mound over a portion of the melt surface preventing feed from spreading across the melt surface and creating an opening on the glass surface. Without the visual evidence, an operator may conclude that feed rates should be increased, which could exacerbate the problem. It is likely that the maximum production rate for each set of test conditions would have been significantly impacted for most of the tests if the cold cap conditions were not monitored visually. Consequently, it is recommended that the ability to maintain production rates without use of visual information be evaluated, if that is the planned WTP operating mode.

SECTION 5.0
OFF-GAS SYSTEM PERFORMANCE

The off-gas treatment system, shown schematically in Figure 1.7 consists of a submerged bed scrubber (SBS); a wet electrostatic precipitator (WESP); a high-efficiency mist eliminator (HEME #1); a heater; a high-efficiency particulate arrestor (HEPA); a sulfur impregnated activated carbon bed (AC-S) unit; a TCO/SCR catalytic unit, which includes a heater, a thermal catalytic oxidation unit (TCO), and a selective catalytic reduction unit (SCR) equipped with an ammonia injection system; a packed-bed caustic scrubber (PBS); a second high-efficiency mist eliminator (HEME #2); and a second HEPA on the bypass off-gas system. The new full size sulfur-impregnated activated carbon bed was installed in November 2004, prior to Test 2B. The AC-S unit was placed in between the HEPA filter and the heater for the TCO/SCR catalytic unit in the off-gas train.

The tests reported herein (Test 1 which consist of 1A1, 1A2, and 1B, and Tests 2A and 2B) together referred to as the "HLW AZ-102 and C-106/AY-102 Tests" represent the feed rheology tests with both feeds and tests with the high-waste-loading C-106/AY-102 glass composition. Tests 1A1, 1A2 and 1B used HLW AZ102 feed, while Tests 2A and 2B were conducted using HLW C-106/AY-102 feed. Table 5.1 provides an overview of the complete test series in the chronological sequence in which the tests were performed, and includes major post-test inspections and equipment modifications. The table also includes key operational events that affected off-gas system performance during the tests.

5.1 Off-Gas System Test Results

Data for each of the off-gas system components, logged by the LabVIEW data acquisition and control software, were imported into MS Excel files for data manipulation and plotting. Time "0" on the x-axis of each data plot corresponds to the start of water feed into the melter at the beginning of each test. Where indicated, data were smoothed by time averaging instantaneous measurements logged at two-minute intervals to reduce data scatter and the number of data points for the plots. The average, minimum, and maximum values of the measured off-gas system parameters are given in Table 5.2. Plots of the typical sequence of gas temperatures through the DM1200 off-gas system at various locations are given in Figures 5.1 through 5.3.

During the course of the above tests, equipment malfunction, power failure, building water supply pressure drop, etc., resulted in test interruptions or deviations from normal equipment operating parameters. As stated above, the key operational events that affected off-gas system performance are listed in Table 5.1.

5.1.1 Melter Pressure

Test 1

The computer-logged melter pressures measured at the instrument port and calculated control air flow rates for Test 1 are plotted in Figure 5.4. The test ended at 215.3 hours. The average melter pressure was -3.2 in. W.C., -3.1 in. W.C., and -3.0 in. W.C for Tests 1A1, 1A2, and 1B, respectively. During Test 1, the melter pressure ranged from -8.0 in. W.C. to 0.3 in. W.C. The control air system, to control melter pressure, was operational and effective during this test and its flow rate averaged 34.1 scfm, 30.8 scfm, and 34.3 scfm for Tests 1A1, 1A2, and 1B, respectively. The single positive melter pressure value of 0.3 in. W.C. occurred at about 152 hours when the partially clogged film cooler was rodded to remove the solid deposits. Events that affected melter pressure during Test 1 include rod-out of film cooler deposits and changes of the feed system from ADS to AOD and back.

Differential pressures across the film cooler are given in Figure 5.5. As is evident from Figure 5.5, clogging of the film cooler was more frequent towards the latter part of Test 1B between about 140 and 210 hours. The film cooler was rodded out a total of 16 times during Test 1 of which twelve took place during Test 1B between 145.2 and 172.4 hours when the film cooler differential pressure values reached up to about 10 in. W.C. This is likely due to the fact that Test 1B was conducted using a dilute feed (glass yield of 340 g/l) and the bubbling rate had be raised to a high value (100 lpm) to increase glass production rate. Even though more solid deposits were observed in the film cooler at the high bubbling rate, there was no noticeable difference in the characteristics of the deposits at the high and low bubbling rates. A view of the partially clogged film cooler at about 156.4 hours is given in Figure 5.6. During this test, the film cooler was rinsed every 12 hours with 5 liters of water; however, this procedure was not very effective in removing solid deposits and preventing clogging. Details of the film cooler wash procedure and rod-out times are given in Table 5.3. Transition line differential pressure during Test 1 is given in Figure 5.7. Transition line differential pressure data were measured from about 18.3 hours until the end of the test. Before this data collection was started, the transition line was tapped manually with a hammer to remove any deposits that may have contributed to clogging. At about 177 hours, the tubing used to measure transition line differential pressure was removed and cleaned. The spike in differential pressure at about 175 hours, seen in Figure 5.7, is most likely a result of the clogged measurement tube.

Test 2A

The computer-logged melter pressures measured at the instrument port and the calculated control air flow rates for Test 2A are plotted in Figure 5.8. The average melter pressure was -2.6 in. W.C. and the melter pressure ranged from -5.2 in. W.C. to -0.2 in. W.C. Events that affected melter pressure during the test include off-gas sampling, realignment of a misaligned feed tube gasket, and cleaning of the melter view port. The test ended at 110.2 hours. The control air system, to control melter pressure, was operational and effective during this test and its flow rate averaged 32.8 scfm. The peak in the control air flow at about 65 hours occurred when the melter

center view port was being cleaned. At 2.6, 16.9, and 17.4 hours, the control air flow settings were lowered to reduce carry over and gas flow through the off-gas system.

The differential pressures across the film cooler and transition line are given in Figures 5.9 and 5.10, respectively. The increase in film cooler differential pressure at about 16.7 hours of operation is a result of clogging. Visual examination of the film cooler showed about 95% occlusion with solid deposits. The differential pressure returned to lower values once the deposits were rodded out. During this test, the film cooler was rinsed every 24 hours with 5 liters of water.

Test 2B

The computer-logged melter pressures measured at the instrument port and the calculated control air flow rates are plotted in Figure 5.11. The average melter pressure was -2.8 in. W.C. and melter pressure ranged from -5.1 in. W.C. to 0.3 in. W.C. The test ended at 108.0 hours. The control air system, to control melter pressure, was operational and effective during this test and its flow rate averaged 23.7 scfm. A positive pressure reading of 0.3 in. W.C. at 64.2 hours was probably due to a large piece of cold-cap breaking and falling into the molten glass. Another positive pressure reading of 0.1 in. W.C. at about 67 hours occurred during a power failure event.

The differential pressures across the film cooler and transition line are shown in Figures 5.12 and 5.13, respectively. During this test, an alternative film cooler cleaner was tested based on the design used at the LAW Pilot Melter, which employs a slotted tube fed by water and pressurized air (Table 5.3). At about 24 hours the film cooler was partially clogged (about 35% occlusion, visually); washing was found to be ineffective and the film cooler was therefore rodded out. Since the washing method was not found to be effective in removing the deposits, after about 24 hours, the film cooler was not washed for the remainder of Test 2B. At 36 hours, the film cooler was inspected and blockage due to solid deposits of about 5% was estimated. At about 46 hours the film cooler was inspected again, and was found to be almost clean. Between 67.1 and 67.4 hours, feeding was stopped due to power failure and the effect can be seen in the differential pressures in Figures 5.12 and 5.13.

5.1.2 SBS Performance

SBS inlet and outlet gas temperatures, pressures and flow rates, pressure drop across the SBS, SBS water temperature, heat exchanger inlet and outlet water temperatures, and flow rates were recorded during the tests. The amounts of heat removed by the SBS jacket, and SBS inner cooling coil were calculated from the measured data.

Test 1

The SBS inlet and outlet gas temperatures are plotted in Figure 5.14. Two large downward spikes in the SBS inlet gas temperature at 29.3 and 192.0 hours are due to removal of

the inlet gas thermocouple connection for video inspection of the SBS. Most of the other downward spikes in the SBS inlet gas temperature are due to periodic cleaning of the film cooler with water which occurred at 12 hour intervals. The inlet gas temperature peaked at 373°C as the cold-cap was being established and averaged 299°C during feeding; the outlet gas temperature peaked at 52.7°C and averaged 49.0°C during Test 1A1. The inlet gas temperature peaked at 325°C as the cold-cap was being established and averaged 285°C during feeding; the outlet gas temperature peaked at 51.7°C and averaged 49.6°C during Test 1A2. The inlet gas temperature peaked at 421°C as the cold-cap was being established and averaged 311°C during feeding; the outlet gas temperature peaked at 55.1°C and averaged 49.6°C during Test 1B. The effect of feed interruptions at 52.2, 94.9, and 172.4 hours can be observed in downward SBS outlet gas temperatures spikes. The inlet, outlet, and differential pressures are shown in Figure 5.15. During Test 1A1, the inlet gas pressure averaged -7.3 in. W.C., the outlet pressure averaged –38.5 in. W.C., and the pressure drop across the SBS averaged about 31.2 in. W.C. During Test 1A2, the inlet gas pressure averaged -6.9 in. W.C., the outlet pressure averaged –38.2 in. W.C., and the pressure drop across the SBS averaged about 31.0 in. W.C. During Test 1B, the inlet gas pressure averaged -8.2 in. W.C., the outlet pressure averaged –39.3 in. W.C., and the pressure drop across the SBS averaged 31.1 in. W.C. The pressure drop across the SBS increased by about 0.4 in. W.C. over 215.3 hours of testing with HLW AZ-102 feed. The downward spikes at 18.3 hours in the inlet and outlet pressures coincide with tapping of the transition line, manually with a hammer by melter operators, to remove any clogging at that location. The SBS down-comer annulus pressure is given in Figure 5.16. Again, a downward spike in the annulus pressure is visible at about 18.3 hours. The SBS off-gas temperatures in the down-comer measured at 12 depths (from 3 to 58 inches at 5 inch intervals) and the SBS sump water temperature are given in Figure 5.17. The thermocouple at a depth of 23 inches was not functional during this test. The measured off-gas temperatures decrease as the depth from the SBS lid increases due to cooling of the gas in the down-comer pipe by the surrounding SBS liquid. The average SBS sump temperatures were 52.8°C, 43.1°C, and 42.7°C, which were 6.2°C, 6.5°C, and 6.9°C less than the SBS outlet gas temperatures for Tests 1A1, 1A2, and 1B, respectively.

Water temperatures at the SBS inner cooling coil inlet, inner cooling coil outlet/jacket inlet, and jacket outlet are given in Figure 5.18. The average water temperature difference was 25.1°C across the SBS inner cooling coil, and 2.1°C across the jacket during Test 1A1. The average water temperature difference was 25.0°C across the SBS inner cooling coil and 2.4°C across the jacket during Test 1A2. The average water temperature difference was 22.8°C and 2.6°C across the SBS inner cooling coil and jacket, respectively, during Test 1B. The SBS cooling coil/SBS jacket water flow rate is plotted in Figure 5.19. At 108.9 hours, the booster pump was brought into service to increase cooling water flow because the SBS outlet gas temperature was drifting 2 to 3°C above the target temperature of 50°C. The average SBS cooling coil/SBS jacket water flow rate was 14.2 gpm, 15.0 gpm, and 21.4 gpm, during Tests 1A1, 1A2 and 1B, respectively. The amounts of heat removed by the SBS inner coil and jacket are shown in Figure 5.20. The heat load data for the SBS inner cooling coil and jacket are calculated based on hourly averaged cooling water temperature increases (outlet temperature minus supply temperature) across the SBS inner cooling coil and cooling jacket multiplied by the same time-averaged water flow rate through each. For Test 1A1, heat removal averaged 76.4 kW

by the SBS inner cooling coil and 6.3 kW by the cooling jacket. This corresponds to about 92% of the heat load to the SBS being removed by the inner cooling coil and about 8% by the cooling jacket. For Test 1A2, heat removal averaged 81.8 kW by the SBS inner cooling coil and 7.8 kW by the cooling jacket. About 91% of the heat load to the SBS was removed by the inner cooling coil and about 9% by the cooling jacket. For Test 1B, heat removal averaged 104.2 kW by the SBS inner cooling coil and 12.3 kW by the cooling jacket. About 89% of the heat load to the SBS was removed by the inner cooling coil and about 11% by the cooling jacket.

Figure 5.21 shows a view from the inside of the bottom of the SBS downcomer. This image was obtained during a video inspection of the SBS downcomer at about 192 hours. The SBS downcomer had a very small amount of solids accumulation. At the end of Test 1, the SBS was not blown down.

Test 2A

The SBS inlet and outlet gas temperatures are plotted in Figure 5.22. The downward spikes in the SBS inlet gas temperature are due to periodic cleaning of the film cooler with water. Another downward spike in the SBS inlet gas temperature occurred at 16.7 hours when the film cooler was rodded out and rinsed. The inlet gas temperature peaked at 457°C as the cold-cap was being established and averaged 270°C during feeding; the outlet gas temperature peaked at 55.9°C and averaged 49.5°C. The inlet, outlet, and differential pressures are shown in Figure 5.23. The inlet gas pressure averaged -5.8 in. W.C., the outlet pressure averaged –37.2 in. W.C., and the pressure drop across the SBS averaged about 31.1 in. W.C. The pressure drop across the SBS increased by about 0.6 in. W.C. over 110.2 hours of testing with HLW C-106/AY-102 feed. The SBS downcomer annulus air pressure is given in Figure 5.24. The downward spikes in inlet and outlet pressures and downcomer annulus air pressure at about 16 hours correspond to removal of the film cooler blockage. SBS off-gas downcomer temperatures measured at 12 depths (from 3 to 58 inches at 5-inch intervals) and SBS sump water temperature are given in Figure 5.25. The thermocouple at a depth of 23 inches was not functional during this test. The average SBS sump temperature was 43.8°C, which is on average 5.7°C less than the SBS outlet gas temperature.

Water temperatures at the SBS inner cooling coil inlet, inner cooling coil outlet/jacket inlet, and jacket outlet are provided in Figure 5.26. The average water temperature difference was 27.1°C across the SBS inner cooling coil and 1.8°C across the jacket. The SBS cooling coil/SBS jacket water flow rate is plotted in Figure 5.27; the average value was 10.9 gpm. The amounts of heat removed by the SBS inner coil and jacket are shown in Figure 5.28. The heat load data for the SBS inner cooling coil and jacket are calculated based on hourly averaged cooling water temperature increases (outlet temperature minus supply temperature) across the SBS inner cooling coil and cooling jacket multiplied by the same time-averaged water flow rate through each. For this test, heat removal averaged 63.6 kW by the SBS inner cooling coil and 4.3 kW by the cooling jacket. About 94% of the heat load to the SBS was removed by the inner cooling coil and about 6% by the cooling jacket.

Figure 5.29 gives a view from the inside of the SBS downcomer at about 67 hours. At this time, small amount of solids accumulation was visible around the edges of the SBS downcomer. At the end of Test 2A, the SBS was not blown down.

Test 2B

The SBS inlet and outlet gas temperatures are plotted in Figure 5.30. The downward spikes in SBS gas temperature towards the beginning of the run are due to periodic cleaning of the film cooler with water and power failure at 67.1 hour. Since the film cooler cleaning with water was ineffective in removing deposits, it was discontinued after about 24 hours. The inlet gas temperature peaked at 443°C as cold-cap was being established and averaged 298°C during feeding; the outlet gas temperature peaked at 59.6°C and averaged 50.9°C. After about 75 hours, per WTP R&T direction, the cooling coil/jacket water flow rate was reduced to increase the SBS operating temperature above 50°C. During this part of Test 2B, the SBS outlet gas temperature averaged about 55°C. Even though operation of the SBS at a temperature higher than 50°C was possible for short periods of time, longer term operation at this higher temperature is likely to cause problems because at this SBS operating temperature, a number of the downstream off-gas components were operating close to their performance limits. The fluctuations in the SBS oulet gas temperature from about 75 to 98 hours are due to the following two reasons. From about 76 to 76.6 hours, the building water chiller was off-line, and between about 75 and 98 hours, the cooling water flow rate was reduced manually to increase the SBS operating temperature. The inlet, outlet, and differential pressures are shown in Figure 5.31. The inlet gas pressure averaged -7.0 in. W.C., the outlet pressure averaged –38.2 in. W.C., and the pressure drop across the SBS averaged about 30.8 in. W.C. The effect of partial film cooler blockage and cleaning at ≈24 hours can be observed in the SBS inlet and outlet gas pressures. The pressure drop across the SBS increased by about 0.5 in. W.C. over 108 hours of testing with HLW C-106/AY-102 feed. The SBS downcomer annulus air pressure is given in Figure 5.32. Off-gas temperatures in the downcomer measured at 12 depths (from 3 to 58 inches at 5-inch intervals) and SBS sump water temperatures are shown in Figure 5.33. The average SBS sump temperature was 45.1°C, which is 5.8°C less than the SBS outlet gas temperature. The SBS process (and sump) water level during operation is given in Figure 5.34. The average water level was 73.4 inches.

Water temperatures at the SBS inner cooling coil inlet, inner cooling coil outlet/jacket inlet, and jacket outlet are given in Figure 5.35. The average water temperature difference was 25.4°C across the SBS inner cooling coil and 1.6°C across the jacket. The upward spike in the cooling coil inlet water temperature is due to the building water chiller being off-line between 76.0 and 76.6 hours. The SBS cooling coil/SBS jacket water flow rate is plotted in Figure 5.36. The average SBS cooling coil/SBS jacket water flow rate was 21.2 gpm. The amounts of heat removed by the SBS inner coil and jacket are shown in Figure 5.37. The heat load data for the SBS inner cooling coil and jacket are calculated based on hourly averaged cooling water temperature increases (outlet temperature minus supply temperature) across the SBS inner cooling coil and cooling jacket multiplied by the same time-averaged water flow rate through each. For this test, heat removal averaged 114.2 kW by the SBS inner cooling coil and 7.3 kW by the cooling jacket. About 94% of the heat load to the SBS was removed by the inner cooling coil

and about 6% by the cooling jacket.

At the end of Test 2B, the SBS was not blown down.

5.1.3 WESP Performance

The inlet and outlet gas temperatures and differential pressure across the WESP were measured and recorded by the computer data acquisition system, while the WESP current and voltage were recorded manually.

Test 1

The WESP inlet and outlet gas temperatures are plotted in Figure 5.38. During Test 1A1, the WESP inlet gas temperature averaged 48.2°C and the outlet temperature averaged 49.0°C, indicating a 0.8°C temperature increase across the WESP. During Test 1A2, the WESP inlet gas temperature averaged 48.8°C and the outlet temperature averaged 49.8°C, indicating a 1.0°C temperature increase across the WESP. During Test 1B, the WESP inlet gas temperature averaged 48.9°C and the outlet temperature averaged 49.8°C, indicating a 0.9°C temperature increase across the WESP. The periodic downward spikes in the WESP outlet temperature are a result of the daily deluge of the WESP. These temperature spikes, even though progressively more diminished in magnitude, can be observed through HEME#1 and HEPA#1. Another three downward spikes at about 52, 95 and 172 hours are due to stoppage of feed. The WESP differential pressure and outlet gas flow rate are plotted in Figure 5.39. The pressure drop across the WESP averaged 2.4 in., 2.8 in., and 2.4 in. W.C during Tests 1A1, 1A2 and 1B, respectively. The average WESP wet gas flow rate was 250 scfm, 249 scfm, and 244 scfm for Tests 1A1, 1A2, and 1B, respectively.

The amount of liquid accumulated in the WESP is plotted as a function of run time in Figure 5.40 where it is compared with the amount of fresh water sprayed into the WESP. The inlet spray water was targeted at 2.0 ± 0.2 gph, as specified by the Test Plan. However, the actual spray water flow rate was ≈ 1.4 gph because of limitations of the spray nozzle coupled with low building water supply pressure. As evident from Figure 5.40, spray water accounts for the majority of the liquid accumulation in the WESP. The difference between accumulated liquid and fresh water sprayed is equal to the amount of liquid removed from the off-gas, which is also plotted in Figure 5.40; the 40-gallon-per-day deluges are not included in the "accumulated liquid" or "fresh waster sprayed" values in this figure. The WESP electrodes were deluged daily, as planned, with water at a nominal rate of 12 gpm for 3.33 minutes.

The WESP voltage and current are plotted as a function of run time in Figure 5.41. The average operating voltages and currents were about 28.5 kV, 29.6 kV, 29.0 kV and 16.1 mA, 16.7 mA, 16.7 mA during Tests 1A1, 1A2, and 1B, respectively. The voltage and current remained steady throughout the tests. Between 159.3 and 169.3 hours, the power supply to the WESP was turned off to replace a cable. During part of this time, the back-up power supply was

in use. The time required to stabilize power to operating values after deluge of the WESP ranged from 1 to 2 minutes and averaged 1.3 minutes, as shown in Table 5.4.

At the end of the test, 74.3 gallons of liquid was initially blown down. After a deluge, an additional 42.3 gallons of liquid was removed. There was a ¾ to 1 inch thick sludge build-up at the bottom of the WESP before the deluge. Figures 5.42 and 5.43 illustrate the WESP collector plates and grid pre-deluge. There was some solids accumulation on both the collector plate and rods. After deluge, about half of the bottom sludge was rinsed away. Figure 5.44 shows that some of the collector rod deposits and flakes remained, post-deluge.

Test 2A

The WESP inlet and outlet gas temperatures are plotted in Figure 5.45. The WESP inlet gas temperature averaged 48.7°C and the outlet temperature averaged 49.1°C, indicating a 0.4°C temperature increase across the WESP during this test. The downward spikes in the WESP outlet temperature are a result of the daily deluge of the WESP. The WESP was not in service until 20.4 hours when a power supply cable was replaced. This is most likely the reason for the WESP inlet temperature being higher than the outlet temperature up to about 20.4 hours. The WESP differential pressure and outlet gas flow rate are plotted in Figure 5.46. The pressure drop across the WESP averaged 2.4 in. W.C. The average WESP wet gas flow rate was 248 scfm. The slight decrease in WESP gas flow rate at about 16.7 hours is probably the result of a film cooler blockage of about 95% of the flow area.

The amount of liquid accumulated in the WESP is plotted as a function of run time in Figure 5.47, where it is compared with the amount of fresh water sprayed into the WESP. The inlet spray water was set to 2.0 ± 0.2 gph, as specified by the Test Plan. The actual spray water flow rate was ≈ 1.94 gph. As evident from Figure 5.47, spray water accounts for the majority of the liquid accumulation in the WESP. The difference between accumulated liquid and fresh water sprayed is equal to the amount of liquid removed from the off-gas, which is also plotted in Figure 5.47. During the first part of the test, it appears that water is evaporated into the WESP gas stream from water sprayed into the WESP. This is because the WESP was not operational until about 20.4 hours with the result that precipitation of aerosols in the off-gas stream that contribute to water accumulation in the WESP did not occur. The WESP electrodes were deluged daily, as planned, with water at a nominal rate of 12 gpm for 3.33 minutes.

The WESP voltage and current are plotted as a function of run time in Figure 5.48. The average operating voltage and current were about 29.1 kV and 16.8 mA, respectively. Once the WESP was placed in service at 20.4 hours, the voltage and current remained steady throughout the test. After deluging, almost no time was required to stabilize power to operating values.

At the end of the test, 67.6 gallons of liquid was initially blown down. After a deluge, an additional 38.7 gallons of liquid was removed. Figure 5.49 shows a pre-deluge view of sludge at the bottom of the WESP. A pre-deluge view of WESP rods and collector plates is provided in Figure 5.50. There were some solid deposits on both collector plates and rods. The post-deluge

view of the WESP rods and collector plates is shown in Figure 5.51. After the deluge, some particulate deposits were still visible at the bottom of the rods, but the bottom floor of the WESP was very clean.

Test 2B

The WESP inlet and outlet gas temperatures are plotted in Figure 5.52. The WESP inlet gas temperature averaged 50.1°C and the outlet temperature averaged 50.7°C, indicating a 0.6 °C temperature increase across the WESP during this test. The WESP inlet and outlet gas temperatures increased during the latter part of the run, in parallel with the SBS outlet gas temperature. The downward spikes in the WESP outlet temperature are a result of the daily deluge of the WESP. The WESP differential pressure and outlet gas flow rate are plotted in Figure 5.53. The pressure drop across the WESP averaged 2.0 in. W.C. The average WESP wet gas flow rate was 231 scfm. The slightly lower average pressure drop across the WESP for Test 2B as compared to Test 2A, and Tests 1A1, 1A2, and 1B is probably due to the lower average gas flow rate for Test 2B as compared to the other tests.

The amount of liquid accumulated in the WESP is plotted as a function of run time in Figure 5.54 where it is compared with the amount of fresh water sprayed into the WESP. The inlet spray water was set to 2.0 ± 0.2 gph as specified by the Test Plan. The actual spray water flow rate was ≈ 2.01 gph. As evident in Figure 5.54, spray water accounts for the majority of the liquid accumulation in the WESP. The difference between accumulated liquid and fresh water sprayed is equal to the amount of liquid removed from the off-gas, which is also plotted in Figure 5.54. The WESP electrodes were deluged daily, as planned, with water at a nominal rate of 12 gpm for 3.33 minutes.

The WESP voltage and current are plotted as a function of run time in Figure 5.55. The average operating voltage and current were about 29.2 kV and 16.7 mA, respectively. Except for the initial current fluctuations, the voltage and current remained steady throughout the test. The time required to stabilize power to operating values after deluge of the WESP ranged from 5 to 7 minutes and averaged 6 minutes, as shown in Table 5.4. We have not identified any specific voltage trends that can be used as an indicator of WESP operability.

At the end of the test, 88.5 gallons of liquid was initially blown down. After a deluge, an additional 54.4 gallons of liquid was removed.

5.1.4 HEME #1

A HEME (HEME #1) that follows the WESP in the off-gas system removes any water droplets that may be present in water-saturated gas exiting the WESP.

For Test 1, the outlet gas temperature and differential pressure are plotted in Figure 5.56. The average HEME #1 outlet gas temperatures were 47.2°C, 47.5°C, and 47.4°C for Tests 1A1,

1A2, and 1B, respectively. The average pressure drops across HEME #1 were 1.1 in. W.C., 1.2 in. W.C., and 1.2 in. W.C for Tests 1A1, 1A2, and 1B, respectively. At the end of the test, 32.4 gallons of liquid was blown-down from HEME #1. The drop in the outlet gas temperature at about 95 hours is a result of feed stoppage between Tests 1A2 and 1B. The minimum differential pressure at about 115 hours occurred when Blower 702 was switched to Blower 701, mainly to equalize run time for the two blowers. For Test 2A, the outlet gas temperature and differential pressure are plotted in Figure 5.57. The average HEME #1 outlet gas temperature was 47.0°C. The average pressure drop across HEME #1 was 1.2 in. W.C. At the end of the test, 31.6 gallons of liquid was blown-down from HEME #1.

For Test 2B, the outlet gas temperature and differential pressure are plotted in Figure 5.58. The average HEME #1 outlet gas temperature was 48.3°C. The average pressure drop across HEME #1 was 1.0 in. W.C. At 5.9 hours the failed sensor line for differential pressure measurement was replaced and data collection was started. At the end of the test, 32.6 gallons of liquid was blown down from HEME #1. The downward spike in HEME #1 differential pressure at 67.1 hours resulted from a power outage.

5.1.5 HEPA Filter

HEME #1 is followed in the off-gas system by a heater, a HEPA filter (HEPA #1), and a Paxton blower (Blower #1). The purpose of the heater is to ensure that water-saturated gas exiting HEME # 1 is heated above its dew point before passing through the HEPA filter in order to prevent moisture condensation in the HEPA filter. The outlet gas temperature and the pressure differential across HEPA #1 are the only two parameters that were monitored by the off-gas data acquisition system, and these are shown in Figures 5.59, 5.60, and 5.61 for Tests 1, 2A, and 2B, respectively. For the tests, the average HEPA #1 outlet temperature was between 63.5°C and 64.6°C. The average differential pressure across HEPA #1 was between 0.1 and 0.6 in. W.C for all test segments except Test 2A. These data indicate that no significant particulate loading or moisture blinding of HEPA #1 took place during Test 1 and Test 2B. During Test 2A, the differential pressure across HEPA # 1 increased from about 0.5 in. W.C. to about 3.0 in. W.C. during the first 20 hours of operation. This is probably due to moisture condensation and solids build-up in HEPA # 1 because the WESP was not operational during this time period. Rapid increase in differential pressure across HEPA#1 when the WESP is not operational has been observed previously [45]. At the end of Test 2A, HEPA #1 filter and its prefilter were replaced. During the latter part of Test 2B, Heater 701 set point was raised from 65°C to 67°C to compensate for the higher SBS operating temperature and prevent condensation in the HEPA.

5.1.6 Activated Carbon Bed

A bulk flow sulfur impregnated activated carbon bed the (AC-S) with Donau carbon BAT-37 media was installed and used during Test 2B. A description of the AC-S unit is given in Section 1.4.6. The operational parameters are presented in this section.

Temperatures at different locations in the AC-S unit are plotted in Figure 5.62. The initial spike in the carbon bed temperatures are most likely due to adsorption of moisture and small amounts of NOx. Higher bed temperatures towards the end of Test 2B are a consequence of the higher SBS operating temperature, which resulted in higher off-gas temperatures throughout the system. Activated carbon bed and outlet screen differential pressures are given in Figure 5.63. The average activated carbon bed and outlet screen differential pressures were 1.4 in. W.C. and 3.4 in. W.C., respectively.

Information on NO_x and CO removal across the AC-S is provided in Table 5.5. During Test 2B, the gaseous species were relatively unaffected by the carbon media. Post test inspection of the AC-S media did not show evidence of any segregation or fluidization of the bed.

5.1.7 TCO/SCR Unit

The TCO/SCR unit consists of a heater, a Thermal Catalytic Oxidizer (TCO), and a Selective Catalytic Reduction (SCR) unit with an ammonia injection system. After the off-gas is heated in the TCO/SCR heater, organics are catalytically oxidized in the TCO. The off-gas is then mixed with ammonia before entering the SCR unit where NO_x is reduced to nitrogen.

Test 1

The TCO/SCR heater inlet gas temperature is plotted in Figure 5.64 and averaged 78.7, 79.3, and 78.3°C for Tests 1A1, 1A2, and 1B, respectively. The TCO inlet, SCR inlet and outlet, and post SCR temperatures during the test are plotted in Figure 5.65. The downward temperature spike at about 95 hours corresponds to stoppage of feed between Tests 1A2 and 1B. The average TCO inlet gas temperature was 474°C for each Test 1 segment (1A1, 1A2, and 1B). Due to the proximity of the heater to the TCO inlet thermocouple, there was a concern that the shine from the heater was leading to an artificially high temperature reading from the TCO inlet thermocouple. Accordingly, the thermocouple was repositioned for Test 2B and the TCO inlet reading dropped by about 70°C for the same heater set point (see below). The average SCR inlet gas temperatures were 403°C, 406°C and 410°C respectively. The average SCR outlet gas temperatures measured at two locations, one foot apart at the outlet of the SCR, were 384°C, and 370°C for Tests 1A1, 387°C and 372°C for Test 1A2, and 389°C and 368°C for Test 1B. The average temperatures after the SCR were 347°C, 348°C and 346°C for Tests 1A1, 1A2, and 1B, respectively. The differential pressures across the TCO, SCR, and TCO/SCR are plotted in Figure 5.66 and averaged 6.4 in. W.C., 3.2 in. W.C., and 9.9 in. W.C., respectively during Test 1.

The TCO catalyst (Engelhard VOC CAT 300H) sections were inspected after Test 1. Views of the inlet and outlet of TCO catalyst sections #1 and #2 are given in Figures 5.67 through 5.71. Some deposits were observed, especially at the inlet of section #1. Per Project direction, both sections of the TCO catalyst were replaced with Engelhard Corp. VOC CAT 360PFC 200 cpsi catalyst blocks. Section 1 of the new catalyst had a volume of 1.25 cubic feet

and section 2 had a volume of 1.00 cubic feet. There was a three inch gap between the two sections of TCO catalyst. The TCO/SCR heater (Heater 801) was inspected after Test 1 and found to have a failed heating element with most of the damage near the lid. A view of the top section of the heater is given in Figure 5.71 and a side view is given in Figure 5.72. A photograph of the failed heating element is given in Figure 5.73.

Test 2A

The TCO/SCR heater inlet gas temperature is plotted in Figure 5.74 and averaged 78.8°C. The SCR inlet and outlet and post SCR temperatures during the test are plotted in Figure 5.75. TCO inlet gas temperature readings are not available for this test because the TCO inlet thermocouple was moved to a position between the TCO catalysts in an attempt to avoid the effect of shine from the heater. The thermocouple readings at this location were unexpectedly low, and averaged about 361°C, particularly in view of the fact that the average SCR inlet gas temperature was 403°C. The average SCR outlet gas temperatures were 388°C and 351°C at two locations, one foot apart, at the outlet of the SCR. The average temperature after the SCR was 335°C.

The differential pressures across the TCO, SCR, and TCO/SCR are plotted in Figure 5.76. Average differential pressures were 5.1 in. W.C. (TCO), 3.0 in. W.C. (SCR), and 8.3 in. W.C. (TCO/SCR).

Test 2B

Prior to Test 2B, per direction from WTP R&T both sections of the TCO catalyst were replaced again, this time with Engelhard Corp. VOC CAT 300S 200 cpsi. Views of the inlet and outlet of the new TCO catalyst sections #1 and #2 are given in Figures 5.77 through 5.80.

The TCO/SCR heater inlet gas temperature is plotted in Figure 5.81 and averaged 76.3°C. The upward temperature spike at 74.6 hours is a result of increasing Heater 701 set point that again is related to operation of the SBS at a higher temperature. The TCO inlet, SCR inlet and outlet, and post SCR temperatures during the test are plotted in Figure 5.82. The discontinuities in the plots correspond to time periods when one or more of the thermocouples were checked for proper operation; no issues were identified. The average TCO inlet gas temperature was 404°C, while the average SCR inlet gas temperature was 397°C. The average SCR outlet gas temperatures were 376°C and 334°C at two locations, one foot apart, at the outlet of the SCR. The average temperature after the SCR was 307°C

The differential pressures across the TCO, SCR, and TCO/SCR are plotted in Figure 5.83. Average differential pressures were 3.9 in. W.C., 2.5 in. W.C., and 6.6 in. W.C., respectively.

5.1.8 Packed Bed Scrubber (PBS)

The TCO/SCR is followed in the off-gas train by a packed bed caustic scrubber (PBS) to remove iodine and acid gases from the off-gas stream. The effluent solution can be pumped out of the PBS sump and process water and caustic solution (25% NaOH) added to control the solid content and pH of the scrubber liquid.

The inlet gas temperature and the pressure drop across the PBS for Test 1 are shown in Figure 5.84. The average PBS differential pressures during Test 1A1, 1A2, and 1B were 4.5 in. W.C., 4.6 in. W.C., and 4.3 in. W.C., respectively. The average PBS inlet gas temperatures were 323°C, 325°C and 322°C during Test 1A1, 1A2, and 1B, respectively. The PBS sump temperatures and pH are plotted in Figure 5.85. The sump temperature averaged 34.0°C, 34.3°C, and 35.4°C during Tests 1A1, 1A2, and 1B, respectively. The corresponding pH values averaged 9.1, 9.2, and 9.2. The downward spike in the PBS sump temperature at about 95 hours corresponds to stoppage of feed between Tests 1A2 and 1B. At the end of the test, no liquids were blown-down from the PBS.

The inlet gas temperature and the pressure drop across the PBS during Test 2A are shown in Figure 5.86. The average PBS differential pressure was 3.0 in. W.C. The average PBS inlet gas temperature was 314°C. The PBS sump temperature and pH are plotted in Figure 5.87 and averaged 32.6°C and 9.2, respectively. At the end of the test, no liquids were blown down from the PBS.

The inlet gas temperature and the pressure drop across the PBS for Test 2B are shown in Figure 5.88. The average PBS differential pressure was 2.9 in. W.C. and the average PBS inlet gas temperature was 288°C. The PBS sump temperature and pH are plotted in Figure 5.89 and averaged 32.9°C and 9.2, respectively. The upward spike in the sump water temperature at about 76 hours is a result of the building chilled water supply being off-line. At the end of the test, 34.3 gallons of liquid was blown down from the PBS.

5.1.9 HEME #2

A HEME (HEME # 2) that follows the PBS in the off-gas system removes any water droplets that may be present in water-saturated gas exiting the PBS.

Inlet and outlet gas temperatures and differential pressure for Test 1 are plotted in Figure 5.90. The average HEME # 2 inlet gas temperatures were 35.5°C, 35.8°C, and 36.7°C and the average outlet temperatures were 36.6°C, 36.8°C, and 37.5°C during Test 1A1, 1A2, and 1B, respectively. The corresponding average pressure drops across HEME # 2 were 5.0 in. W.C., 6.5 in. W.C., and 7.2 in. W.C. At the end of the test, 26.4 gallons of liquid was blown-down from HEME #2.

Inlet and outlet gas temperatures and differential pressures for Test 2A are plotted in

Figure 5.91. The average HEME # 2 inlet gas temperature was 34.0°C and the average outlet gas temperature was 35.0°C. The pressure drop across HEME # 2 increased from about 3.5 in. W.C. to about 5.5 in. W.C. during the course of the test. At the end of the test, 24.1 gallons of liquid was blown-down from HEME #2. The HEME #2 filter media was inspected and photographed after Test 2A. The outer surface of the HEME #2 filter media was dirty along the circumference and bottom, as shown in Figure 5.92. The inner surface of the filter media was fairly dark with some deposits, as shown in Figure 5.93. A new filter was installed in HEME #2 after Test 2A. These deposits could be solids entrained from the PBS. However, it should be noted that this is the first time that the HEME#2 element was replaced since the off-gas system was commissioned.

Inlet and outlet gas temperatures and differential pressures for Test 2B are plotted in Figure 5.94. The average HEME # 2 inlet gas temperature was 34.6°C and the average outlet gas temperature was 35.1°C. The upward spikes in the inlet and outlet temperatures at about 76 hours are a result of the building chilled water supply being off-line, which caused an increase in the outlet gas temperature from the PBS. The average pressure drop across HEME # 2 was 2.8 in. W.C. At the end of the test, 30.2 gallons of liquid was blown-down from HEME #2.

5.1.10 Final Paxton Blower (Blower-801)

No operational issues were noted for Blower 801 during these tests.

5.1.11 Emergency Off-Gas System

After Test 2A, the emergency off-gas system (EOG) was inspected and cleaned. Views of the EOG piping showing solid deposits are given in Figures 5.95 and 5.96. About 7.8 kg of solid material was removed from the emergency off-gas piping. From their appearance, the solid material looks like feed carryover with somewhat higher concentrations of more volatile components such as sulfur, and alkali and boron oxides. A post-cleaning view of a section of EOG piping is given in Figure 5.97.

5.1.12 Effluent Liquid Treatment System

Effluent liquids from the SBS, WESP, PBS, HEM#1, and HEME # 2 are all piped to a series of sampling tanks that discharge to three 500-gallon storage tanks for neutralization, mixing, and storage. The largest effluent volume is overflow (blow-down) from the SBS, which is pumped to one of two SBS sampling tanks. Caustic solution (25% NaOH) from the same caustic tank that supplies the PBS can also be added to the 500-gallon storage tank that receives acidic effluents from SBS sampling tanks; this storage tank is therefore referred to as the neutralization tank.

5.2 SBS, WESP, HEME, and PBS Process Fluids

5.2.1 SBS Fluids

One-liter samples were collected from the SBS sump each time liquids were blown down and at the end of each test. Selected samples were subjected to total dissolved solids (TDS) and total suspended solids (TSS) determinations by gravimetric analysis of filtered material and the evaporated filtrate. An additional sample was filtered to generate solids and filtrate for complete chemical analysis, which included pH determination, direct current plasma emission spectroscopy (DCP) analysis for metals, ion selective electrode (ISE) for ammonium, and ion chromatography for all other anions; the dried filtered solids underwent microwave-assisted acid dissolution prior to chemical analysis.

All of the SBS sump samples that were taken throughout the DM1200 tests are listed in Table 5.6; the middle letter in the sample name is "S" for the SBS samples. The table provides pH values for each sample, as well as the blow-down volume from which each SBS sample was taken and the cumulative SBS blow-down volume. The analyzed chemical compositions for samples taken at or near the end of each test are provided in Table 5.7. The pH values for the SBS liquids for each test are plotted in Figure 5.98 as a function of the amount of glass produced. The sump solution pH varied within a narrow range of 7.9 to 8.9 due to the low concentrations of volatile constituents in the feeds, such as nitrates which have a strong effect on SBS solution pH. The SBS solution pH reached steady-state with respect to emissions and blow-down rate in the first test at about 8.7, which is consistent with previous tests using AZ-102 feed [8]. The pH dropped to 7.9 in response to processing C-106/AY-102 feed, then rose back to about 8.6 in response to processing the high-waste-loading C-106/AY-102 feed. The adjusted rheology C-106/AY-102 formulation contained several volatile species such as selenium and iodine which were unique to that simulant and which may have caused the SBS solutions to become less basic.

Figures 5.99 – 5.101 compare the amount of water fed to the total volumetric accumulations in the SBS over the course of each test. Included is the water fed to cool the melter plenum at the start of each test to create a cold cap and thereby minimize subsequent off-gas surges due to pulsed feeding onto bare glass (this is the same feed start-up protocol as that used at West Valley). The amount of water fed into the melter is proportional to the amount of water in the feed and the slurry feed rate; hence Tests 2A and 2B, which used a single feed at a single feed rate had a constant water feed rate to the melter for each of the two tests. In contrast, feed with three different water contents was processed during Test 1, resulting in several water feed rate changes. Some of these changes were small due to offsetting decreases in feed rate with increases in feed water content. The difference between the amounts of SBS water coming from the feed and the amounts blown down represents the amount of water carried out in the off-gas stream as a result of it being saturated at the SBS sump temperature, as well as a small amount of entrained droplets. This amount is largely determined by the SBS sump water temperature, which was targeted at 50°C (except for the last day of Test 2B) and averaged within one degree of this target in all the tests. Changes in the water feed rate to the melter were therefore reflected in the amount of water accumulation in the SBS.

Figures 5.102 - 5.110 compare the feed compositions to the SBS dissolved and suspended

fractions determined from samples taken at the end of tests from each of the three feed compositions. As expected, the dissolved solids consist mainly of soluble species such as halogens, boron, alkali metals, sulfate and, in the case of the rheology-adjusted C-106/AY-102 feed, selenium (which is a consequence of the different waste basis). These species are readily volatilized from the glass and cold cap in the melter as soluble salts. Similar results were obtained from analysis of SBS solutions in tests with other HLW simulants [4, 7-11, 19]. Dissolved chlorine and fluorine were observed in significant proportions in all of the tests, even though chlorine was only targeted in the feed for Test 2A and fluorine in none of the feeds, indicating that these halides were present in the feed as a contaminant. Iodine was measured as a dissolved species in significant concentrations in Test 2A as a result of its high volatility and incorporation in the feed recipe. Nitrite and nitrate constitute a large fraction of the dissolved SBS solids in LAW melter tests [18, 42, 43] but are present only in small quantities in these samples due to their much lower concentrations in the melter feeds. The suspended solids more closely resemble the feed and consist primarily of iron, silicon, sodium, zinc, and aluminum, as well as high concentrations (relative to those in the feed) of the more volatile constituent, selenium, in samples from Test 2A. The dissolved and suspended fractions were of near equal masses for each test. The amount of dissolved and suspended material measured in samples from tests with adjusted rheology feed was about twice that measured in previous tests with feed of the same composition [8, 9]. The primary reason for this increase is the operation of the SBS at a sump temperature of 50°C instead of 40°C, which results in less dilution of solids from condensed feed water. Other contributing factors include a 5 to 25% increase in production rate, and modifications to the SBS, which may enhance solids suspension.

5.2.2 WESP, PBS, and HEME Fluids

One-liter samples were collected from the WESP, PBS, and HEME sumps each time liquids were blown down and at the end of the tests. All of the WESP and PBS sump samples that were taken throughout the test are listed in Tables 5.8 and 5.9; the middle letter in the sample name is "W" and "P" for the WESP and PBS samples, respectively. The tables provide pH values for each sample, as well as the blow-down volume from which each sample was taken and the cumulative blow-down volumes. Between 80 and 120 gallons of liquid was blown down from the WESP daily: the first 40 to 80 gallons from the previous day's accumulation of water from spraying and condensation (typically, the sample with suffix "A" in the name) and the second from the 40-gallon deluge (typically, the sample with suffix "B" in the name). The PBS was blown down as required to maintain constant volume. The pH of the PBS sump is maintained between 9 and 10 during testing by the addition of 25% sodium hydroxide solution.

Results from the analysis of sump samples from the WESP taken at the end of each test, before and after the deluge, are given in Table 5.10. The composites (pre- and post-deluge) chemical composition of samples from each of the three feed compositions is illustrated in Figures 5.111 - 5.113. The WESP solution pH values were higher (7 to 8.5 vs. 2 to 7) than for the early HLW tests [3, 4] due to dilution from the added deluge, higher than for the previous LAW Sub-Envelope B1 tests [42] (7 to 8.5 vs. 2 to 4) due to the lower concentrations of nitrates/nitrites in the feed, and comparable to more recent HLW tests that also employed a daily

deluge for cleaning the WESP electrodes [7-11]. Exceptions are samples from Test 2A, which were very acidic (pH values as low as 2.4) due to high concentrations of selenium in the sump solutions. A near total absence of suspended material was measured in both the pre-deluge blow-down solutions. Higher, but still low, concentrations of suspended material were found in post-deluge solutions; this material was presumably material that was dislodged from the electrodes. Volatile salts (alkali halides, borates, sulfates, and selenium in Test 2A) carried over from the SBS and constituents from previous tests or impurities in feed and tap water are major constituents in the WESP solutions. The observed solution chemistry supports the expectation that the majority of the coarser, less-soluble species were removed by the SBS, leaving predominantly highly soluble species for accumulation in the WESP. Depending on the concentration of soluble species in the feed, the concentration of total solids in the WESP pre-deluge sample is four to ten times lower than the contemporaneous SBS sample. The concentrations of most elements are higher in the solutions prior to the deluge, although the relative proportion of elements is very similar.

The amount of solution removed from the first HEME (immediately downstream of the WESP) at the end of each test and corresponding chemical analysis is given in Table 5.11. The HEME was continuously sprayed at a rate of 0.2 gal/hr, resulting in the addition of about 20 gallons of water for each of the four near-100-hour tests. The liquid accumulated during each of the tests was five to ten gallons greater than the amount sprayed as a result condensation. The pH of HEME solutions followed the same trend as the contemporaneous WESP samples: the pH values are near neutral for all the tests except Test 2A, which had pH values near 3. The chemical analysis of the HEME solutions indicate the solutions are diluted WESP solutions, which is consistent with the HEME collecting mist carried over from the WESP. Nitrate, nitrite, and ammonia are higher in the HEME solutions than the contemporaneous WESP solutions suggesting that the HEME is more efficient at removing these constituents from the exhaust stream or that these constituents are being leached from the HEME filter media.

5.2.3 Estimates of Accumulations in SBS, WESP and HEME Fluids

Estimates of elemental accumulations in the SBS, WESP, and HEME blow-down solutions for Tests 1A and 2A are provided in Tables 5.12 and 5.13. These tests were selected for these calculations since melter emissions data were available and the results can be compared to previous tests conducted with feed of the same chemical composition but different rheology [8, 9]. The accumulation totals are the product of the analyses given in Tables 5.7, 5.10, and 5.11 with the total accumulated liquids given in Tables 5.6, 5.8, and 5.9. A single sample analysis from the end of each test was used for the estimates. The accumulations given, therefore, are mostly upper estimates, since the concentration values were taken near the end of tests and the concentrations certainly increased over the course of the test. They do not include the solids in the SBS bowl or in the downcomer. The accumulations estimated from blow-down data are also compared to test average melter emissions data as percent of feed (see Section 7.0). During the test with rheology-adjusted AZ-102 feed, the equivalent of more than five kilograms of boron, iron, sodium, and silicon as well as a little over one kilogram of aluminum and zinc accumulated

in the SBS. During the test with rheology-adjusted C-106/AY-102 feed, only selenium had a estimated accumulation greater than five kilograms and boron, chlorine, iodine, iron, sodium, and silicon had SBS accumulations between one and four kilograms. Despite the significant accumulated masses, the SBS liquids constitute a significant proportion of the elemental mass balance only for the most volatile constituents, namely selenium, sulfur, and halogens. Several constituents have estimated accumulations in the SBS fluids of about one to three percent of feed in at least one of the tests: As, B, Ca, Cd, Cs, Cr, Fe, Na, Pb, Ti, Zn and nitrite/nitrates. Estimates of accumulations in WESP solutions are much smaller than for the SBS solutions, although similar in that they are dominated by halogens, sulfur, alkali metals, and boron. The only elements with a significant proportion of the elemental mass in WESP solutions was selenium and to a lesser degree chlorine. Accumulations in the HEME solutions are even smaller than those in the WESP fluids since the volume of HEME fluids is small and the measured concentrations are lower. Elements present in tap water such as calcium, potassium, magnesium and chlorine are over estimated as percentages of feed in the various solutions, particularly when feed concentrations are low, due to spraying and cleaning of equipment with city tap water. Contamination in chemical additives (see Section 2.7.3) also can result in biases in percentage estimations. The elemental feed percentages measured in melter emissions are in excellent agreement with the sum of the estimated accumulations in the SBS, WESP, and HEME for most elements in both tests. The deviation is less than a factor of two for all elements in both tests except for iodine, which has been observed in previous tests to not be fully removed from the melter exhaust by the primary off-gas system [8, 9, 42]. Estimates of elemental accumulations in process fluids from previous tests with feed of the same composition but different rheology [8, 9] are very similar to those calculated in these tests, indicating that feed rheology does not have a discernable effect on melter emissions.

5.3 HEPA and HEME Filter Media

During Test 2B, samples of HEME and HEPA filter media provided by the WTP Project were tested for their durability in gas streams containing HF and HCl. One of the HEME filter media was a Johns Manville product (VSL ID: JMGR), for use as a collection layer. Another HEME filter media was from Holliner (VSL ID: HGFGM), for use as outer drainage layer. One HEPA filter media that was tested was Flanders DH700 Standard (VSL ID: FLDN700). The other HEPA filter media was Flanders DH713 HF (VSL ID: FLDN713). A view of the filter media assembly used for testing is given in Figure 5.117. The locations of the four filters are numbered 1 to 4 in Figure 5.117. The filter installation location numbers, their descriptions, and corresponding VSL identification numbers for the filters and samples analyzed after the test are given in Table 5.14.

This test was performed using a slipstream from the DM1200 main off-gas flow after the HEPA. During the test, the slipstream was spiked with two gas mixtures: 5% hydrogen chloride (HCl) in nitrogen and 1% hydrogen fluoride (HF) in nitrogen supplied in gas cylinders. The mixtures were injected into the slipstream at the rate of 0.655 slm (1.39 scfh) and 1.4 slm (2.96 scfh), respectively, from the bottom of the filter media assembly. The gases were delivered from two separate size D cylinders equipped with nitrogen-purged regulators and mass flow

controllers. After these two gas mixtures were mixed with the slipstream in a mixing manifold, the spiked gas stream was passed through the four filters installed in parallel. Valves shown near the top part of Figure 5.117, or at the exit of the filter media, were adjusted to maintain a 0.75 in. W.C. differential pressure that was targeted across each filter. After passing through the filters separately, the gas streams were combined and returned to the main off-gas flow upstream of the PBS. The average total gas flow through the filter media assembly was 25.2 scfm. The test was scheduled to last 100 hrs continuously, but the actual duration was 49 hours because of water condensation problems. The injection of relatively large amounts of unheated gas in combination with the chemical effects of the highly soluble HF and HCl spikes likely contributed to the observed but unintended condensation effects.

The filter media were tested during Test 2B, between 25.4 and 83.5 hours. The inlet and outlet gas temperatures for the filter bank are plotted in Figure 5.118. The average inlet and outlet gas temperatures were 71.5°C and 56.8°C, respectively. After HEPA#1, the off-gas passes through a Paxton blower and heat tapes are used on the line to the filter bank, both of which increase the temperature of the inlet gas to the filter bank. Due to condensation, the outlet gas temperature decreased rapidly, especially after 69 hours. The effect of water condensation on differential pressure of the filter bank can be seen in Figure 5.119. After the test, the filter assembly was opened and the filters were inspected. Filter FLDN713 was soaked, FLDN700 was wet, and filters JMGR and HGFGM were very moist. Figure 5.120 indicates pressue drops across the valves used to control gas flow through each of the filters which were set to ≈ 0.75 in. W.C at the beginning of the test. There was no flow control adjustment once valve positions were initially set. Due to condensation, pressure drops across valves supplying gas to FLDN700 and FLDN713 increased over the course of testing.

After the test, the filters were removed and examined for deposits and damage. A macro image of sample 1Z2-O-116A (JMGR) filter scanned at 1200 dpi is shown in Figure 5.121. The dark colored very small pieces seen on the filter are probably metal pieces that originated from the piping. Comparative secondary electron images of original (left) and exposed (right) samples of filter 1Z2-O-116A (JMGR) are shown in Figure 5.122. A medium magnification SEM micrograph of residue adhered to filter sample 1Z2-O-116A (JMGR) is shown in Figure 5.123. Samples were prepared by mounting original and tested filters side-by-side on carbon tape, in some cases in cut cross section, and heavily gold coated to eliminate charging. EDS spectra from various locations on the residue are given in Figure 5.124. An EDS spectrum of the original material of sample 1Z2-O-116A is given in Figure 5.125. DCP analyzed chemical compositions of original filter materials are presented Table 5.15. Both the EDS and DCP analyses of sample 1Z2-O-116A (JMGR) show that the sample consists of silicon and smaller amounts of sodium, magnesium, aluminum, and calcium. The fluorine and chlorine peaks are also visible in Figures 5.124, which may be due to the reaction products of HF and HCl with the filter material. Analysis results indicate that calcium, magnesium, and aluminum were depleted in the exposed filter material.

A macro image of sample 1Z2-O-116B (HGFGM) filter scanned at 1200 dpi is shown in Figure 5.126. Comparative secondary electron images of original (left) and exposed (right) samples of filter 1Z2-O-116B (HGFGM) are shown in Figure 5.127. A medium magnification

SEM micrograph of the residue adhered to filter 1Z2-O-116B (HGFGM) is shown in Figure 5.128. EDS spectra from various locations on the residue are given in Figure 5.129. An EDS spectrum of the original material of sample 1Z2-O-116B is given in Figure 5.130. DCP analyzed compositions of original filter materials are given in Table 5.15. Both the EDS and DCP analyses of original sample 1Z2-O-116B (HGFGM) show that the sample consist of silicon and smaller amounts of sodium, magnesium, aluminum, calcium, and boron. The fluorine and chlorine peaks are also visible in Figure 5.129, which may be due to reaction products of HF and HCl with the filter material. Analysis results indicate that magnesium was absent in the exposed filter material whereas aluminum and calcium were still present.

A macro image of sample 1Z2-O-116C (FLDN700) filter scanned at 1200 dpi is shown in Figure 5.131. Partial disintegration of the exposed filter sample 1Z2-O-116C and holes can be seen in this figure. The exposed material was about half of its original thickness. Comparative secondary electron images of original (left) and exposed (right) samples of filter 1Z2-O-116C (FDNL700) are shown in Figures 5.132 and 5.133. A medium magnification SEM micrograph of residue adhered to the filter and a corresponding EDS spectrum of sample 1Z2-O-116C (FDNL700) are given in Figure 5.134. An EDS spectrum of the original material of sample 1Z2-O-116C is given in Figure 5.135. DCP analyzed compositions of original filter materials are presented Table 5.15. Both the EDS and DCP analyses of the original sample 11Z2-O-116C (FDNL700) showed that the sample consists of silicon and smaller amounts of sodium, aluminum, barium, zinc, potassium, calcium, and boron; chlorine, iron, and chromium peaks are also seen in Figure 5.134. The chlorine peak may be due to a reaction product of HCl with the filter material while the iron and chromium probably originated from the piping. Interestingly, SEM/EDS analysis of the fibers from the exposed filter material indicated that sodium, aluminum, barium, zinc, potassium, and calcium were absent.

A macro image of sample 1Z2-O-116D (FLDN713) filter scanned at 1200dpi is shown in Figure 5.136. Partial disintegration of the used filter sample 1Z2-O-116D and large holes can be seen in this figure. Comparative secondary electron images of original (left) and exposed (right) samples of filter 1Z2-O-116D (FLDN713) are shown in Figures 5.137 and 5.138. The exposed material was about one-quarter of its original thickness. An SEM micrograph of residue and precipitate adhered to filter 1Z2-O-116D (FDNL713) is shown in Figure 5.139. EDS Spectrum 1, from the precipitate evident in the Figure 5.139, and EDS spectrum 2 from general residue on filter 1Z2-O-116D (FDNL713), are given in Figure 5.140. An EDS spectrum of the original material of sample 1Z2-O-116D is given in Figure 5.141. DCP analyzed compositions of the original filter materials are presented Table 5.15. Both the EDS and DCP analyses of the original sample 11Z2-O-116D (FDNL713) show that the sample consists of silicon and smaller amounts of sodium, aluminum, barium, zinc, potassium, calcium, and boron. The chlorine peak is also visible in Figure 5.140. The chlorine peak may be due to a reaction product of HCl with the filter material. Interestingly, similar to sample 11Z2-O-116C, SEM/EDS analysis of the exposed fibers showed that, sodium, aluminum, barium, zinc, and potassium were absent from the exposed filter material; calcium was still present in the sample.

Based on these results, in terms of the resistance of filters to the HF and HCl environments occurring in these tests, the best material was the HEME filter material from

Holliner (VSL ID: HGFGM); second best was the HEME filter material from Johns Manville (VSL ID: JMGR). The third best was the HEPA filter material from Flanders, DH700 Standard (VSL ID: FLDN700); the worst was Flanders DH713 HF (VSL ID: FLDN713). However, it must be noted that the effects of condensation may have skewed the results and that the observed amount of condensation was greatest for FLDN713 and FLDN700 and least for JMGR and HGFGM.

SECTION 6.0
GLASS PRODUCT

Over twenty one metric tons of glass product was discharged from the melter through an airlift system into 55-gallon drums. The discharged product glass was sampled from each drum by removing sufficient glass from the top for total inorganic analysis. Product glass masses, discharge date, and the analyses performed are listed in Table 6.1.

6.1 Compositional Analysis

Glass samples were crushed and analyzed directly by XRF. The target values for the boron and lithium oxide concentrations were used for normalizing the XRF data, since boron and lithium were not determined by XRF. Analyzed compositions for discharged glass samples are provided in Table 6.2. There was good agreement with the target composition for the majority of oxides and, in particular, for the major oxides, as described for feed samples in Section 2.7.3. All major and intermediate oxides were within 10% of the target composition with the exception of zirconium and zinc in the AZ-102 tests, zinc and magnesium in the test with adjusted rheology C-106/AY-102 feed, and aluminum in tests with the high-waste-loading C-106/AY-102 feed. The AZ-102 zirconium deviation was very similar to that observed in the feed samples (about 25%) and glass produced during the DM100 tests (see Section 3.3); the zinc deviation was slightly below 10% in the feed samples, and is slightly above 10% in the discharged glass. The zirconium deviation in the feed and glass samples is likely due to higher than assumed zirconium content in the source chemical. The deviations in the C-106/AY-102 samples were all less than fifteen percent and can be attributed in part to the lack of three melt pool turnovers for each of the two compositions. This notion is supported by the feed sample and DM100 data, which only have deviations of zinc for the adjusted rheology C-106/AY-102 formulation. Also, previous tests with the high-waste-loading C-106/AY-102 compositions showed no deviations greater than 10% for intermediate and major oxides [13]. Barium, chlorine, chromium, potassium, sulfur, and titanium were measured at low levels in the glasses from tests in which they were not included in the target composition or in the glass prior to the respective test. Chromium is generated by corrosion of melter components, and the others originate as contaminants in the glass forming additives. Common elements targeted at low concentrations, such as calcium and potassium, are over-represented in the glass product also, due to trace contamination in the glass forming additives. Ruthenium and yttrium were introduced as a spike in the immediately preceding test to trace the behavior of these elements in melt pool [11] and, therefore, were observed in samples at the beginning of the first test. No iodine was measured in any of the glasses even though it was spiked into the feed during the test with adjusted rheology C-106/AY-102. This lack of iodine retention in glass is in keeping with its high volatility and previous tests with HLW simulants containing no added reductants [7-10, 19, 41].

Corroborative analysis using DCP on solutions of acid-dissolved glass was performed on select glasses produced from each test; the results are compared to the XRF analysis in Table 6.3. Values for all of the major oxides compare favorably with the XRF analysis and target

composition except for sodium, which often exhibits a low bias using this procedure [13, 43]. The closeness of the DCP boron and lithium analyses to the target validates the use of the target boron and lithium concentrations for normalizing the XRF data.

Compositional trends from the XRF data are plotted for selected elements in Figures 6.1-6.6. The figures illustrate many of the points apparent in the tabular summaries of the data: good agreement with target for all major oxides except zirconium after the melt pool has experienced or approached three turnovers (~6000 kg of glass produced) and compositional changes as the glass pool transitions from the AZ-102 and the two C-106/AY-102 formulations. Few compositional changes at the beginning of testing were observed other than a decrease in zirconium concentration due to the similarity between the AZ-101 composition, which was in the glass pool [11] at the start of these tests and the AZ-102 composition. The turnover from the AZ-102 to the adjusted rheology C-106/AY-102 composition is best observed as decreases in the concentrations of zirconium and nickel and increases in concentrations of strontium and manganese, as well as a series of toxic metals shown in Figure 6.5 and chromium in Figure 6.6. The turnover from the rheology-adjusted C-106/AY-102 to the high-waste-loading C-106/AY-102 composition is best observed as decreases in the concentrations of strontium and manganese as well as many toxic metals, and increases in iron, zirconium, a series of metals depicted in Figure 6.4, and volatile constituents (chromium and sulfur) in Figure 6.6.

6.2 Iron Redox State

The iron oxidation states for glass samples from all four tests were measured using colorometric methods. The method detection limit of 0.3% divalent iron reported here is dependent on several factors including the level (12.5 to 14 wt%) of Fe_2O_3 in the target glasses. Sample information including name, test, and the amount of glass produced for all samples analyzed for divalent iron are given in Table 6.4. Divalent iron concentrations decreased over the course of the tests from 8.3 percent of the total iron in the preceding test [11], to below measurable amounts at the end of the last test. These low levels of reduced iron were anticipated given that reductants were not added to the feed in these tests and the low concentrations of TOC in the simulant recipes.

6.3 Discharge Riser Glass

Per a WTP Test Exception [44], several glass samples were taken from the DM1200 air-lift riser after 2.4 days of idling following the completion of the high-waste-loading C-106/AY-102 test. The samples were taken immediately before the following MACT tests [46], the schedule for which determined the maximum idling duration that was possible. For comparison, additional samples were taken 72 days after the HLW MACT tests, which were performed with a lower waste loading formulation [46]. Like the previous DM100 tests with the high-waste-loading C-106/AY-102 formulation (see Section 3.3), sampling and analysis were performed to determine if the high-waste-loading C-106/AY-102 formulation was prone to excessive spinel crystallization at idling temperatures. A list of all the DM1200 samples taken, date of sampling, location of sampling, and analytical results are provided in Table 6.5. An

illustration of the DM1200 air-lift riser annotated with a detailed temperature profile is given in Figure 6.7. Samples were taken from the riser by removing glass directly from the discharge stream at the onset of the glass pour. This sampling method has been used extensively in past tests to provide samples for iron oxidation state evaluation and to measure the concentrations of noble metals such as ruthenium [7, 11, 19]. If plug flow through the riser is assumed, the rate of glass discharge and the volume of glass in the riser were such that the first discharge sample would correspond to glass from the top of the riser, the second would correspond to glass from the bottom of the riser, and the third would correspond to glass from the melt pool. While it is likely that the introduction of air into the riser causes some mixing of the glass in the riser, which would complicate this distinction, the early discharge samples should still have contained a significant fraction of the glass that had been idling in the riser. The temperature range from the melt surface to the riser bottom is 804 to 965°C, with the hottest portion at the level of the electrodes. No spinels were observed in any of the DM1200 riser samples. This difference in results from the DM100 samples may be due to the short amount of idling time and the differences in temperature profile between the two melters. It is not surprising that no spinels would be observed after the MACT tests despite the much longer idling time given the lower iron concentration (12.56 vs. 14.03 wt. % Fe_2O_3) in the glass composition that was used for the HLW MACT tests.

SECTION 7.0
MONITORED OFF-GAS EMISSIONS

7.1 Particulate and Gaseous Emissions

Six samples were taken from the melter exhaust using 40-CFR-60 Methods 3, 5, and 29 to examine particulate and certain gaseous fluxes. Triplicate samples were taken during tests with the adjusted rheology AZ-102 and C-106/AY-102 feeds to examine the variability of the melter emissions during a single test and to compare with data from previous tests that processed the same feed composition at a different rheology [8, 9]. Sampling durations were targeted at one hour; however, fine particulate often clogged the sampling filters resulting in shorter sampling durations. Teflon filters were used to allow for analysis of all feed components. The majority of the off-gas analyte concentrations were derived from laboratory data on solutions extracted from air samples (filters and various solutions) together with measurements of the volume of air sampled. The volume of air sampled and the rate at which it can be sampled are defined in 40-CFR-60 and SW-846. Isokinetic sampling, which entails removing gas from the exhaust at the same velocity that the air is flowing in the duct (40-CFR-60, Methods 1-5), was used. Typically, a sample size of 30 dscf is taken at a rate of between 0.5 and 0.75 dscfm. Total particulate loading was determined by gravimetric analysis of the standard particle filter and of probe-rinse solutions. Downstream of the particulate filter in the sampling train are iced impingers with acidic (5% concentrated nitric acid plus 10% hydrogen peroxide) and basic (2 N sodium hydroxide) solutions. The analysis of these solutions permits the determination of total gaseous emissions of several elements, notably halides and sulfur. Two of the three samples for each feed composition were within 10% of isokinetic; the single samples for each test outside the range were within 18% of isokinetic. The difficulty in obtaining isokinetic data for all samples can be attributed to the rapid blinding of the Teflon filters. Results from samples outside of the 10% window were similar to the other samples for the same melter condition, indicating a lack of sampling bias for these samples.

All melter exhaust sampling results including exhaust water content, elemental emission rates and DFs obtained during the tests are provided in Tables 7.1 and 7.2. 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 0.3 μm heated filter. Results for each of the triplicate samples for each test were very similar to each other, as evidenced by the total particulate emissions for each sample being within ten percent of the mean value. The consistency of emission results indicates that, at least over the sampling period, conditions in the melter (particularly cold cap coverage) were relatively constant. Previous tests conducted at the same melter conditions, at the same feed solids content, and the same feed composition except for the rheology adjustment, had a solids carryover from the melter of 1.26% and 0.67% for AZ-102 and C-106/AY-102 feeds, respectively [8, 9]. The solids carryover values in tests with the rheology-adjusted feeds were 0.77% and 0.75%, respectively, which is comparable to the previous C-106/AY-102 tests but significantly lower than the previous AZ-102 tests. Particulate emissions from the previous

AZ-102 were considerably higher than those measured for any waste compositions processed under the same melter conditions [7-10] even though the feed does not contain more volatile species. The high emission rate measured for the previous AZ-102 test is probably due therefore to transient operating conditions, such as an opening in the cold cap close to the melter exhaust port or excessive spraying of feed due to a partially clogged feed nozzle. The similarity of melter emission rates for the rheology-adjusted feed and all other emission data taken under the same melter conditions indicate that feed rheology alone does not have a significant effect on the extent of melter emissions.

The average compositions of feed and melter emissions (excluding oxygen, carbon, nitrate, and nitrite) for samples taken are displayed in Figures 7.1-7.4. Notice that the relative percentages of volatiles, such as halides, increase downstream as the major constituents decrease. For example, silicon, which constitutes about forty two percent of the AZ-102 glass (Figure 7.1), comprises half as much of the AZ-102 melter emissions (Figure 7.2). Conversely, sulfur, which constitutes only 0.03 percent of the AZ-102 glass, constitutes about a two orders of magnitude larger fraction of the melter emissions. The enhancement of melter emissions with volatiles is even greater in the tests with the C-106/AY-102 compositions due to the inclusion of the highly volatile elements selenium and iodine. The composition of the particles and gases in the melter exhaust are very similar to previous tests with same simulants [8, 9] indicating that changes in feed rheology do not have an observable effect on the elemental content of the emissions. Impinger solutions from off-gas sampling were analyzed for all of the elements in the feed, but only halides, boron, sulfur, and selenium were detected. The presence of these elements in the gas fraction is consistent with observations from previous studies [7-11, 13, 18, 19, 41-43, 46]. Iodine was exclusively detected as a gaseous species, also consistent with previous observations.

7.2 FTIR Analysis

Off-gas analysis by Fourier Transform Infrared (FTIR) spectroscopy was performed using an On-Line Technologies Inc. Model 2010 Multi-Gas™ Analyzer. Data were recorded at 71 s intervals, corresponding to an average of 128 scans at 0.5 cm^{-1} spectral resolution. The melter off-gas supplied to the FTIR spectrometer was extracted using a heated sampling and transfer loop, which removed a gas sample stream from the off-gas system at 5 liters per minute. The sampling and transfer loop was maintained at 150°C throughout in order to prevent analyte loss due to condensation.

Off-gas emissions were monitored by FTIR spectroscopy throughout each test for a set of selected species over discrete time intervals at specified off-gas system locations. Tables 7.3 – 7.6 display summaries of the average and range of analyte concentrations measured over the course of the tests. The melter emissions data show the expected ratios of constituents for a feed low in nitrate, nitrite, and organic carbon: low concentrations of nitrogen oxides, with NO being the most abundant nitrogen oxide present, and few byproducts of organic combustion, such as carbon monoxide. Nitrogen oxides are unaffected by the primary off-gas system and are present in the exhaust stream at too low a concentration to evaluate their destruction across the catalyst. Concentrations of measured gaseous species did not change across the carbon column, which

was installed for the last test, except for nitrogen dioxide, which dropped from a test average of 2.4 ppmv to less than 1 ppmv. During testing with the AZ-102 simulant, all measured concentrations except for water decreased with increasing water dilution of the feed. The measured species in the melter exhaust during the test with rheology-adjusted AZ-102 feed (Test 1A) and rheology-adjusted C-106/AY-102 feed (Test 2B) are very similar in concentration to those measured previously while processing the same feeds without rheology adjustment [8, 9] supporting the notion that feed rheology has a negligible effect on gaseous emissions. Water emissions downstream of the SBS were relatively constant due to the SBS sump temperature being maintained within a narrow range. Another aspect of the emissions is the high degree of variation during testing, as can be discerned from the concentration ranges.

7.3 Hydrogen by Gas Chromatography

Monitoring for hydrogen was performed using Gas Chromatography (GC). The GC was equipped with a 3' × 1/8" stainless-steel column packed with molecular sieve 5A and a thermal conductivity detector operated with an argon carrier gas at 4 psi and a column temperature of 40°C. The unit was calibrated against a certified standard gas (1090 ppmv hydrogen in air) that was progressively diluted using mass-flow controllers to obtain six different hydrogen concentrations ranging between 1090 ppmv and 10 ppmv. The limit of detection of this system was below the 10-ppmv lower calibration point, but was not further quantified. Measurements were made only at the WESP outlet and are indicative of melter emissions, since no hydrogen is removed by the SBS or WESP. Hydrogen values are compared to data from previous tests [7, 9] conducted at the same bubbling rate in Table 7.7. Low concentrations were measured in all tests, similar to previous tests with AZ-101 feed. Hydrogen concentrations were lower in tests with diluted feed due to a lower feed rate of organic compounds into the melter. The higher value measured for the previous test with C-106/AY-102 feed is about twice as high as hydrogen concentrations measured in other tests with feeds that do not contain added reductants.

SECTION 8.0
SUMMARY AND CONCLUSIONS

Melter tests were conducted on the DM1200 to determine the effects of feed rheology, feed solids content, and bubbler configuration on glass production rate and off-gas system performance while processing the HLW AZ-101 and C-106/AY-102 feed compositions. Several of these tests were preceded by screening tests on the DM100 melter system. Four tests of 92 to 114 hours in duration were conducted using different feed rheologies, feed solids contents, waste loadings, and bubbler configurations for comparisons to results from previous melter tests. Several of the tests employed rheology-adjusted feeds that were intended to provide better representations of the rheological properties of some of the more viscous actual waste samples that have been characterized; the majority of the previous melter testing has been performed with HLW waste simulants that are of somewhat lower viscosity. The test results showed that the rheology-adjusted feeds processed at rates that were four to fifty percent higher than in analogous tests with the less viscous feeds, indicating that the previous test results likely give an accurate to conservative estimate of processing rate. Tests with AZ-102 simulants showed that reduction of the waste solids content to the expected Project minimum value (corresponding to a glass yield of 340 g/L) dramatically reduced the feed processing rate, to the extent that the target glass production rate of 1050 kg/m^2/day could not be achieved. Efforts to achieve the target rate included adjustment of bubbling rates as well as skewing of the total bubbler flow between the bubblers. Significant differences in processing rate were observed as a function of simulant composition for rheology-adjusted feeds and at lower feed solids contents, suggesting that the previously held conclusion that the processing rates for different HLW simulants are virtually identical may only apply to the four HLW simulants previously tested, which were simulants with high waste solids contents and with lower viscosities.

The optimized bubbler configuration, with double-outlet bubblers in modified locations, resulted in obtaining the target production rate of 1050 kg/m^2/day with the high-waste-loading C-106/AY-102 formulation, despite the high water content of the feed [1]. A production rate of only 900 kg/m^2/day was achieved with the AZ-102 composition at the same waste solids content; however, this rate is a sixty percent increase from previous tests with AZ-101 feed at the same waste solids content using two *single*-outlet bubblers.

The adjusted rheology AZ-102 feed was processed without difficulties with the simulated ADS pump on the DM100 but could not be processed with the actual ADS pump on the DM1200. Observations during attempts to process the feed suggest that the feed was not moving through the pump screen, remaining caked to the outside of the pump in a manner similar to the LAW Sub-Envelope B feeds tested previously. The feed was subsequently diluted from 20% UDS from pretreatment to 17% UDS, after which the feed was processed without incident. No

[1] Note that for a given solids content in the feed from pretreatment, the water content in the *melter* feed increases as the waste loading is increased. Consequently, the high-waste-loading C-106/AY-102 melter feed has a higher water content than its lower-waste-loading predecessor (at the same solids content from pretreatment) and, as a result, present a greater glass production rate challenge.

feed system difficulties were encountered with the rheology-adjusted or high-waste-loading C-106/AY-102 feeds. The higher viscosity feeds were easily processed in the DM100 and DM1200 melters, spreading well across the melt surface and forming stable cold caps.

The general performance of the DM1200 melter and off-gas treatment system was good. Design modifications to the internals of the SBS, directed by the Project to address the build-up of solids in the downcomer, were completed and installed prior to the tests. The limited testing performed subsequent to these changes suggests that the build-up of deposits in the downcomer may be less extensive as a result of the modifications. Numerous film cooler blockages requiring mechanical clean-out occurred throughout the tests, particularly during high-bubbling periods with low solids content feed. A slotted spraying wand, fed with air and water, that was inserted into the film cooler region was ineffective at preventing deposits from forming and at removing deposits occluding the film cooler. A sulfur-impregnated carbon bed was installed in between the HEPA filter and the catalyst unit prior to the last test. No problems with the carbon bed were encountered; however, the concentrations of gaseous species such as volatile organics and nitrogen oxides were very low during these tests. Extensive sets of process engineering data were collected during the tests.

The glass product was close to the intended composition for all elements except zirconium once the melt inventory was turned over; the absolute deviations for zirconium were small and did not impact the test objectives. After processing the high-waste-loading C-106/AY-102 formulation and idling the melters for various amounts of time, glass samples were taken from the air-lift discharge risers of the DM100 and DM1200 to determine the extent of spinel crystallization in the riser. The samples were analyzed by various microscopic methods. The results indicated that a limited amount of spinels (~0.4 vol%) formed in the DM100 riser after idling whereas no spinels were observed in the DM1200 riser samples. The difference may be due to the much shorter idling duration for the DM1200 samples as a result of the schedule for the subsequent HLW MACT tests, as well as differences in temperature and composition.

Isokinetic particulate samples were taken at the melter outlet for tests using rheology-adjusted feed. The purpose of these samples was to determine the effects of changes in feed rheology on melter emissions. Particulate carryover from the melter was comparable to most previous tests conducted at the same melter conditions. The composition of the melter emissions was unchanged by differences in feed rheology. Elemental DF values were determined across the melter and compared to elemental accumulations in off-gas system effluent solutions. Other emissions data collected during the tests included concentrations of various gaseous species throughout the primary off-gas system by FTIR and hydrogen concentrations by gas chromatography at the WESP outlet. The carbon column installed prior to the last test had very little effect on the concentrations of gaseous species in the off gas; however, the concentrations of most species, including nitrogen oxides, were already very low.

The volumes of processing solutions generated in the SBS, WESP, HEME, and PBS were documented during testing and representative samples were subjected to chemical analysis. The SBS solutions were close to neutral pH, due in large part to the lack of acid gases in the exhaust stream. The major dissolved species were halogens, boron, and alkali metals, while the

suspended species closely resembled the feed composition. The measured SBS TSS and TDS values were comparable to each other during each test and had concentrations ranging between 3 and 7 g/L. The WESP sump fluid was also in the neutral pH region except during the test with selenium in the feed; as has been observed previously, the selenium concentrated in the WESP solutions, turning them acidic. The WESP solutions contained significant concentrations of dissolved boron, sulfate, and alkali halides, with negligible suspended solids. The WESP was sprayed continuously during these tests and was deluged with 40 gallons of water once daily, resulting in a daily blow-down volume of between 70 and 150 gallons. The 8,583 gallons of liquid that accumulated in the SBS during testing originated from the condensation of water from the melter feed.

SECTION 9.0
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Table 2.1. Compositional Summary of Different Waste Streams and Blended Solids for the AZ-102 HLW Simulant.

Feed Constituent	**AZ-102 Solids** FRP02 (lb/day)	**Recycle Stream** RWD01 (lb/day)	**Separation Factor** (fraction remained)	**Cs-Eluate** CNP12 (lb/day)	**Tc-Eluate** TEP12 (lb/day)	**Blended Solids** HLP09b (lb/day)
Ag	7.68E+00	4.17E-21	1.00E+00	-	-	7.68E+00
Al	1.75E+03	1.77E+00	4.20E-01	5.29E-01	2.12E-02	7.36E+02
As	5.19E-01	1.21E-01	1.00E+00	-	-	6.40E-01
B	3.60E+01	3.11E+00	1.00E+00	6.66E-01	6.80E-02	3.98E+01
Ba	6.13E+00	1.64E-04	2.42E-01	-	-	1.48E+00
Be	1.18E-01	0.00E+00	1.00E+00	-	-	1.18E-01
Bi	9.70E-01	2.34E-04	1.00E+00	-	-	9.71E-01
Ca	4.19E+01	8.14E-02	9.88E-01	3.41E-02	2.32E-03	4.15E+01
Cd	2.97E+02	6.19E-04	8.27E-02	-	-	2.46E+01
Ce	8.56E+00	5.88E+00	7.72E-02	-	-	1.11E+00
Cl	4.24E+00	9.42E-02	7.95E-02	-	1.29E-02	3.57E-01
Co	6.82E-01	0.00E+00	1.00E+00	-	-	6.82E-01
Carbonate	5.27E+02	2.24E+00	1.31E-01	-	-	6.91E+01
Cr	2.11E+01	2.15E-01	1.52E-01	6.83E-02	3.32E-03	3.31E+00
Cs	6.82E-01	0.00E+00	1.15E-01	2.73E-01	-	3.52E-01
Cu	2.30E+00	2.37E-44	1.00E+00	2.90E-01	-	2.59E+00
F	8.96E+00	1.27E+00	8.25E-02	-	-	8.44E-01
Fe	2.19E+03	1.41E+00	9.94E-01	1.19E-01	2.22E-02	2.18E+03
Hg	2.01E-01	1.90E-05	1.00E+00	-	-	2.01E-01
K	5.14E+01	6.82E-01	9.29E-02	1.86E+00	4.15E-02	6.74E+00
La	8.09E+01	1.80E-02	9.85E-01	-	-	7.96E+01
Li	9.99E-02	8.15E-01	1.00E+00	-	-	9.15E-01
Mg	1.07E+01	7.28E-06	1.00E+00	-	3.32E-04	1.07E+01
Mn	5.60E+01	8.20E-02	9.99E-01	-	3.32E-04	5.60E+01
Mo	1.22E+00	0.00E+00	1.00E+00	-	-	1.22E+00
Na	7.29E+02	3.59E+02	1.15E-01	1.71E+01	3.32E-01	1.43E+02
Nd	2.96E+01	0.00E+00	1.00E+00	-	-	2.96E+01
Ni	8.84E+01	1.07E-01	9.83E-01	2.56E-01	2.65E-03	8.73E+01
Nitrite	3.13E+02	2.56E-01	7.84E-02	-	-	2.46E+01
Nitrate	7.86E+00	8.21E+02	7.77E-02	4.92E+01	-	1.14E+02
Hydroxide	1.08E+02	3.16E+01	5.97E-01	-	-	8.32E+01
Hydroxide(Bound)	5.74E+03	0.00E+00	7.68E-02	-	-	4.41E+02
Pb	1.63E+01	2.00E-02	1.00E+00	1.19E-01	-	1.64E+01
Pd	9.82E-01	1.95E-09	1.00E+00	-	-	9.82E-01
Phosphate	3.81E+01	5.01E-03	2.20E-01	5.23E-02[@]	2.03E-03[@]	8.43E+00
Pr	5.60E+00	0.00E+00	1.00E+00	-	-	5.60E+00
Rb	8.39E-02	0.00E+00	1.00E+00	-	-	8.39E-02
Rh	5.90E-01	0.00E+00	-[*]	-	-	5.90E-01
Ru	2.63E+00	0.00E+00	-	-	-	0.00E+00
Sb	7.17E-02	0.00E+00	-	-	-	0.00E+00
Se	1.68E-01	0.00E+00	-	-	-	0.00E+00
Si	1.11E+02	6.46E+00	9.97E-01	4.61E-01	9.29E-02	1.18E+02
Sulfate	1.36E+02	2.46E+01	7.69E-02	-	-	1.23E+01
Sr	2.39E+00	0.00E+00	9.58E-01	-	-	2.29E+00
Ta	3.94E-02	0.00E+00	-	-	-	0.00E+00
Te	9.30E-01	0.00E+00	-	-	-	0.00E+00
Th	4.25E+00	0.00E+00	-	-	-	0.00E+00
Ti	6.42E-01	1.39E-03	1.00E+00	-	-	6.43E-01
Tl	3.94E-02	0.00E+00	-	-	-	0.00E+00
TOC	3.90E+01	0.00E+00	7.67E-02	-	-	2.99E+00
U	2.33E+02	0.00E+00	-	6.14E-01	0.00E+00	6.14E-01
V	5.02E-01	0.00E+00	-	-	-	0.00E+00
Y	2.06E+00	0.00E+00	-	-	-	0.00E+00
Zn	1.47E+00	4.71E-01	1.00E+00	5.12E-02	3.32E-04	2.00E+00
Zr	3.26E+02	3.13E-01	9.99E-01	-	-	3.26E+02
TOTAL	**1.30E+04**	**1.26E+03**[#]	-	7.16E+01	6.02E-01	4.69E+03

[*]Analytes with undetermined separation factors are omitted. [#]1.28E+03 if H^+ is included. [@]Converted from P. "-" Empty data field

Table 2.2. Compositional Summary (Oxide Basis) of the AZ-102 HLW Simulant, Glass Additives, Target Test Glass, and the Reference Glass (HLW98-80) [8].

Wt%	AZ-102 HLW Simulant	Glass Former (as wt% of glass)	Melter Test Target Glass	HLW98-80
Ag_2O	--	--	--	0.034%
Al_2O_3	23.10%	--	5.60%	5.590%
B_2O_3	2.13%	12.00%	12.52%	12.529%
CaO	0.97%	--	0.23%	0.233%
CdO	0.47%	--	0.11%	0.114%
Cl	--	--	--	--
Cs_2O	0.21%	--	0.05%	--
F	--	--	--	--
Fe_2O_3	51.80%	--	12.56%	12.530%
K_2O	0.13%	--	0.03%	0.032%
La_2O_3	1.55%	--	0.38%	0.376%
Li_2O	0.03%	3.25%	3.26%	3.260%
MgO	0.30%	--	0.07%	0.073%
MnO*	1.47%	--	0.36%	0.357%
Na_2O	3.20%	11.25%	12.02%	12.033%
Nd_2O_3	0.68%	--	0.17%	0.165%
NiO	1.85%	--	0.45%	0.447%
P_2O_5	0.10%	--	0.03%	0.024%
PbO	0.29%	--	0.07%	0.070%
SiO_2	4.18%	47.25%	48.26%	48.308%
SO_3	0.17%	--	0.04%	0.041%
ZnO	0.04%	2.00%	2.01%	2.012%
ZrO_2	7.32%	--	1.78%	1.772%
TOTAL	100.0%	75.75%	100.00%	100.000%
Volatiles (g/100 g oxide)				
Carbonate	1.145	--	--	--
Nitrite	0.407	--	--	--
Nitrate	1.883	--	--	--
TOC	0.050	--	--	--

*MnO_2 in Reference [22] "—" Empty data field

Table 2.3. Composition of Melter Feed to Produce 1 Metric Ton of Target Glass from AZ-102 HLW Simulant (20 wt% undissolved solids).

AZ-102 HLW Simulant		Glass-Forming Additives	
Starting Materials	**Target Weight (kg)***	**Starting Materials**	**Target Weight (kg)**
$Al(OH)_3$	90.23	--	--
H_3BO_3	9.28	$Na_2B_4O_7 \cdot 10H_2O$	331.99
$CaCO_3$	4.26	--	--
CdO	1.14	--	--
NaCl	--	--	--
CsOH (50% solution)	1.07	--	--
NaF	--	--	--
$Fe(OH)_3$ (13% slurry)	1290.02	--	--
KNO_3	0.71	--	--
$La(OH)_3 \cdot 3H_2O$	5.69	--	--
Li_2CO_3	0.20	Li_2CO_3	82.44
$Mg(OH)_2$	1.05	--	--
MnO_2	4.42	--	--
NaOH	6.10	Na_2CO_3	102.06
Nd_2O_3	1.67	--	--
$Ni(OH)_2$	5.76	--	--
$FePO_4 \cdot xH_2O$ (80%)	0.67	--	--
PbO	0.72	--	--
SiO_2	10.25	SiO_2	477.27
Na_2SO_4	0.74	--	--
ZnO	0.10	ZnO	20.20
$Zr(OH)_4 \cdot xH_2O$ (50%)	45.89	--	--
Na_2CO_3	0.20	--	--
$NaNO_2$	1.52	--	--
$NaNO_3$	5.70	--	--
$H_2C_2O_4 \cdot 2H_2O$	0.64	--	--
Water	103.00	--	--
TOTAL	1591.03	TOTAL	1013.96
--		FEED TOTAL	2604.99

*Target weight values have been adjusted based on assumed assay information of starting materials.
"—" Empty data field

Table 2.4. Compositional Summary of Different Waste Streams and Blended Solids for the C-106/AY-102 HLW Simulant.

Waste Component	C-106/AY-102 Solids	Recycle Stream	Separation Factor	Sr/TRU Product	Cs-Eluate	Tc-Eluate	Blended Solids
Stream Number	FRP02	PWD01	—	—	CNP12	TEP12	HLP09b
—	(lb/day)	(lb/day)	(fraction remained)	(lb/day)	(lb/day)	(lb/day)	(lb/day)
Ag	9.20E+01	5.49E-21	4.885*	—	—	—	9.20E+01
Al	3.19E+03	2.17E+00	0.395	—	5.13E+00	7.54E-02	1.27E+03
As	9.77E+01	1.32E-01	1.825*	—	—	—	9.78E+01
B	1.83E+01	2.88E+00	2.759*	—	7.27E+00	—	2.84E+01
Ba	6.59E+01	2.69E-04	0.054	—	6.24E-03	2.10E-03	3.55E+00
Be	4.89E+00	0.00E+00	1.000	—	—	—	4.89E+00
Bi	1.71E+00	2.58E-04	5.303*	—	—	—	1.71E+00
Ca	4.01E+02	9.03E-02	0.360	—	9.31E-01	2.22E-02	1.45E+02
Cd	1.07E+01	1.57E-04	0.028	—	1.19E-02	2.05E-03	3.10E-01
Ce	5.08E+01	5.90E+00	0.041	—	—	—	2.33E+00
Cl	3.83E+01	2.13E+00	0.064	—	5.94E+01	1.14E+01	7.34E+01
Co	2.05E+01	0.00E+00	1.000	—	—	5.59E-03	2.05E+01
Carbonate	4.73E+03	2.41E+00	0.185	—	—	—	8.74E+02
Cr	1.27E+02	2.01E-01	0.281	—	1.38E-01	5.45E-03	3.58E+01
Cs	7.84E-01	0.00E+00	0.186	—	6.33E-02	3.35E-07	2.09E-01
Cu	2.34E+01	6.86E-33	200.513*	—	3.75E-01	3.89E-03	2.38E+01
F	1.30E+01	7.49E-01	0.037	—	—	—	5.07E-01
Fe	5.87E+03	1.49E+00	1.897*	—	9.57E-02	5.63E-03	5.95E+03
Hg	2.56E+01	2.09E-05	4.438*	—	—	—	2.56E+01
K	2.09E+01	9.11E-01	0.134	—	9.77E-01	2.03E-02	3.91E+00
La	1.39E+02	1.98E-02	2.753*	—	—	2.00E-02	1.39E+02
Li	0.00E+00	7.57E-01	2.848	—	—	5.65E-03	2.16E+00
Mg	2.21E+02	4.89E-06	2.154	—	1.50E-01	4.17E-03	4.76E+02
Mn	1.26E+03	9.01E-02	1.000	4.49E+02	8.20E-03	7.73E-04	1.71E+03
Mo	3.94E+00	0.00E+00	1.000	—	—	2.07E-03	3.94E+00
Na	4.28E+03	3.65E+02	0.059	—	**2.02E+01**	**9.14E-01**	2.93E+02
Nd	8.71E+01	0.00E+00	1.000	—	—	—	8.71E+01
Ni	2.20E+02	1.10E-01	0.411	—	5.85E-01	6.68E-03	9.13E+01
Nitrite	4.47E+01	5.06E-01	0.050	—	—	—	2.28E+00
Nitrate	2.93E+01	8.67E+02	0.037	—	1.14E+02	—	1.47E+02
Hydroxide	8.33E+03	3.16E+01	0.114	—	—	—	9.56E+02
Hydroxide(Bound)	5.34E+03	0.00E+00	0.076	—	—	—	4.06E+02
Pb	2.56E+02	2.27E-02	0.353	—	0.00E+00	2.11E-02	9.04E+01
Pd	0.00E+00	2.15E-09	5.392	—	—	—	1.16E-08
Phosphate	1.15E+03	1.66E-02	0.074	—	—	—	8.53E+01
Pr	0.00E+00	0.00E+00	1.000	—	—	—	0.00E+00
Rb	0.00E+00	0.00E+00	1.000	—	—	—	0.00E+00
Rh	0.00E+00	0.00E+00	1.000	—	—	—	0.00E+00
Ru	0.00E+00	0.00E+00	1.000	—	—	—	0.00E+00
Sb	5.91E+01	0.00E+00	2.434	—	—	—	1.44E+02
Se	9.77E+01	0.00E+00	1.825	—	—	—	1.78E+02
Si	6.36E+02	6.02E+00	4.398*	—	2.13E+00	5.69E-02	6.44E+02
Sulfate	3.48E+01	5.45E-01	0.034	—	—	—	1.20E+00
Sr	2.52E+01	0.00E+00	0.985	4.99E+02	—	1.05E-03	5.24E+02
Ta	0.00E+00	0.00E+00	—	—	—	—	0.00E+00
Te	5.83E+00	0.00E+00	—	—	—	—	0.00E+00
Th	0.00E+00	0.00E+00	—	—	—	—	0.00E+00
Ti	1.07E+01	1.53E-03	5.306	—	—	5.02E-03	5.69E+01
Tl	1.97E+02	0.00E+00	—	—	—	—	0.00E+00
TOC	2.96E+02	0.00E+00	0.017	—	—	—	4.92E+00
U	2.18E+02	0.00E+00	—	—	2.01E-01	—	2.01E-01
V	4.89E+01	0.00E+00	—	—	—	9.14E-03	9.14E-03
Y	0.00E+00	0.00E+00	—	—	—	—	0.00E+00
Zn	1.30E+01	4.36E-01	2.843	—	4.66E-02	2.87E-03	3.81E+01
Zr	6.14E+01	3.44E-01	4.576*	—	—	6.94E-03	1.30E+02
TOTAL	**3.79E+04**	**1.31E+03****	—	**9.48E+02**	**2.12E+02**	**1.26E+01**	**1.49E+04**

* Separation Factors not Used in Calculation (see text). ** Includes negligible components that are omitted. – Indicates empty data field.

Table 2.5. Compositional Summary (Oxide Basis) of the C-106/AY-102 HLW Simulant, Glass Additives, Target Test Glass, and the Reference Glass (HLW98-86).

Oxide	C-106/AY-102 HLW Simulant	Glass Former (as wt% of glass)	C-106/AY-102 Melter Target Glass	HLW98-86
Ag_2O	—	—	—	0.15%
Al_2O_3	12.77%	1.75%	5.29%	5.29%
As_2O_3	0.69%	—	0.19%	0.19%
B_2O_3	0.49%	9.25%	9.39%	9.39%
CaO	1.09%	—	0.30%	0.30%
Cl	0.39%	—	0.11%	0.11%
Cr_2O_3	0.28%	—	0.08%	0.08%
Cs_2O	0.18%	—	0.05%	—
CuO	0.16%	—	0.04%	0.04%
Fe_2O_3	45.35%	—	12.58%	12.56%
I	0.36%	—	0.10%	—
La_2O_3	0.87%	—	0.24%	0.24%
Li_2O	0.02%	3.00%	3.01%	3.01%
MgO	4.21%	—	1.17%	1.17%
MnO**	14.41%	—	4.00%	3.99%
Na_2O	2.11%	11.25%	11.83%	11.84%
Nd_2O_3	0.54%	—	0.15%	0.15%
NiO	0.62%	—	0.17%	0.17%
P_2O_5	0.34%	—	0.09%	0.09%
PbO	0.52%	—	0.14%	0.14%
Sb_2O_3	0.92%	—	0.25%	0.26%
SeO_2	1.34%	—	0.37%	0.37%
SiO_2	7.35%	45.00%	47.04%	47.07%
SrO	3.31%	—	0.92%	0.92%
TiO_2	0.51%	—	0.14%	0.14%
ZnO	0.25%	2.00%	2.07%	2.07%
ZrO_2	0.93%	—	0.26%	0.26%
TOTAL	100.0%	72.25%	100.00%	100.00%
Volatiles (g/100 g oxide)	—	—	—	—
Carbonate	4.650	—	—	—
Nitrite	0.034	—	—	—
Nitrate	2.174	—	—	—
TOC	0.073	—	—	—

**MnO_2 in Reference [22]. — Empty data field.

Table 2.6. Composition of Melter Feed to Produce 1 Metric Ton of Target Glass from C-106/AY-102 HLW Simulant (20 wt% Suspended Solids).

C-106/AY-102 HLW Simulant		Glass-Forming Additives	
Starting Materials	**Target Weight (kg)***	**Starting Materials**	**Target Weight (kg)**
$Al(OH)_3$	57.08	Al_2O_3	17.68
As_2O_3	1.93	--	--
H_3BO_3	2.43	$Na_2B_4O_7 \cdot 10H_2O$	255.91
$CaCO_3$	5.49	--	--
NaCl	1.81	--	--
Cr_2O_3	0.78	--	--
CsOH (50% solution)	1.06	--	--
CuO	0.45	--	--
$Fe(OH)_3$ (13% slurry)	1287.78	--	--
NaI	1.19	--	--
$La(OH)_3 \cdot 3H_2O$	3.66	--	--
Li_2CO_3	0.18	Li_2CO_3	76.10
$Mg(OH)_2$	17.25	--	--
MnO_2	49.49	--	--
Na_2CO_3	6.12	Na_2CO_3	123.20
Nd_2O_3	1.52	--	--
$Ni(OH)_2$	2.21	--	--
$FePO_4 \cdot xH_2O$ (80%)	2.51	--	--
PbO	1.46	--	--
Sb_2O_3	2.57	--	--
SeO_2	3.75	--	--
SiO_2	20.61	SiO_2	454.55
$SrCO_3$	13.41	--	--
TiO_2	1.42	--	--
ZnO	0.71	ZnO	20.20
$Zr(OH)_4 \cdot xH_2O$ (50%)	6.70	--	--
$NaNO_2$	0.05	--	--
$NaNO_3$	3.00	--	--
$H_2C_2O_4 \cdot 2H_2O$	0.38	--	--
Water	233.50	--	--
TOTAL	1727.24	TOTAL	947.64
--	--	FEED TOTAL	2674.88

*Target weights adjusted for assay information of starting materials.
-- Indicates empty data field.

Table 2.7. Compositional Summary (Oxide Basis) of the C-106/AY-102 Actual Waste, AW-101 Cesium-Eluate, Blended Waste, and the HLW Simulant.

Oxide (wt%)	Analyzed C-106/AY-102 Solid	Analyzed AW-101 Cesium-Eluate	Blended C-106/AY-102 Actual Waste	HLW Simulant
Ag_2O	0.50%	–	0.50%	–
Al_2O_3	13.17%	–	13.16%	13.29%
B_2O_3	0.70%	33.18%	0.73%	0.74%
BaO	0.20%	1.68%	0.20%	0.20%
CaO	1.23%	–	1.23%	1.24%
CdO	0.03%	0.38%	0.03%	–
Ce_2O_3	0.27%	4.91%	0.27%	0.27%
Cr_2O_3	0.60%	0.69%	0.60%	0.61%
Cs_2O	–	3.36%	0.00%	0.00%
CuO	0.09%	2.57%	0.09%	—
Fe_2O_3	37.78%	0.41%	37.74%	38.12%
Gd_2O_3	0.02%	–	0.02%	–
K_2O	0.03%	–	0.03%	–
La_2O_3	0.20%	0.85%	0.20%	0.22%
Li_2O	0.11%	7.34%	0.12%	0.12%
MgO	0.39%	–	0.39%	0.39%
MnO	7.61%	–	7.60%	7.68%
MoO_3	0.09%	–	0.09%	–
Na_2O	14.48%	35.73%	14.50%	14.68%
NiO	1.11%	1.36%	1.11%	1.12%
P_2O_5	1.51%	–	1.51%	1.53%
PbO	1.46%	–	1.46%	1.47%
SO_3	0.51%	–	0.51%	0.52%
Sb_2O_5	0.11%	–	0.11%	–
SiO_2	14.28%	–	14.27%	14.41%
SnO_2	0.16%	6.83%	0.17%	0.17%
SrO	0.46%	0.71%	0.46%	0.46%
TiO_2	0.09%	–	0.09%	–
U_3O_8	1.40%	–	1.40%	–
V_2O_5	0.04%	–	0.04%	–
ZnO	0.08%	–	0.08%	0.08%
ZrO_2	1.25%	–	1.25%	2.68%
TOTAL	99.96%	100.00%	99.96%	100.00%

"–" Empty data field.

Table 2.8. Compositional Summary (Oxide Basis) of the HLW High Waste Loading C-106/AY-102 Simulant, Glass Additives, Target Test Glass, and the Reference Glass (HLW04-09).

Oxide (wt%)	HLW Simulant	Glass Former (as wt% of glass)	Melter Test Target Glass	HLW04-09
Ag_2O	—	—	—	0.19%
Al_2O_3	13.29%	—	4.89%	4.88%
B_2O_3	0.74%	10.00%	10.27%	10.27%
BaO	0.20%	—	0.07%	0.07%
CaO	1.24%	—	0.46%	0.46%
CdO	—	—	—	0.01%
Ce_2O_3	0.27%	—	0.10%	0.10%
Cr_2O_3	0.61%	—	0.22%	0.22%
Cs_2O	0.00%	—	0.00%	0.00%
CuO	—	—	—	0.03%
Fe_2O_3	38.12%	—	14.03%	14.01%
Gd_2O_3	—	—	—	0.01%
K_2O	—	—	—	0.01%
La_2O_3	0.22%	—	0.08%	0.07%
Li_2O	0.12%	2.60%	2.64%	2.64%
MgO	0.39%	—	0.14%	0.14%
MnO	7.68%	—	2.82%	2.82%
MoO_3	—	—	—	0.03%
Na_2O	14.68%	7.15%	12.55%	12.53%
NiO	1.12%	—	0.41%	0.41%
P_2O_5	1.53%	—	0.56%	0.56%
PbO	1.47%	—	0.54%	0.54%
SO_3	0.52%	—	0.19%	0.19%
Sb_2O_5	—	—	—	0.04%
SiO_2	14.41%	42.45%	47.75%	47.75%
SnO_2	0.17%	—	0.06%	0.06%
SrO	0.46%	—	0.17%	0.17%
TiO_2	—	—	—	0.03%
U_3O_8	—	—	—	0.52%
V_2O_5	—	—	—	0.01%
ZnO	0.08%	1.00%	1.03%	0.73%
ZrO_2	2.68%	—	0.98%	0.46%
TOTAL	100.00%	63.20%	100.0%	100.0%
Volatiles (g/100 g glass)	—	—	—	—
Carbonate	4.650	—	—	—
Nitrite	0.012	—	—	—
Nitrate	0.784	—	—	—
TOC	0.026	—	—	—

"—" Empty data field.

Table 2.9. Composition of Melter Feed To Produce 1 Metric Ton of Target High Waste Loading Glass from C-106/AY-102 HLW Simulant (20 wt% undissolved solids).

C-106/AY-102 HLW Simulant		Glass-Forming Additives	
Starting Materials	**Target Weight (kg)***	**Starting Materials**	**Target Weight (kg)**
$Al(OH)_3$	78.78	–	–
B_2O_3	4.87	$Na_2B_4O_7 \cdot 10H_2O$	276.66
$BaCO_3$	0.97	–	–
$CaCO_3$	8.33	–	–
CeO_2	1.06	–	–
Cr_2O_3	2.25	–	–
$Fe(OH)_3$ (13% slurry)	1378.96	–	–
$La(OH)_3 \cdot 3H_2O$	1.24	–	–
Li_2CO_3	1.13	Li_2CO_3	65.95
$Mg(OH)_2$	2.12	–	–
MnO_2	34.97	–	–
Na_2OH	6.82	Na_2CO_3	46.62
$Ni(OH)_2$	5.31	–	–
$FePO_4 \cdot xH_2O$ (80%)	14.91	–	–
PbO	5.48	–	–
$Na_2SiO_3 \cdot 5H_2O$	125.47	–	–
SiO_2	18.75	SiO_2	428.79
Na_2SO_4	3.40	–	–
SnO_2	0.64	–	–
$SrCO_3$	2.46	–	–
ZnO	0.30	ZnO	10.10
$Zr(OH)_4 \cdot xH_2O$ (50%)	25.45	–	–
Na_2CO_3	17.83	–	–
$NaNO_2$	0.07	–	–
$NaNO_3$	3.97	–	–
$H_2C_2O_4 \cdot 2H_2O$	0.51	–	–
Water	481.25	–	–
TOTAL	2227.30	TOTAL	828.12
–	–	FEED TOTAL	3055.42

*Target weights adjusted for assay information of starting materials
"–" Empty data field

Table 2.10. Properties of Melter Feed Samples.

Waste Type	Test	Date	Name	% Water	Density	Glass Yield		pH
					g/ml	(kg/kg)	(g/l)	
AZ-102 Adjusted Rheology	DM100	03/18/04	BLI-F-113A	54.31	1.44	0.387	557	10.50
		03/19/04	BLI-F-129A	54.81	1.43	0.386	552	10.41
		Average		54.56	1.44	0.386	555	10.46
	DM1200 1A1	6/21/04	1U2-F-26A	54.70	1.45	0.384	557	10.63
		6/22/04	1U2-F-64A	53.90	1.45	0.390	566	10.69
		Average		54.27	1.45	0.387	561	10.66
	DM1200 1A2	6/23/04	1U2-F-106A	60.50	1.35	0.336	453	10.60
		6/24/04	1U2-F-141A	58.40	1.37	0.350	480	10.61
		Average		59.43	1.36	0.343	467	10.60
AZ-102 Nominal	Previous DM1200 Test [8]			54.10	1.42	0.386	546	10.43
	Previous DM100 Test [37]			54.36	1.42	0.385	546	10.57
	DM100	03/15/04	BLI-F-66A	53.89	1.45	0.389	564	10.48
		03/15/04	BLI-F-80A	55.01	1.39	0.383	532	10.44
		03/15/04	BLI-F-82A	53.88	1.46	0.391	571	10.48
		03/16/04	BLI-F-95A	55.68	1.38	0.380	524	10.44
		Average		54.62	1.42	0.386	548	10.46
	DM1200 1B	6/25/04	1V2-F-32A	67.10	1.29	0.274	353	10.43
		6/26/04	1V2-F-74A	67.40	1.29	0.275	355	10.45
		6/27/04	1V2-F-109A	68.10	1.28	0.264	337	10.43
		6/29/04	1W2-F-26A	68.61	1.29	0.266	343	10.38
		6/29/04	1W2-F-37A	67.90	1.28	0.272	348	10.36
		Average		67.82	1.29	0.270	347	10.41
C-106/ AY-102 Nominal	Previous DM1200 Test [9]			54.2	1.42	0.389	553	10.23
	Previous DM1200 Test [19]			53.8	1.45	0.380	553	10.14
C-106/ AY-102 Adjusted Rheology	DM1200 2A	8/03/04	1W2-F-105A	56.66	1.41	0.361	509	10.28
		8/03/04	1W2-F-129A	56.18	1.43	0.366	523	10.32
		8/04/04	1X2-F-14A	55.96	1.42	NA	NA	10.32
		8/05/04	1X2-F-48A	NA	NA	NA	NA	NA
		8/05/04	1X2-F-48B	NA	NA	NA	NA	NA
		8/05/04	1X2-F-48C	56.10	1.43	NA	NA	10.32
		8/06/04	1X2-F-83A	55.96	1.44	0.375	541	10.36
		8/06/04	1X2-F-83B	NA	NA	NA	NA	NA
		8/06/04	1X2-F-83C	NA	NA	NA	NA	NA
		8/07/04	1X2-F-88A	NA	NA	NA	NA	NA
		8/07/04	1X2-F-88B	NA	NA	NA	NA	NA
		Average		56.14	1.43	0.369	524	10.33
C-106/ AY-102 High Waste Loading	Subsequent DM100 Test , Nominal Feed [13]			61.9	1.26	0.326	411	11.10
	Subsequent DM100 Test, Adjusted Rheology			62.0	1.34	0.325	436	11.34
	DM100	07/19/04	BLJ-F-12A	62.80	1.32	0.317	419	11.04
		07/20/04	BLJ-F-27A	62.62	1.33	0.316	420	10.97
		07/21/04	BLJ-F-43A	62.26	1.33	0.318	422	10.97
		Average		62.56	1.33	0.317	420	10.99
	DM1200 2B	11/09/04	1X2-F-145A	NA	NA	NA	NA	10.98
		11/09/04	1Y2-F-36A	NA	1.28	NA	NA	10.91
		11/10/04	1Y2-F-75A	69.48	1.28	0.272	348	10.90
		11/11/04	1Y2-F-116A	NA	1.28	NA	NA	10.84
		11/12/04	1Y2-F-147A	NA	1.28	NA	NA	10.88
		Average		69.48	1.28	0.272	348	10.90

NA – Not analyzed

Table 2.11. Rheological Characteristics of DM1200 Feed Samples.

Waste Type	Test	Sampling Date	Sample Name	Yield Stress (Pa)	Viscosity (Poise)		
					@10/s	@100/s	@1000/s
AZ-102	Previous DM1200 Test [8]			9.2	5.38	0.80	-
	1A1	6/21/04	1U2-F-26A	57.0	57.05	7.56	1.08
		6/22/04	1U2-F-64A	59.1	57.96	7.78	1.12
		Average		58.1	57.51	7.67	1.10
	1A2	6/23/04	1U2-F-106A	25.8	22.15	2.92	0.48
		6/24/04	1U2-F-141A	31.0	30.04	4.06	0.63
		Average		28.4	26.10	3.49	0.56
	1B	6/25/04	1V2-F-32A	1.3	0.67	0.14	0.06
		6/26/04	1V2-F-74A	1.5	0.59	0.13	0.06
		6/27/04	1V2-F-109A	1.9	0.55	0.12	0.06
		6/29/04	1W2-F-26A	1.6	0.59	0.12	0.06
		6/29/04	1W2-F-37A	1.1	0.52	0.12	0.06
		Average		1.5	0.58	0.13	0.06
C-106 /AY-102	Previous DM1200 Test [9]			5.5	2.62	0.42	-
	Previous DM1200 Test* [19]			11.2	14.51	1.80	-
	2A	8/3/2004	1W2-F-105A	28.0	26.72	3.68	0.58
		8/3/2004	1W2-F-129A	32.0	28.82	3.92	0.62
		8/4/2004	1X2-F-14A	30.9	27.87	3.85	0.61
		8/5/2004	1X2-F-48A	NA	NA	NA	NA
		8/5/2004	1X2-F-48B	NA	NA	NA	NA
		8/5/2004	1X2-F-48C	31.6	29.09	3.85	0.62
		8/6/2004	1X2-F-83A	29.9	26.04	3.52	0.58
		8/6/2004	1X2-F-83B	NA	NA	NA	NA
		8/6/2004	1X2-F-83C	NA	NA	NA	NA
		8/7/2004	1X2-F-88A	NA	NA	NA	NA
		8/7/2004	1X2-F-88B	NA	NA	NA	NA
		Average		30.5	27.71	3.76	0.60
	2B	11/9/2004	1X2-F-145A	NA	NA	NA	NA
		11/9/2004	1Y2-F-36A	NA	NA	NA	NA
		11/10/2004	1Y2-F-75A	3.2	0.67	0.13	0.07
		11/11/2004	1Y2-F-116A	NA	NA	NA	NA
		11/12/2004	1Y2-F-147A	NA	NA	NA	NA

* - Sample contained high levels of sugar.
NA – Not analyzed

Table 2.12. XRF Analyzed Compositions of AZ-102 Melter Feed Samples (wt%).

Melter	-	DM100						DM1200		
Constituent	Target	BLI-F-66A	BLI-F-80A	BLI-F-82A	BLI-F-95A	BLI-F-113A	BLI-F-129A	1U2-F-26A	1U2-F-64A	1U2-F-106A
Al_2O_3	5.6	5.68	5.77	5.99	5.89	6.12	5.36	5.70	5.66	5.90
B_2O_3*	12.52	12.52	12.52	12.52	12.52	12.52	12.52	12.52	12.52	12.52
BaO	§	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01
CaO	0.23	0.32	0.33	0.32	0.33	0.33	0.36	0.34	0.34	0.34
CdO	0.11	0.13	0.11	0.11	0.12	0.14	0.84	0.16	0.13	0.11
Cs_2O	0.05	0.05	0.05	0.04	0.07	0.06	0.12	0.05	0.04	0.04
Fe_2O_3	12.56	11.94	11.62	11.94	12.20	12.17	13.59	12.24	12.55	12.34
K_2O	0.03	0.16	0.16	0.15	0.14	0.15	<0.01	0.13	0.13	0.13
La_2O_3	0.38	0.39	0.39	0.40	0.41	0.41	0.45	0.40	0.41	0.42
Li_2O*	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26
MgO	0.07	0.06	0.18	0.07	0.10	0.05	0.04	0.13	0.13	0.12
MnO	0.36	0.36	0.36	0.37	0.37	0.38	0.41	0.37	0.38	0.37
Na_2O	12.02	12.51	12.57	12.50	11.70	11.58	12.00	12.55	12.18	12.65
Nd_2O_3	0.17	0.17	0.16	0.18	0.17	0.18	0.20	0.18	0.19	0.18
NiO	0.45	0.39	0.39	0.42	0.42	0.42	0.44	0.40	0.43	0.41
P_2O_5	0.03	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04
PbO	0.07	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.05
SiO_2	48.26	47.76	47.94	47.47	47.83	47.71	45.98	47.22	47.10	46.90
SO_3	0.04	0.08	0.06	0.07	0.07	0.08	0.07	0.07	0.07	0.07
SrO	§	<0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	0.01	0.01
TiO_2	§	0.06	0.07	0.08	0.08	0.08	0.07	0.07	0.07	0.08
ZnO	2.01	1.81	1.79	1.83	1.90	1.89	1.96	1.82	1.91	1.79
ZrO_2	1.78	2.22	2.17	2.14	2.31	2.32	2.19	2.28	2.37	2.25
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target value
§ - Not a target constituent
"-" Empty data field

Table 2.12. XRF Analyzed Compositions of AZ-102 Melter Feed Samples (wt%), (continued).

Melter	-	DM1200						All Samples	
Constituent	Target	1U2-F-141A	1V2-F-32A	1V2-F-74A	1V2-F-109A	1W2-F-26A	1W2-F-37A	Avg.	%Dev.
Al_2O_3	5.6	5.92	5.99	5.94	6.07	5.97	6.01	5.87	4.74
As_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
B_2O_3*	12.52	12.52	12.52	12.52	12.52	12.52	12.52	12.52	NC
BaO	§	<0.01	0.01	0.01	<0.01	0.01	0.01	0.01	NC
CaO	0.23	0.35	0.38	0.38	0.37	0.37	0.37	0.35	NC
CdO	0.11	0.12	0.11	0.12	0.11	0.11	0.13	0.17	NC
Cs_2O	0.05	0.04	0.04	0.05	0.05	0.06	0.05	0.05	NC
Fe_2O_3	12.56	12.23	12.23	12.72	12.35	12.28	11.87	12.28	-2.20
K_2O	0.03	0.14	0.13	0.14	0.14	0.13	0.13	0.13	NC
La_2O_3	0.38	0.40	0.41	0.42	0.41	0.41	0.40	0.41	NC
Li_2O*	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	NC
MgO	0.07	0.14	0.13	0.16	0.12	0.11	0.15	0.11	NC
MnO	0.36	0.37	0.37	0.40	0.39	0.38	0.36	0.38	NC
Na_2O	12.02	12.71	12.00	11.83	11.81	12.02	12.21	12.19	1.39
Nd_2O_3	0.17	0.17	0.17	0.19	0.18	0.18	0.18	0.18	NC
NiO	0.45	0.40	0.42	0.44	0.43	0.42	0.40	0.42	NC
P_2O_5	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.04	NC
PbO	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	NC
SiO_2	48.26	46.90	47.46	46.80	47.37	47.44	47.74	47.31	-1.97
SO_3	0.04	0.06	0.04	0.05	0.05	0.06	0.05	0.06	NC
SrO	§	0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	NC
TiO_2	§	0.08	0.08	0.08	0.08	0.08	0.08	0.08	NC
ZnO	2.01	1.79	1.83	1.90	1.80	1.80	1.75	1.84	-8.58
ZrO_2	1.78	2.28	2.31	2.46	2.39	2.29	2.22	2.28	28.04
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	NC

* Target value
§ - Not a target constituent
"-" Empty data field
NC – Not calculated

Table 2.13. XRF Analyses of C-106/AY-102 Melter Feed Samples (wt%).

Constituent	Target	1W2-F-105A	1W2-F-129A	1X2-F-83C	Avg.	%Dev.
Al_2O_3	5.31	5.48	5.42	5.97	5.62	5.91
As_2O_3	0.19	0.18	0.18	0.18	0.18	NC
B_2O_3*	9.38	9.38	9.38	9.38	9.38	NC
BaO	§	<0.01	<0.01	<0.01	<0.01	NC
CaO	0.30	0.39	0.38	0.36	0.38	NC
CdO	§	<0.01	<0.01	<0.01	<0.01	NC
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	NC
Cl	0.11	0.04	0.03	0.04	0.04	NC
Cr_2O_3	0.08	0.08	0.08	0.08	0.08	NC
Cs_2O	0.05	0.06	0.04	0.05	0.05	NC
CuO	0.04	0.04	0.04	0.05	0.04	NC
Fe_2O_3	12.62	11.52	11.73	11.82	11.69	-7.39
K_2O	§	0.13	0.12	0.12	0.12	NC
La_2O_3	0.24	0.25	0.24	0.25	0.25	NC
Li_2O*	3.01	3.01	3.01	3.01	3.01	NC
MgO	1.17	1.17	1.17	1.20	1.18	1.07
MnO	4.01	3.76	3.79	3.78	3.78	-5.74
Na_2O	11.83	12.93	12.52	12.49	12.65	6.93
Nd_2O_3	0.15	0.15	0.15	0.15	0.15	NC
NiO	0.17	0.13	0.13	0.13	0.13	NC
P_2O_5	0.09	0.11	0.13	0.12	0.12	NC
PbO	0.14	0.12	0.10	0.12	0.11	NC
Sb_2O_3	0.26	0.31	0.30	0.29	0.30	NC
SeO_2	0.37	0.09	0.06	0.10	0.08	NC
SiO_2	47.01	47.65	48.05	47.12	47.61	1.28
SnO_2	§	<0.01	<0.01	<0.01	<0.01	NC
SO_3	§	0.10	0.06	0.08	0.08	NC
SrO	0.92	0.76	0.77	0.80	0.78	NC
TiO_2	0.14	0.19	0.19	0.20	0.19	NC
ZnO	2.07	1.65	1.62	1.77	1.68	-18.89
ZrO_2	0.26	0.32	0.31	0.32	0.32	NC
Sum	100.00	100.00	100.00	100.00	100.00	NC

* Target value
§ - Not a target constituent
"-" Empty data field
NC – Not calculated

Table 2.14. XRF Analyzed Compositions for the High Waste Loading C-106/AY-102 Melter Feed Samples (Wt%).

Melter	-	DM100 BL			DM1200	All Samples	
Constituent	Target	BLJ-F-12A	BLJ-F-27A	BLJ-F-43A	1Y2-F-75A	Average	%Dev.
Al_2O_3	4.89	5.19	5.32	5.69	5.23	5.36	9.52
B_2O_3*	10.27	10.27	10.27	10.27	10.27	10.27	NC
BaO	0.07	0.08	0.07	0.08	0.11	0.08	NC
CaO	0.46	0.54	0.56	0.53	0.54	0.54	NC
Ce_2O_3	0.10	0.09	0.11	0.09	0.10	0.10	NC
Cl	§	0.01	<0.01	<0.01	<0.01	<0.01	NC
Cr_2O_3	0.22	0.23	0.24	0.23	0.23	0.23	NC
Fe_2O_3	14.03	13.91	14.51	13.90	13.43	13.94	-0.65
K_2O	§	0.11	0.10	0.11	<0.01	0.08	NC
La_2O_3	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	NC
Li_2O*	2.64	2.64	2.64	2.64	2.64	2.64	NC
MgO	0.14	0.16	0.14	0.18	0.12	0.15	NC
MnO	2.82	2.77	2.98	2.87	2.89	2.88	2.02
Na_2O	12.55	13.52	12.68	12.40	12.97	12.89	2.73
NiO	0.41	0.40	0.43	0.40	0.39	0.40	NC
P_2O_5	0.56	0.63	0.65	0.62	0.63	0.63	NC
PbO	0.54	0.47	0.50	0.48	0.46	0.48	NC
SiO_2	47.75	46.13	45.92	46.72	47.41	46.54	-2.52
SnO_2	0.06	0.08	0.08	0.08	0.08	0.08	NC
SO_3	0.19	0.15	0.13	0.11	0.11	0.12	NC
SrO	0.17	0.16	0.17	0.16	0.16	0.16	NC
TiO_2	§	0.07	0.06	0.07	0.06	0.07	NC
ZnO	1.03	1.04	1.03	1.02	0.92	1.00	-2.73
ZrO_2	0.98	1.33	1.40	1.33	1.26	1.33	NC
Sum	100.00	100.00	100.00	100.00	100.00	100.00	NC

* Target value
§ - Not a target constituent
"-" Empty data field
NC – Not calculated

Table 3.1. Summary of DM100 (Melt Pool Surface Area = 0.108 m^2) Test Conditions and Results.

Time	Feed Start	3/15/04, 11:00	3/18/04, 00:13	7/19/04, 09:36
	Feed End	3/18/04, 00:01	3/19/04, 23:32	7/23/04, 19:52
	Interval	61.0 hr	47.3 hr	106.3 hr
Water Feeding for Cold Cap		1 hr	0	0.4 hr
Slurry Feeding		60.0 hr	47.3 hr	105.9 hr
Average Bubbling Rate		8.9 lpm	9.0 lpm	11.3 lpm
Feed	Simulant	AZ-102	AZ-102	High Waste Loading C-106/AY-102
	Rheology	Nominal	Adjusted	Nominal
	Used	892 kg	752 kg	1976 kg
	Glass yield	548[@] g/l	555[@] g/l	420[@] g/l
		0.384[#] kg/kg	0.384[#] kg/kg	0.327[#] kg/kg
	Average Rate	14.9 kg/hr	15.9 kg/hr	18.7 kg/hr
Glass Produced	Poured	330.5 kg	284.1 kg	619.1 kg
	Average Rate[$]	1213 kg/m^2/day	1322 kg/m^2/day	1299 kg/m^2/day
	Average Rate[*]	1272 kg/m^2/day	1362 kg/m^2/day	1356 kg/m^2/day

@ - Measured values.
# - Target values.
$ - Rates calculated from glass poured.
*- Rates calculated from feed data.

Table 3.2. Glass Discharged, Masses, and Analysis Performed on DM100 Samples.

Waste Type	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
AZ-102	Nominal	03/15/04	BLI-G-78A	-	29.34	29.34
			BLI-G-79A	XRF		
			BLI-G-80A	-	22.90	52.24
			BLI-G-82A	XRF		
			BLI-G-82B	-	27.50	79.74
		03/16/04	BLI-G-83A	XRF		
			BLI-G-86A	-	30.10	109.84
			BLI-G-87A	XRF		
			BLI-G-91A	-	38.10	147.94
			BLI-G-93A	XRF		
			BLI-G-93B	-	27.30	175.24
			BLI-G-95A	XRF		
			BLI-G-96A	-	23.08	198.32
			BLI-G-96B	XRF		
		03/17/04	BLI-G-100A	-	24.80	223.12
			BLI-G-100B	XRF		
			BLI-G-101A	-	34.02	257.14
			BLI-G-102A	XRF		
			BLI-G-106A	-	25.50	282.64
			BLI-G-107A	XRF		
			BLI-G-107B	-	25.70	308.34
			BLI-G-107C	XRF		
			BLI-G-109A	-	22.20	330.54
			BLI-G-109B	XRF		
	Adjusted Rheology		BLI-G-113A	-	25.50	356.04
		03/18/04	BLI-G-114A	XRF		
			BLI-G-114B	-	28.86	384.90
			BLI-G-115A	XRF		
			BLI-G-117A	-	23.92	408.82
			BLI-G-121A	XRF		
			BLI-G-122A	-	27.00	435.82
			BLI-G-123A	XRF		
			BLI-G-125A	-	28.50	464.32
			BLI-G-126A	XRF		
		03/19/04	BLI-G-126B	-	35.20	499.52
			BLI-G-129A	XRF		
			BLI-G-129B	-	27.00	526.52
			BLI-G-131A	XRF		
			BLI-G-132A	-	28.50	555.02
			BLI-G-133A	XRF		
			BLI-G-136A	-	26.50	581.52
			BLI-G-136B	XRF		

"-" Empty data field

Table 3.2. Glass Discharged, Masses, and Analysis Performed on DM100 Samples (continued).

Waste Type	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
AZ-102		03/19/04	BLI-G-138A	-	26.00	607.52
			BLI-G-138B	XRF		
			BLI-G-140A	-	14.08	621.60
C-106/AY-102	**High Waste Loading**	07/19/04	BLJ-G-13A	XRF		
			BLJ-G-13B	-	24.40	646.00
			BLJ-G-13C	XRF		
			BLJ-G-14A	XRF	18.90	664.90
			BLJ-G-14B	-	19.90	684.80
		07/20/04	BLJ-G-18A	XRF		
			BLJ-G-19A	-	25.00	709.80
			BLJ-G-19B	XRF		
			BLJ-G-22A	-	25.20	735.00
			BLJ-G-22B	XRF		
			BLJ-G-25A	-	29.00	764.00
			BLJ-G-26A	XRF		
			BLJ-G-27A	-	19.50	783.50
			BLJ-G-27B	XRF		
			BLJ-G-27C	-	19.26	802.76
			BLJ-G-29A	XRF		
		07/21/04	BLJ-G-32A	-	25.90	828.66
			BLJ-G-34A	XRF		
			BLJ-G-35A	-	21.40	850.06
			BLJ-G-35B	XRF		
			BLJ-G-36A	-	20.40	870.46
			BLJ-G-36B	XRF		
			BLJ-G-37A	-	29.10	899.56
			BLJ-G-42A	XRF		
			BLJ-G-42B	-	18.20	917.76
			BLJ-G-43A	XRF		
			BLJ-G-43B	-	32.52	950.28
			BLJ-G-44A	XRF		
		07/22/04	BLJ-G-48A	-	24.54	974.82
			BLJ-G-48B	XRF		
			BLJ-G-48C	-	25.20	1000.02
			BLJ-G-51A	XRF		
			BLJ-G-52A	-	28.30	1028.32
			BLJ-G-53A	XRF		
			BLJ-G-54A	-	30.10	1058.42
			BLJ-G-54B	XRF		
			BLJ-G-58A	-	24.48	1082.90
			BLJ-G-58B	XRF		
		07/23/04	BLJ-G-62A	-	23.18	1106.08
			BLJ-G-62B	XRF		
			BLJ-G-62C	-	24.68	1130.76
			BLJ-G-63A	XRF		

"-" Empty data field

Table 3.2. Glass Discharged, Masses, and Analysis Performed on DM100 Samples (continued).

Waste Type	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
C-106/AY-102	High Waste Loading	07/23/04	BLJ-G-63B	-	25.90	1156.66
			BLJ-G-70A	XRF		
			BLJ-G-71A	-	27.68	1184.34
			BLJ-G-71B	XRF		
			BLJ-G-71C	-	30.46	1214.80
			BLJ-G-72A	XRF		
			BLJ-G-72B	XRF	18.86	1233.66

"-" Empty data field

Table 3.3. XRF Analyzed Compositions for Glass Discharged from DM100 (wt%).

Waste Type	AZ-102									
Rheology	Nominal									
Glass (kg)	-	29.34	52.24	79.74	109.84	147.94	175.24	198.32	223.12	257.14
Constituent	Target	BLI-G-79A	BLI-G-82A	BLI-G-83A	BLI-G-87A	BLI-G-93A	BLI-G-95A	BLI-G-96B	BLI-G-100B	BLI-G-102A
Al_2O_3	5.6	6.42	6.19	6.32	6.22	6.12	6.05	6.02	6.06	5.99
B_2O_3*	12.52	12.51	12.51	12.51	12.51	12.52	12.52	12.52	12.52	12.52
BaO	§	<0.01	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CaO	0.23	0.36	0.36	0.35	0.34	0.33	0.33	0.34	0.33	0.34
CdO	0.11	0.16	0.15	0.14	0.13	0.13	0.13	0.13	0.13	0.12
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cl	§	<0.01	<0.01	0.01	0.01	<0.01	0.01	0.01	0.01	0.01
Cr_2O_3	§	0.10	0.09	0.08	0.08	0.06	0.06	0.06	0.05	0.05
Cs_2O	0.05	0.01	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05
CuO	§	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fe_2O_3	12.56	10.84	11.27	11.11	11.08	10.87	11.21	11.41	11.66	11.95
K_2O	0.03	0.16	0.15	0.17	0.17	0.16	0.16	0.16	0.14	0.16
La_2O_3	0.38	0.34	0.37	0.37	0.37	0.37	0.37	0.38	0.38	0.41
Li_2O*	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26
MgO	0.07	0.15	0.15	0.10	0.10	0.17	0.14	0.14	0.15	0.13
MnO	0.36	0.34	0.35	0.34	0.35	0.34	0.36	0.36	0.36	0.38
Na_2O	12.02	11.82	11.50	11.10	11.82	12.57	12.20	11.94	12.01	12.30
Nd_2O_3	0.17	0.15	0.17	0.17	0.15	0.16	0.16	0.15	0.16	0.17
NiO	0.45	0.37	0.40	0.39	0.38	0.38	0.39	0.40	0.42	0.43
P_2O_5	0.03	0.05	<0.01	0.05	0.06	0.04	0.04	0.05	0.06	0.06
PbO	0.07	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.06
SiO_2	48.26	48.76	48.67	49.25	48.77	48.42	48.39	48.35	47.87	47.30
SnO_2	§	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SO_3	0.04	<0.01	0.01	0.03	0.03	0.04	0.05	0.05	0.05	0.07
SrO	§	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.03
TiO_2	§	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.07
ZnO	2.01	1.66	1.73	1.70	1.69	1.67	1.73	1.77	1.83	1.83
ZrO_2	1.78	2.36	2.45	2.34	2.28	2.20	2.23	2.30	2.33	2.31
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field

Table 3.3. XRF Analyzed Compositions for Glass Discharged from DM100 (wt%), (continued).

Waste Type	AZ-102									
Rheology	-	Nominal				Adjusted				
Glass (kg)	-	257.14	282.64	308.34	330.54	356.04	384.90	408.82	435.82	464.32
Constituent	Target	BLI-G-102A	BLI-G-107A	BLI-G-107C	BLI-G-109B	BLI-G-114A	BLI-G-115A	BLI-G-121A	BLI-G-123A	BLI-G-126A
Al_2O_3	5.6	5.99	6.05	5.80	5.78	5.79	5.88	5.74	5.75	5.79
B_2O_3*	12.52	12.52	12.52	12.52	12.52	12.52	12.52	12.52	12.52	12.52
BaO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CaO	0.23	0.34	0.33	0.33	0.32	0.32	0.33	0.31	0.33	0.32
CdO	0.11	0.12	0.10	0.15	0.14	0.13	0.11	0.12	0.12	0.11
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cl	§	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01
Cr_2O_3	§	0.05	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04
Cs_2O	0.05	0.05	0.05	0.07	0.07	0.06	0.05	0.06	0.05	0.05
CuO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Fe_2O_3	12.56	11.95	11.24	12.03	11.58	11.63	11.60	11.64	11.89	11.86
K_2O	0.03	0.16	0.14	0.15	0.14	0.15	0.17	0.16	0.16	0.15
La_2O_3	0.38	0.41	0.38	0.40	0.39	0.40	0.39	0.40	0.39	0.39
Li_2O*	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26
MgO	0.07	0.13	0.13	0.12	0.14	0.09	0.09	0.09	0.07	0.10
MnO	0.36	0.38	0.36	0.38	0.36	0.36	0.37	0.37	0.38	0.37
Na_2O	12.02	12.30	12.76	11.46	12.09	12.40	11.89	12.48	11.94	12.14
Nd_2O_3	0.17	0.17	0.16	0.17	0.16	0.16	0.16	0.17	0.16	0.17
NiO	0.45	0.43	0.40	0.43	0.41	0.41	0.42	0.42	0.43	0.43
P_2O_5	0.03	0.06	0.05	0.04	0.03	0.04	0.05	0.03	0.05	<0.01
PbO	0.07	0.06	0.05	0.06	0.05	0.06	0.06	0.06	0.06	0.06
SiO_2	48.26	47.30	48.17	48.13	48.28	47.99	48.46	47.95	48.18	48.09
SnO_2	§	<0.01	<0.01	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01
SO_3	0.04	0.07	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
SrO	§	0.03	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01	0.01
TiO_2	§	0.07	0.08	0.07	0.07	0.07	0.08	0.07	0.07	0.07
ZnO	2.01	1.83	1.72	1.89	1.80	1.79	1.80	1.79	1.84	1.83
ZrO_2	1.78	2.31	1.95	2.41	2.26	2.24	2.16	2.23	2.23	2.16
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field

Table 3.3. XRF Analyzed Compositions for Glass Discharged from DM100 (wt%) (continued).

Waste Type	AZ-102								
Rheology	-	Adjusted						-	
Glass (kg)	-	499.52	526.52	555.02	581.52	607.52	621.60	540-622	
Constituent	Target	BLI-G-129A	BLI-G-131A	BLI-G-133A	BLI-G-136B	BLI-G-138B	BLI-G-140A	Average	%Dev.
Al_2O_3	5.6	5.65	5.63	5.62	5.62	5.59	5.62	5.61	0.18
B_2O_3*	12.52	12.52	12.52	12.52	12.52	12.52	12.52	12.52	NC
BaO	§	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
CaO	0.23	0.32	0.31	0.32	0.32	0.32	0.32	0.32	NC
CdO	0.11	0.13	0.14	0.14	0.13	0.14	0.12	0.13	NC
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
Cl	§	0.01	0.01	0.01	<0.01	<0.01	0.01	0.01	NC
Cr_2O_3	§	0.04	0.03	0.03	0.03	0.03	0.03	0.03	NC
Cs_2O	0.05	0.07	0.06	0.06	0.05	0.06	0.06	0.06	NC
CuO	§	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
Fe_2O_3	12.56	11.61	11.87	11.91	11.75	11.87	11.89	11.85	-5.62
K_2O	0.03	0.14	0.14	0.15	0.15	0.15	0.15	0.15	NC
La_2O_3	0.38	0.39	0.38	0.41	0.40	0.39	0.40	0.40	NC
Li_2O*	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	NC
MgO	0.07	0.09	0.08	0.09	0.07	0.08	0.07	0.08	NC
MnO	0.36	0.36	0.38	0.36	0.36	0.37	0.37	0.37	NC
Na_2O	12.02	12.86	12.49	12.15	12.62	12.45	12.54	12.44	3.48
Nd_2O_3	0.17	0.16	0.17	0.17	0.17	0.17	0.18	0.17	NC
NiO	0.45	0.42	0.43	0.43	0.42	0.42	0.42	0.42	NC
P_2O_5	0.03	0.04	0.04	0.03	0.04	0.05	0.04	0.04	NC
PbO	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	NC
SiO_2	48.26	47.70	47.72	48.00	47.87	47.84	47.87	47.89	-0.76
SnO_2	§	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	NC
SO_3	0.04	0.08	0.06	0.07	0.06	0.06	0.07	0.07	NC
SrO	§	0.01	0.01	0.01	0.01	0.01	<0.01	<0.01	NC
TiO_2	§	0.07	0.06	0.07	0.06	0.07	0.06	0.06	NC
ZnO	2.01	1.77	1.83	1.84	1.80	1.82	1.79	1.81	-9.89
ZrO_2	1.78	2.21	2.29	2.28	2.22	2.27	2.14	2.23	25.20
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00-	NC

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field
NC – Not calculated

Table 3.3. XRF Analyzed Compositions for Glass Discharged from DM100 (wt%) (continued).

Waste Type	High Waste Loading C-106/AY-102									
Glass (kg)	-	646.00	664.90	684.80	709.80	735.00	764.00	783.50	802.76	828.66
Constituent	Target	BLJ-G-13B	BLJ-G-14A	BLJ-G-18A	BLJ-G-19B	BLJ-G-22B	BLJ-G-26A	BLJ-G-27B	BLJ-G-29A	BLJ-G-34A
Al_2O_3	4.89	5.94	5.93	5.77	5.60	5.60	5.61	5.60	5.57	5.56
B_2O_3*	10.27	12.12	12.04	11.85	11.65	11.47	11.29	11.19	11.09	10.98
BaO	0.07	0.02	0.02	0.03	0.04	0.08	0.05	0.07	0.06	0.08
CaO	0.46	0.36	0.37	0.37	0.41	0.40	0.41	0.42	0.44	0.44
CdO	§	0.11	0.10	0.07	0.04	0.07	0.06	0.05	0.05	<0.01
Ce_2O_3	0.10	0.01	<0.01	0.02	0.03	0.05	0.04	0.04	0.05	0.05
Cl	§	<0.01	0.01	0.01	<0.01	<0.01	0.01	0.01	0.01	0.01
Cr_2O_3	0.22	0.16	0.16	0.16	0.18	0.18	0.20	0.20	0.21	0.21
Cs_2O	<0.01	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
CuO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fe_2O_3	14.03	12.14	12.17	11.36	12.76	12.00	12.27	11.91	12.53	12.23
K_2O	§	0.16	0.16	0.15	0.15	0.15	0.15	0.14	0.14	0.15
La_2O_3	0.08	0.32	0.32	0.24	0.27	0.21	0.19	0.15	0.14	0.13
Li_2O*	2.64	3.23	3.13	3.08	3.02	2.97	2.92	2.89	2.87	2.84
MgO	0.14	0.10	0.10	0.11	0.10	0.14	0.12	0.14	0.11	0.14
MnO	2.82	0.84	0.97	1.12	1.44	1.48	1.62	1.75	1.91	1.97
Na_2O	12.55	11.92	11.95	13.04	12.30	13.35	13.26	13.49	12.49	13.41
Nd_2O_3	§	0.14	0.13	0.11	0.10	0.09	0.07	0.06	0.05	0.05
NiO	0.41	0.42	0.40	0.36	0.42	0.38	0.39	0.36	0.39	0.37
P_2O_5	0.56	0.14	0.20	0.25	0.28	0.32	0.35	0.41	0.42	0.44
PbO	0.54	0.13	0.15	0.21	0.24	0.24	0.26	0.28	0.31	0.31
SiO_2	47.75	47.80	47.96	48.42	47.30	47.56	47.43	47.85	48.02	47.67
SnO_2	0.06	0.02	0.02	0.03	0.03	0.04	0.05	0.05	0.05	0.06
SO_3	0.19	0.05	0.07	0.08	0.09	0.09	0.11	0.12	0.12	0.13
SrO	0.17	0.04	0.04	0.05	0.07	0.08	0.09	0.09	0.10	0.10
TiO_2	§	0.07	0.07	0.06	0.07	0.06	0.06	0.06	0.06	0.06
ZnO	1.03	1.60	1.53	1.31	1.46	1.27	1.28	1.15	1.19	1.12
ZrO_2	0.98	2.11	1.95	1.70	1.89	1.69	1.67	1.49	1.57	1.47
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field

Table 3.3. XRF Analyzed Compositions for Glass Discharged from DM100 (wt%) (continued).

Waste Type	High Waste Loading C-106/AY-102								
Glass (kg)	-	850.06	870.46	899.56	917.76	950.28	974.82	1000.02	1028.32
Constituent	Target	BLJ-G-35B	BLJ-G-36B	BLJ-G-42A	BLJ-G-43A	BLJ-G-44A	BLJ-G-48B	BLJ-G-51A	BLJ-G-53A
Al_2O_3	4.89	5.40	5.49	5.65	5.46	5.38	5.22	5.47	5.09
B_2O_3*	10.27	10.90	10.84	10.75	10.71	10.63	10.59	10.55	10.51
BaO	0.07	0.07	0.07	0.07	0.07	0.07	0.09	0.08	0.10
CaO	0.46	0.45	0.46	0.47	0.46	0.48	0.49	0.48	0.50
CdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ce_2O_3	0.10	0.06	0.08	0.07	0.07	0.07	0.08	0.08	0.09
Cl	§	0.01	<0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01
Cr_2O_3	0.22	0.21	0.21	0.22	0.22	0.23	0.23	0.23	0.24
Cs_2O	<0.01	0.01	0.01	<0.01	0.01	0.01	0.01	<0.01	0.01
CuO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fe_2O_3	14.03	12.70	12.93	12.70	12.68	13.19	13.32	12.91	13.86
K_2O	§	0.14	0.14	0.16	0.14	0.13	0.13	0.15	0.11
La_2O_3	0.08	0.12	0.10	0.09	0.08	0.07	0.07	0.06	0.06
Li_2O*	2.64	2.82	2.80	2.78	2.76	2.74	2.73	2.72	2.71
MgO	0.14	0.11	0.12	0.11	0.14	0.14	0.13	0.16	0.11
MnO	2.82	2.09	2.18	2.23	2.29	2.44	2.50	2.46	2.69
Na_2O	12.55	13.10	12.39	12.75	13.08	12.92	12.63	13.00	12.82
Nd_2O_3	§	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.02
NiO	0.41	0.38	0.40	0.38	0.38	0.40	0.40	0.38	0.42
P_2O_5	0.56	0.46	0.48	0.50	0.51	0.51	0.57	0.54	0.55
PbO	0.54	0.34	0.35	0.35	0.36	0.40	0.41	0.40	0.45
SiO_2	47.75	47.60	47.91	47.80	47.72	47.21	47.43	47.54	46.65
SnO_2	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08
SO_3	0.19	0.13	0.14	0.15	0.14	0.15	0.14	0.15	0.14
SrO	0.17	0.11	0.12	0.12	0.12	0.13	0.14	0.13	0.15
TiO_2	§	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
ZnO	1.03	1.13	1.13	1.07	1.03	1.08	1.09	1.02	1.11
ZrO_2	0.98	1.49	1.48	1.41	1.39	1.44	1.44	1.35	1.47
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field

Table 3.3. XRF Analyzed Compositions for Glass Discharged from DM100 (wt%) (continued).

Waste Type	High Waste Loading C-106/AY-102										
Glass (kg)	-	1058.42	1082.90	1106.08	1130.76	1156.66	1184.34	1214.80	1233.66	1156-1215	
Constituent	Target	BLJ-G-54B	BLJ-G-58B	BLJ-G-62B	BLJ-G-63A	BLJ-G-70A	BLJ-G-71B	BLJ-G-72A	BLJ-G-72B	Avg.	%Dev.
Al_2O_3	4.89	5.25	6.04	5.18	5.34	5.23	4.98	5.13	5.22	5.14	5.13
B_2O_3*	10.27	10.47	10.44	10.42	10.40	10.39	10.37	10.35	10.35	10.36	NC
BaO	0.07	0.08	0.07	0.08	0.08	0.07	0.11	0.08	0.11	0.09	NC
CaO	0.46	0.48	0.47	0.47	0.48	0.48	0.49	0.50	0.49	0.49	NC
CdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
Ce_2O_3	0.10	0.08	0.08	0.05	0.09	0.09	0.09	0.08	0.07	0.08	NC
Cl	§	0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	NC
Cr_2O_3	0.22	0.22	0.22	0.22	0.23	0.22	0.24	0.23	0.23	0.23	NC
Cs_2O	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	NC
CuO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
Fe_2O_3	14.03	12.31	12.58	12.58	12.30	12.39	13.54	13.11	12.59	12.91	-7.98
K_2O	§	0.12	0.16	0.13	0.13	0.12	0.19	0.14	0.13	0.14	NC
La_2O_3	0.08	0.11	0.04	0.05	0.04	0.03	0.03	0.03	0.03	0.03	NC
Li_2O*	2.64	2.70	2.69	2.69	2.68	2.68	2.67	2.67	2.67	2.67	NC
MgO	0.14	0.13	0.16	0.14	0.08	0.10	0.12	0.10	0.11	0.11	NC
MnO	2.82	2.41	2.46	2.49	2.49	2.49	2.73	2.66	2.56	2.61	-7.58
Na_2O	12.55	13.80	12.61	13.73	13.61	13.08	13.49	12.89	13.31	13.19	5.13
Nd_2O_3	§	0.01	0.02	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	NC
NiO	0.41	0.36	0.36	0.36	0.36	0.35	0.40	0.39	0.36	0.37	NC
P_2O_5	0.56	0.55	0.55	0.57	0.58	0.61	0.56	0.59	0.63	0.60	NC
PbO	0.54	0.38	0.39	0.40	0.40	0.39	0.45	0.43	0.40	0.42	NC
SiO_2	47.75	48.00	48.05	47.82	48.16	48.79	46.67	47.89	48.15	47.88	0.26
SnO_2	0.06	0.07	0.07	0.07	0.07	0.06	0.09	0.07	0.08	0.07	NC
SO_3	0.19	0.15	0.15	0.16	0.16	0.16	0.15	0.15	0.18	0.16	NC
SrO	0.17	0.13	0.13	0.13	0.13	0.13	0.15	0.14	0.14	0.14	NC
TiO_2	§	0.07	0.06	0.05	0.05	0.05	0.06	0.07	0.05	0.06	NC
ZnO	1.03	0.92	0.95	0.95	0.91	0.91	1.04	0.99	0.92	0.97	-6.28
ZrO_2	0.98	1.20	1.23	1.25	1.20	1.15	1.36	1.29	1.21	1.25	NC
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	NC

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field
NC – Not calculated

Table 3.4. Optical Microscopy and SEM Results on DM100 Riser and Melt Pool Dip Samples after Processing the High Waste Loading C-106/AY-102 Formulation.

Sampling Date/Time		Idling (Days)	Sampling Point	Temperature at Sampling Point	Name	Characteristics of Crystalline Phases
07/28/04	08:15	4.3	Riser	858 - 920°C	BLJ-D-78A	Spinel, 1-50 μm, most 30-50 μm, 0.3 vol. %, Figure 3.10 and 3.11
	08:20	4.3	Riser	858 - 920°C	BLJ-D-78B	Spinel, mostly 1-100 μm, most 1-2 μm, 0.4 vol. %, Figure 3.12
	08:50	4.4	Melter Pool	1000 - 1070°C	BLJ-D-78C	No crystals present
07/29/04	08:39	5.4	Riser	858 - 920°C	BLJ-D-78D	Spinel, 1-50 μm, most 1-20 μm, 0.4 vol.%, Figure 3.13
			Melter Pool	1000 - 1070°C	BLJ-D-78E	No crystals present
07/30/04	13:47	6.6	Riser	858 - 920°C	BLJ-D-79A	Spinel, 1-50 μm, most 1-20 μm, 0.4 vol. %, Figure 3.14
			Melter Pool	1000 - 1070°C	BLJ-D-79B	No crystals present
02/16/05	14:17	105.5*	Riser Air Lance	899 - 920°C	BLK-D-41A	Localized, discontinuous thin layers of spinel crystals, Figure 3.15
04/28/05	12:55	176.4*	Riser	858 - 920°C	BLK-D-41B	No crystals present
	13:50	176.5*	Suction from Riser Bottom	858 °C	BLK-O-41A	One or two spinel crystals observed, Figure 3.16
04/29/05	09:40	177.3*	Riser	858 - 920°C	BLK-D-41C	No crystals present

* Idling time after processing HLW SIPP feed [13].

Table 4.1. Summary of DM1200 AZ-102 and C-106/AY-102 Test Conditions and Results.

-		1A1	1A2	1B	2A	2B
Time	Feed Start	6/21/04 13:36	6/23/04 18:40	6/25/04 16:15	8/02/04 15:15	11/08/04 09:30
	Feed End	6/23/04 17:46	6/25/04 12:33	6/30/04 11:30	8/07/04 17:33	11/12/04 19:18
	Interval	52.2 hr	41.9 hr	115.3 hr	110.3 hr	105.8 hr
Water Feeding for Cold Cap		2.0 hr	NA	1.3 hr	3.0 hr	1.0 hr
Slurry Feeding		50.2 hr	41.9 hr	114 hr	107.3 hr	104.8 hr
Cold cap burn		NA	1.2 hr	1.5 hr	2 hr	2.2 hr
Bubbling	Bubblers	"J" , single outlet	"J" , single outlet	Prototypic, Double Outlet	"J" , single outlet	Prototypic, Double Outlet
	Location	6" above floor	6" above floor	On floor	6" above floor	On floor
	Control	Constant	Constant	Optimized	Constant	Optimized
	Average Total	60 lpm	64 lpm	100 lpm	63 lpm	87 lpm
	Steady State	65 lpm	65 lpm	65 lpm	65 lpm	90 lpm
Feed	Simulant	AZ-102	AZ-102	AZ-102	C-106/AY-102	High waste loading C-106/AY-102
	Rheology	Adjusted	Adjusted	Nominal	Adjusted	Nominal
	Glass Yield	0.384 kg/kg	0.347 kg/kg	0.27 kg/kg	0.372 kg/kg	0.263 kg/kg
		560 g/l	480 g/l	340 g/l	540 g/l	340 g/l
	Used	7877 kg	6836 kg	20002 kg	14300 kg	20100 kg
	Average Rate	156.9 kg/hr	163.2 kg/hr	175.5 kg/hr	130.8 kg/hr	191.8 kg/hr
Glass Produced	Poured	2932 kg	2465 kg	5576 kg	5193 kg	5168 kg
	Average Rate$	1168 $kg/m^2/day$	1177 $kg/m^2/day$	978 $kg/m^2/day$	968 $kg/m^2/day$	986 $kg/m^2/day$
	Average Rate*	1204 $kg/m^2/day$	1133 $kg/m^2/day$	948 $kg/m^2/day$	982 $kg/m^2/day$	1008 $kg/m^2/day$
	Steady State Rate*	1350 $kg/m^2/day$	1150 $kg/m^2/day$	900 $kg/m^2/day$	1010 $kg/m^2/day$	1050 $kg/m^2/day$

$ - Rates calculated from glass poured.
*- Rates calculated from feed data.
Note: Rates do not take into account the time for water feeding and cold cap burn-off.
NA: Not applicable.

Table 4.2. DM1200 Melter System Measured Parameters for HLW AZ-102 Simulant Validation Test (6/21/04 – 6/30/04).

-			1A1			1A2			1B		
			avg	min	max	avg	min	max	avg	min	max
TEMPERATURE (°C)	Glass	13" from floor E	1147	1098	1172	1150	1122	1167	1132	1020	1172
		15.5" from floor E	1144	1098	1173	1146	1120	1165	1129	1021	1170
		18" from floor E	1144	1096	1176	1146	1121	1167	1130	1016	1171
		27" from floor E	1157	1075	1176	1160	1130	1181	1144	1065	1184
		13" from floor W	1144	1116	1166	1147	1124	1176	1146	1107	1175
		15.5" from floor W	1141	1112	1165	1144	1116	1176	1145	1111	1175
		18" from floor W	1138	1107	1158	1140	1111	1171	1144	1108	1174
		27" from floor W	1145	1093	1179	1149	1113	1185	1149	1106	1180
	Plenum	8" below ceiling	568	481	791	533	495	593	611	410	874
		17" below ceiling	579	504	808	517	481	599	663	480	936
		Exposed	566	354	790	549	471	726	644	348	949
	Discharge	TC 1	1012	932	1060	1013	955	1063	996	868	1072
		TC 2	1028	954	1080	1030	1002	1083	1020	946	1094
		Air Flow	61	58	69	60	55	66	62	56	72
		Riser	1141	986	1187	1158	1138	1190	1111	1052	1162
	Electrode	East	1141	1021	1158	1149	1112	1156	1121	1045	1157
		West	1116	1035	1132	1123	1095	1133	1092	1033	1116
		Bottom	1006	930	1020	1016	1002	1023	1054	963	1101
	Film Cooler	Added Air	82	78	84	82	65	83	82	64	89
		Outlet	380	77	467	328	75	392	403	78	539
Glass	Density (g/cc)		2.38	2.30	2.49	2.37	2.32	2.43	2.34	2.17	2.44
	Level (" from floor)		32.84	31.30	33.68	32.94	31.68	34.08	33.64	31.09	37.15
	Resistance (ohms)		0.0838	0.0806	0.0946	0.0825	0.0787	0.0853	0.0869	0.0772	0.1019
Electrodes	Current (A)		1451	1165	1523	1489	1235	1515	1534	1148	1604
	Voltage (V)		121	105	126	123	97	125	133	112	158
	Power (kW)		176	125	192	183	120	187	205	130	246
Lance Bubblers	1	Rate (lpm)	29.0	1.6	32.1	31.7	18.7	32.1	49.6	1.6	118.9
	2	Rate (lpm)	29.5	1.4	59.8	31.7	18.1	32.7	49.3	1.5	120.9
Total Lance Bubbling (lpm)			59.5	4.0	92.4	64.4	37.8	65.5	100.0	4.0	240.5

"-" Empty data field

Table 4.3. DM1200 Melter System Measured Parameters for HLW C-106/AY-102 Simulant Validation Test 2A and 2B.

-			2A			2B		
			avg	min	max	avg	min	max
TEMPERATURE (°C)	Glass	13" from floor E	1147	1040	1174	1144	1108	1161
		15.5" from floor E	1144	1046	1170	1143	1107	1158
		18" from floor E	1145	1042	1171	1141	1103	1158
		27" from floor E	1121	981	1180	1132	1034	1155
		13" from floor W	1156	1137	1192	1142	1108	1182
		15.5" from floor W	1155	1137	1190	1139	1104	1158
		18" from floor W	1154	1136	1191	1138	1099	1160
		27" from floor W	1133	1108	1171	1132	947	1152
	Plenum	8" below ceiling	480	393	804	535	489	797
		17" below ceiling	589	464	786	517	416	760
		Exposed	493	165	812	561	319	750
	Discharge	TC 1	1010	903	1051	1027	983	1073
		TC 2	1025	935	1073	1048	1005	1087
		Air Flow	55	51	88	57	51	63
		Riser	1098	1005	1166	1125	983	1153
	Electrode	East	1134	1040	1166	1135	1045	1149
		West	1084	1041	1130	1100	1035	1114
		Bottom	1017	939	1033	1065	977	1084
	Film Cooler	Added Air	86	67	90	82	76	85
		Outlet	356	74	522	353	81	548
Glass	Density (g/cc)		2.38	2.25	2.47	2.40	2.31	2.51
	Level (" from floor)		32.91	30.38	34.06	33.00	29.86	33.94
	Resistance (ohms)		0.0933	0.0806	0.1059	0.0881	0.0835	0.1052
Electrodes	Current (A)		1283	1019	1389	1530	1069	1599
	Voltage (V)		120	108	124	135	108	140
	Power (kW)		154	110	162	206	120	219
Lance Bubblers	1	Rate (lpm)	30.7	1.5	32.1	42.6	2.0	54.3
	2	Rate (lpm)	30.9	1.4	32.1	43.4	1.9	55.2
Total Lance Bubbling (lpm)			62.6	4.0	65.1	87.0	4.9	110.4

"-" Empty data field

Table 5.1. Summary of Off-Gas Operational Events, Equipment Inspections, and Modifications During the Test Series.

Prior to Test 1	Pre-Test modifications: 1. Before the test, SBS cold water flow control valve actuator was replaced due to failure of the previous one. 2. WESP inlet spray nozzle was replaced to have a wider water spray and eliminate dripping. 3. Installed a thermocouple for measuring the film cooler internal temperature (MM-TR-09).			
Test	**Operational notes**		**Inspections**	**Post-test equipment modifications**
	Run time (hours)	**Run time note**		
1A1	Feed started at 6/21/04 14:36 Feed: AZ-102 (Silver mordenite and carbon columns were NOT used.)		1. SBS downcomer video taken (during test) at 29.3, 76.1, 192, and 217 hours. 2. WESP was inspected, post-test.	None
	1.1-1.9	Secured ADS feed system. Started feeding with AOD system		
	0-18.3	Transition line differential pressure inlet port was not connected.		
	18.3 - 19.3	Clogging of transition line and film cooler (80-85%). Cleaned by tapping and rodding.		
	20.4	Replaced SBS liquid recirculation flow rate indicator.		
	52.2	Stopped feeding with AOD system – end of Test 1A1		
1A2	53.1	Started feeding with ADS system – start of Test 1A2		
	53.0- 64.4	All spraying (SBS, WESP and HEME) stopped except for the ADS system due to building water supply pressure drop.		
	94.9	Feed stopped at end of Test 1A2		

Table 5.1. Summary of Off-Gas Operational Events, Equipment Inspections, and Modifications During the Test Series. (continued).

Test	Operational notes		Inspections	Post-test equipment modifications
	Run time (hours)	Run time note		
1B	99.9	Started Test 1B with new AZ-102 feed	1. TCO catalyst sections were inspected.	1. Heater 801 was inspected and replaced with a new one. 2. Replaced HEPA and its prefilter in EOG line. 3. Two sections of the TCO catalyst were replaced with Engelhard Corp. VOC CAT 360PFC, 200 CPSI. 4. Modified the film cooler spray to utilize a wand inserted through top viewport to the bottom of the film cooler. (Volume of spray water maintained at 5 liters) 5. A new thermocouple that was placed in the TCO between the two catalyst beds was shifted to TCO inlet.
	108.9	SBS cold water booster pump was placed in service.		
	132.5 - 133.2	The SBS recirculation pump, (SBS-PW-P-501) was replaced due to leaking seal.		
	145 - 208	Film cooler was cleaned by rodding numerous times (about 16)		
	159.3	Secured power to the WESP due to power supply problems		
	162.8 – 164.4	WESP back-up power supply in use.		
	168.9	Replaced power supply cable to the WESP and restored power.		
	172.4 – 173.4	Feeding stopped to allow cold-cap conditions to improve.		
	177.1	Transition line DP measuring tubing was cleaned.		
	205.5	Feeding with ADS system stopped. Feeding with AOD system started to empty the feed tank and maximize test duration.		
	Feed stopped at 6/30/04 11:30			

Table 5.1. Summary of Off-Gas Operational Events, Equipment Inspections, and Modifications During the Test Series. (continued).

Test	Operational notes		Inspections	Post-test equipment modifications
	Run time (hours)	Run time note		
2A	Feed started at 8/2/2004 18:15 Feed: C106/AY102 (Carbon and silver mordenite columns were NOT used.)		1. WESP was inspected	1. Replaced Blower 702 head. 2. Replaced HEPA and prefilter. 3. HEME # 2 filter media was replaced.
	15.8-20.4	WESP power supply cable was replaced.		
	16.7	Film cooler was 95 % occluded and was cleaned by rodding.		
	39.9 and 65.0	Cleaned blockage from the melter center view port. EOG was activated at this time.		
	43.4	Video inspection of film cooler showed no blockage.		
	91.4	Film cooler was clogged about 10 % and was washed.		
	Feed stopped at 8/7/2004 05:31			

Table 5.1. Summary of Off-Gas Operational Events, Equipment Inspections, and Modifications During the Test Series. (continued).

Prior to Test 2B	Pre-Test Modifications: 1. EOG piping was inspected and all solid deposits were removed. 2. Installed thermocouples at the top, bottom and middle of the activated carbon bed. 3. Two sections of the TCO catalyst were replaced with Engelhard Corp. VOC CAT 300S, 200 CPSI. 4. Installed a multi-flow path filter media system in place of silver mordenite column in the slip stream.The system has provisions for HF and HCl gas injection to test its effect on the filter media. 5. Activated carbon-bed system was installed between HEPA and TCO/SCR system and filled with Donau carbon BAT37 to the 28" level. 6. Modified the film cooler rinse mechanism to combine water and compressed air purge during wash. Cycle time is 120 seconds for a 5 liter flush.			
Test	**Operational notes**		**Inspections**	**Post-test equipment modifications**
	Run time (hours)	**Run time note**		
2B	Feed started at 11/8/2004 10:30 Feed : C106/AY102		Post test inspection of the AC-S media did not show evidence of any segregation.	None
	5.9	HEME #1 differential pressure sensor line was replaced.		
	14.1	SBS booster pump was started.		
	23.9 – 24.3	Film cooler clogged at about 30-35%. Film cooler was rinsed and rodded.		
	24.4	Film cooler spray rod was not reinstalled after rinsing (due to ineffectiveness of rinsing).		
	28.1-28.5	AC-S outlet screen DP sensor was not working.		
	30.1	TCO mid-bed thermocouple was moved to the TCO inlet.		
	34.7 and 36.4	LabVIEW DM1200 operating system malfunction. Blowers and heaters were reset.		
	52.6-55.4	TCO and SCR DP data not recorded due to sensor line malfunction.		
	54.6-54.8	Post SCR temperatures data not recorded due to thermocouple malfunction.		
	55.4-55.9	AC-S unit was bypassed for pressure testing.		
	67.1-67.4	Power failure affecting off-gas system blowers. Feed stopped in response to blower outage.		
	75.1	Heater 701 set point was changed from 65 to 67 °C.		
	99.3	AC-S unit was bypassed for the remainder of the test.		
	Feed stopped at 11/12/2004 19:18			

Table 5.2. Off-Gas System Measured Parameters.

Test		1A1			1A2			1B		
		Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Melter	Pressure at Level Detector Port ("water)	-3.2	-4.9	-1.4	-3.0	-5.6	-0.2	-2.9	-7.9	0.2
	Pressure at Instrument Port ("water)	-3.2	-5.0	-1.4	-3.1	-5.8	-0.1	-3.0	-8.0	0.3
	Control Air Flow Rate (scfm)	34.1	6.8	67.9	30.8	10.2	57.7	34.3	5.0	83.3
Film Cooler Differential Pressure ("water)		1.2	0.3	10.1	1.1	0.4	3.7	1.8	0	10.7
Transition Line Differential Pressure ("water)		2.5	1.0	9.6	2.5	1.1	5.5	3.3	0.6	13.2
SBS	Differential Pressure ("water)	31.2	27.9	34.1	31.0	27.5	34.2	31.1	19.0	34.0
	Inlet gas pressure ("water)	-7.3	-25.1	-4.1	-6.9	-11.9	-2.7	-8.2	-23.3	-2.2
	Outlet gas pressure ("water)	-38.5	-62.4	-34.1	-38.2	-44.0	-34.5	-39.3	-53.2	-28.4
	Downcomer Annulus Pressure (psia)	14.3	13.3	14.4	14.3	14.2	14.5	14.3	13.8	14.5
	Inlet gas Temp. (°C)	299	49	373	285	56	325	311	49	421
	Outlet gas Temp. (°C)	49.0	34.9	52.7	49.6	45.6	51.7	49.6	46.2	55.1
	C. Coil W. Inlet Temp (°C)	16.8	14.8	18.6	17.1	14.7	18.0	18.0	14.6	21.0
	C. Coil W. Outlet Temp (°C)	41.9	27.5	45.1	42.1	38.4	45.0	40.8	32.9	45.7
	Jacket W. Outlet Temp (°C)	44.0	29.5	47.3	44.5	40.8	46.7	43.4	36.5	47.6
	Sump Temp. (°C)	42.8	29.3	46.3	43.1	39.3	45.6	42.7	38.4	47.3
	Offgas Downcomer Temp @3" (°C)	246	179	290	230	182	248	258	186	336
	Offgas Downcomer Temp @8" (°C)	261	190	307	245	193	265	274	198	351
	Offgas Downcomer Temp @13" (°C)	265	195	312	251	199	270	280	204	357
	Offgas Downcomer Temp @18" (°C)	263	194	309	248	197	267	276	203	353
	Offgas Downcomer Temp @23" (°C)	-	-	-	-	-	-	-	-	-
	Offgas Downcomer Temp @28" (°C)	257	192	301	244	195	262	272	201	344
	Offgas Downcomer Temp @33" (°C)	252	191	293	241	194	259	267	200	336
	Offgas Downcomer Temp @38" (°C)	237	182	275	227	183	244	252	191	316
	Offgas Downcomer Temp @43" (°C)	226	173	262	218	175	234	241	183	300
	Offgas Downcomer Temp @48" (°C)	217	154	254	210	165	227	231	174	286
	Offgas Downcomer Temp @53" (°C)	192	86	234	191	96	208	206	90	259
	Offgas Downcomer Temp @58" (°C)	71	58	81	72	62	78	73	59	80
	C. Coil/Jacket W. Flow Rate (gal/min)	14.2	6.4	28.6	15.0	6.2	17.1	21.4	6.2	29.9
	Recirc. pump discharge Temp (°C)	48.7	35.7	51.4	49.4	45.6	50.7	49.4	43.7	51.9
	Recirc. pump discharge Pressure (psi)	38.6	0.0	40.1	38.7	34.6	39.9	38.5	33.3	40.3
WESP	Differential Pressure ("water)	2.4	1.1	3.4	2.8	1.7	4.1	2.4	0.7	3.9
	Inlet gas Temp. (°C)	48.2	36.6	51.5	48.8	44.6	51.0	48.9	45.4	54.0
	Outlet gas Temp. (°C)	49.0	31.4	51.4	49.8	31.2	51.5	49.8	31.1	53.5
	Wet Gas Flow Rate (scfm)	250	200	284	249	224	273	244	183	296
	Voltage (kV)	28.5	25.9	30.7	29.6	23.8	31.2	29.0	24.6	31.0
	Current (mA)	16.1	9.8	17.7	16.7	13.3	17.5	16.7	12.8	18.4
HEME #1	Differential Pressure ("water)	1.1	0.6	1.5	1.2	0.9	1.5	1.2	0.4	1.8
	Outlet Gas Temp. (°C)	47.2	38.9	49.4	47.5	39.0	48.9	47.4	38.5	50.0
HEPA 1	Differential Pressure ("water)	0.4	0.1	0.5	0.5	0.4	0.6	0.6	0.2	0.9
	Outlet Gas Temp. (°C)	64.4	57.8	66.3	64.5	57.9	66.3	64.6	57.5	67.1
TCO/SCR Heater Inlet Gas Temp. (°C)		78.7	75.3	85.2	79.3	76.1	81.5	78.3	56.0	83.0
TCO	Inlet Gas Temp. (°C)	474	461	487	474	461	485	474	451	490
	Differential Pressure ("water)	6.5	4.8	7.8	6.6	5.7	7.6	6.3	3.8	8.2
SCR	Inlet Gas Temp. (°C)	403	389	413	406	398	413	410	363	425
	Outlet Gas Temp. Right (°C)	384	373	394	387	381	395	389	363	406
	Outlet Gas Temp. Left (°C)	370	361	379	372	368	379	368	351	380
	Differential Pressure ("water)	3.2	2.6	3.8	3.3	2.9	3.7	3.1	2.2	4.0
	Post Outlet Gas Temp. (°C)	347	341	352	348	345	354	346	332	355
PBS	Inlet Gas Temp. (°C)	323	316	329	325	322	330	322	310	331
	PBS Sump Temp. (°C)	34.0	30.6	35.5	34.3	31.9	35.7	35.4	32.5	38.3
	Differential Pressure ("water)	4.5	2.1	6.5	4.6	3.2	5.9	4.3	2.3	7.1
HEME #2	Differential Pressure ("water)	5.0	3.6	6.1	6.5	5.7	7.2	7.2	4.8	8.7
	Inlet Gas Temp. (°C)	35.5	32.0	36.8	35.8	33.4	36.9	36.7	34.1	38.8
	Outlet Gas Temp. (°C)	36.6	34.2	37.9	36.8	34.8	37.9	37.5	35.2	39.8
Exhaust Stack Absolute Pressure ("water)		-8.2	-9.1	0.3	-9.0	-9.3	-8.1	-8.8	-9.0	-7.5

Table 5.2. Off-Gas System Measured Parameters (continued.)

Test		2A			2B		
		Avg.	Min.	Max.	Avg.	Min.	Max.
Melter	Pressure at Level Detector Port ("water)	-2.6	-5.2	-0.2	-2.8	-5.0	0.3
	Pressure at Instrument Port ("water)	-2.6	-5.3	-0.2	-2.8	-5.1	0.3
	Control Air Flow Rate (scfm)	32.8	8.1	72.6	23.7	8.2	55.9
Film Cooler Differential Pressure ("water)		1.3	0.4	9.2	1.3	0	6.7
Transition Line Differential Pressure ("water)		2.0	0.3	4.8	2.6	0.9	7.0
SBS	Differential Pressure ("water)	31.1	28.4	33.8	30.8	27.6	33.4
	Inlet gas pressure ("water)	-5.8	-14.5	-3.0	-7.0	-15.2	-3.8
	Outlet gas pressure ("water)	-37.2	-46.1	-35.2	-38.2	-46.9	-34.7
	Downcomer Annulus Pressure (psia)	14.3	14.0	14.4	14.5	14.2	14.7
	Inlet gas Temp. (°C)	270	65	457	298	127	443
	Outlet gas Temp. (°C)	49.5	45.7	55.9	50.9	44.2	59.6
	C. Coil W. Inlet Temp (°C)	16.0	14.4	18.3	18.4	14.8	32.7
	C. Coil W. Outlet Temp (°C)	43.1	39.1	49.8	43.7	38.2	53.0
	Jacket W. Outlet Temp (°C)	44.9	41.1	51.0	45.3	39.7	54.5
	Sump Temp. (°C)	43.8	40.0	50.9	45.1	38.6	54.1
	Offgas Downcomer Temp @3" (°C)	214	122	383	237	142	355
	Offgas Downcomer Temp @8" (°C)	229	145	402	254	165	382
	Offgas Downcomer Temp @13" (°C)	236	153	402	261	175	393
	Offgas Downcomer Temp @18" (°C)	233	152	402	258	174	387
	Offgas Downcomer Temp @23" (°C)	-	-	-	257	176	385
	Offgas Downcomer Temp @28" (°C)	230	153	400	255	175	379
	Offgas Downcomer Temp @33" (°C)	227	153	390	251	174	370
	Offgas Downcomer Temp @38" (°C)	212	142	369	238	166	351
	Offgas Downcomer Temp @43" (°C)	199	122	349	228	156	332
	Offgas Downcomer Temp @48" (°C)	184	91	333	219	130	316
	Offgas Downcomer Temp @53" (°C)	143	71	280	191	86	263
	Offgas Downcomer Temp @58" (°C)	66	59	78	76	68	82
	C. Coil/Jacket W. Flow Rate (gal/min)	10.9	6.0	17.1	21.2	5.9	30.1
	Recirc. pump discharge Temp (°C)	49.3	46.7	52.5	50.6	43.7	58.9
	Recirc. pump discharge Pressure (psi)	39.2	33.1	40.6	39.4	33.2	40.7
WESP	Differential Pressure ("water)	2.4	1.5	2.9	2.0	1.1	2.9
	Inlet gas Temp. (°C)	48.7	45.9	55.4	50.1	43.5	59.2
	Outlet gas Temp. (°C)	49.1	33.0	53.1	50.7	25.7	59.0
	Wet Gas Flow Rate (scfm)	248	222	261	231	190	263
	Voltage (kV)	29.1	28.0	31.9	29.2	25.2	31.4
	Current (mA)	16.8	13.3	17.4	16.7	12.0	18.3
HEME #1	Differential Pressure ("water)	1.2	0.8	1.4	1.0	0.6	1.3
	Outlet Gas Temp. (°C)	47.0	38.8	52.0	48.3	36.2	55.8
HEPA 1	Differential Pressure ("water)	2.8	0.6	3.5	0.1	0.0	0.3
	Outlet Gas Temp. (°C)	63.6	56.9	69.6	63.5	60.7	66.3
TCO/SCR Heater Inlet Gas Temp. (°C)		78.8	75.9	81.5	76.3	74.6	79.3
TCO	Inlet Gas Temp. (°C)	-	-	-	404	381	424
	Differential Pressure ("water)	5.1	4.4	5.7	3.9	2.7	5.2
SCR	Inlet Gas Temp. (°C)	403	392	421	397	375	427
	Outlet Gas Temp. Right (°C)	388	379	407	376	354	412
	Outlet Gas Temp. Left (°C)	351	341	372	334	311	374
	Differential Pressure ("water)	3.0	2.5	3.3	2.5	1.8	3.5
	Post Outlet Gas Temp. (°C)	335	327	353	307	269	358
PBS	Inlet Gas Temp. (°C)	314	308	331	288	254	336
	PBS Sump Temp. (°C)	32.6	30.7	35.6	32.9	29.1	44.4
	Differential Pressure ("water)	3.0	1.7	4.0	2.9	1.6	7.0
HEME #2	Differential Pressure ("water)	4.7	3.2	5.5	2.8	2.3	3.3
	Inlet Gas Temp. (°C)	34.0	32.4	36.5	34.6	30.3	46.0
	Outlet Gas Temp. (°C)	35.0	33.1	38.1	35.1	31.4	45.7
Exhaust Stack Absolute Pressure ("water)		-8.9	-9.4	0.1	-9.7	-10.1	2.5

Table 5.3. Film Cooler Wash Procedures.

Test	Film cooler wash device	Wash procedure	Film cooler rod outs
1A1	Water injection from ¼" tubing into the film cooler inlet air stream. This method was used in all previous tests.	5 liters of water, injected to mix with film cooler air stream every 12 hours.	1
1A2			0
1B			16
2A	Spraying wand inserted from the top of film cooler flange access; spray point located at the pipe centerline and ~3" above bottom of film cooler.	5 liters of water sprayed from the nozzle every 24 hours. The water is distributed throughout the bottom of the film cooler with this spray pattern.	2
2B	Wash lance inserted from the top of film cooler flange access. Water is injected from 8 slits (4 at the bottom, 4 in the middle) in the lance.	5 liters of water sprayed from a wash lance every 12 hours. The rinse method is pulsed flow with a total of 5 liters of water delivered in 120 seconds. Air at ~80 psig is used to purge the water line between water injection cycles. Water and air injection cycle times are 10 seconds each (6 cycles of water, and 6 cycles of air). Use of lance was discontinued after a rinse at ~24 hours due to ineffectiveness (deposits observed by camera were unaffected by wash).	1

Table 5.4. Time Needed to Restore Power after Deluge of WESP and Duration of Spray Water Flow Interruptions during Tests 1, 2A and 2B.

Test	Date	Time	Time Required to Restore Power (Minutes)	Duration of Spray Water Flow Interruption (Minutes)
1	6/22/2004	10:23	1	10
	6/23/2004	12:36	1	11
	6/24/2004	9:54	1	13
	6/25/2004	10:10	1	10
	6/26/2004	10:46	2	11
	6/27/2004	10:03	1	11
	6/28/2004	8:50	Out of Service	-
	6/29/2004	10:36	2	11
	Average		**1.3**	**11.0**
2A	8/3/2004	13:52	0	13
	8/4/2004	12:20	0	15
	8/5/2004	12:04	0	15
	8/6/2004	11:54	0	16
	Average		**0.0**	**14.8**
2B	11/9/2004	10:37	6	24
	11/10/2004	12:12	5	13
	11/11/2004	10:43	7	16
	Average		**6.0**	**17.7**

"-" Empty data cell

Table 5.5. Nitrogen Oxides and Carbon Monoxide Removal Across Carbon Column During Test 2B.

Gaseous Species	Conc. at WESP Outlet (ppmv)	Flux at WESP outlet (mol/hr))	Conc. at Carbon Column Outlet (ppmv)	Flux at Carbon Column outlet (mol/hr)	NOx, CO, NH_3 removal (%)	DF
N_2O	<1	<0.016	<1.0	<0.016	NC	NC
NO	72.1	1.173	67.3	1.095	NC	NC
NO_2	2.5	0.041	<1	<0.016	NC	NC
Total NOx	<75.6	<1.230	<69.3	<1.127	~8.3	~1.1
CO	8.6	0.140	9.9	0.161	-15.1	0.9
CO_2	4200	68.3	4400	71.6	NC	NC
NH_3	<1	<0.016	<1	<0.016	~0	~1.0

"NC" Not calculated.

Table 5.6. Listing of Samples from SBS Blow-Downs.

Waste Type	Test	Date	Sample Name	pH	Blow-Down Vol. (gal)	Cumulative Vol. (gal)
AZ-102	1A	06/21/04	1U2-S-18A	8.50	40.11	40.11
			1U2-S-24A	1.92	39.90	80.01
			1U2-S-28A	8.00	40.00	120.01
		06/22/04	1U2-S-29A	8.07	40.80	160.81
			1U2-S-32A	8.15	39.20	200.01
			1U2-S-34A	8.20	40.00	240.01
			1U2-S-47A	8.20	40.00	280.01
			1U2-S-48A	8.25	40.00	320.01
			1U2-S-59A	8.23	40.00	360.01
			1U2-S-60A	8.24	40.00	400.01
			1U2-S-62A	8.24	40.00	440.01
			1U2-S-64A	8.29	40.00	480.01
			1U2-S-66A	8.50	40.10	520.11
		06/23/04	1U2-S-69A	8.40	39.90	560.01
			1U2-S-71A	8.50	40.10	600.11
			1U2-S-81A	8.53	40.00	640.11
			1U2-S-82A	8.35	40.00	680.11
			1U2-S-83A	8.29	40.00	720.11
			1U2-S-84A	8.36	39.97	760.08
			1U2-S-97A	8.35	40.00	800.08
			1U2-S-103A	8.35	40.00	840.08
			1U2-S-106A	8.42	40.00	880.08
			IU2-S-108A	8.42	40.00	920.08
		06/24/04	1U2-S-109A	8.53	40.00	960.08
			1U2-S-112A	8.43	40.00	1000.08
			1U2-S-114A	8.48	40.10	1040.18
			1U2-S-117A	8.50	40.00	1080.18
			1U2-S-118A	8.48	40.00	1120.18
			1U2-S-127A	8.47	40.00	1160.18
			1U2-S-137A	8.47	39.90	1200.08
			1U2-S-138A	8.45	40.00	1240.08
			1U2-S-139A	8.49	40.00	1280.08
			1U2-S-143A	8.51	40.00	1320.08
			1U2-S-144A	8.49	40.00	1360.08
		06/25/04	1U2-S-145A	8.46	40.10	1400.18
			1U2-S-154A	8.56	40.00	1440.18
			1V2-S-10A	8.56	40.10	1480.28
			1V2-S-11A	8.54	40.00	1520.28
			1V2-S-12A	8.47	43.00	1563.28
			1V2-S-13A	8.53	39.70	1602.98
			1V2-S-29A	8.87	40.00	1642.98
	1B		1V2-S-32A	8.63	40.10	1683.08
			1V2-S-34A	8.62	40.10	1723.18
		06/26/04	1V2-S-36A	8.68	39.80	1762.98

Table 5.6. Listing of Samples from SBS Blow-Downs (continued).

Waste Type	Test	Date	Sample Name	pH	Blow-Down Vol. (gal)	Cumulative Vol. (gal)
AZ-102	1B	06/26/04	1V2-S-47A	8.67	40.00	1802.98
			1V2-S-49A	8.59	37.00	1839.98
			1V2-S-50A	8.59	40.00	1879.98
			1V2-S-51A	8.64	40.00	1919.98
			1V2-S-53A	8.68	40.00	1959.98
			1V2-S-53B	8.64	40.00	1999.98
			1V2-S-55A	8.67	40.80	2040.78
			1V2-S-57A	8.69	39.20	2079.98
			1V2-S-58A	8.64	40.00	2119.98
			1V2-S-70A	8.65	40.00	2159.98
			1V2-S-71A	8.55	40.00	2199.98
			1V2-S-72A	8.63	40.00	2239.98
			1V2-S-75A	8.59	40.00	2279.98
			1V2-S-76A	8.66	40.30	2320.28
		06/27/04	1V2-S-77A	8.65	40.20	2360.48
			1V2-S-81A	8.68	39.70	2400.18
			1V2-S-81B	8.66	50.00	2450.18
			1V2-S-82A	8.64	39.80	2489.98
			1V2-S-83A	8.57	40.00	2529.98
			1V2-S-86A	8.73	40.00	2569.98
			1V2-S-87A	8.74	40.00	2609.98
			1V2-S-89A	8.62	40.00	2649.98
			1V2-S-90A	8.62	40.00	2689.98
			1V2-S-92A	8.64	40.00	2729.98
			1V2-S-101A	8.61	39.90	2769.88
			1V2-S-105A	8.63	40.00	2809.88
			1V2-S-106A	8.64	39.90	2849.78
			1V2-S-107A	8.62	40.00	2889.78
			1V2-S-109A	8.64	40.00	2929.78
			1V2-S-110A	8.61	40.00	2969.78
			1V2-S-111A	8.63	40.00	3009.78
		06/28/04	1V2-S-123A	8.67	40.00	3049.78
			1V2-S-123B	8.64	40.30	3090.08
			1V2-S-124A	8.63	39.70	3129.78
			1V2-S-126A	8.63	40.00	3169.78
			1V2-S-128A	8.62	40.10	3209.88
			1V2-S-129A	8.67	39.70	3249.58
			1V2-S-130A	8.65	40.00	3289.58
			1V2-S-132A	8.70	39.90	3329.48
			1V2-S-134A	8.64	45.10	3374.58
			1V2-S-135A	8.63	40.00	3414.58
			1V2-S-137A	8.66	40.00	3454.58
			1V2-S-138A	8.69	40.00	3494.58

Table 5.6. Listing of Samples from SBS Blow-Downs (continued).

Waste Type	Test	Date	Sample Name	pH	Blow-Down Vol. (gal)	Cumulative Vol. (gal)
AZ-102	1B	06/28/04	1V2-S-149A	8.53	40.00	3534.58
			1V2-S-151A	8.73	40.00	3574.58
			1V2-S-152A	8.71	44.90	3619.48
		06/29/04	1V2-S-154A	8.69	40.80	3660.28
			1V2-S-155A	8.72	40.00	3700.28
			1W2-S-25A	8.72	39.30	3739.58
			1W2-S-26A	8.74	40.00	3779.58
			1W2-S-27A	8.79	40.40	3819.98
			1W2-S-28A	8.76	39.60	3859.58
			1W2-S-30A	8.75	39.94	3899.52
			1W2-S-32A	8.69	40.10	3939.62
			1W2-S-33A	8.74	39.90	3979.52
			1W2-S-36A	8.78	40.00	4019.52
			1W2-S-37A	8.76	40.00	4059.52
			1W2-S-38A	8.66	40.00	4099.52
			1W2-S-38B	8.41	40.00	4139.52
			1W2-S-42A	8.64	40.00	4179.52
		06/30/04	1W2-S-51A	8.61	40.40	4219.92
			1W2-S-57A	8.66	39.60	4259.52
			1W2-S-58A	8.69	40.50	4300.02
			1W2-S-60A	8.75	40.00	4340.02
			1W2-S-61A	8.74	40.00	4380.02
			1W2-S-70A	8.77	39.50	4419.52
C-106/ AY-102	2A	08/02/04	1W2-S-101A	8.74	40.10	4459.62
		08/03/04	1W2-S-105A	8.59	40.00	4499.62
			1W2-S-108A	8.58	40.50	4540.12
			1W2-S-112A	8.56	39.50	4579.62
			1W2-S-122A	8.55	40.00	4619.62
			1W2-S-124A	8.53	40.00	4659.62
			1W2-S-126A	8.49	40.00	4699.62
			1W2-S-129A	8.48	40.00	4739.62
			1W2-S-141A	8.47	40.00	4779.62
		08/04/04	1W2-S-142A	8.38	40.09	4819.71
			1W2-S-145A	8.38	40.00	4859.71
			1W2-S-147A	8.31	40.00	4899.71
			1X2-S-5A	8.23	40.00	4939.71
			1X2-S-10A	8.23	40.10	4979.81
			1X2-S-12A	8.16	40.00	5019.81
			1X2-S-15A	8.19	40.00	5059.81
		08/05/04	1X2-S-26A	8.17	40.00	5099.81
			1X2-S-28A	8.13	39.90	5139.71
			1X2-S-30A	8.12	40.00	5179.71
			1X2-S-34A	8.09	40.00	5219.71

Table 5.6. Listing of Samples from SBS Blow-Downs (continued).

Waste Type	Test	Date	Sample Name	pH	Blow-Down Vol. (gal)	Cumulative Vol. (gal)
C-106/ AY-102	2A	08/05/04	1X2-S-37A	8.04	40.10	5259.81
			1X2-S-46A	8.03	40.00	5299.81
			1X2-S-48A	8.00	40.00	5339.81
		08/06/04	1X2-S-61A	7.93	40.10	5379.91
			1X2-S-63A	7.97	39.80	5419.71
			1X2-S-65A	7.95	40.00	5459.71
			1X2-S-67A	7.92	40.00	5499.71
			1X2-S-69A	7.92	40.00	5539.71
			1X2-S-80A	7.97	40.00	5579.71
			1X2-S-83A	7.92	40.00	5619.71
		08/07/04	1X2-S-86A	7.97	40.00	5659.71
			1X2-S-88A	7.95	40.00	5699.71
	2B	11/08/04	1X2-S-134A	7.97	40.07	5739.78
			1X2-S-136A	8.04	40.00	5779.78
			1X2-S-137A	8.05	40.00	5819.78
			1X2-S-139A	8.15	40.00	5859.78
			1X2-S-141A	8.31	40.00	5899.78
			1X2-S-142A	8.38	40.00	5939.78
			1X2-S-144A	8.51	40.00	5979.78
		11/09/04	1X2-S-146A	8.48	40.00	6019.78
			1X2-S-147A	8.60	40.00	6059.78
			1Y2-S-5A	8.68	39.80	6099.58
			1Y2-S-9A	8.64	40.20	6139.78
			1Y2-S-12A	8.6	39.90	6179.68
			1Y2-S-12B	8.62	40.00	6219.68
			1Y2-S-22A	8.59	40.40	6260.08
			1Y2-S-24A	8.62	39.60	6299.68
			1Y2-S-25A	8.53	40.10	6339.78
			1Y2-S-28A	8.49	39.80	6379.58
			1Y2-S-29A	8.49	40.00	6419.58
			1Y2-S-30A	8.51	40.00	6459.58
			1Y2-S-31A	8.51	40.00	6499.58
			1Y2-S-31B	8.47	40.00	6539.58
			1Y2-S-32A	8.59	40.00	6579.58
			1Y2-S-36A	8.57	40.20	6619.78
		11/10/04	1Y2-S-37A	8.63	41.50	6661.28
			1Y2-S-47A	8.55	40.00	6701.28
			1Y2-S-50A	8.55	40.10	6741.38
			1Y2-S-51A	8.6	40.20	6781.58
			1Y2-S-52A	8.58	39.80	6821.38
			1Y2-S-53A	8.53	40.20	6861.58
			1Y2-S-54A	8.56	40.10	6901.68
			1Y2-S-55A	8.57	40.00	6941.68

Table 5.6. Listing of Samples from SBS Blow-Downs (continued).

Waste Type	Test	Date	Sample Name	pH	Blow-Down Vol. (gal)	Cumulative Vol. (gal)
C-106/ AY-102	2B	11/10/04	1Y2-S-65A	8.61	40.20	6981.88
			1Y2-S-68A	8.49	40.00	7021.88
			1Y2-S-68B	8.42	40.00	7061.88
			1Y2-S-70A	8.56	40.00	7101.88
			1Y2-S-72A	8.58	40.00	7141.88
			1Y2-S-73A	8.5	40.00	7181.88
			1Y2-S-74A	8.59	40.00	7221.88
			1Y2-S-74B	8.51	40.00	7261.88
			1Y2-S-76A	8.62	40.00	7301.88
			1Y2-S-76B	8.64	39.90	7341.78
		11/11/04	1Y2-S-86A	8.64	40.60	7382.38
			1Y2-S-87A	8.66	40.10	7422.48
			1Y2-S-89A	8.61	40.00	7462.48
			1Y2-S-92A	8.67	40.00	7502.48
			1Y2-S-94A	8.71	40.30	7542.78
			1Y2-S-95A	8.64	40.00	7582.78
			1Y2-S-96A	8.56	40.10	7622.88
			1Y2-S-107A	8.45	40.00	7662.88
			1Y2-S-109A	8.56	40.00	7702.88
			1Y2-S-110A	8.61	40.00	7742.88
			1Y2-S-112A	8.65	40.00	7782.88
			1Y2-S-113A	8.61	40.00	7822.88
			1Y2-S-114A	8.61	40.00	7862.88
			1Y2-S-116A	8.58	40.00	7902.88
			1Y2-S-118A	8.65	40.00	7942.88
			1Y2-S-119A	8.66	40.00	7982.88
			1Y2-S-122A	8.7	40.60	8023.48
		11/12/04	1Y2-S-132A	8.61	40.00	8063.48
			1Y2-S-133A	8.69	36.20	8099.68
			1Y2-S-133B	8.62	42.40	8142.08
			1Y2-S-134A	8.63	40.70	8182.78
			1Y2-S-136A	8.51	40.00	8222.78
			1Y2-S-137A	8.58	40.00	8262.78
			1Y2-S-139A	8.45	40.00	8302.78
			1Y2-S-139B	8.75	40.00	8342.78
			1Y2-S-140A	8.77	40.00	8382.78
			1Y2-S-141A	8.72	40.00	8422.78
			1Y2-S-145A	8.74	40.00	8462.78
			1Y2-S-146A	8.77	40.00	8502.78
			1Y2-S-146B	8.73	40.00	8542.78
			1Y2-S-147A	8.69	40.00	8582.78

Table 5.7. Analytical Results for Selected SBS Blow-Down Fluids (mg/l).

Waste Type	AZ-102					
Test	1A			1B		
Sample ID	1V2-S-13A			1W2-S-70A		
Glass (kg)	5245			10827		
pH	8.53			8.77		
-	Sus*	Dis.#	Total	Sus*	Dis.#	Total
Solid (mg/l)	5628	4876	10504	6910	4596	11506
Al	174.81	1.01	175.82	715.57	0.52	716.09
B	87.80	803.18	890.98	350.67	836.26	1186.93
Ba	0.11	0.01	0.12	0.70	0.01	0.71
Ca	22.62	7.25	29.87	93.95	3.40	97.35
Cd	12.04	0.09	12.13	32.53	0.05	32.58
Cs	8.33	4.73	13.06	17.87	3.65	21.52
Cr	0.90	0.28	1.18	2.09	0.26	2.35
Cu	<0.02	<0.02	<0.02	0.70	<0.02	0.70
Fe	1076.52	1.04	1077.56	3827.58	1.40	3828.98
K	2.93	10.03	12.96	12.01	6.26	18.27
Li	11.71	85.56	97.27	70.64	93.39	164.03
Mg	11.71	4.48	16.19	49.42	2.97	52.39
Mn	7.88	<0.04	7.88	52.91	<0.04	52.91
Na	158.71	948.81	1107.52	636.84	876.49	1513.33
Ni	25.66	0.13	25.79	128.01	0.11	128.12
P	<0.6	<0.6	<0.6	18.43	<0.6	18.43
Pb	6.53	1.01	7.54	28.76	0.84	29.60
Sb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Se	<0.9	1.11	1.11	<0.9	<0.9	<0.9
Si	1100.50	11.39	1111.89	4247.35	9.79	4257.14
Sr	0.34	0.03	0.37	0.84	0.02	0.86
Ti	5.40	0.03	5.43	23.73	0.04	23.77
Zn	176.83	0.48	177.31	656.94	0.62	657.56
Zr	92.75	0.18	92.93	536.89	0.10	536.99
F	NA	49.38	49.38	NA	27.70	27.70
Cl	NA	109.24	109.24	NA	83.16	83.16
I	NA	<0.1	<0.1	NA	<0.1	<0.1
NH_4^+	NA	<4.8	<4.8	NA	<5.7	<5.7
Nitrate	NA	47.87	47.87	NA	30.45	30.45
Nitrite	NA	47.69	47.69	NA	31.47	31.47
Sulfate	NA	296.84	296.84	NA	231.59	231.59

"-" Empty data field
* Suspended solid
# Dissolved solid

Table 5.7. Analytical Results for Selected SBS Blow-down Fluids (mg/l) (continued).

Waste Type	C-106/AY-102					
Test	2A			2B		
Sample ID	1X2-S-88A			1Y2-S-147A		
Glass (kg)	15938			21333		
pH	7.95			8.69		
-	Sus*	Dis.#	Total	Sus*	Dis.#	Total
Solid (mg/l)	5970	5292	11262	3380	3480	6860
Al	103.72	0.95	104.67	256.95	0.44	257.39
As	16.28	5.73	22.01	5.80	1.47	7.27
B	70.55	474.55	545.10	116.08	475.64	591.72
Ba	0.60	0.01	0.61	11.88	0.06	11.94
Ca	18.09	6.39	24.48	71.01	4.91	75.92
Cd	0.96	<0.03	0.96	0.75	<0.03	0.75
Cr	4.94	1.73	6.67	25.61	4.37	29.98
Cs	7.12	7.27	14.39	2.19	0.28	2.47
Cu	1.57	0.02	1.59	0.48	<0.02	0.48
Fe	819.28	2.89	822.17	1904.00	2.19	1906.19
K	3.14	4.24	7.38	4.98	1.98	6.96
Li	12.78	64.61	77.39	36.39	76.81	113.20
Mg	35.58	31.18	66.76	26.90	2.24	29.14
Mn	32.32	0.50	32.82	86.58	0.08	86.66
Na	121.09	661.80	782.89	265.83	623.70	889.53
Ni	10.49	0.10	10.59	67.19	0.08	67.27
P	<0.6	<0.6	<0.6	32.37	5.96	38.33
Pb	6.51	0.82	7.33	76.95	1.19	78.14
Sb	15.80	5.64	21.44	5.05	<0.50	5.05
Se	152.69	1104.80	1257.49	<0.1	9.80	9.80
Si	664.18	18.31	682.49	2060.71	26.13	2086.84
Sn	<0.1	<0.1	<0.1	<0.1	0.81	0.81
Sr	54.76	10.68	65.44	37.76	0.74	38.50
Ti	11.94	0.06	12.00	12.15	0.03	12.18
Zn	134.60	2.40	137.00	172.48	1.08	173.56
Zr	9.17	0.05	9.22	72.93	0.04	72.97
F	NA	29.49	29.49	NA	12.91	12.91
Cl	NA	525.45	525.45	NA	100.45	100.45
I	NA	289.09	289.09	NA	9.05	9.05
NH_4^+	NA	<5.7	<5.7	NA	7.30	7.30
Nitrate	NA	3.23	3.23	NA	16.56	16.56
Nitrite	NA	6.64	6.64	NA	12.86	12.86
Sulfate	NA	206.58	206.58	NA	403.22	403.22

"-" Empty data field
* Suspended solid
# Dissolved solid

Table 5.8. Listing of Samples from WESP Blow-Downs.

Waste Type	Test	Date	Name	pH	Blow-Down Vol. (gal)	Cumulative Blow-Down Vol. (gal)
AZ-102	1A	06/22/04	1U2-W-47A	7.71	30.70	30.70
			1U2-W-47B	7.42	41.10	71.80
		06/23/04	1U2-W-84A	7.77	44.20	116.00
			1U2-W-84B	7.57	40.40	156.40
		06/24/04	1U2-W-117A	8.20	27.70	184.10
			1U2-W-117B	7.89	39.60	223.70
		06/25/04	1V2-W-12A	8.15	42.78	266.48
			1V2-W-12B	8.00	39.58	306.06
	1B	06/26/04	1V2-W-54A	8.25	45.40	351.46
			1V2-W-54B	7.88	40.70	392.16
		06/27/04	1V2-W-89A	8.03	48.60	440.76
			1V2-W-89B	7.63	41.40	482.16
		06/28/04	1V2-W-130A	6.30	44.80	526.96
			1V2-W-130B	7.67	40.70	567.66
		06/29/04	1W2-W-29A	8.27	53.90	621.56
			1W2-W-29B	8.16	41.00	662.56
		06/30/04	1W2-W-75A	8.34	74.28	736.84
			1W2-W-75B	8.35	42.30	779.14
C-106/ AY-102	2A	08/03/04	1W2-W-123A	8.00	36.90	816.04
			1W2-W-123B	7.52	39.30	855.34
		08/04/04	1X2-W-5A	6.43	45.50	900.84
			1X2-W-5B	7.16	39.70	940.54
		08/05/04	1X2-W-34A	3.72	65.50	1006.04
			1X2-W-34B	6.82	41.40	1047.44
		08/06/04	1X2-W-68A	3.43	66.10	1113.54
			1X2-W-68B	6.57	42.00	1155.54
		08/07/04	1X2-W-103A	2.39	67.60	1223.14
			1X2-W-103B	3.14	38.70	1261.84
	2B	11/09/04	1Y2-W-23A	7.79	61.90	1323.74
			1Y2-W-23B	7.29	39.10	1362.84
		11/10/04	1Y2-W-65A	7.78	58.60	1421.44
			1Y2-W-65B	7.62	40.10	1461.54
		11/11/04	1Y2-W-107A	7.84	57.10	1518.64
			1Y2-W-107B	7.61	41.10	1559.74
		11/13/04	1Z2-W-5A	8.11	88.50	1648.24
			1Z2-W-5B	8.13	54.40	1702.64

Table 5.9. Listing of Samples from PBS Blow-Downs.

Waste Type	Test	Date	Name	pH	Blow-Down Vol. (gal)	Cumulative Blow-Down Vol. (gal)
AZ-102	1A	06/22/04	IU2-P-29A	9.12	30.70	30.70
			IU2-P48A	9.03	29.50	60.20
			1U2-P-62A	9.42	16.30	76.50
		06/23/04	1U2-P-70A	9.38	37.40	113.90
			1U2-P96A	9.47	30.10	144.00
			1U2-P-107A	9.16	22.30	166.30
		06/24/04	1U2-P-114A	9.04	34.10	200.40
			1U2-P-137A	9.03	22.20	222.60
			1U2-P-143A	9.32	26.60	249.20
		06/25/04	1V2-P-10A	9.08	31.30	280.50
			1V2-P-28A	9.44	24.30	304.80
	1B	06/26/04	1V2-P-36A	9.24	35.70	340.50
			1V2-P-55A	9.17	35.60	376.10
			1V2-P-76A	9.10	31.80	407.90
		06/27/04	1V2-P-88A	9.39	35.50	443.40
			1V2-P-108A	9.14	26.10	469.50
		06/28/04	1V2-P-126A	9.11	29.20	498.70
			1V2-P-137A	8.96	29.10	527.80
		06/29/04	1V2-P-155A	9.08	29.00	556.80
			1W2-P-30A	9.16	37.50	594.30
			1W2-P-38A	*8.97*	23.40	617.70
		06/30/04	1W2-P-58A	9.14	28.30	646.00
C-106/ AY-102	2A	08/02/04	1W2-P-103A	9.05	33.70	679.70
		08/03/04	1W2-P-108A	9.17	25.20	704.90
			1W2-P-126A	9.31	29.40	734.30
			1W2-P-141A	8.94	36.30	770.60
		08/04/04	1W2-P-147A	9.33	32.40	803.00
			1X2-P-11A	9.33	25.55	828.55
		08/05/04	1X2-P-26A	9.36	35.00	863.55
			1X2-P-32A	9.10	29.90	893.45
			1X2-P-46A	9.25	24.00	917.45
		08/06/04	1X2-P-61A	8.98	30.00	947.45
			1X2-P-67A	9.09	32.20	979.65
			1X2-P-80A	9.28	25.10	1004.75
			1X2-P-86A	9.01	26.40	1031.15
		08/07/04	1X2-P-102A	9.28	23.30	1054.45
	2B	11/08/04	1X2-P-139A	9.21	20.60	1075.05
		11/09/04	1X2-P-147A	9.15	29.40	1104.45
			1Y2-P-25A	9.05	34.10	1138.55
		11/10/04	1Y2-P-37A	8.96	29.00	1167.55
			1Y2-P-54A	8.73	37.30	1204.85
			1Y2-P-74A	8.81	24.10	1228.95

Table 5.9. Listing of Samples from PBS Blow-Downs (continued).

Waste Type	Test	Date	Name	pH	Blow-Down Vol. (gal)	Cumulative Blow-Down Vol. (gal)
C-106/ AY-102	2B	11/11/04	1Y2-P-89A	8.85	31.70	1260.65
			1Y2-P-111A	9.17	36.20	1296.85
			1Y2-P-118A	9.10	31.20	1328.05
		11/12/04	1Y2-P-134A	8.90	31.50	1359.55
			1Y2-P-141A	9.17	35.70	1395.25
		11/13/04	1Z2-P-5A	9.95	34.30	1429.55

Table 5.10. Analytical Results for Dissolved Solids in Select WESP Blow-Down Fluids (mg/l).

Waste Type	AZ-102				C-106/AY-102			
Test	1A		1B		2A		2B	
Sample I.D.	1V2-WL-12A	1V2-WL-12B	1W2-WL-75A	1W2-WL-75B	1X2-WL-103A	1X2-WL-103B	1Z2-WL-5A	1Z2-WL-5B
Glass (kg)	5144		10827		15938		21333	
TSS (mg/l)	<1	22	8	18	1	11	<1	<1
TDS (mg/l)	1790	626	1100	574	2500	549	1242	758
pH	8.15	8.00	8.34	8.35	2.39	3.14	8.11	8.13
Al	0.16	<0.03	0.15	0.11	2.11	1.40	0.10	0.06
As	0.35	<0.2	0.39	0.39	20.21	2.30	5.64	1.78
B	150.11	39.44	85.33	28.09	38.37	3.68	37.12	15.60
Ba	0.03	0.01	0.04	0.01	0.08	0.06	0.04	0.02
Ca	40.90	41.41	43.27	42.72	46.27	39.39	42.19	42.05
Cd	0.40	0.46	0.12	0.19	4.81	3.69	0.05	<0.03
Cr	0.41	0.09	0.27	0.17	4.77	0.56	2.53	1.30
Cs	9.82	3.36	7.05	5.47	16.22	2.10	1.15	0.61
Cu	<0.02	<0.02	<0.02	0.03	0.50	0.21	<0.02	<0.02
Fe	<0.05	<0.05	<0.05	<0.05	1.04	0.20	<0.05	<0.05
K	10.97	4.93	6.50	4.74	7.77	4.14	6.21	4.86
Li	33.60	7.98	19.68	6.51	11.94	0.75	16.43	7.13
Mg	8.53	8.36	8.35	8.83	7.62	7.36	8.23	8.92
Mn	<0.04	<0.04	<0.04	<0.04	0.29	0.06	<0.04	<0.04
Na	365.26	108.20	204.94	85.79	277.98	26.60	284.95	121.15
Ni	<0.04	<0.04	<0.04	<0.04	0.27	0.07	<0.04	<0.04
P	<0.60	<0.60	<0.60	<0.60	0.28	0.14	0.84	<0.60
Pb	<0.1	<0.1	0.13	<0.1	0.22	<0.1	<0.1	<0.1
Sb	<0.5	<0.5	<0.5	<0.5	1.12	<0.5	<0.5	<0.5
Se	5.77	1.52	2.38	1.14	3201.10	267.72	16.20	8.68
Si	8.07	6. 22	5.40	4.14	7.83	4.02	6.37	7.61
Sn	NA	NA	<0.25	<0.25	NA	NA	0.41	<0.25
Sr	<0.02	<0.02	0.26	0.22	0.56	0.22	0.29	0.30
Ti	<0.30	<0.30	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zn	0.18	0.18	0.05	0.14	11.81	7.97	0.02	<0.02
Zr	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
F	19.89	5.85	8.72	3.13	2.91	1.80	3.27	1.74
Cl	119.06	60.93	85.37	68.42	177.71	41.76	92.74	75.09
I	<0.10	<0.10	<0.10	<0.10	<0.1	<0.10	3.76	2.44
NH_4^+	3.90	2.70	13.90	9.80	50.40	3.10	23.40	3.00
Nitrate	24.71	29.51	19.74	32.33	<0.1	14.82	11.75	25.00
Nitrite	63.03	15.72	30.13	4.31	9.94	<0.10	12.27	21.64
Sulfate	448.54	161.50	319.68	136.20	282.24	49.35	414.33	248.51

NA – Not analyzed and not a target species

Table 5.11 Analytical Results for HEME #1 Blow-Down Fluids (mg/l).

Waste Type	AZ-102		C-106/AY-102	
Test	1A	1B	2A	2B
Sample I.D.	1V2-H1-13A	1W2-H1-75A	1X2-H1-103A	1Z2-H1-5A
Glass (kg)	5245	10827	15938	21333
Blow-down Volume (gal)	23.9	32.4	31.6	32.6
TSS (mg/l)	<1	8	1	6
TDS (mg/l)	136	262	461	214
pH	7.36	7.03	3.68	7.55
Al	<0.03	0.04	0.35	0.04
As	<0.2	0.52	1.79	0.25
B	19.38	21.47	13.34	12.27
Ba	0.02	0.03	0.04	0.02
Ca	31.69	30.03	29.67	27.42
Cd	0.29	0.19	0.47	0.05
Cr	<0.01	0.07	0.29	0.01
Cs	0.21	0.46	1.51	0.19
Cu	0.02	0.03	0.09	<0.02
Fe	<0.05	<0.05	0.13	<0.05
K	2.64	3.95	4.86	2.28
Li	0.56	1.30	2.68	0.31
Mg	6.46	5.47	5.98	5.32
Mn	<0.04	<0.04	<0.04	<0.04
Na	15.62	31.98	52.97	11.85
Ni	<0.04	<0.04	0.22	<0.04
P	<0.6	<0.6	<0.6	0.74
Pb	<0.1	<0.1	<0.1	<0.1
Sb	<0.5	<0.5	<0.5	<0.5
Se	1.86	10.55	121.85	5.77
Si	2.94	2.78	2.76	1.52
Sn	NA	<0.25	NA	<0.25
Sr	0.11	0.14	0.21	0.13
Ti	<0.02	<0.02	<0.02	<0.02
Zn	0.46	0.46	1.18	0.10
Zr	<0.02	<0.02	<0.02	<0.02
F	2.81	1.83	2.41	1.07
Cl	20.37	22.98	44.48	18.81
I	<0.10	<0.10	7.33	<0.10
NH_4^+	84.4	360.5	37.50	180.00
Nitrate	39.51	227.59	253.36	30.39
Nitrite	306.10	202.65	0.45	197.45
Sulfate	34.99	53.97	82.72	33.21

Table 5.12. Upper Estimates of Accumulations in Off-Gas Liquids During Test 1A.

Analyte	Feed (kg)	% Feed In Melter Emissions	SBS		WESP		HEME	
			Mass (g)	% Fed	Mass (g)	% Fed	Mass (g)	% Fed
Al	159.9	0.59	1098	0.7	0.1	<0.1	<0.1	<0.1
B	209.8	2.03	5563	2.7	110.2	0.1	1.8	<0.1
Ca	8.9	1.48	186.5	2.1	47.9	0.5	2.9	<0.1
Cd	5.2	0.99	75.8	1.5	0.5	<0.1	<0.1	<0.1
Cs	2.5	3.04	81.5	3.2	7.7	0.3	<0.1	<0.1
Fe	474.1	1.00	6728	1.4	<0.1	<0.1	<0.1	<0.1
K	1.3	3.68	80.9	6.0	9.2	0.7	0.2	<0.1
Li	81.7	0.52	607.3	0.7	24.2	<0.1	0.1	<0.1
Mg	2.3	3.15	101.1	4.4	9.8	0.4	0.6	<0.1
Mn	15.0	0.41	49.2	0.3	<0.1	<0.1	<0.1	<0.1
Na	481.2	1.02	6915	1.4	275.3	0.1	1.4	<0.1
Ni	19.1	0.66	161.0	0.8	<0.1	<0.1	<0.1	<0.1
P	0.7	0.97	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pb	3.5	1.13	47.1	1.3	<0.1	<0.1	<0.1	<0.1
Si	1217.4	0.41	6942	0.6	4.7	<0.1	0.3	<0.1
Zn	87.2	0.92	1107	1.3	0.2	<0.1	<0.1	<0.1
Zr	71.1	0.52	580.2	0.8	<0.1	<0.1	<0.1	<0.1
Nitrate and Nitrite	27.9	-	596.6	2.1	77.3	0.3	33.4	0.1
S	0.9	88.6	618.6	71.6	118.4	13.7	1.1	0.1

NA – Not analyzed, NC – Not calculated
< = less than

Table 5.13. Upper Estimates of Accumulations in Off-Gas Liquids During Test 2A.

Analyte	Fed (kg)	% Feed In Melter Emissions	SBS		WESP		HEME	
			Mass (g)	% Fed	Mass (g)	% Fed	Mass (g)	% Fed
Al	149.5	0.38	509.2	0.3	3.2	<0.1	<0.1	<0.1
As	7.7	2.01	107.1	1.4	20.6	0.3	0.2	<0.1
B	155.1	1.66	2652	1.7	38.6	<0.1	1.6	<0.1
Ca	11.4	1.15	119.1	1.0	78.6	0.7	3.6	<0.1
Cr	2.9	1.10	32.5	1.1	4.9	0.2	<0.1	<0.1
Cs	2.5	5.73	70.0	2.8	16.8	0.7	0.2	<0.1
Cu	1.7	0.77	7.7	0.5	0.7	<0.1	<0.1	<0.1
Fe	469.9	0.76	4000	0.9	1.1	<0.1	<0.1	<0.1
I	5.3	75.96	1406	26.4	<0.1	<0.1	0.9	<0.1
Li	74.3	0.41	376.5	0.5	11.6	<0.1	0.3	<0.1
Mg	37.5	0.74	324.8	0.9	13.7	<0.1	0.7	<0.1
Mn	165.2	0.23	159.7	0.1	0.3	<0.1	<0.1	<0.1
Na	466.8	0.82	3809	0.8	279.3	0.1	6.4	<0.1
Ni	7.1	0.80	51.5	0.7	0.3	<0.1	<0.1	<0.1
P	2.1	1.80	<0.1	<0.1	0.4	<0.1	<0.1	<0.1
Pb	6.9	0.66	35.7	0.5	0.2	<0.1	<0.1	<0.1
Sb	11.6	0.87	104.3	0.9	1.0	<0.1	<0.1	<0.1
Se	14.0	49.82	6117	43.7	3181.4	22.7	14.6	0.1
Si	1169.9	0.35	3320	0.3	10.9	<0.1	0.3	<0.1
Sr	41.4	0.77	318.3	0.8	0.7	<0.1	<0.1	<0.1
Ti	4.5	1.25	58.4	1.3	0.0	<0.1	<0.1	<0.1
Zn	88.5	0.75	666.4	0.8	18.1	<0.1	0.1	<0.1
Zr	10.2	0.56	44.8	0.4	0.0	<0.1	<0.1	<0.1
Cl	5.9	32.14	2556	43.7	201.3	3.4	5.3	0.1
Nitrate and Nitrite	11.5	-	48.0	0.4	36.3	0.3	30.5	0.3
S	<0.1	-	335.4	NC	101.5	NC	3.3	NC

NA – Not analyzed, NC – Not calculated
< = less than

Table 5.14. Identification of Tested Filter Media.

Filter Media Description	Filter Installation Location	VSL Identification Number	Analyzed Sample Identification Number
HEME filter from Johns Manville	#1	JMGR	1Z2-O-116A
HEME filter from Holliner	#2	HGFGM	1Z2-O-116B
HEPA filter Flanders DH700 Standard	#3	FLDN700	1Z2-O-116C
HEPA filter Flanders DH713 HF	#4	FLDN713	1Z2-O-116D

Table 5.15. DCP Analyzed Compositions of Original Filter Media (wt%).

Sample I.D.	JMGR	HGFGM	FLDN700	FLDN713
Al_2O_3	1.79	2.63	4.94	5.04
B_2O_3	0.21	5.66	10.27	10.18
BaO	0.01	<0.01	3.97	3.90
CaO	3.74	5.40	2.06	2.05
CdO	<0.01	<0.01	<0.01	<0.01
Cr_2O_3	<0.01	0.01	<0.01	<0.01
Fe_2O_3	0.09	0.07	0.12	0.12
K_2O	0.66	0.76	2.37	2.35
Li_2O	0.02	0.03	0.02	0.02
MgO	2.70	2.75	0.36	0.36
MnO	<0.01	<0.01	0.01	<0.01
Na_2O	13.63	14.30	7.86	7.86
P_2O_5	0.19	0.09	0.16	0.12
PbO	0.01	0.01	0.01	0.01
SiO_2	69.85	66.24	54.56	52.19
SrO	0.01	<0.01	0.10	0.09
TiO_2	0.03	0.01	0.04	0.04
ZnO	<0.01	0.01	3.45	3.48
ZrO_2	0.01	0.04	0.04	0.04
Sum	92.95	98.01	90.33	87.88

Table 6.1. Glass Discharged, Masses, and Analysis Performed for DM1200.

Waste	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
AZ-102	1A1	06/21/04	1U2-G-23A	-	511.0	511.0
			1U2-G-24A	-		
			1U2-G-26A	-		
			1U2-G-26B	-		
			1U2-G-27A	-		
			1U2-G-28A	-		
			1U2-G-28B	-		
			1U2-G-29A	-		
		06/22/04	1U2-G-30A	-		
			1U2-G-30B	XRF		
			1U2-G-32A	-	515.5	1,026.5
			1U2-G-32B	-		
			1U2-G-32C	-		
			1U2-G-34A	-		
			1U2-G-35A	-		
			1U2-G-35B	-		
			1U2-G-46A	-		
			1U2-G-47A	-		
			1U2-G-48A	-		
			1U2-G-48B	XRF		
			1U2-G-49A	-	508.3	1,534.8
			1U2-G-49B	-		
			1U2-G-59A	-		
			1U2-G-59B	-		
			1U2-G-60A	-		
			1U2-G-60B	-		
			1U2-G-61A	-		
			1U2-G-61B	-		
			1U2-G-62A	-		
			1U2-G-62B	XRF		
			1U2-G-64A	-	498.0	2,032.8
			1U2-G-64B	-		
			1U2-G-66A	-		
			1U2-G-66B	-		
			1U2-G-66C	-		
		06/23/04	1U2-G-69A	-		
			1U2-G-69B	-		
			1U2-G-70A	-		
			1U2-G-70B	-		
			1U2-G-71A	XRF		
			1U2-G-71B	-		
			1U2-G-80A	-		
			1U2-G-80B	-		

"-" Empty data field

Table 6.1. Glass Discharged, Masses, and Analysis Performed for DM1200 (continued).

Waste Type	Test#	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
AZ-102	1A1	06/23/04	1U2-G-81A	-	506.0	2,538.8
			1U2-G-81B	-		
			1U2-G-82A	-		
			1U2-G-83A	-		
			1U2-G-83B	-		
			1U2-G-84A	XRF		
			1U2-G-84B	-	507.0	3,045.8
			1U2-G-84C	-		
			1U2-G-96A	-		
			1U2-G-96B	-		
			1U2-G-97A	-		
			1U2-G-97B	-		
			1U2-G-100A	-		
			1U2-G-100B	-		
	1A2		1U2-G-105A	-		
			1U2-G-106A	XRF		
			1U2-G-107A	-	518.5	3,564.3
			1U2-G-108A	-		
		06/24/04	1U2-G-109A	-		
			1U2-G-110A	-		
			1U2-G-110B	-		
			1U2-G-110C	-		
			1U2-G-112A	-		
			1U2-G-114A	XRF		
			1U2-G-116A	-	495.0	4,059.3
			1U2-G-116B	-		
			1U2-G-117A	-		
			1U2-G-117B	-		
			1U2-G-118A	-		
			1U2-G-118B	-		
			1U2-G-127A	-		
			1U2-G-127B	-		
			1U2-G-137A	XRF		
			1U2-G-138A	-	513.5	4,572.8
			1U2-G-138B	-		
			1U2-G-139A	-		
			1U2-G-139B	-		
			1U2-G-141A	-		
			1U2-G-141B	-		
			1U2-G-143A	-		
			1U2-G-144A	-		
			1U2-G-144B	-		
			1U2-G-144C	XRF		

"-" Empty data field

Table 6.1. Glass Discharged, Masses, and Analysis Performed for DM1200 (continued).

Waste	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
AZ-102	1A2	06/25/04	1U2-G-145A	-	520.5	5,093.3
			1U2-G-145B	-		
			1U2-G-154A	-		
			1V2-G-5A	-		
			1V2-G-5B	-		
			1V2-G-5C	-		
			1V2-G-10A	-		
			1V2-G-10B	-		
			1V2-G-11A	-		
			1V2-G-11B	XRF		
			1V2-G-12A	-	303.5	5,396.8
			1V2-G-12B	-		
			1V2-G-13A	-		
			1V2-G-13B	-		
			1V2-G-23A	-		
			1V2-G-23B	XRF,DCP, Fe^{2+}		
AZ-102	1B		1V2-G-29A	-	496.5	5,893.3
			1V2-G-30A	-		
			1V2-G-32A	-		
			1V2-G-33A	-		
			1V2-G-34A	-		
		06/26/04	1V2-G-46A	-		
			1V2-G-46B	-		
			1V2-G-47A	-		
			1V2-G-47B	-		
			1V2-G-49A	XRF		
			1V2-G-50A	-	500.5	6,393.8
			1V2-G-51A	-		
			1V2-G-51B	-		
			1V2-G-53A	-		
			1V2-G-55A	-		
			1V2-G-55B	-		
			1V2-G-57A	-		
			1V2-G-58A	-		
			1V2-G-69A	XRF		
			1V2-G-70A	-		
			1V2-G-71A	-		
			1V2-G-71B	-		
			1V2-G-74A	-		
			1V2-G-75A	-		
			1V2-G-76A	-		
			1V2-G-76B	-		

"-" Empty data field

Table 6.1. Glass Discharged, Masses, and Analysis Performed for DM1200 (continued).

Waste	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
AZ-102	1B	06/27/04	1V2-G-77A	-	506.0	6,899.8
			1V2-G-78A	-		
			1V2-G-81A	XRF		
			1V2-G-82A	-	515.5	7,415.3
			1V2-G-83A	-		
			1V2-G-84A	-		
			1V2-G-84B	-		
			1V2-G-86A	-		
			1V2-G-87A	-		
			1V2-G-89A	-		
			1V2-G-90A	-		
			1V2-G-92A	XRF		
			1V2-G-102A	-	509.0	7,924.3
			1V2-G-102B	-		
			1V2-G-105A	-		
			1V2-G-106A	-		
			1V2-G-107A	-		
			1V2-G-107B	-		
			1V2-G-109A	-		
			1V2-G-110A	-		
			1V2-G-110B	XRF		
			1V2-G-111A	-	519.5	8,443.8
			1V2-G-122A	-		
		06/28/04	1V2-G-123A	-		
			1V2-G-124A	-		
			1V2-G-124B	-		
			1V2-G-126A	-		
			1V2-G-128A	-		
			1V2-G-129A	-		
			1V2-G-130A	-		
			1V2-G-131A	XRF		
			1V2-G-132A	-	497.5	8,941.3
			1V2-G-134A	-		
			1V2-G-135A	-		
			1V2-G-136A	-		
			1V2-G-136B	-		
			1V2-G-137A	-		
			1V2-G-138A	-		
			1V2-G-149A	XRF		
			1V2-G-150A	-		
			1V2-G-150B	-		
			1V2-G-151A	-		
			1V2-G-151B	-		

"-" Empty data field

Table 6.1. Glass Discharged, Masses, and Analysis Performed for DM1200 Continued.

Waste	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
AZ-102	1B	06/28/04	1V2-G-152A	-	509.5	9,450.8
		06/29/04	1V2-G-154A	-		
			1V2-G-155A	-		
			1W2-G-24A	-		
			1W2-G-24B	-		
			1W2-G-25A	XRF		
			1W2-G-26A	-	505.5	9,956.3
			1W2-G-27A	-		
			1W2-G-28A	-		
			1W2-G-29A	-		
			1W2-G-30A	-		
			1W2-G-32A	-		
			1W2-G-32B	-		
			1W2-G-35A	-		
			1W2-G-36A	-		
			1W2-G-36B	XRF, DCP		
			1W2-G-37A	-	507.5	10,463.8
			1W2-G-38A	-		
			1W2-G-38B	-		
			1W2-G-39A	-		
			1W2-G-39B	-		
		06/30/04	1W2-G-42A	-		
			1W2-G-51A	-		
			1W2-G-57A	-		
			1W2-G-58A	XRF. DCP		
			1W2-G-59A	-	509.0	10,972.8
			1W2-G-60A	-		
			1W2-G-61A	-		
			1W2-G-61B	-		
			1W2-G-70A	-		
			1W2-G-75A	-		
			1W2-G-75B	XRF,DCP, Fe^{2+}		
C-106/AY-102	2A	08/02/04	1W2-G-101A	-	517.0	11,489.8
			1W2-G-102A	-		
			1W2-G-103A	-		
		08/03/04	1W2-G-105A	-		
			1W2-G-105B	-		
			1W2-G-106A	-		
			1W2-G-107A	-		
			1W2-G-111A	-		
			1W2-G-111B	-		
			1W2-G-112A	XRF		
			1W2-G-113A	-		

"-" Empty data field

Table 6.1. Glass Discharged, Masses, and Analysis Performed for DM1200 (continued).

Waste	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
C-106/ AY-102	2A	08/03/04	1W2-G-113B	-	502.0	11,991.8
			1W2-G-122A	-		
			1W2-G-122B	-		
			1W2-G-123A	-		
			1W2-G-124A	-		
			1W2-G-124B	-		
			1W2-G-126A	-		
			1W2-G-127A	XRF		
			1W2-G-127B	-	516.0	12,507.8
			1W2-G-129A	-		
			1W2-G-140A	-		
			1W2-G-140B	-		
			1W2-G-141A	-		
		08/04/04	1W2-G-142A	-		
			1W2-G-142B	-		
			1W2-G-142C	-		
			1W2-G-144A	-		
			1W2-G-145A	XRF		
			1W2-G-146A	-	521.0	13,028.8
			1W2-G-146B	-		
			1W2-G-147A	-		
			1W2-G-147B	-		
			1X2-G-5A	-		
			1X2-G-9A	-		
			1X2-G-9B	-		
			1X2-G-9C	-		
			1X2-G-10A	XRF		
			1X2-G-11A	-	531.5	
			1X2-G-11B	-		
			1X2-G-12A	-		
			1X2-G-14A	-		
			1X2-G-14B	-		
			1X2-G-15A	-		
		08/05/04	1X2-G-26	-		
			1X2-G-26B	-		
			1X2-G-26C	-		
			1X2-G-27A	XRF		13,560.3
			1X2-G-27B	-		
			1X2-G-28A	-		
			1X2-G-30A	-		
			1X2-G-31A	-		
			1X2-G-31B	-		
			1X2-G-31C	-		
			1X2-G-34A	-		

"-" Empty data field

Table 6.1. Glass Discharged, Masses, and Analysis Performed for DM1200 (continued).

Waste	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
C-106 /AY-102	2A	08/05/04	1X2-G-34B	-	498.0	14,058.3
			1X2-G-36A	XRF		
			1X2-G-37A	-	532.0	14,590.3
			1X2-G-37B	-		
			1X2-G-37C	-		
			1X2-G-46A	-		
			1X2-G-46B	-		
			1X2-G-47A	-		
			1X2-G-47B	-		
			1X2-G-48A	-		
			1X2-G-60A	-		
			1X2-G-60B	XRF		
		08/06/04	1X2-G-61A	-	527.0	15,117.3
			1X2-G-62A	-		
			1X2-G-63A	-		
			1X2-G-63B	-		
			1X2-G-64A	-		
			1X2-G-65A	-		
			1X2-G-65B	-		
			1X2-G-67A	-		
			1X2-G-67B	-		
			1X2-G-68A	XRF		
			1X2-G-68B	-	517.0	15,634.3
			1X2-G-69A	-		
			1X2-G-69B	-		
			1X2-G-70A	-		
			1X2-G-70B	-		
			1X2-G-80A	-		
			1X2-G-80B	-		
			1X2-G-83A	-		
			1X2-G-83B	-		
			1X2-G-84A	XRF		
			1X2-G-86A	-	531.0	16,165.3
		08/07/04	1X2-G-86B	-		
			1X2-G-87A	-		
			1X2-G-88A	-		
			1X2-G-88B	-		
			1X2-G-89A	-		
			1X2-G-102A	XRF,DCP, Fe^{2+}		
C-106 /AY-102	2B	11/08/04	1X2-G-137A	-		
			1X2-G-138A	-		
			1X2-G-140A	-		
			1X2-G-140B	-		
			1X2-G-141A	-		

"-" Empty data field

Table 6.1. Glass Discharged, Masses, and Analysis Performed for DM1200 (continued).

Waste	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
C-106 /AY-102	2B	11/08/04	1X2-G-142A	-	523.5	16,688.8
			1X2-G-144A	-		
		11/09/04	1X2-G-145A	-		
			1X2-G-146A	XRF		
			1X2-G-147A	-	512.5	17,201.3
			1Y2-G-5A	-		
			1Y2-G-5B	-		
			1Y2-G-11A	-		
			1Y2-G-11B	-		
			1Y2-G-12A	-		
			1Y2-G-21A	-		
			1Y2-G-22A	-		
			1Y2-G-24A	-		
			1Y2-G-24B	XRF		
			1Y2-G-25A	-	510.0	17,711.3
			1Y2-G-28A	-		
			1Y2-G-28B	-		
			1Y2-G-29A	-		
			1Y2-G-30A	-		
			1Y2-G-30B	-		
			1Y2-G-31A	-		
			1Y2-G-31B	-		
			1Y2-G-32A	-		
			1Y2-G-32B	XRF		
			1Y2-G-36A	-	515.5	18,226.8
		11/10/04	1Y2-G-37A	-		
			1Y2-G-47A	-		
			1Y2-G-47B	-		
			1Y2-G-50A	-		
			1Y2-G-51A	-		
			1Y2-G-51B	-		
			1Y2-G-53A	-		
			1Y2-G-52A	-		
			1Y2-G-53B	XRF		
			1Y2-G-54A	-	524.0	18,750.8
			1Y2-G-55A	-		
			1Y2-G-55B	-		
			1Y2-G-65A	-		
			1Y2-G-68A	-		
			1Y2-G-68B	-		
			1Y2-G-70A	-		
			1Y2-G-70B	-		
			1Y2-G-72A	-		
			1Y2-G-73A	XRF		

"-" Empty data field

Table 6.1. Glass Discharged, Masses, and Analysis Performed for DM1200 (continued).

Waste	Test	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
C-106 /AY-102	2B	11/10/2004	1Y2-G-73B	-	513.0	19,263.8
			1Y2-G-74A	-		
			1Y2-G-74B	-		
			1Y2-G-75A	-		
			1Y2-G-76A	-		
			1Y2-G-86A	-		
		11/11/04	1Y2-G-86B	-		
			1Y2-G-87A	-		
			1Y2-G-87B	-		
			1Y2-G-89A	XRF		
			1Y2-G-92A	-	523.5	19,787.3
			1Y2-G-94A	-		
			1Y2-G-94B	-		
			1Y2-G-95A	-		
			1Y2-G-96A	-		
			1Y2-G-107A	-		
			1Y2-G-108A	-		
			1Y2-G-108B	-		
			1Y2-G-110A	-		
			1Y2-G-111A	XRF		
			1Y2-G-112A	-	515.0	20,302.3
			1Y2-G-113A	-		
			1Y2-G-113B	-		
			1Y2-G-114A	-		
			1Y2-G-114B	-		
			1Y2-G-116A	-		
			1Y2-G-118A	-		
			1Y2-G-119A	-		
			1Y2-G-119B	-		
			1Y2-G-122A	XRF		
		11/12/04	1Y2-G-132A	-	519.0	20,821.3
			1Y2-G-132B	-		
			1Y2-G-133A	-		
			1Y2-G-134A	-		
			1Y2-G-135A	-		
			1Y2-G-136A	-		
			1Y2-G-137A	-		
			1Y2-G-139A	-		
			1Y2-G-139B	XRF		
			1Y2-G-140A	-	512.0	21,333.3
			1Y2-G-141A	-		
			1Y2-G-141B	-		
			1Y2-G-144A	-		
			1Y2-G-145A	-		
			1Y2-G-146A	-		
			1Y2-G-146B	-		
			1Y2-G-147A	XRF,DCP, Fe^{2+}		

"-" Empty data field

Table 6.2. XRF Analyzed Compositions for Glass Discharged from DM1200 (wt%).

Test	1A										
Waste	AZ-102										
Glass (kg)	-	511	1027	1535	2033	2539	3046	3564	4059	4573	5093
Constituent	Target	1U2-G-30B	1U2-G-48B	1U2-G-62B	1U2-G-71A	1U2-G-84A	1U2-G-106A	1U2-G-119A	1U2-G-137A	1U2-G-144C	1V2-G-11B
Al_2O_3	5.6	5.77	5.60	5.82	5.90	5.88	5.83	5.75	5.79	5.77	5.70
As_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
B_2O_3*	12.52	12.05	12.16	12.24	12.31	12.36	12.39	12.42	12.45	12.46	12.48
BaO	§	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
CaO	0.23	0.34	0.36	0.35	0.33	0.34	0.34	0.34	0.33	0.34	0.34
CdO	0.11	0.09	0.10	0.09	0.10	0.11	0.12	0.12	0.12	0.11	0.13
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cl	§	<0.01	0.01	<0.01	0.01	0.01	<0.01	0.01	0.01	<0.01	0.01
Cr_2O_3	§	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Cs_2O	0.05	0.01	0.03	0.03	0.04	0.05	0.05	0.05	0.06	0.06	0.06
CuO	§	0.03	0.02	0.02	0.01	0.01	<0.01	0.01	0.00	<0.01	<0.01
Fe_2O_3	12.56	11.65	12.22	12.17	11.56	12.07	11.77	12.01	11.99	11.92	12.42
K_2O	0.03	0.15	0.14	0.15	0.15	0.15	0.17	0.16	0.14	0.17	0.16
La_2O_3	0.38	0.42	0.43	0.41	0.39	0.43	0.39	0.40	0.40	0.40	0.41
Li_2O*	3.26	3.46	3.41	3.38	3.35	3.33	3.31	3.30	3.29	3.28	3.28
MgO	0.07	0.11	0.14	0.10	0.15	0.14	0.17	0.13	0.11	0.17	0.12
MnO	0.36	0.27	0.30	0.31	0.30	0.33	0.33	0.35	0.35	0.35	0.37
Na_2O	12.02	12.25	11.88	11.82	13.01	12.35	12.72	12.39	12.73	12.75	11.87
Nd_2O_3	0.17	0.29	0.28	0.26	0.23	0.22	0.21	0.21	0.20	0.19	0.19
NiO	0.45	0.51	0.53	0.50	0.45	0.45	0.44	0.43	0.43	0.42	0.44
P_2O_5	0.03	0.01	0.01	0.02	0.03	0.02	0.03	0.04	0.03	0.03	0.00
PbO	0.07	0.04	0.05	0.05	0.05	0.06	0.06	0.05	0.06	0.05	0.06
RuO_2	§	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sb_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SeO_2	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SiO_2	48.26	46.30	46.14	46.57	46.54	46.52	46.90	47.11	46.82	47.05	47.29
SO_3	0.04	0.07	0.07	0.07	0.10	0.09	0.10	0.09	0.09	0.10	0.09
SrO	§	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.01
TiO_2	§	0.09	0.08	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.07
Y_2O_3	§	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
ZnO	2.01	1.77	1.89	1.87	1.73	1.83	1.76	1.78	1.79	1.74	1.85
ZrO_2	1.78	4.16	4.00	3.55	3.11	3.09	2.79	2.73	2.67	2.52	2.60
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field

Table 6.2. XRF Analyzed Compositions for Glass Discharged from DM1200 (wt%) (continued).

Test	-	1A	1B								
Waste	AZ-102										
Glass (kg)	-	5397	5893	6394	6900	7415	7924	8444	8941	9451	9956
Constituent	Target	1V2-G-23B	1V2-G-49A	1V2-G-69A	1V2-G-81A	1V2-G-92A	1V2-G-110B	1V2-G-131A	1V2-G-149A	1W2-G-25A	1W2-G-36B
Al_2O_3	5.6	5.70	5.79	5.78	5.81	5.82	5.83	5.91	5.90	5.89	5.87
As_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
B_2O_3*	12.52	12.48	12.49	12.50	12.50	12.51	12.51	12.51	12.51	12.52	12.52
BaO	§	0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
CaO	0.23	0.34	0.34	0.35	0.35	0.35	0.35	0.36	0.35	0.36	0.35
CdO	0.11	0.13	0.12	0.13	0.13	0.12	0.13	0.11	0.12	0.13	0.13
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cl	§	0.01	<0.01	<0.01	0.01	<0.01	0.01	0.01	<0.01	<0.01	0.01
Cr_2O_3	§	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Cs_2O	0.05	0.06	0.05	0.05	0.06	0.06	0.06	0.05	0.05	0.06	0.07
CuO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fe_2O_3	12.56	11.71	11.87	12.07	11.96	11.58	11.74	11.35	11.44	11.69	11.88
K_2O	0.03	0.16	0.16	0.16	0.15	0.16	0.16	0.16	0.15	0.16	0.15
La_2O_3	0.38	0.39	0.40	0.41	0.39	0.40	0.39	0.41	0.40	0.41	0.39
Li_2O*	3.26	3.28	3.27	3.27	3.27	3.27	3.26	3.26	3.26	3.26	3.26
MgO	0.07	0.12	0.09	0.14	0.07	0.12	0.09	0.10	0.14	0.15	0.13
MnO	0.36	0.35	0.36	0.37	0.36	0.36	0.37	0.36	0.36	0.37	0.38
Na_2O	12.02	13.27	12.61	12.28	12.32	12.94	12.74	12.71	13.20	12.71	12.60
Nd_2O_3	0.17	0.18	0.18	0.18	0.18	0.18	0.19	0.17	0.18	0.17	0.17
NiO	0.45	0.39	0.42	0.43	0.42	0.41	0.41	0.39	0.39	0.40	0.42
P_2O_5	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.04
PbO	0.07	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.06	0.06
RuO_2	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sb_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SeO_2	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SiO_2	48.26	47.05	47.46	47.39	47.62	47.53	47.52	48.13	47.49	47.43	47.34
SO_3	0.04	0.11	0.11	0.09	0.09	0.09	0.09	0.08	0.00	0.08	0.08
SrO	§	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	<0.01
TiO_2	§	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Y_2O_3	§	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ZnO	2.01	1.71	1.73	1.78	1.74	1.67	1.69	1.63	1.65	1.71	1.76
ZrO_2	1.78	2.38	2.34	2.44	2.37	2.26	2.30	2.11	2.15	2.30	2.29
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field

Table 6.2. XRF Analyzed Compositions for Glass Discharged from DM1200 (wt%) (continued).

Test	1B					2A					
Waste	AZ-102					C-106/AY-102					
Glass (kg)	-	10464	10973	6000-10973		-	16689	17201	17711	18227	18751
Constituent	Target	1W2-G-58A	1W2-G-75B	Average	%Dev	Target	1W2-G-112A	1W2-G-127A	1W2-G-145A	1X2-G-10A	1X2-G-27A
Al_2O_3	5.6	5.99	5.91	5.87	4.86	5.31	5.81	5.81	5.64	5.64	5.69
As_2O_3	§	<0.01	<0.01	<0.01	NC	0.19	0.04	0.07	0.10	0.12	0.12
B_2O_3*	12.52	12.52	12.52	12.51	NC	9.38	11.78	11.24	10.80	10.47	10.21
BaO	§	0.01	0.01	0.01	NC	§	0.01	<0.01	<0.01	<0.01	<0.01
CaO	0.23	0.35	0.36	0.35	NC	0.30	0.35	0.36	0.37	0.37	0.37
CdO	0.11	0.12	0.12	0.13	NC	§	0.10	0.07	0.06	<0.01	<0.01
Ce_2O_3	§	<0.01	<0.01	<0.01	NC	§	<0.01	<0.01	<0.01	<0.01	<0.01
Cl	§	<0.01	<0.01	<0.01	NC	0.11	0.02	0.04	0.05	0.06	0.06
Cr_2O_3	§	0.02	0.01	0.01	NC	0.08	0.05	0.06	0.06	0.07	0.07
Cs_2O	0.05	0.06	0.06	0.06	NC	0.05	0.06	0.05	0.06	0.06	0.05
CuO	§	<0.01	<0.01	<0.01	NC	0.04	0.01	0.02	0.02	0.03	0.03
Fe_2O_3	12.56	11.35	12.05	11.71	-6.76	12.62	11.20	11.33	11.56	11.50	11.23
I	<0.01	<0.01	<0.01	<0.01	NC	0.10	<0.01	<0.01	<0.01	<0.01	<0.01
K_2O	0.03	0.16	0.17	0.16	NC	§	0.14	0.15	0.13	0.13	0.13
La_2O_3	0.38	0.37	0.40	0.40	NC	0.24	0.34	0.32	0.31	0.29	0.28
Li_2O*	3.26	3.26	3.26	3.26	NC	3.01	3.20	3.16	3.12	3.10	3.08
MgO	0.07	0.09	0.13	0.11	NC	1.17	0.38	0.53	0.66	0.78	0.86
MnO	0.36	0.35	0.38	0.37	NC	4.01	1.15	1.66	2.18	2.49	2.74
Na_2O	12.02	12.71	12.67	12.69	5.59	11.83	13.51	12.94	12.82	13.10	13.32
Nd_2O_3	0.17	0.17	0.18	0.18	NC	0.15	0.17	0.16	0.16	0.16	0.16
NiO	0.45	0.39	0.42	0.41	NC	0.17	0.32	0.29	0.27	0.23	0.20
P_2O_5	0.03	0.04	0.04	0.04	NC	0.09	0.06	0.07	0.08	0.09	0.09
PbO	0.07	0.05	0.06	0.06	NC	0.14	0.06	0.08	0.08	0.08	0.09
Sb_2O_3	§	<0.01	<0.01	<0.01	NC	0.26	0.07	0.10	0.15	0.19	0.19
SeO_2	§	<0.01	<0.01	<0.01	NC	0.37	0.05	0.07	0.08	0.08	0.09
SiO_2	48.26	48.12	47.00	47.56	-1.45	47.01	47.52	47.94	47.78	47.65	47.81
SO_3	0.04	0.08	0.08	0.07	NC	§	0.05	0.06	0.07	0.08	0.08
SrO	§	<0.01	0.01	0.01	NC	0.92	0.18	0.30	0.41	0.48	0.52
TiO_2	§	0.07	0.07	0.07	NC	0.14	0.09	0.11	0.13	0.15	0.15
ZnO	2.01	1.64	1.79	1.70	-15.30	2.07	1.59	1.62	1.64	1.64	1.58
ZrO_2	1.78	2.09	2.30	2.26	26.98	0.26	1.66	1.39	1.19	1.00	0.80
Sum	100.00	100.00	100.00	100.00	NC	100.00	100.00	100.00	100.00	100.00	100.00

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field
NC – Not calculated

Table 6.2. XRF Analyzed Compositions for Glass Discharged from DM1200 (wt%), (continued).

Test	2A							2B			
Waste	C-106/AY-102							C-106/AY-102			
Glass (kg)	-	14058	14590	15117	15634	16165	16165	-	16689	17201	17711
Constituent	Target	1X2-G-36A	1X2-G-60B	1X2-G-68A	1X2-G-84A	1X2-G-102A	%Dev.	Target	1X2-G-146A	1Y2-G-24B	1Y2-G-32B
Al_2O_3	5.31	5.48	5.45	5.50	5.44	5.43	2.26	4.89	5.53	5.46	5.47
As_2O_3	0.19	0.16	0.17	0.16	0.17	0.18	NC	§	0.14	0.11	0.09
B_2O_3*	9.38	10.02	9.87	9.76	9.67	9.60	NC	10.27	9.76	9.88	9.97
BaO	§	<0.01	<0.01	<0.01	<0.01	<0.01	NC	0.07	<0.01	0.04	0.05
CaO	0.30	0.39	0.39	0.39	0.38	0.39	NC	0.46	0.44	0.45	0.47
CdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	NC	§	<0.01	<0.01	<0.01
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	NC	0.10	0.02	0.03	0.05
Cl	0.11	0.06	0.06	0.06	0.07	0.07	NC	§	<0.01	<0.01	0.01
Cr_2O_3	0.08	0.08	0.08	0.08	0.08	0.09	NC	0.22	0.14	0.16	0.17
Cs_2O	0.05	0.06	0.06	0.05	0.06	0.06	NC	§	0.04	0.03	0.02
CuO	0.04	0.04	0.04	0.04	0.04	0.05	NC	§	0.04	0.02	0.02
I	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	NC	<0.01	<0.01	<0.01	<0.01
Fe_2O_3	12.62	12.26	12.53	11.95	11.84	12.29	-2.57	14.03	12.75	12.82	12.48
K_2O	§	0.13	0.12	0.13	0.12	0.12	NC	§	0.13	0.12	0.14
La_2O_3	0.24	0.29	0.28	0.27	0.27	0.27	NC	0.08	0.21	0.20	0.17
Li_2O*	3.01	3.06	3.05	3.04	3.03	3.03	NC	2.64	2.94	2.87	2.81
MgO	1.17	0.88	0.94	1.01	1.05	1.00	-14.10	0.14	0.80	0.71	0.58
MnO	4.01	3.16	3.45	3.43	3.47	3.66	-8.64	2.82	3.53	3.36	3.18
Na_2O	11.83	12.42	12.21	12.50	12.93	12.28	3.83	12.55	11.63	11.80	12.75
Nd_2O_3	0.15	0.16	0.16	0.16	0.15	0.17	NC	§	0.12	0.10	0.08
NiO	0.17	0.22	0.21	0.18	0.18	0.18	NC	0.41	0.24	0.27	0.28
P_2O_5	0.09	0.10	0.10	0.11	0.12	0.11	NC	0.56	0.24	0.31	0.37
PbO	0.14	0.10	0.11	0.10	0.11	0.11	NC	0.54	0.20	0.24	0.28
Sb_2O_3	0.26	0.23	0.25	0.25	0.26	0.27	NC	§	0.24	0.18	0.14
SeO_2	0.37	0.10	0.11	0.10	0.10	0.12	NC	§	<0.01	<0.01	<0.01
SiO_2	47.01	47.10	46.79	47.42	47.22	47.14	0.18	47.75	47.57	47.68	47.48
SnO_2	§	<0.01	<0.01	<0.01	<0.01	<0.01	NC	0.06	0.02	0.03	0.04
SO_3	§	0.08	0.08	0.09	0.09	0.09	NC	0.19	0.06	0.09	0.12
SrO	0.92	0.65	0.72	0.69	0.71	0.76	NC	0.17	0.64	0.53	0.45
TiO_2	0.14	0.17	0.18	0.18	0.18	0.19	NC	§	0.16	0.14	0.13
ZnO	2.07	1.78	1.84	1.74	1.73	1.82	-11.94	1.03	1.65	1.48	1.30
ZrO_2	0.26	0.80	0.73	0.60	0.54	0.52	NC	0.98	0.77	0.86	0.90
Sum	100.00	100.00	100.00	100.00	100.00	100.00	NC	100.00	100.00	100.00	100.00

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field
NC – Not calculated

Table 6.2. XRF Analyzed Compositions for Glass Discharged from DM1200 (wt%), (continued).

Test	2B								
Waste	High Waste Loading C-106/AY-102								
Glass (kg)	-	18227	18751	19264	19787	20302	20821	21333	21333
Constituent	Target	1Y2-G-53B	1Y2-G-73A	1Y2-G-89A	1Y2-G-111A	1Y2-G-122A	1Y2-G-139B	1Y2-G-147A	%Dev.
Al_2O_3	4.89	5.37	5.40	6.15	5.83	5.52	5.64	5.53	13.09
As_2O_3	§	0.06	0.04	0.04	0.03	0.02	0.02	0.01	NC
B_2O_3*	10.27	10.04	10.10	10.14	10.17	10.19	10.21	10.22	NC
BaO	0.07	0.04	0.06	0.07	0.07	0.07	0.07	0.08	NC
CaO	0.46	0.48	0.48	0.51	0.52	0.52	0.51	0.53	NC
CdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
Ce_2O_3	0.10	0.05	0.06	0.06	0.07	0.08	0.08	0.08	NC
Cl	§	0.01	0.01	0.01	0.01	<0.01	0.01	0.01	NC
Cr_2O_3	0.22	0.19	0.19	0.20	0.22	0.22	0.22	0.23	NC
Cs_2O	§	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	NC
CuO	§	0.02	0.01	0.01	0.01	0.01	<0.01	0.01	NC
Fe_2O_3	14.03	12.60	12.44	13.04	13.27	13.11	12.75	13.42	-4.34
K_2O	§	0.13	0.13	0.15	0.13	0.12	0.16	0.12	NC
La_2O_3	0.08	0.11	0.09	0.06	0.06	0.05	0.04	0.03	NC
Li2O*	2.64	2.77	2.74	2.72	2.70	2.69	2.67	2.67	NC
MgO	0.14	0.55	0.41	0.35	0.33	0.29	0.27	0.28	NC
MnO	2.82	3.14	2.99	3.11	3.09	3.03	2.89	2.95	4.73
Na_2O	12.55	12.75	13.11	12.61	12.48	12.96	12.84	12.77	1.78
Nd_2O_3	§	0.06	0.04	0.04	0.03	0.02	0.02	0.01	NC
NiO	0.41	0.30	0.30	0.34	0.35	0.35	0.35	0.38	NC
P_2O_5	0.56	0.43	0.47	0.48	0.53	0.56	0.56	0.57	NC
PbO	0.54	0.31	0.33	0.38	0.07	0.42	0.40	0.44	NC
Sb_2O_3	§	0.09	0.08	0.07	0.06	0.04	0.03	0.02	NC
SeO_2	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
SiO_2	47.75	47.63	47.77	46.59	46.76	46.95	47.65	46.85	-1.88
SnO_2	0.06	0.05	0.06	0.06	0.06	0.07	0.07	0.07	NC
SO_3	0.19	0.14	0.14	0.14	0.16	0.15	0.15	0.17	NC
SrO	0.17	0.38	0.33	0.31	0.29	0.26	0.22	0.23	NC
TiO_2	§	0.11	0.09	0.11	0.09	0.08	0.07	0.08	NC
ZnO	1.03	1.22	1.12	1.14	1.11	1.04	0.96	0.99	-3.69
ZrO_2	0.98	0.94	0.98	1.10	1.17	1.17	1.13	1.24	NC
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	NC

* Target values calculated based on simple well-stirred tank model
§ - Not a target constituent
"-" Empty data field
NC – Not calculated

Table 6.3. XRF and DCP Analysis of Major and Minor Oxides of Selected Glass Samples (wt%).

Waste	AZ-102										C-106/AY-102					
Test	1A			1B							2A			2B		
Glass (kg)	-	5397		-	9956		10464		10973		-	16165		-	21333	
Constituent	Target	1V2-G-23B		Target	1W2-G-36B		1W2-G-58A		1W2-G-75B		Target	1X2-G-102A		Target	1Y2-G-147A	
		XRF	DCP		XRF	DCP	XRF	DCP	XRF	DCP		XRF	DCP		XRF	DCP
Al_2O_3	5.60	5.70	5.50	5.60	5.87	5.41	5.99	5.55	5.91	5.57	5.31	5.43	5.06	4.89	5.53	4.60
B_2O_3	12.48	12.48	12.67	12.52	12.52	12.12	12.52	12.16	12.52	11.97	9.60	9.60	9.69	10.22	10.22	10.12
Fe_2O_3	12.56	11.71	11.35	12.56	11.88	11.74	11.35	12.00	12.05	12.05	12.63	12.29	11.52	14.03	13.42	12.03
Li_2O	3.28	3.28	2.85	3.26	3.26	2.82	3.26	2.89	3.26	2.89	3.03	3.03	3.20	2.67	2.67	2.78
MgO	0.07	0.12	0.23	0.07	0.13	0.21	0.09	0.21	0.13	0.21	1.17	1.00	1.16	0.14	0.28	0.33
MnO	0.36	0.35	0.37	0.36	0.38	0.37	0.35	0.37	0.38	0.36	4.01	3.66	3.10	2.82	2.95	2.41
Na_2O	12.02	13.27	10.01	12.02	12.60	10.25	12.71	10.26	12.67	10.24	11.84	12.28	9.92	12.55	12.77	10.01
SiO_2	48.26	47.05	46.26	48.26	47.34	47.48	48.12	47.32	47.00	47.34	47.05	47.14	45.92	47.75	46.85	46.93
ZnO	2.01	1.71	1.82	2.01	1.76	1.77	1.64	1.77	1.79	1.76	2.07	1.82	1.78	1.03	0.99	0.96
ZrO_2	1.78	2.38	2.33	1.78	2.29	2.11	2.09	2.12	2.30	2.11	0.26	0.52	0.54	0.98	1.24	1.20
Sum	98.42	98.05	93.39	98.44	98.03	94.28	98.12	94.65	98.01	94.50	96.97	96.77	91.89	97.08	96.92	91.37

"-" Empty data field

Note: for XRF-analyzed compositions, target values for B_2O_3 and Li_2O were used which were calculated based on a simple well-stirred tank model.

Table 6.4. Measured Iron Oxidation State of Select Glass Samples.

Test	Waste	Date	Time	Sample I.D.	Cum. Glass (kg)	% Fe^{+2}/Total Fe
1A	AZ-102	06/25/04	13:54	1V2-G-23B	5397	6.4
1B		06/30/04	14:21	1W2-G-75B	10973	3.1
2A	C-106/AY-102	08/07/04	07:25	1X2-G-102A	16165	0.4
2B		11/12/04	20:34	1Y2-G-147A	21333	<0.3

Table 6.5. Examination Results of Optical Microscopy on Riser Glass Samples after Processing the High Waste Loading, C-106/AY-102 Formulation.

Sampling Date/Time		Idling (Days)	Sampling Point	Temperature at Sampling Point	Name	Crystalline Phases
11/15/04	10:35	2.4	First 5 kg of discharge	930-965°C	1Z2-N-13A	None observed
			Second 5 kg of discharge	804-930°C	1Z2-N-13B	None observed
			Third 5 kg of discharge	804-1087°C	1Z2-N-13C	None observed
02/22/05	16:39	72.0#	First 5 kg of discharge	930-965°C	N-12C-34A	None observed
			Second 5 kg of discharge	804-930°C	N-12C-34B	None observed

NE – Not Examined
Idling time after processing HLW MACT feed [45].

Table 7.1. Results from Melter Emissions Sampling for Test 1A (Adjusted Rheology AZ-102 Feed).

		-	Melter Emissions Rate (mg/min)					
		% Isokinetic	94.7	82.1	95.5	Average Rate	% Feed	DF
		% Moisture	29.6	30.5	28.1			
		Feed Rate (mg/min)	06/23/04 12:55 – 13:55	6/23/04 14:39 – 15:19	06/23/04 16:20 – 17:10			
Particulate	Total[$]	1187988	8372	9938	9307	9206	0.77	129
	Al	33328	173.12	214.85	197.10	195.02	0.59	170.9
	B	43712	572.30	664.10	607.43	614.61	1.41	71.1
	Ca	1850	26.27	28.61	27.48	27.45	1.48	67.4
	Cd	1108	12.43	7.19	13.13	10.92	0.99	101.5
	Cs	531	15.06	17.69	15.68	16.14	3.04	32.9
	Fe	98804	911.70	1045.38	1009.01	988.70	1.00	99.9
	K	280	9.72	11.25	9.90	10.29	3.68	27.2
	Li	17036	83.26	93.46	86.92	87.88	0.52	193.9
	Mg	475	14.29	15.53	15.05	14.96	3.15	31.8
	Mn	3137	11.09	13.50	13.55	12.71	0.41	246.7
	Na	100328	974.58	1089.96	1014.10	1026.21	1.02	97.8
	Ni	3978	22.27	28.70	28.25	26.41	0.66	150.6
	P	147	1.33	1.23	1.70	1.42	0.97	103.5
	Pb	731	7.49	8.68	8.52	8.23	1.13	88.8
	S	180	95.38	84.15	88.57	89.37	49.65	2.0
	Si	253799	871.13	1189.26	1069.63	1043.34	0.41	243.3
	Zn	18167	155.00	183.92	162.97	167.30	0.92	108.6
	Zr	14825	59.01	80.25	94.02	77.76	0.52	190.7
Gas	B	43712	260.14	284.90	273.85	272.96	0.62	160.1
	S	180	65.23	73.35	71.87	70.15	38.97	2.6

[$] - From gravimetric analysis of filters and rinse dry downs

Table 7.2. Results from Melter Emissions Sampling for Test 2A (Adjusted Rheology C-106/AY-102 Feed).

		-	Melter Emissions Rate (mg/min)					
		% Isokinetic	97.4	86.9	94.3	Average Rate	% Feed	DF
		% Moisture	25.8	25.4	25.4			
		Feed Rate (mg/min)	08/05/04 15:00 – 15:21	08/05/04 17:08 – 17:22	08/06/04 11:27 – 11:42			
Particulate	Total[$]	992352	7840	7824	6767	7477	0.75	133
	Al	23643	91.94	95.27	85.22	90.81	0.38	260.4
	As	1211	24.81	NA	23.98	24.40	2.01	49.6
	B	24527	220.54	268.75	192.15	227.15	0.93	108.0
	Ca	1805	22.34	21.79	18.26	20.80	1.15	86.8
	Cl	926	165.43	202.94	181.23	183.2	19.78	5.1
	Cr	461	5.65	5.20	4.42	5.09	1.10	90.6
	Cs	397	38.95	18.05	11.30	22.77	5.73	17.4
	Cu	269	2.76	1.69	1.78	2.08	0.77	129.5
	Fe	74332	563.14	611.51	513.87	562.84	0.76	132.1
	Li	11768	47.71	51.12	45.65	48.16	0.41	244.4
	Mg	5938	45.95	43.08	43.35	44.13	0.74	134.6
	Mn	26139	81.30	46.51	53.66	60.49	0.23	432.1
	Na	73936	631.18	642.27	549.60	607.68	0.82	121.7
	Ni	1124	7.97	11.22	7.88	9.02	0.80	124.6
	P	331	5.15	6.45	6.25	5.95	1.80	55.6
	Pb	1094	8.27	6.76	6.69	7.24	0.66	151.1
	S	0	55.17	28.69	28.69	37.52	NC	NC
	Sb	1829	7.04	36.59	4.02	15.88	0.87	115.2
	Se	2216	1186.67	1100.62	946.88	1078.06	48.65	2.1
	Si	185118	692.64	647.39	601.20	647.08	0.35	286.1
	Sr	6548	52.66	48.29	49.38	50.11	0.77	130.7
	Ti	706	9.33	8.92	8.25	8.83	1.25	79.9
	Zn	13997	105.48	113.39	96.64	105.17	0.75	133.1
	Zr	1620	7.96	12.19	6.88	9.01	0.56	179.8
Gas	B	24527	194.41	197.46	145.88	179.25	0.73	136.8
	Cl	926	171.36	92.70	79.29	114.45	12.36	8.1
	F	0	0.87	1.54	0.67	1.03	NC	NC
	I	842	666.97	657.47	580.16	634.87	75.40	1.3
	S	0	16.22	18.16	18.25	17.54	NC	NC
	Se	2216	50.29	9.13	18.59	26.00	1.17	85.2

$ - From gravimetric analysis of filters and front-half nitric acid analytical results
NA – Not Analyzed
NC – Not Calculated

Table 7.3. Average Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy, AZ-102 Tests.

-	Melter Outlet			SBS Outlet			WESP Outlet		
Test	**1A1**	**1A2**	**1B**	**1A1**	**1A2**	**1B**	**1A1**	**1A2**	**1B**
N_2O	2.5	2.2	1.6	3.4	3.2	2.3	3.6	2.9	2.2
NO	200	180	140	260	250	210	260	220	200
NO_2	3.6	4.7	6.1	10	4.8	6.9	16	12	14
NH_3	< 1.0	< 1.0	< 1.0	< 1.0	1.2	< 1.0	< 1.0	1.4	< 1.0
H_2O [%]	28	28	31	11	11	11	10	10	10
CO_2	6200	5100	5000	8200	7600	6800	8500	7100	6600
HNO_2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
HNO_3	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
HCN	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
SO_2	2.1	1.2	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
acetonitrile	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
acrylonitrile	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
CO	8.1	5.2	2.9	12	8.7	5.5	12	8.1	5.1
HCl	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
HF	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Table 7.4. Range of Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy, AZ-102 Tests.

-	Melter Outlet			SBS Outlet			WESP Outlet		
Test	**1A1**	**1A2**	**1B**	**1A1**	**1A2**	**1B**	**1A1**	**1A2**	**1B**
N_2O	1.7 – 3.9	1.6 – 3.0	< 1.0 – 2.9	1.4 – 5.6	1.7 – 4.6	< 1.0 – 3.5	2.7 – 5.3	1.4 – 4.0	< 1.0 – 3.0
NO	74 – 370	100 – 290	5.8 – 260	94 – 480	94 – 410	52 – 290	160 – 440	71 – 370	8.1 – 300
NO_2	< 1.0 – 8.6	1.7 – 9.1	< 1.0 – 13	1.7 – 31	1.8 – 11	1.5 – 13	7.4 – 33	2.1 – 25	2.3 – 24
NH_3	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0 – 1.7	< 1.0	< 1.0 – 1.3	< 1.0 – 1.8	< 1.0
H_2O [%]	12 – 54	18 – 43	18 – 50	4.7 – 13	8.7 – 13	9.7 – 12	5.8 – 13	8.4 – 12	6.6 – 12
CO_2	10 – 14000	200 – 11000	50 – 10000	3500 – 14000	4100 – 11000	3200 – 9300	6000 – 14000	3700 – 11000	2000 – 9200
HNO_2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
HNO_3	< 1.0	< 1.0 – 1.0	< 1.0 – 1.2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
HCN	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
SO_2	< 1.0 – 5.5	< 1.0 – 3.6	< 1.0	< 1.0 – 2.6	< 1.0 – 2.3	< 1.0	< 1.0	< 1.0 – 1.7	< 1.0
acetonitrile	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
acrylonitrile	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
CO	1.5 – 19	< 1.0 – 9.8	< 1.0 – 6.7	3.9 – 26	3.4 – 16	< 1.0 – 9.9	5.2 – 24	1.6 – 17	< 1.0 – 10
HCl	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
HF	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Table 7.5. Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy, Viscous C-106/AY-102 Test (Test 2A).

-	Melter Outlet		SBS Outlet		WESP Outlet	
	Avg.	Range	Avg.	Range	Avg.	Range
N_2O	< 1.0	NA	< 1.0	< 1.0 – 1.0	< 1.0	< 1.0 – 1.2
NO	35	4.3 – 66	43	22 – 77	42	25 – 78
NO_2	< 1.0	NA	< 1.0	NA	< 1.0	< 1.0 – 1.4
NH_3	< 1.0	NA	1.2	< 1.0 – 7.2	< 1.0	NA
H_2O [%]	16	9.5 - 26	7.0	5.5 – 8.3	6.5	4.1 – 7.9
CO_2	5100	4 – 9800	4600	2700 – 6800	4500	3000 – 7200
HNO_2	< 1.0	NA	< 1.0	NA	< 1.0	NA
HNO_3	< 1.0	NA	< 1.0	NA	< 1.0	NA
HCN	< 1.0	NA	< 1.0	NA	< 1.0	NA
SO_2	1.5	< 1.0 – 3.7	< 1.0	< 1.0 – 2.0	< 1.0	< 1.0 – 1.8
acetonitrile	< 1.0	NA	< 1.0	NA	< 1.0	NA
acrylonitrile	< 1.0	NA	< 1.0	NA	< 1.0	NA
CO	2.5	< 1.0 – 5.4	2.4	< 1.0 – 5.4	2.4	< 1.0 – 6.1
HCl	< 1.0	NA	< 1.0	NA	< 1.0	NA
HF	< 1.0	NA	< 1.0	NA	< 1.0	NA

Table 7.6. Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy, High Waste Loading C-106/AY-102 Test (Test 2B).

-	Melter outlet		SBS outlet		WESP outlet		HEPA outlet		Carbon Column outlet	
	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
N_2O	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	< 1.0 - 1.0
NO	42.0	< 1.0 -102.1	77.3	5.6 - 170.4	72.1	26.0 - 160.4	67.6	36.7 - 124.6	67.3	30.9 - 128.1
NO_2	< 1.0	NA	1.5	< 1.0 - 3.5	2.5	< 1.0 - 5.6	2.4	< 1.0 - 5.1	< 1.0	NA
NH_3	< 1.0	NA	1.6	< 1.0 - 4.2	< 1.0	NA	< 1.0	NA	< 1.0	NA
H_2O [%]	31.4	17.3 - 54.3	10.7	6.4 - 17.6	9.7	4.2 - 15.0	8.2	5.5 - 11.5	8.7	6.0 -13.5
CO_2	2400	20 - 6000	4500	20 - 8800	4200	1800 – 7600	4200	2200 – 7000	4400	2700 – 7100
Nitrous Acid	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA
Nitric Acid	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA
HCN	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA
SO_2	< 1.0	NA	< 1.0	< 1.0 - 2.1	< 1.0	< 1.0 - 1.9	< 1.0	NA	< 1.0	NA
Acetonitrile	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA
Acrylonitrile	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA
CO	4.7	< 1.0 - 9.8	9.6	1.2 - 17.5	8.6	2.6 - 17.9	8.7	2.1 - 16.6	9.9	4.2 - 18.1
HCl	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA
HF	1.0	< 1.0 - 1.5	< 1.0	NA	< 1.0	NA	< 1.0	NA	< 1.0	NA

Table 7.7. Hydrogen Concentrations [ppmv] Measured by Gas Chromatography on Tests Conducted at 65 lpm Bubbling.

Test	[7]		1A	1B	2A	[9]
Simulant	AZ-101	Diluted AZ-101	Adjusted Rheology AZ-102	Diluted AZ-102	Adjusted Rheology C-106/AY-102	C-106/AY-102
Hydrogen Concentration	13	8	18	14	8	31

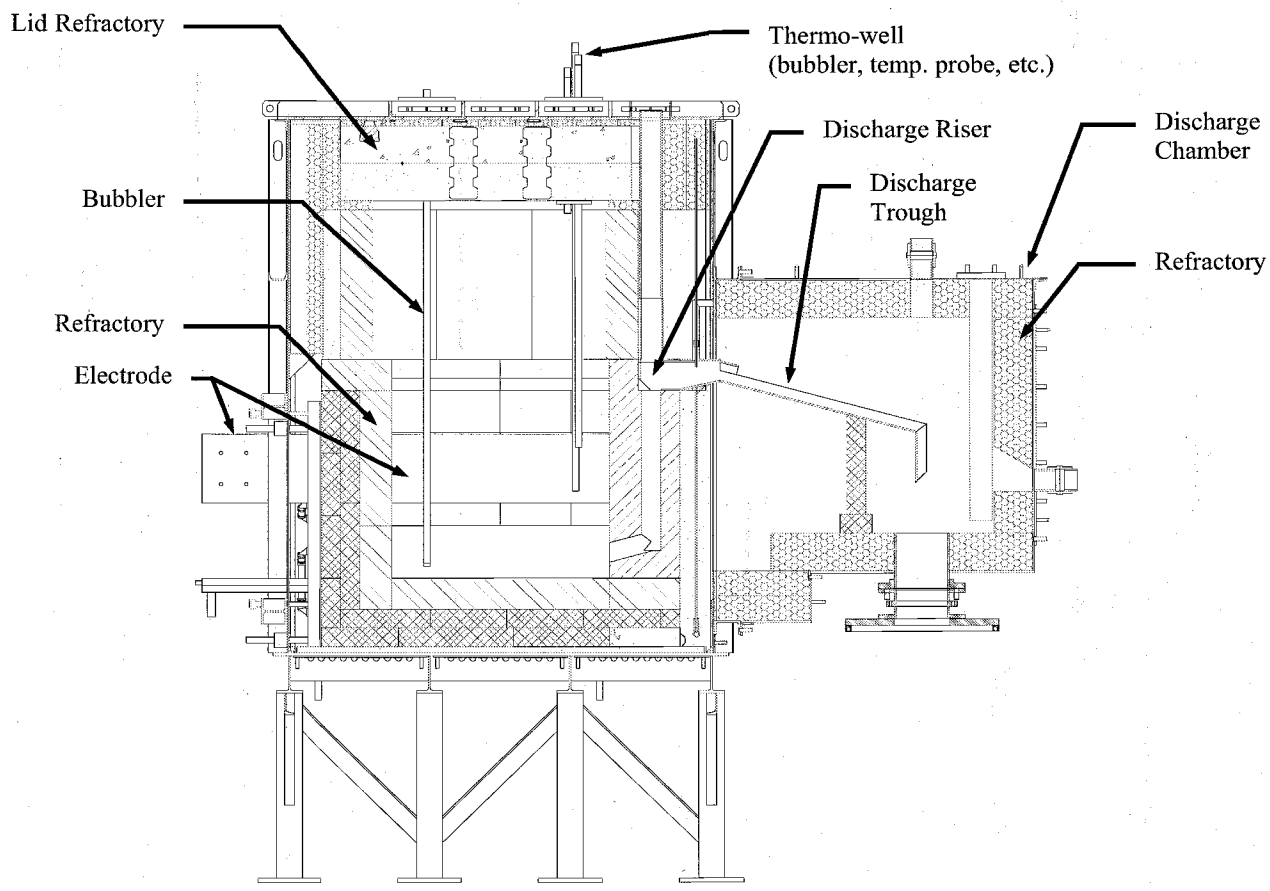

Figure 1.1. Cross-section of the DM1200 melter through the discharge chamber.

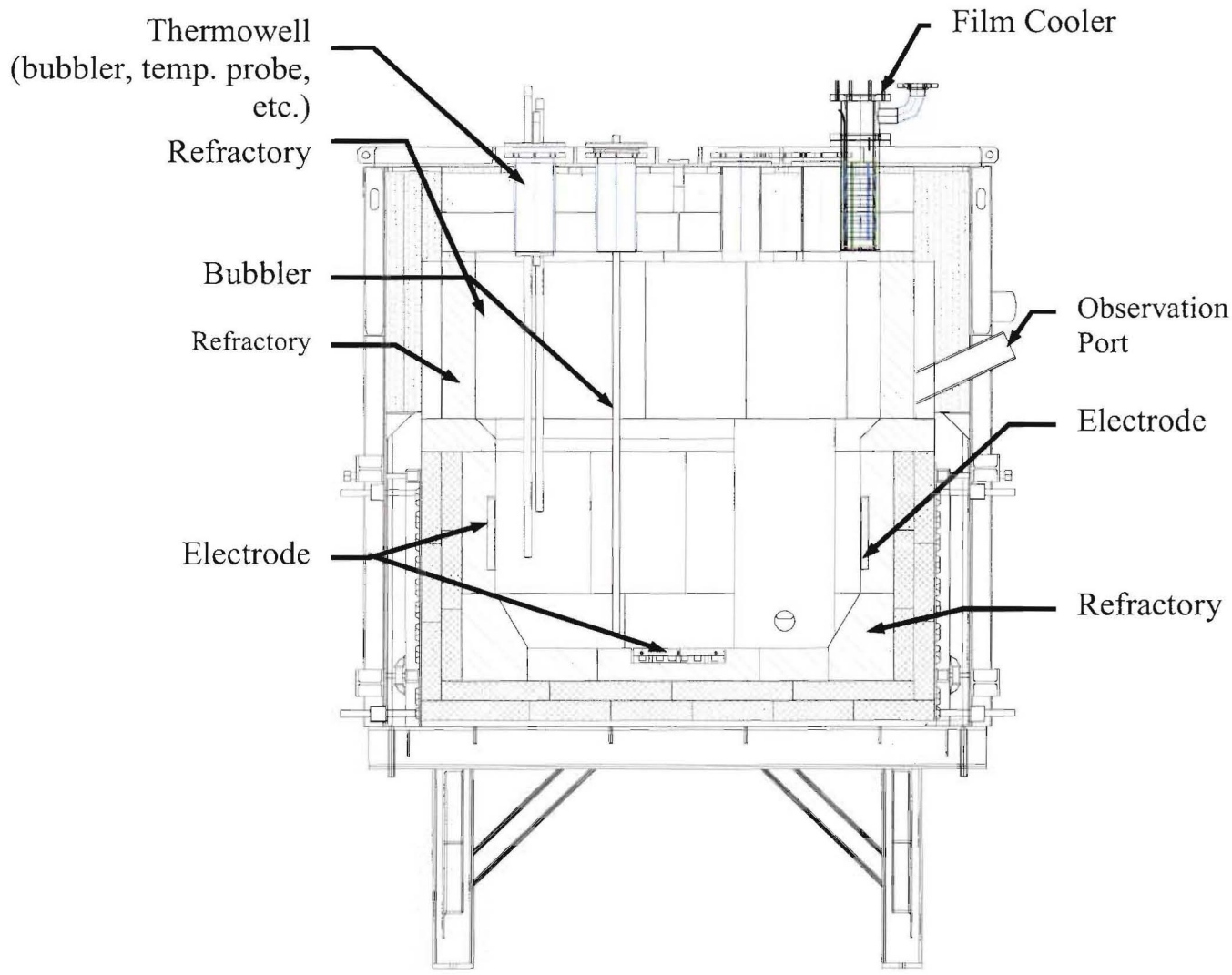

Figure 1.2. Cross-section through the DM1200 melter showing electrodes.

Figure 1.3. Single-outlet "J" bubbler.

Figure 1.4. Double-outlet "J" bubbler.

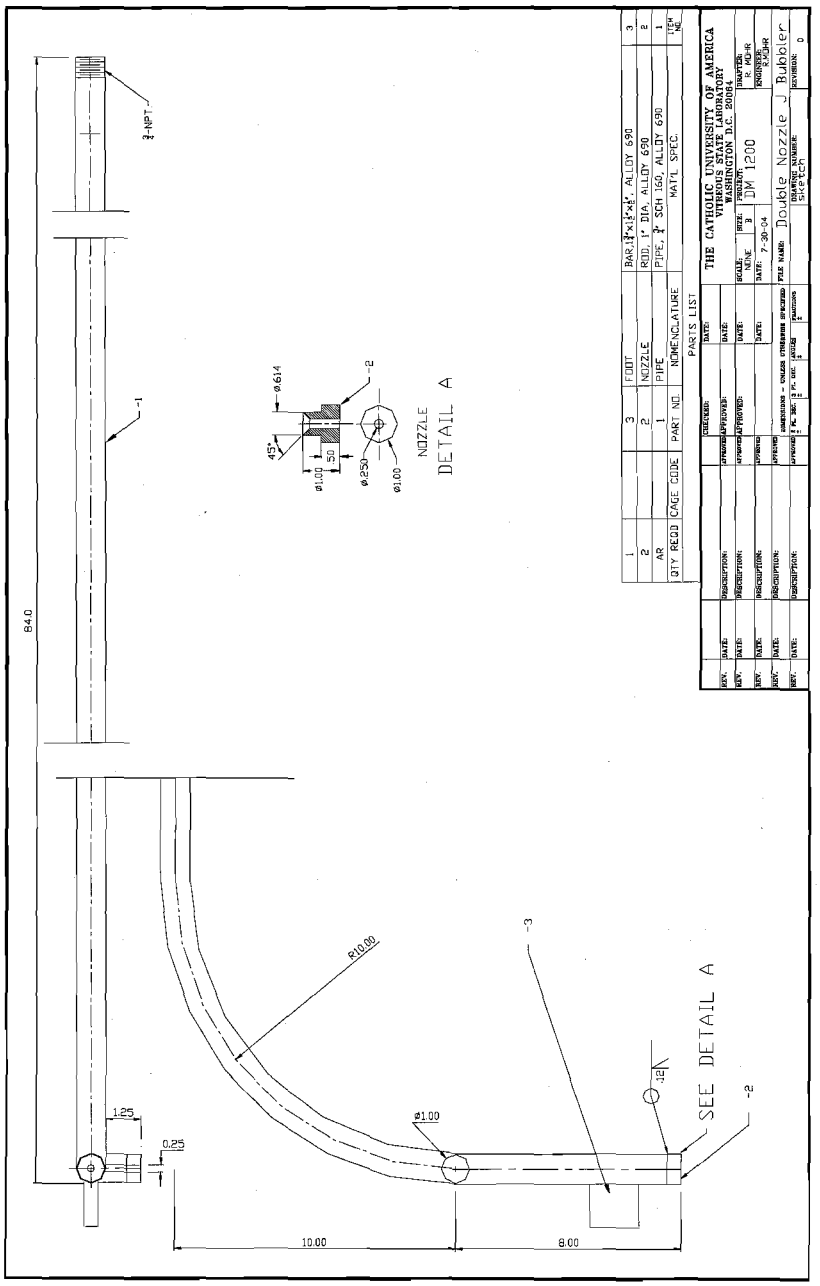

Figure 1.5. Diagram of double-outlet "J" bubbler.

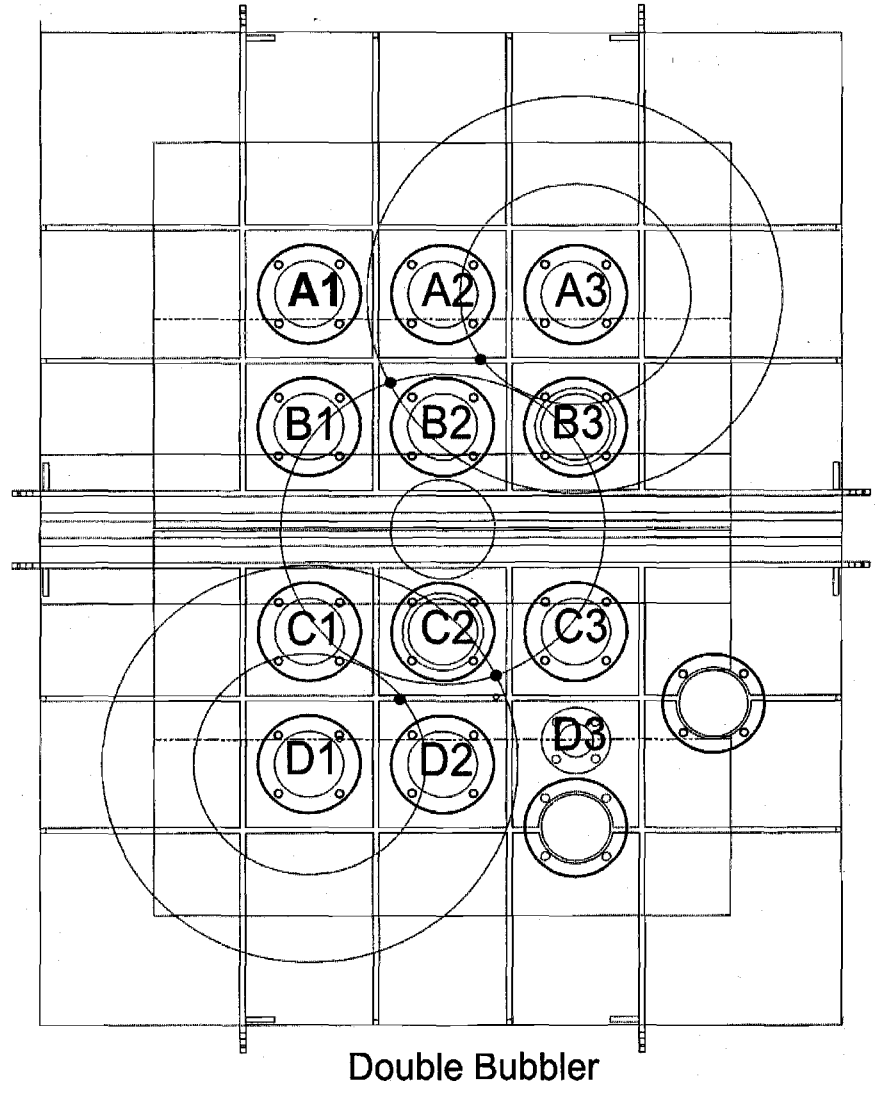

Figure 1.6. Placement of double-outlet bubblers. Note: solid circles represent location of bubbler outlet.

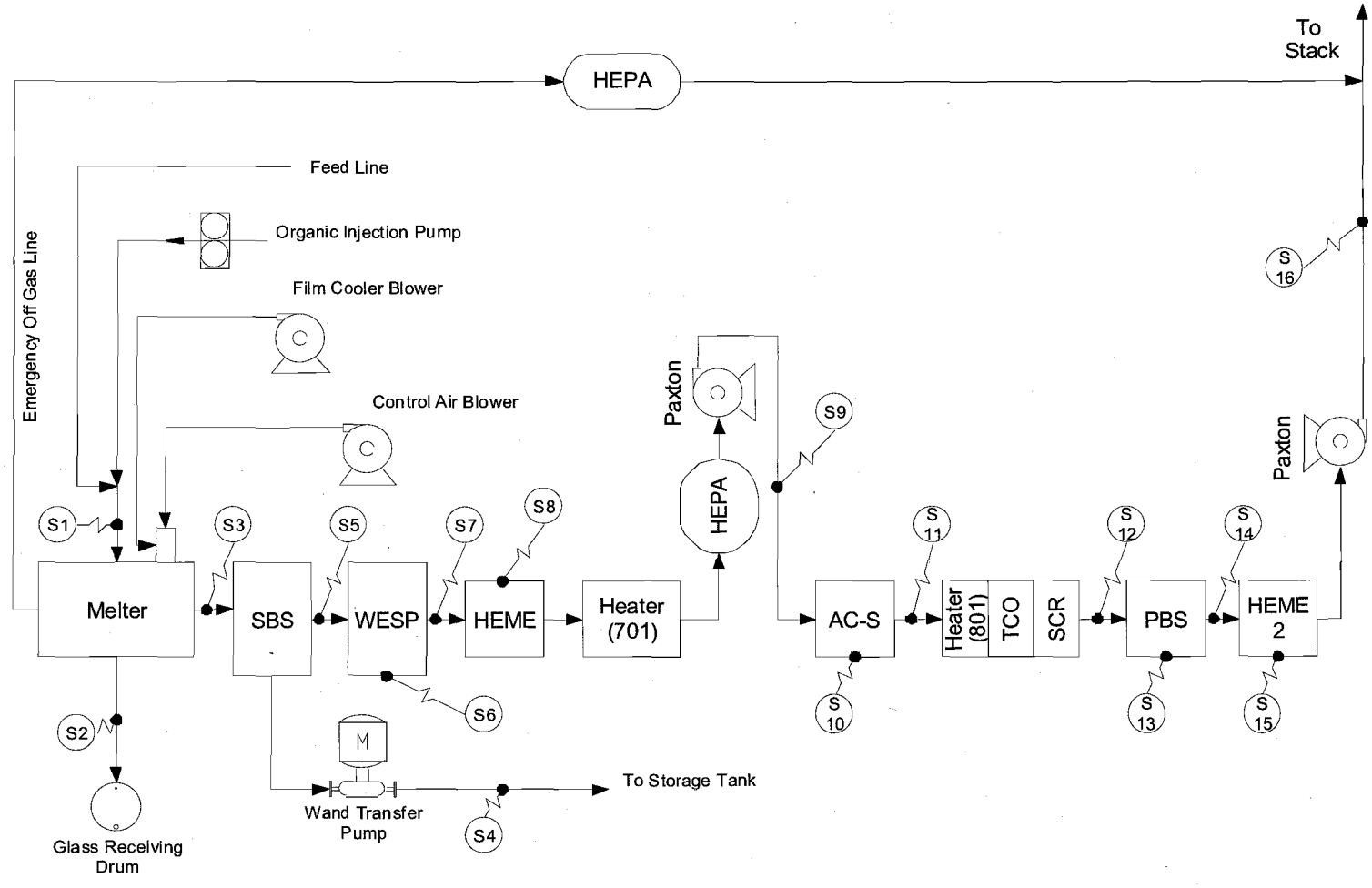

Figure 1.7. Schematic diagram of DM1200 off-gas system. "Sx" indicates sampling point.

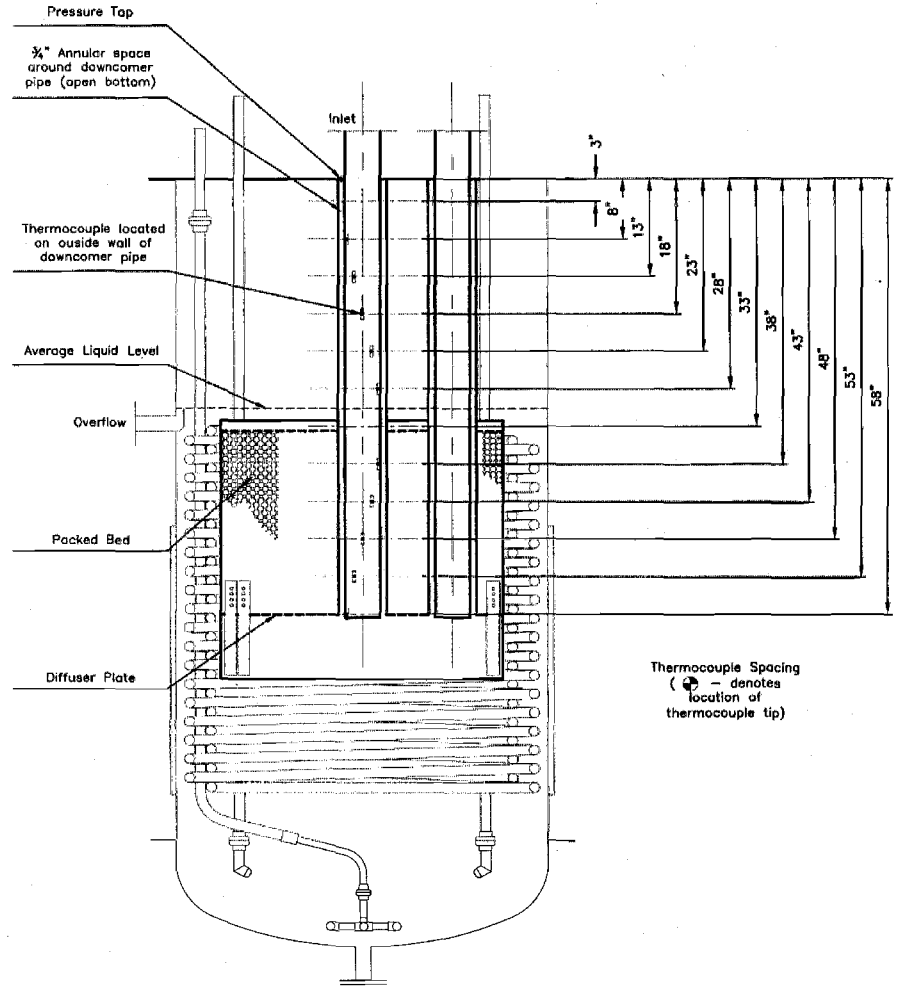

Figure 1.8. Schematic of SBS internals and monitoring points.

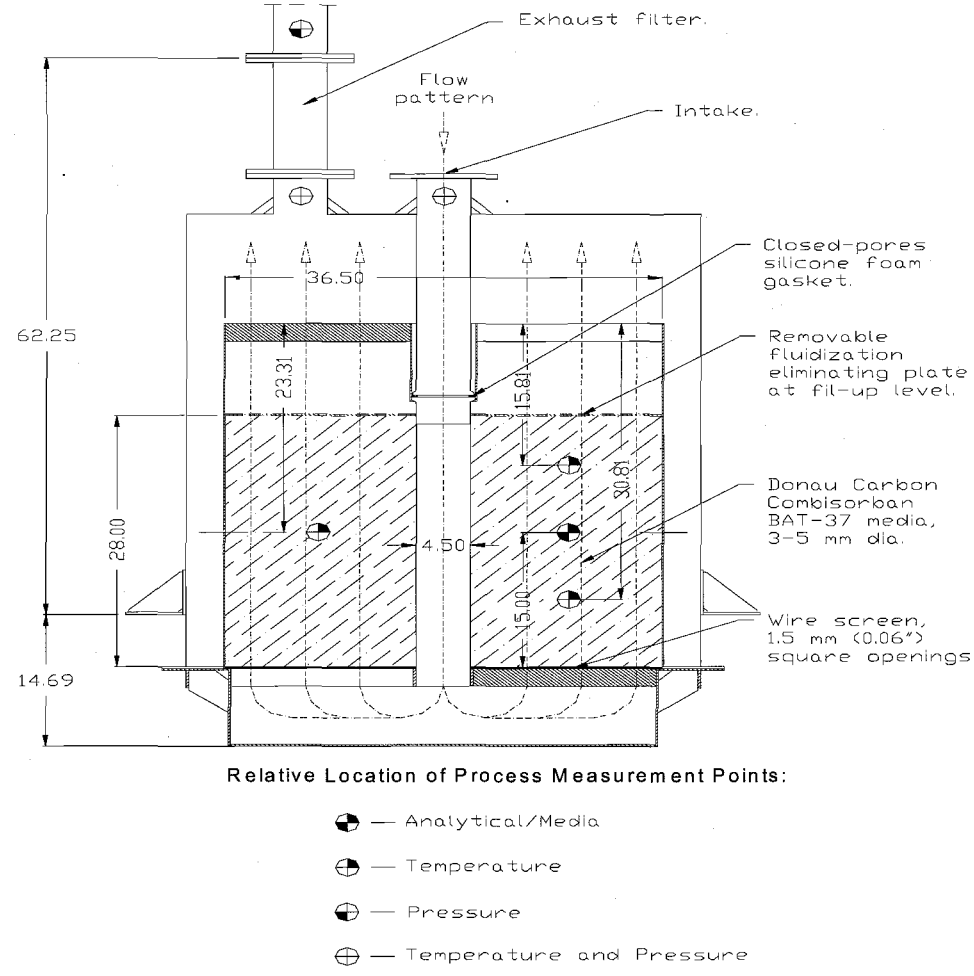

Figure. 1.9 Schematic of the AC-S bed. Exterior of the vessel is insulated to prevent heat loss (not shown). Unless otherwise indicated, dimensions are in inches.

Figure 1.10.View of the installed sulfur impregnated activated carbon bed.

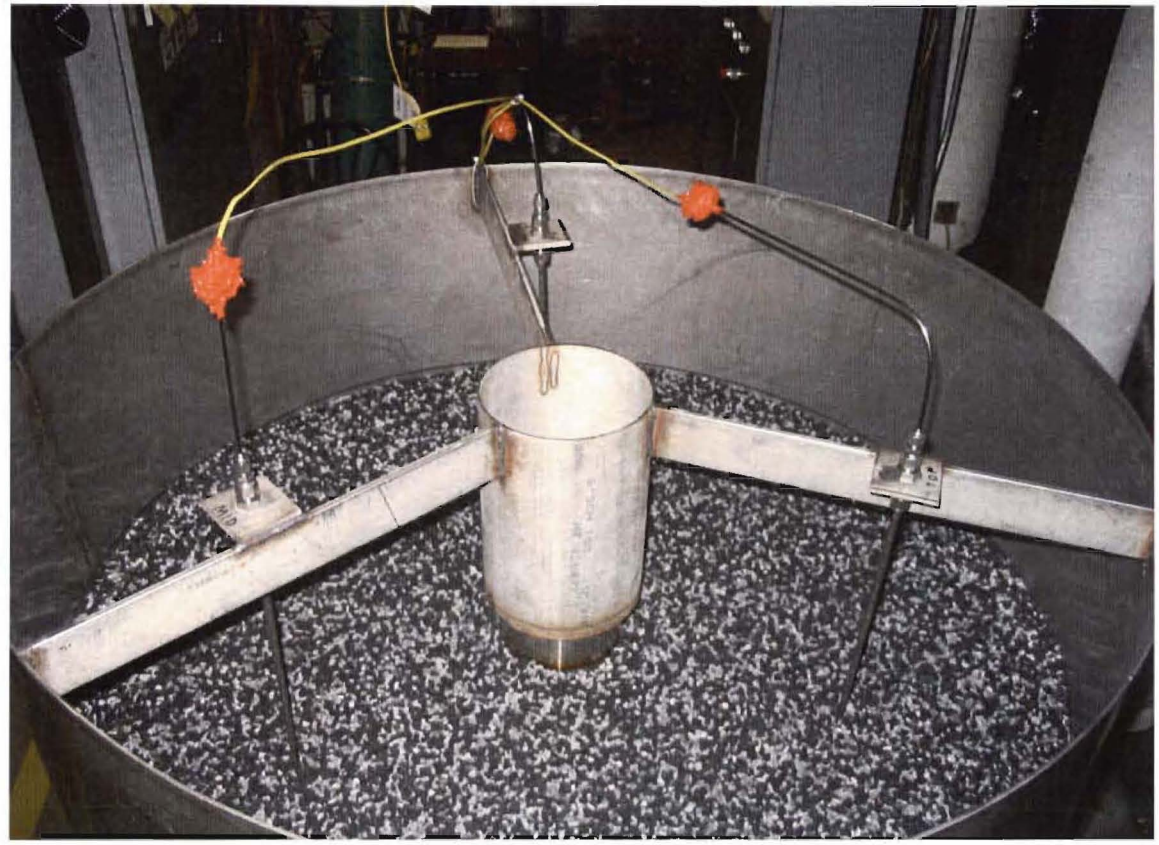

Figure 1.11. View of carbon in the bed and top, middle, and bottom thermocouples.

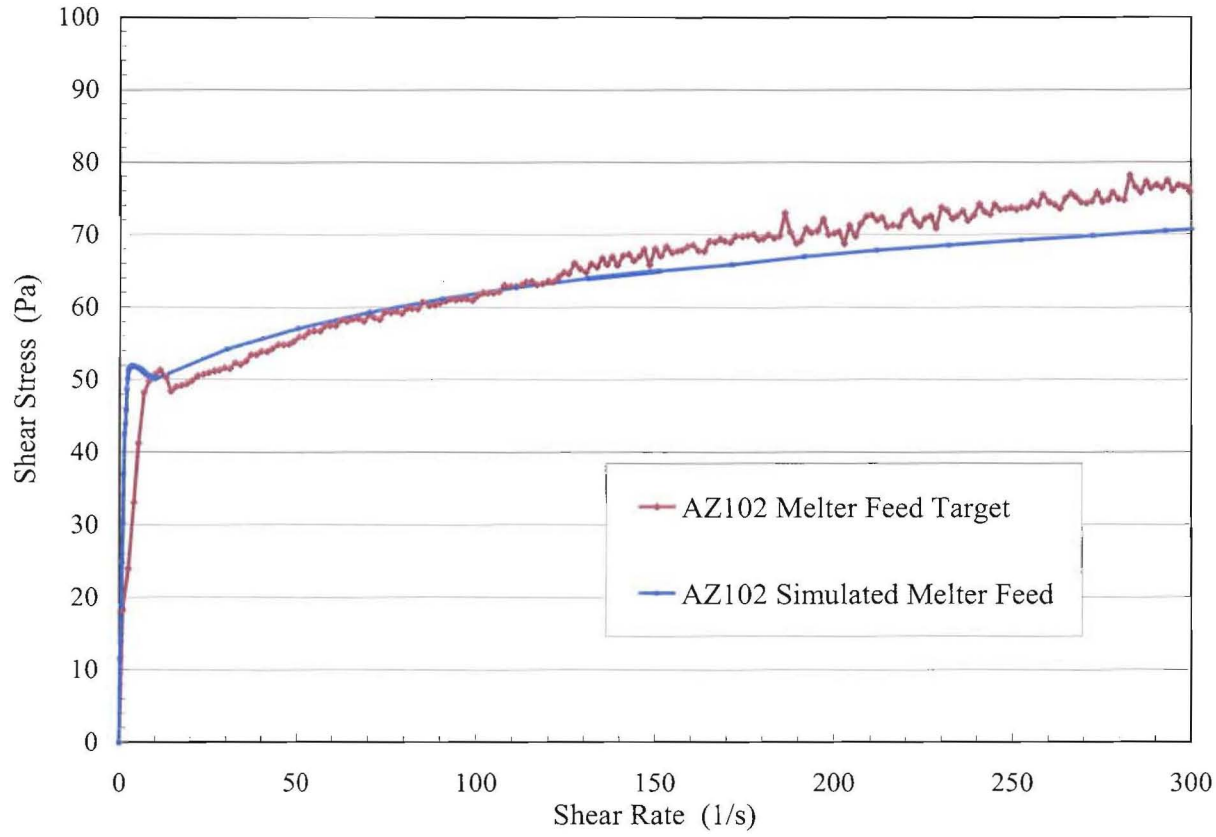

Figure 2.1. Shear stress vs. shear rate for adjusted-rheology AZ-102 simulated melter feed compared to target provided by WTP R&T.

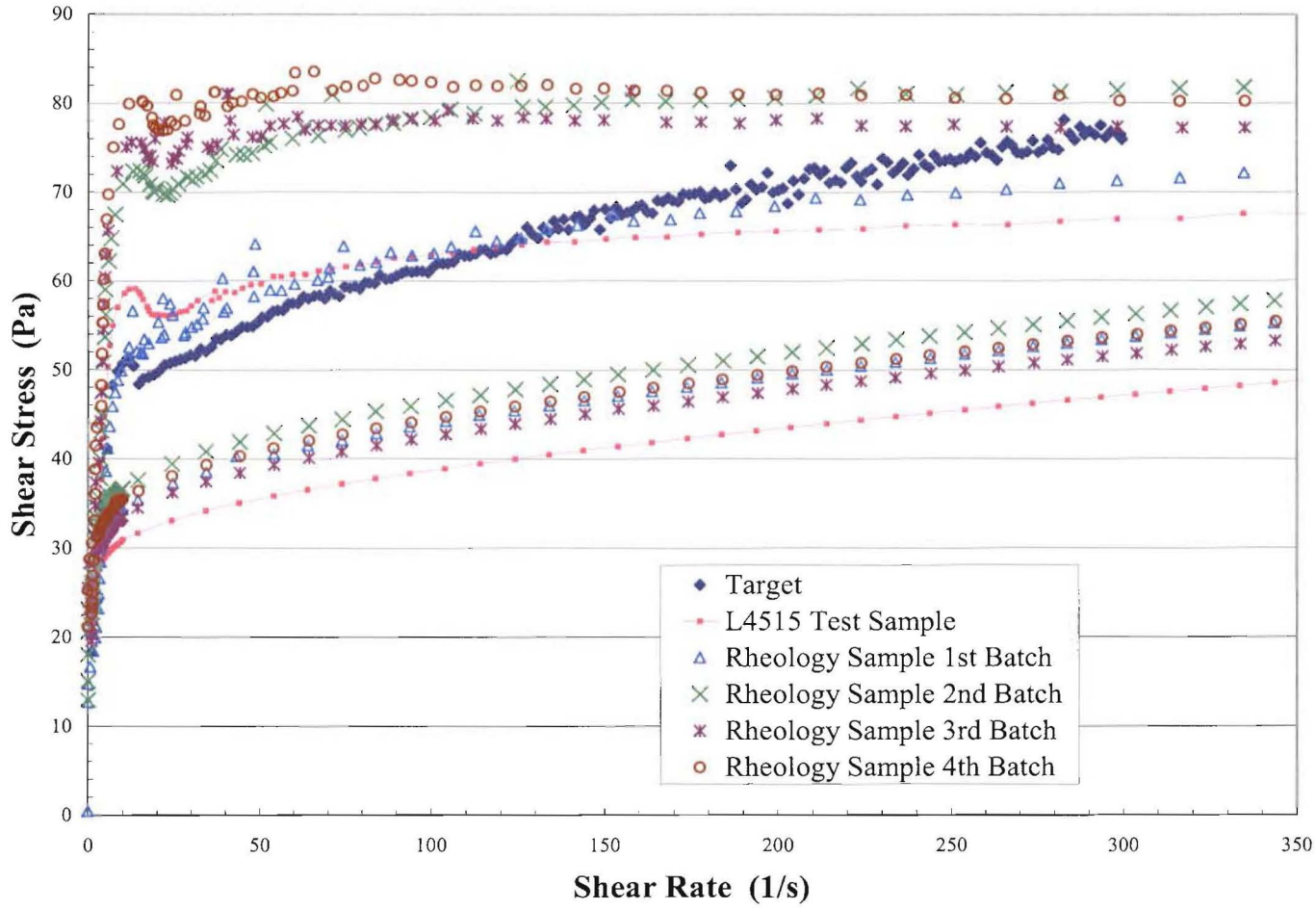

Figure 2.2. Shear stress vs. shear rate for adjusted-rheology C-106/AY-102 simulated melter feed compared to target provided by WTP R&T.

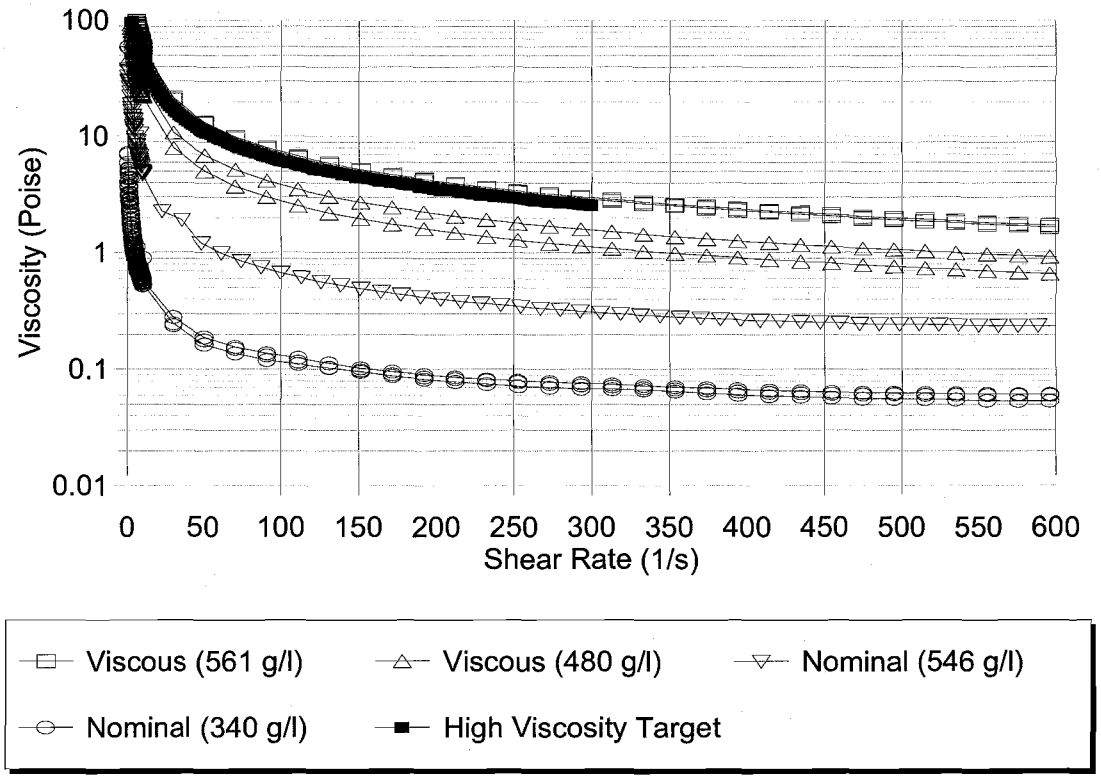

Figure 2.3. Viscosity vs. shear rate of AZ-102 melter feed samples.
Note: Nominal (546 g/l) feed results are from previous test [8].

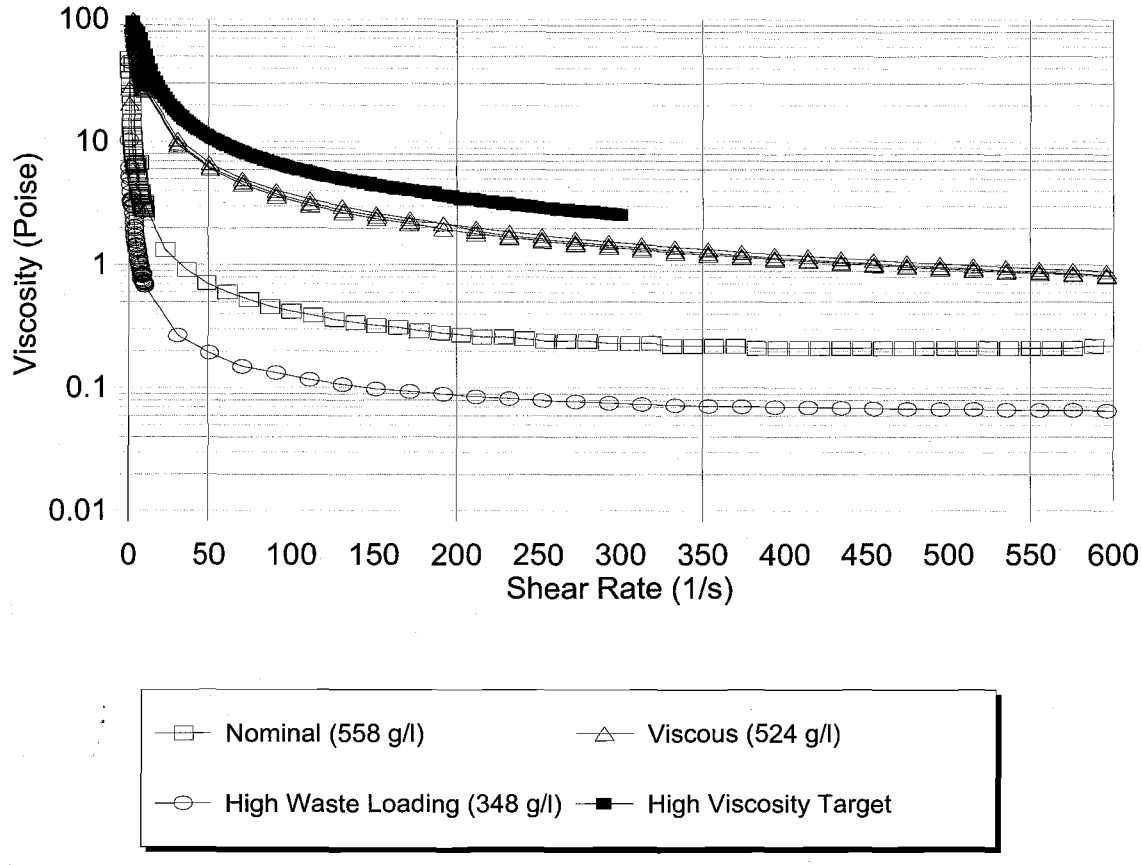

Figure 2.4. Viscosity vs. shear rate of C-106/AY-102 melter feed samples.
Note: Nominal (558 g/l) feed results are from previous test [9]

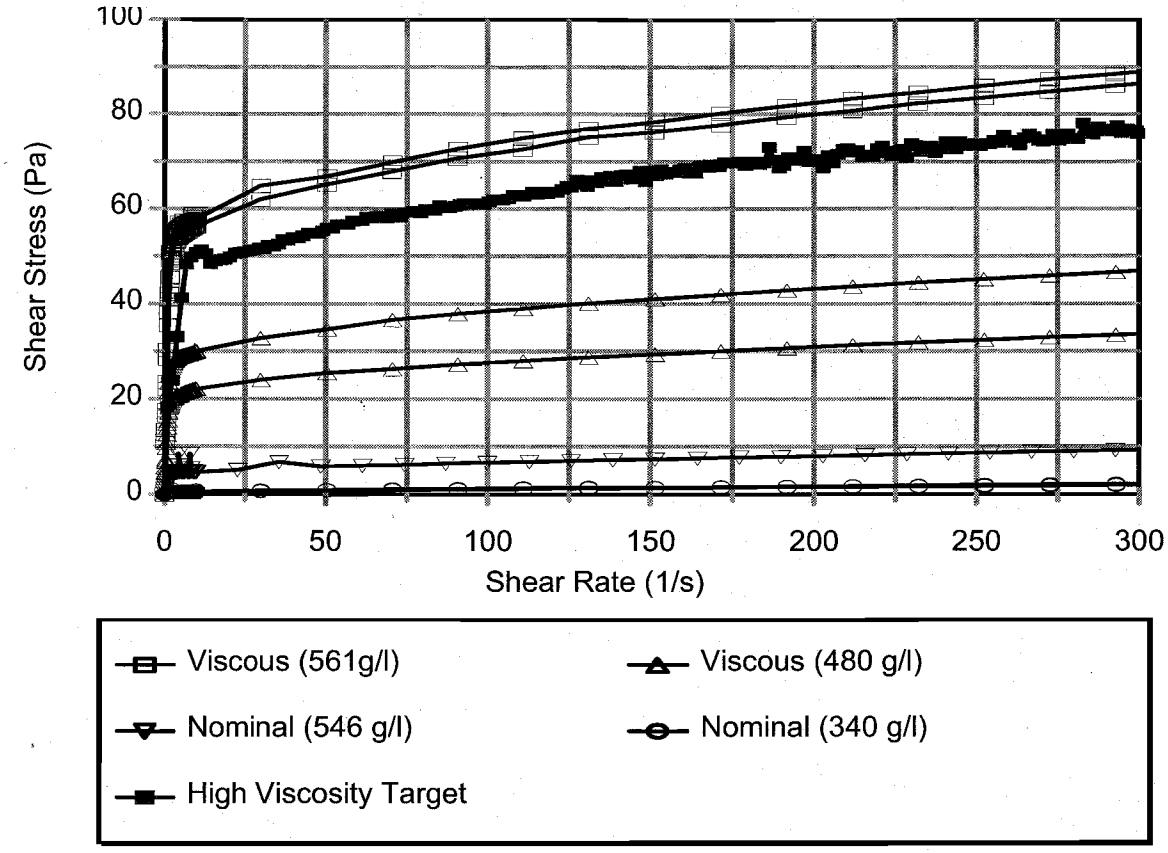

Figure 2.5. Shear stress vs. shear rate of AZ-102 melter feed samples.
Note: Nominal (546 g/l) feed results are from previous test [8]

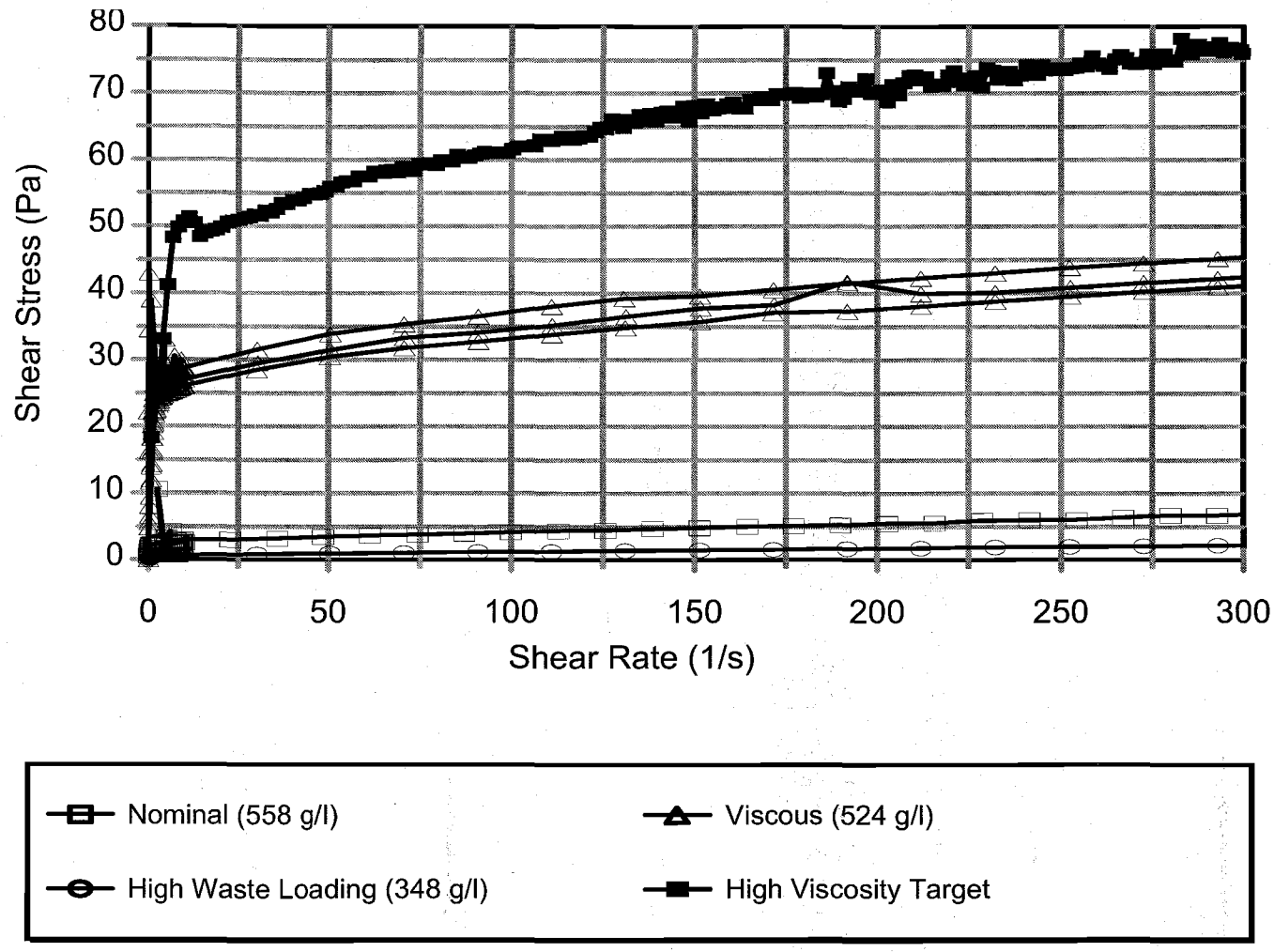

Figure 2.6. Shear stress vs. shear rate of C-106/AY-102 melter feed samples.
Note: Nominal (558 g/l) feed results are from previous test [9]

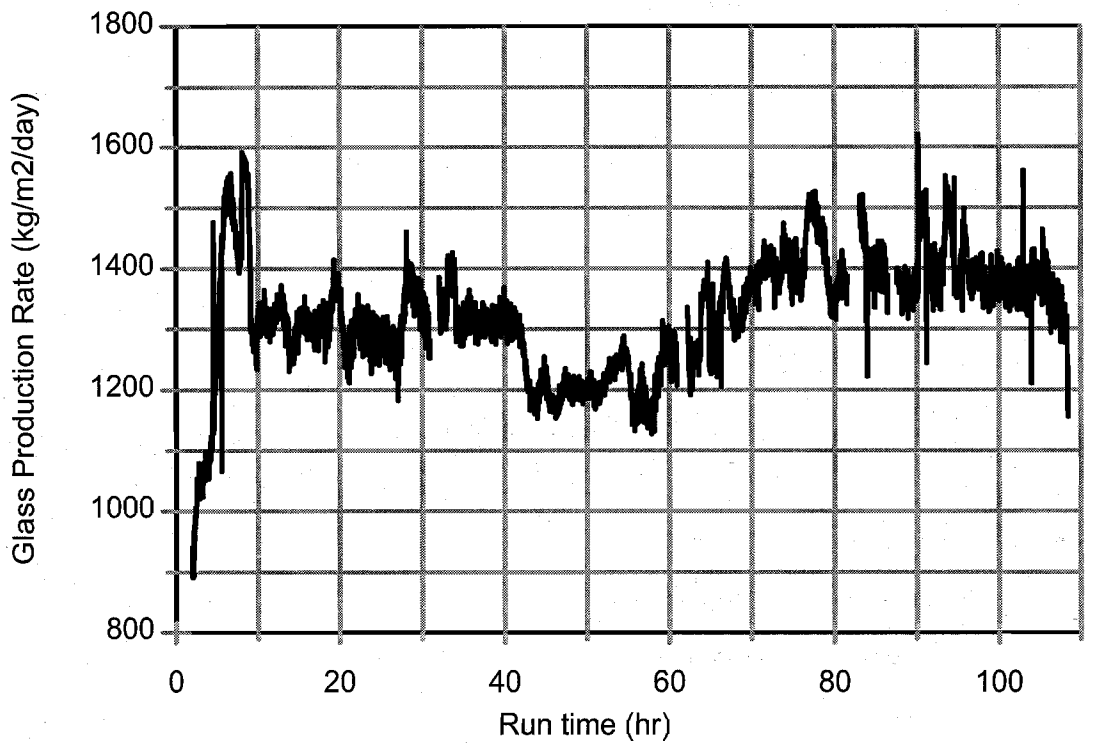

Figure 3.1.a. Production rates (hourly moving average) for AZ-102 DM100 tests.

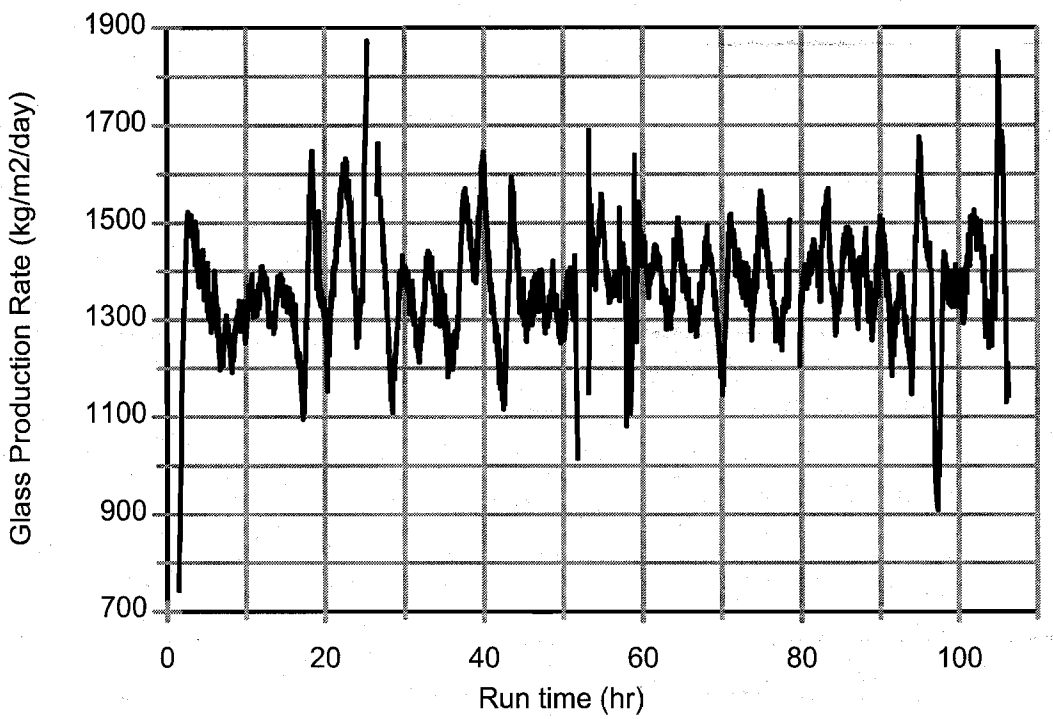

Figure 3.1.b. Production rate (hourly moving average) for the high waste loading C-106/AY-102 DM100 test.

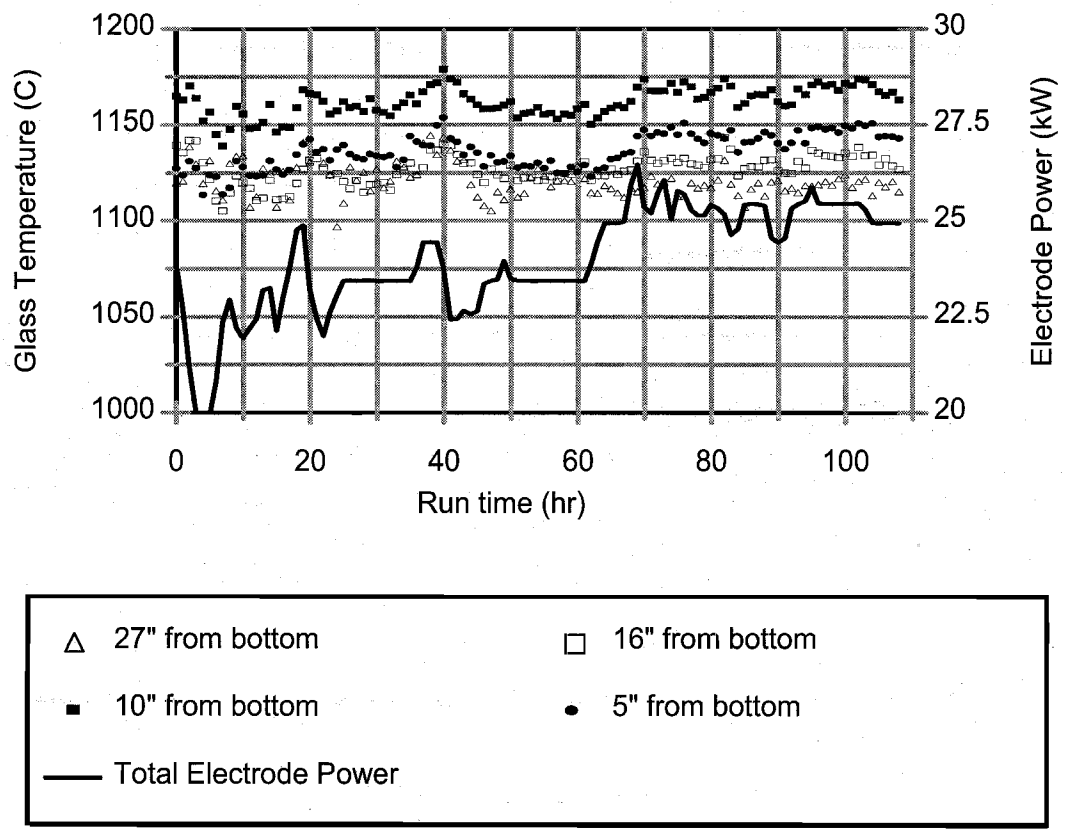

Figure 3.2.a Glass temperatures and electrode power for AZ-102 DM100 tests.

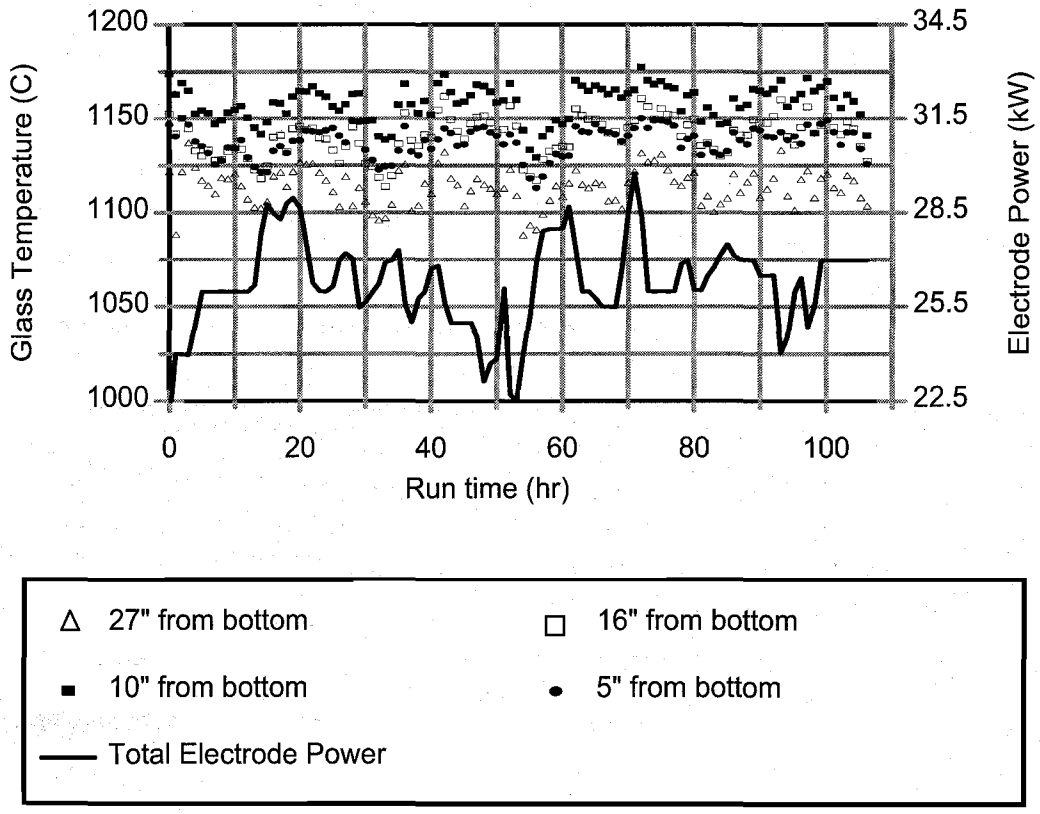

Figure 3.2.b. Glass temperatures and electrode power for the high waste loading C-106/AY-102 DM100 test.

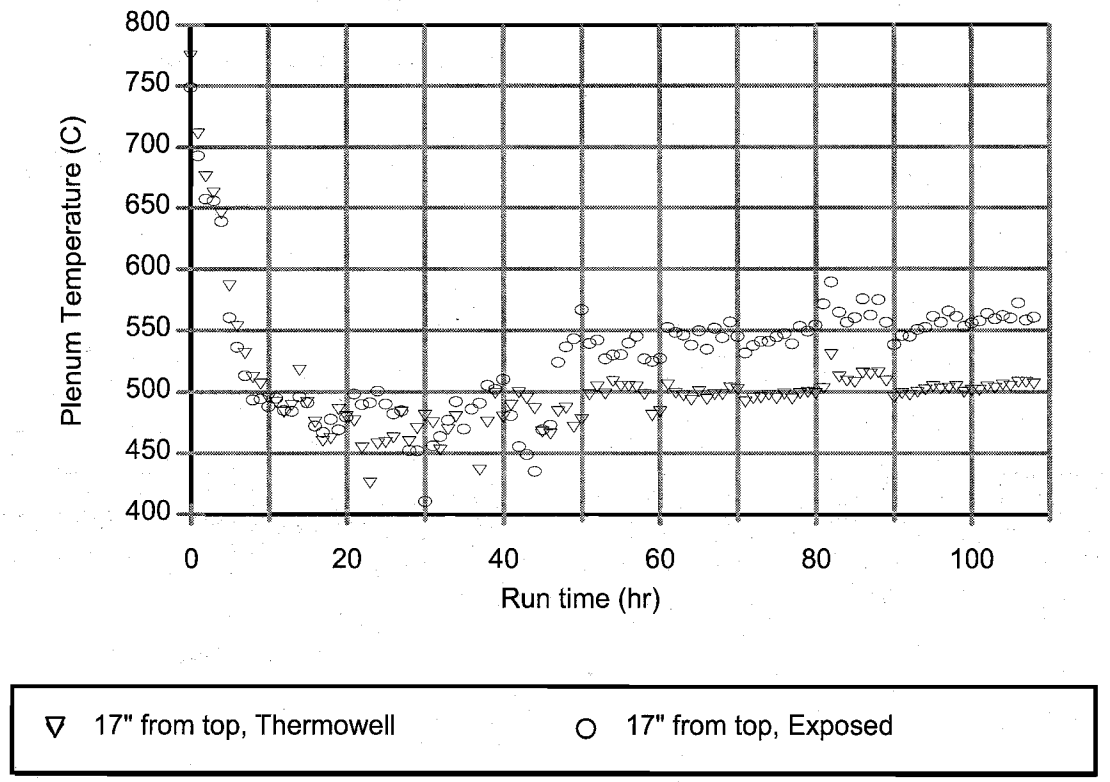

Figure 3.3.a. Plenum temperatures for the AZ-102 DM100 tests.

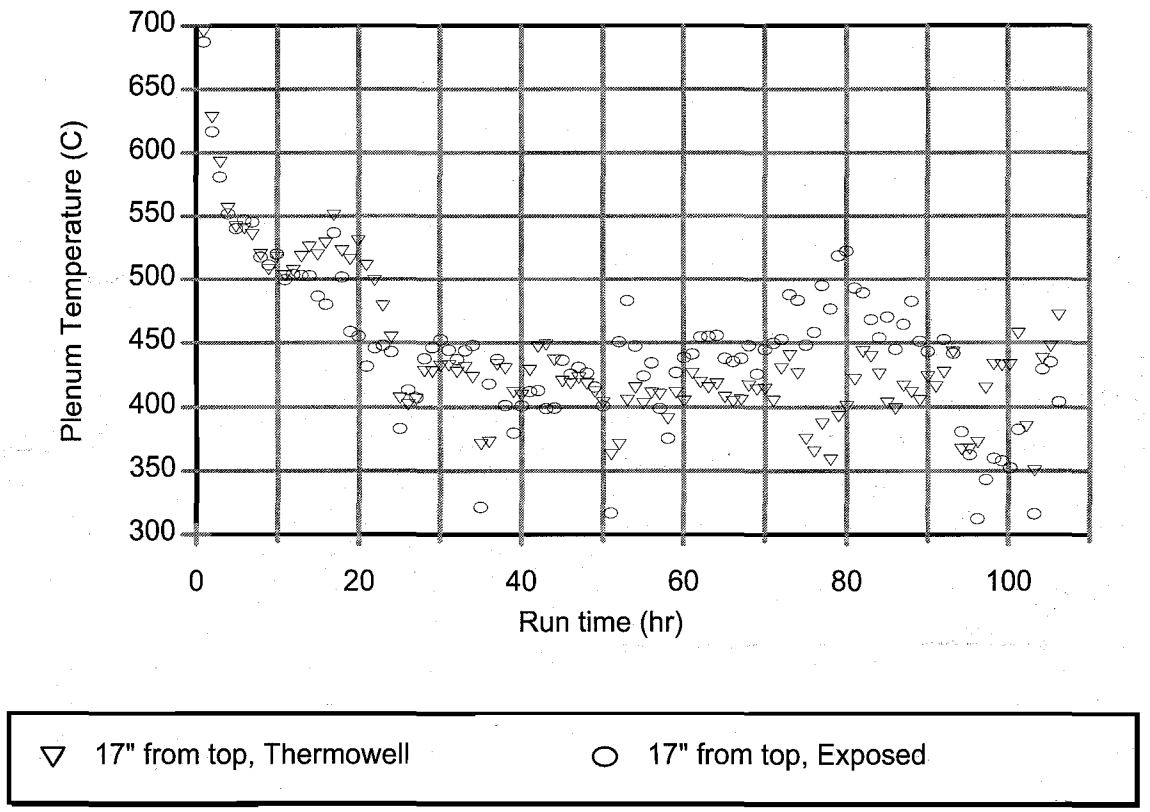

Figure 3.3.b. Plenum temperatures for the high waste loading C-106/AY-102 DM100 test.

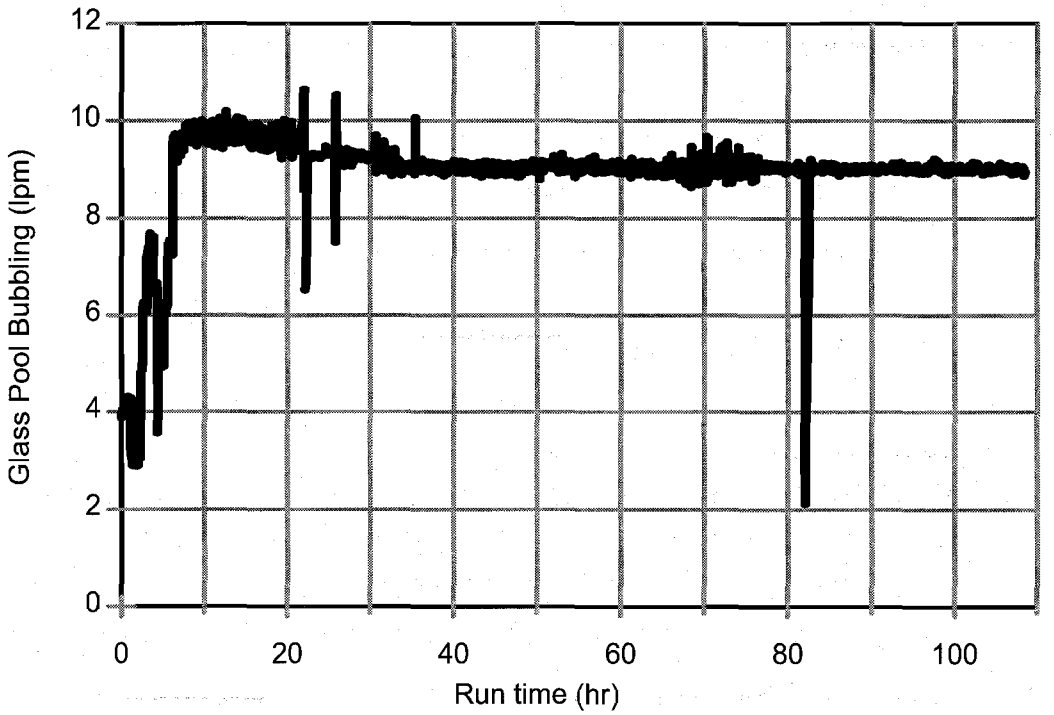

Figure 3.4.a. Glass pool bubbling for the AZ-102 DM100 test.

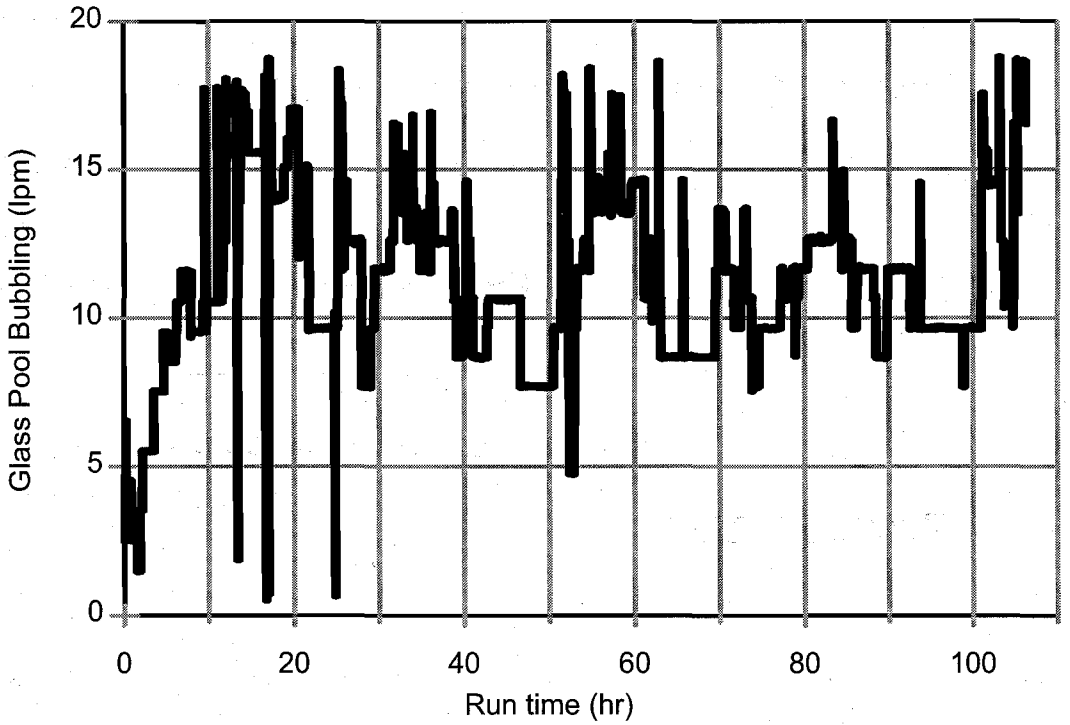

Figure 3.4.b. Glass pool bubbling for the high waste loading C-106/AY-102 DM100 test.

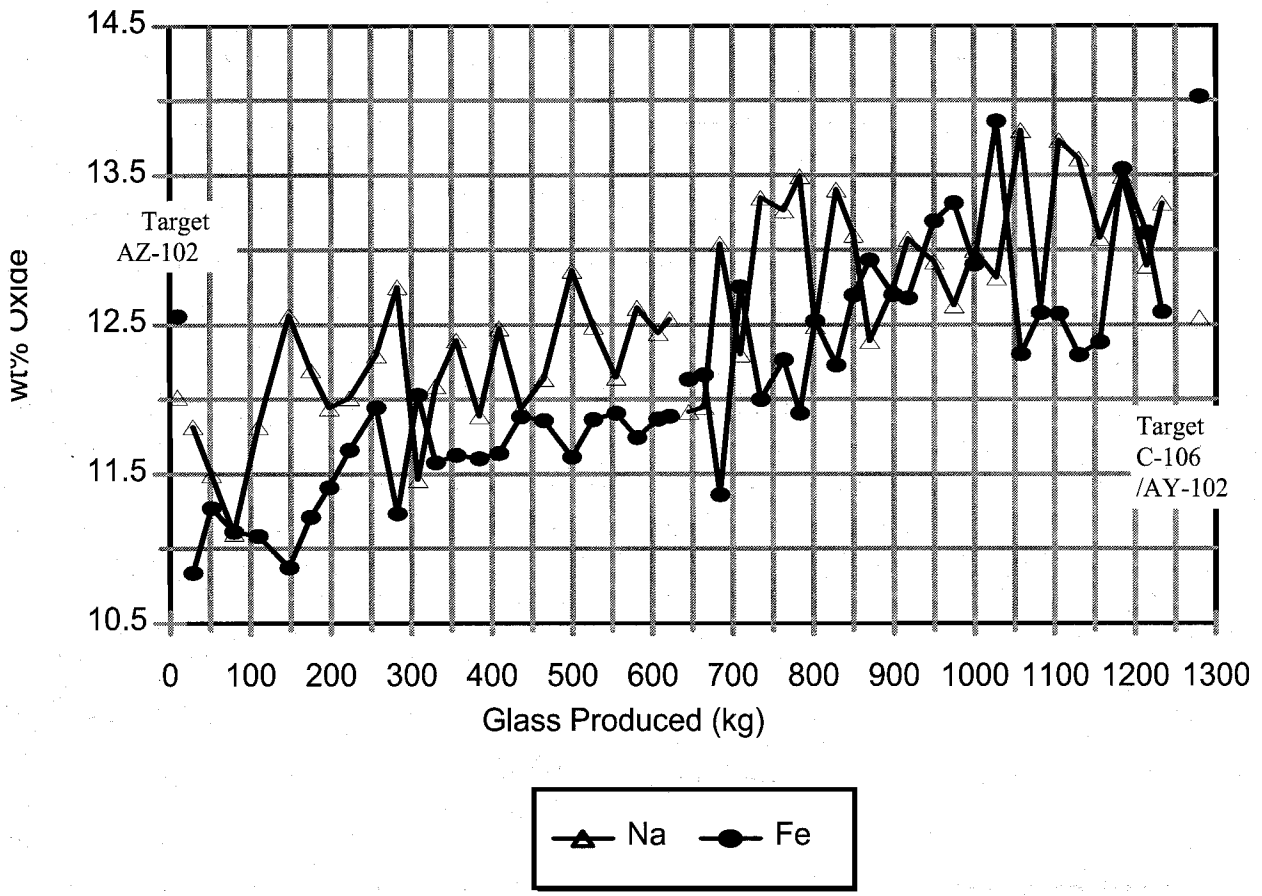

Figure 3.5. XRF analysis of iron and sodium oxides in DM100 glasses.

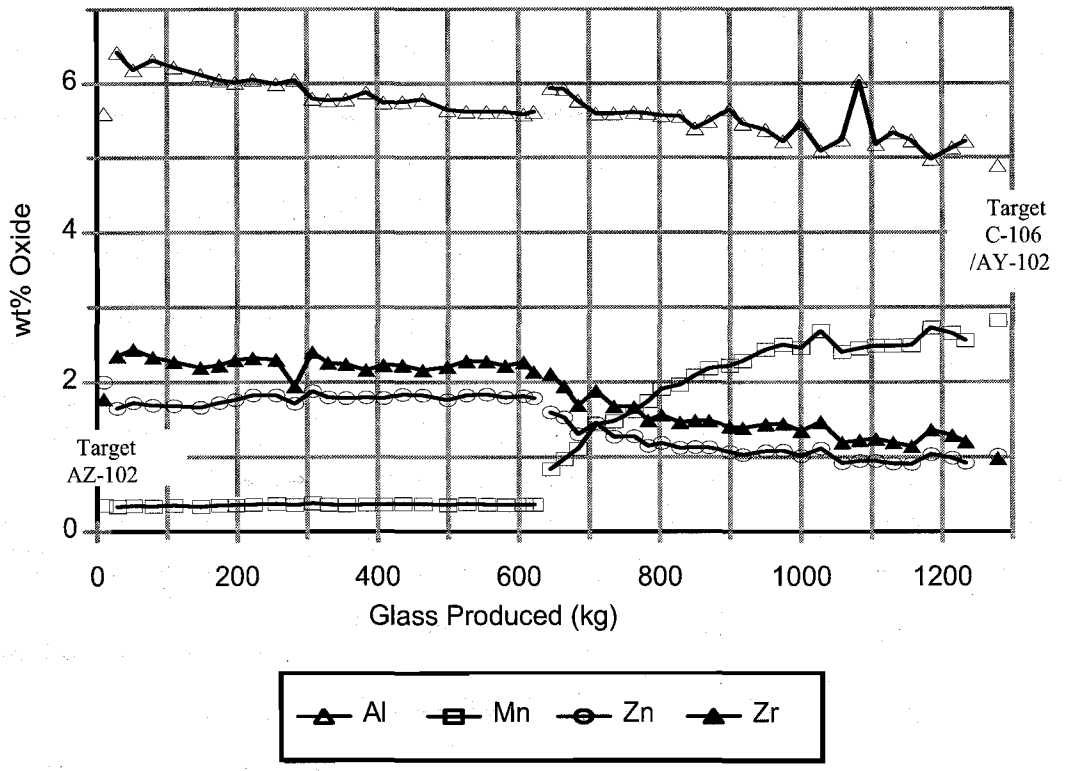

Figure 3.6. XRF analysis of select oxides during DM100 tests.

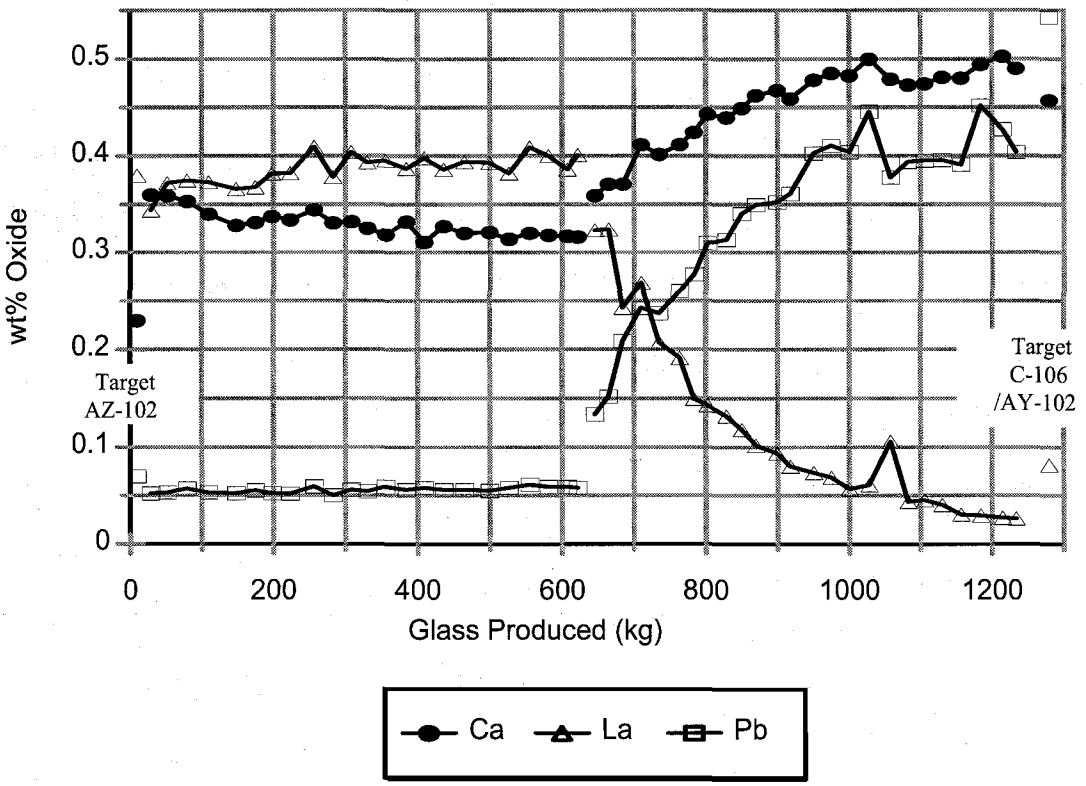

Figure 3.7. XRF analysis of select minor oxides during DM100 tests.

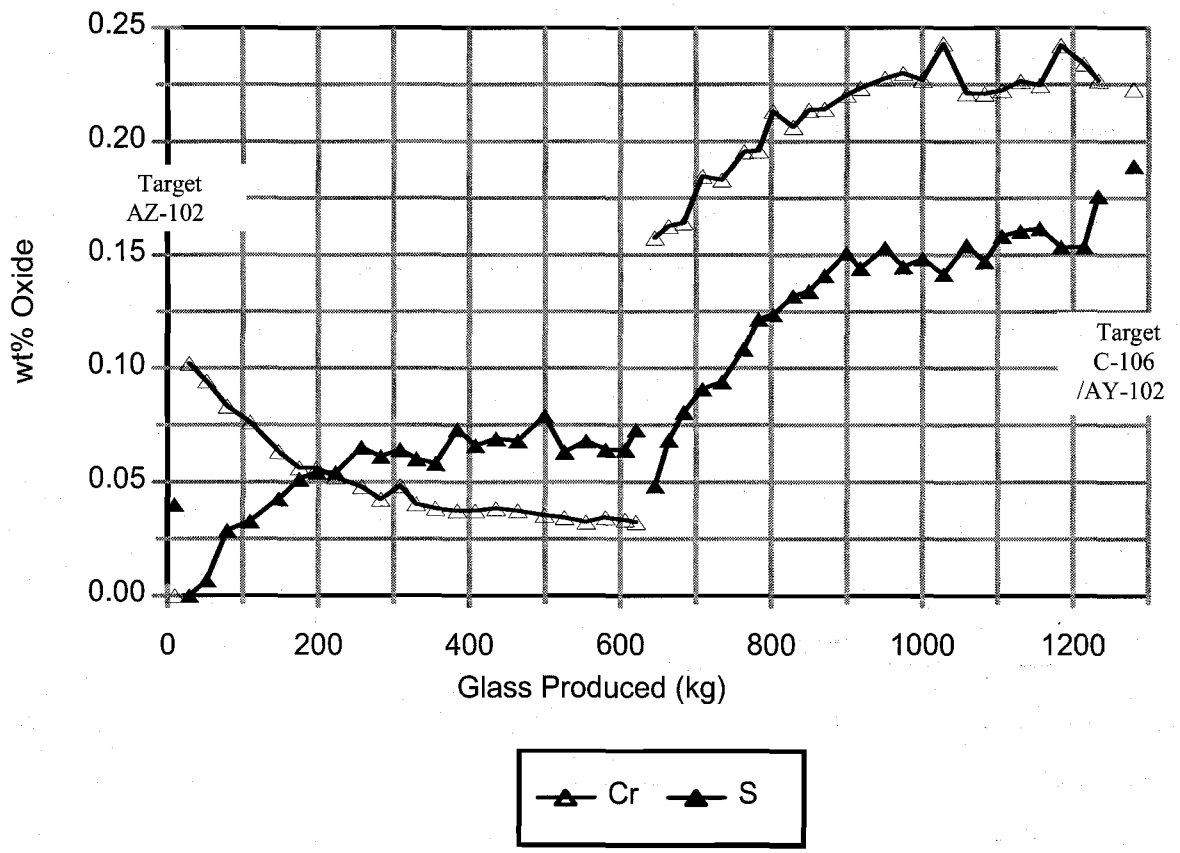

Figure 3.8. XRF analysis of chromium and sulfur oxides in DM100 glasses.

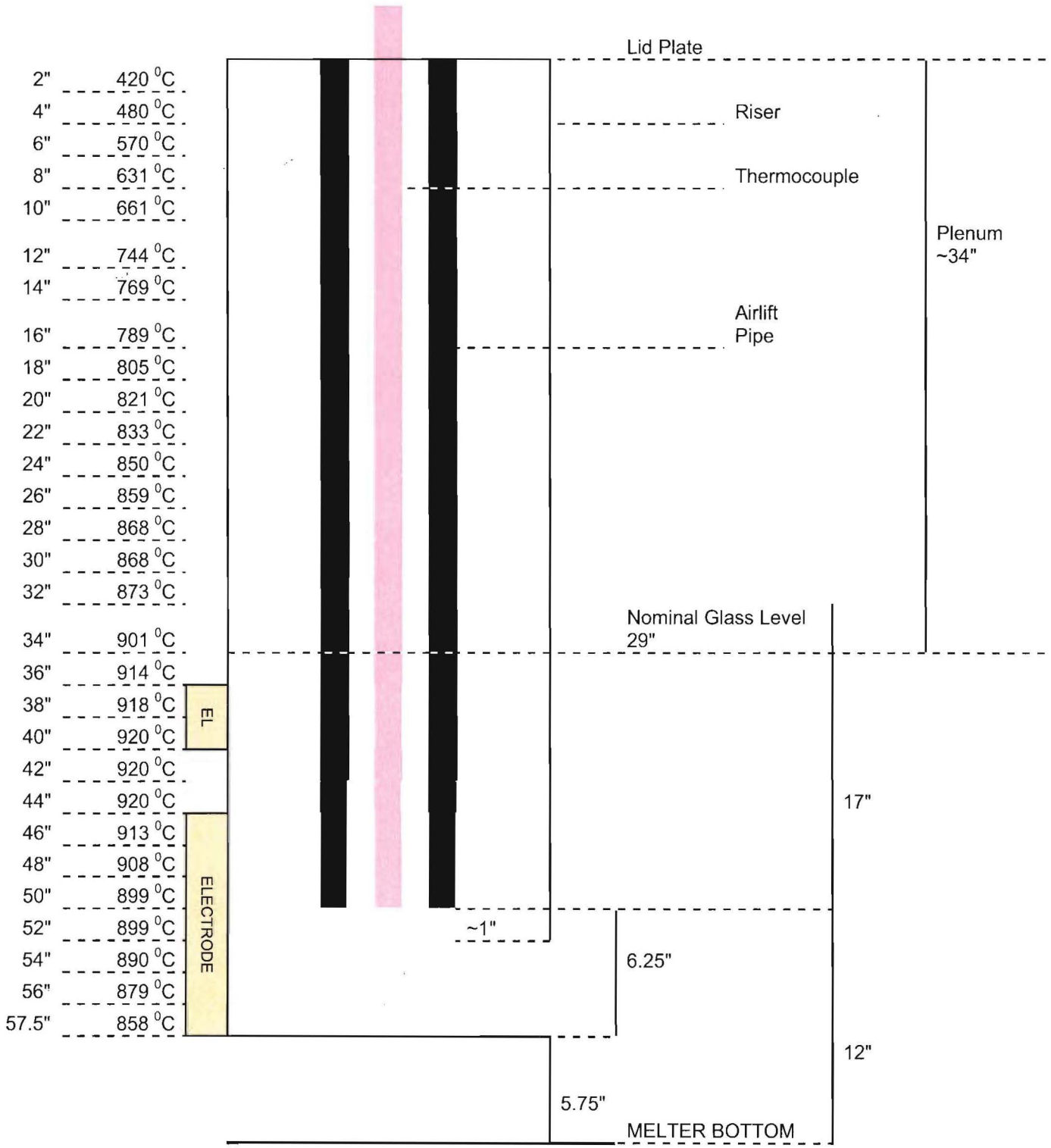

Figure 3.9. DM100 discharge riser temperature profile. Note: Measurements made at an average glass temperature of 1007 – 1069 °C and discharge chamber temperature of 900 ^{0}C.

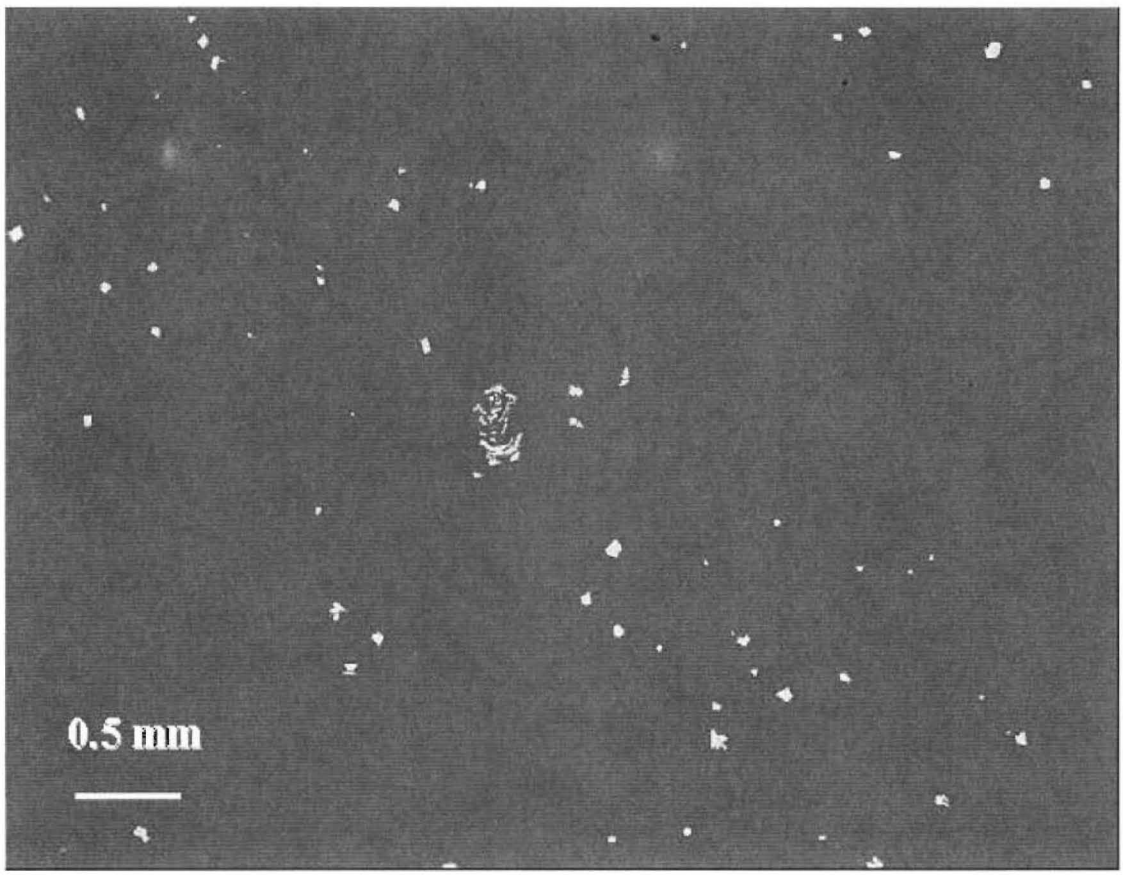

Figure 3.10. SEM micrograph of spinel crystals in glass (BLJ-D-78A) from the DM100 riser after 104 hours of idling.

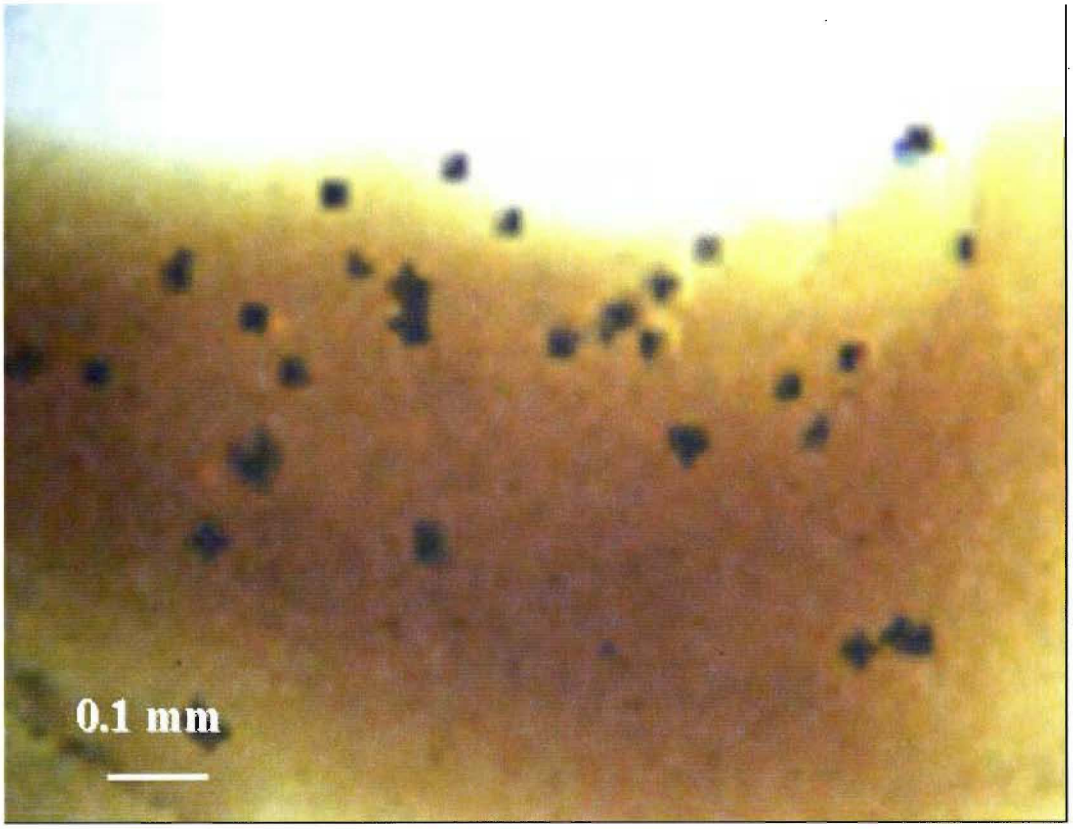

Figure 3.11. Optical micrograph of spinel crystals in glass (BLJ-D-78A) from the DM100 riser after 104 hours of idling.

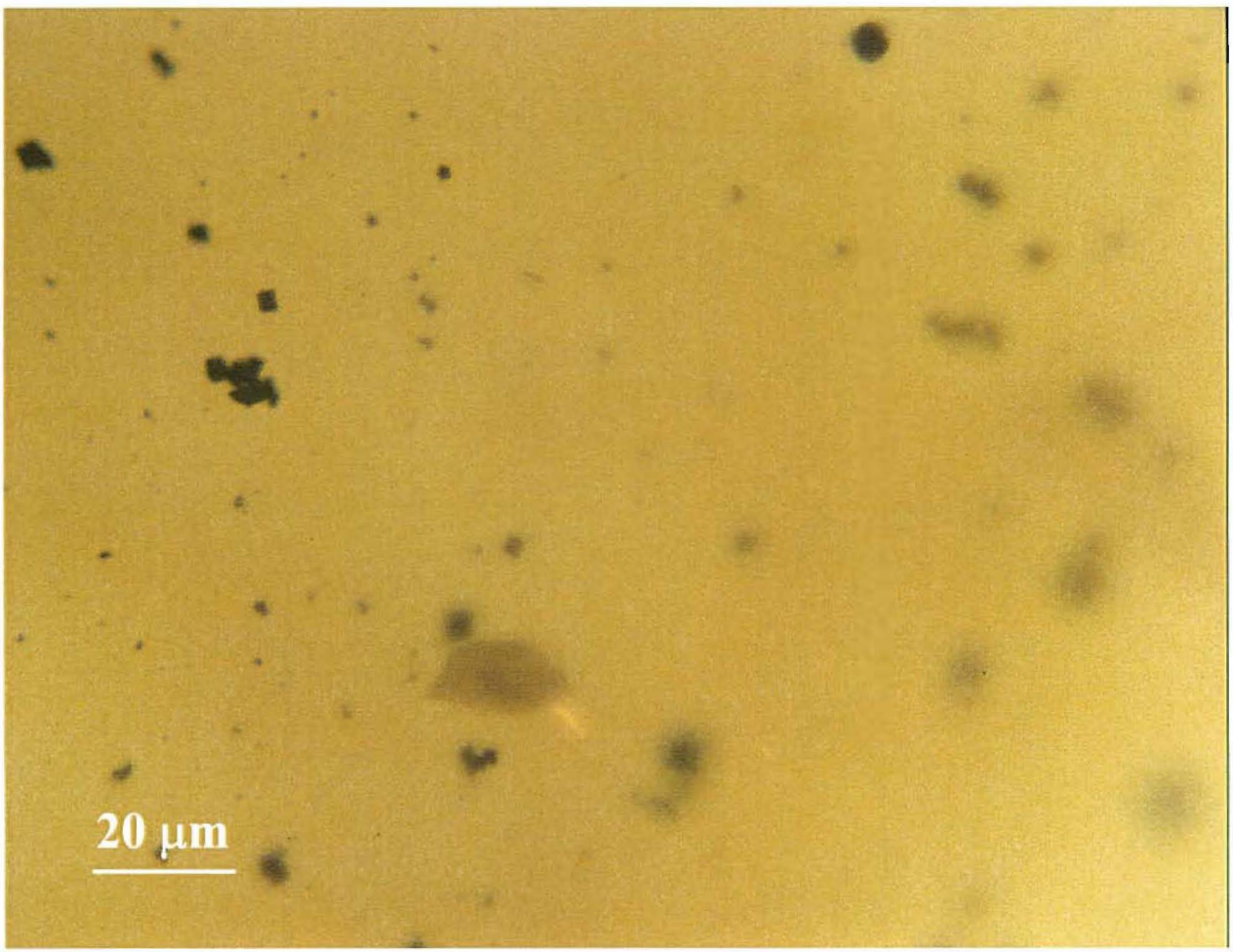

Figure 3.12. Optical micrograph of spinel crystals in glass (BLJ-D-78B) from the DM100 riser after 104 hours of idling.

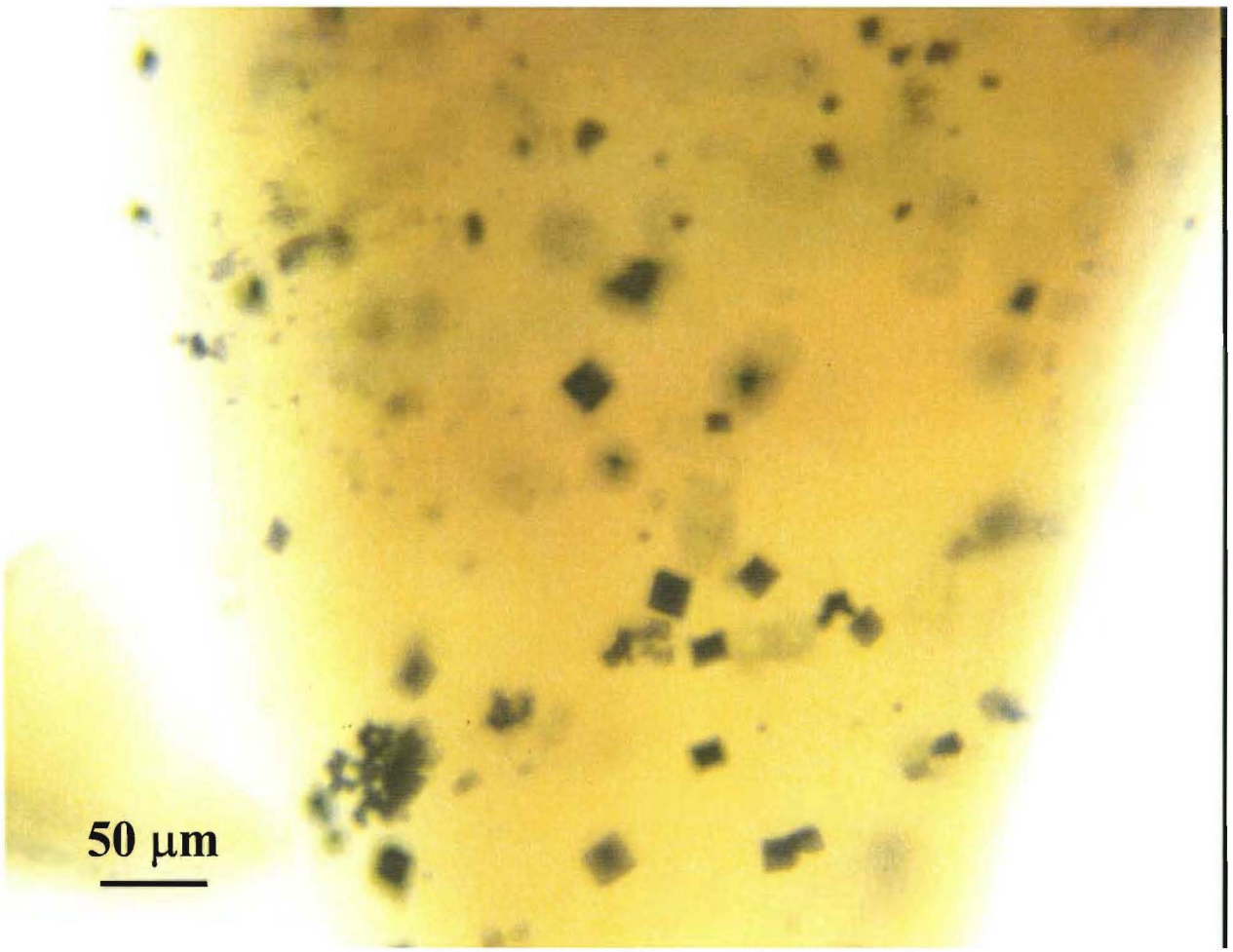

Figure 3.13. Optical micrograph of spinel crystals in glass (BLJ-D-78D) from the DM100 riser after 129 hours of idling.

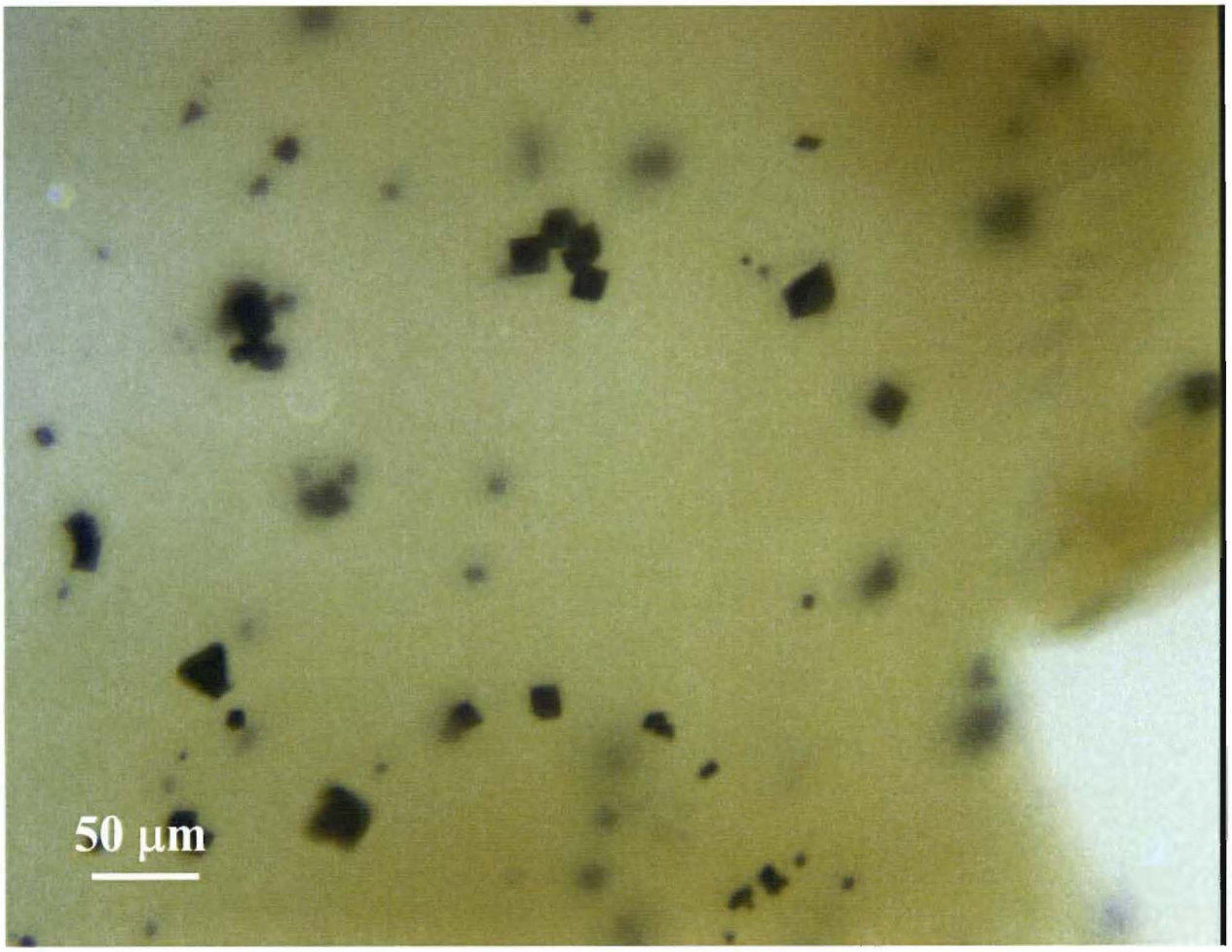

Figure 3.14. Optical micrograph of spinel crystals in glass (BLJ-D-79A) from the DM100 riser after 158 hours of idling.

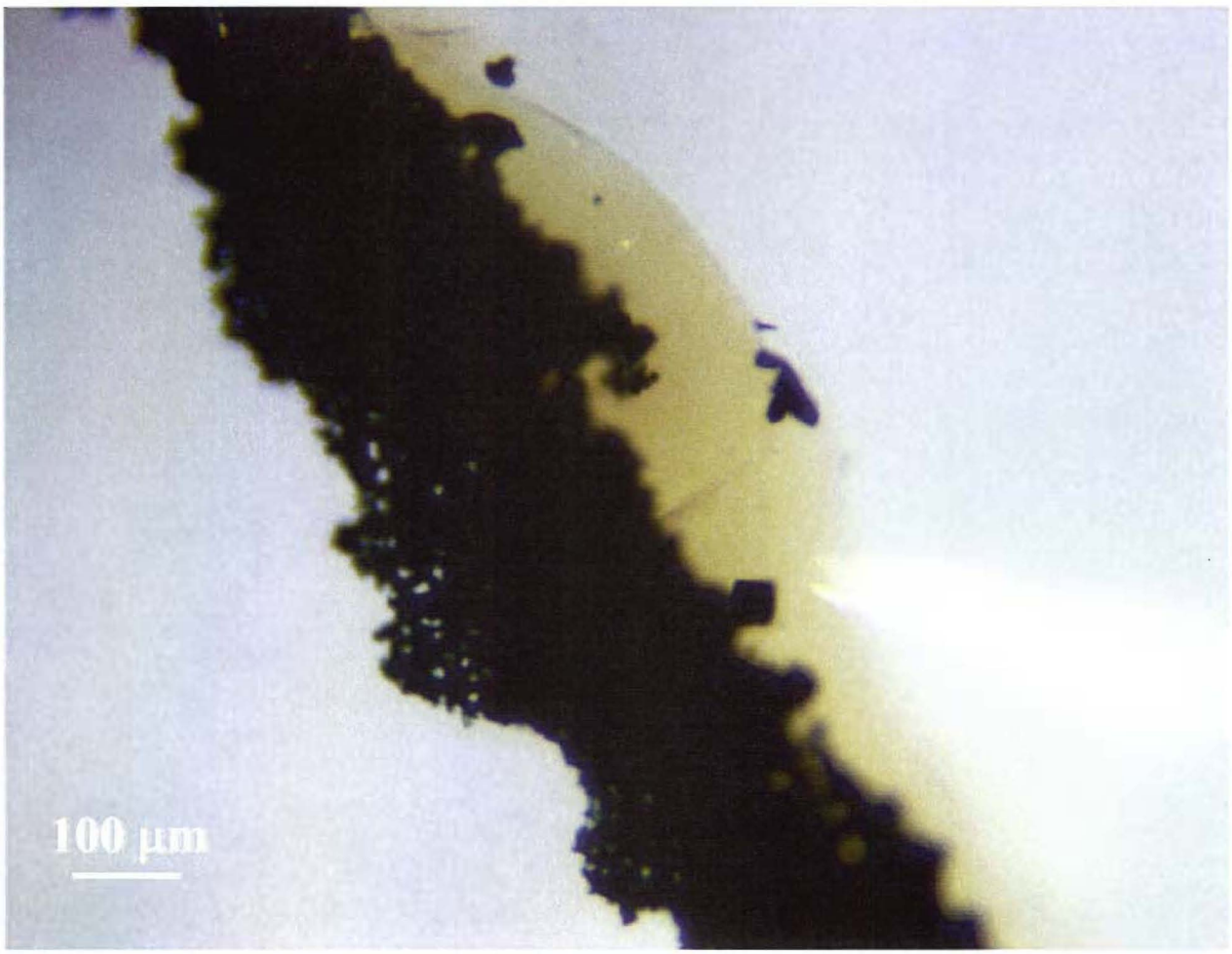

Figure 3.15. Optical micrograph of spinel crystals in glass (BLK-D-41A) from the DM100 air-lift riser pipe after 105 days of idling.

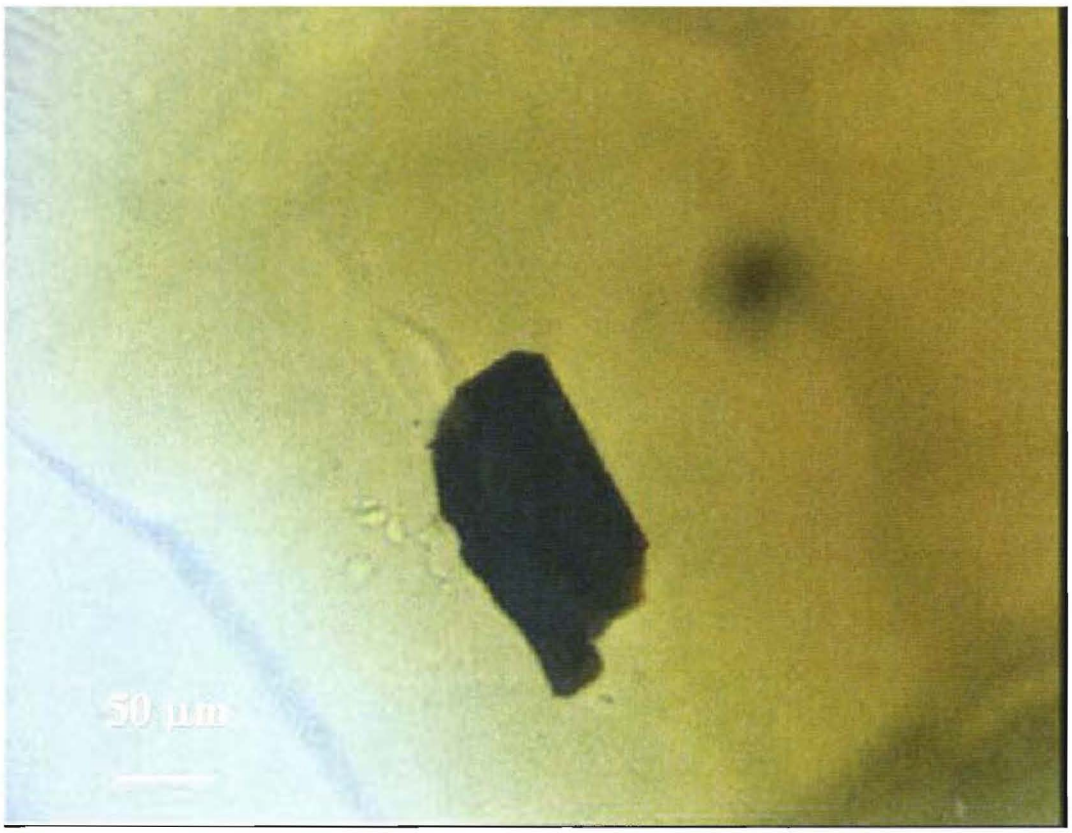

Figure 3.16. Optical micrograph of spinel crystals in glass (BLK-O-41A) from the DM100 riser after 177 days of idling.

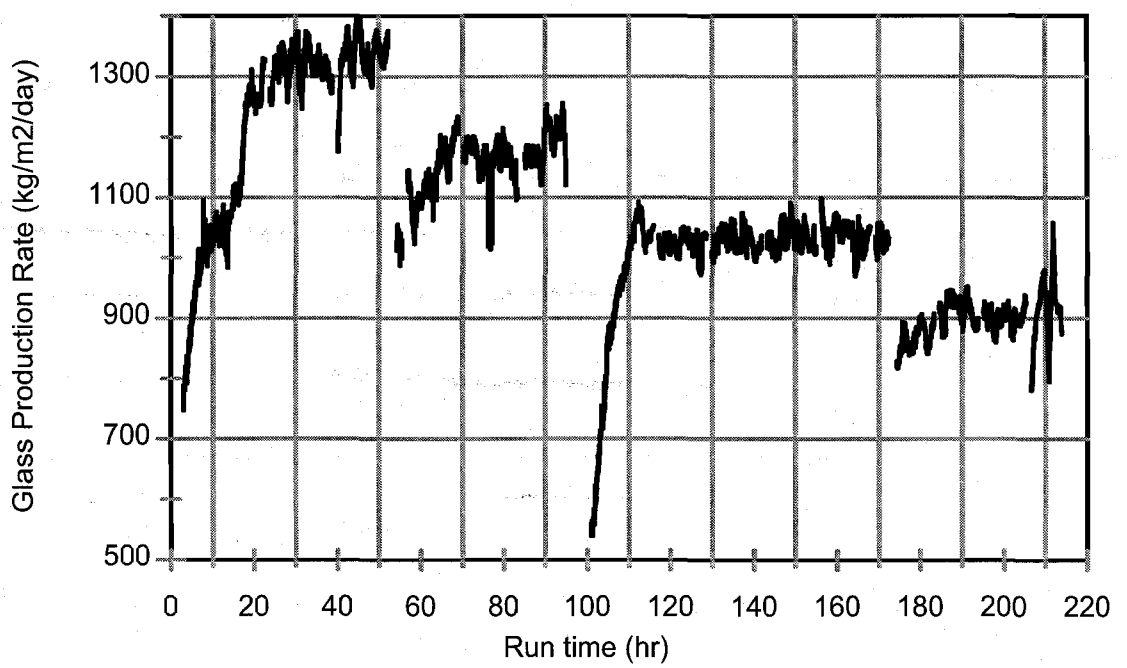

Figure 4.1.a. Production rates (hourly moving average) for AZ-102 DM1200 Tests (Test 1).

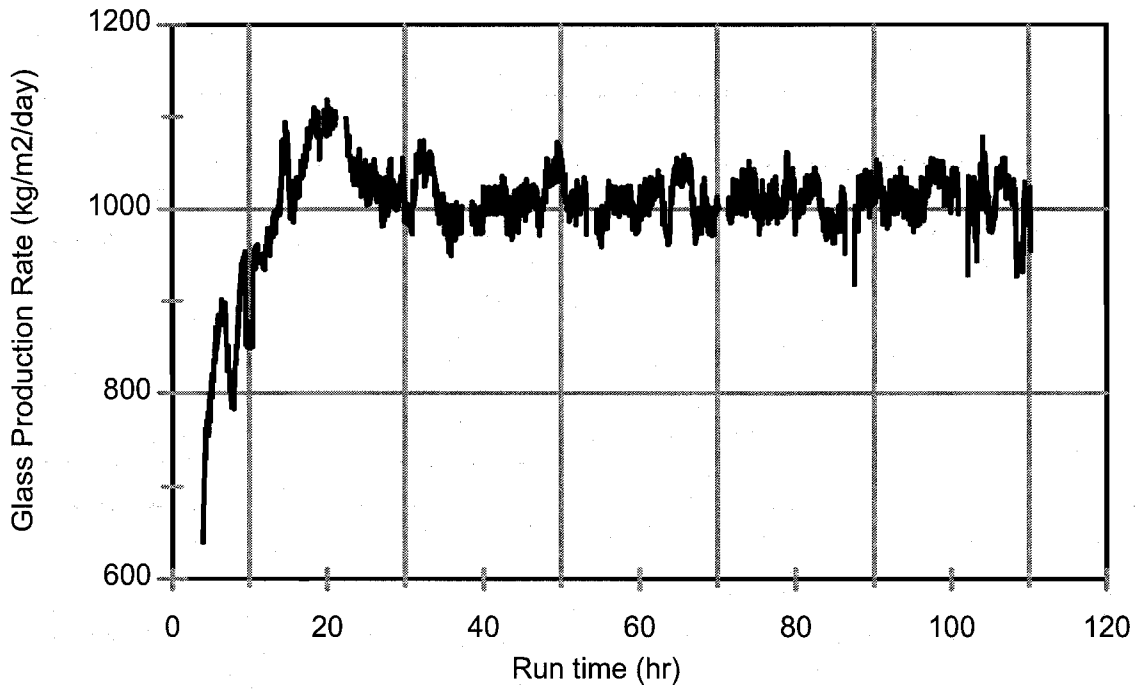

Figure 4.1.b. Production rates (hourly moving average) for high viscosity, C-106/AY-102 DM1200 Test (Test 2A).

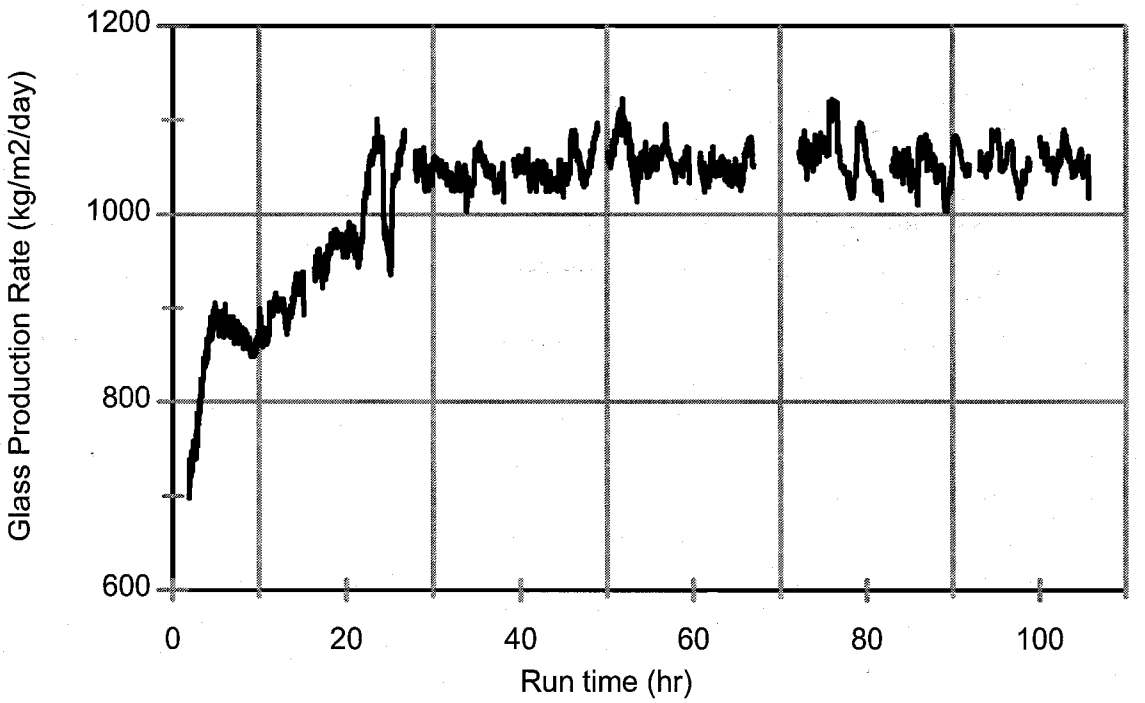

Figure 4.1.c. Production rate (hourly moving average) for the high waste loading C-106/AY-102 Test (Test 2B).

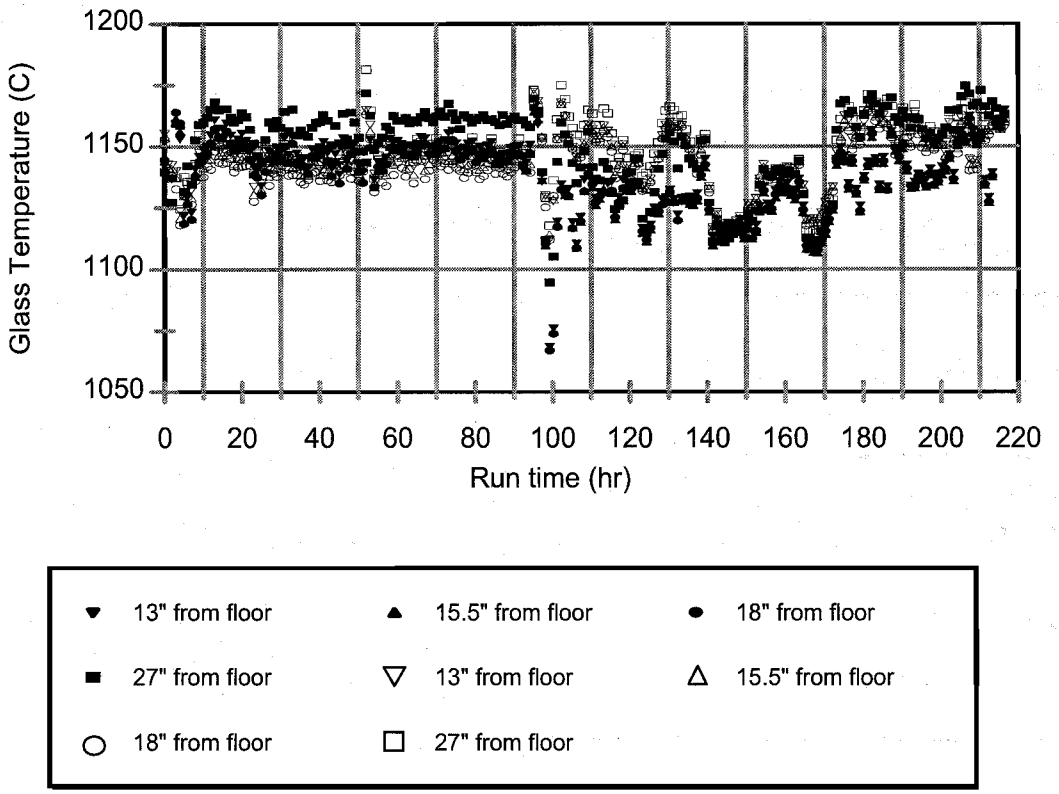

Figure 4.2.a. Glass temperatures (hourly averages) for AZ-102 DM1200 Tests (Test 1).

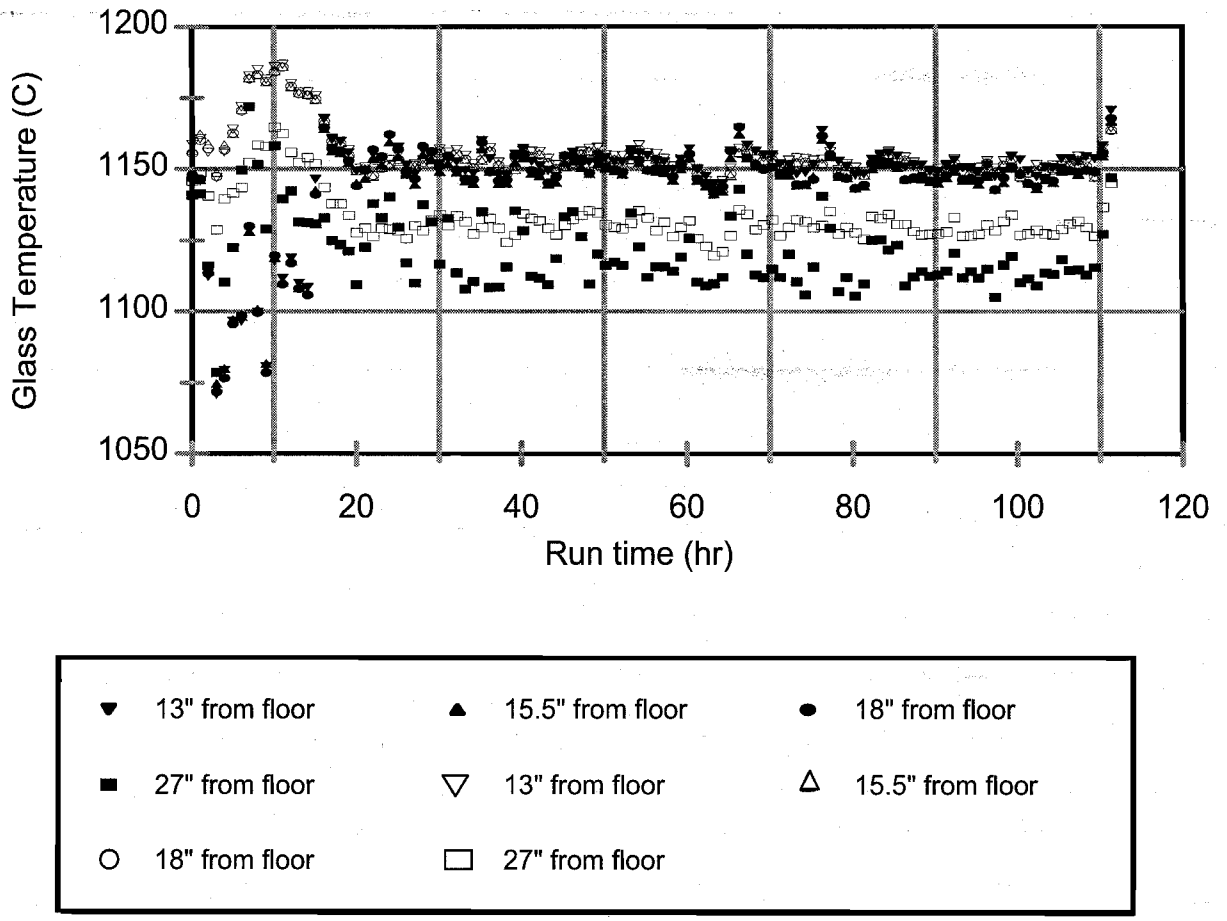

Figure 4.2.b. Glass temperatures (hourly averages) for the adjusted rheology C-106/AY-102 Test (Test 2A).

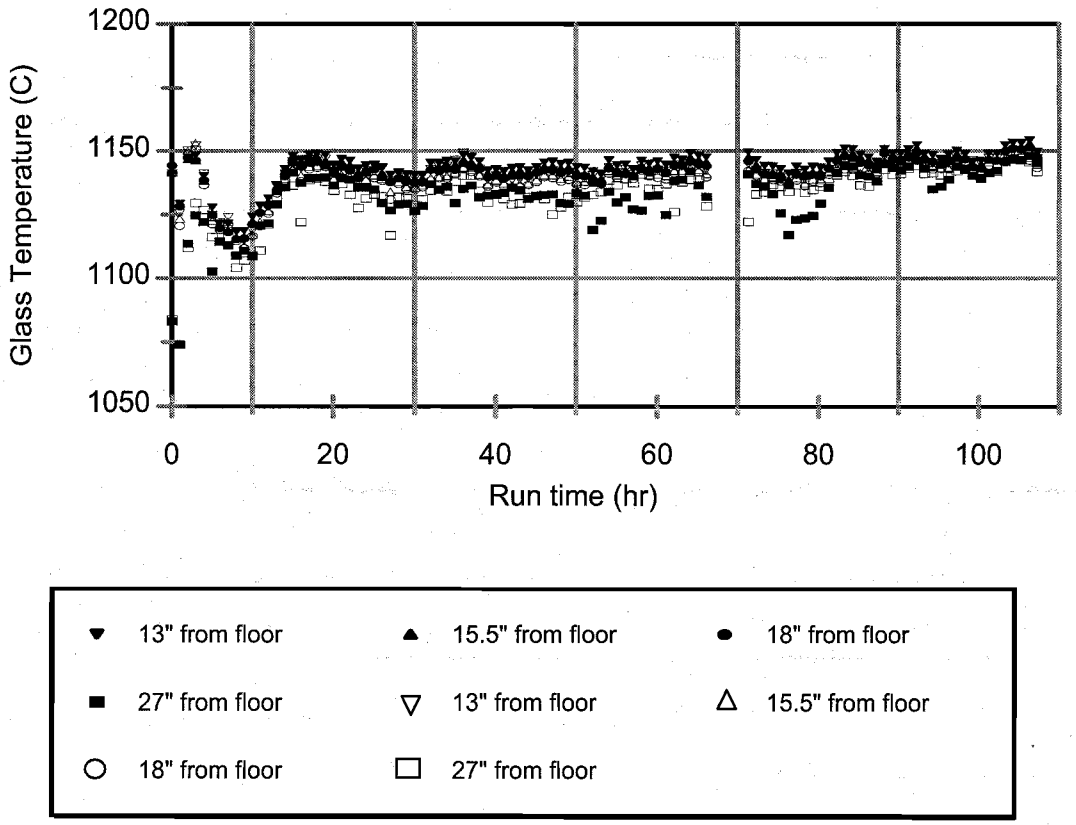

Figure 4.2.c. Glass temperatures (hourly averages) for the high waste loading C-106/AY-102 Test (Test 2B).

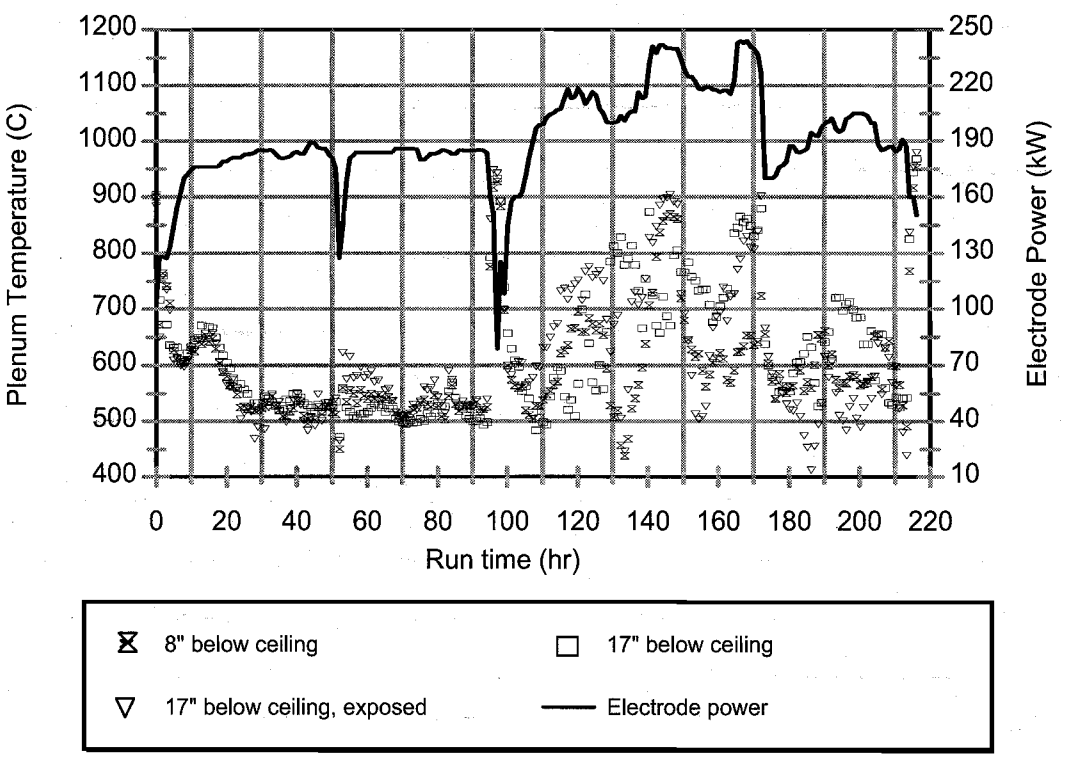

Figure 4.3.a. Plenum temperatures and electrode power (hourly averages) for AZ-102 DM1200 tests (Test 1).

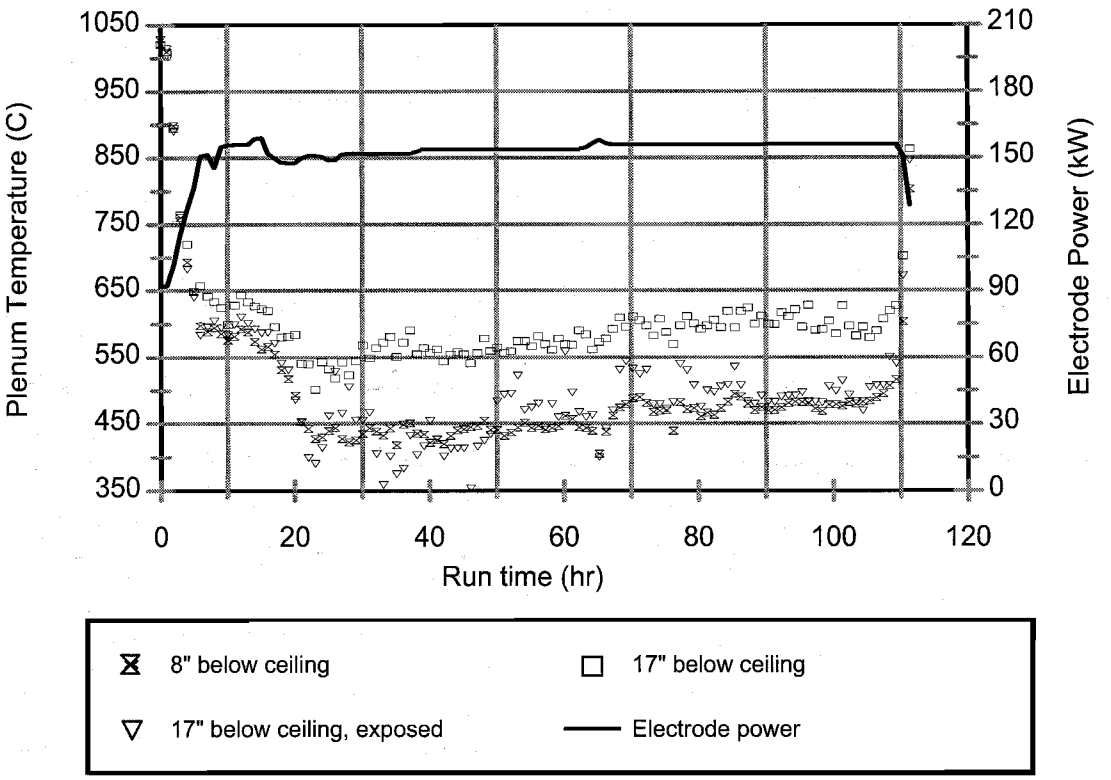

Figure 4.3.b. Plenum temperatures and electrode power (hourly averages) for the adjusted rheology C-106/AY-102 Test (Test 2A).

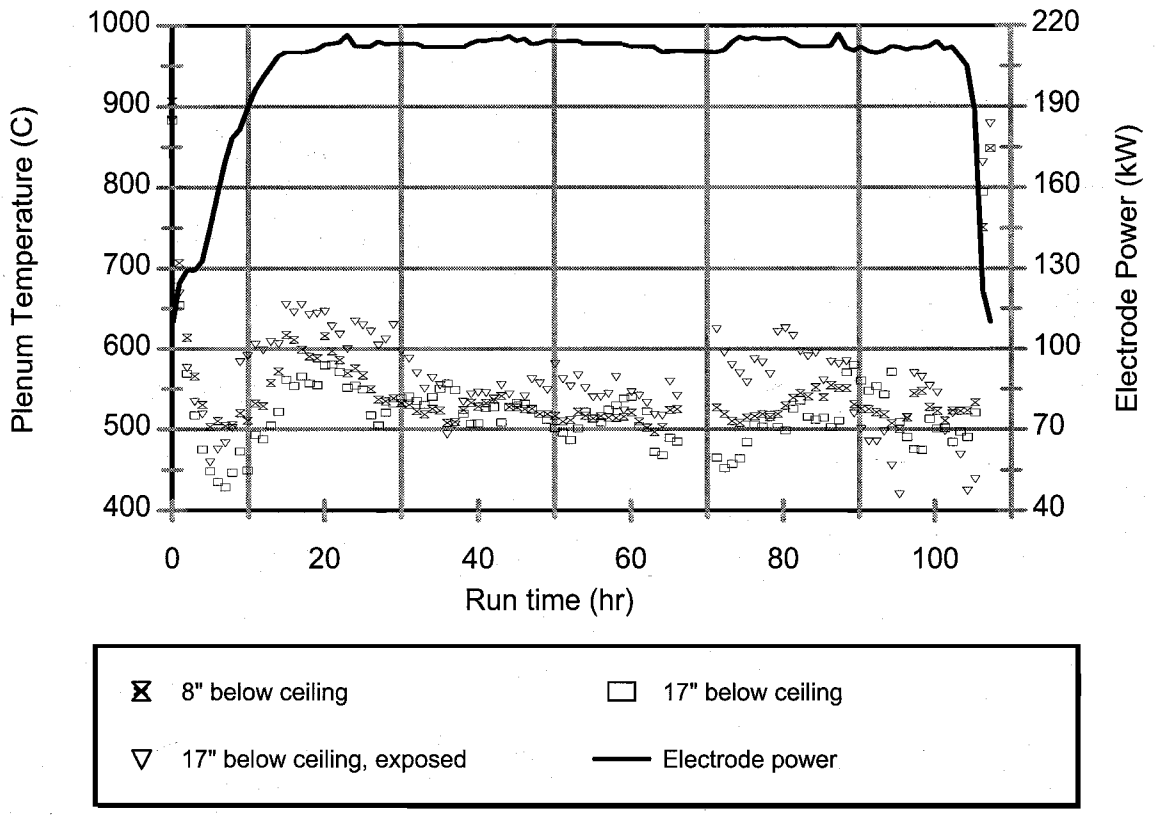

Figure 4.3.c. Plenum temperatures and electrode power (hourly averages) for the high waste loading C-106/AY-102 Test (Test 2B).

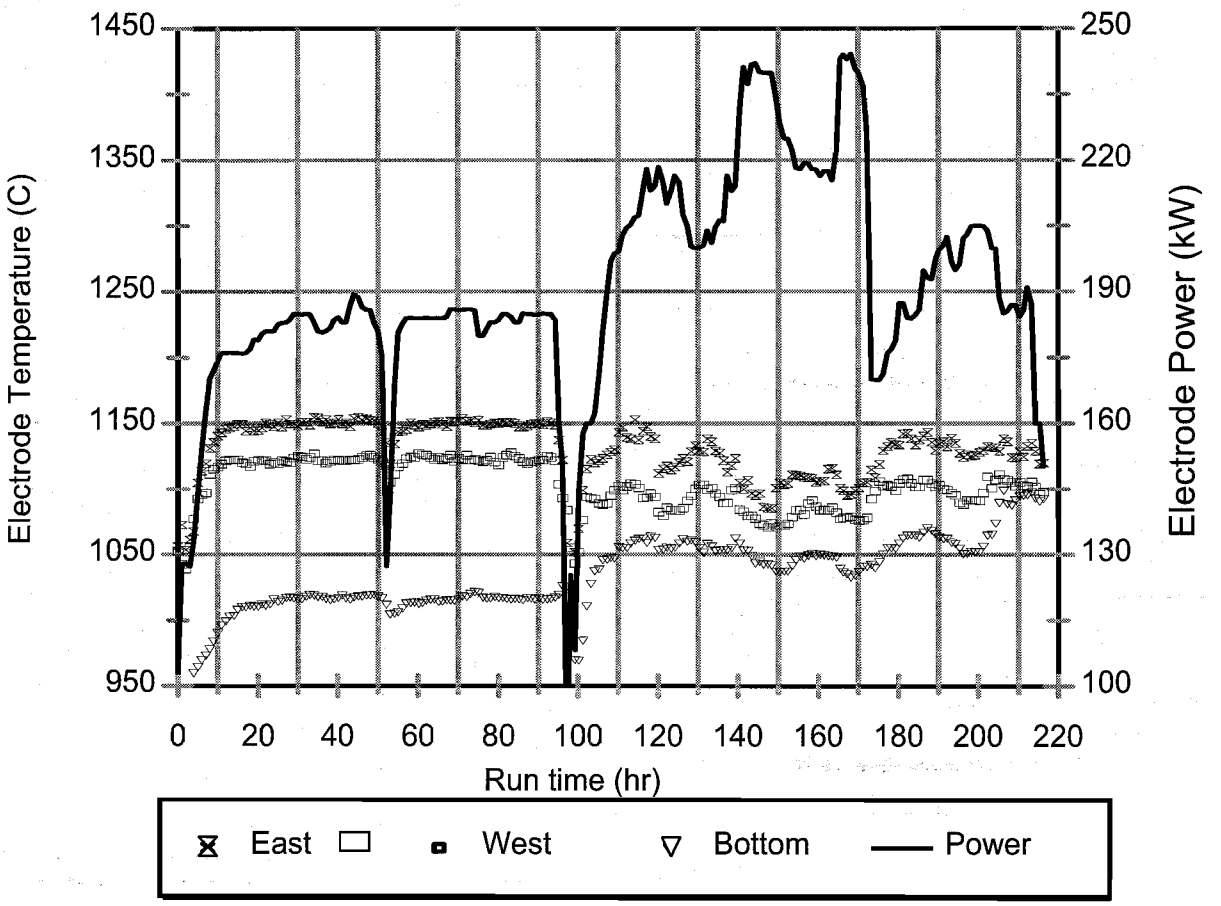

Figure 4.4.a. Electrode temperatures and power (hourly averages) for AZ-102 DM1200 tests (Test 1).

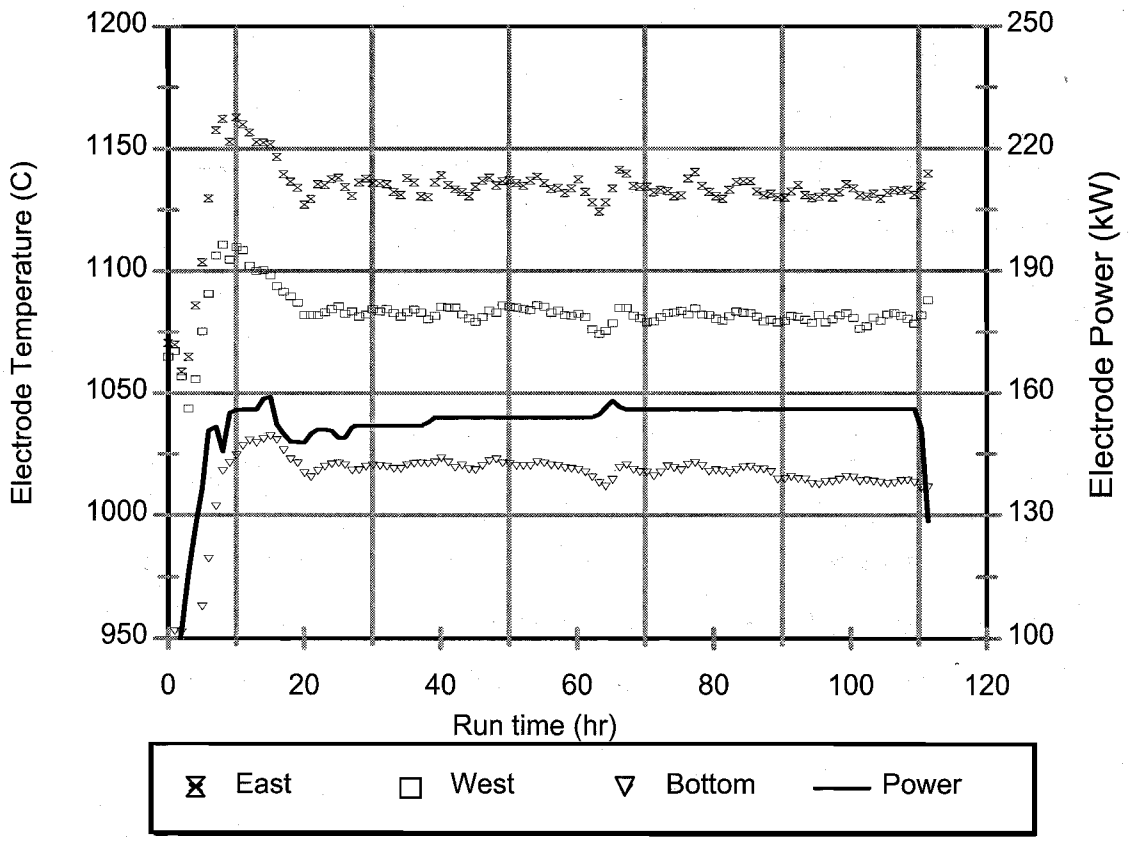

Figure 4.4.b. Electrode temperatures and power (hourly averages) for the adjusted rheology C-106/AY-102 Test (Test 2A).

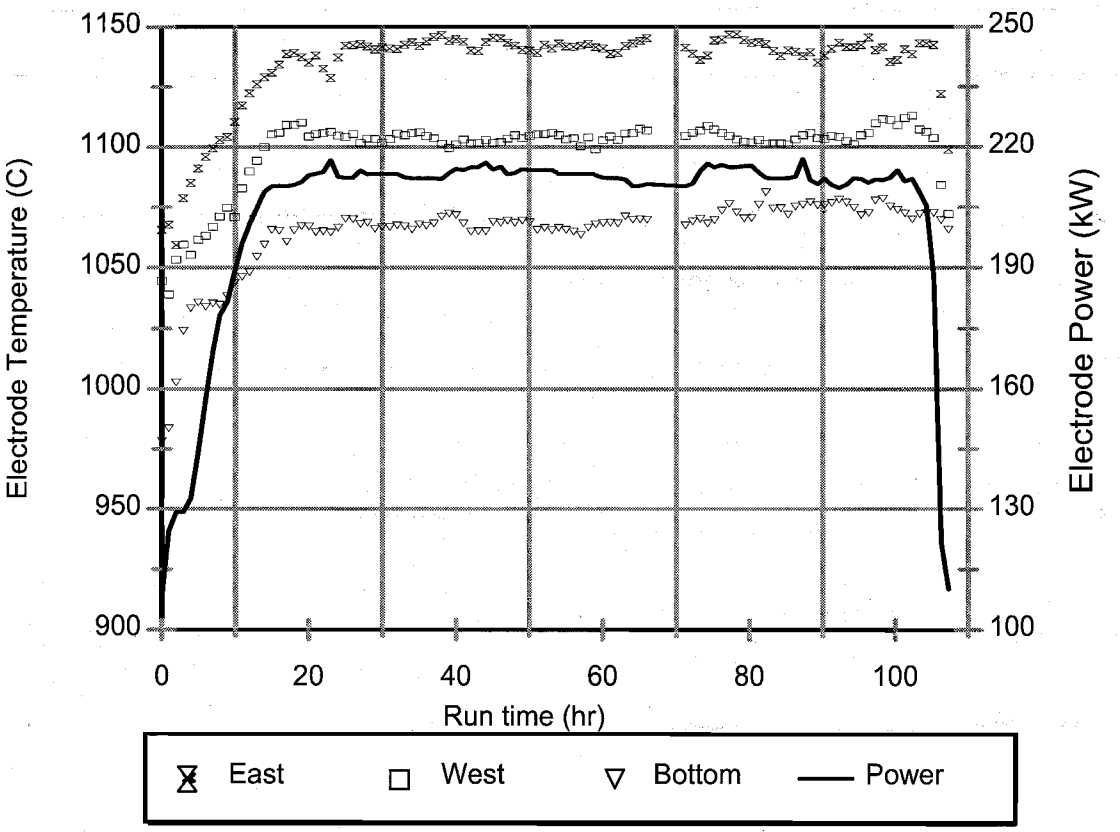

Figure 4.4.c. Electrode temperatures and power (hourly averages) for the high waste loading C-106/AY-102 Test (Test 2B).

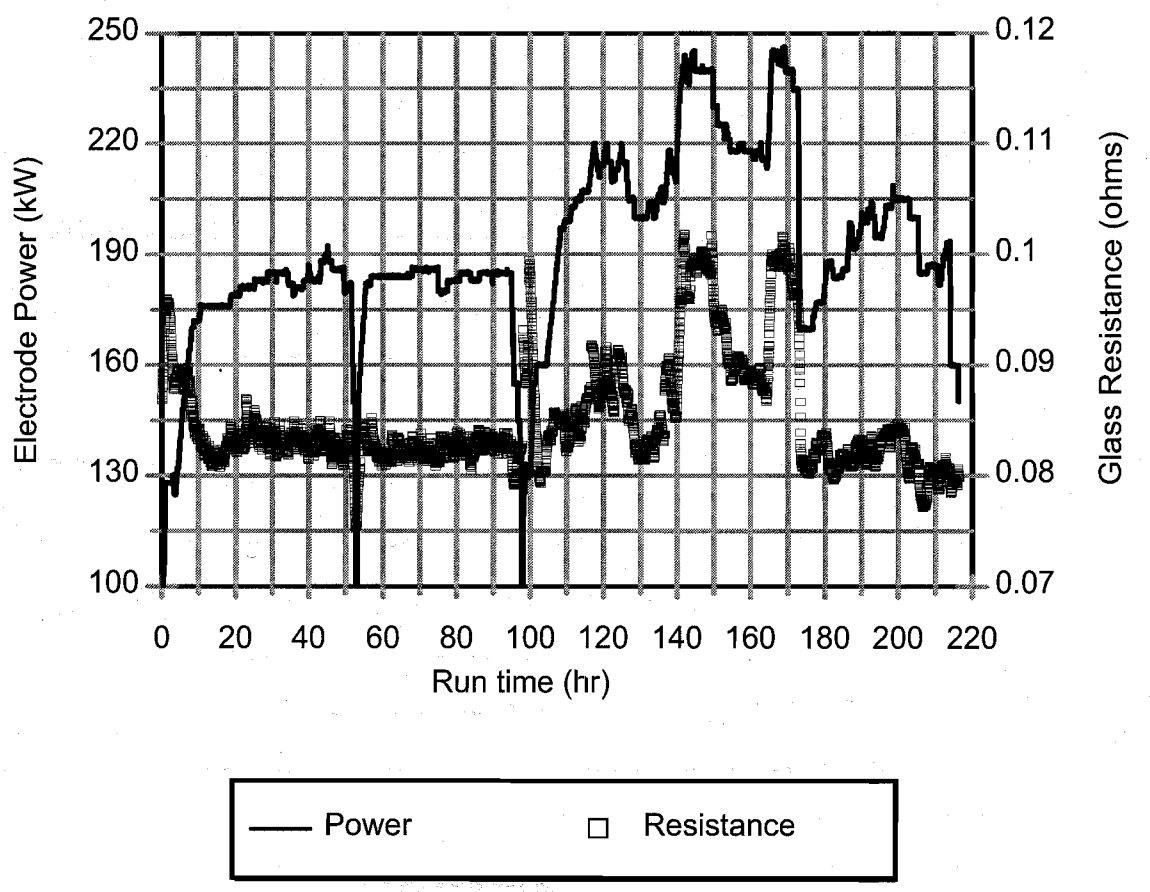

Figure 4.5.a. Electrode power and glass resistance for AZ-102 DM1200 Test (Test 1).

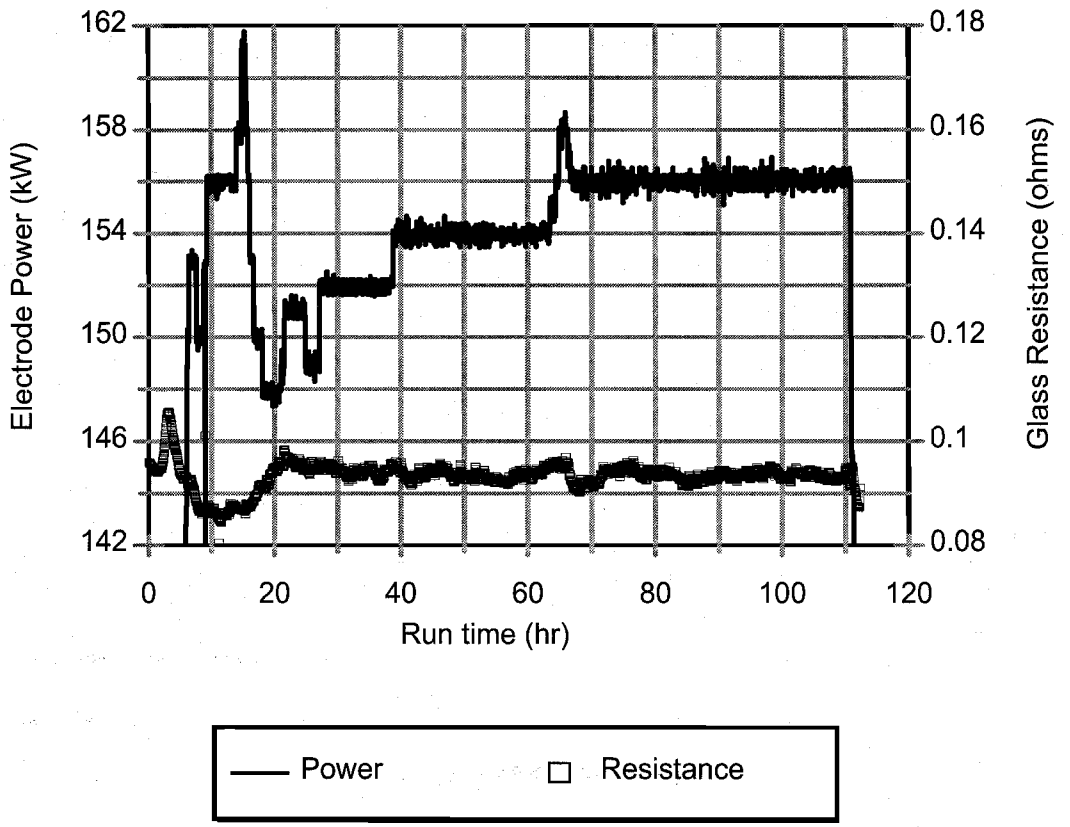

Figure 4.5.b. Electrode power and glass resistance for the adjusted rheology C-106/AY-102 DM1200 test (Test 2A).

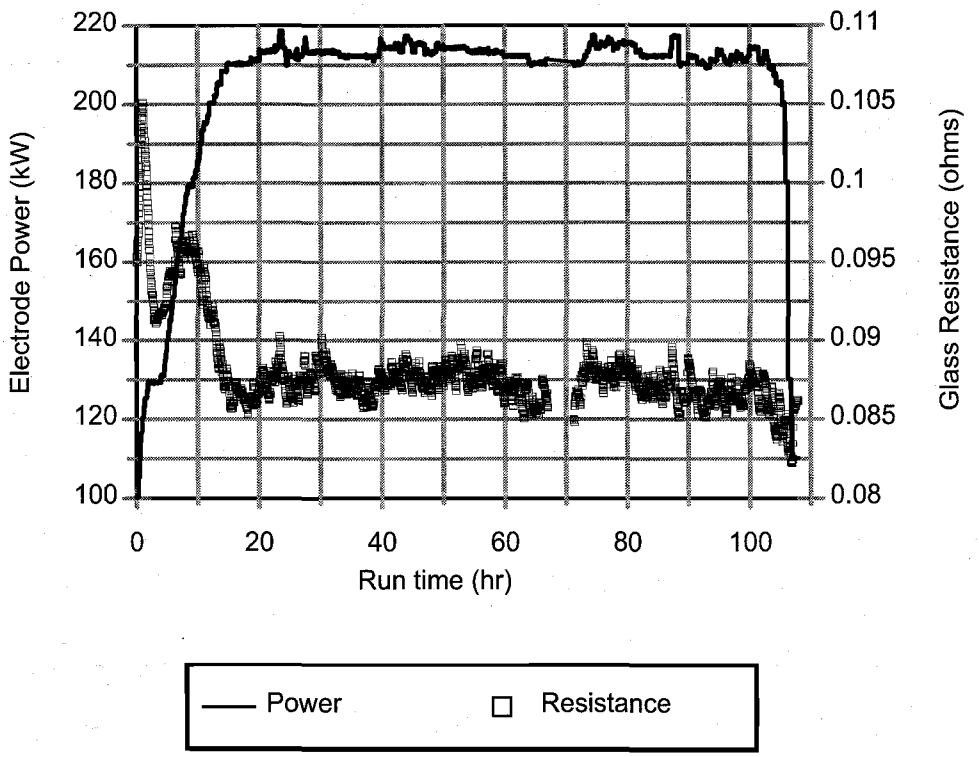

Figure 4.5.c. Electrode power and glass resistance for the high waste loading C-106/AY-102 DM1200 test (Test 2B).

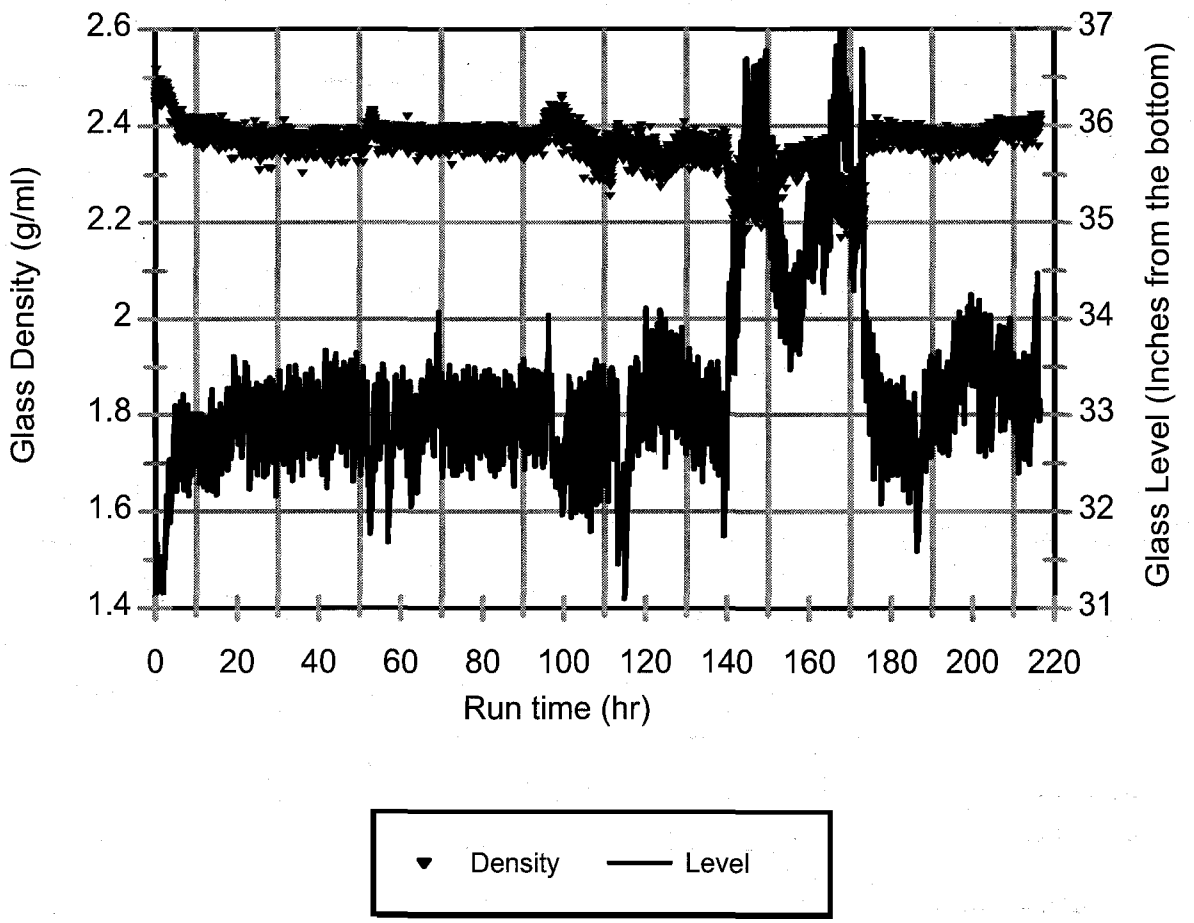

Figure 4.6.a. Glass density and level for AZ-102 DM1200 tests (Test 1).

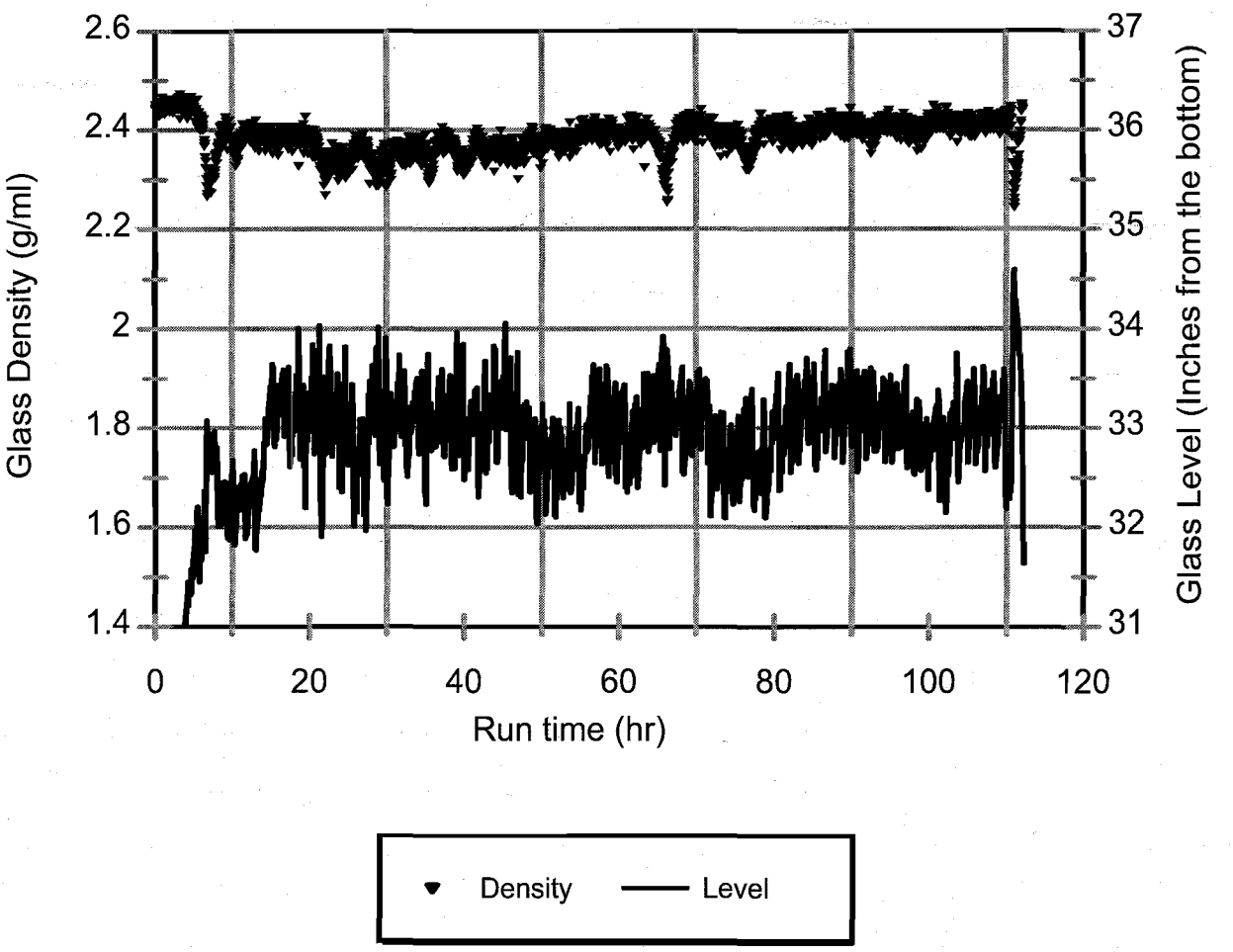

Figure 4.6.b. Glass density and level for the adjusted rheology C-106/AY-102 DM1200 test (Test 2A).

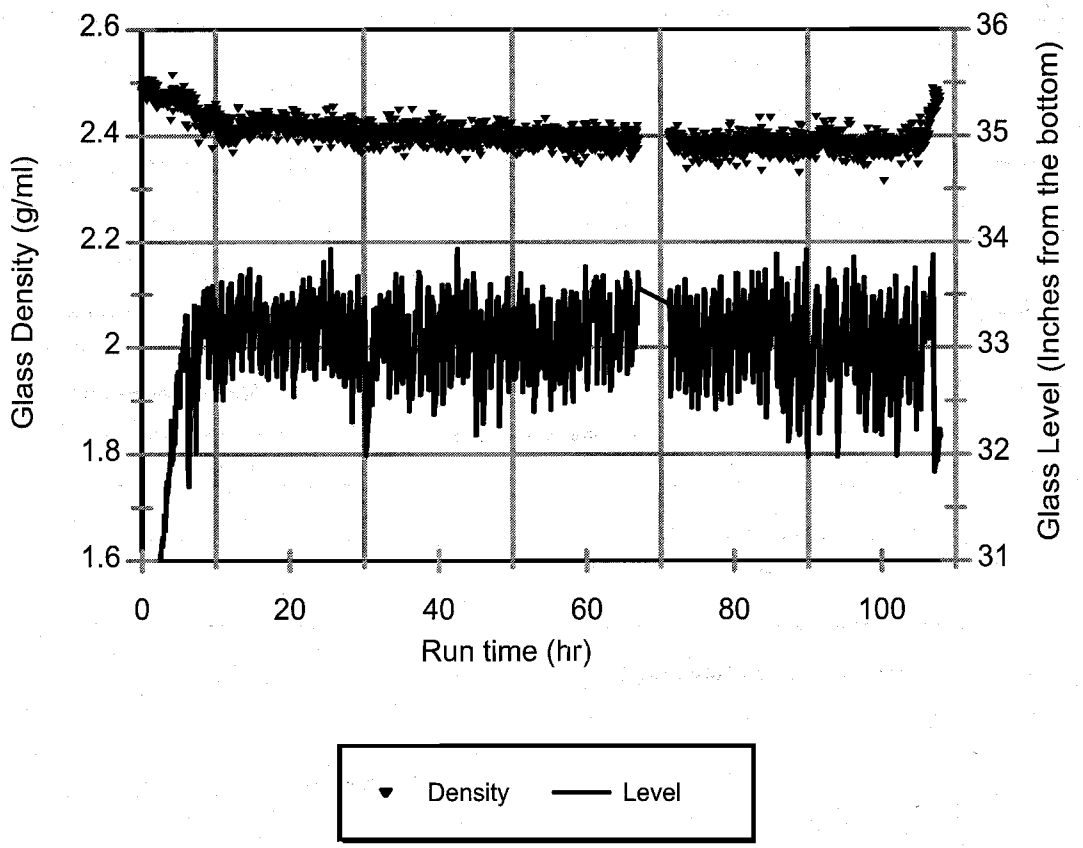

Figure 4.6.c. Glass density and level for the high waste loading C-106/AY-102 DM1200 test (Test 2B).

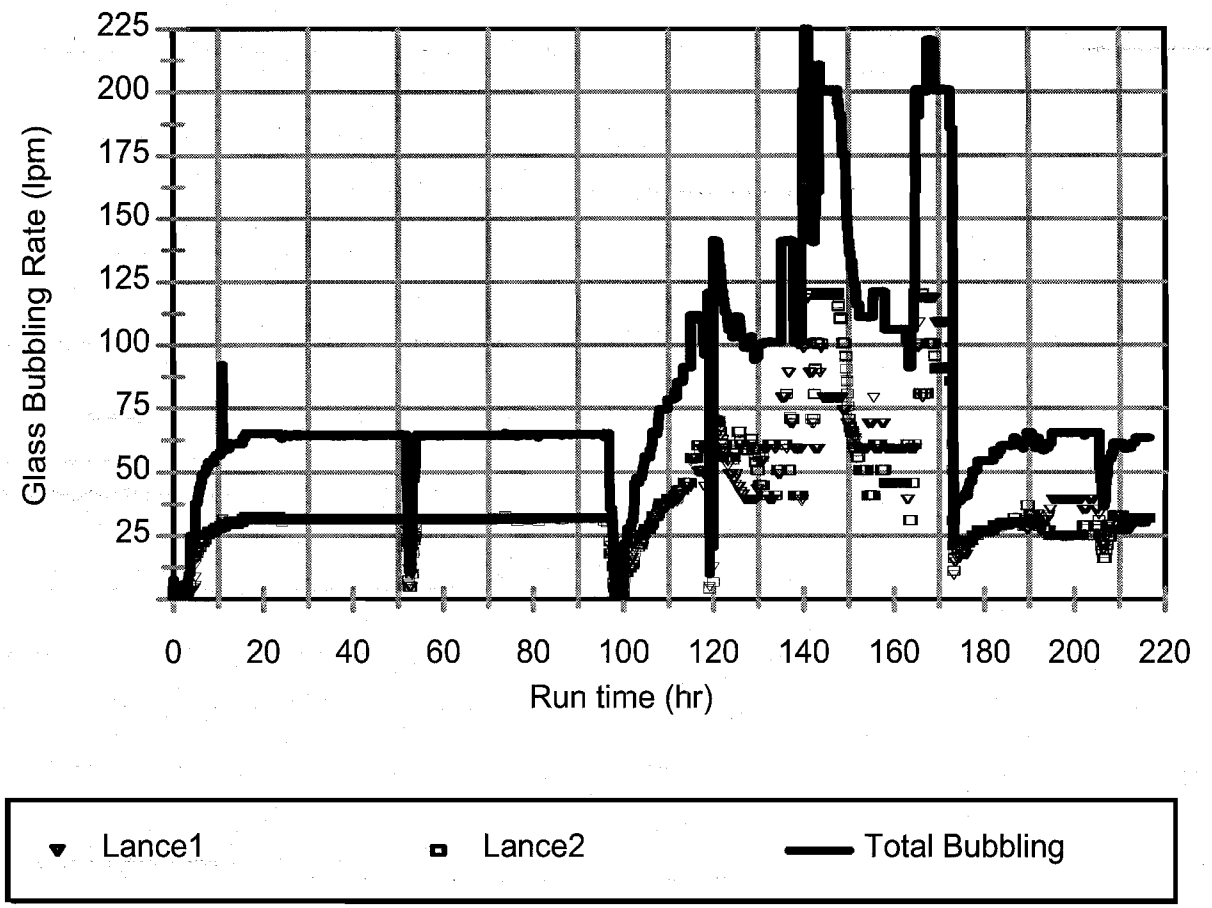

Figure 4.7.a. Glass pool bubbling for AZ-102 DM1200 Test (Test 1).

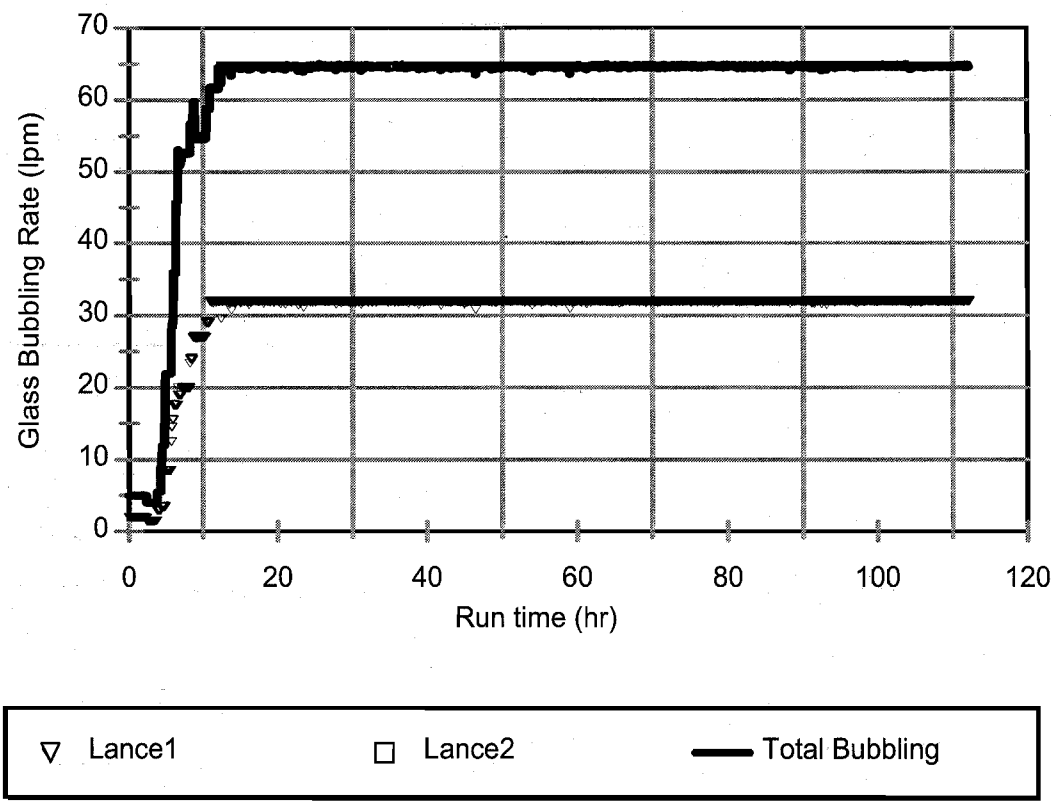

Figure 4.7.b. Glass pool bubbling for the adjusted rheology C-106/AY-102 DM1200 test (Test 2A).

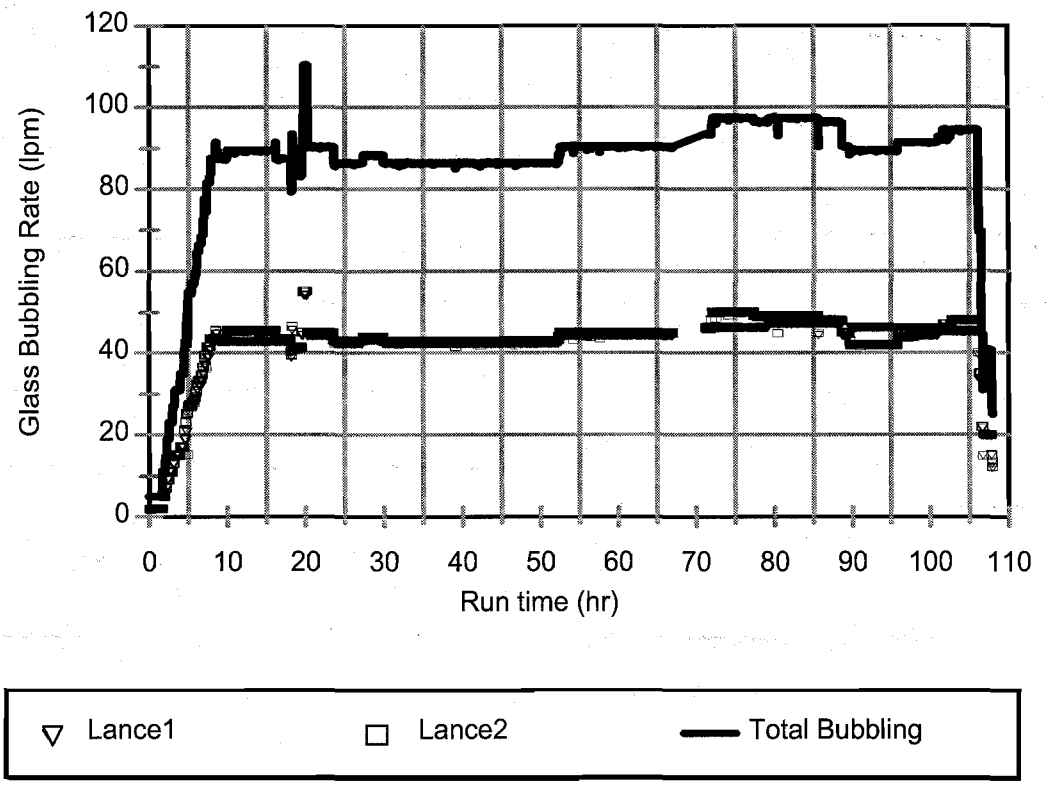

Figure 4.7.c. Glass pool bubbling for the high waste loading C-106/AY-102 DM1200 test (Test 2B).

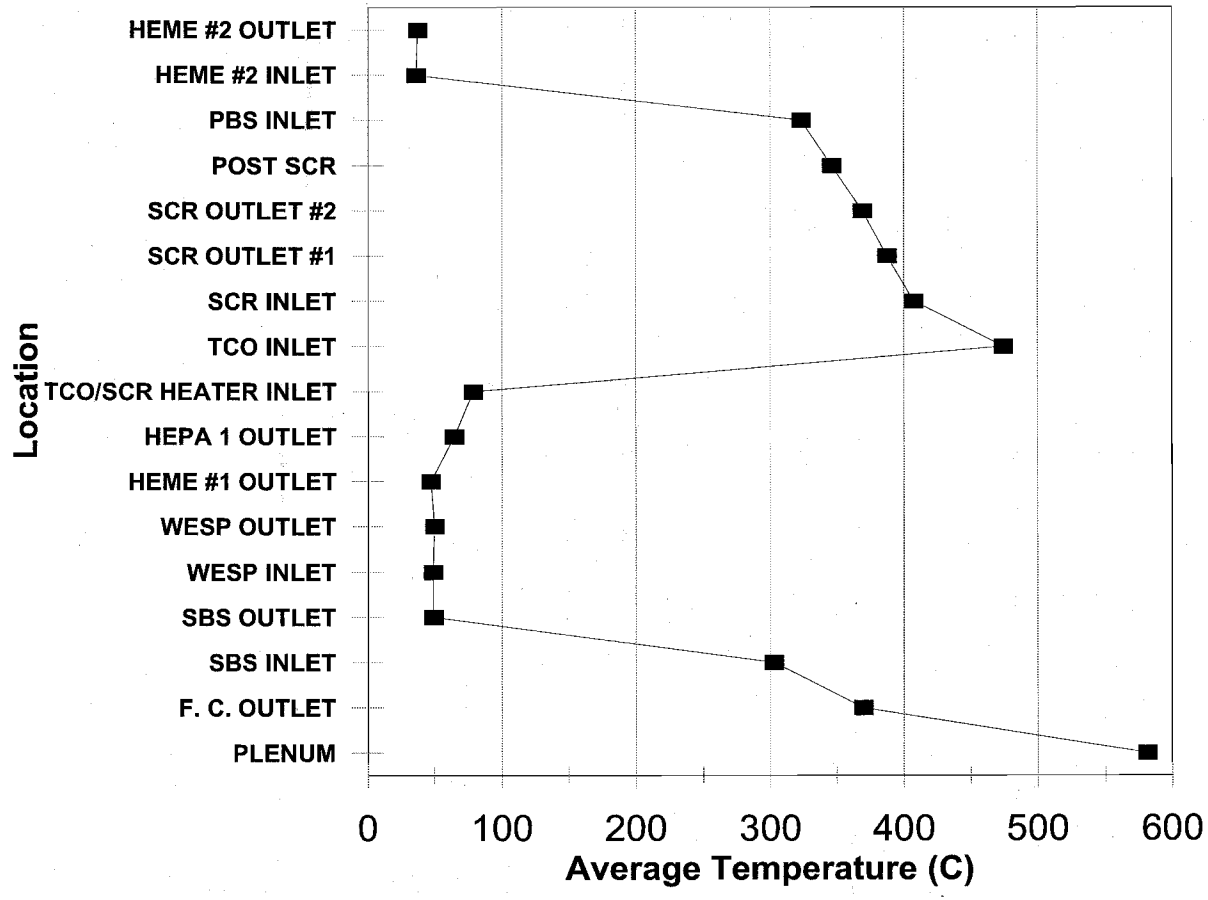

Figure 5.1. Average gas temperatures along the DM1200 off-gas train during Test 1.

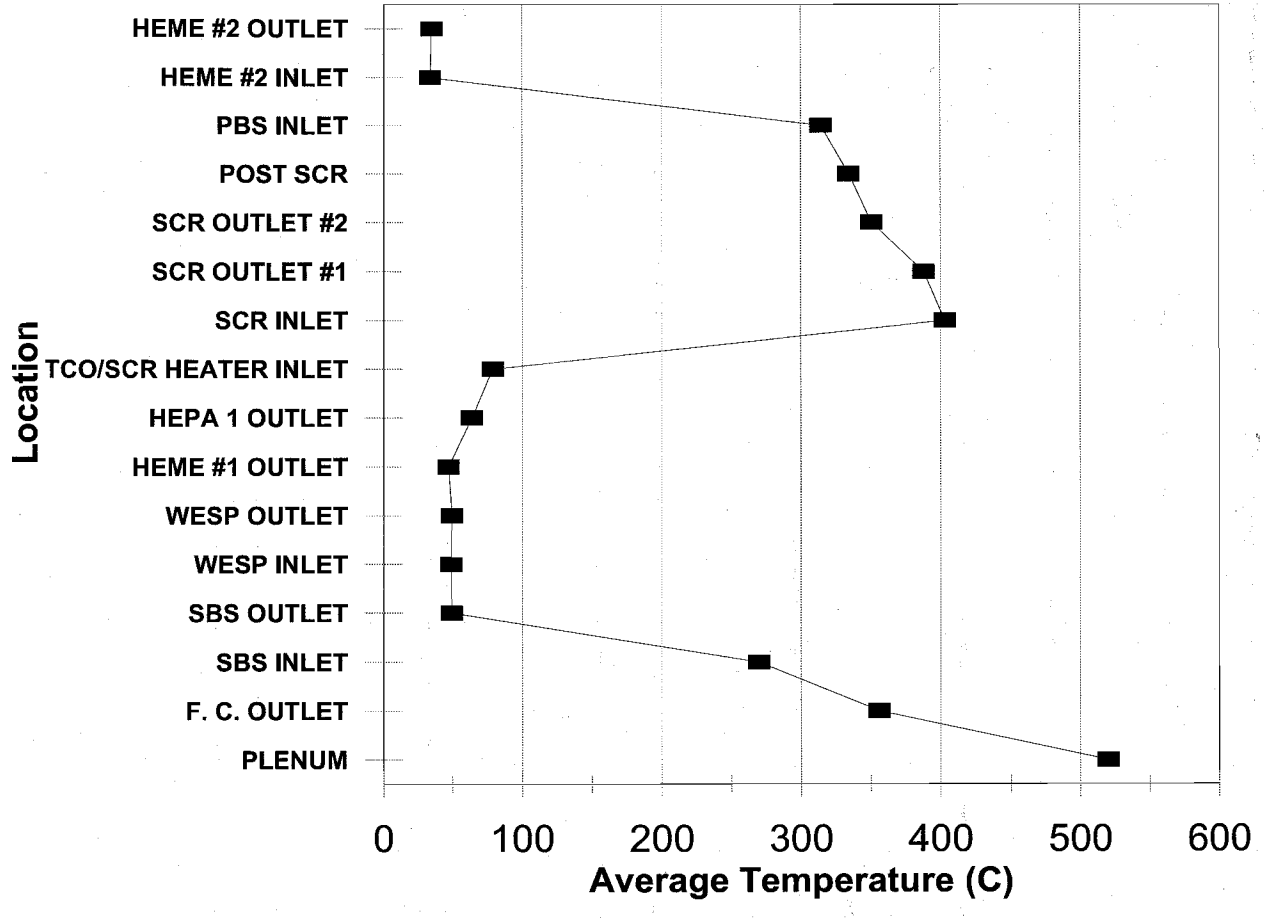

Figure 5.2. Average gas temperatures along the DM1200 off-gas train during Test 2A.

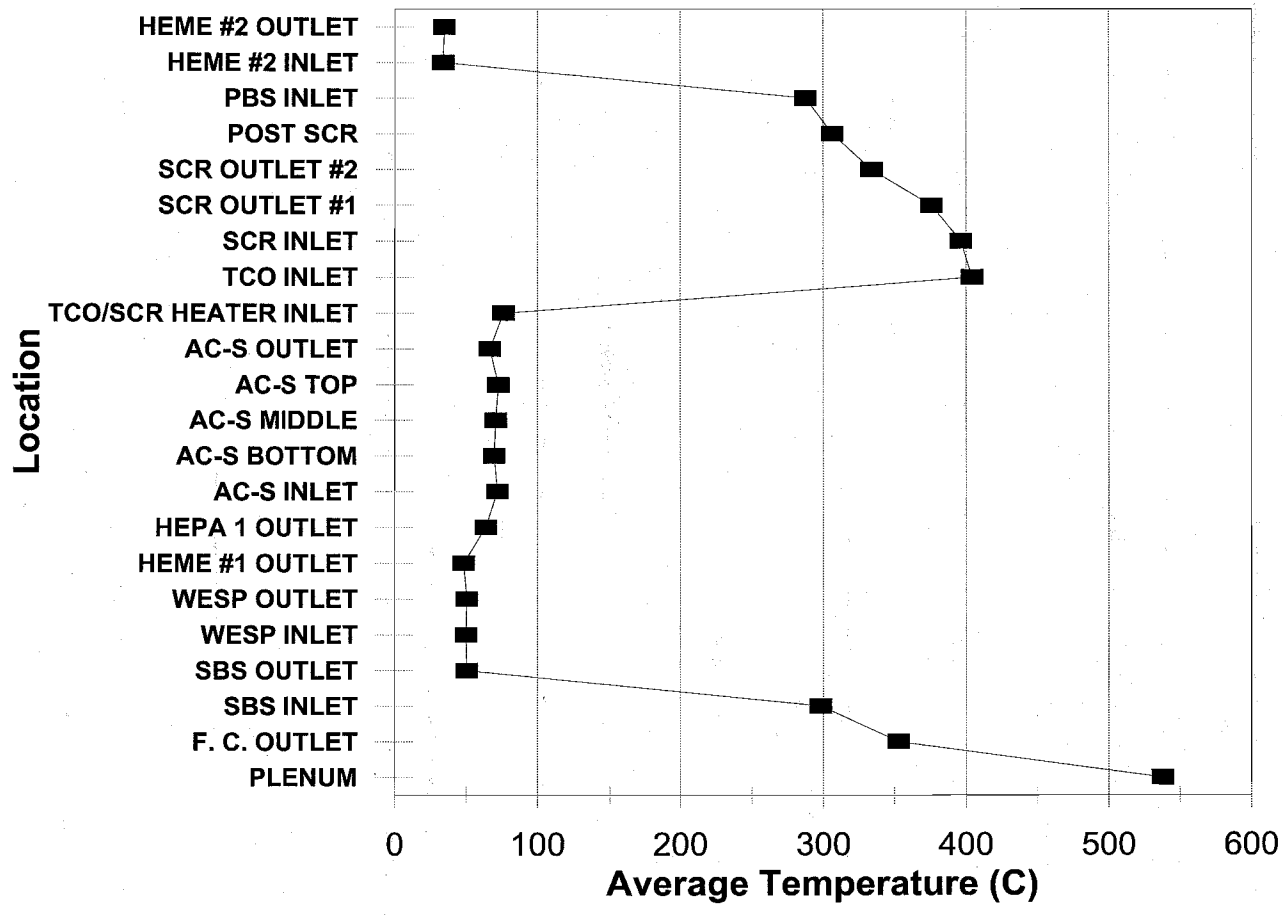

Figure 5.3. Average gas temperatures along the DM1200 off-gas train during Test 2B.

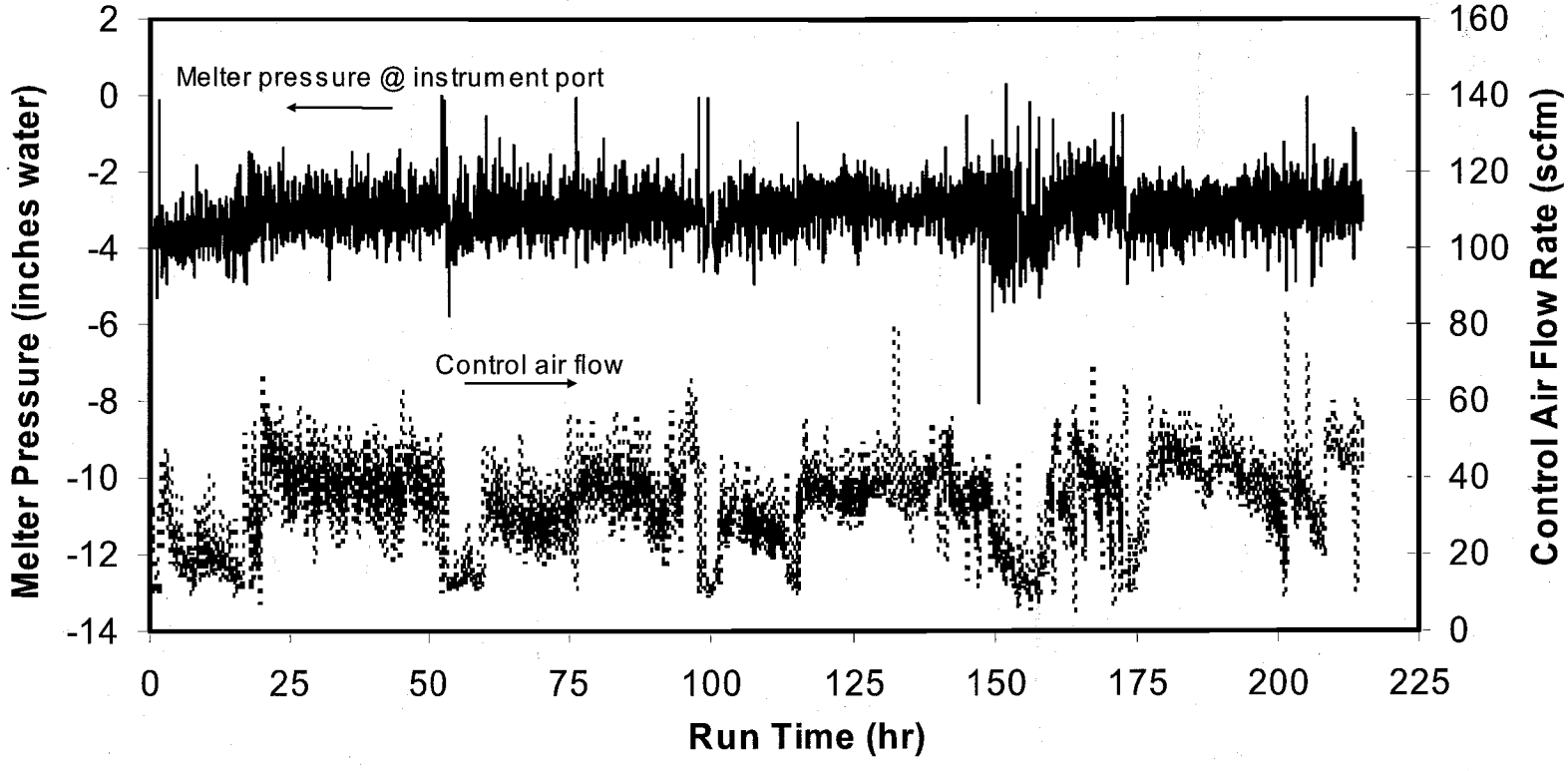

Figure 5.4. Melter pressure at instrument port and control air flow rate during Test 1.

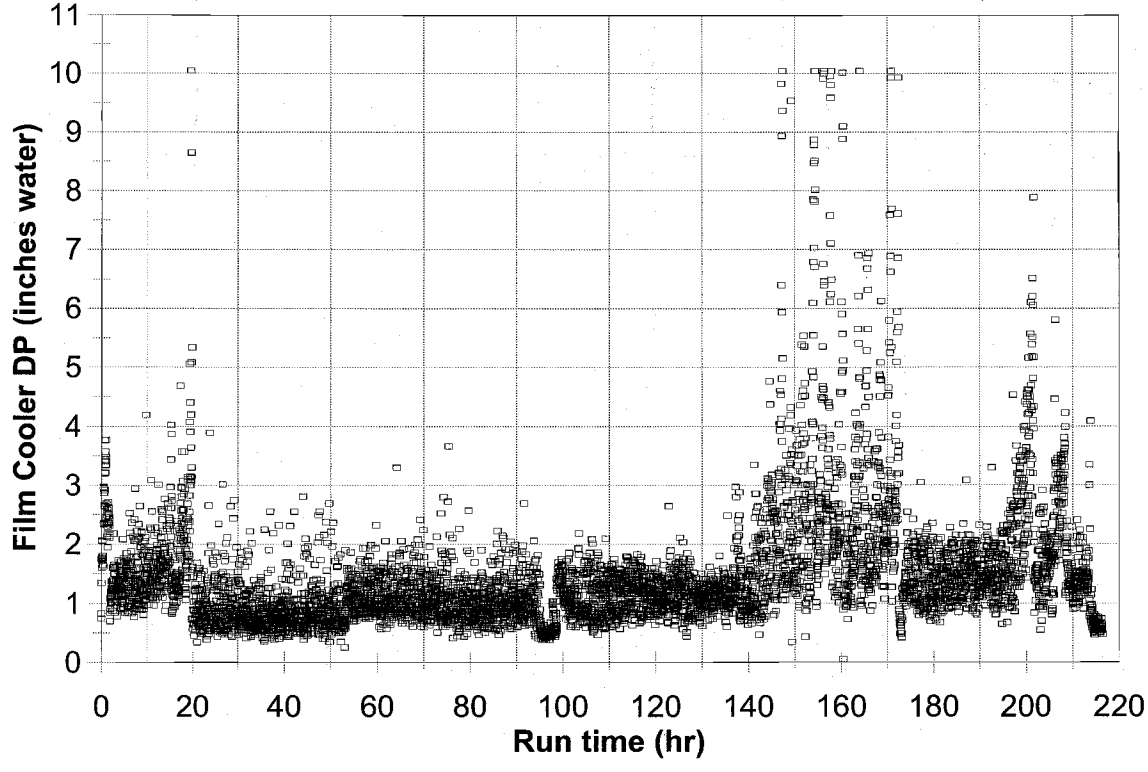

Figure 5.5. Film cooler differential pressure during Test 1.

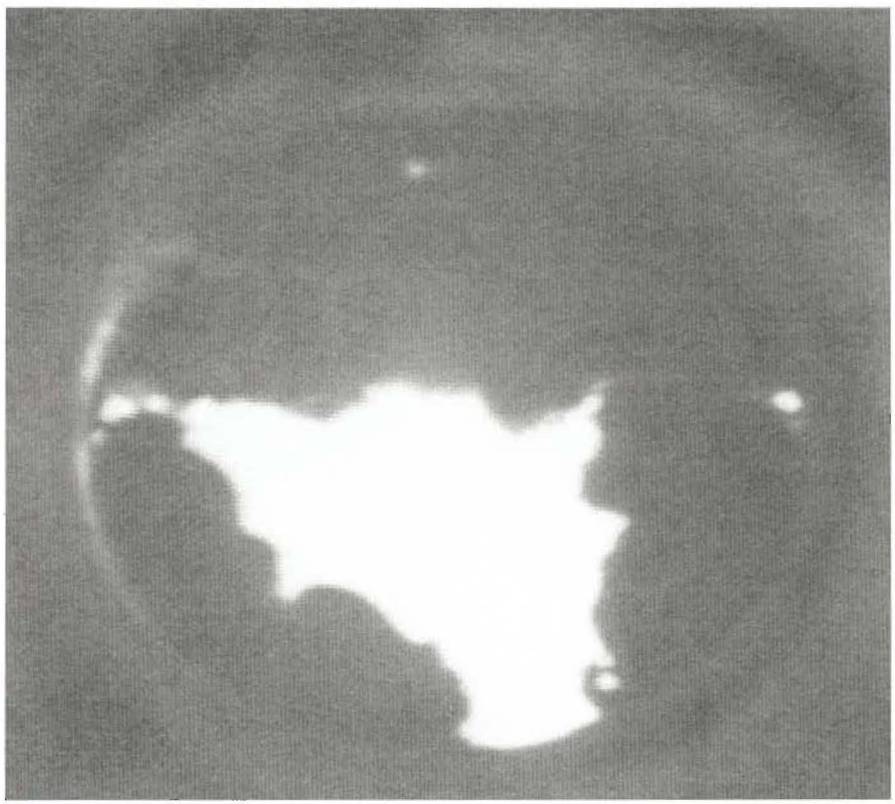

Figure 5.6. View of the partially clogged film cooler (from the top) at 156.4 hours during Test 1.

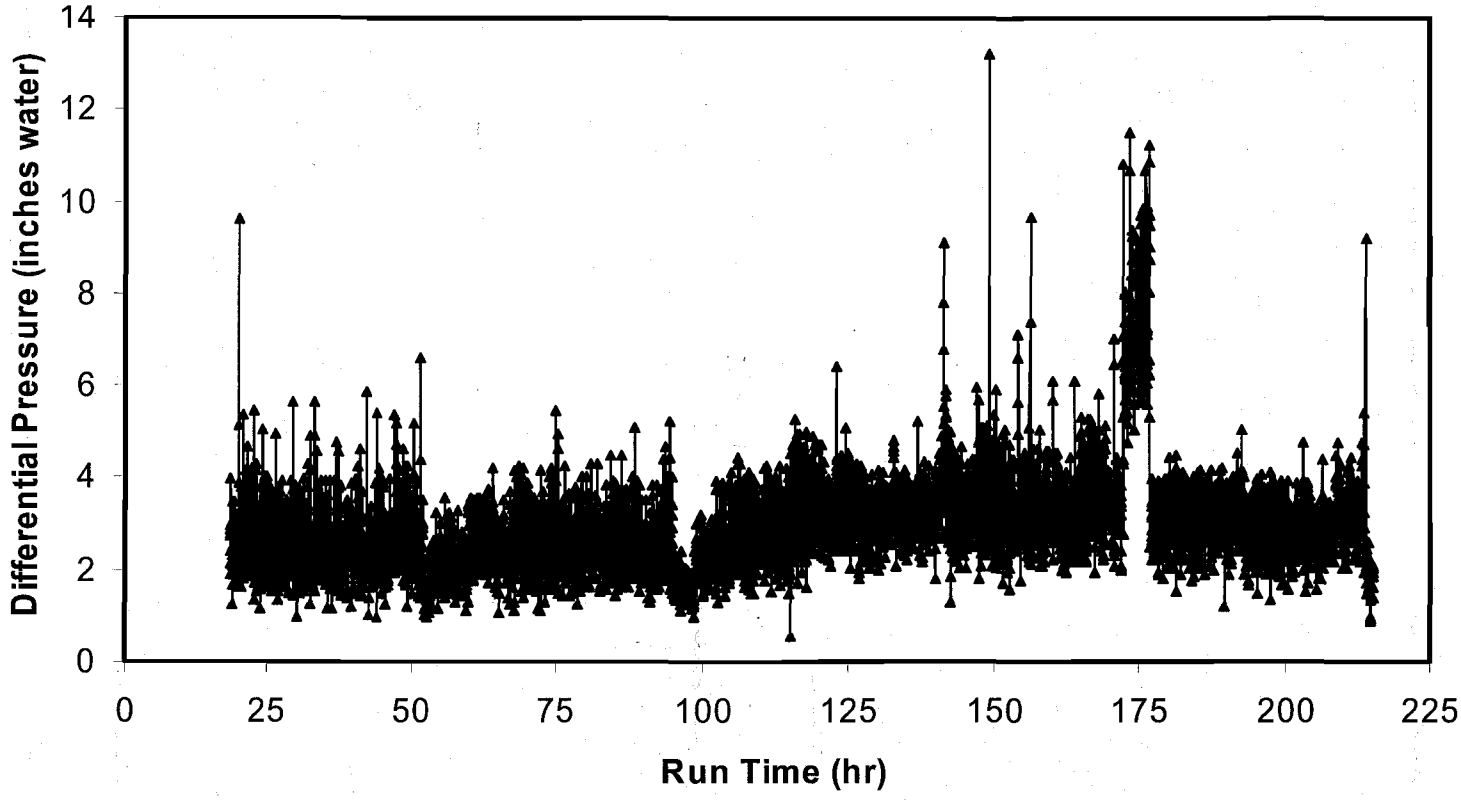

Figure 5.7. Transition line differential pressure during Test 1.

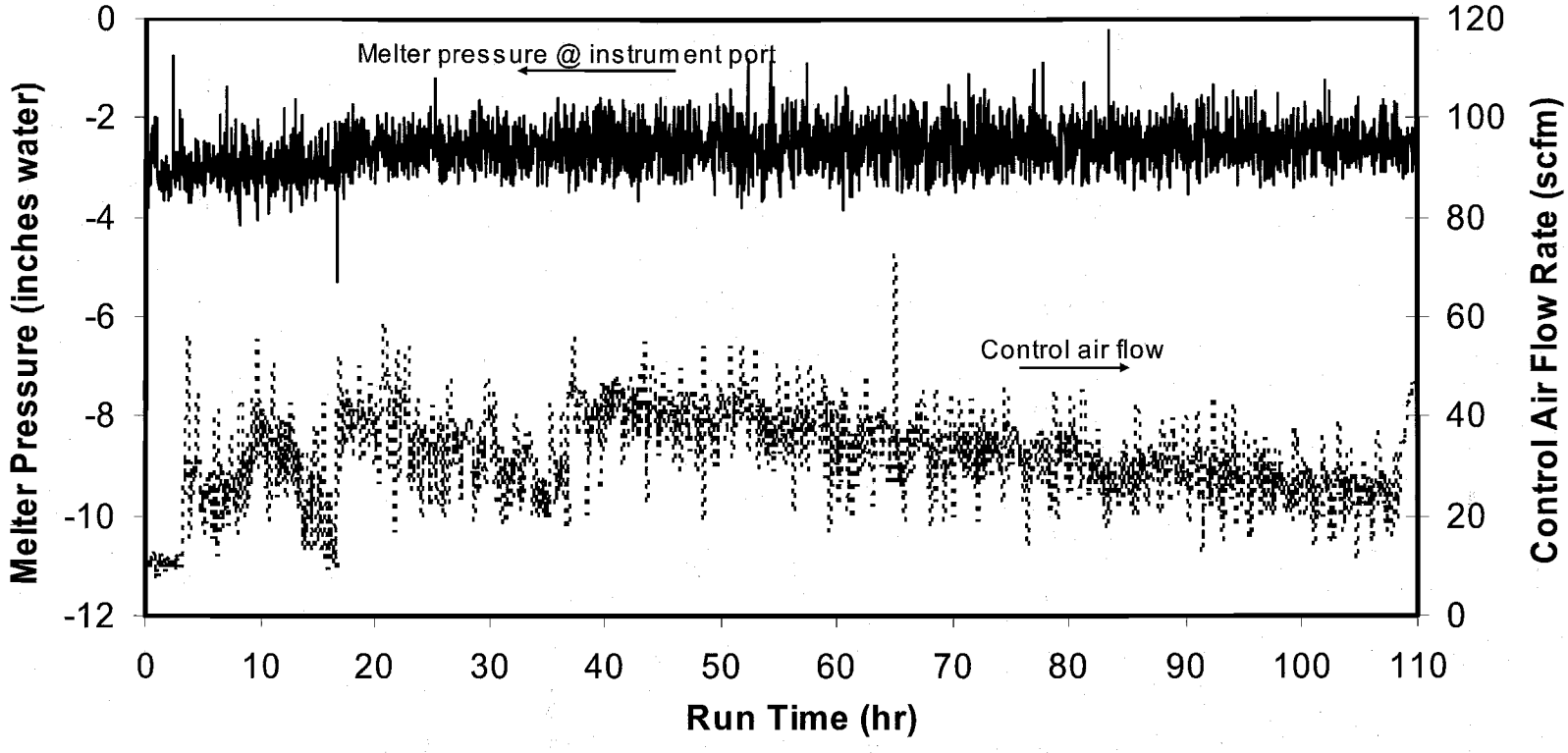

Figure 5.8 Melter pressure at instrument port and control air flow rate during Test 2A.

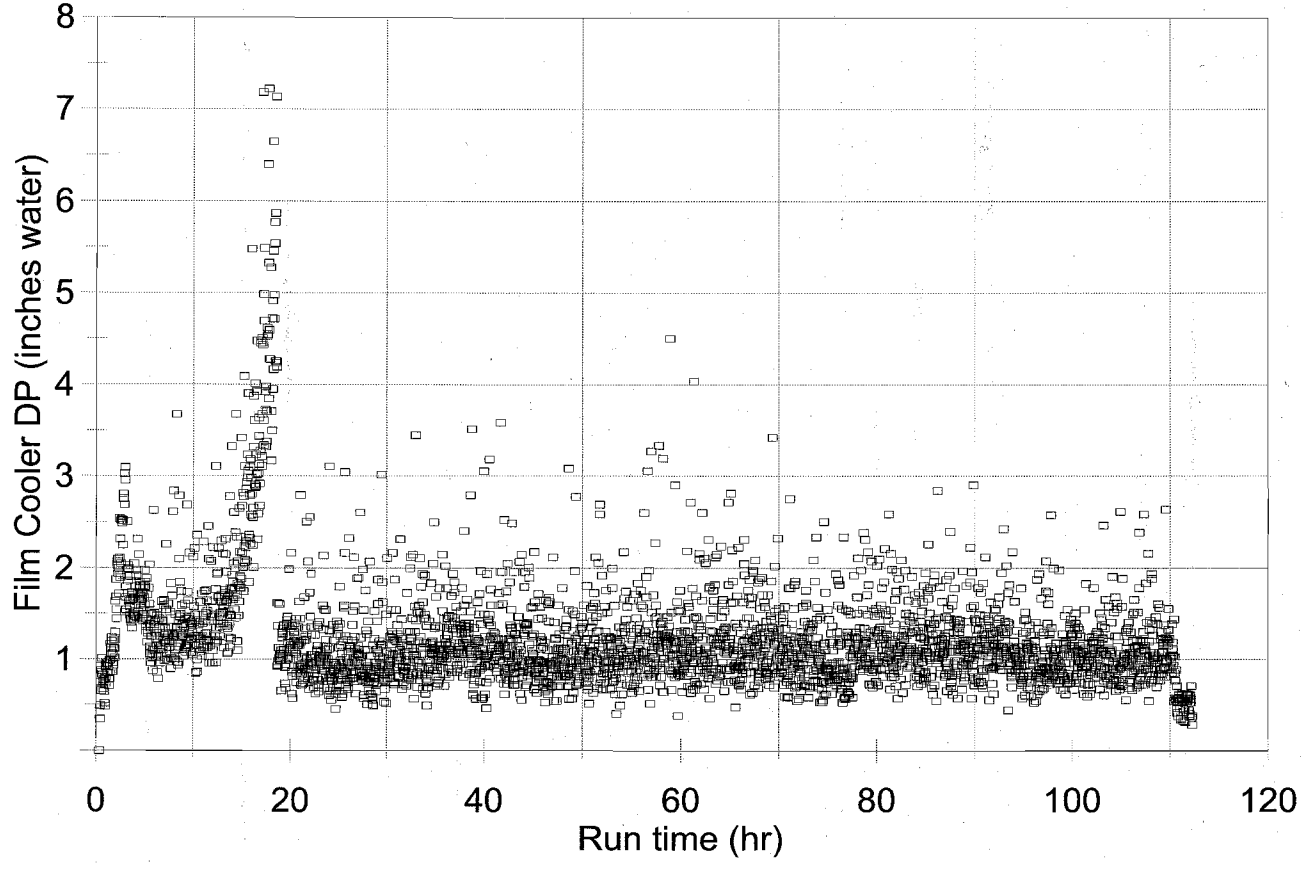

Figure 5.9. Film cooler differential pressure during Test 2A.

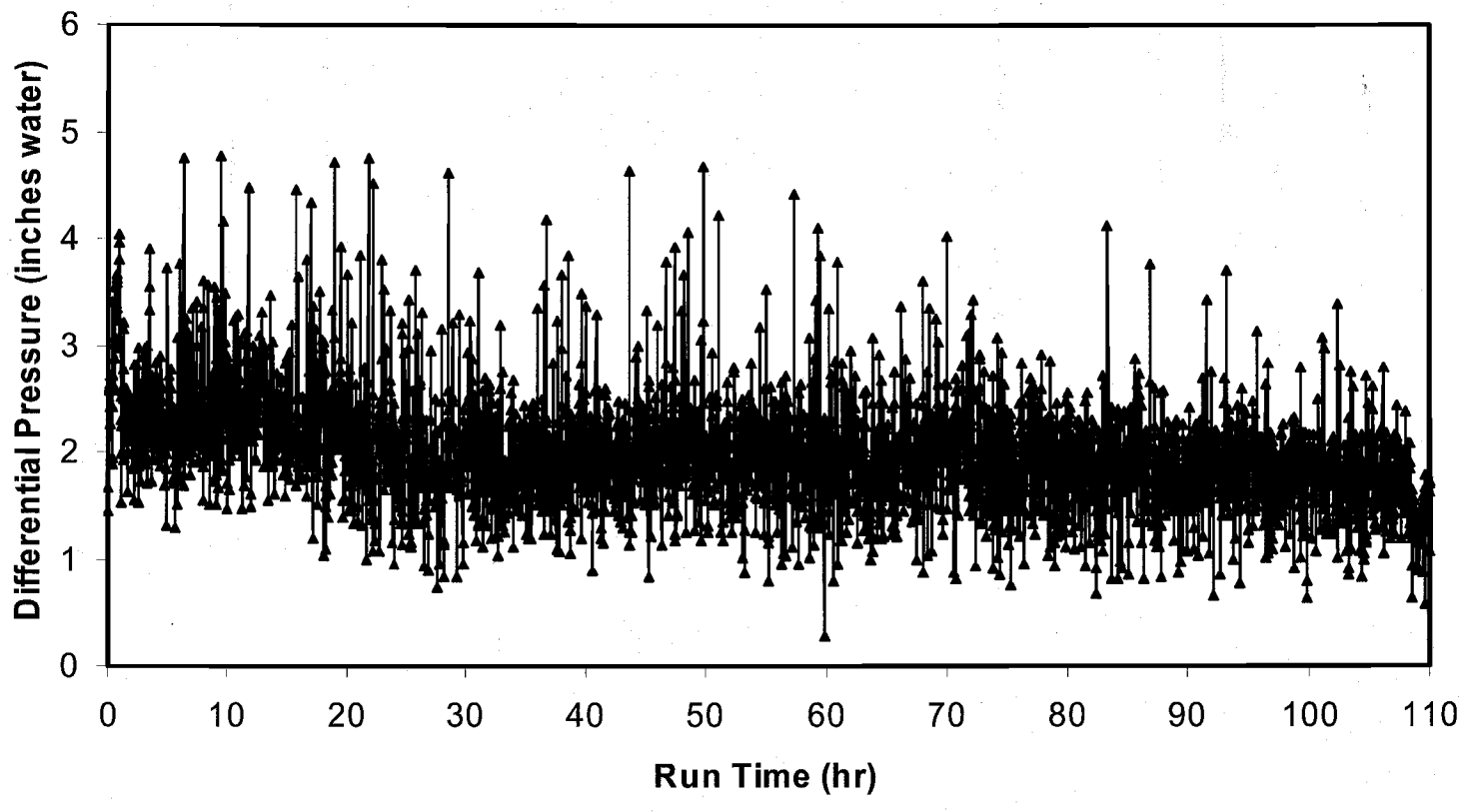

Figure 5.10. Transition line differential pressure during Test 2A.

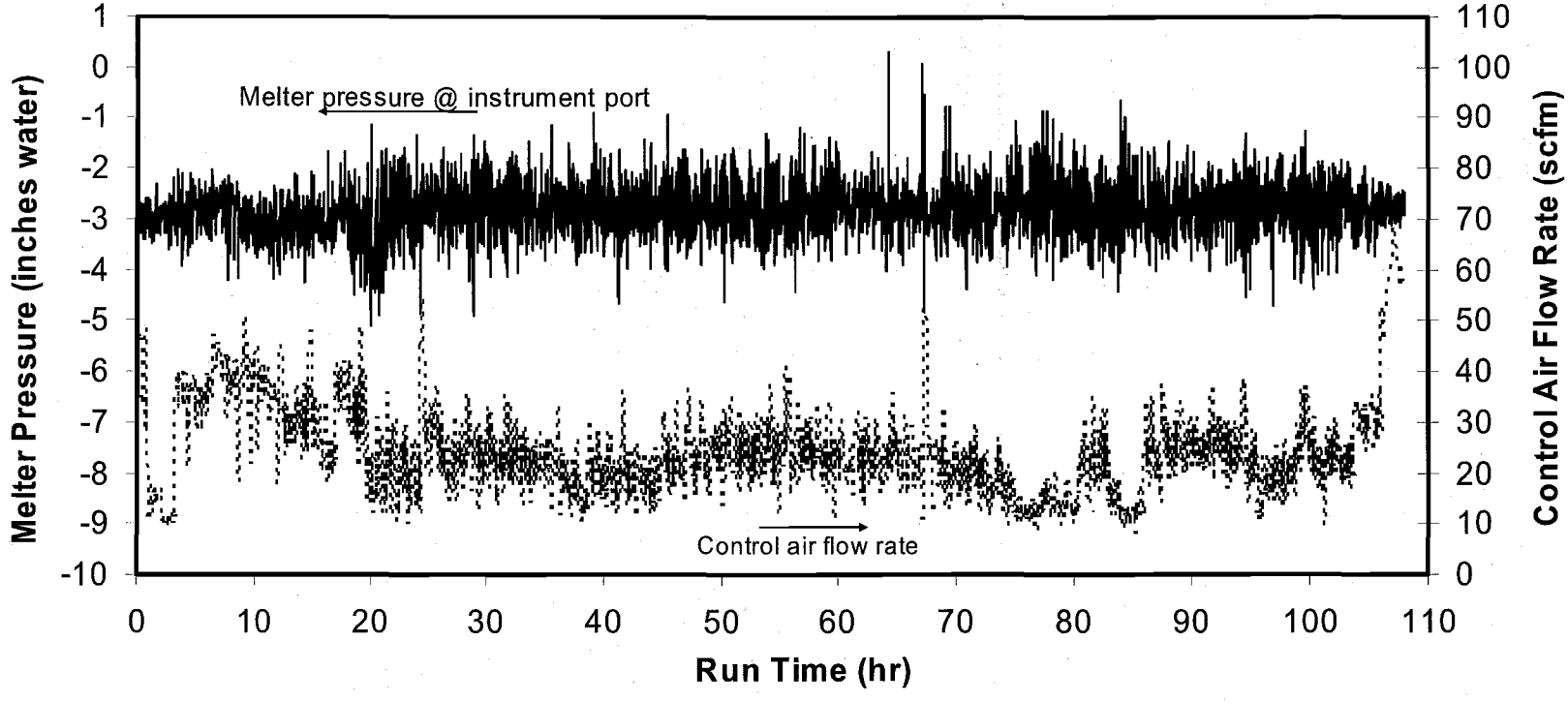

Figure 5.11. Melter pressure at instrument port and control air flow rate during Test 2B.

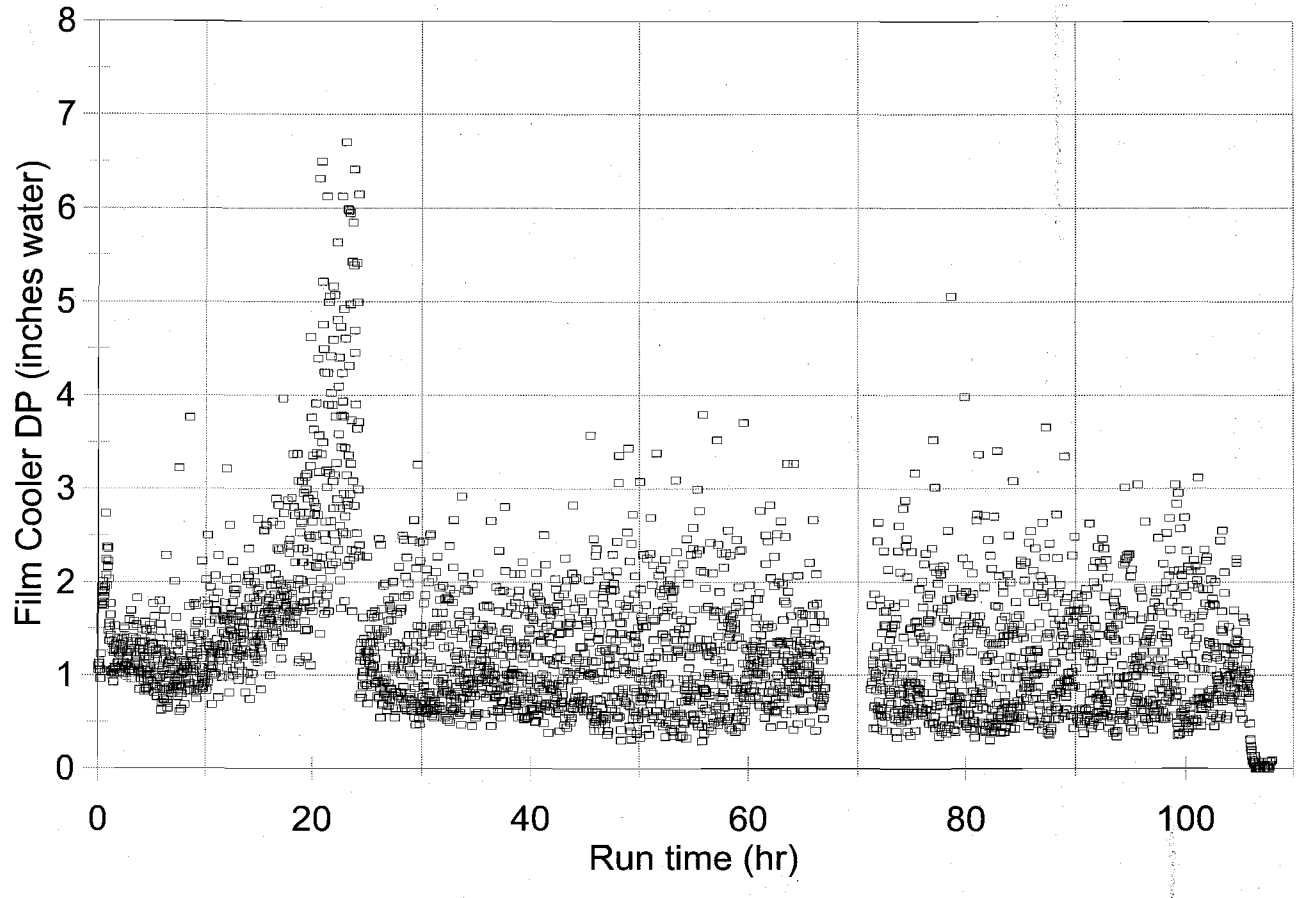

Figure 5.12. Film cooler differential pressure during Test 2B.

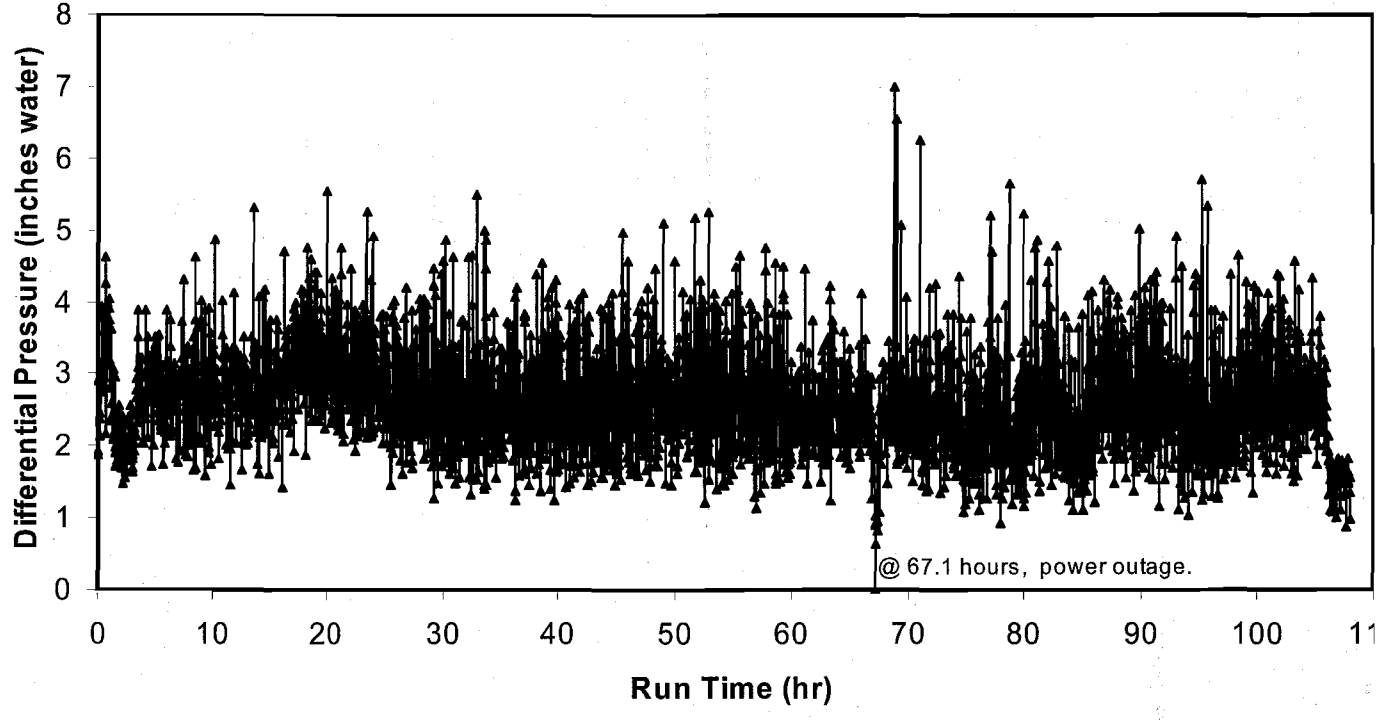

Figure 5.13. Transition line differential pressure during Test 2B.

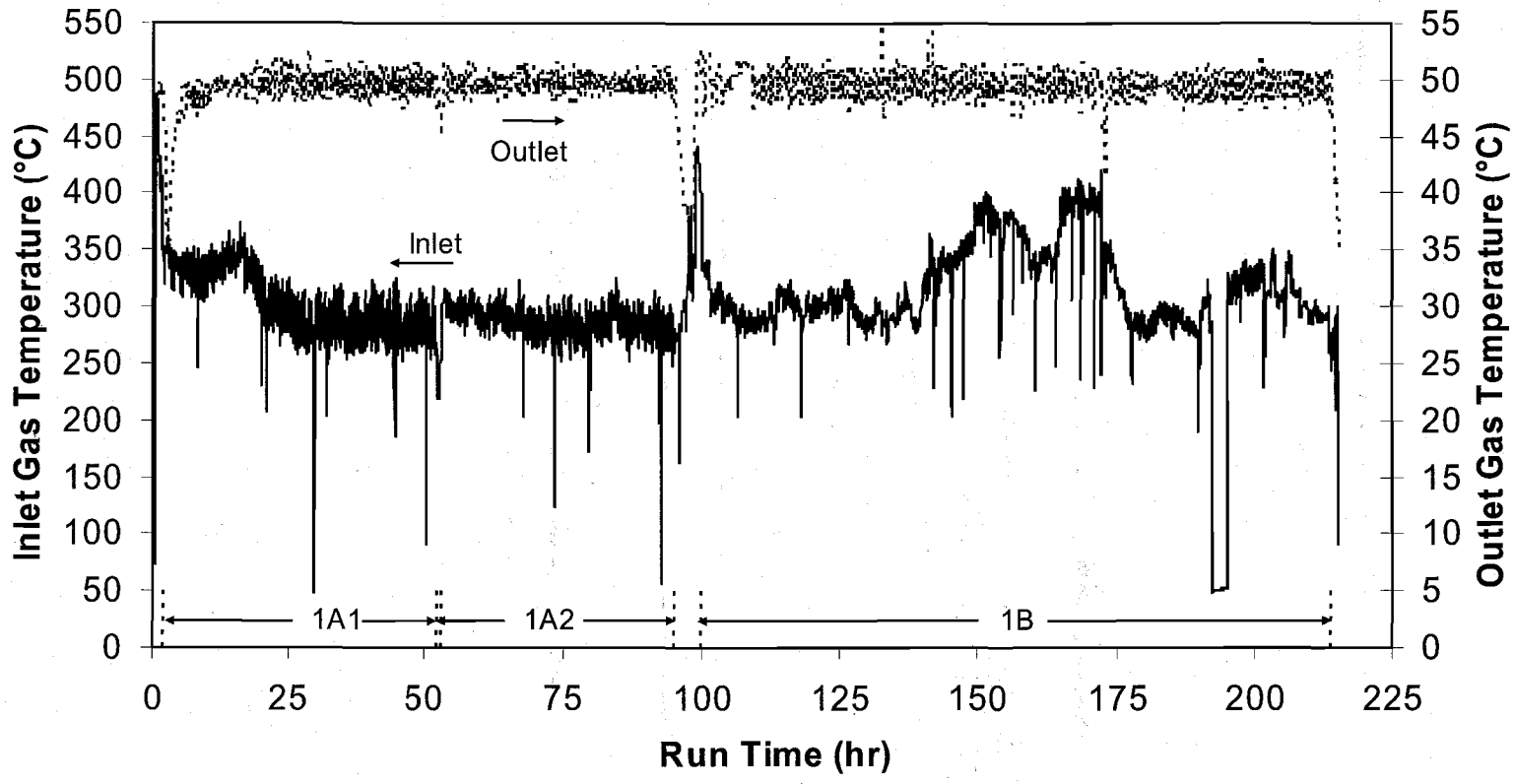

Figure 5.14. SBS inlet and outlet gas temperatures during Test 1.

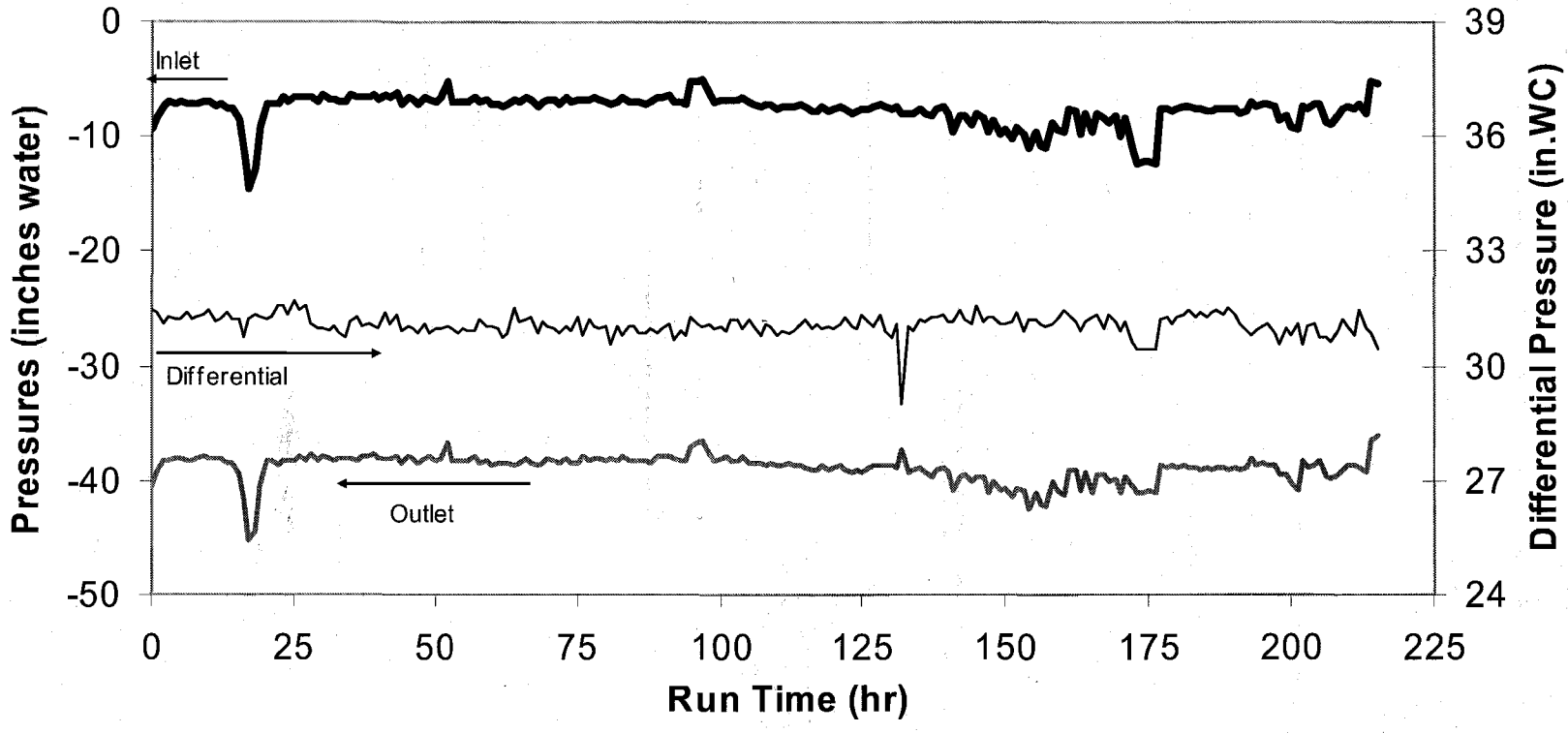

Figure 5.15. SBS inlet, outlet, and differential pressures (hourly average values) during Test 1.

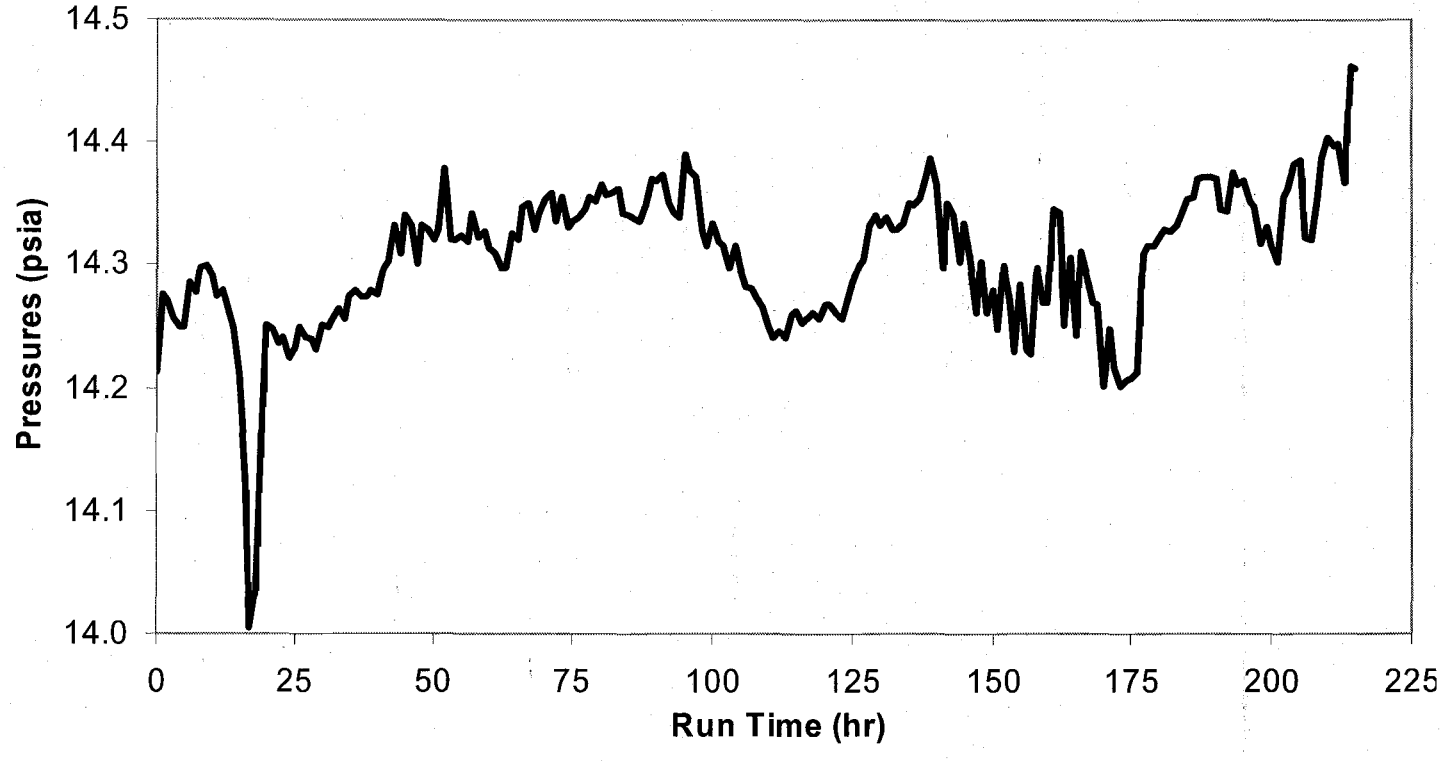

Figure 5.16. SBS downcomer annulus pressure (hourly average values) during Test 1.

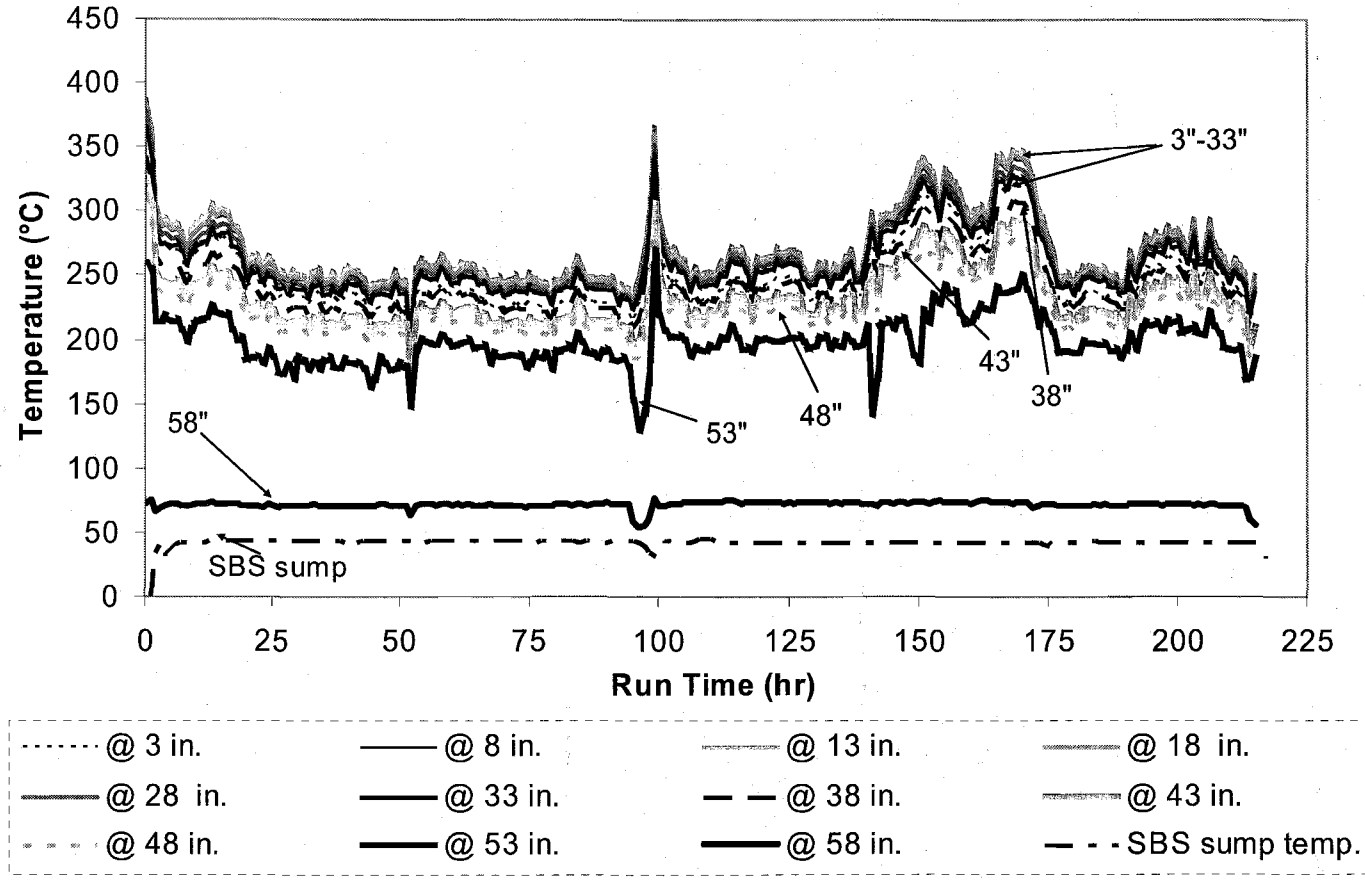

Figure 5.17. Off-gas temperatures in the SBS downcomer and sump water temperatures (hourly average values) during Test 1.

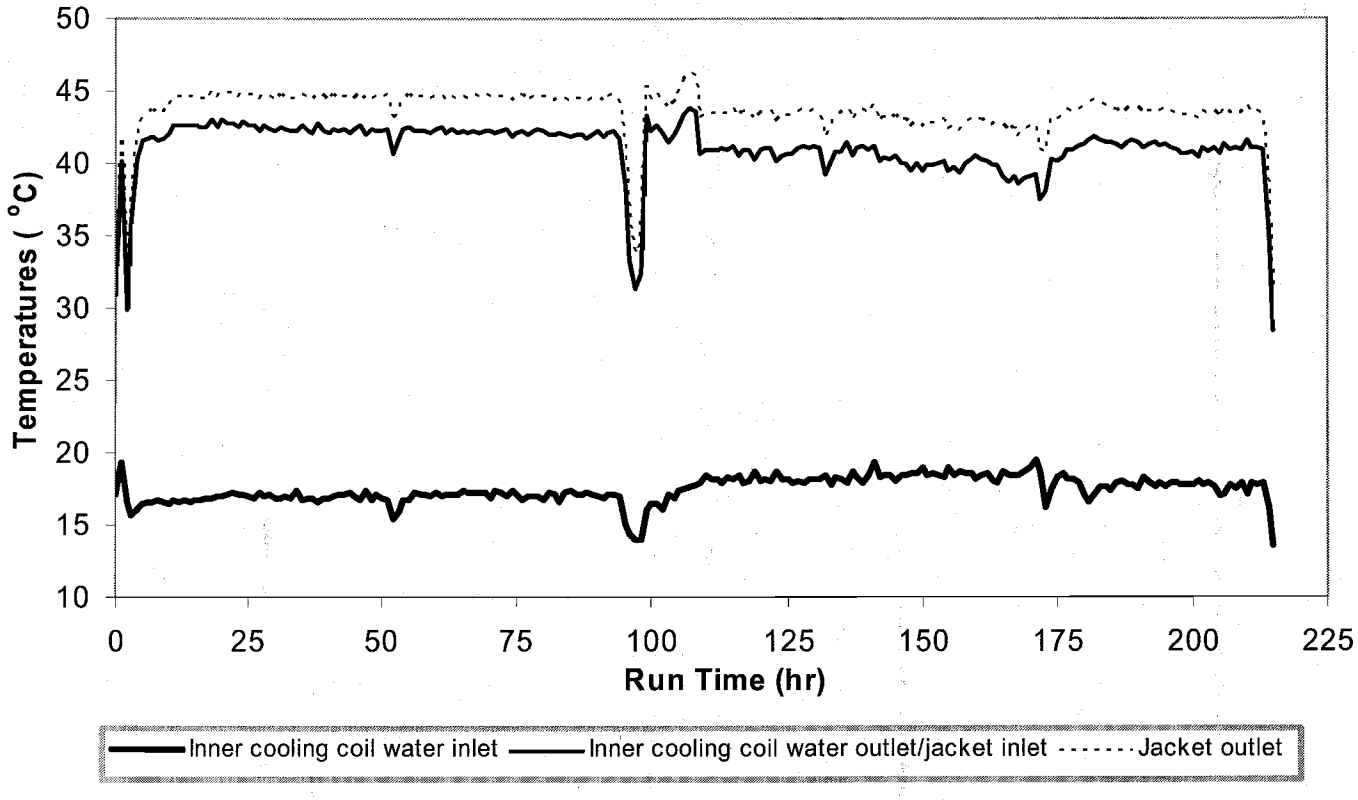

Figure 5.18. SBS cooling coil inlet, cooling coil outlet/jacket inlet and jacket outlet water temperatures (hourly average values) during Test 1.

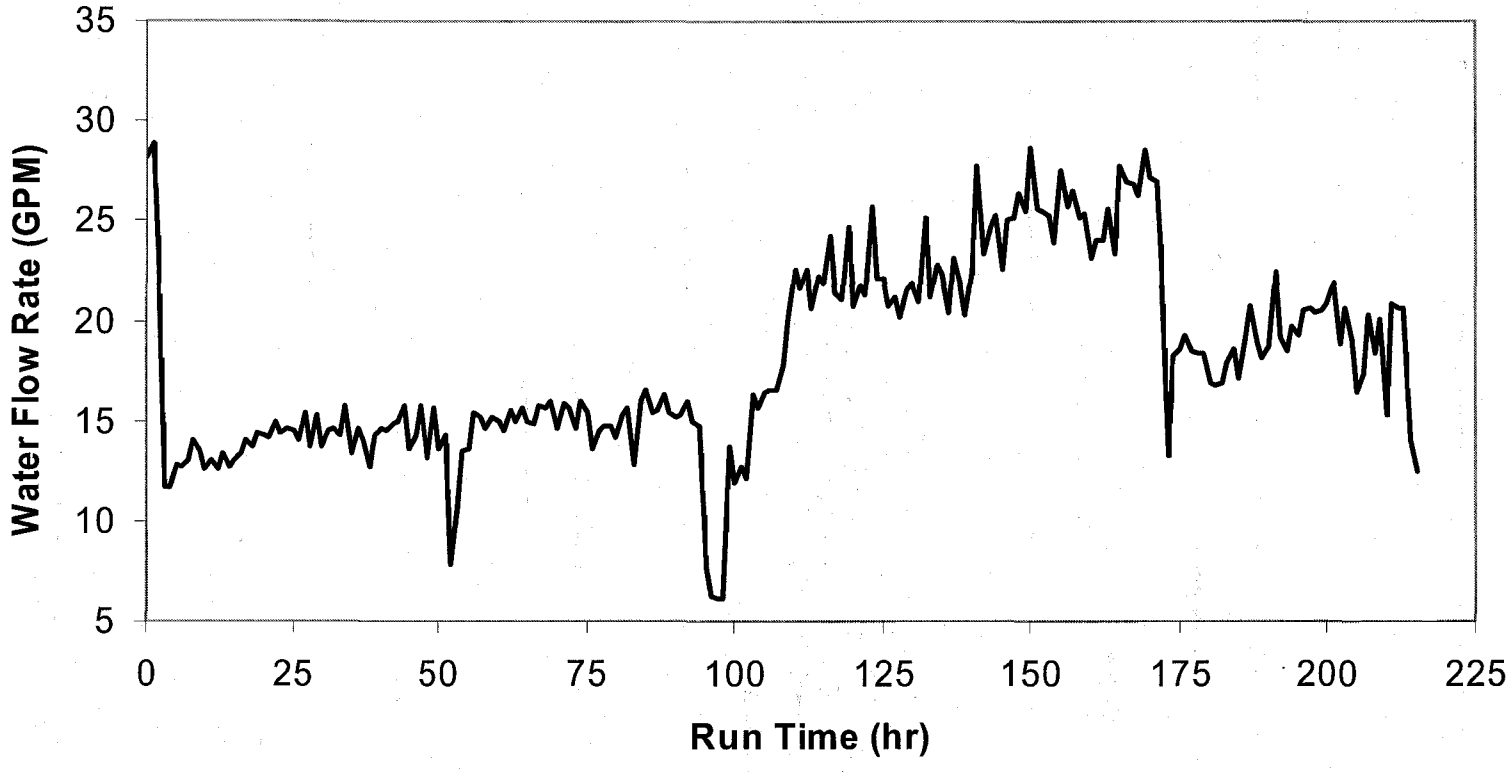

Figure 5.19. SBS cooling coil/jacket water flow rate (hourly average values) during Test 1.

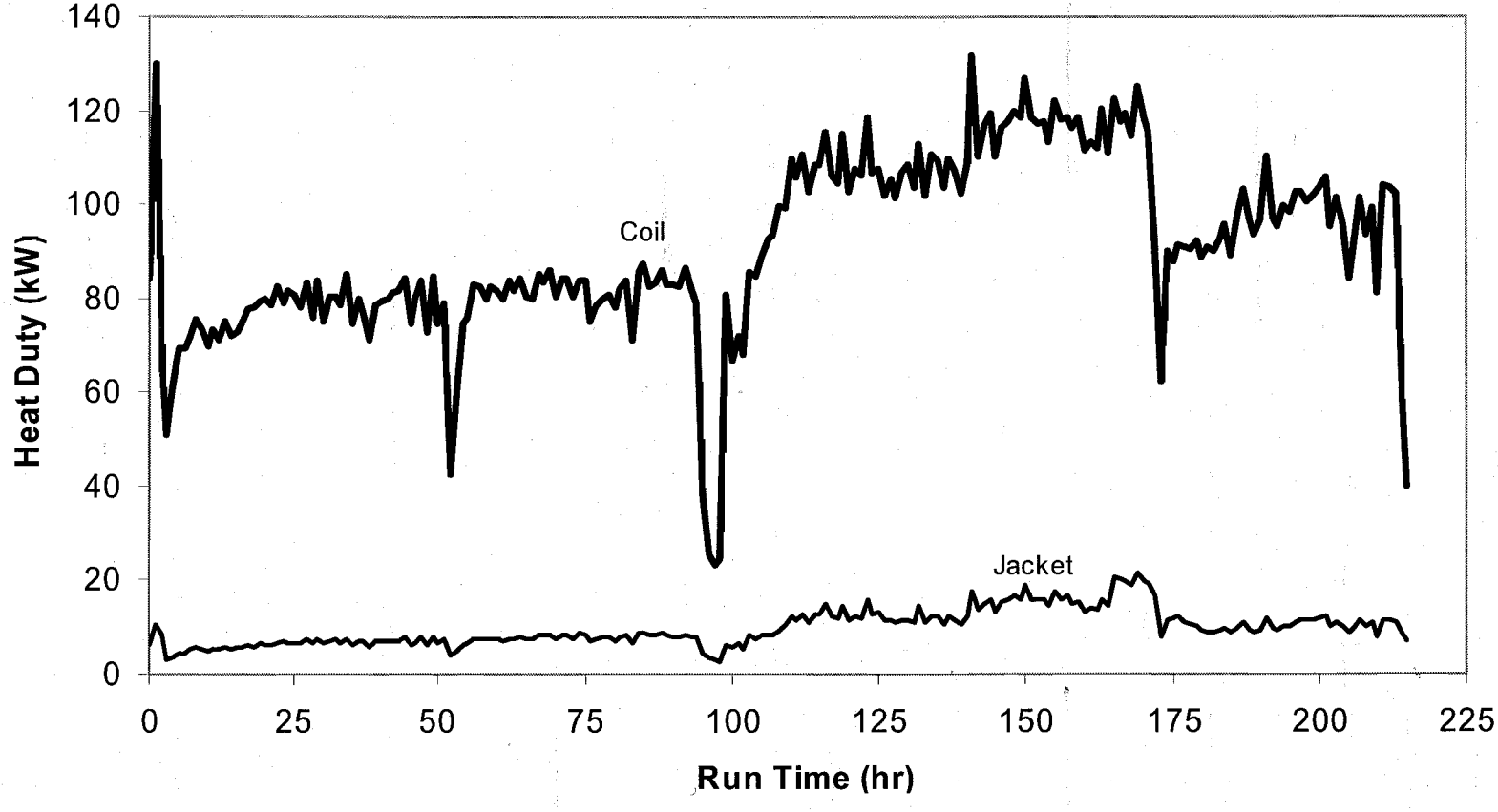

Figure 5.20. Calculated heat loads on the inner coil and jacket (hourly average values) during Test 1.

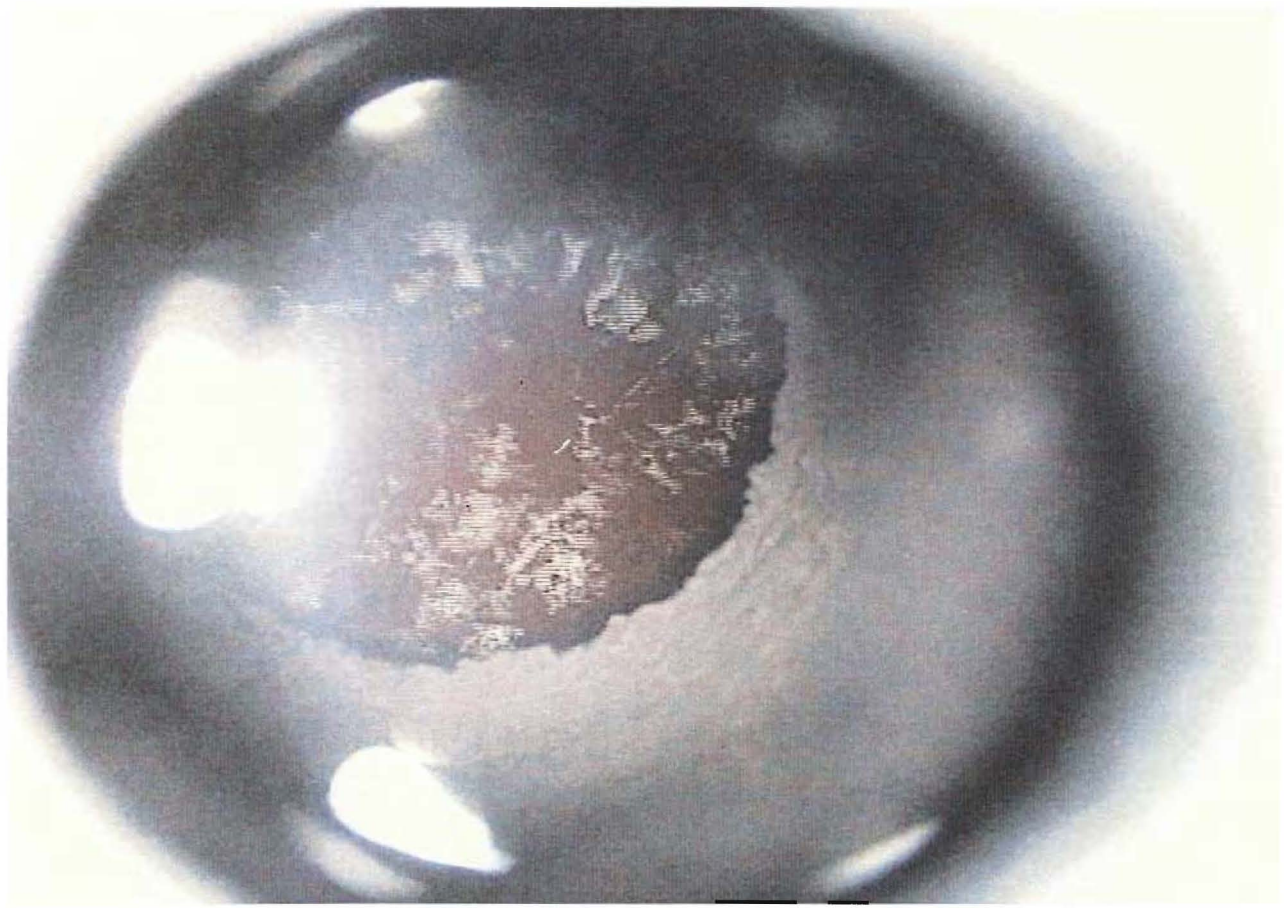

Figure 5.21. View from the inside of the bottom of the SBS downcomer at 192 hours.

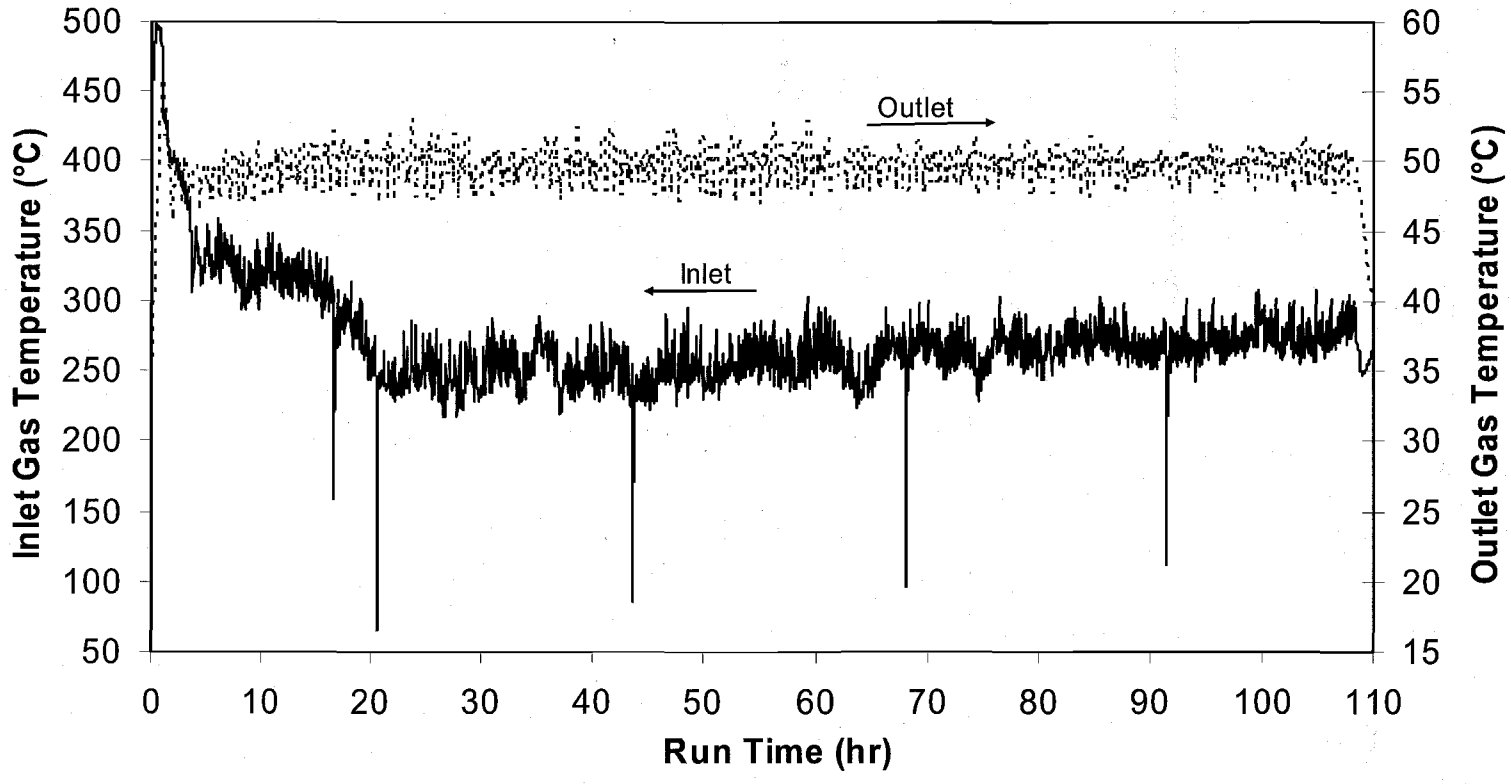

Figure 5.22. SBS inlet and outlet gas temperatures during Test 2A.

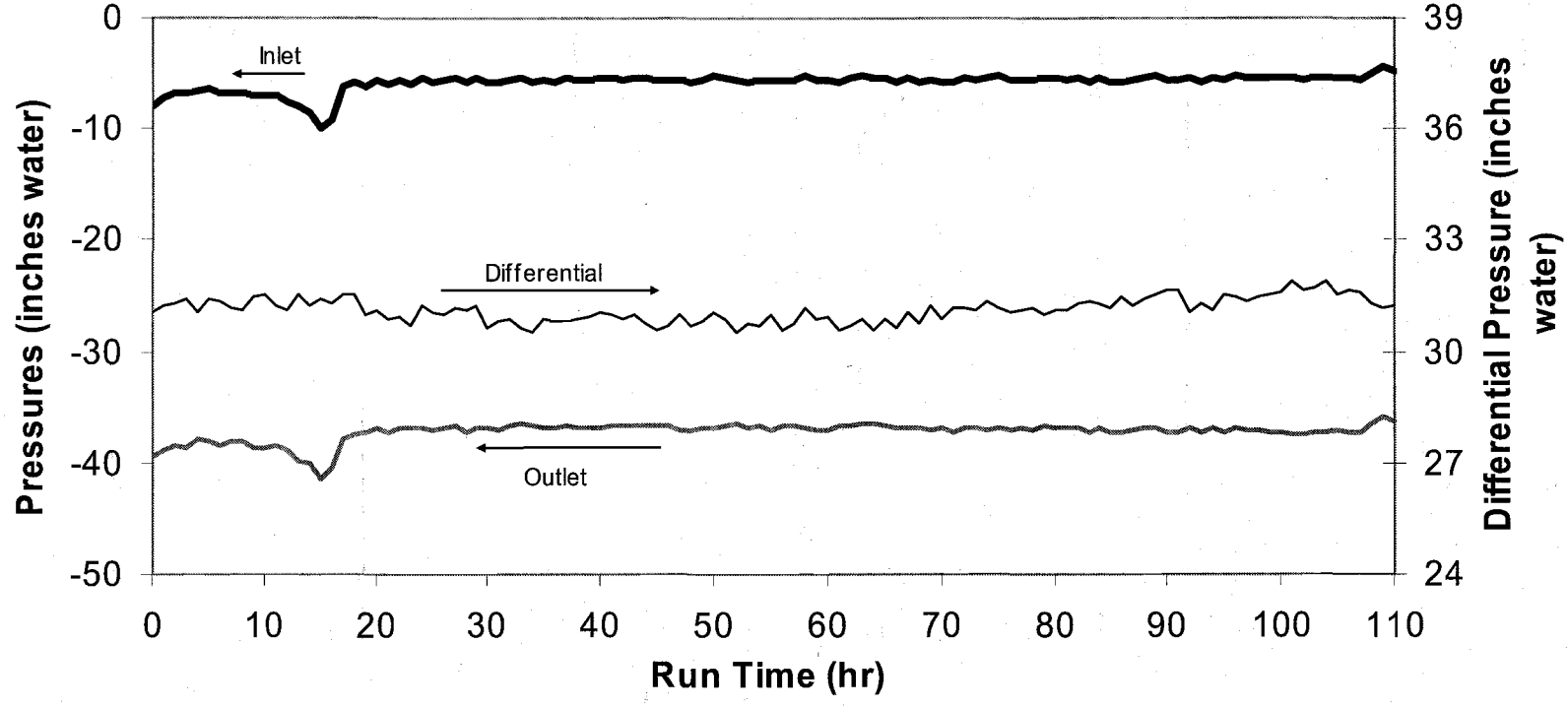

Figure 5.23. SBS inlet, outlet, and differential pressures (hourly average values) during Test 2A.

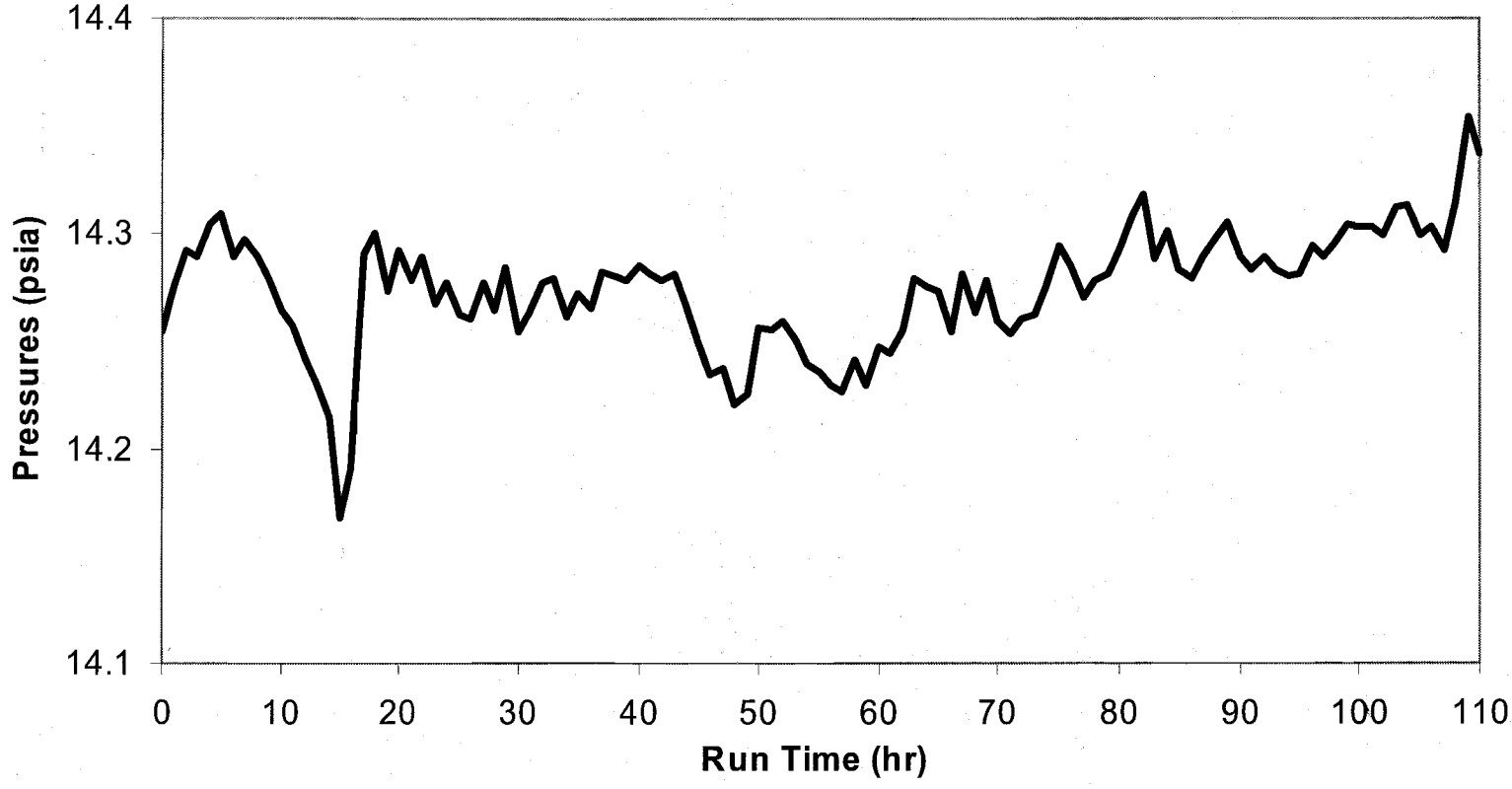

Figure 5.24. SBS downcomer annulus pressure (hourly average values) during Test 2A.

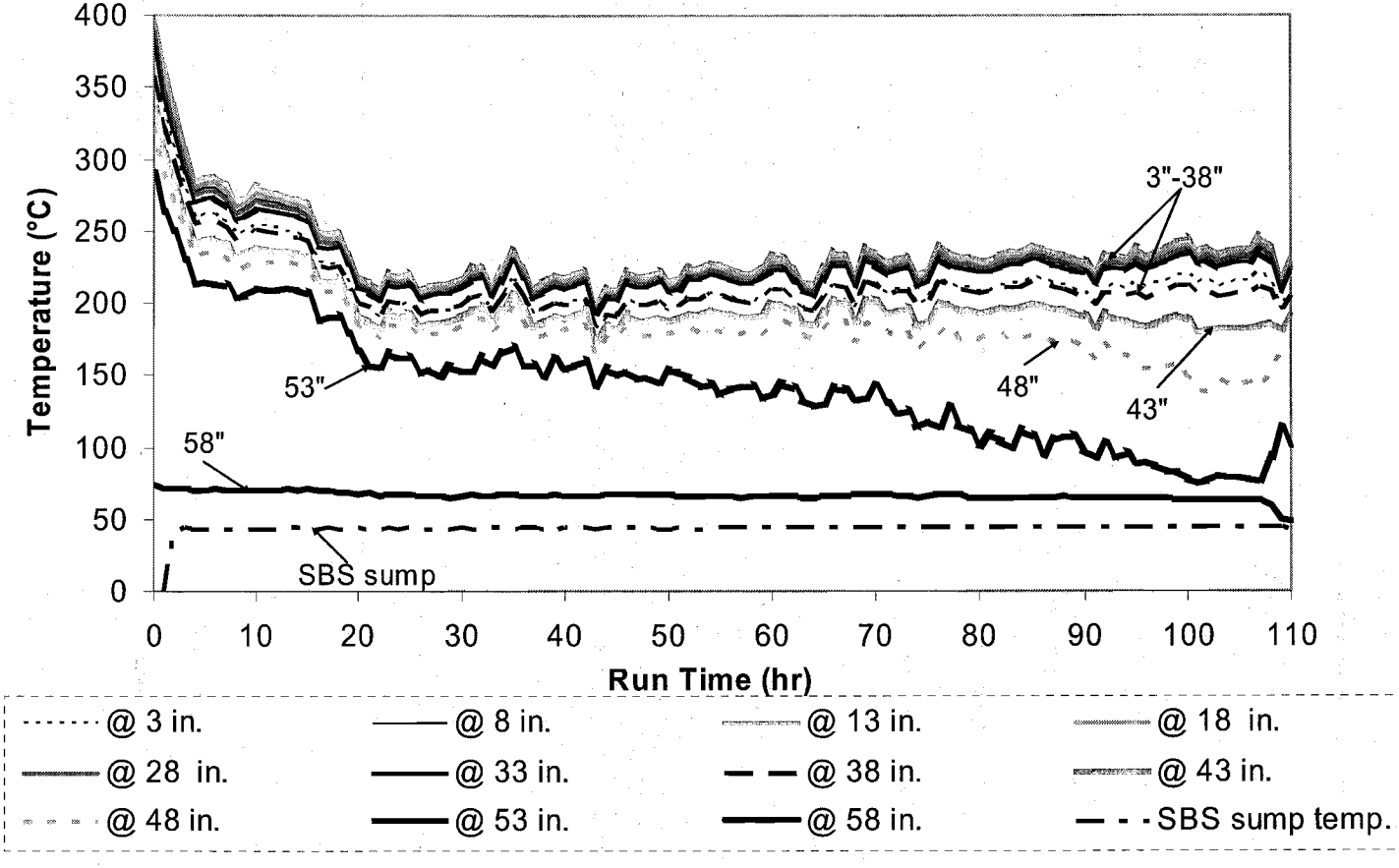

Figure 5.25. Off-gas temperatures in the SBS downcomer and sump water temperatures (hourly average values) during Test 2A.

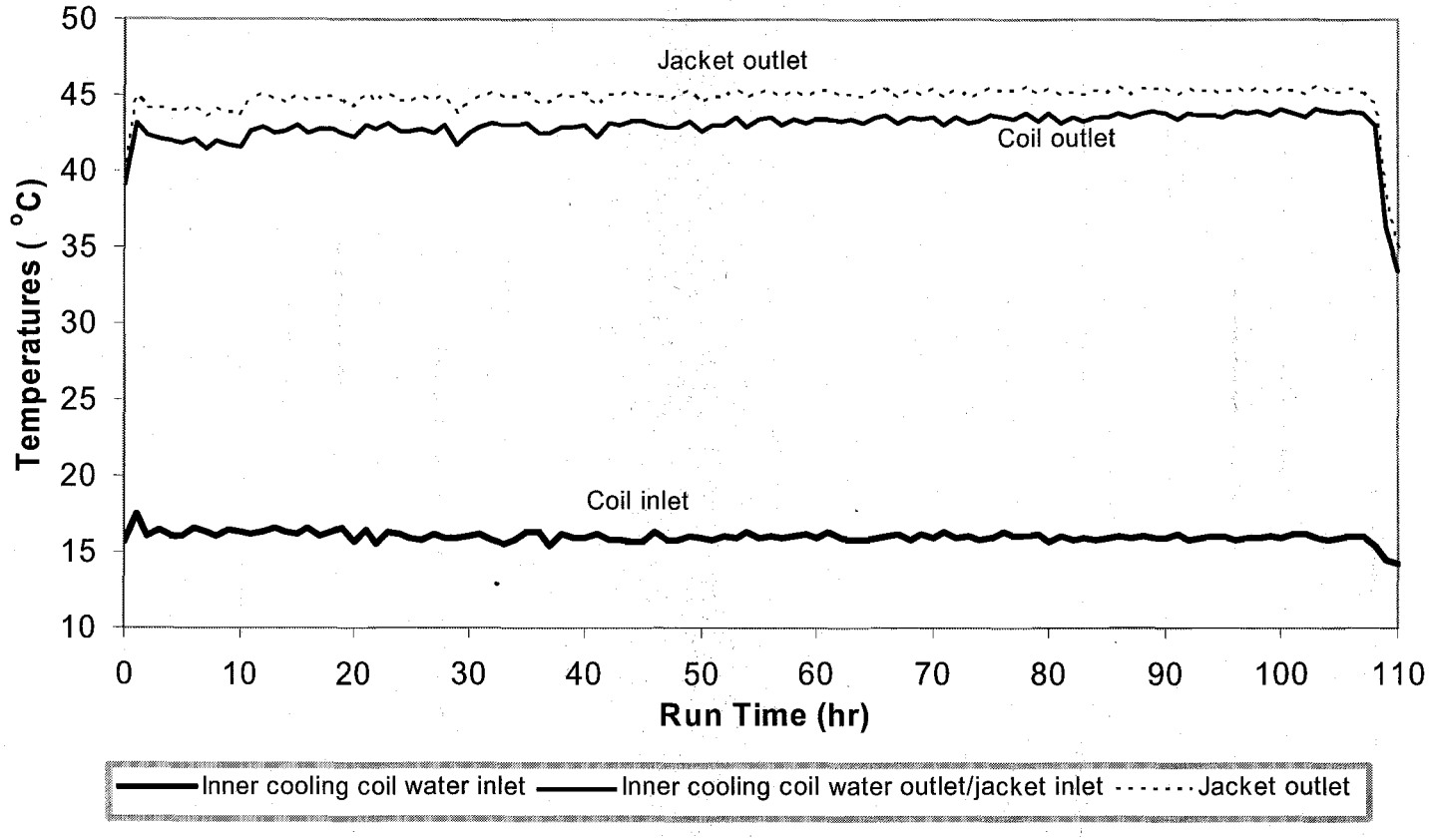

Figure 5.26. SBS cooling coil inlet, cooling coil outlet/jacket inlet and jacket outlet water temperatures (hourly average values) during Test 2A.

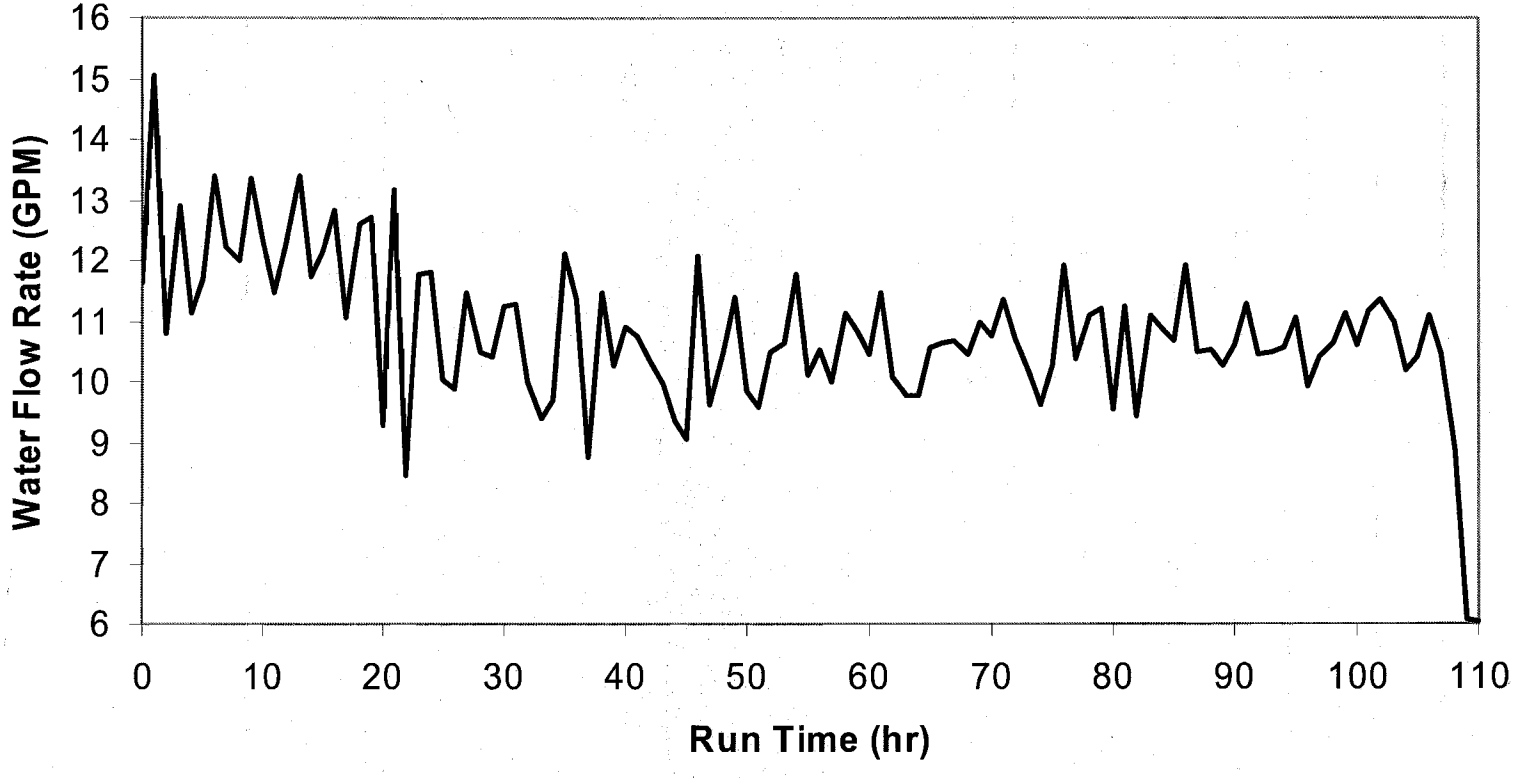

Figure 5.27. SBS cooling coil/jacket water flow rate (hourly average values) during Test 2A.

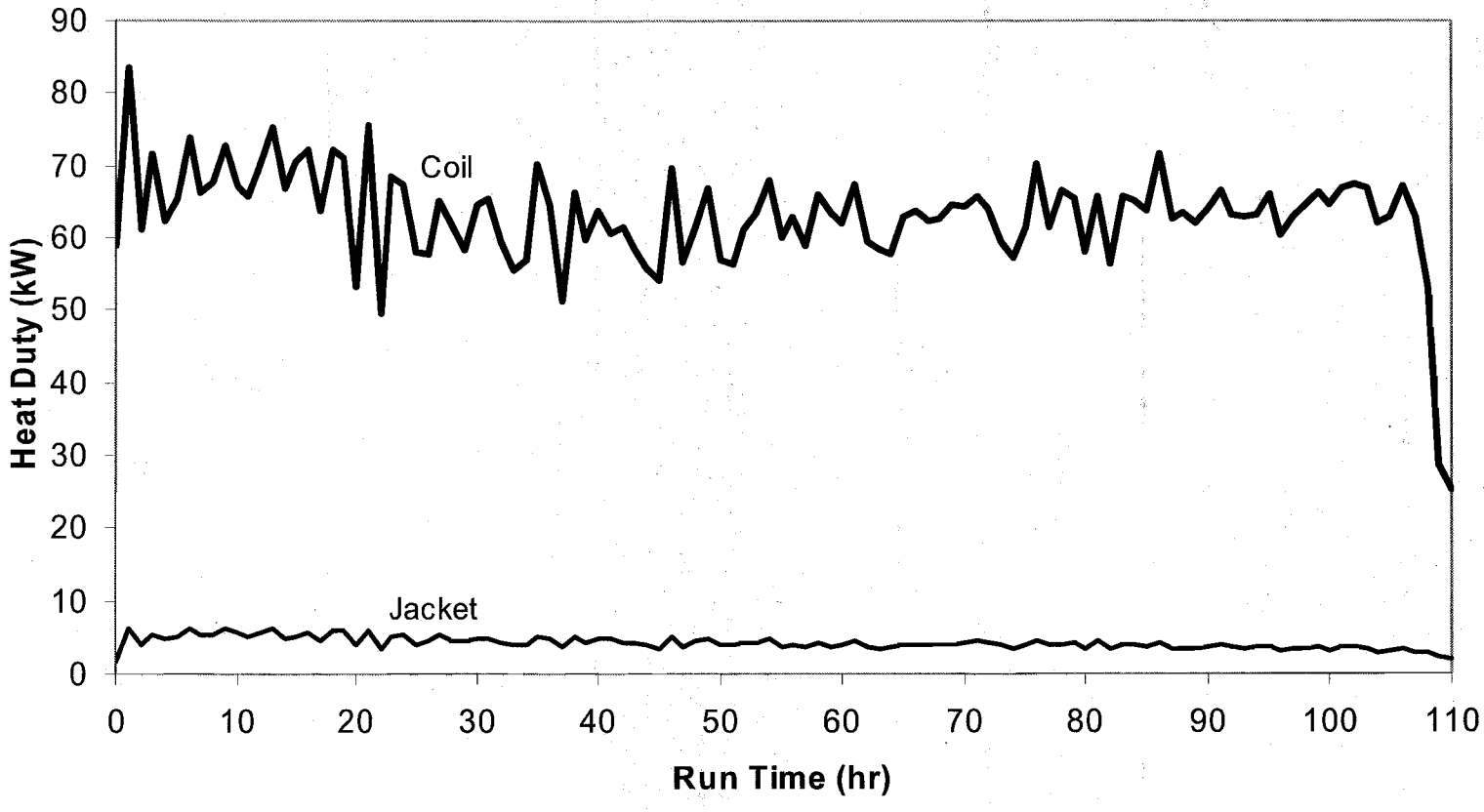

Figure 5.28. Calculated heat loads on the inner coil and jacket (hourly average values) during Test 2A.

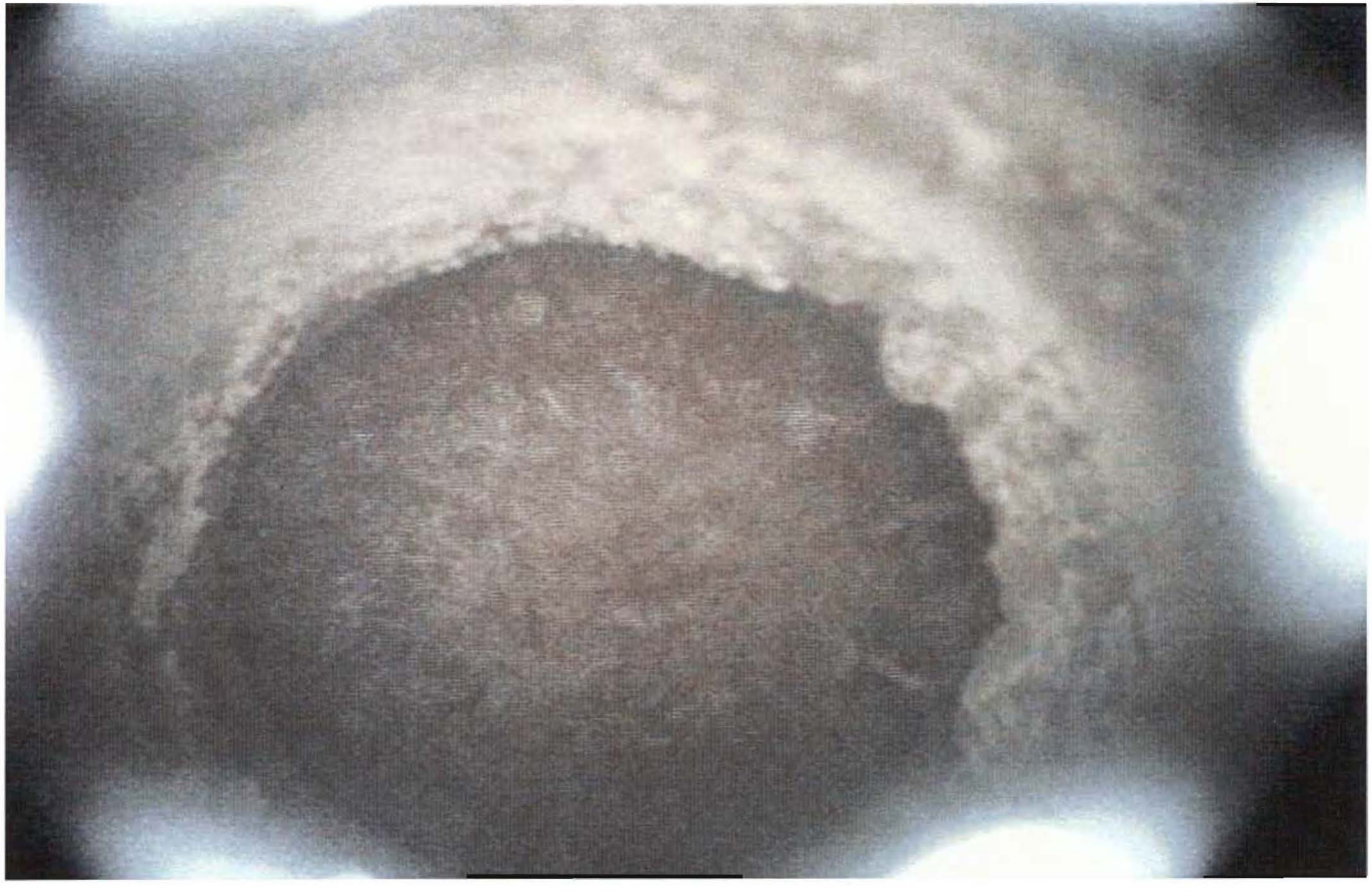

Figure 5.29. View from the inside of the bottom of the SBS downcomer at 67 hours during Test 2A.

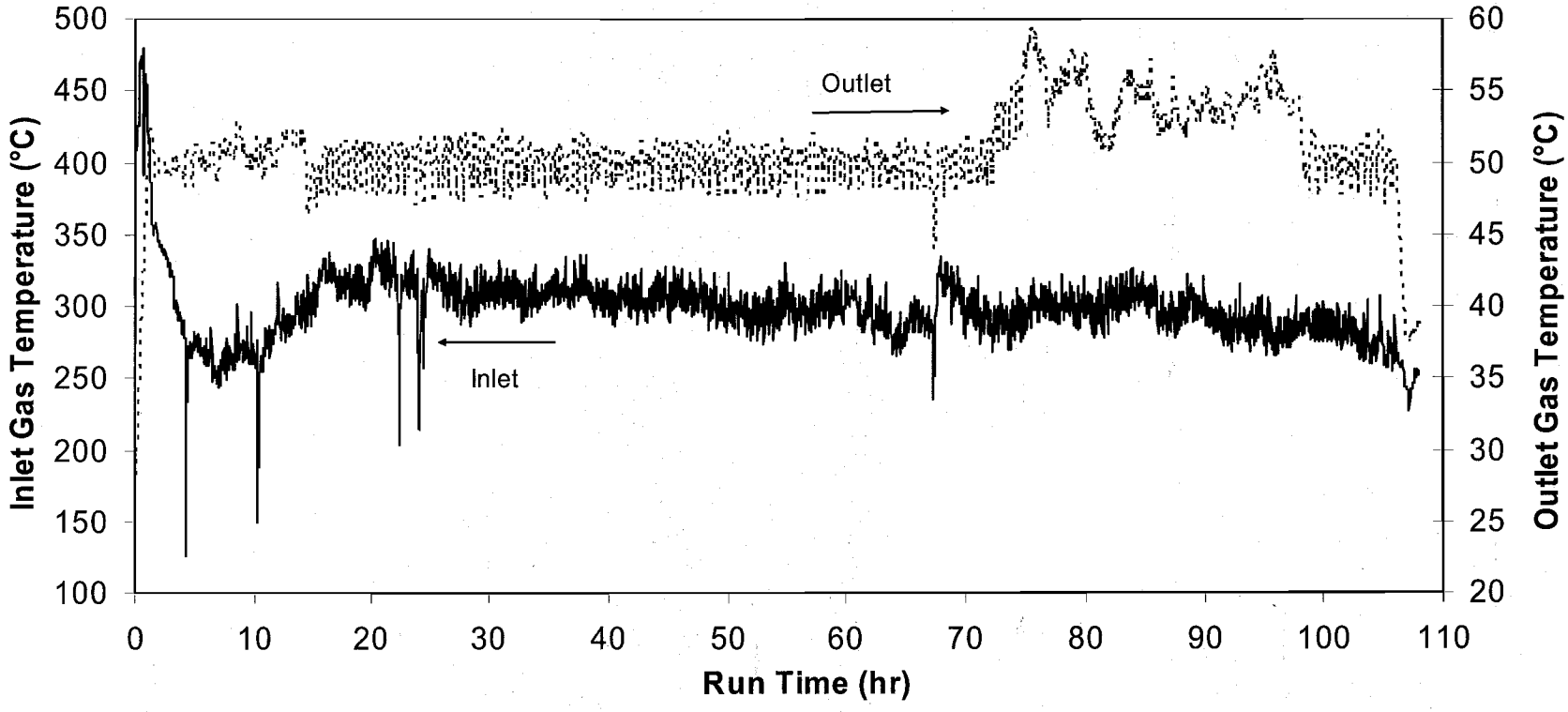

Figure 5.30. SBS inlet and outlet gas temperatures during Test 2B.

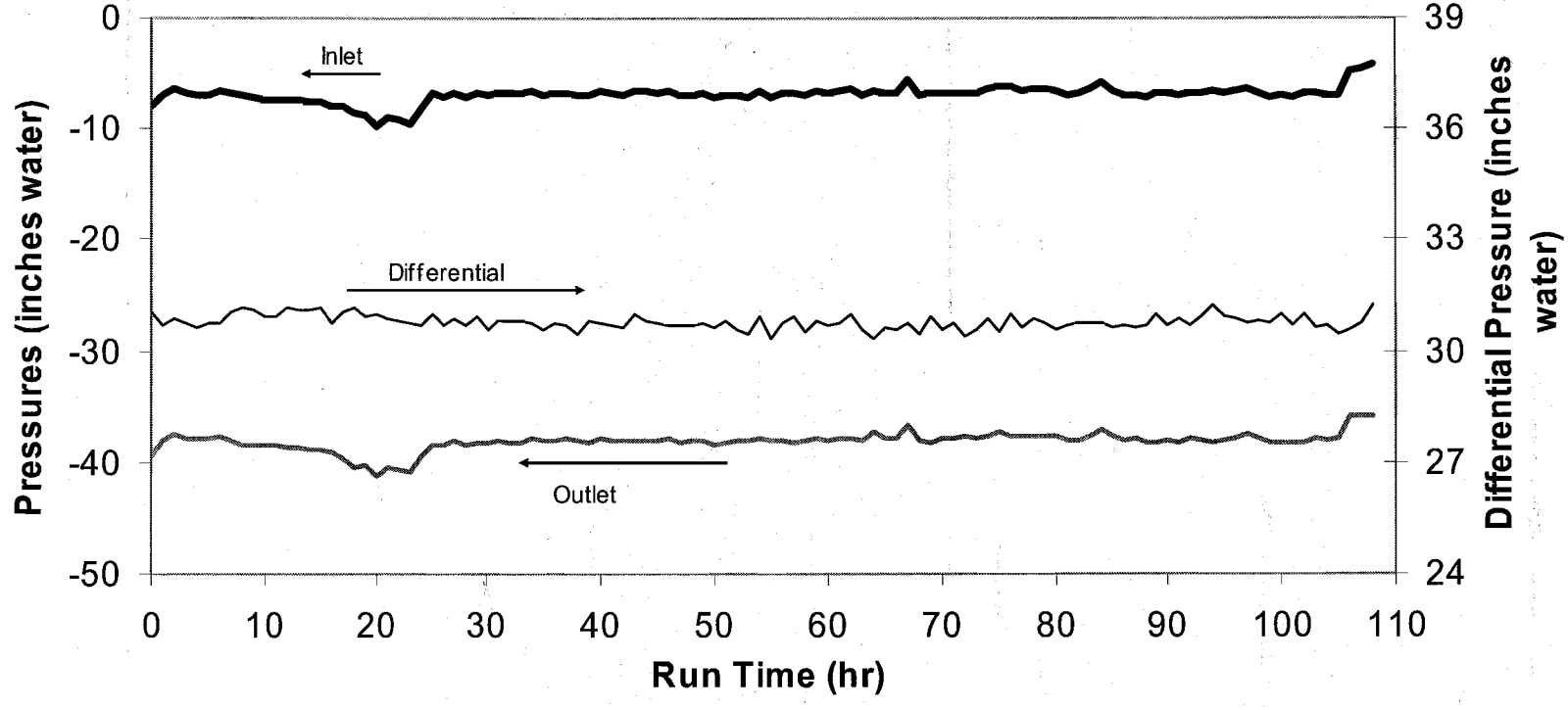

Figure 5.31. SBS inlet, outlet, and differential pressures (hourly average values) during Test 2B.

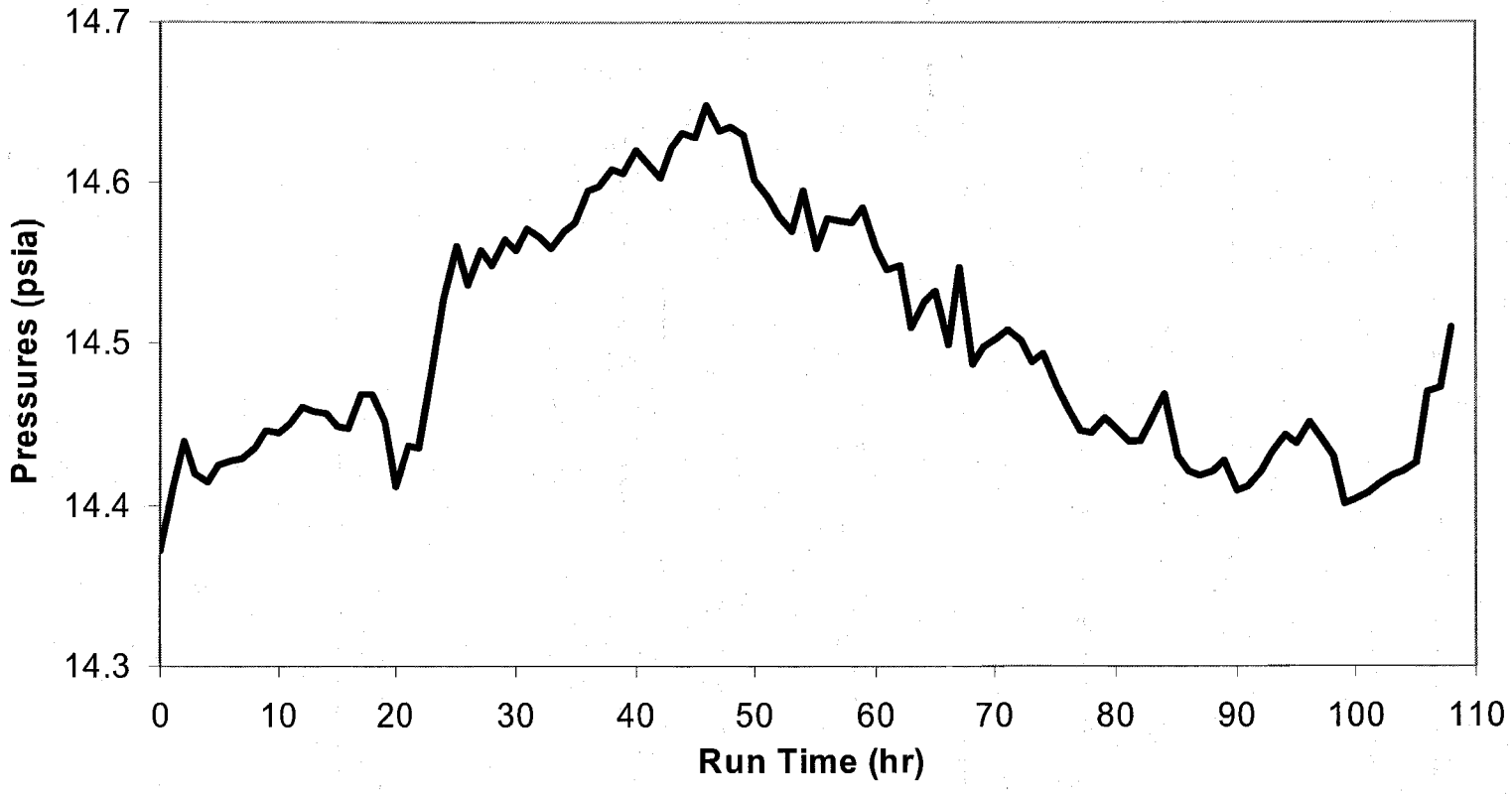

Figure 5.32. SBS downcomer annulus pressure (hourly average values) during Test 2B.

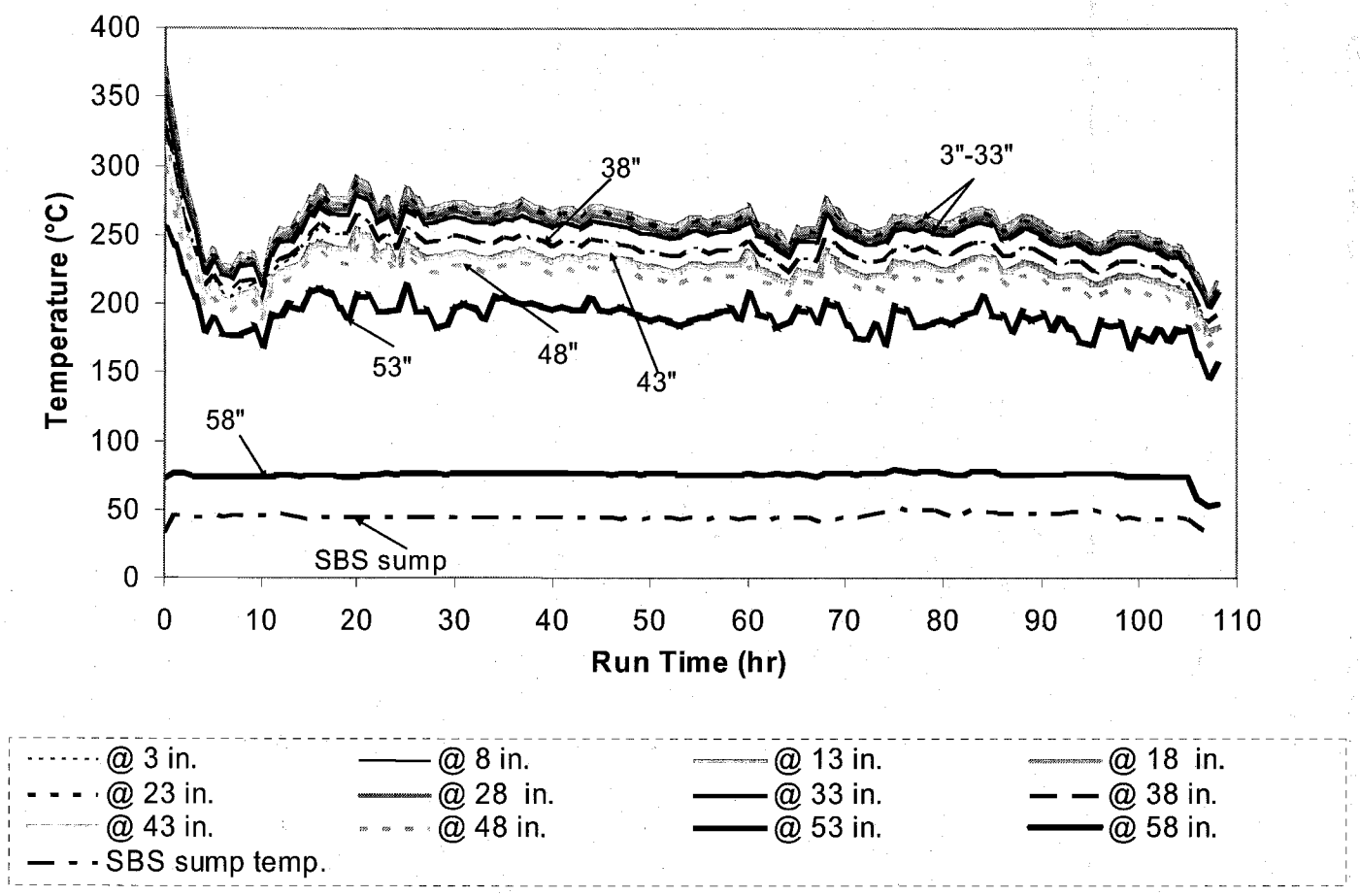

Figure 5.33. Off-gas temperatures in the SBS downcomer and sump water temperatures (hourly average values) during Test 2B.

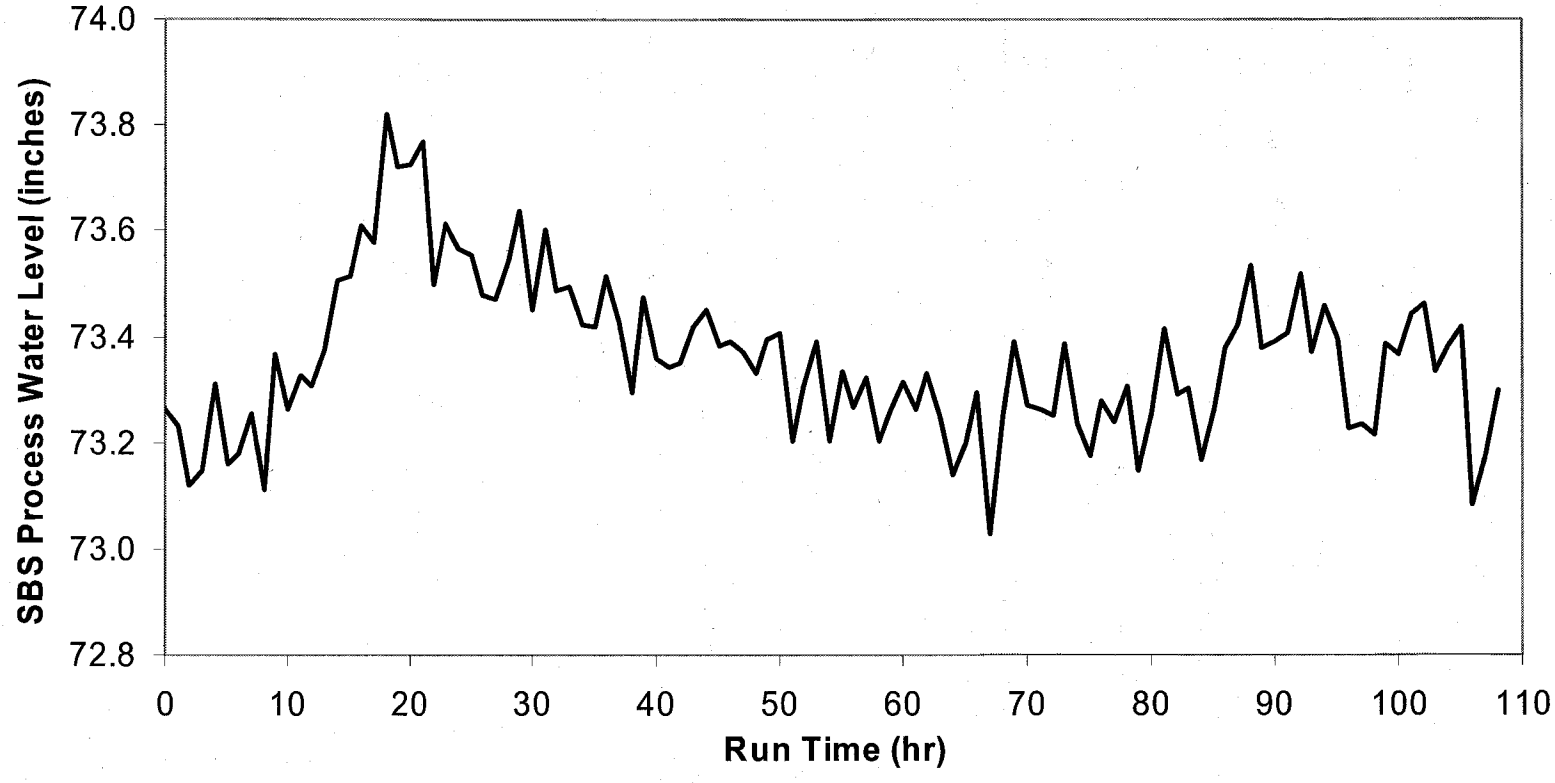

Figure 5.34. SBS process water level (hourly average values).

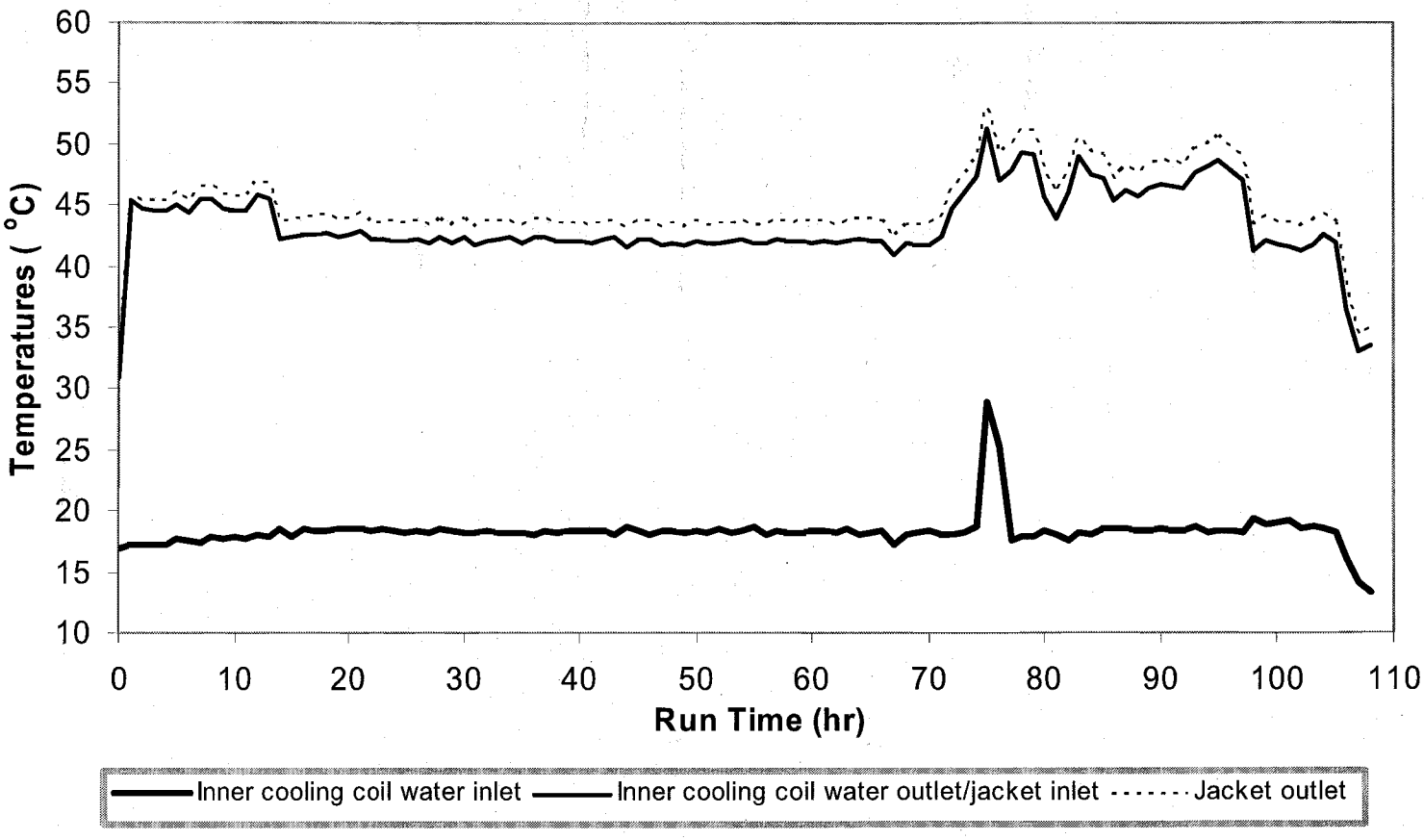

Figure 5.35. SBS cooling coil inlet, cooling coil outlet/jacket inlet and jacket outlet water temperatures (hourly average values) during Test 2B.

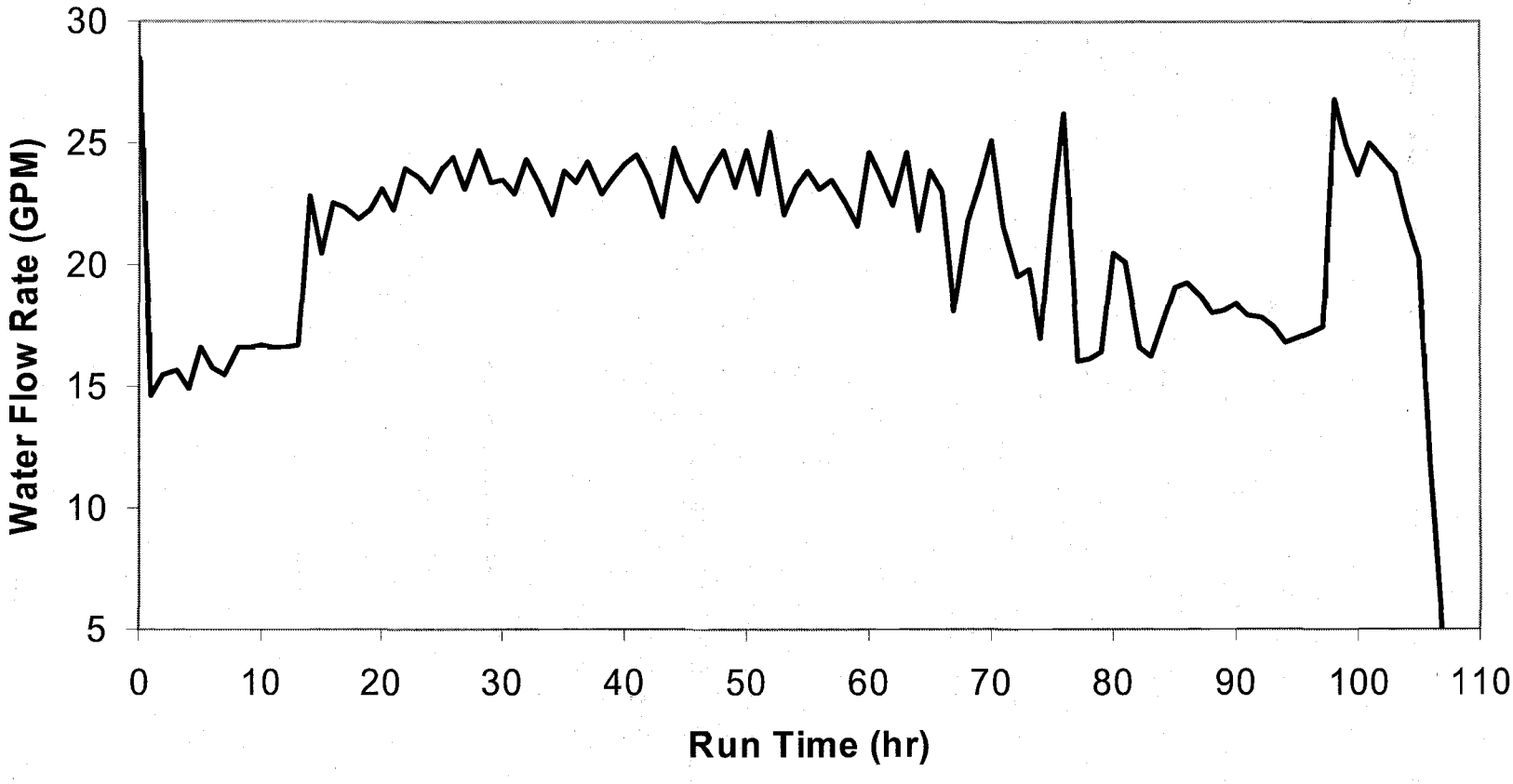

Figure 5.36. SBS cooling coil/jacket water flow rate (hourly average values) during Test 2B.

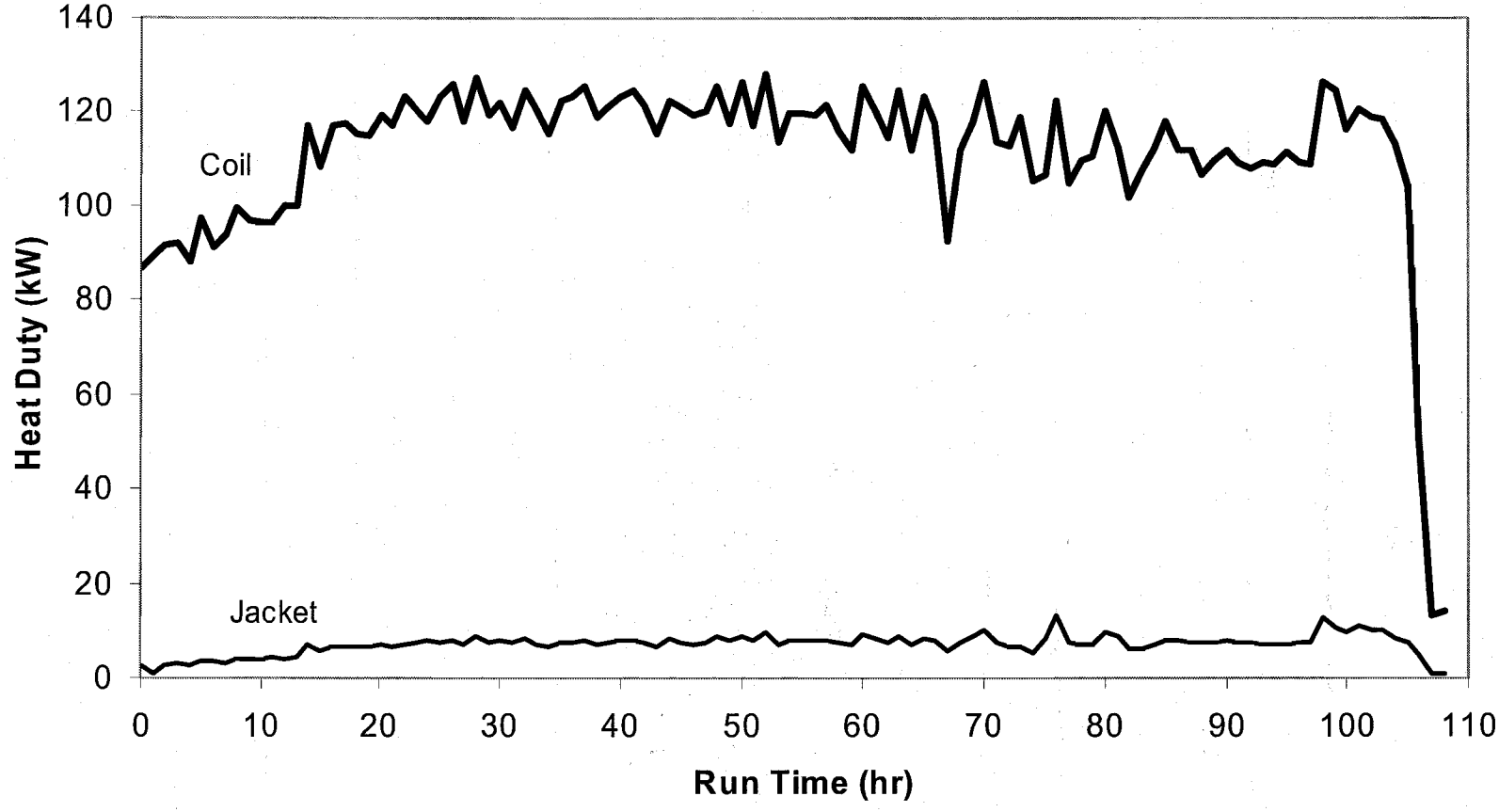

Figure 5.37. Calculated heat loads on the inner coil and jacket (hourly average values) during Test 2B.

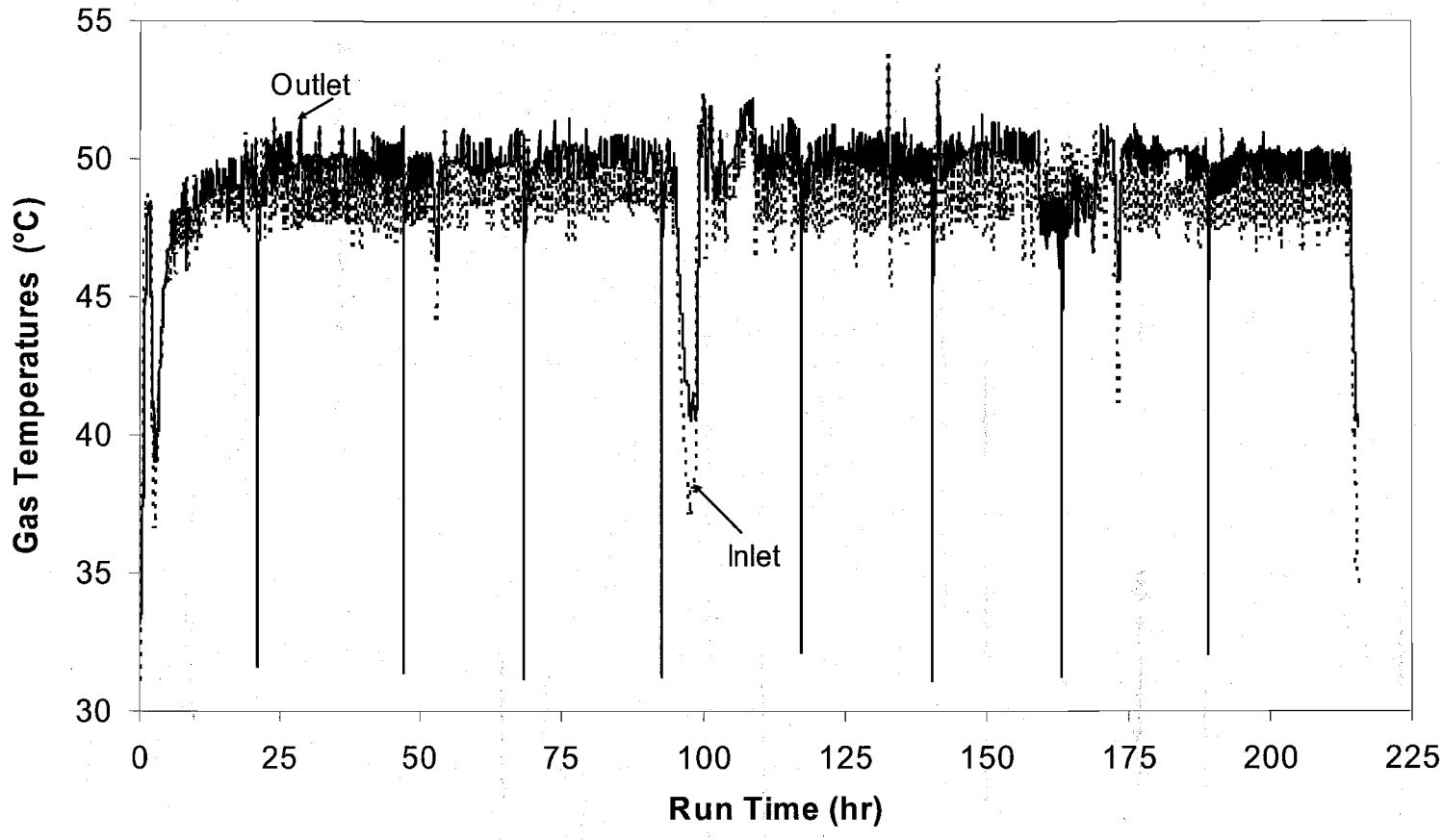

Figure 5.38. WESP inlet and outlet gas temperatures during Test 1. (Note: downward outlet temperature spikes are the result of WESP deluges.)

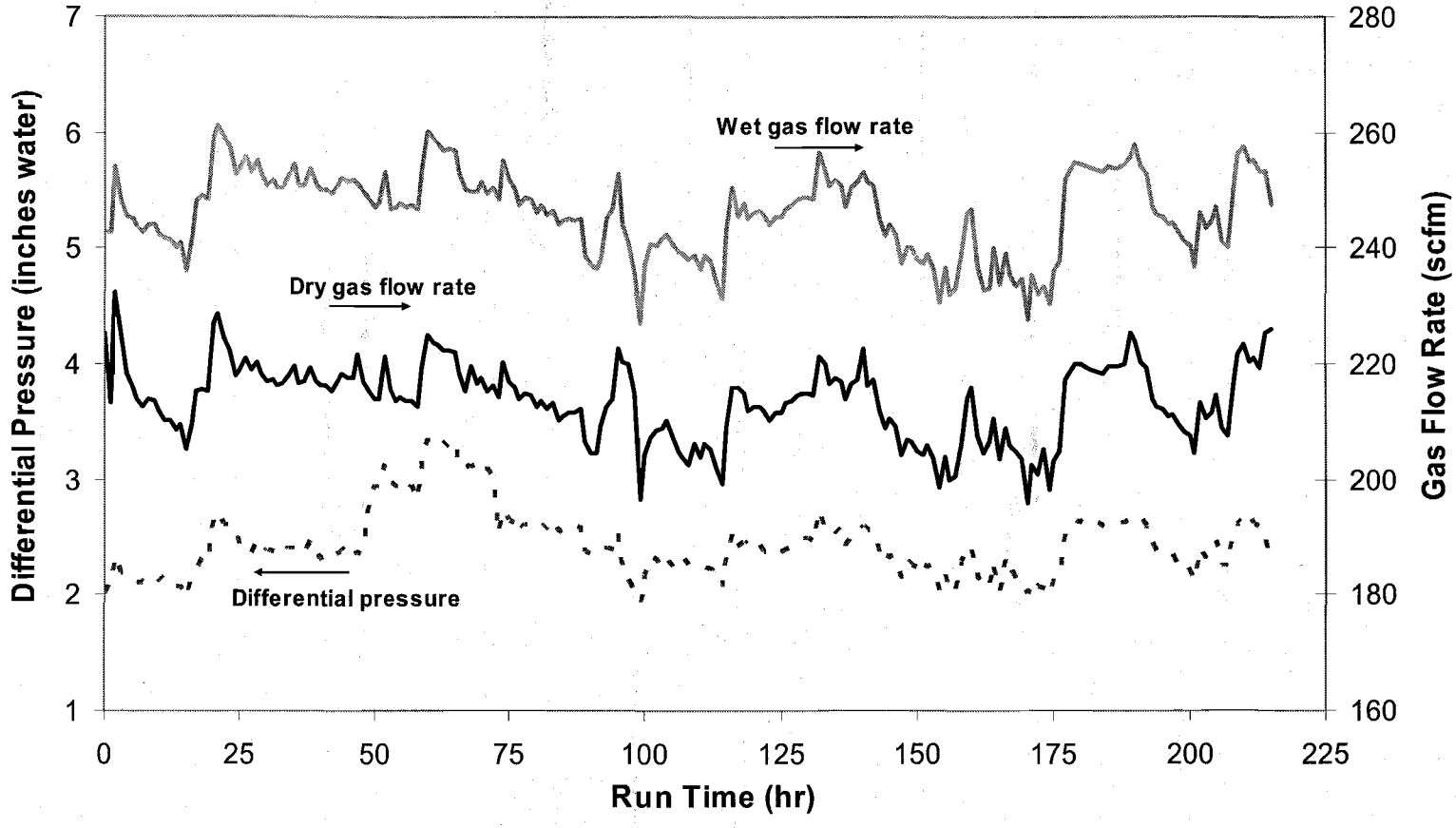

Figure 5.39. WESP differential pressure and outlet gas flow rate (hourly average values) during Test 1.

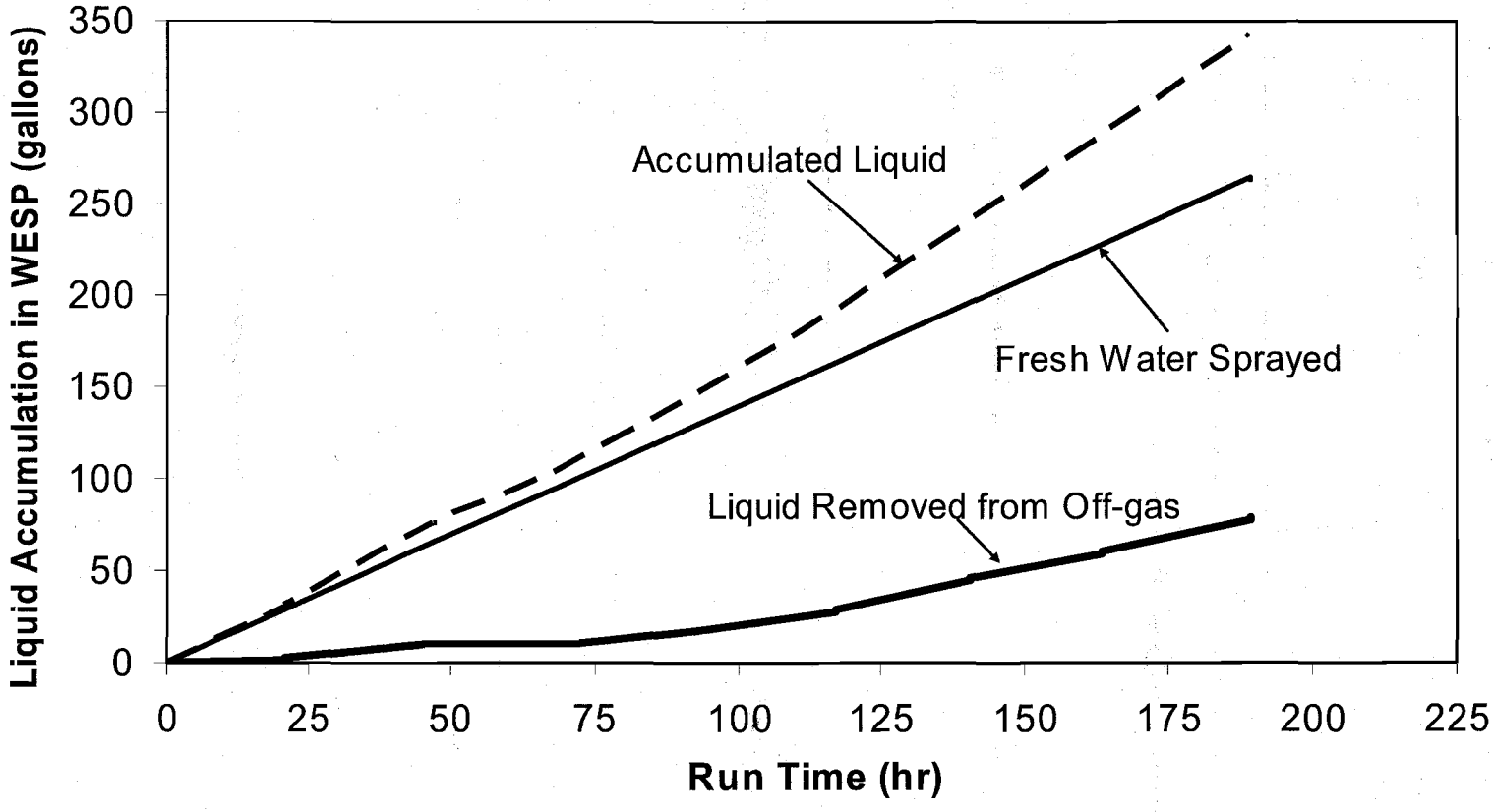

Figure 5.40. Accumulated WESP blow-down volume, accumulated fresh spray water, and water removed from off-gas during Test 1.

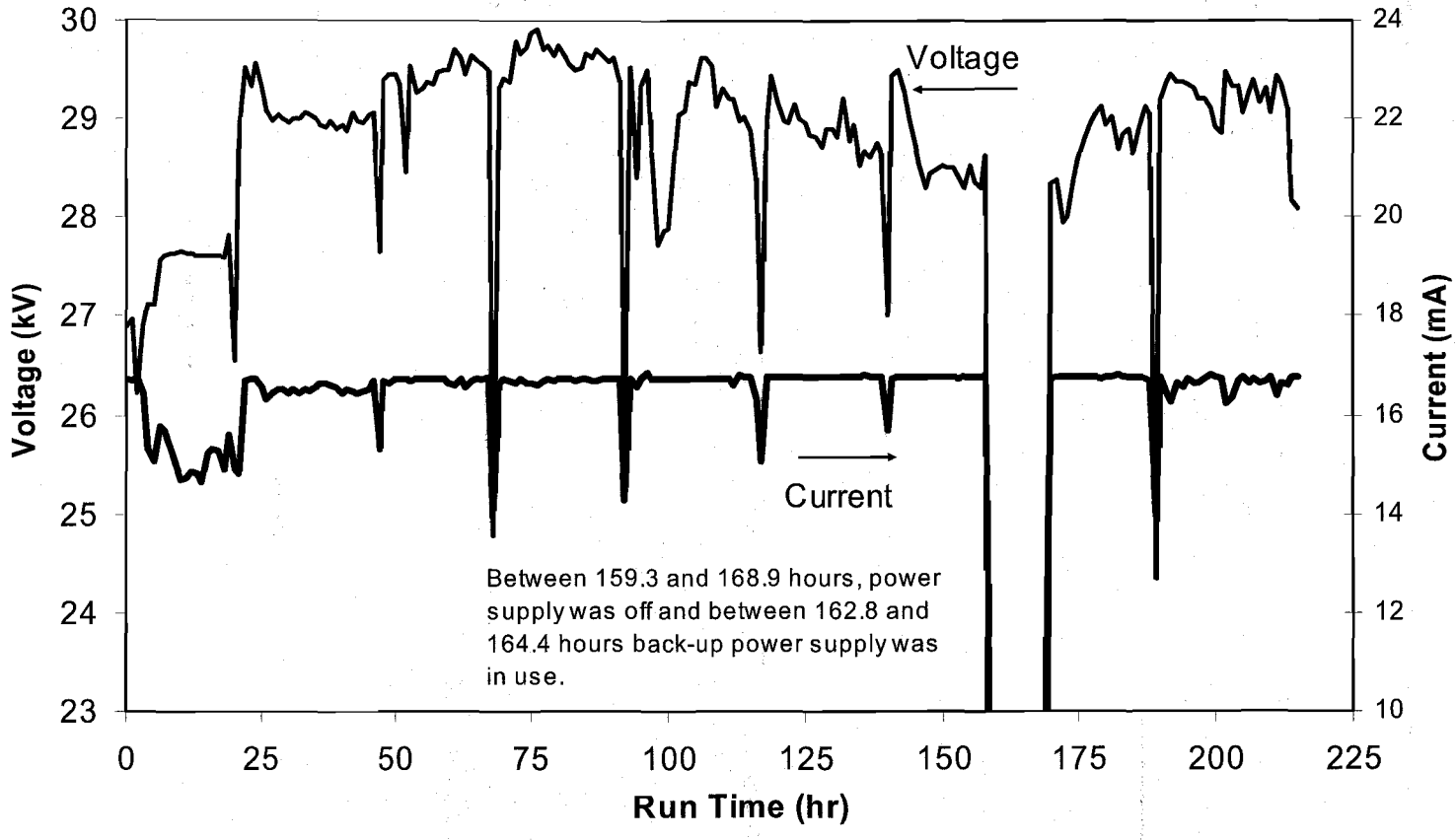

Figure 5.41. Voltage and current across the WESP during Test 1.

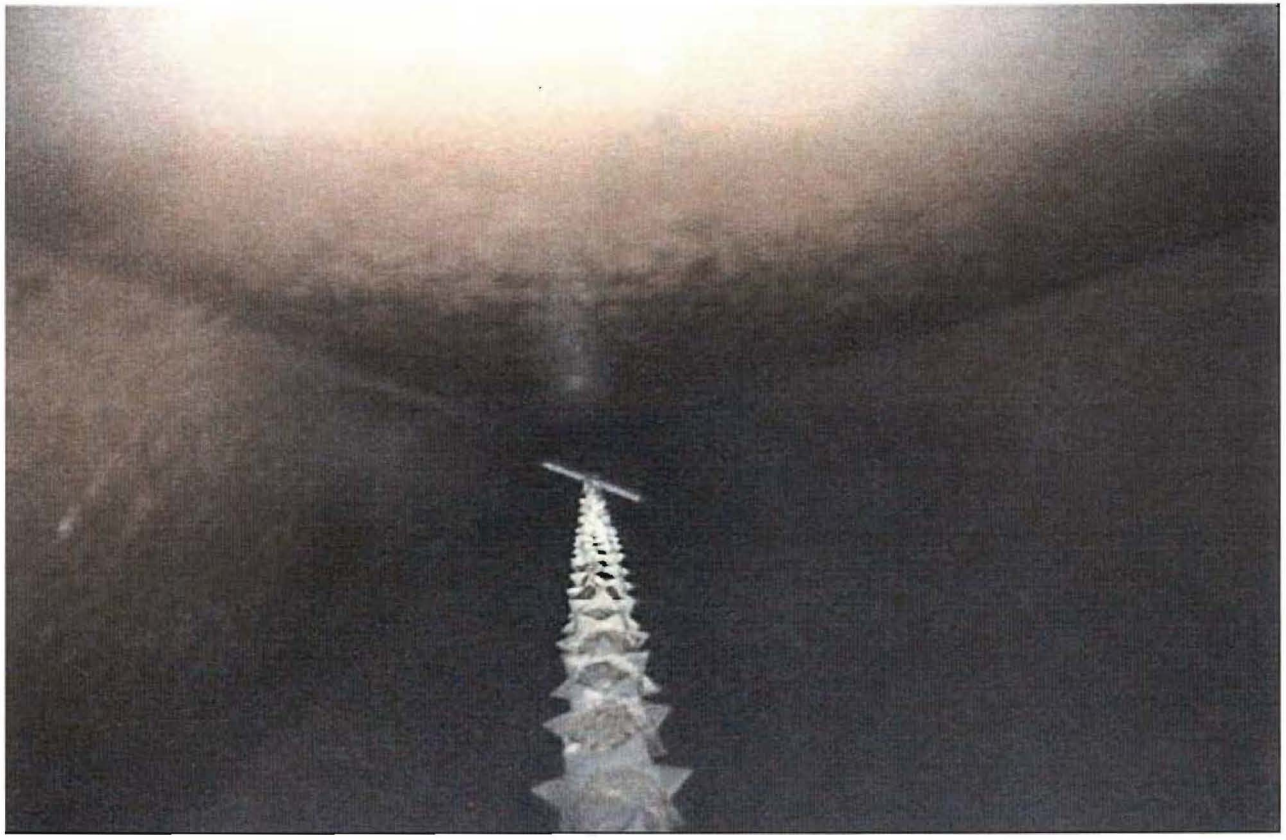

Figure 5.42. Pre-deluge view of WESP rod and collector plate after Test 1.

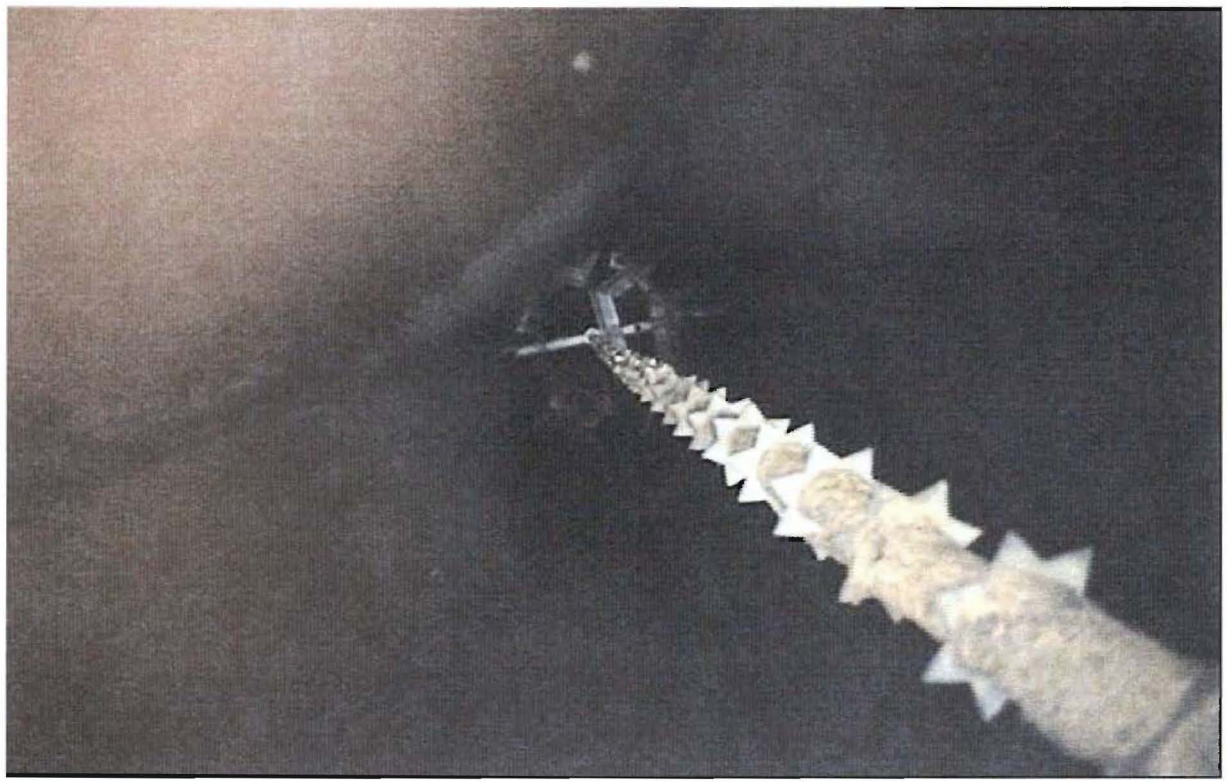

Figure 5.43. Another pre-deluge view of WESP rod and collector plate after Test 1.

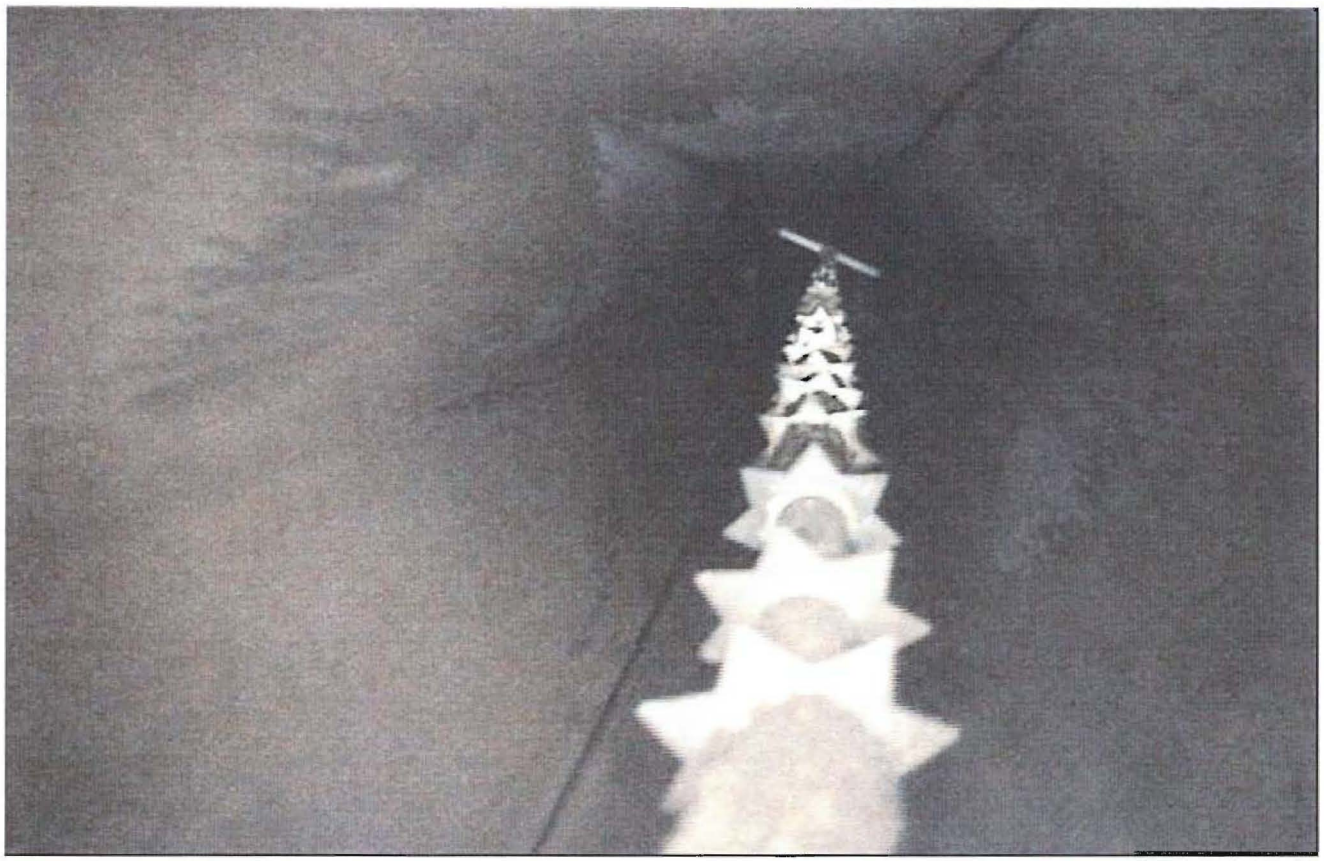

Figure 5.44. Post-deluge view of WESP rod and collector plate after Test 1.

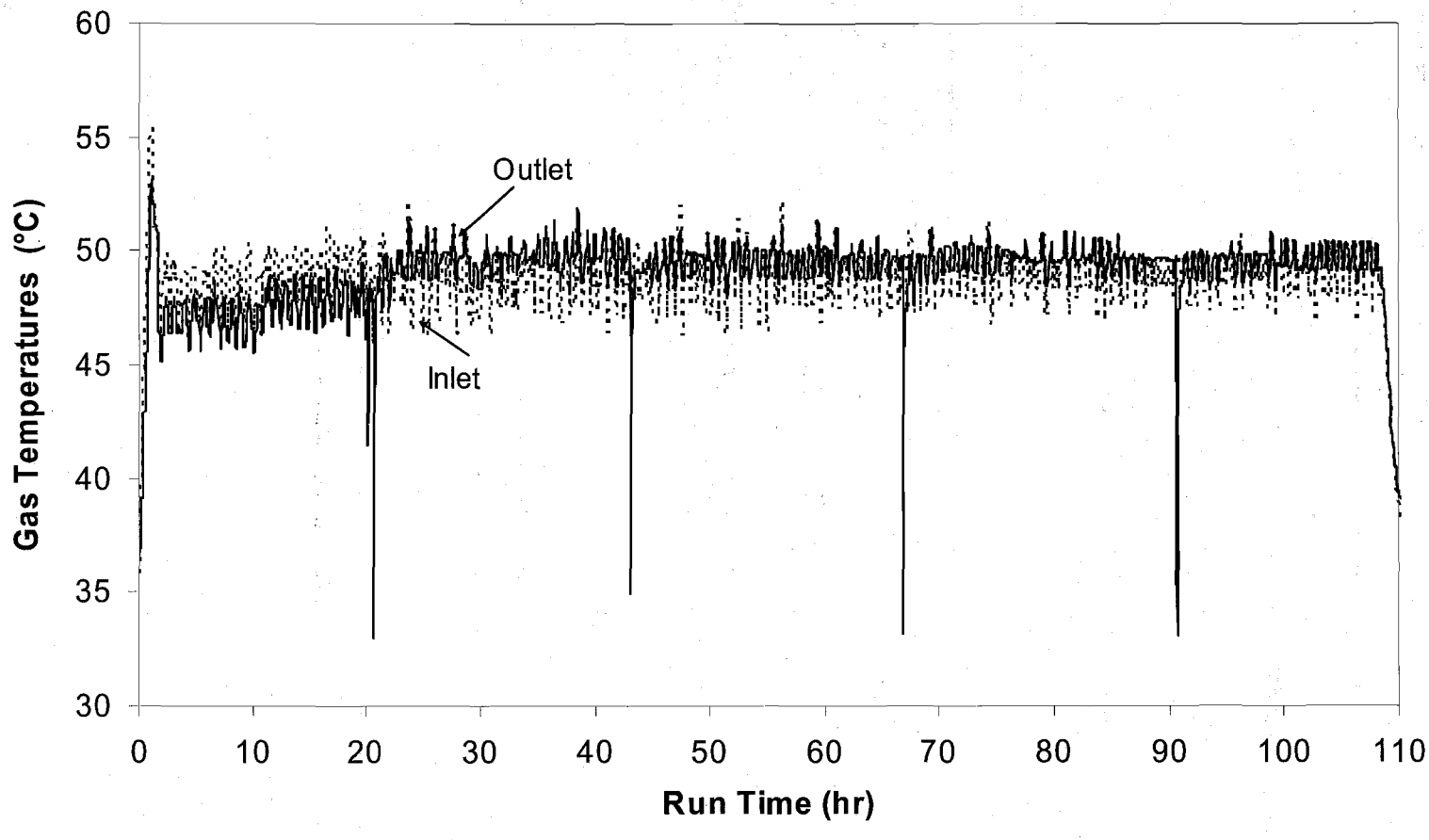

Figure 5.45. WESP inlet and outlet temperatures during Test 2A. (Note: downward outlet temperature spikes are the result of WESP deluges.)

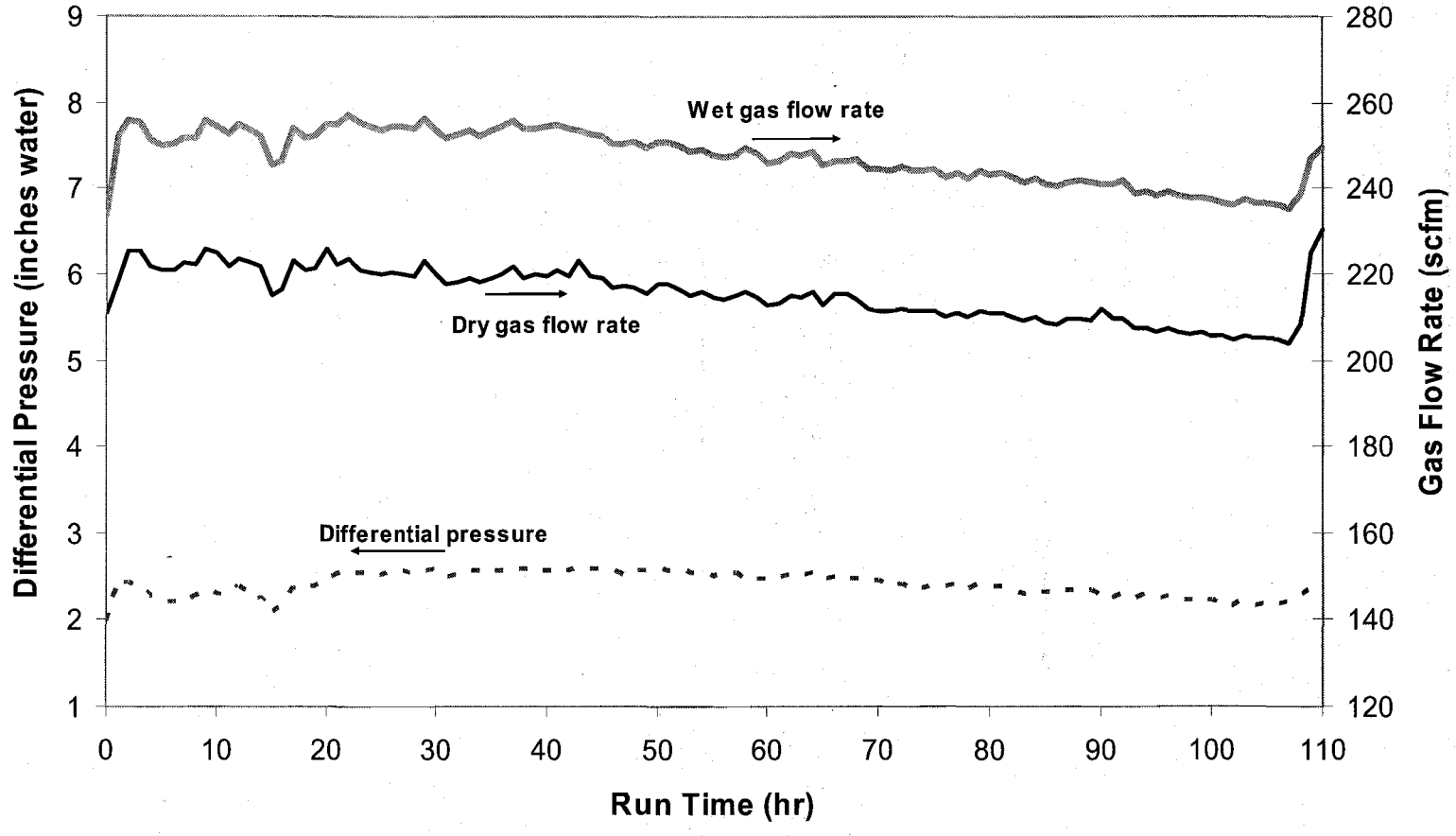

Figure 5.46. WESP differential pressure and outlet gas flow rate (hourly average values) during Test 2A.

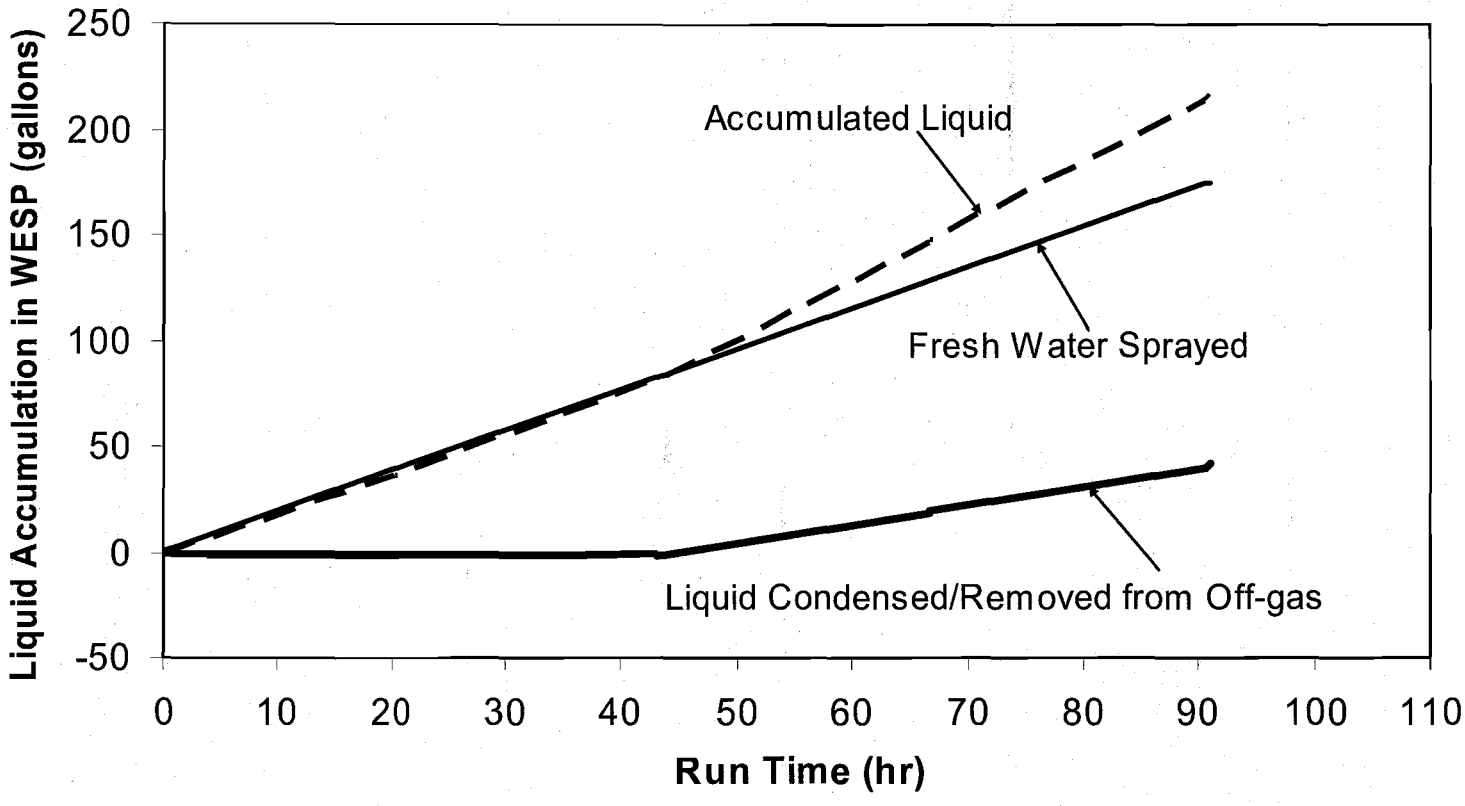

Figure 5.47. Accumulated WESP blow-down volume, accumulated fresh spray water and water removed from off-gas during Test 2A.

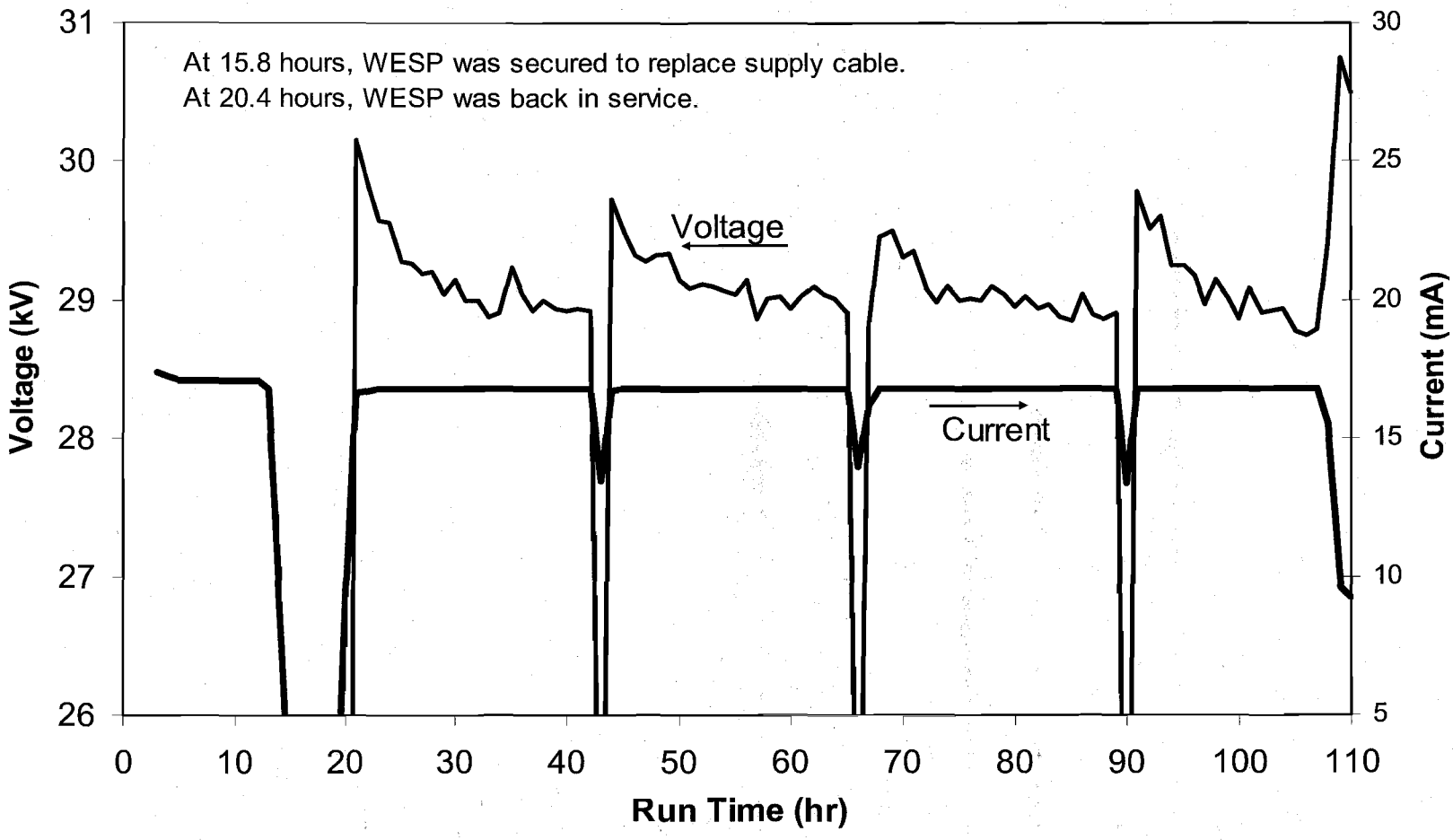

Figure 5.48. Voltage and current across the WESP during Test 2A.

Figure 5.49. Pre-deluge view of WESP floor after Test 2A.

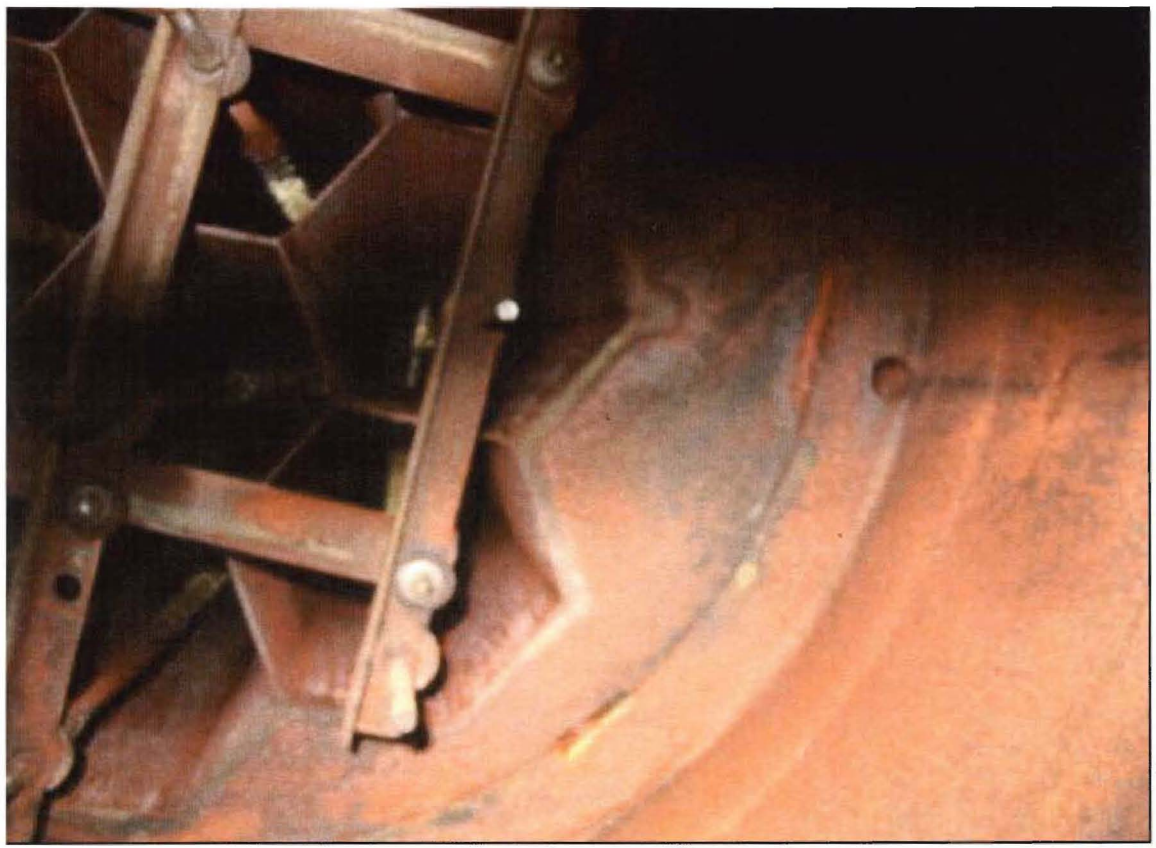

Figure 5.50. Pre-deluge view of WESP rod and collector plate after Test 2A.

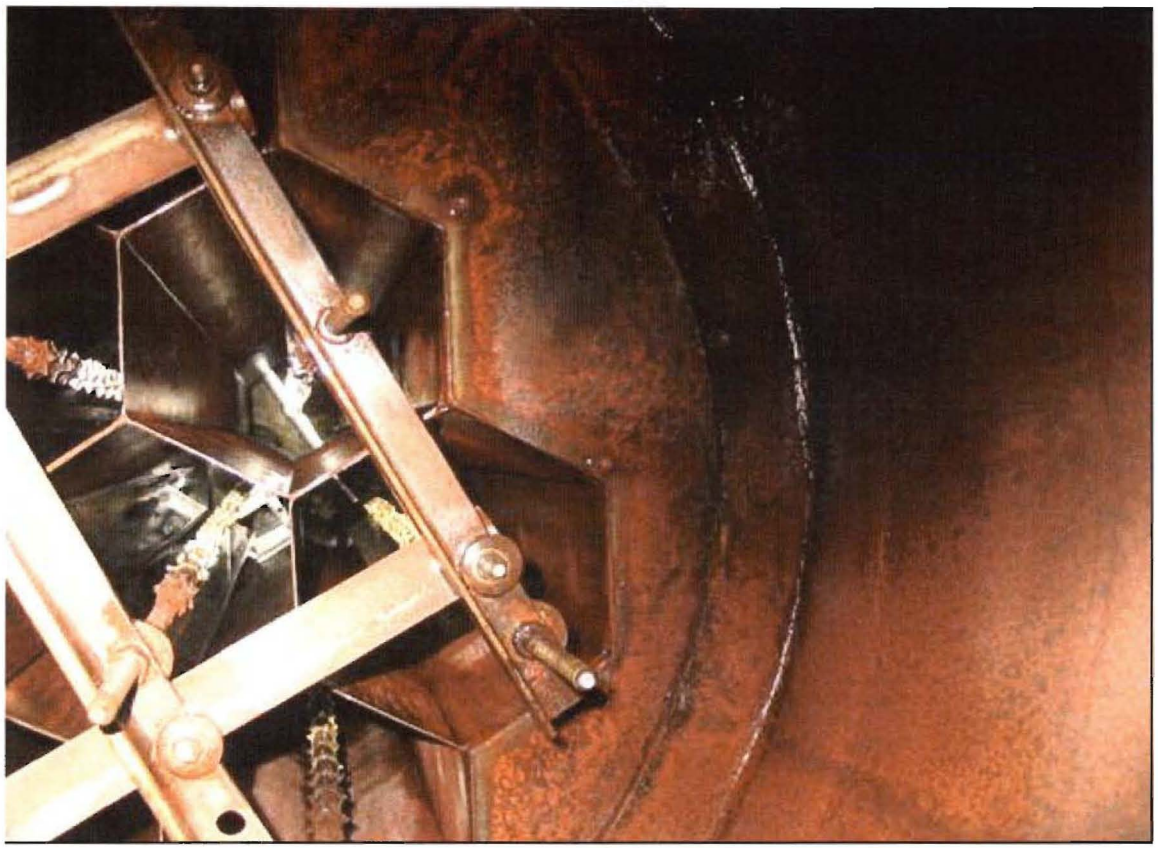

Figure 5.51. Post-deluge view of WESP rod and collector plate after Test 2A.

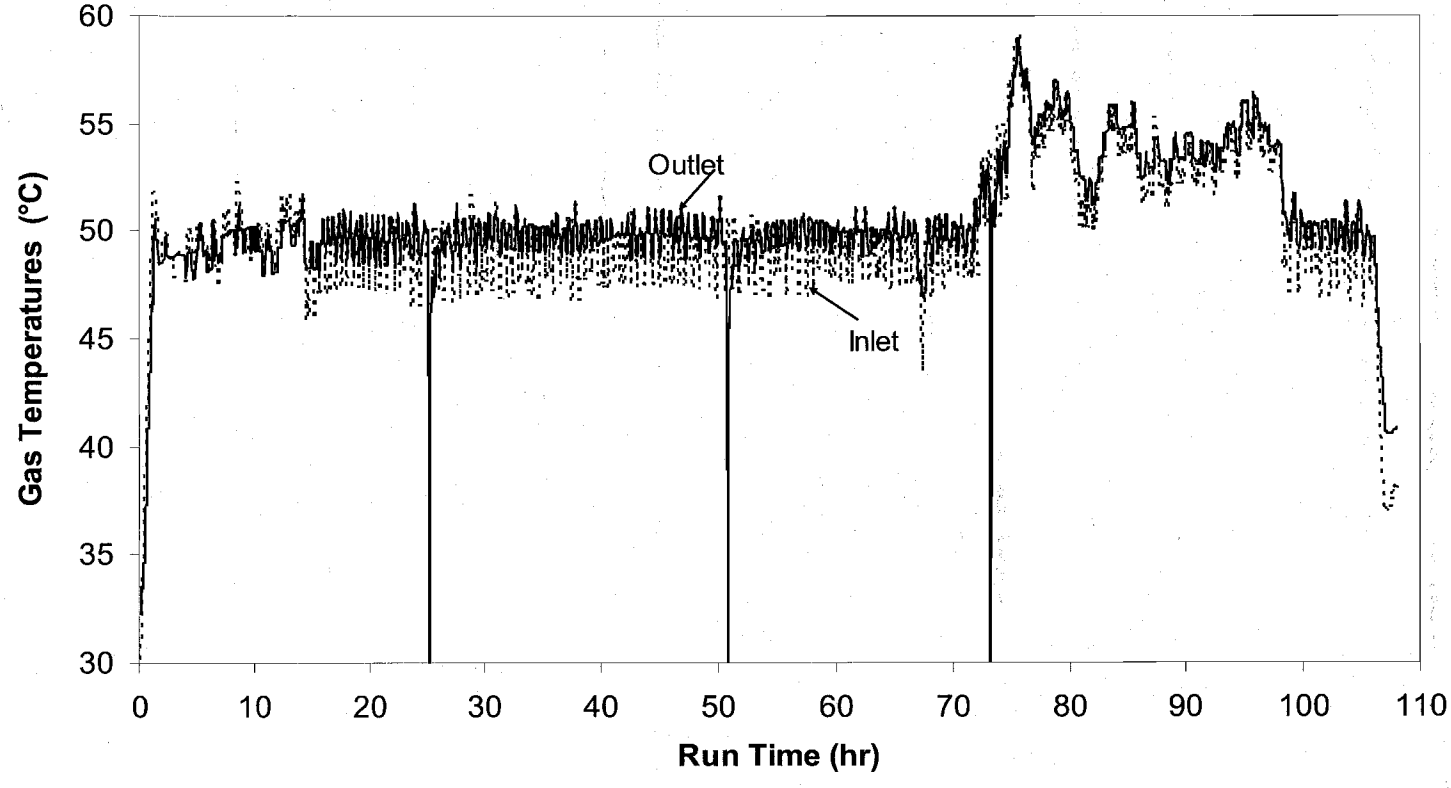

Figure 5.52. WESP inlet and outlet gas temperature during Test 2B. (Note: downward outlet temperature spikes are the result of WESP deluges.)

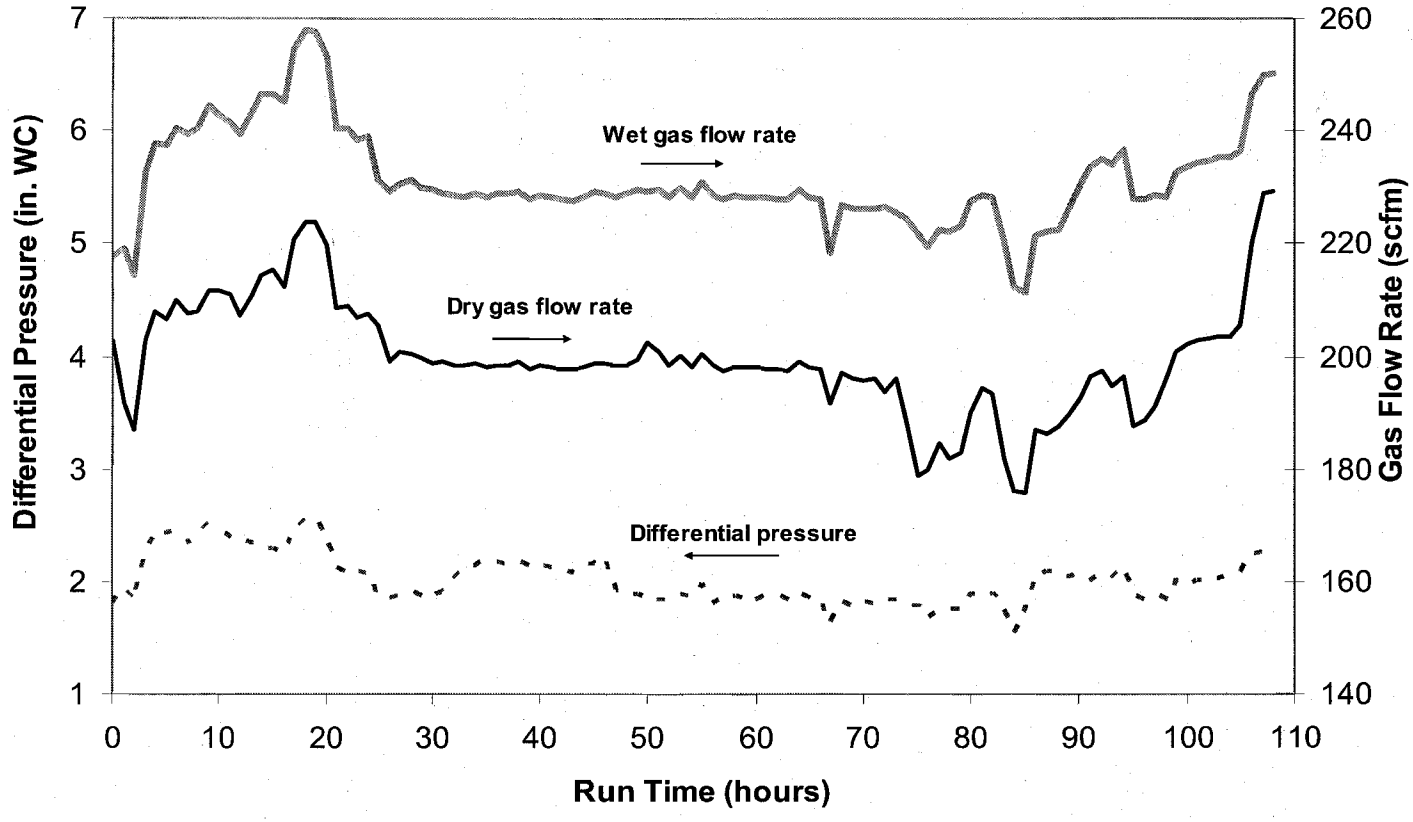

Figure 5.53. WESP differential pressure and gas flow rate (hourly average values) during Test 2B.

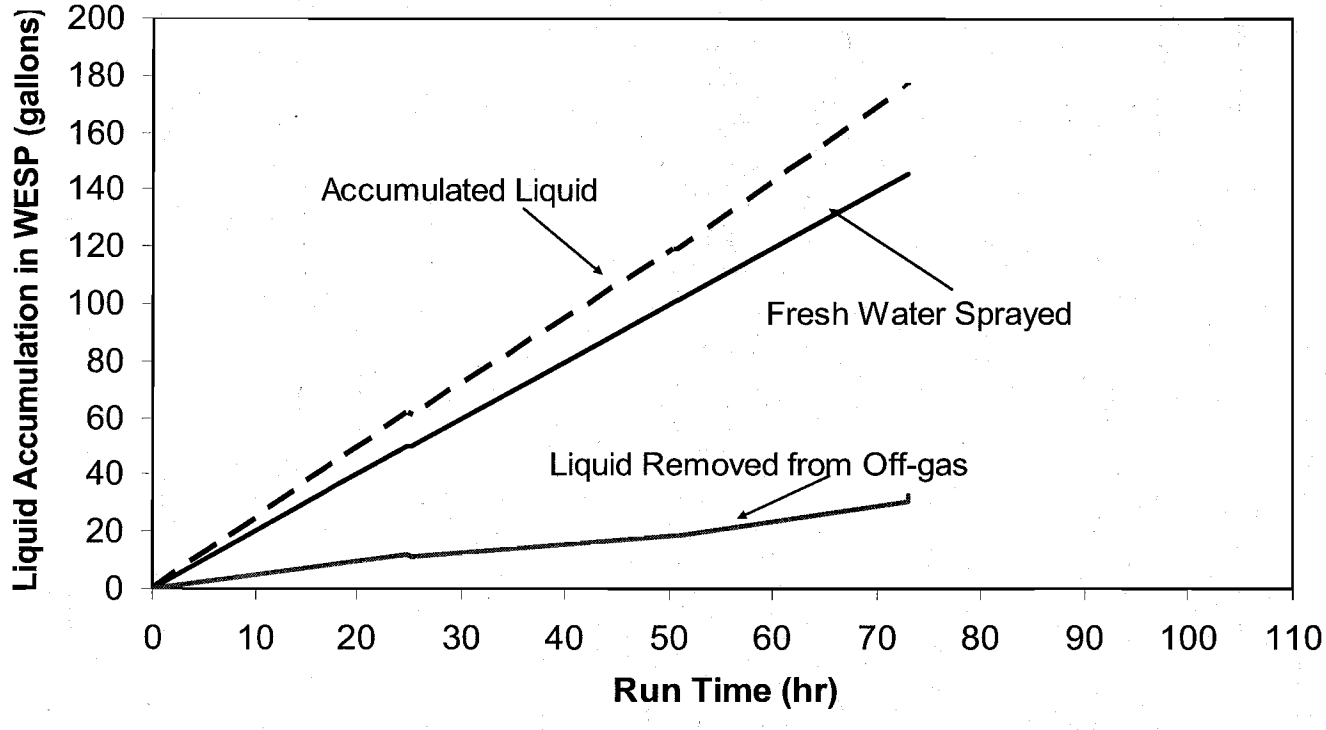

Figure 5.54. Accumulated WESP blow down volume, accumulated fresh spray water, and water removed from off-gas during Test 2B.

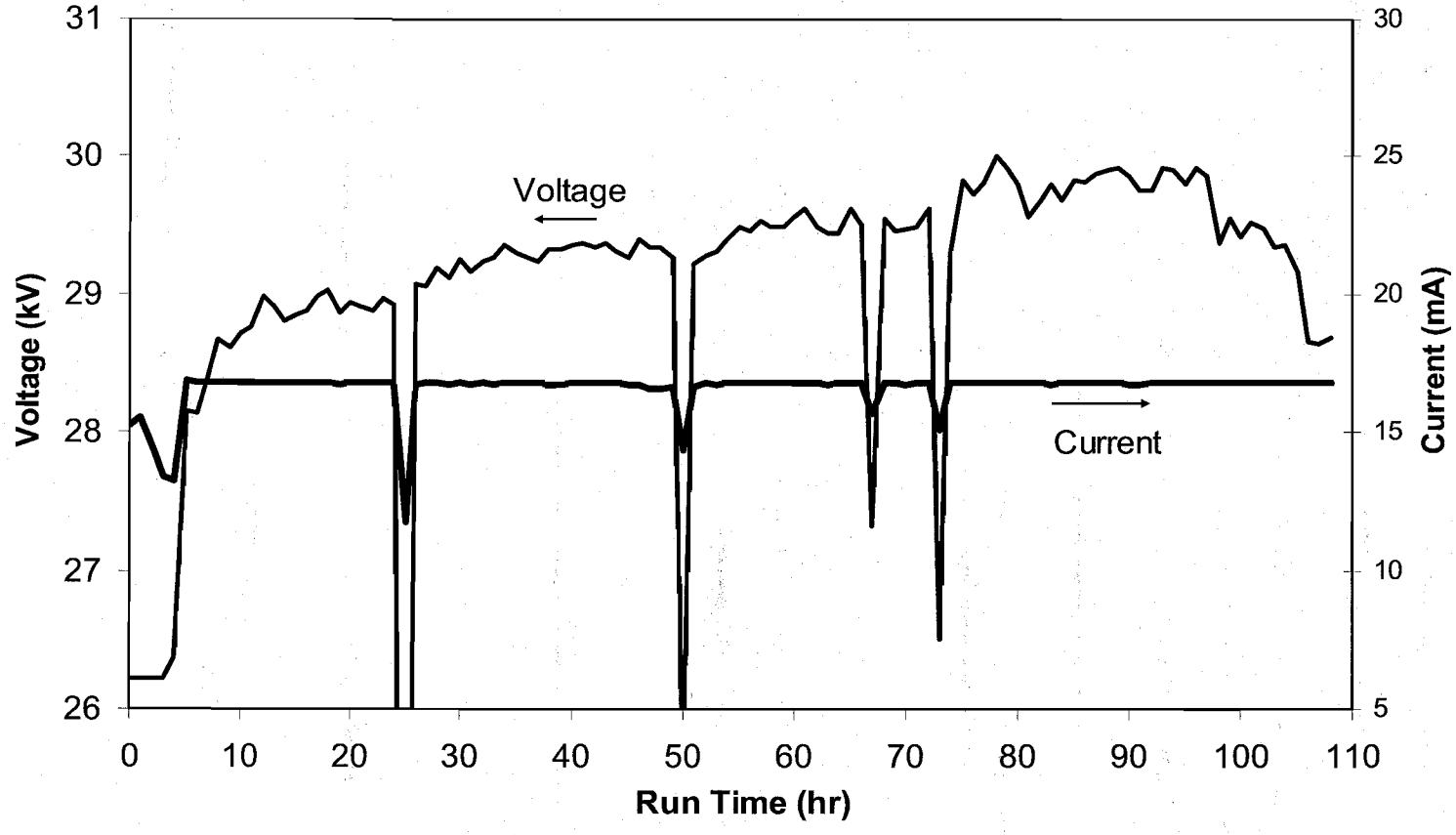

Figure 5.55. Voltage and current across the WESP during Test 2B. (Note: during the deluges, power to the WESP was turned off.)

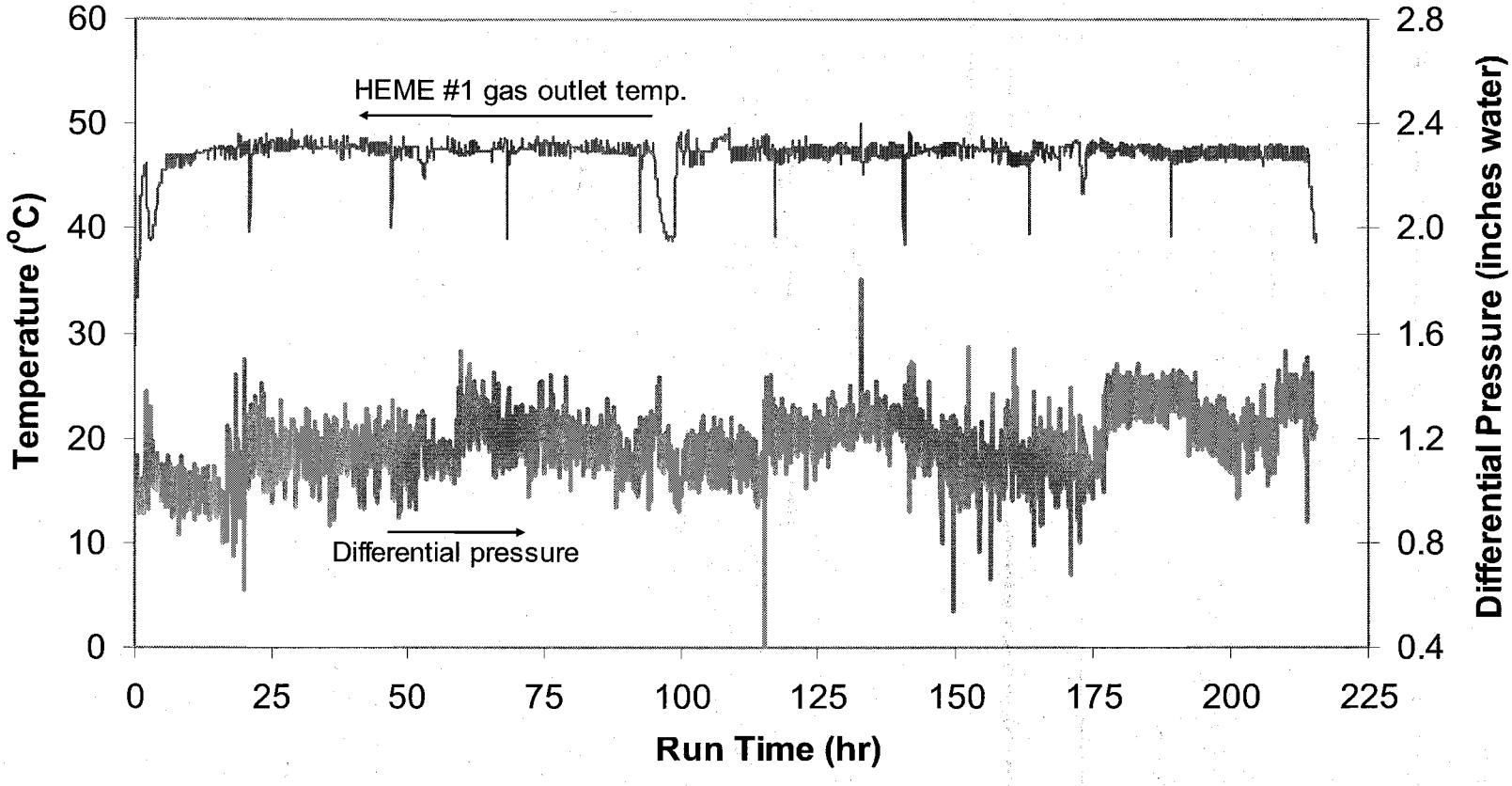

Figure 5.56. Outlet gas temperature and differential pressure for HEME #1 during Test 1.

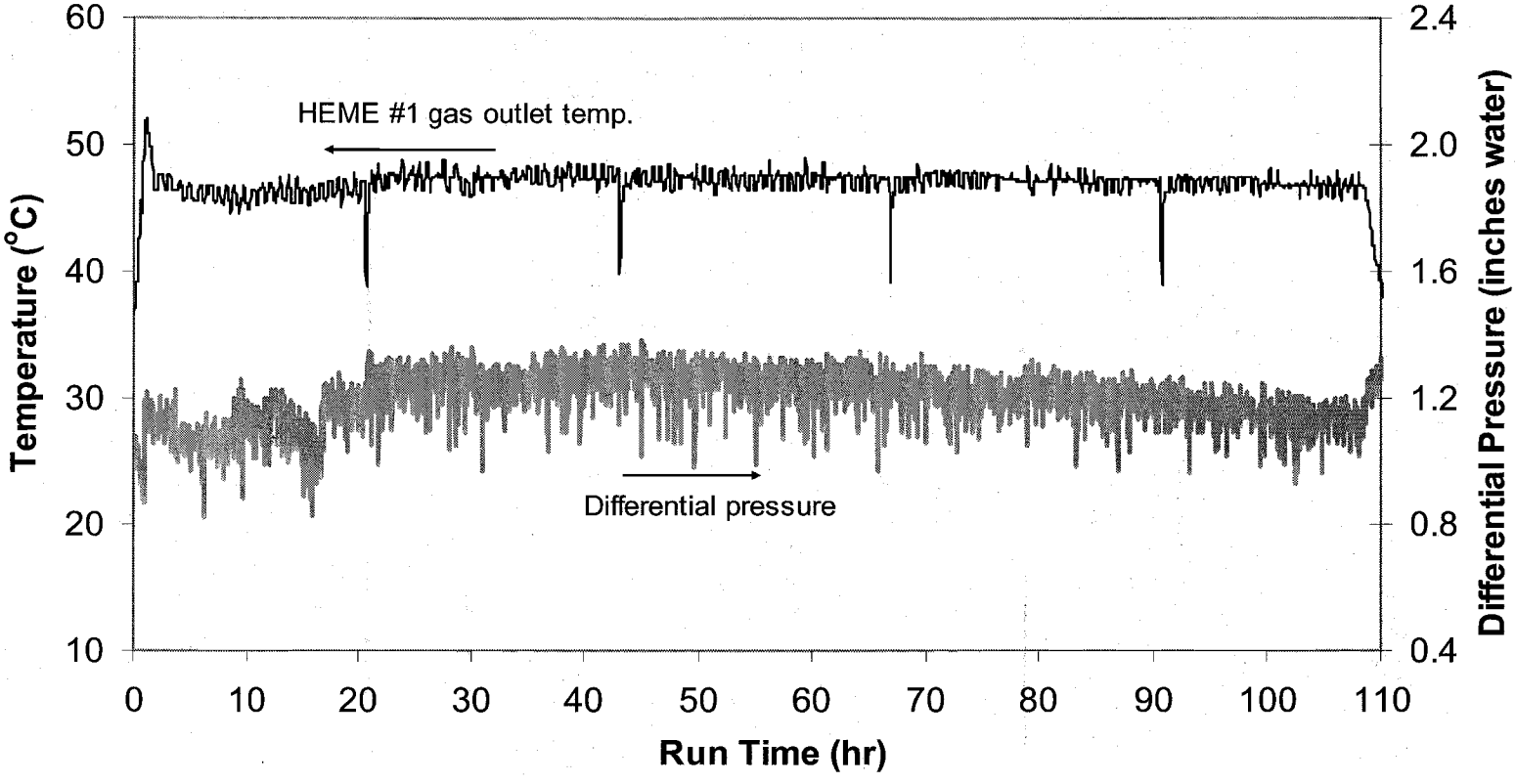

Figure 5.57. Outlet gas temperature and differential pressure for HEME #1 during Test 2A.

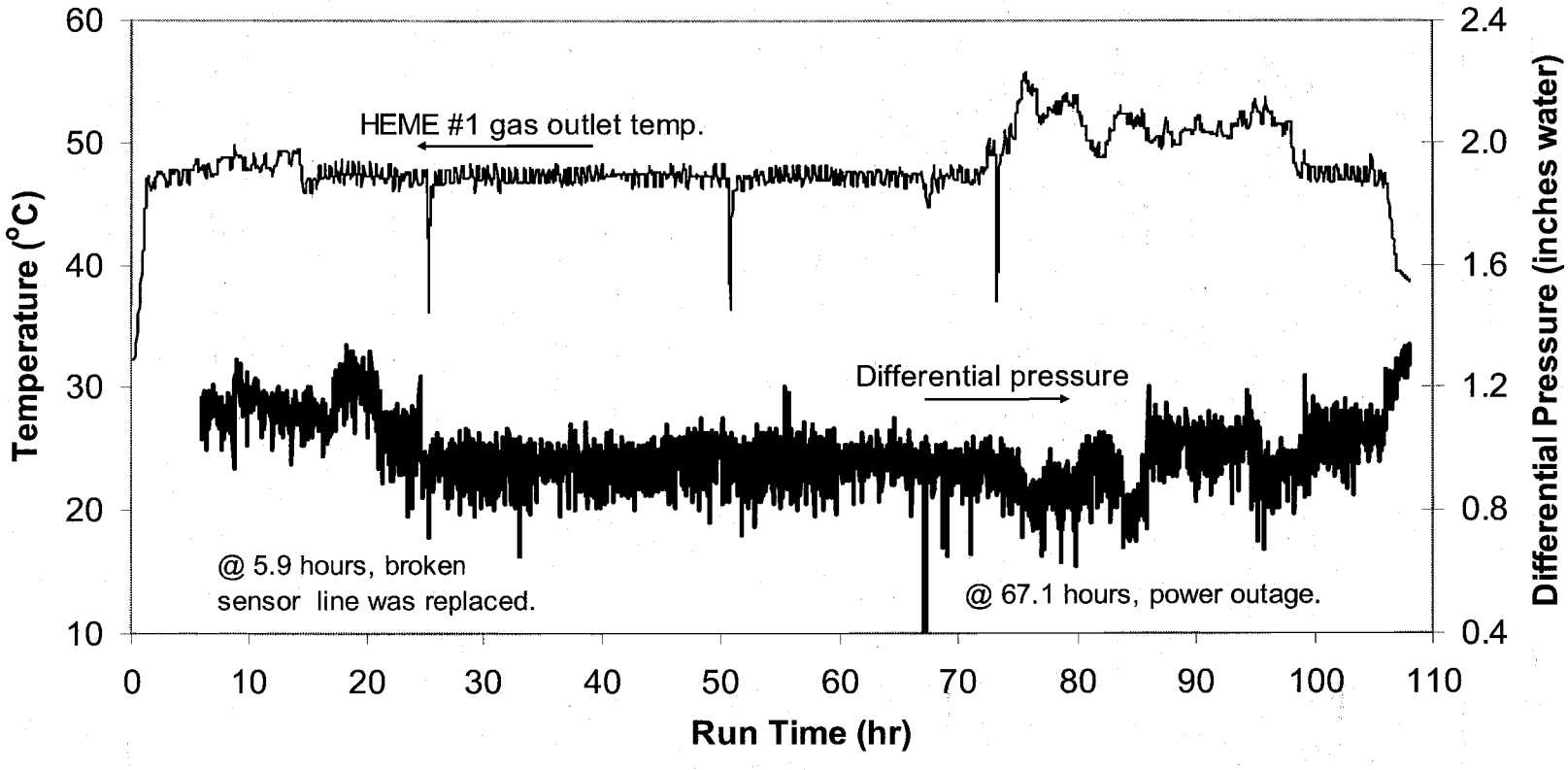

Figure 5.58. Outlet gas temperature and differential pressure for HEME #1 during Test 2B.

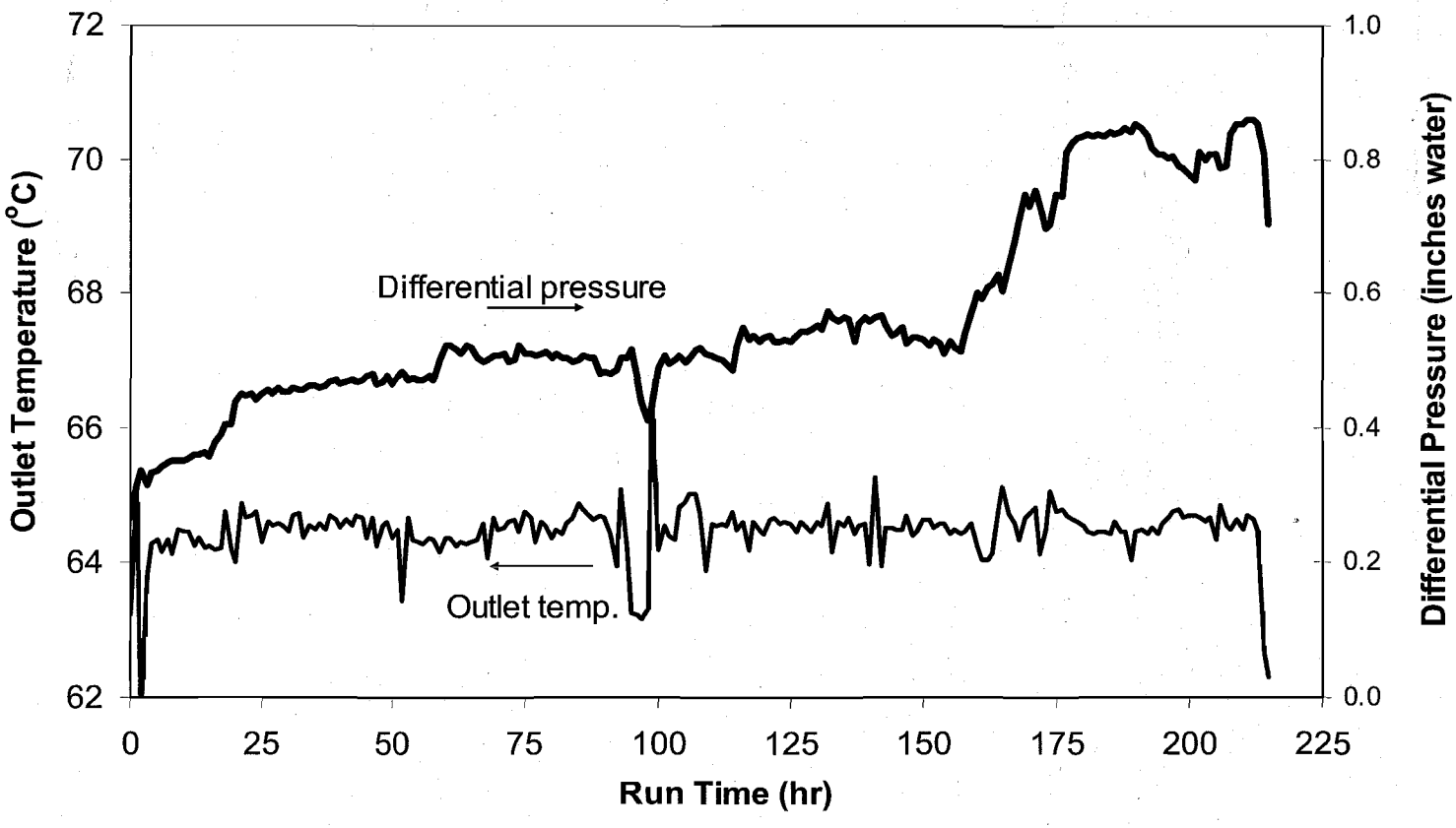

Figure 5.59. Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 1.

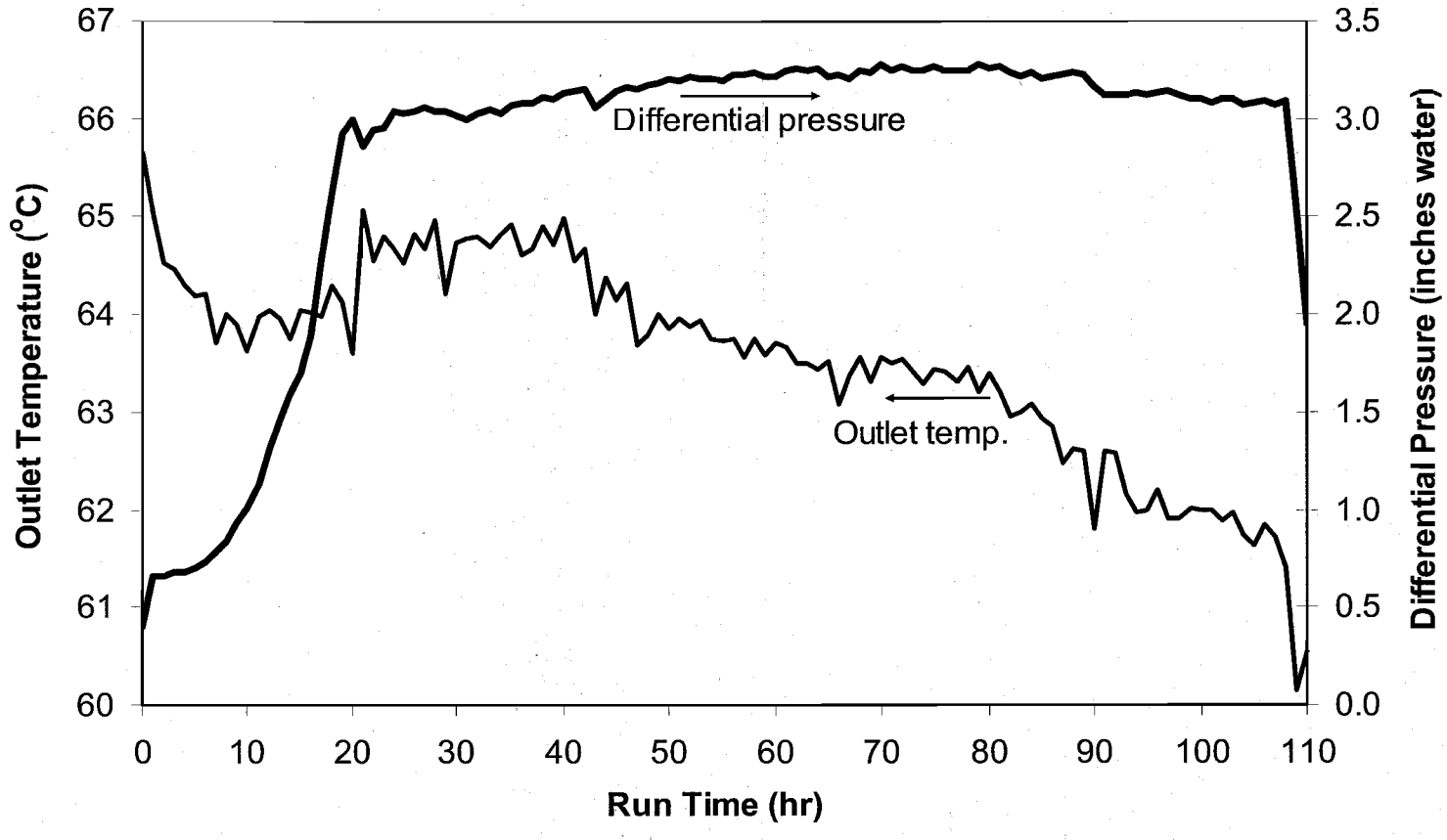

Figure 5.60. Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 2A.

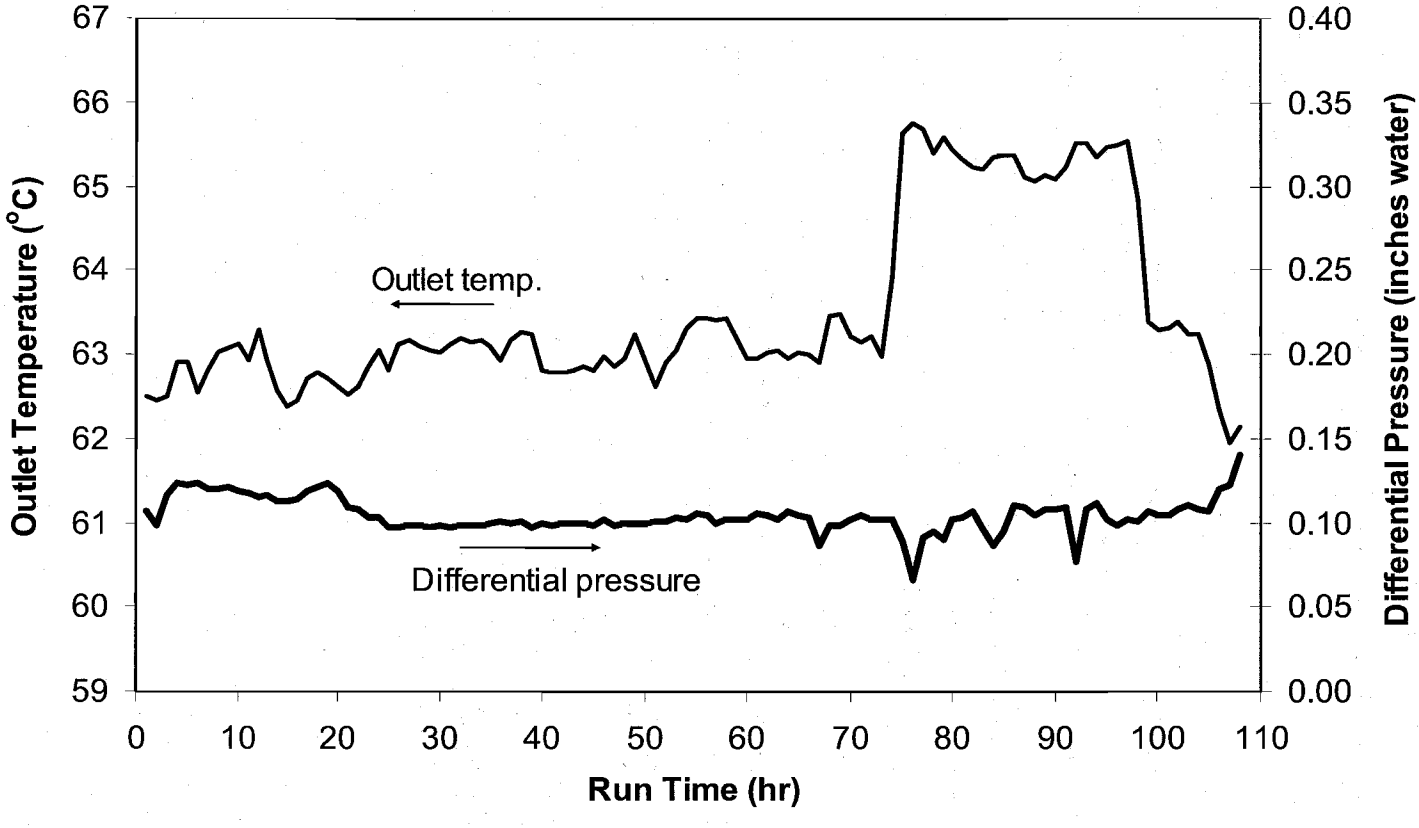

Figure 5.61. Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 2B.

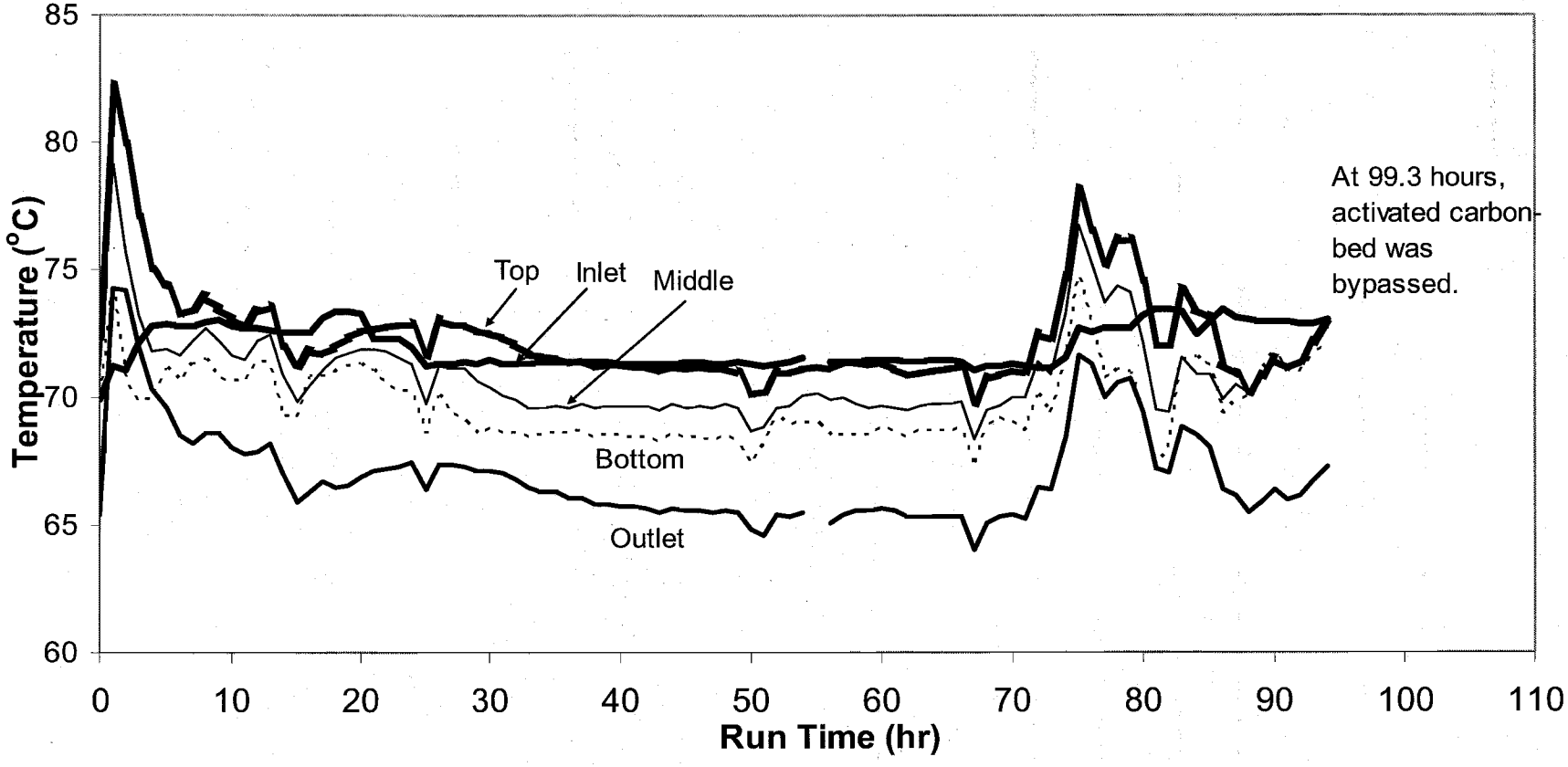

Figure 5.62. Activated carbon bed temperatures (hourly average values) during Test 2B.

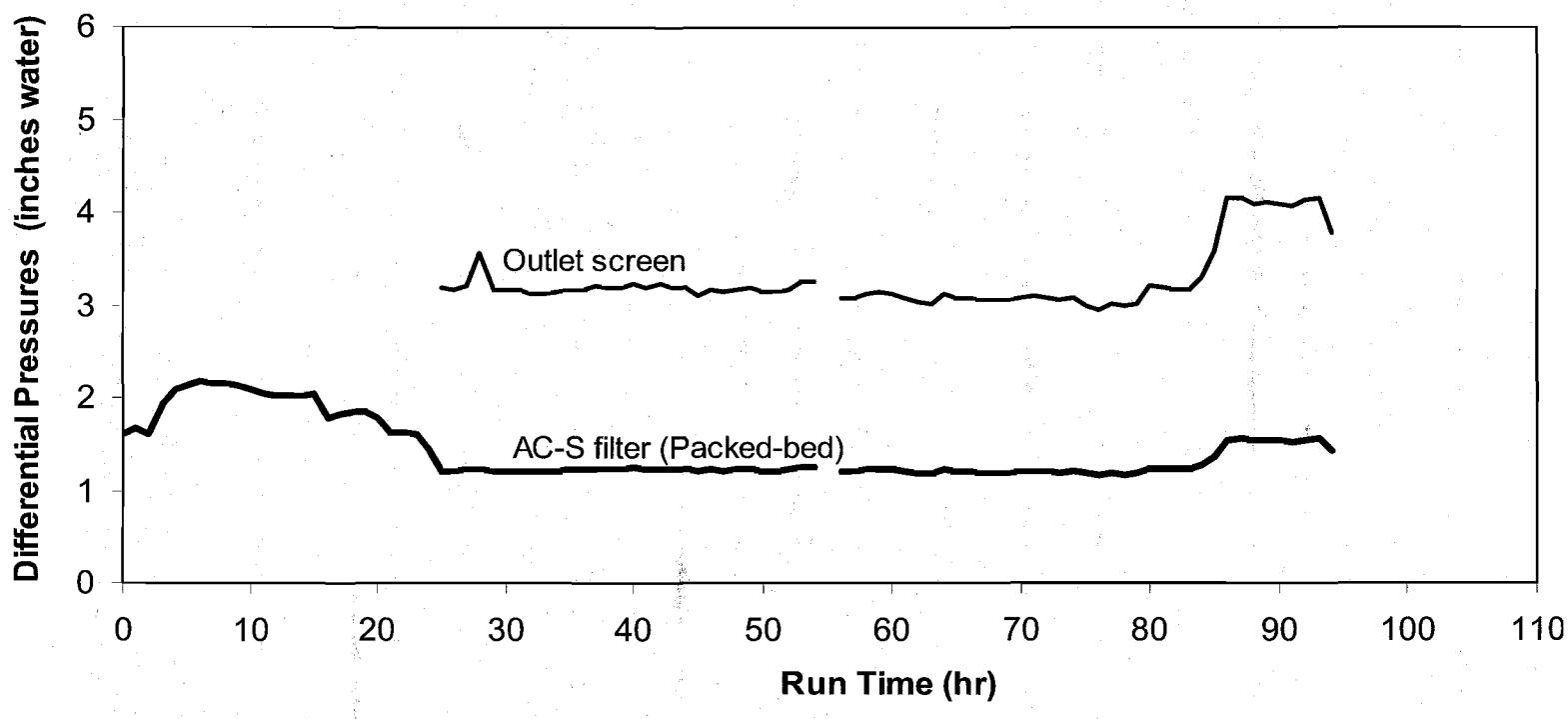

Figure 5.63. Activated carbon bed and outlet screen differential pressures (hourly average values) during Test 2B.

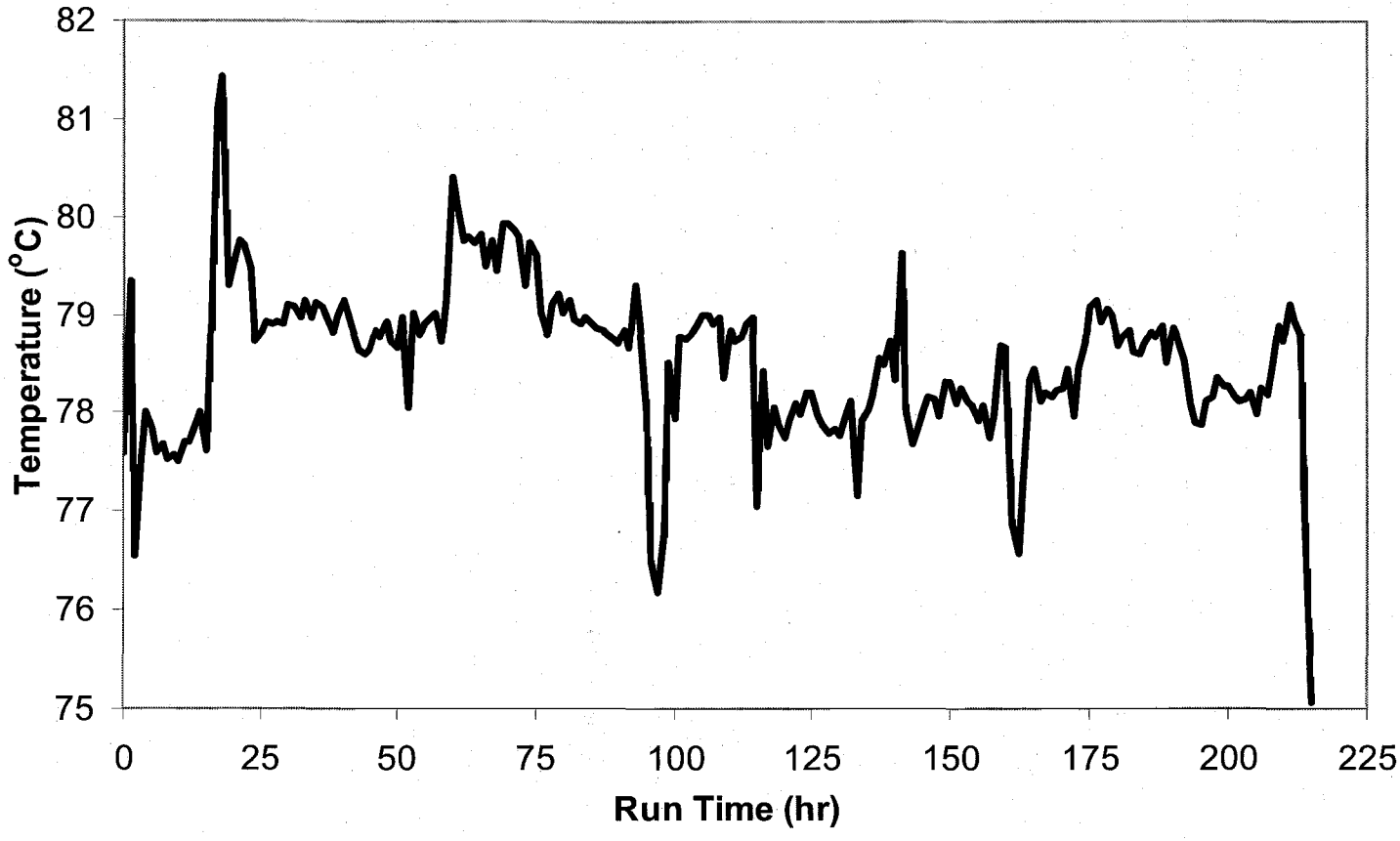

Figure 5.64. TCO/SCR heater inlet gas temperature during Test 1.

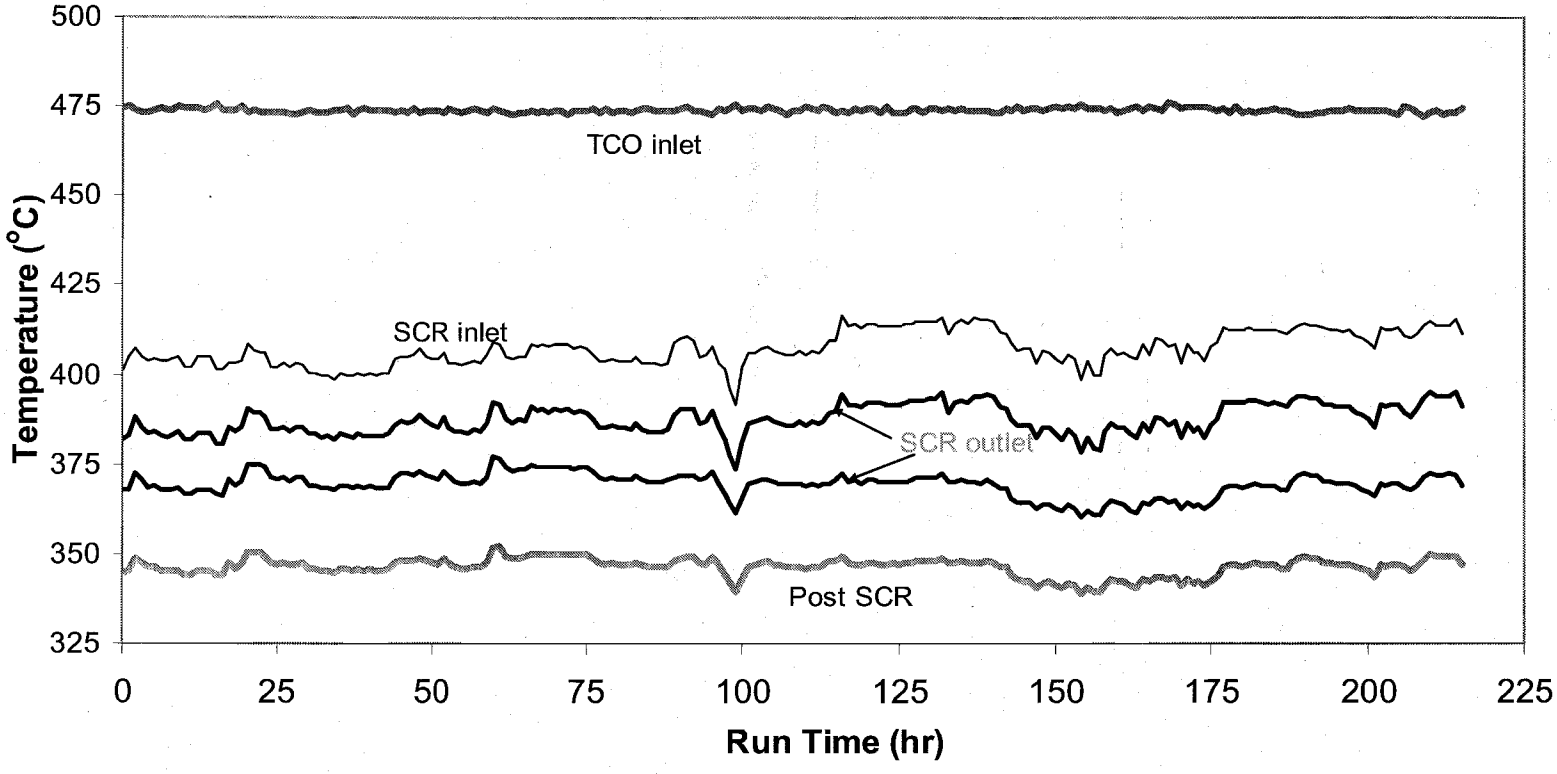

Figure 5.65. TCO/SCR temperatures (hourly average values) during Test 1.

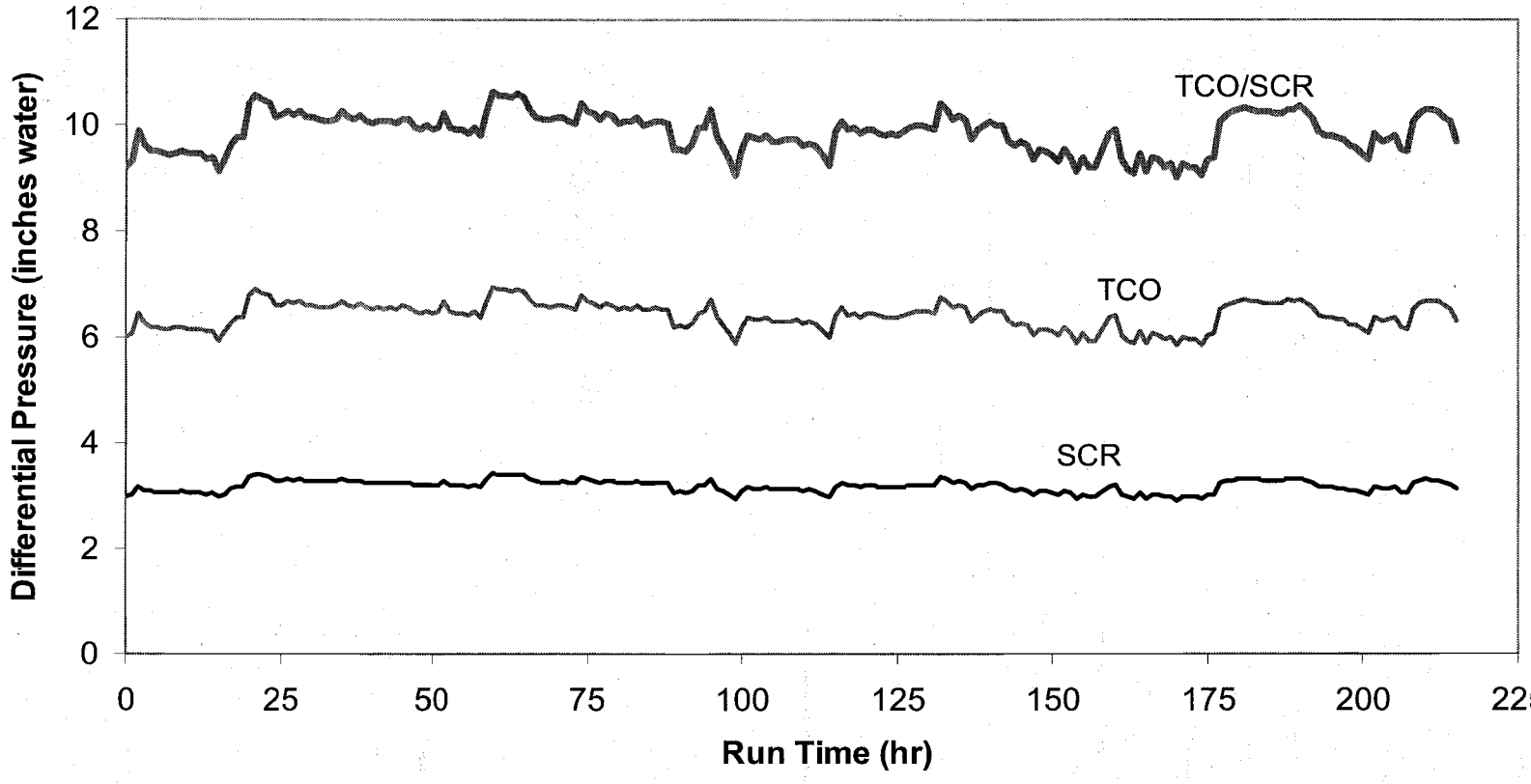

Figure 5.66. TCO/SCR differential pressures (hourly average values) during Test 1.

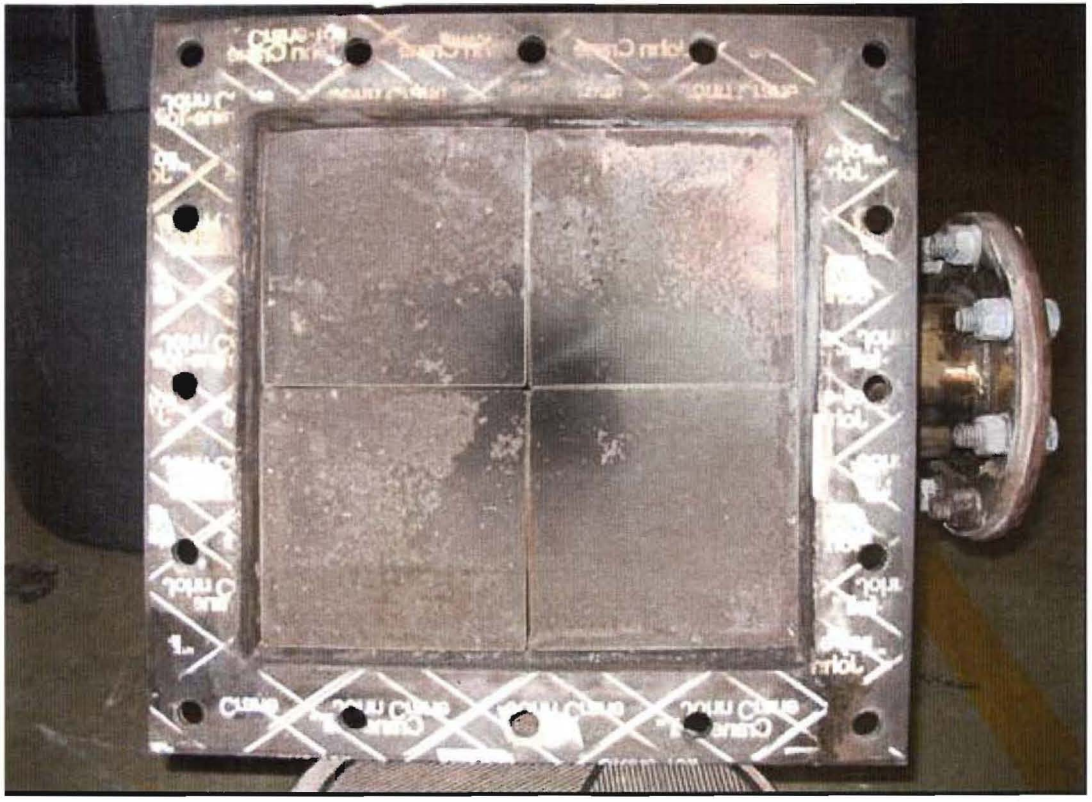

Figure 5.67. View of the inlet of used TCO catalyst section #1 after Test 1.

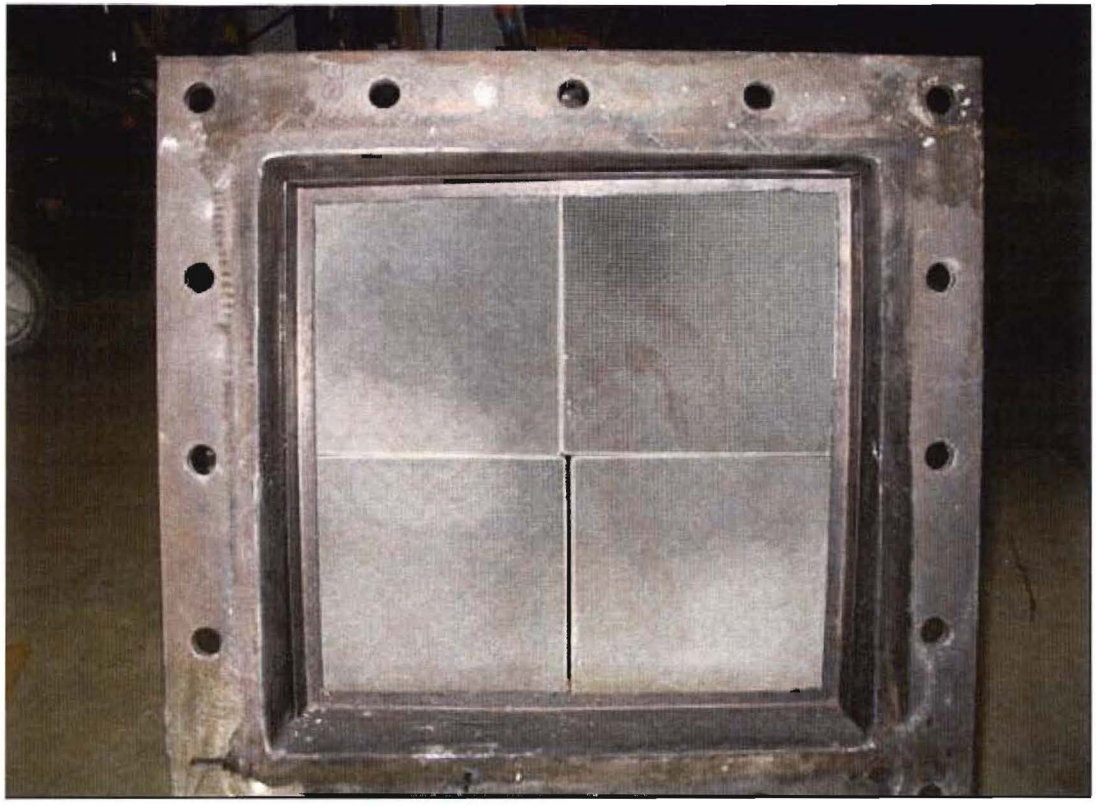

Figure 5.68. View of the outlet of used TCO catalyst section #1 after Test 1.

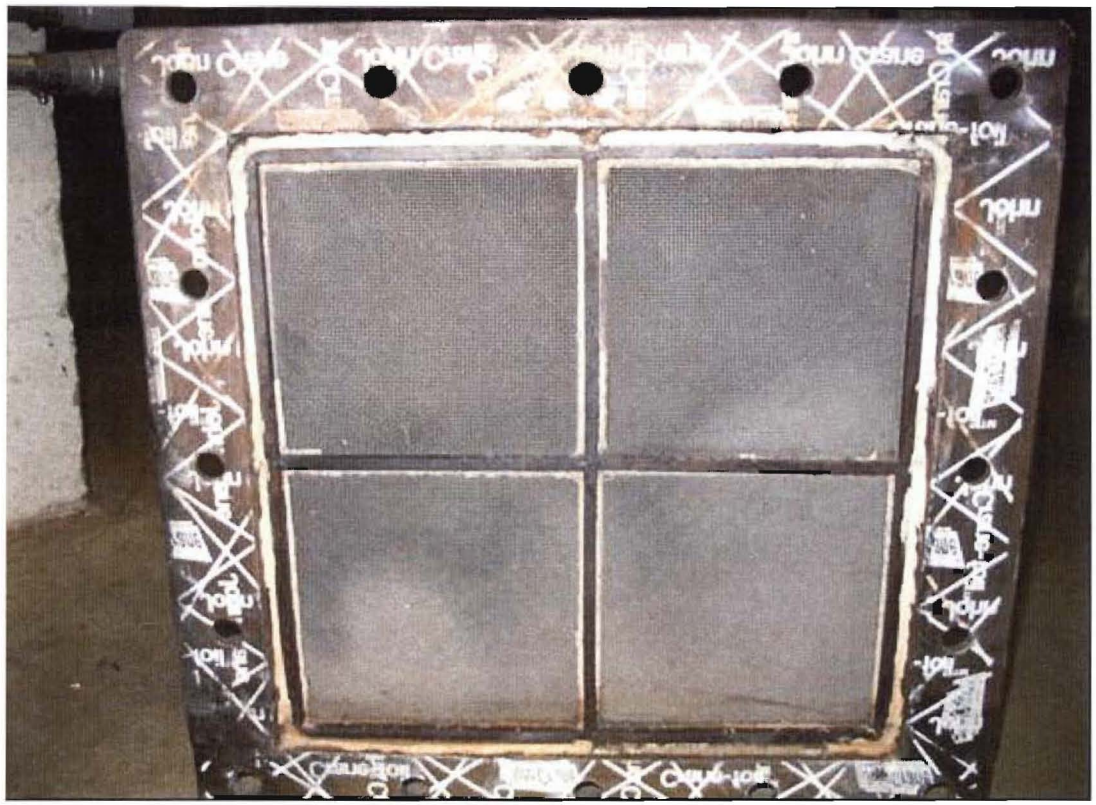

Figure 5.69. View of the inlet of the used TCO catalyst section #2 after Test 1.

Figure 5.70. View of the outlet of used TCO catalyst section #2 after Test 1.

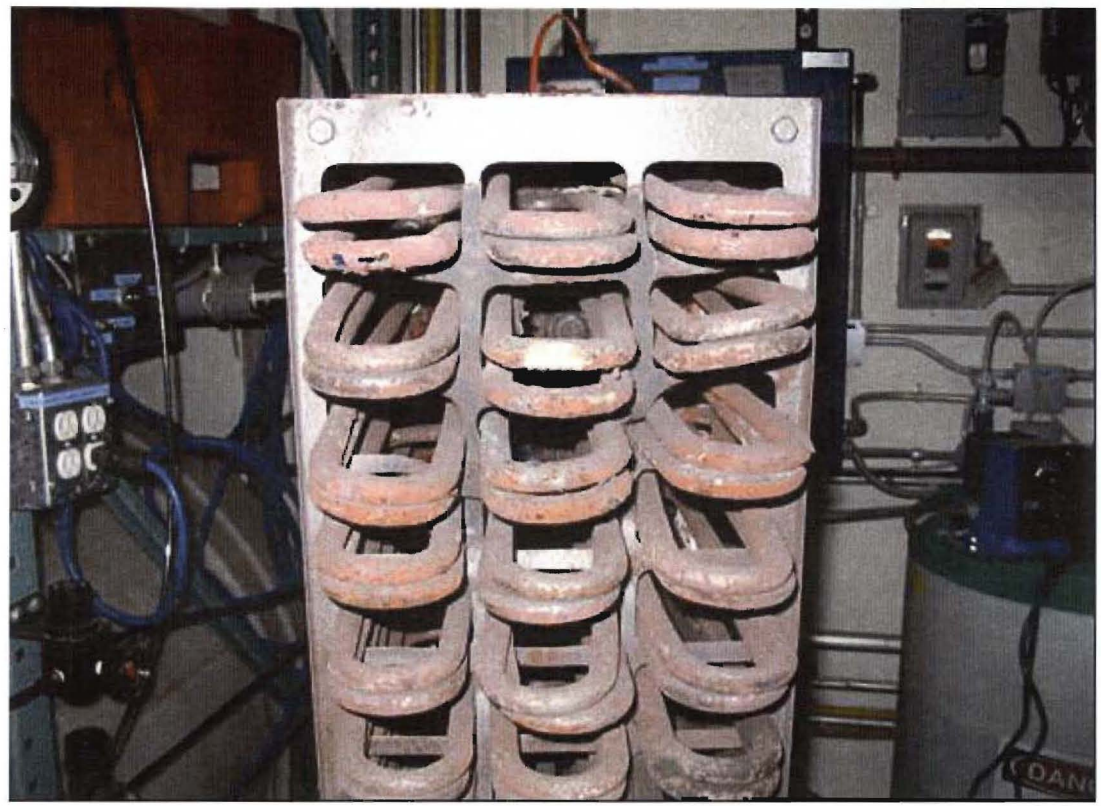

Figure 5.71. End view of Heater 801 top section after Test 1.

Figure 5.72. Side view of Heater 801 after Test 1.

Figure 5.73. Close up of Heater 801 showing failed heating element after Test 1.

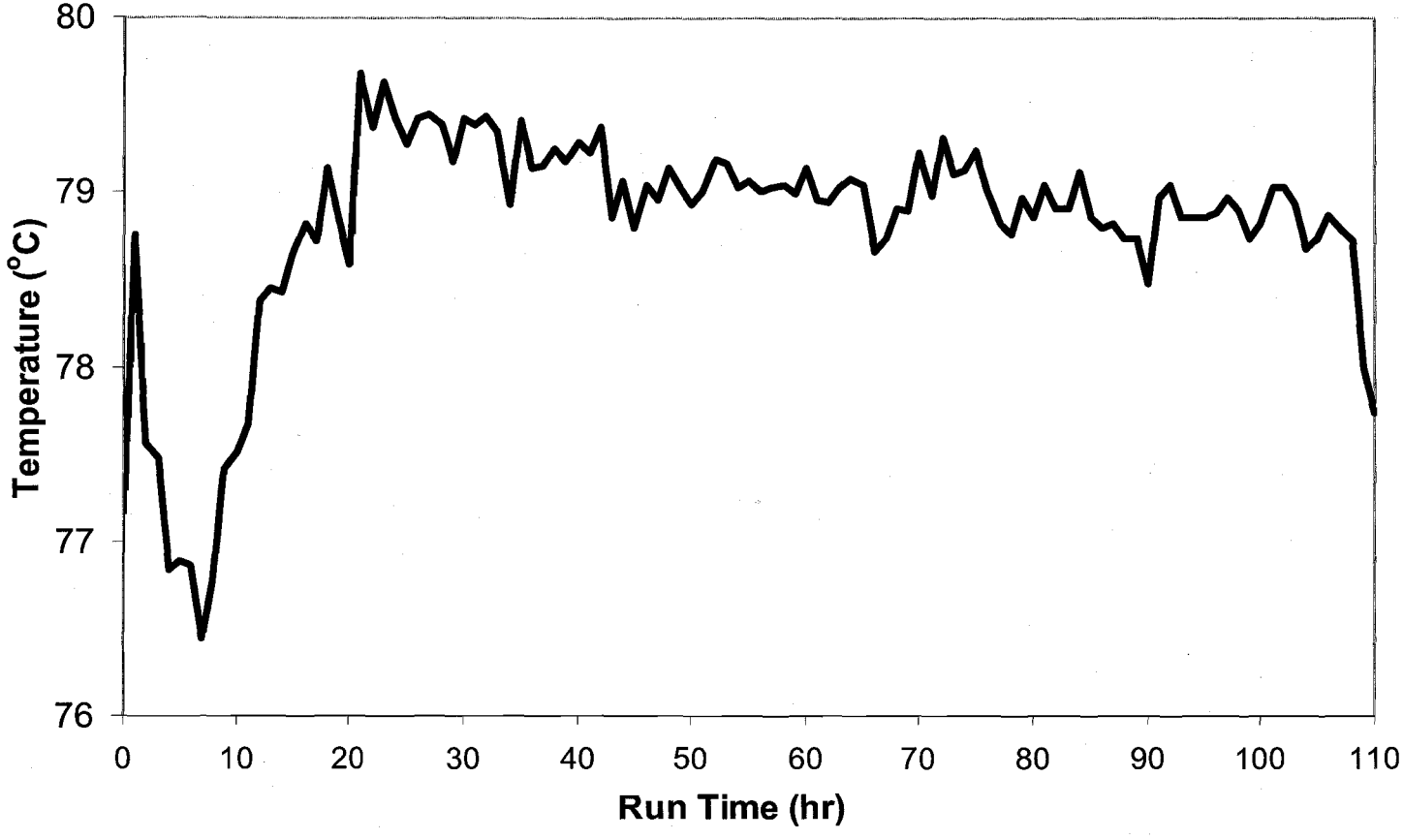

Figure 5.74. TCO/SCR heater inlet gas temperature during Test 2A.

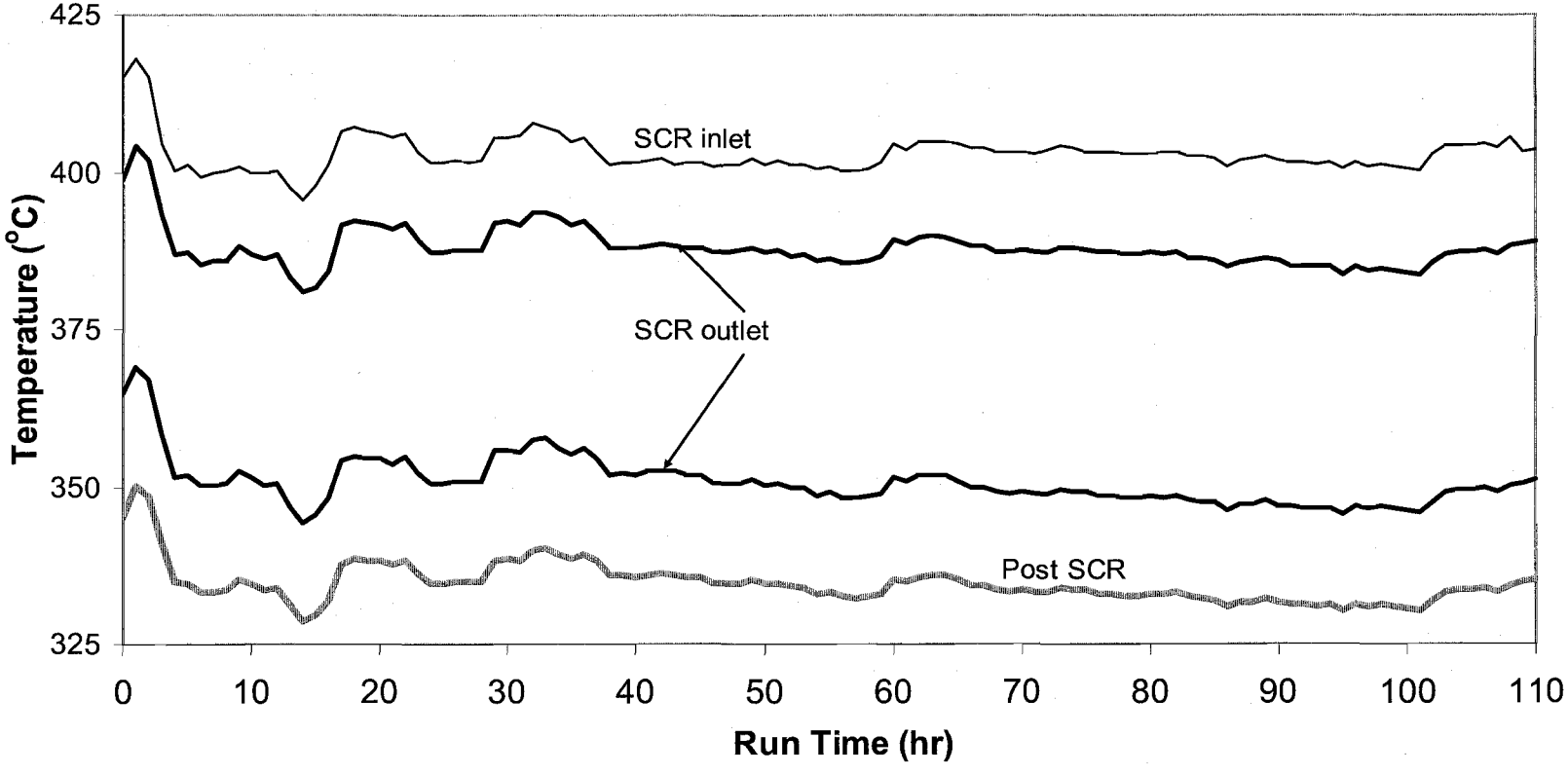

Figure 5.75. TCO/SCR temperatures (hourly average values) during Test 2A.

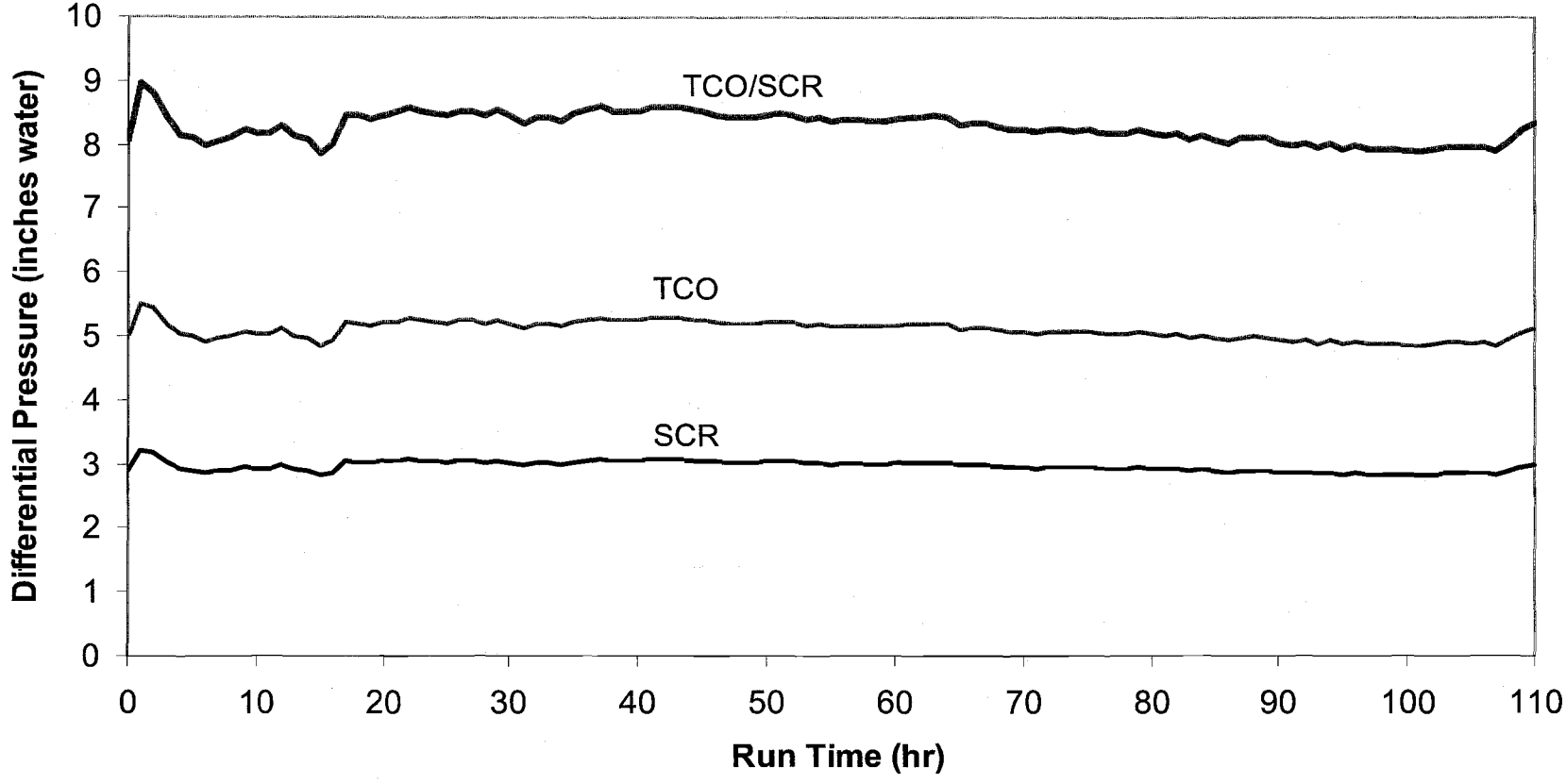

Figure 5.76. TCO/SCR differential pressures (hourly average values) during Test 2A.

Figure 5.77. View of the inlet of TCO catalyst (Engelhard Corp. VOC CAT 300S 200 CPSI) section #1 before Test 2B.

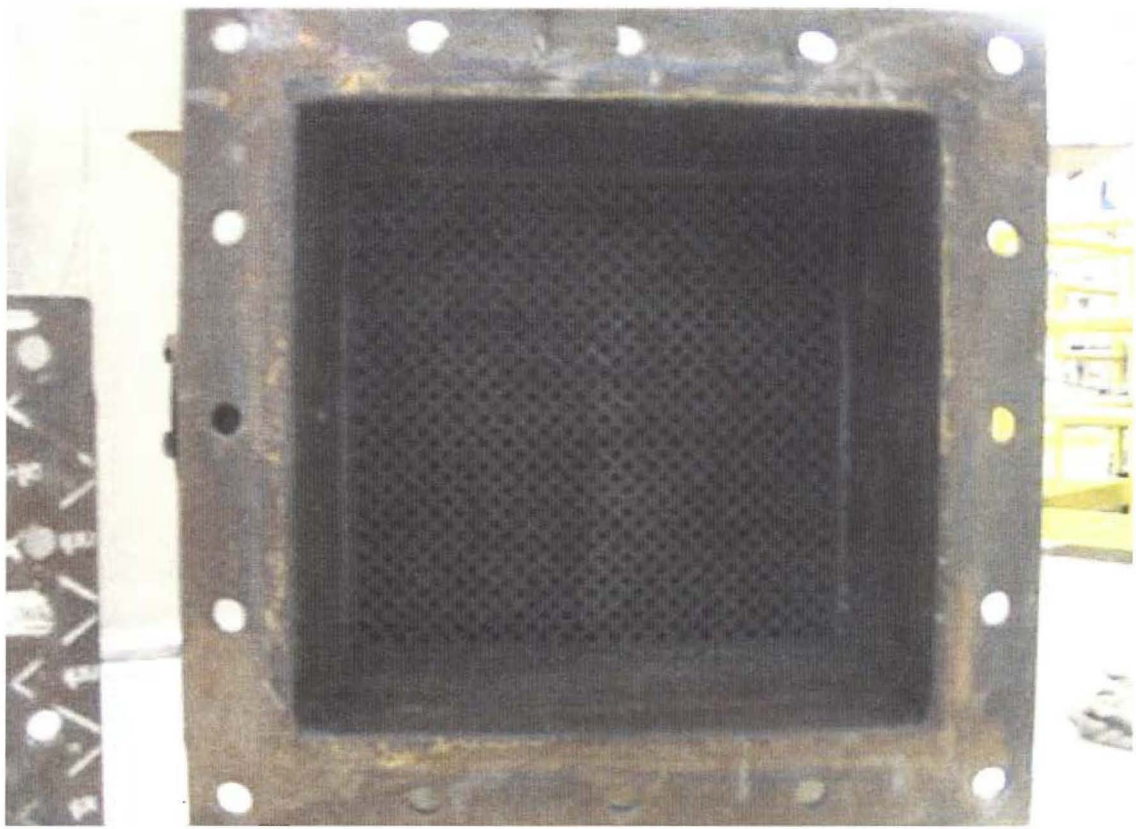

Figure 5.78. View of the outlet of TCO catalyst (Engelhard Corp. VOC CAT 300S 200 CPSI) section #1 before Test 2B.

Figure 5.79. View of the inlet of TCO catalyst (Engelhard Corp. VOC CAT 300S 200 CPSI) section #2 before Test 2B.

Figure 5.80. View of the outlet of TCO catalyst (Engelhard Corp. VOC CAT 300S 200 CPSI) section #2 before Test 2B.

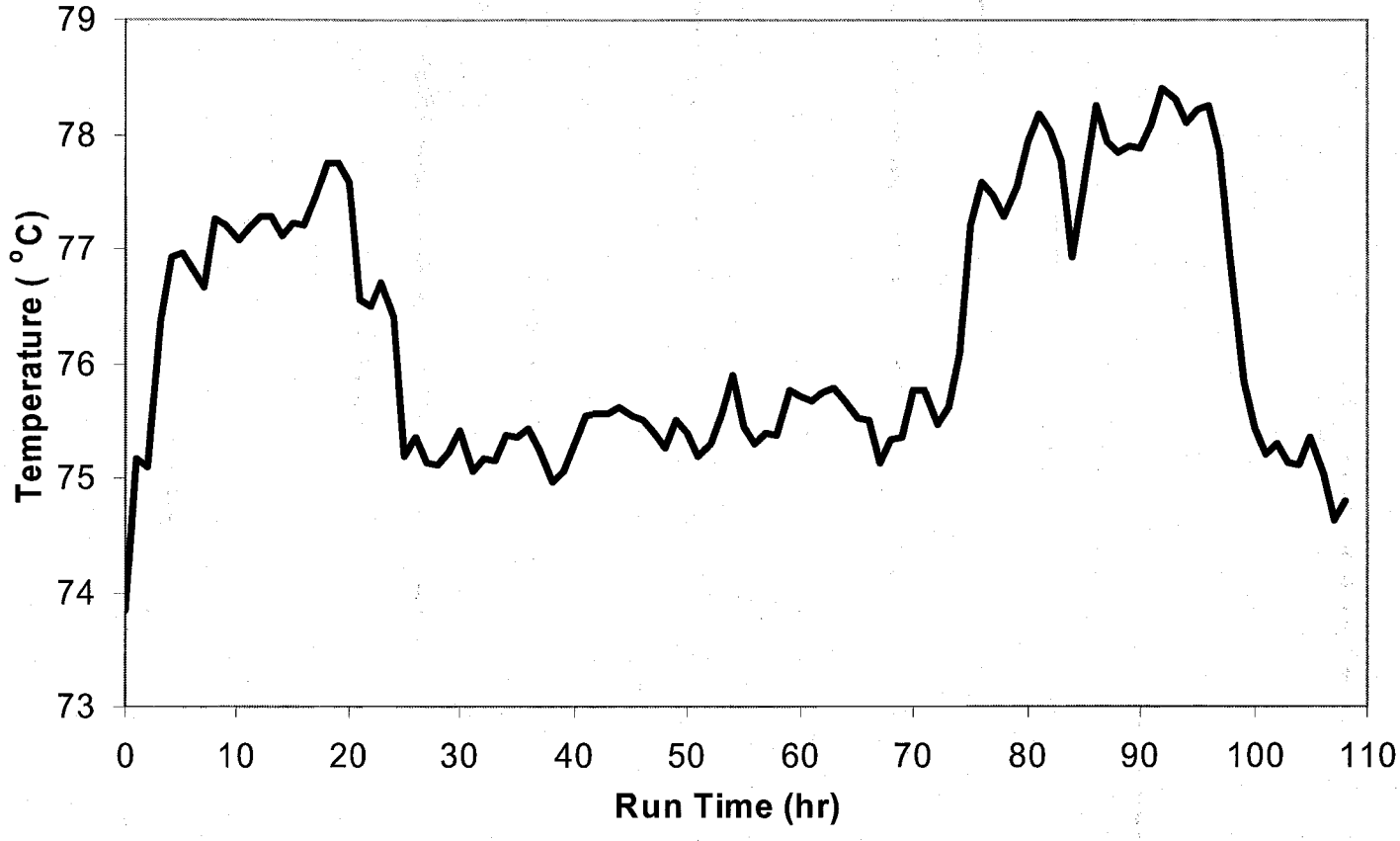

Figure 5.81. TCO/SCR heater inlet gas temperature during Test 2B.

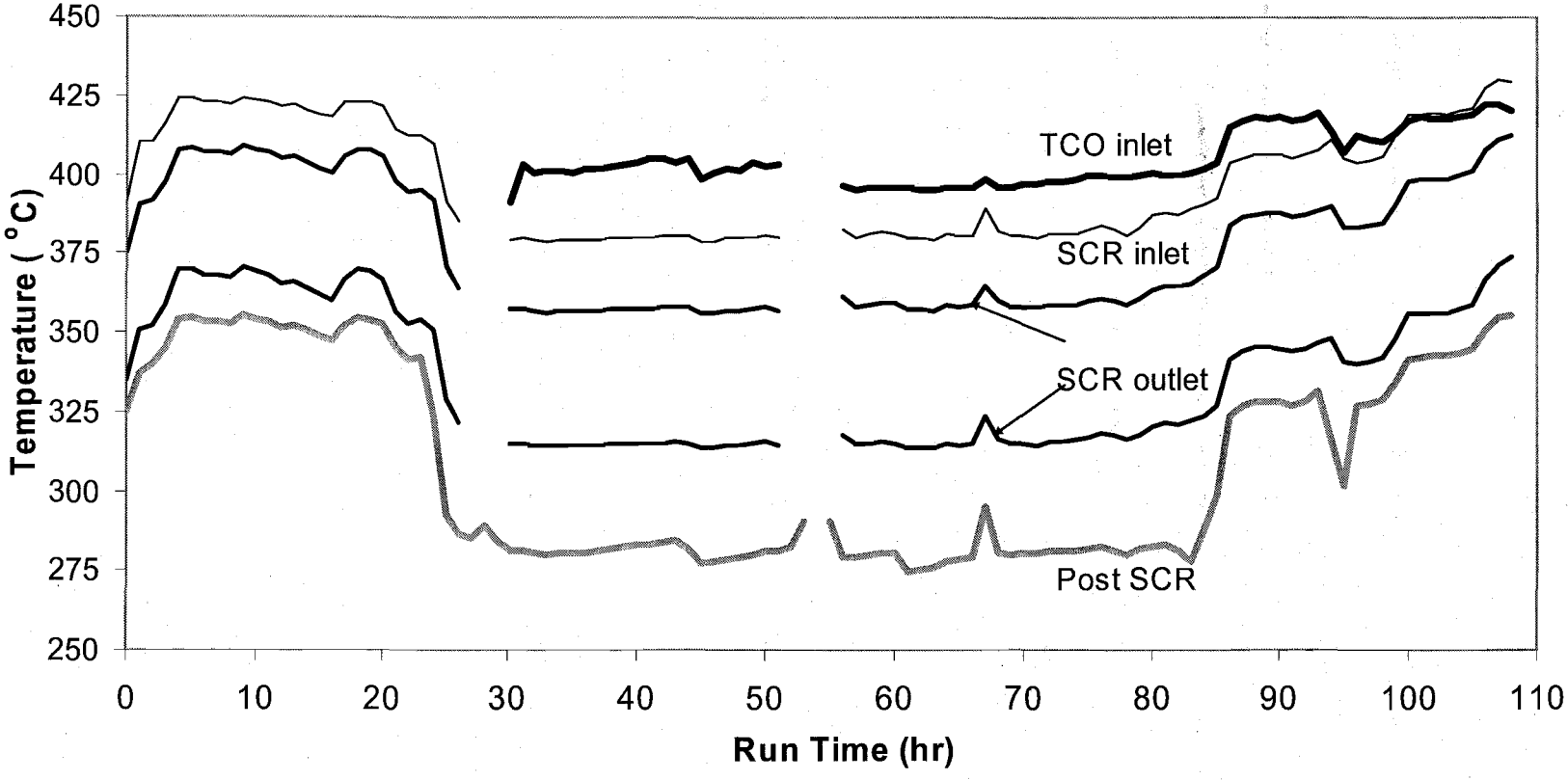

Figure 5.82. TCO/SCR temperatures (hourly average values) during Test 2B.

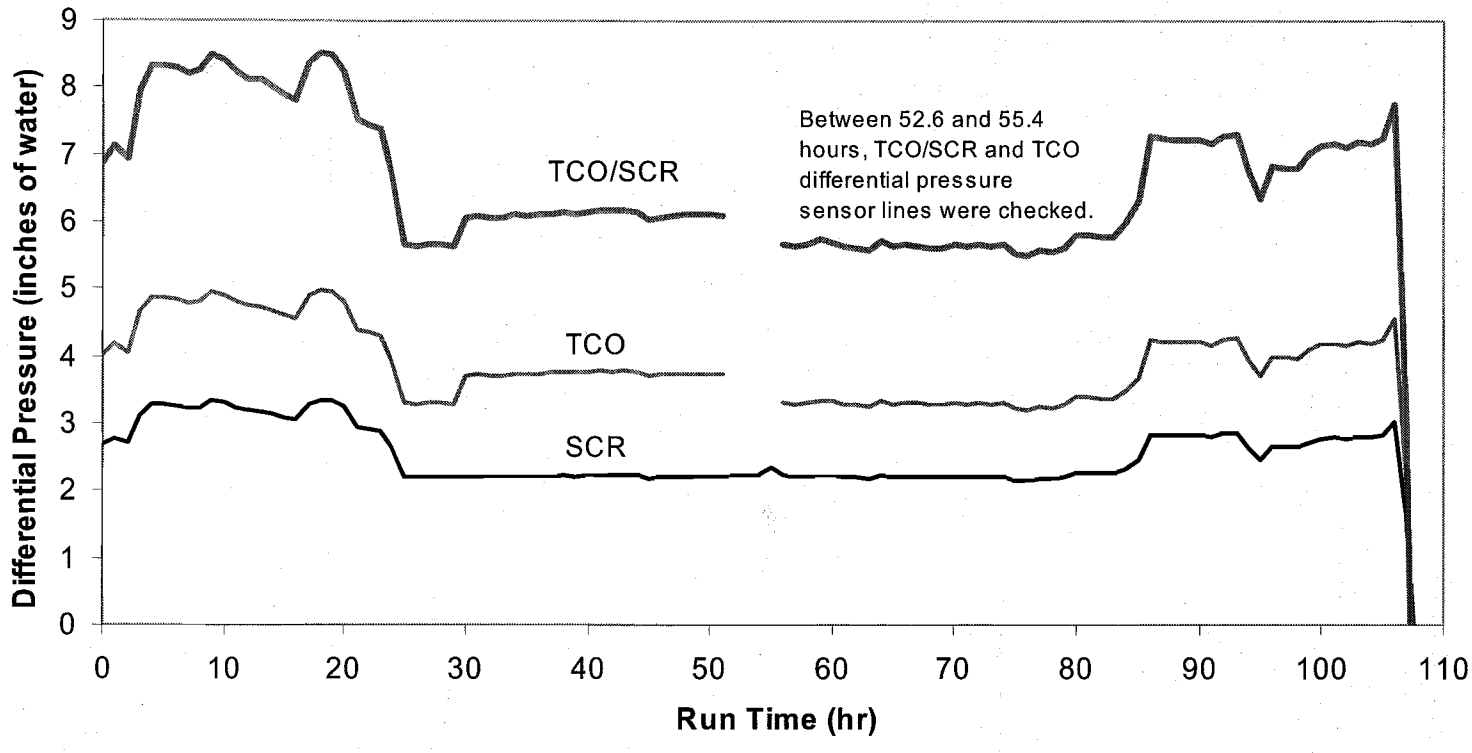

Figure 5.83. TCO/SCR differential pressures (hourly average values) during Test 2B.

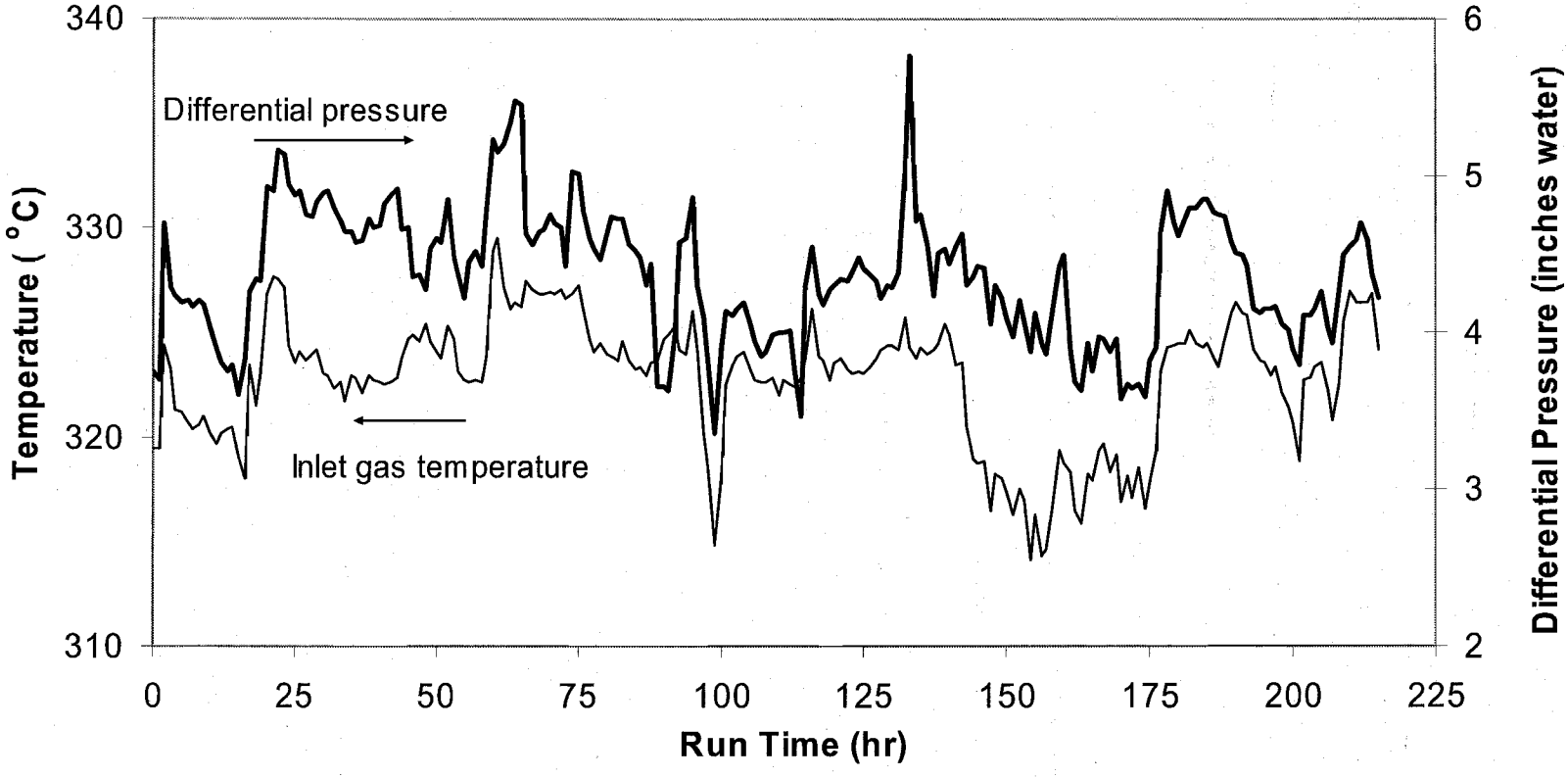

Figure 5.84. Inlet gas temperature and differential pressure for PBS (hourly average values) during Test 1.

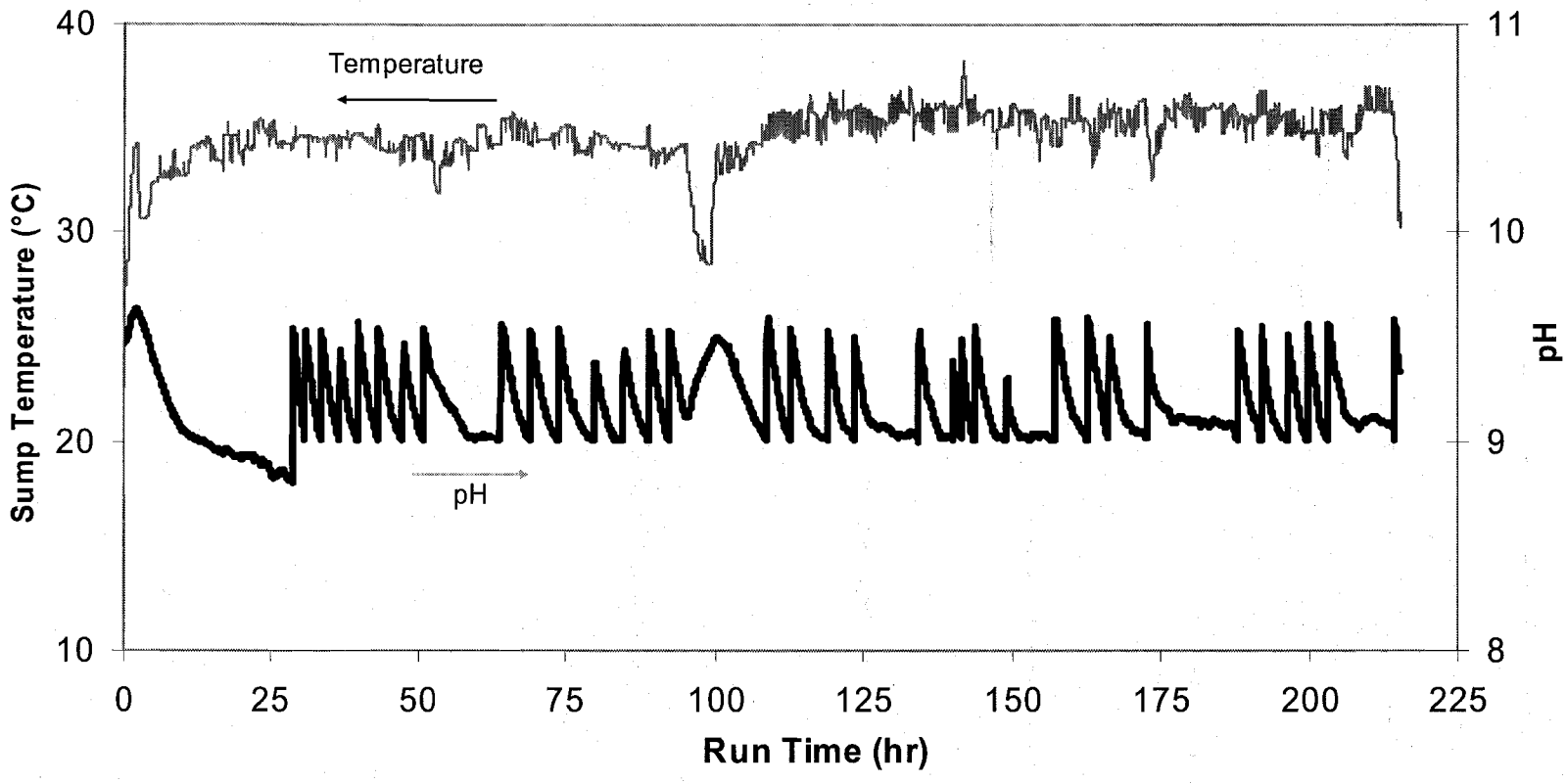

Figure 5.85. Sump temperature and pH for PBS during Tests 1.

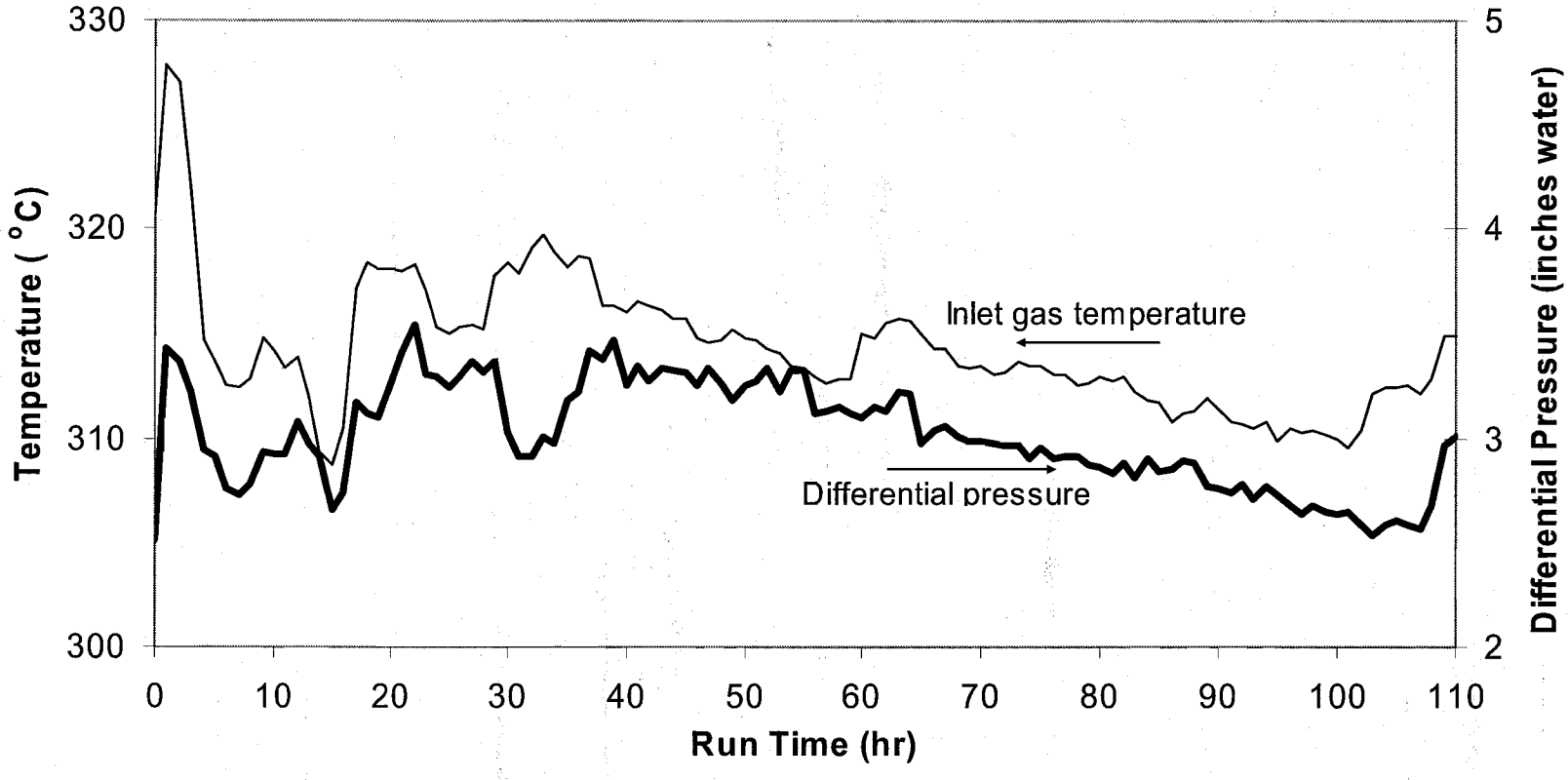

Figure 5.86. Inlet gas temperature and differential pressure for PBS (hourly average values) during Test 2A.

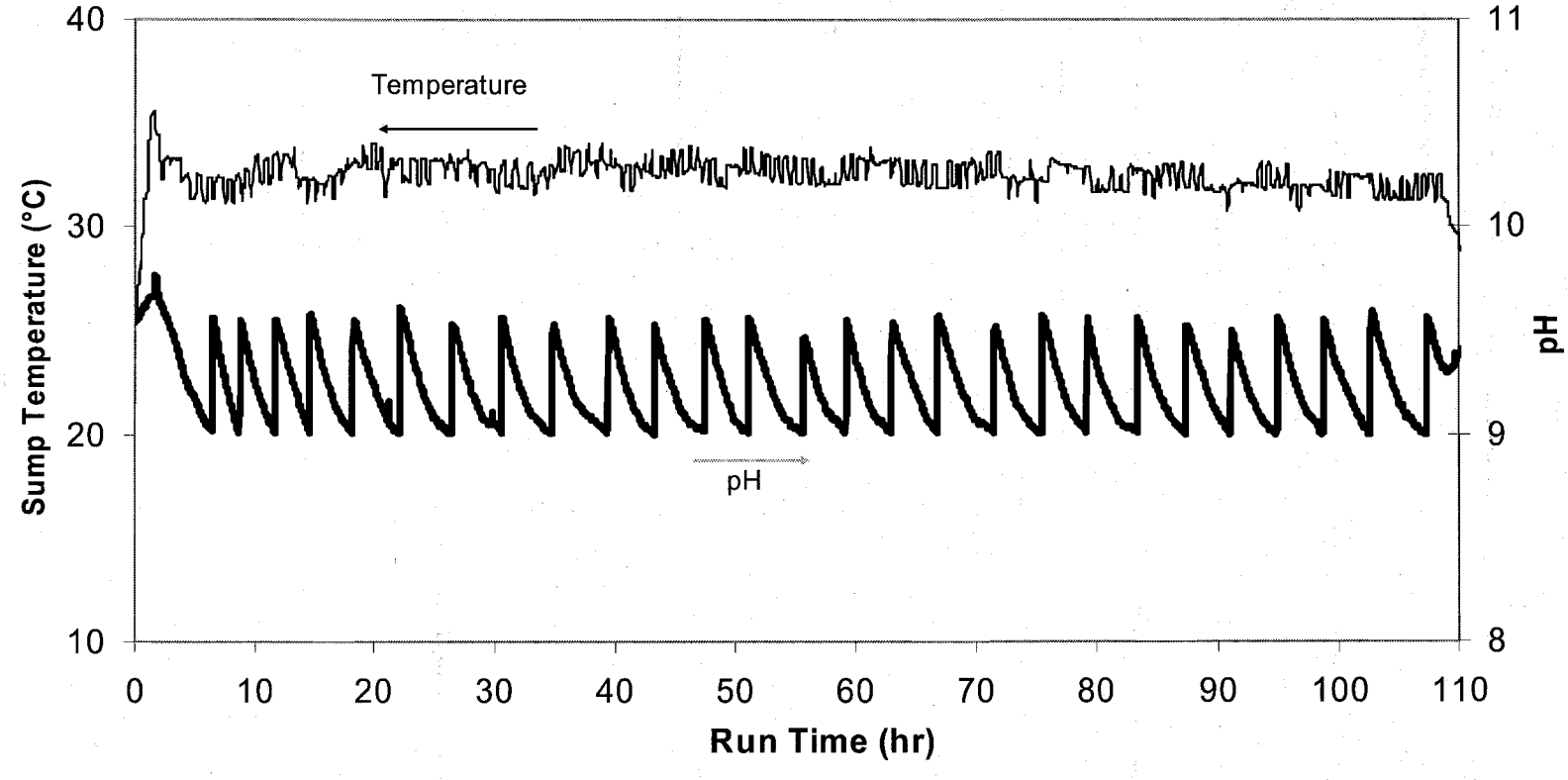

Figure 5.87. Sump temperature and pH for PBS during Tests 2A.

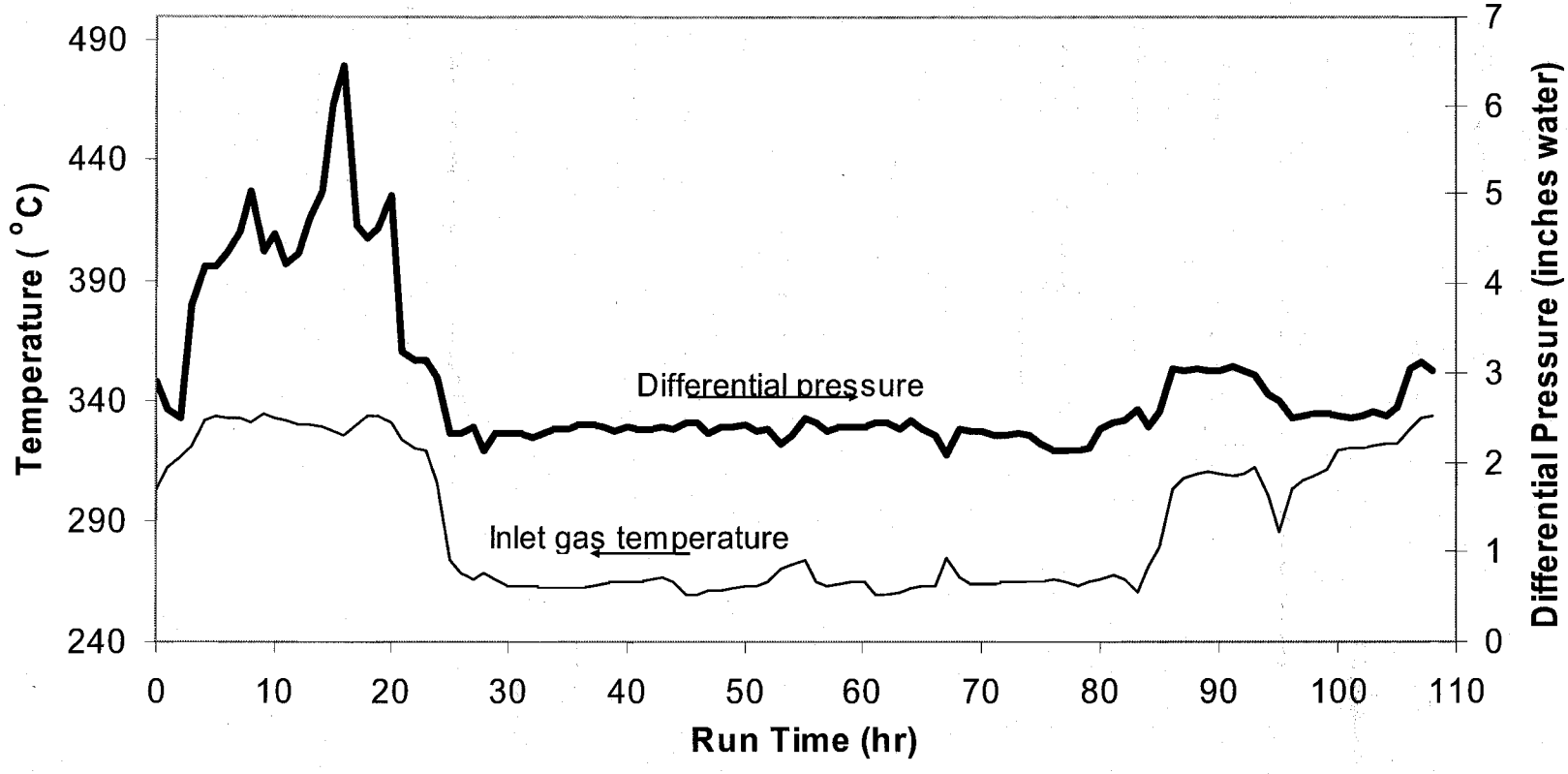

Figure 5.88. Inlet gas temperature and differential pressure for PBS (hourly average values) during Test 2B.

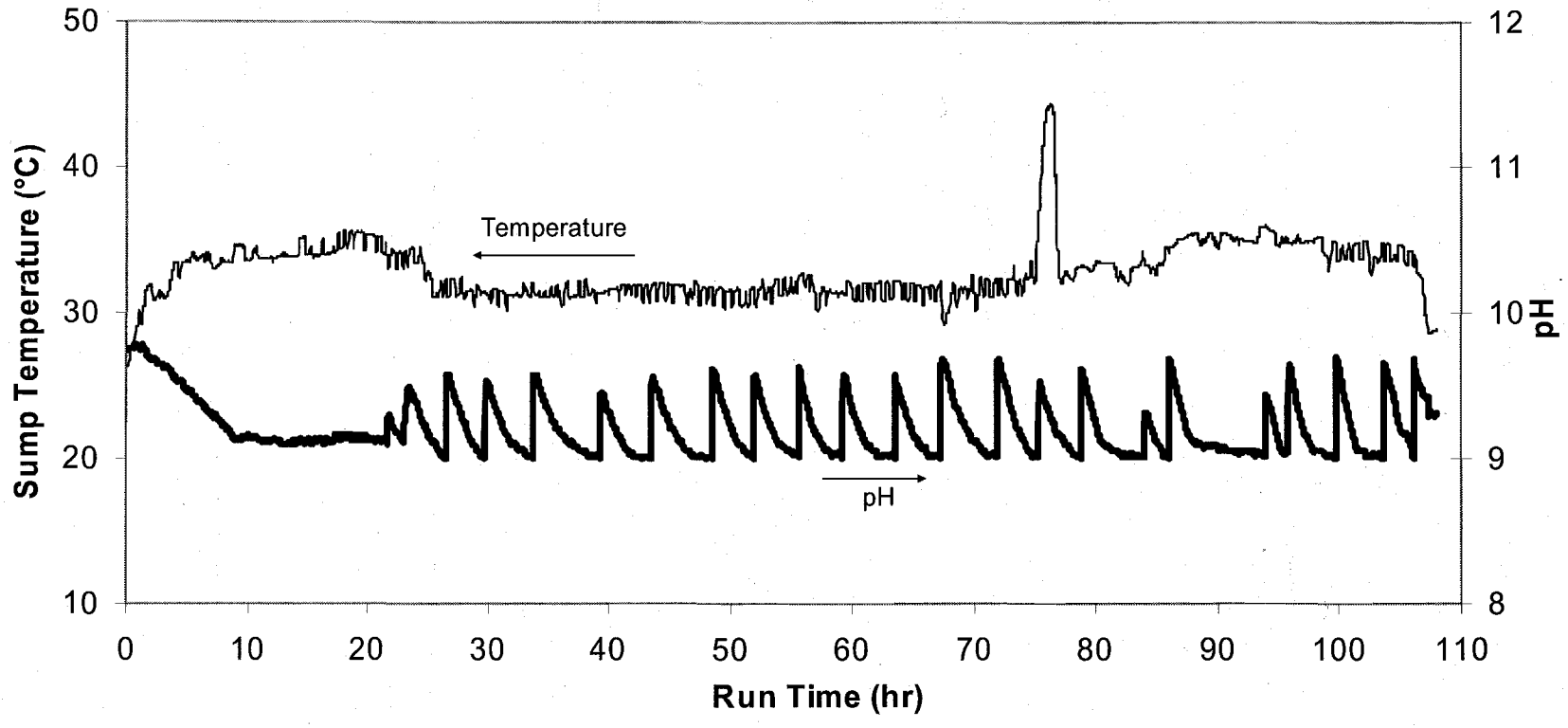

Figure 5.89. Sump temperature and pH for PBS during Test 2B.

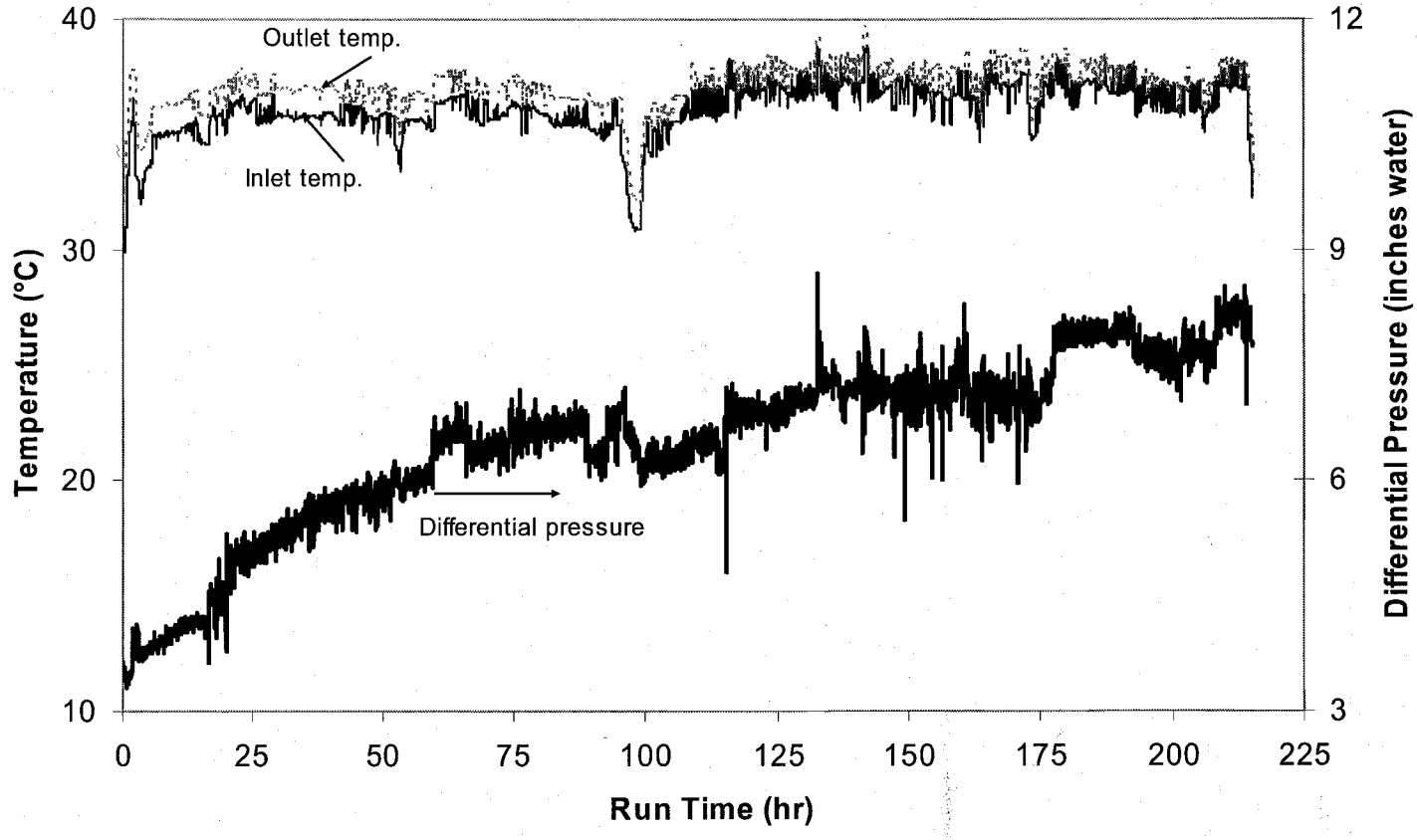

Figure 5.90. Inlet and outlet gas temperatures and differential pressure for HEME #2 during Test 1.

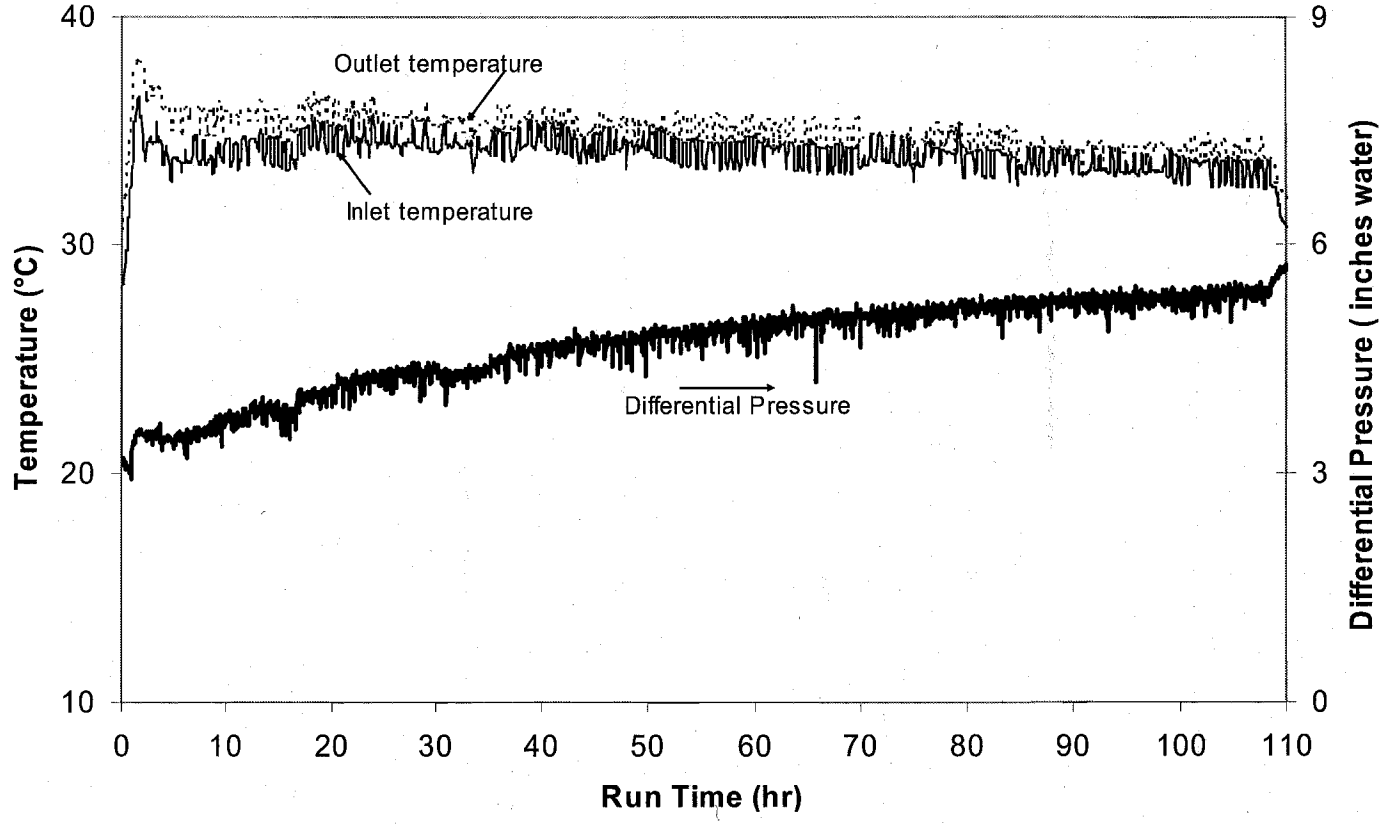

Figure 5.91. Inlet and outlet gas temperatures and differential pressure for HEME #2 during Test 2A.

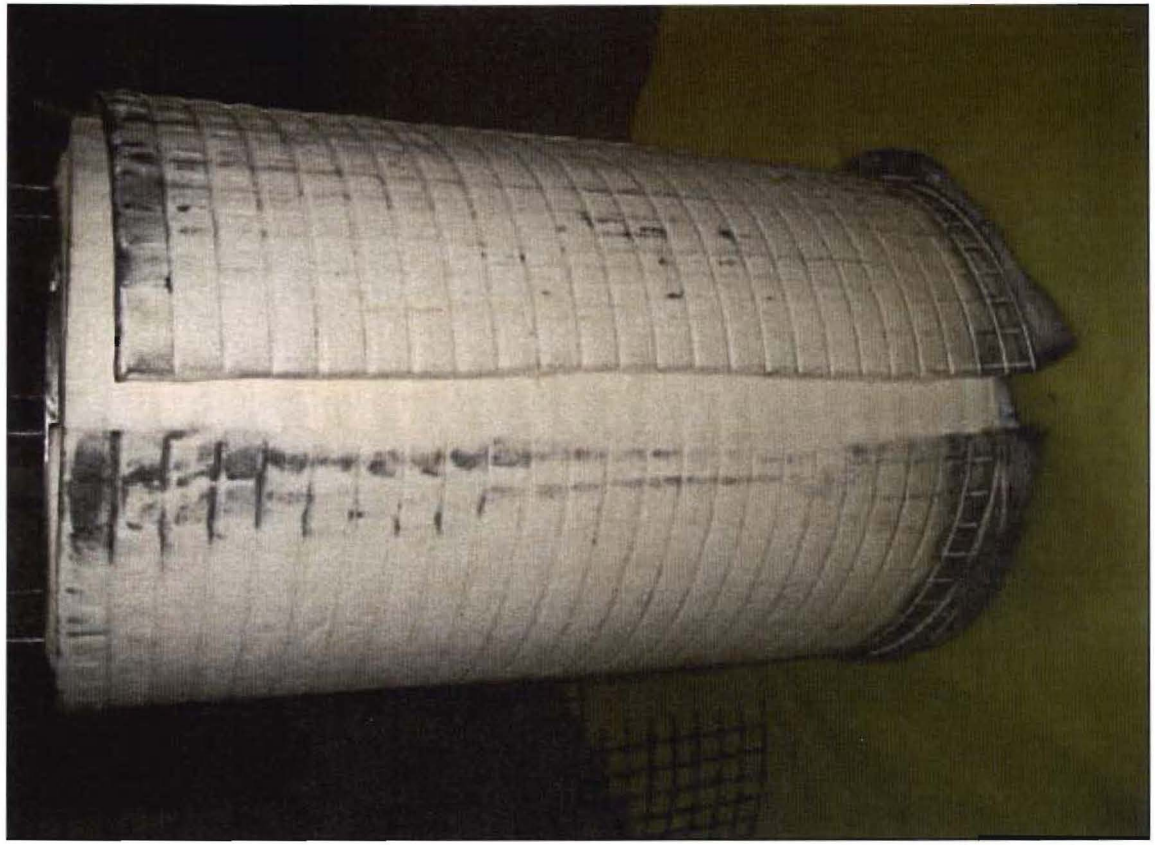

Figure 5.92. View of the outer surface of HEME 2 filter media after Test 2A.

Figure 5.93. View of the inner surface of HEME 2 filter media after Test 2A.

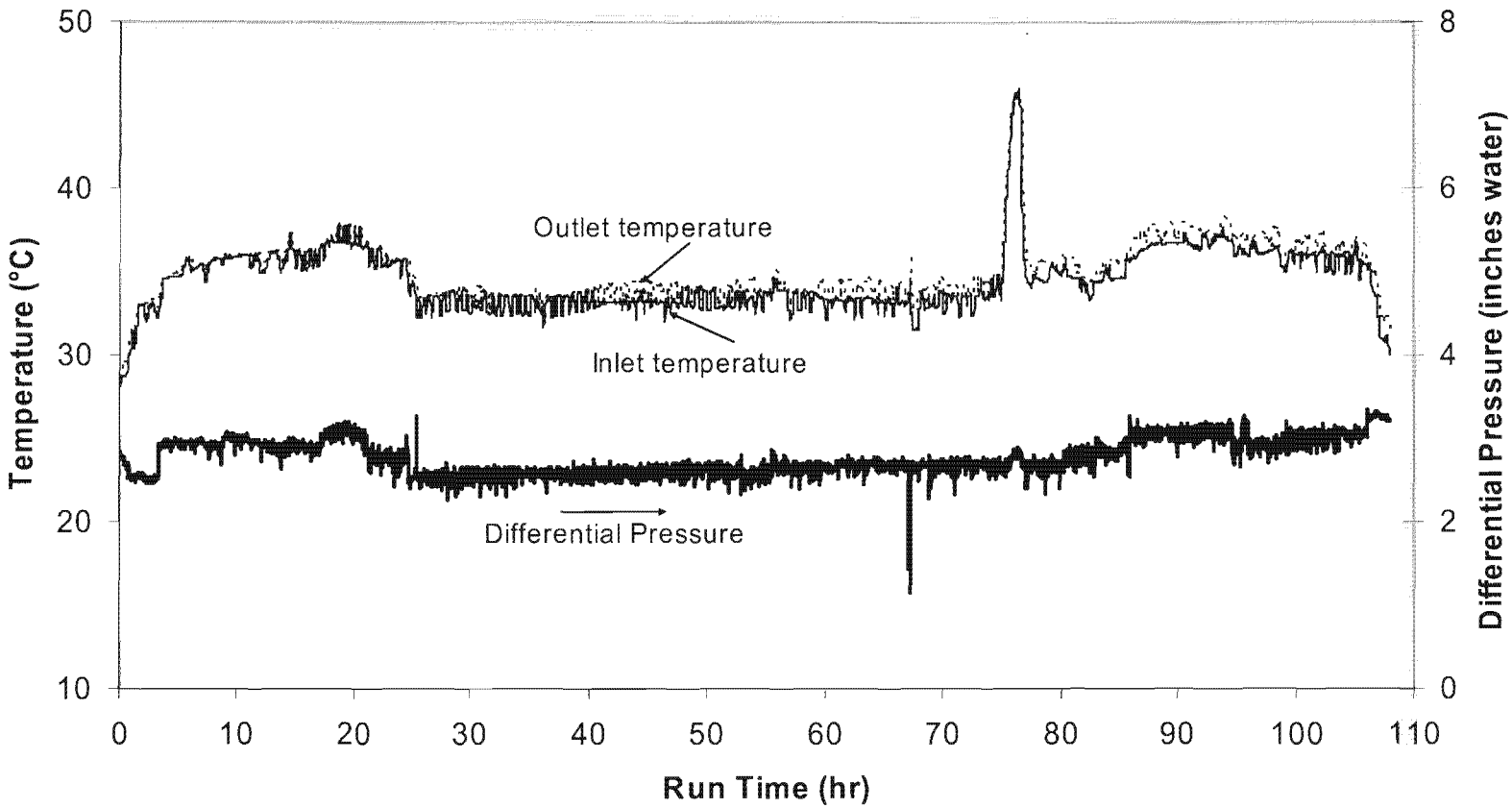

Figure 5.94. Inlet and outlet gas temperatures and differential pressure for HEME #2 during Test 2B.

Figure 5.95. View of EOG Piping, 1st 90° elbow, looking back into elbow from outlet.

Figure 5.96. View of EOG piping/flange at melter connection after Test 2A.

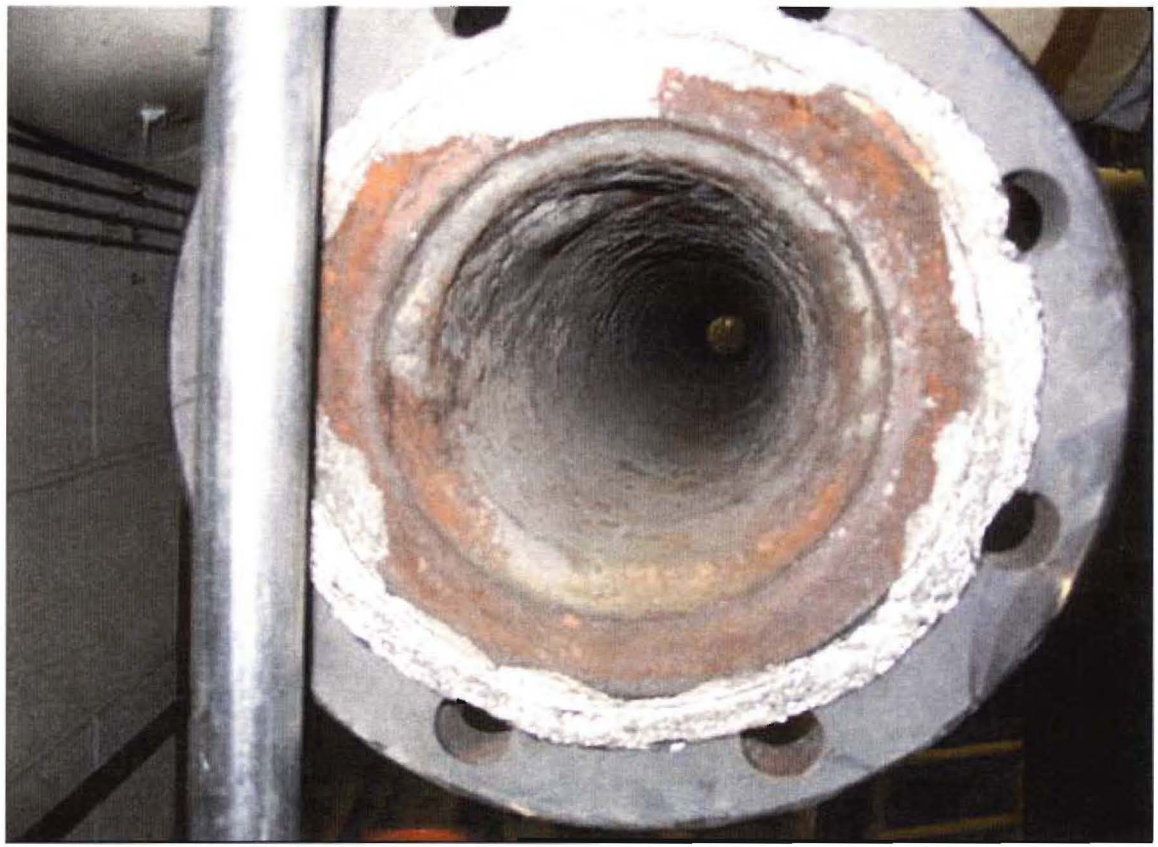

Figure 5.97. Post cleaning view of straight section of EOG pipe, after 1st 90° elbow.

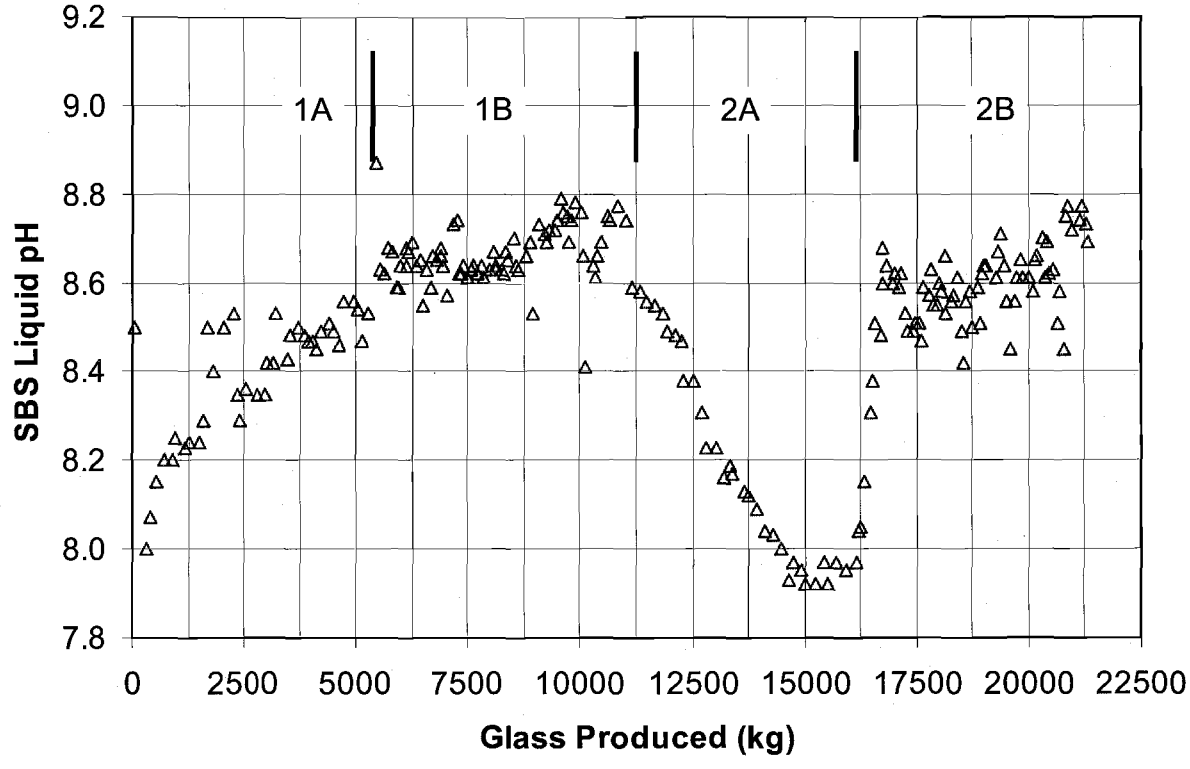

Figure 5.98. pH of SBS blow-down solutions.

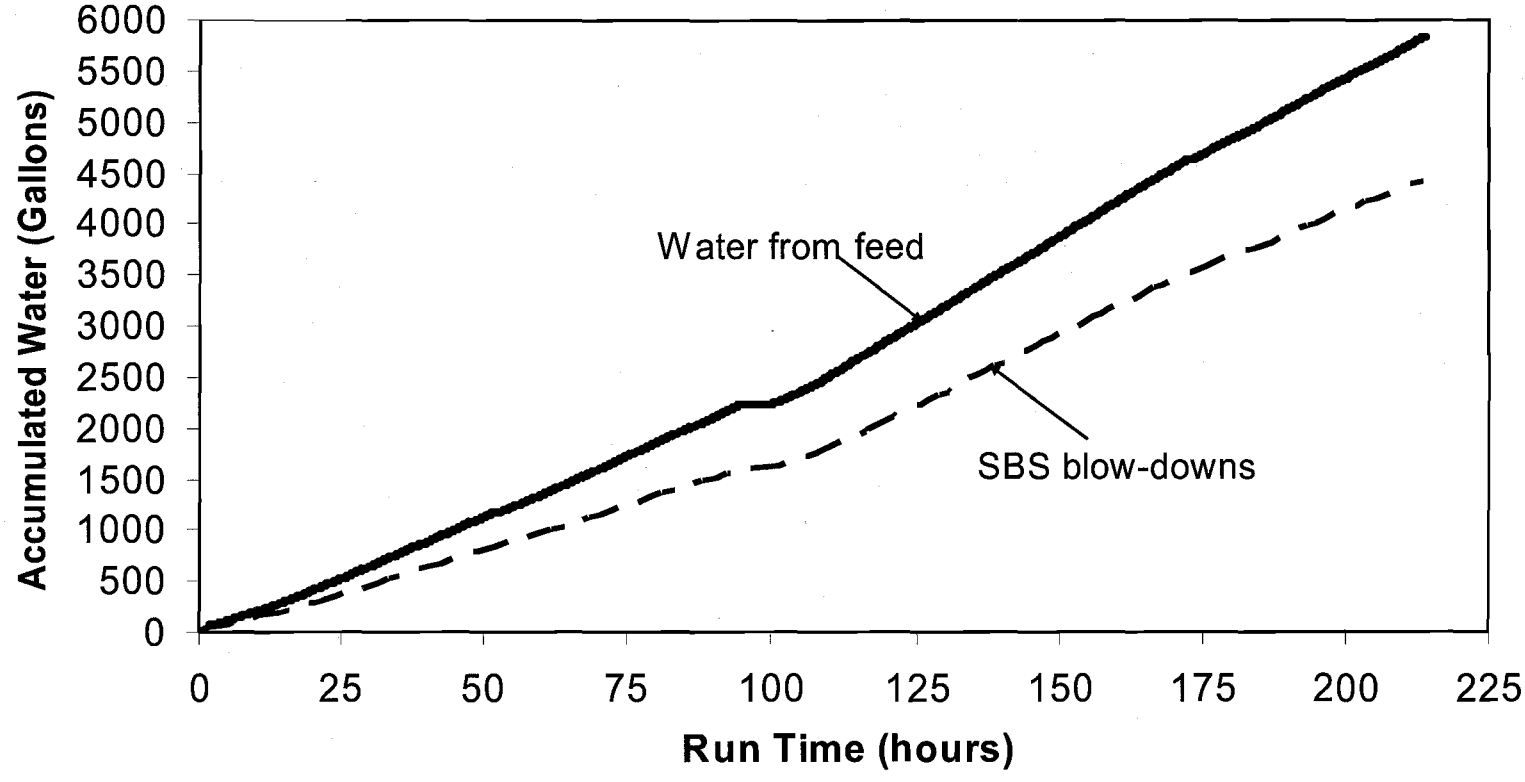

Figure 5.99. Accumulated SBS blow-down volume and accumulated feed water during Test 1.

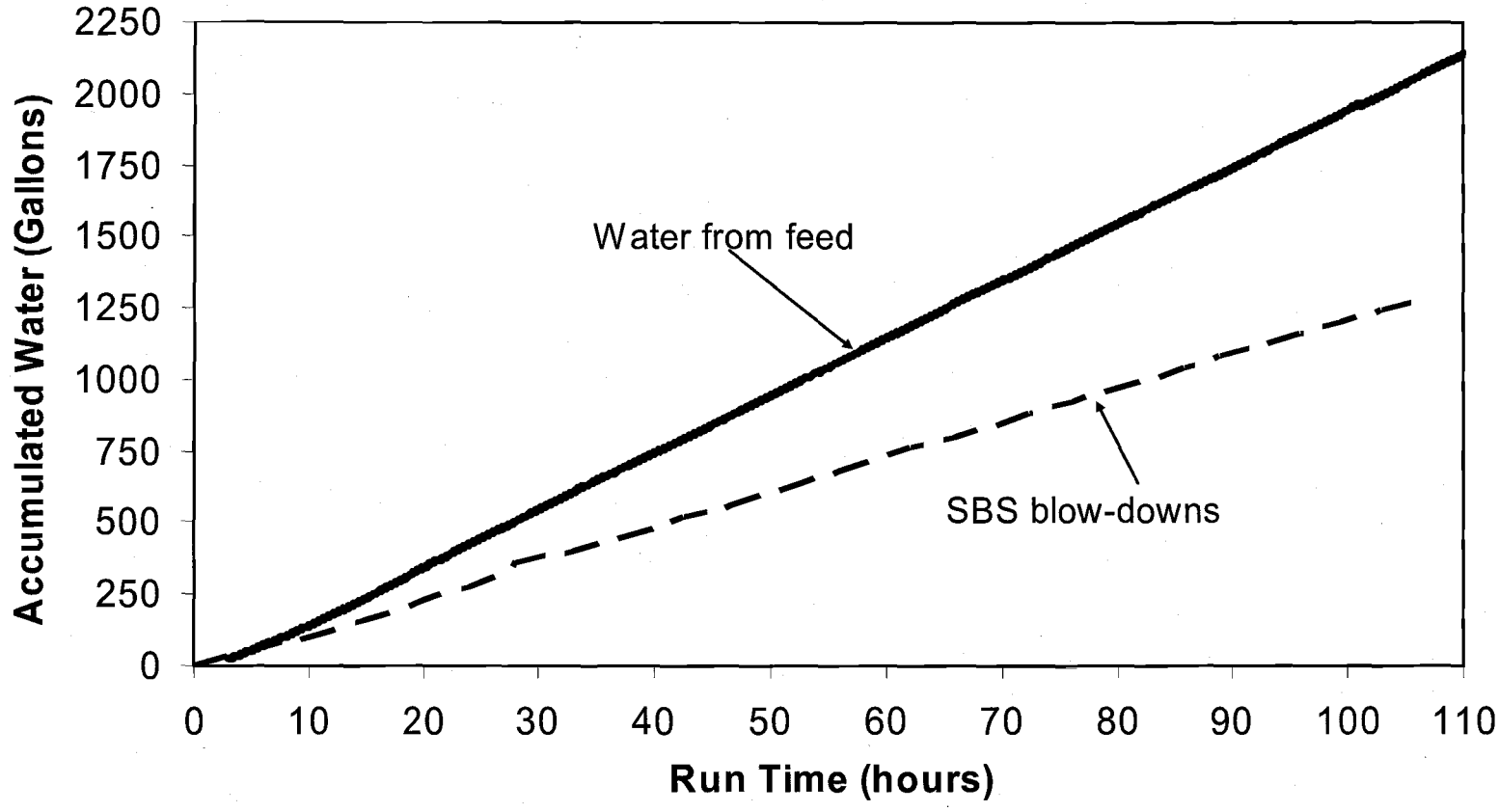

Figure 5.100. Accumulated SBS blow-down volume and accumulated feed water during Test 2A.

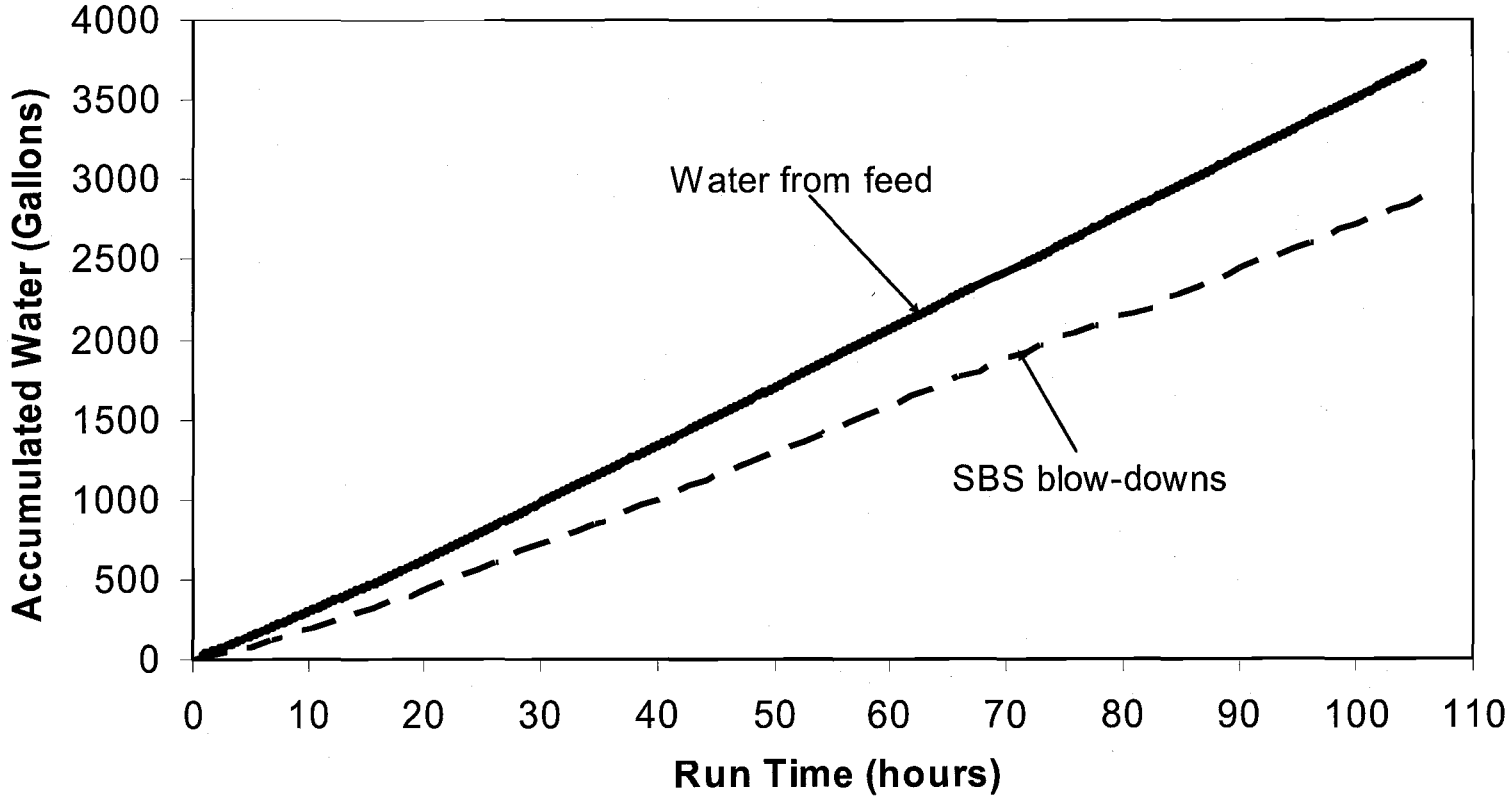

Figure 5.101. Accumulated SBS blow-down volume and accumulated feed water during Test 2B.

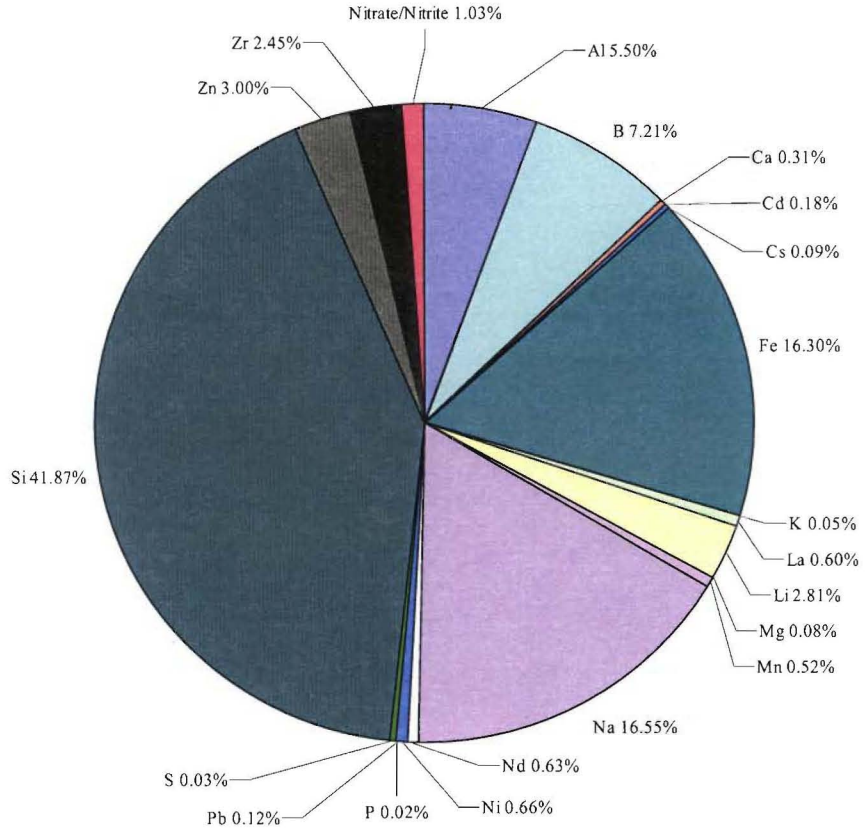

Figure 5.102. AZ-102 feed composition (excludes oxygen and carbon).

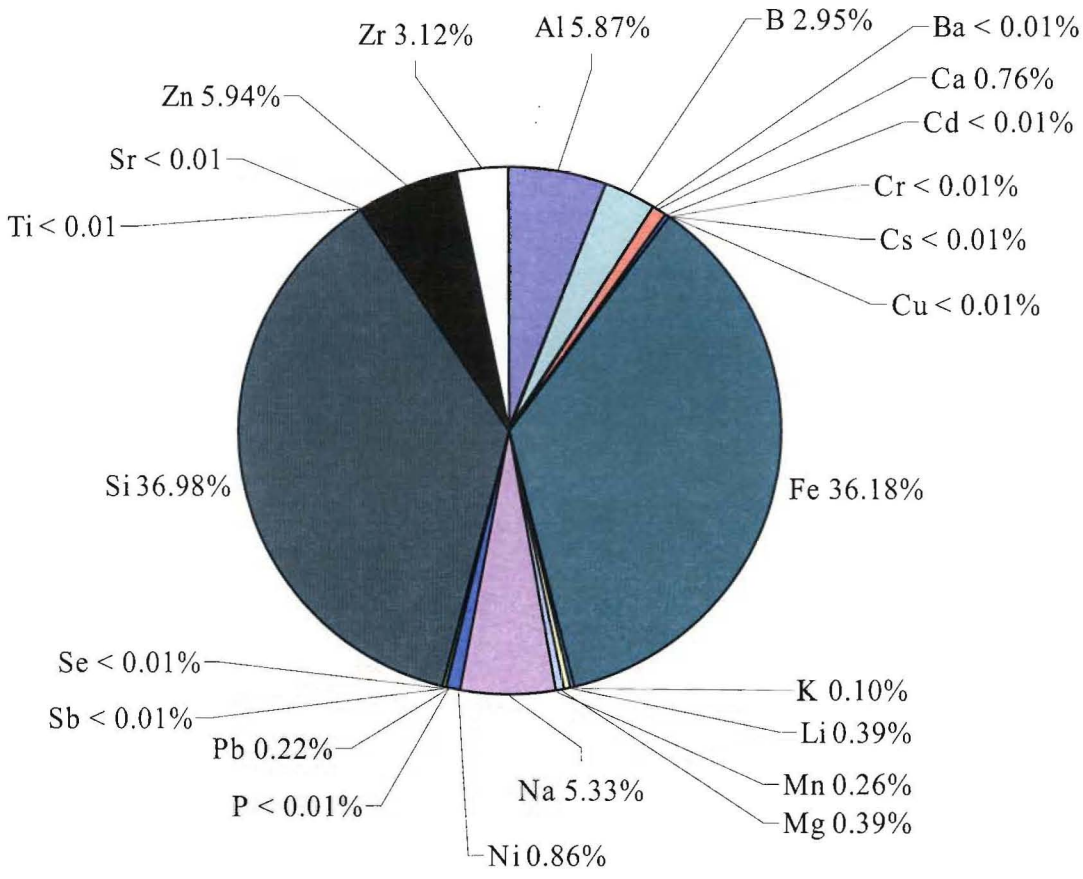

Figure 5.103. Suspended solids composition from Test 1A, SBS sample (1V2-S-13A).

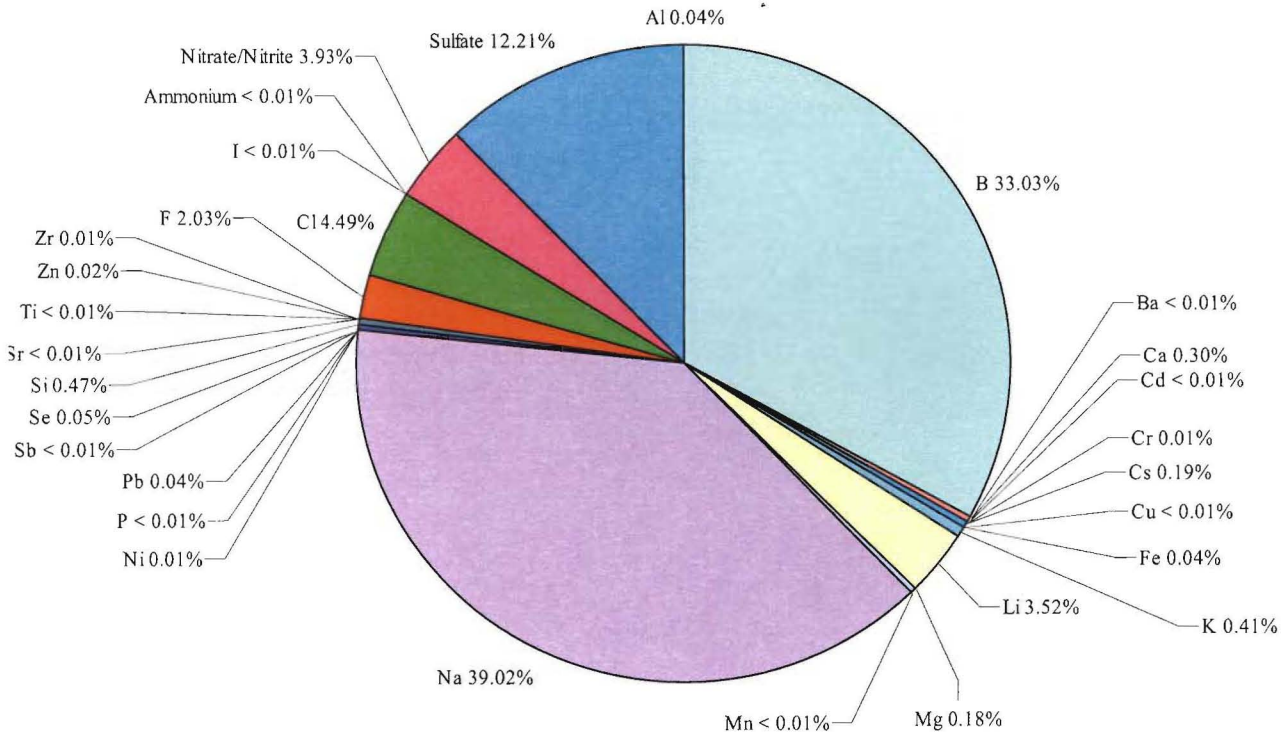

Figure. 5.104. Dissolved solids composition from Test 1A, SBS sample (1V2-S-13A).

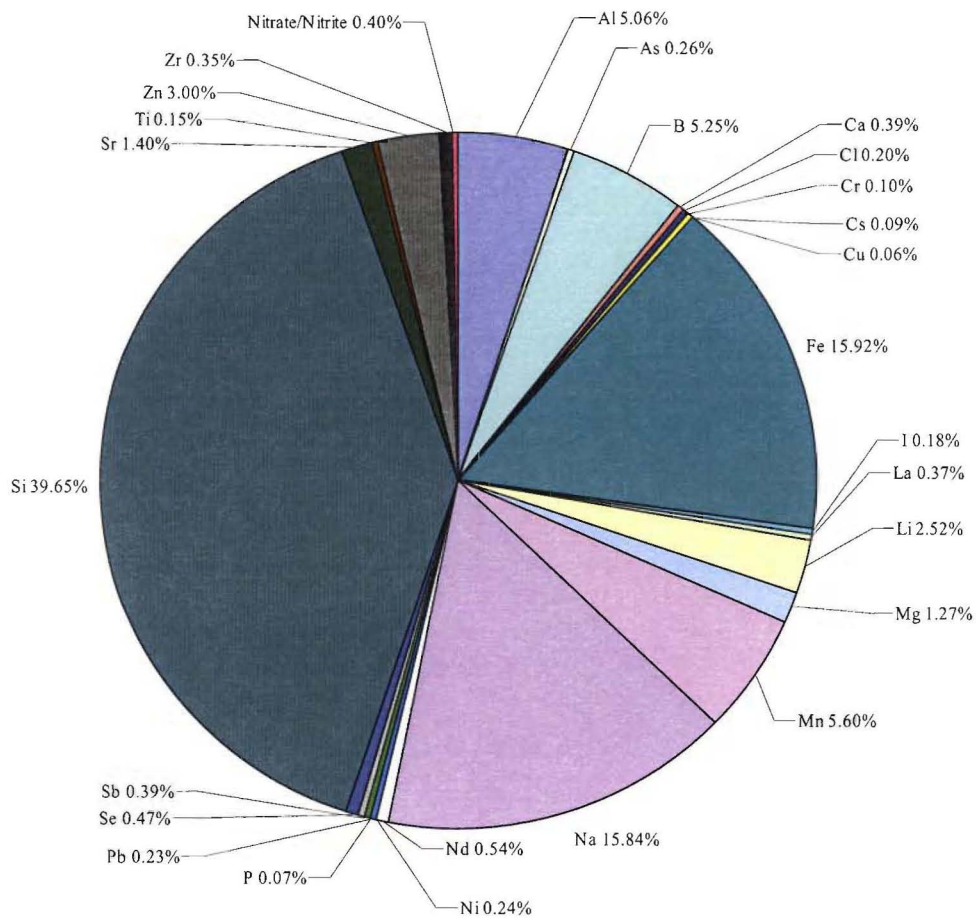

Figure 5.105. C-106/AY-102 feed composition for Test 2A (excludes oxygen and carbon).

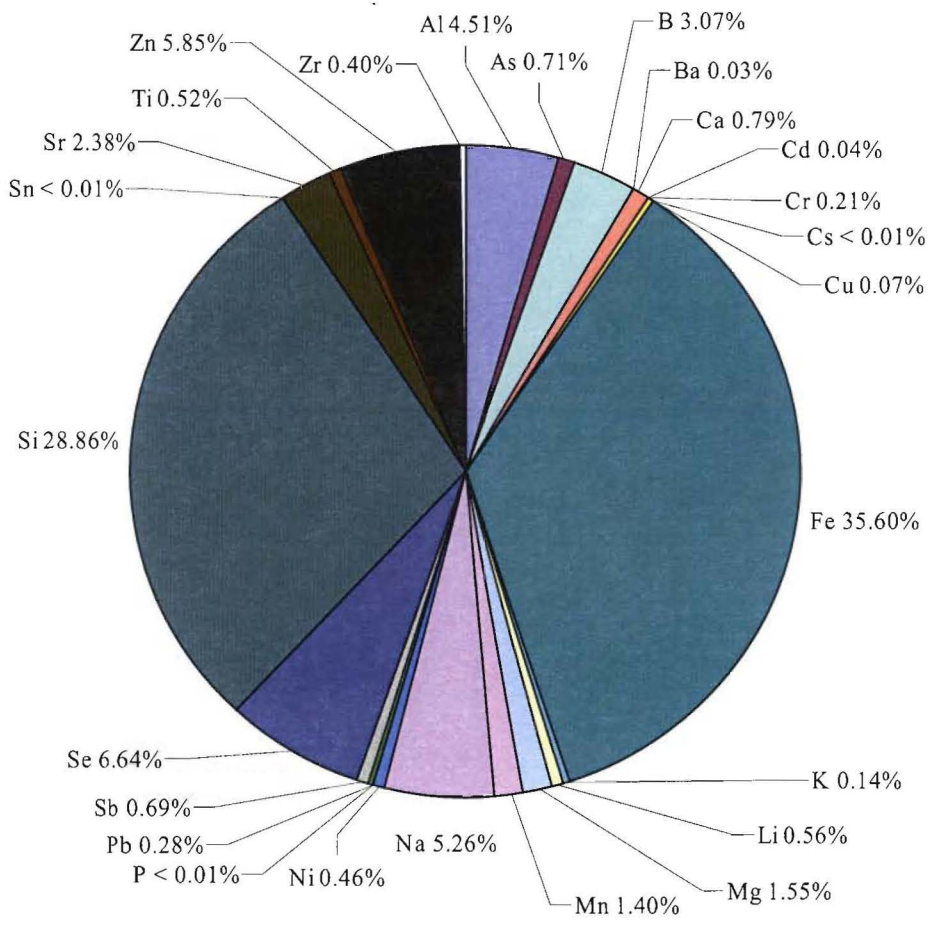

Figure 5.106. Suspended solids composition from Test 2A, SBS sample (1X2-S-88A).

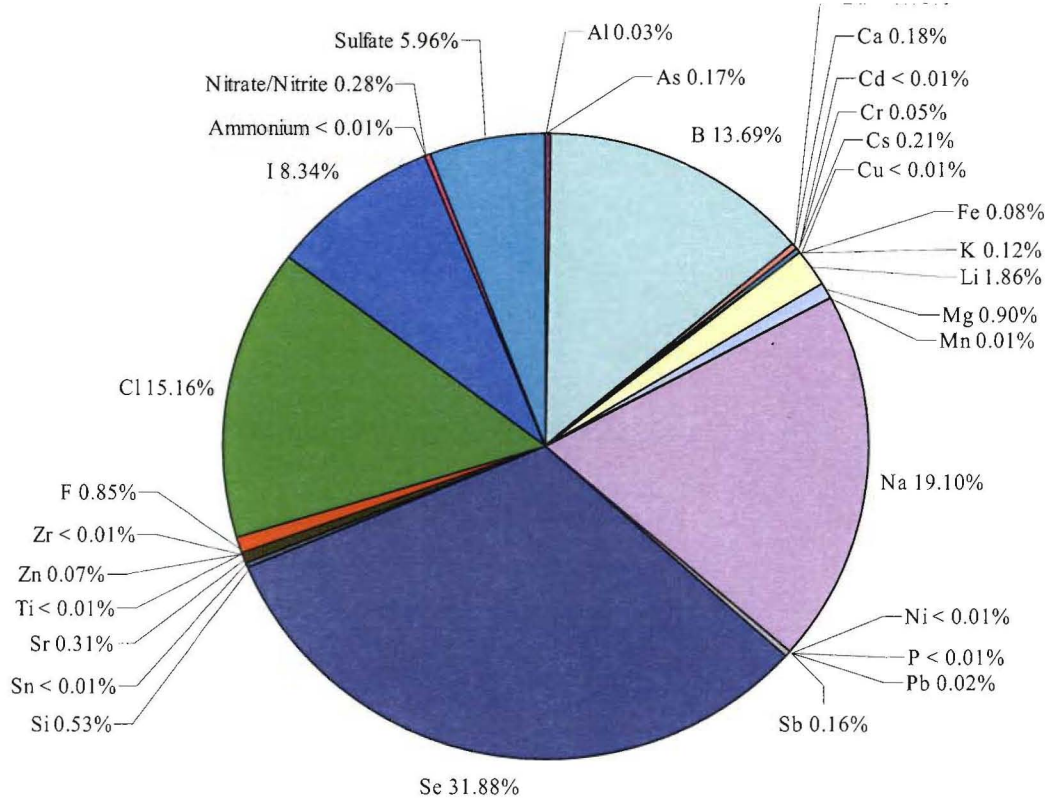

Figure 5.107. Dissolved solids composition from Test 2A, SBS sample (1X2-S-88A).

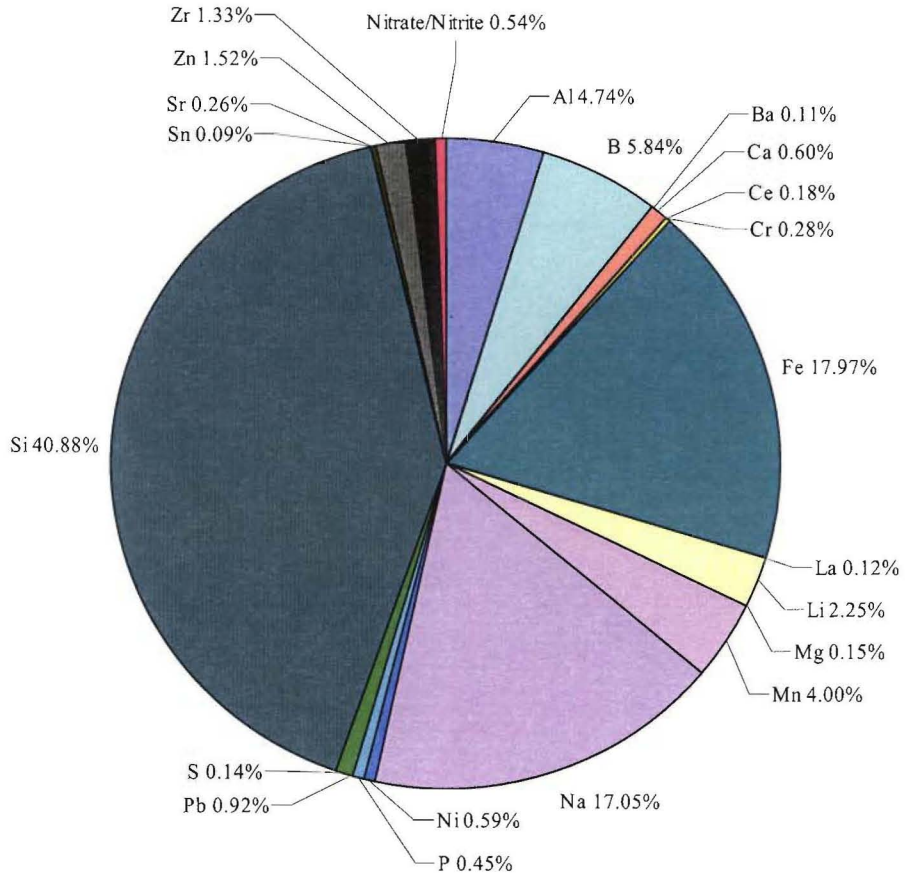

Figure 5.108. High waste loading, C-106/AY-102 feed composition for Test 2B (excludes oxygen and carbon).

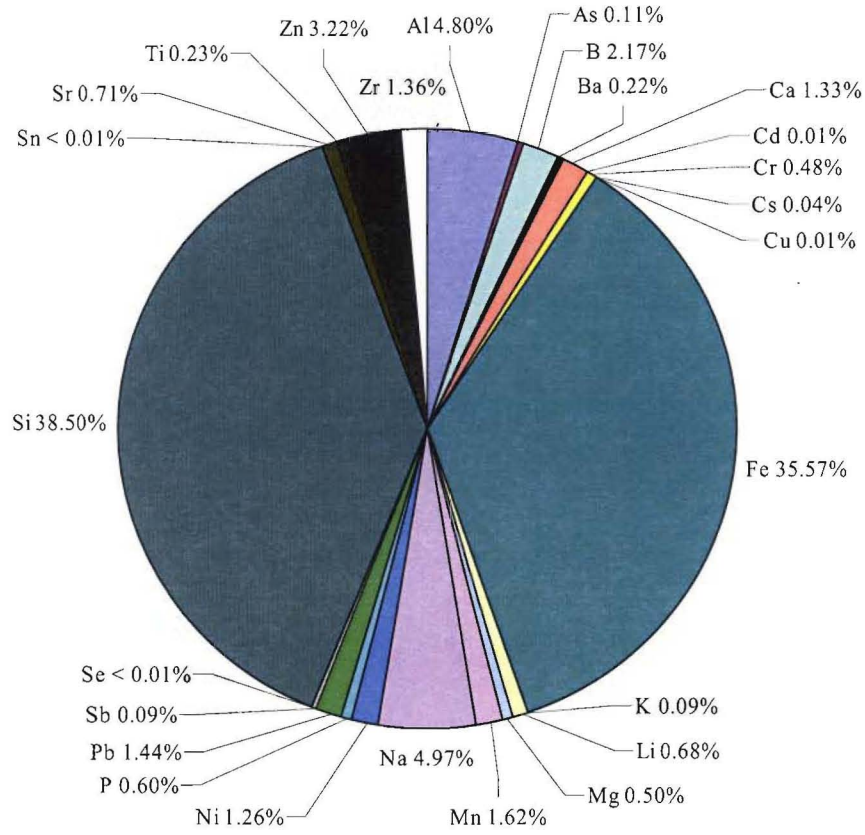

Figure 5.109. Suspended solids composition from Test 2B, SBS sample (1Y2-S-147A).

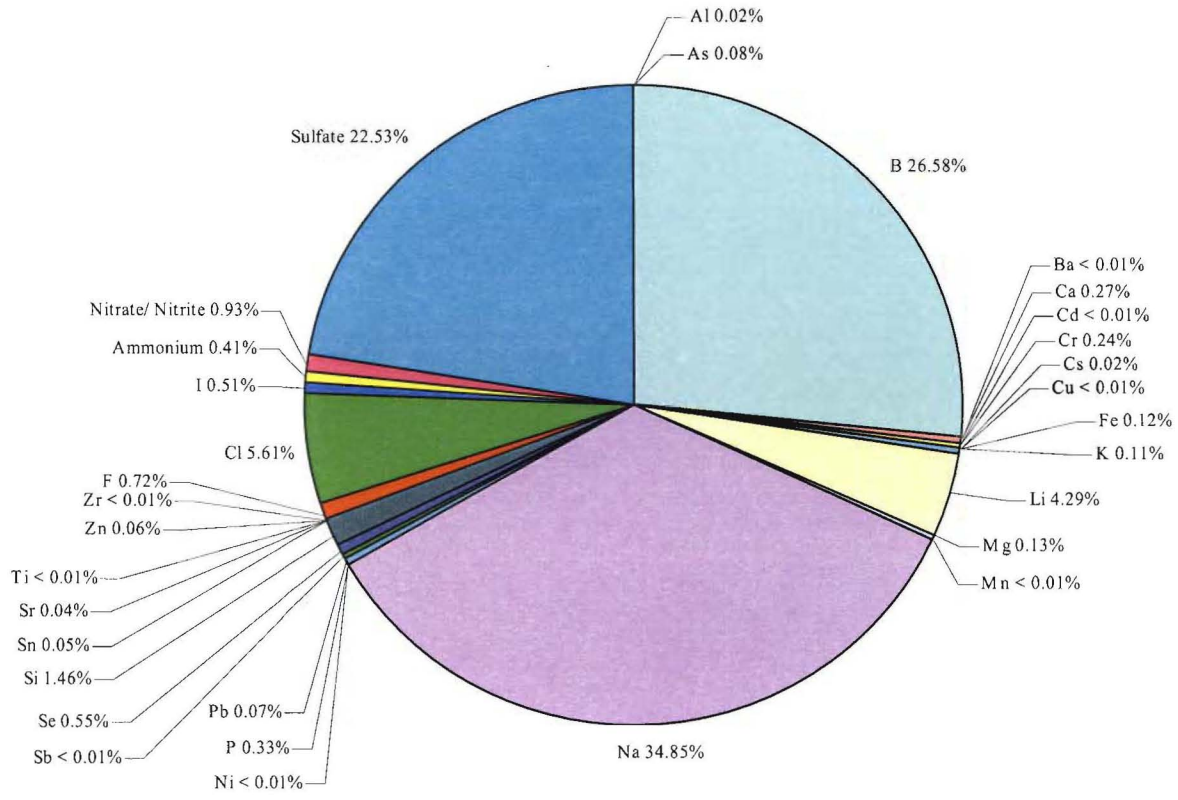

Figure 5.110. Dissolved solids composition from Test 2B, SBS sample (1Y2-S-147A).

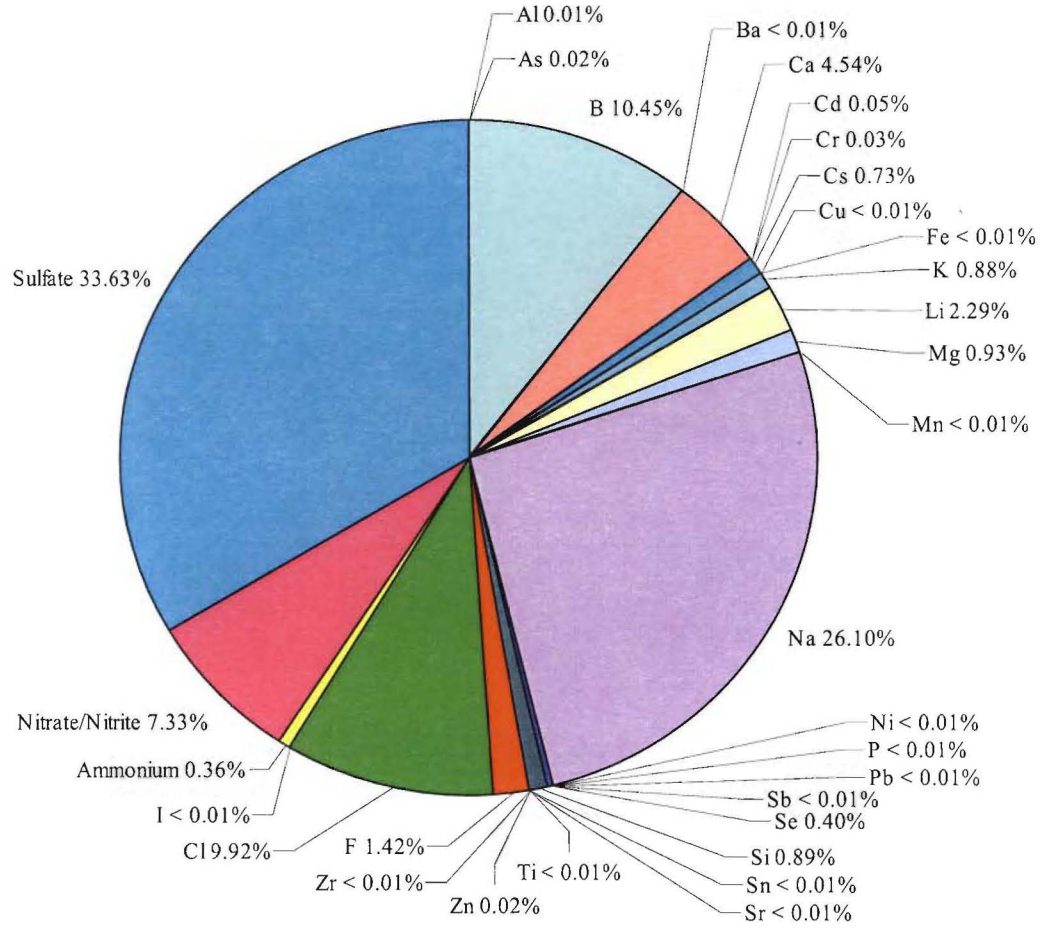

Figure 5.111. Dissolved solids composition from Test 1A WESP samples (1V2-W-12A and B).

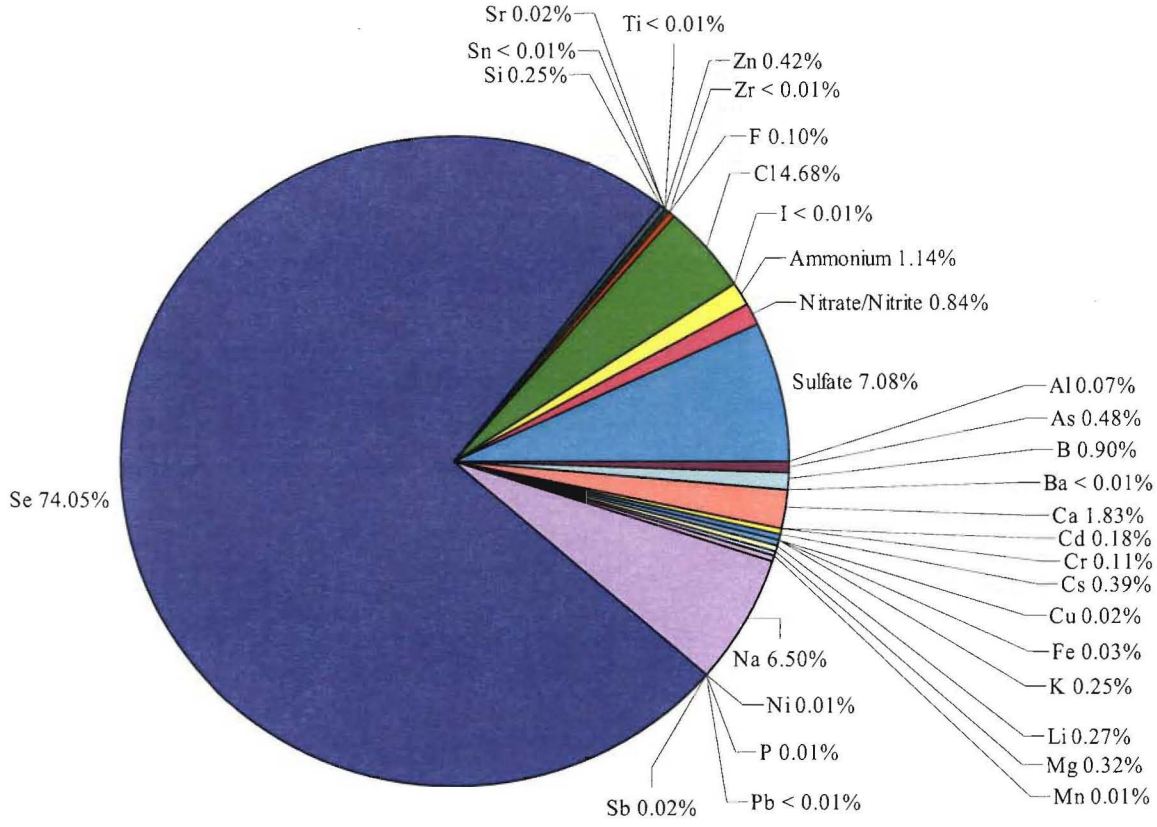

Figure 5.112. Dissolved solids composition from Test 2A WESP samples (1X2-W-103A and B).

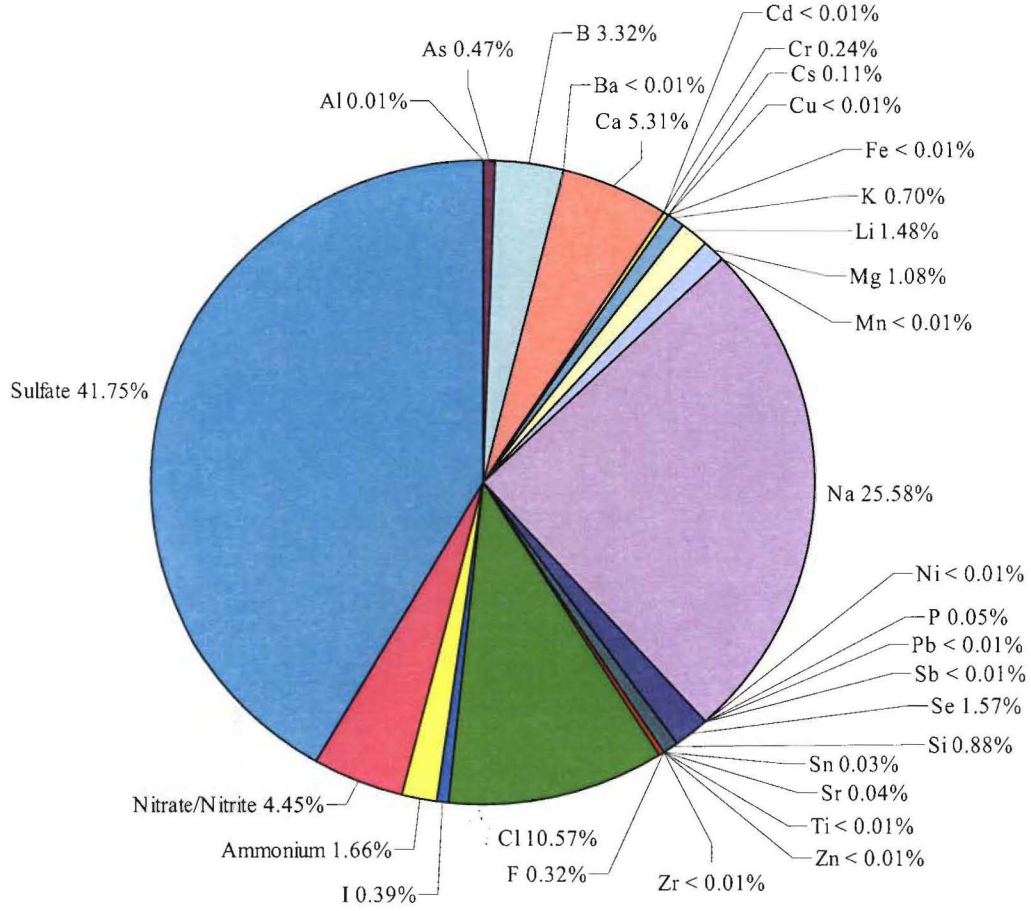

Figure 5.113. Dissolved solids composition from Test 2B WESP samples (1Z2-W-5A and B).

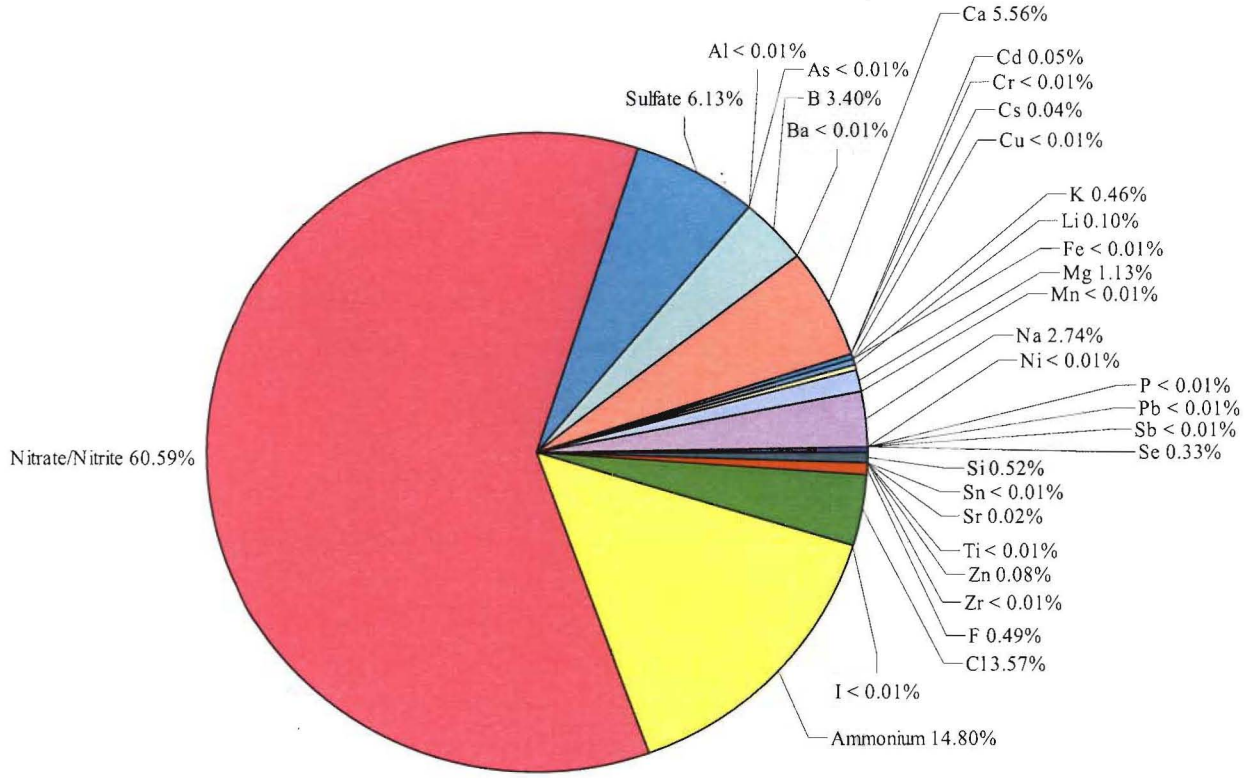

Figure 5.114. Dissolved solids composition from Test 1A HEME sample (1V2-H1-13A).

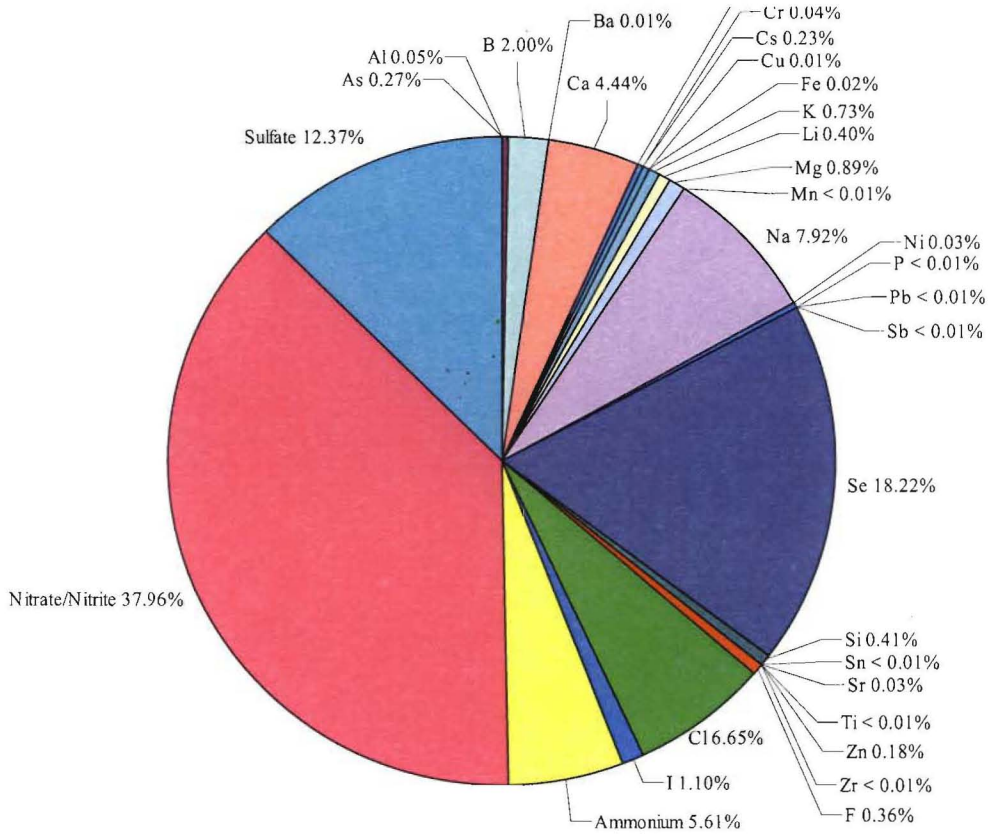

Figure 5.115. Dissolved solids composition from Test 2A HEME sample (1X2-H1-103A).

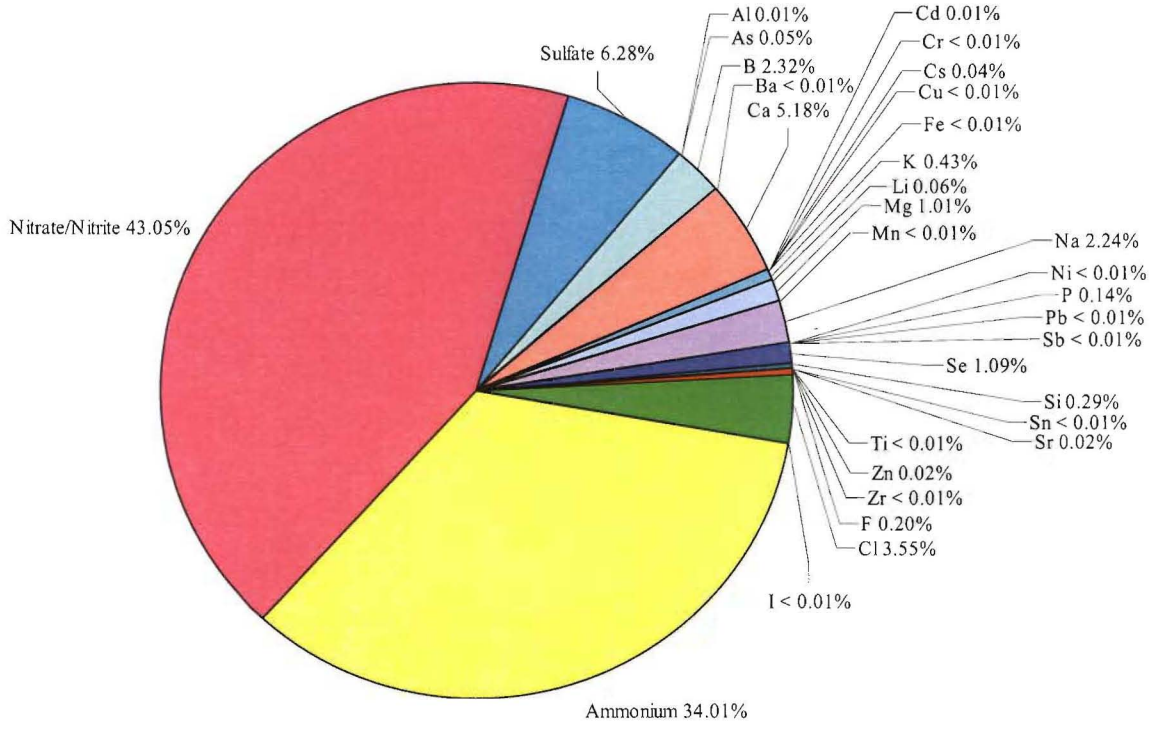

Figure 5.116. Dissolved solids composition from Test 2B HEME sample (1Z2-H1-5A).

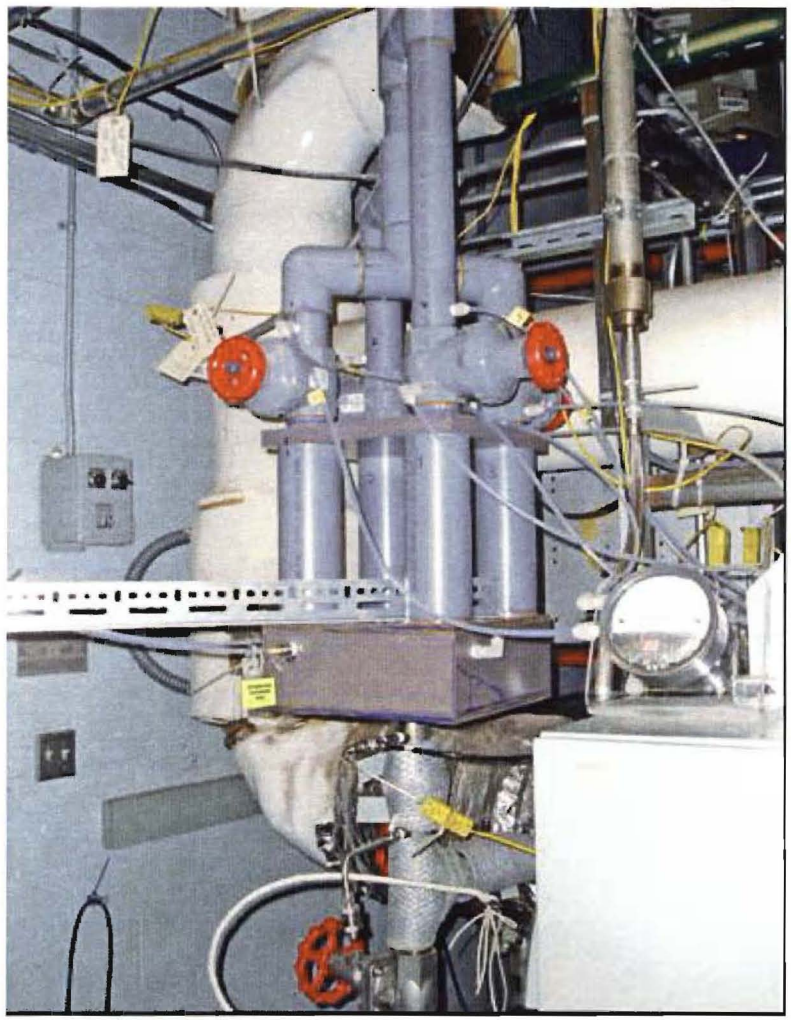

Figure 5.117. View of the filter media assembly.

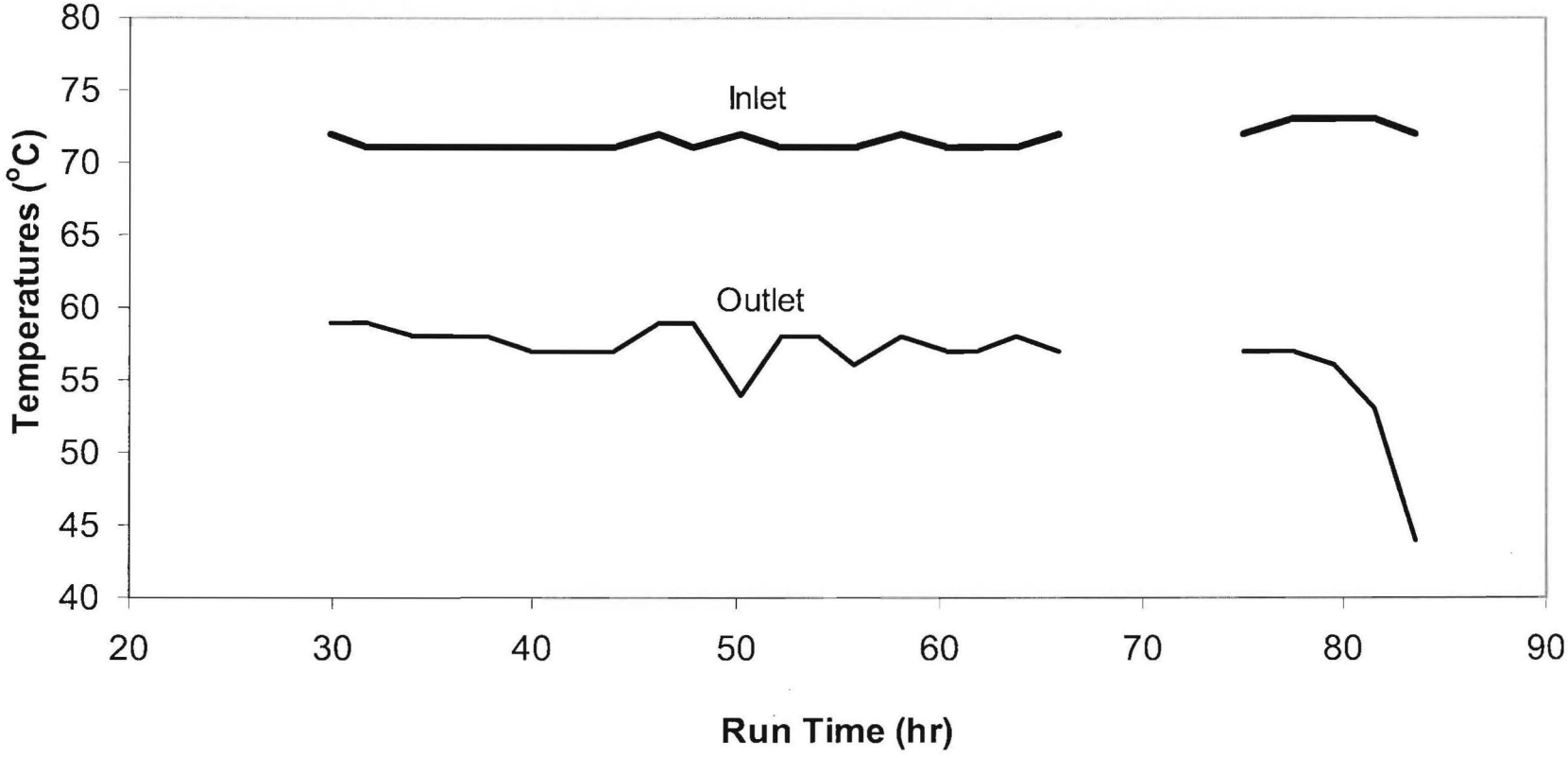

Figure 5.118. Filter media inlet and outlet temperatures.

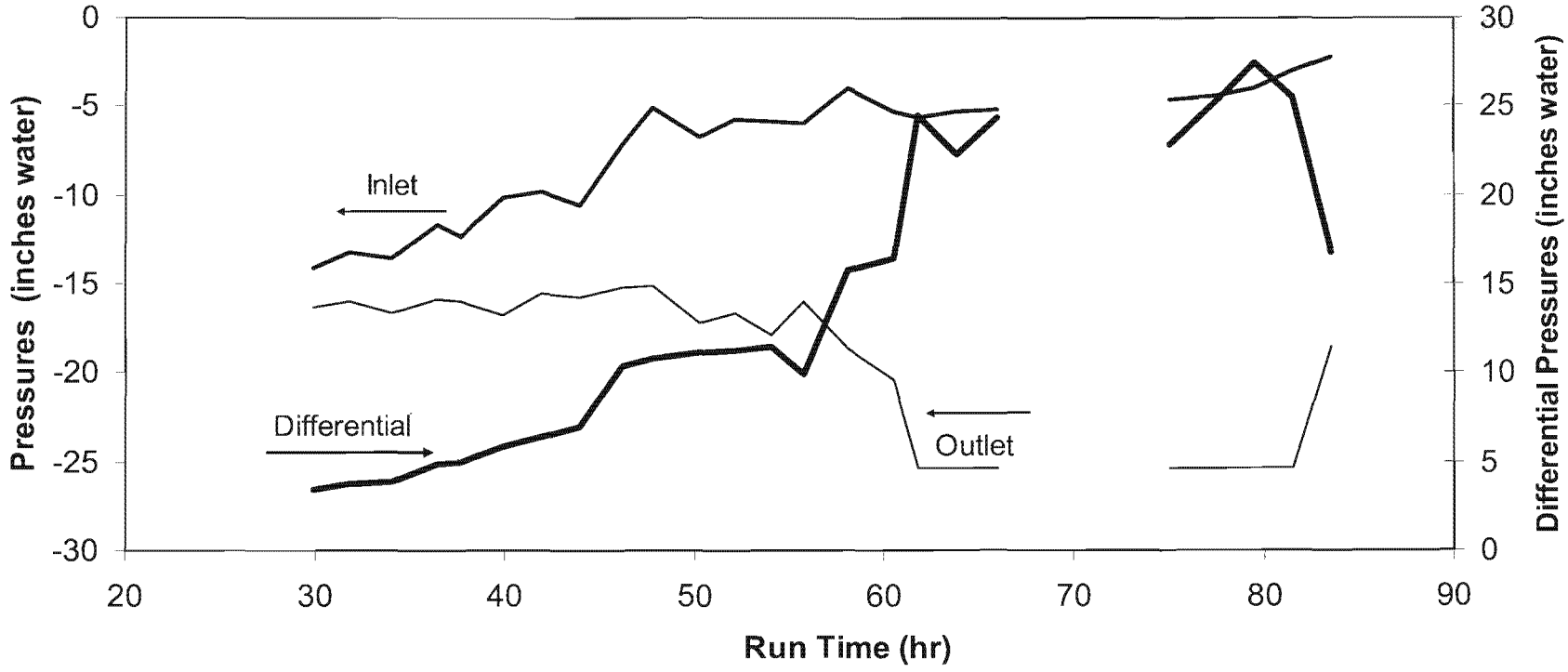

Figure 5.119. Filter media inlet, outlet and differential pressures.

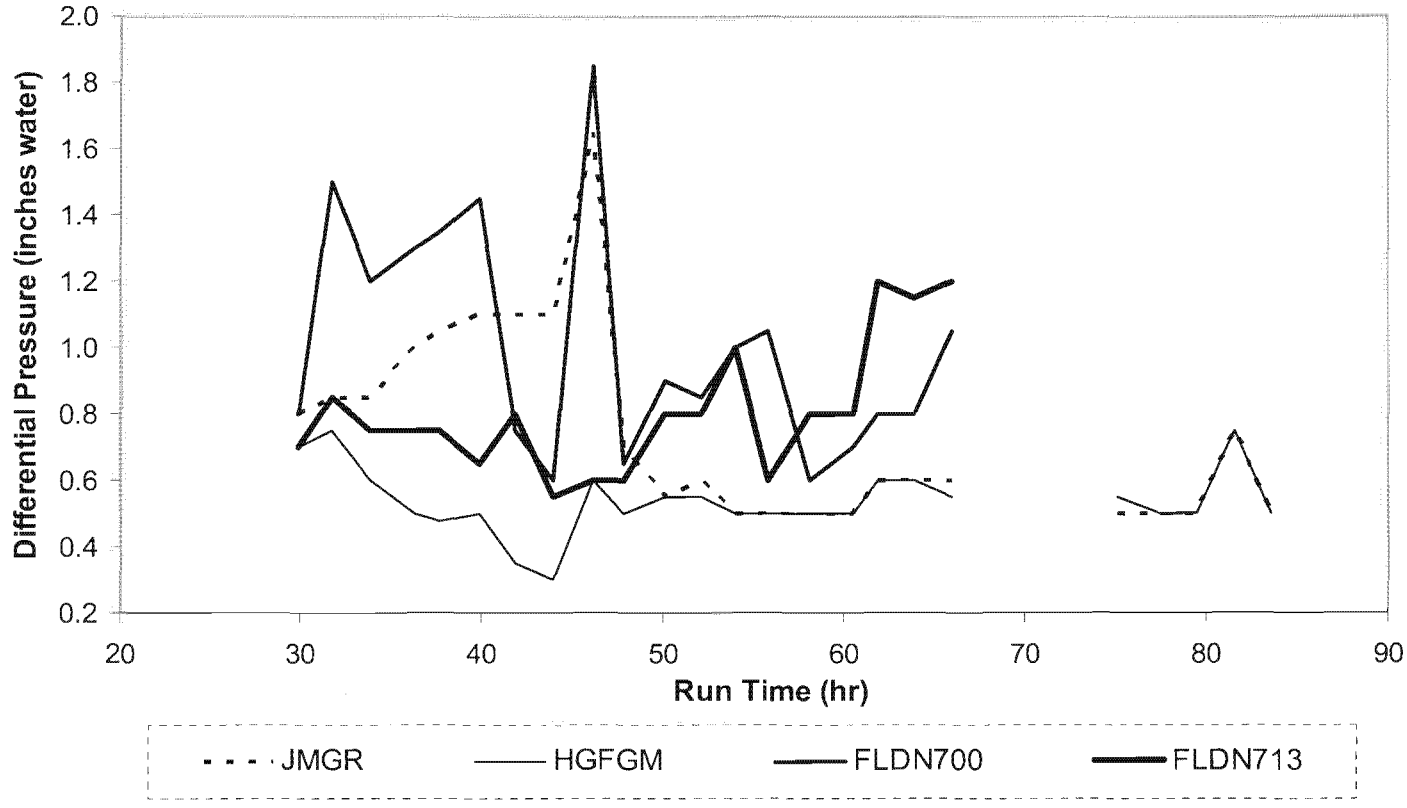

Figure 5.120. Differential pressures across each filter media.

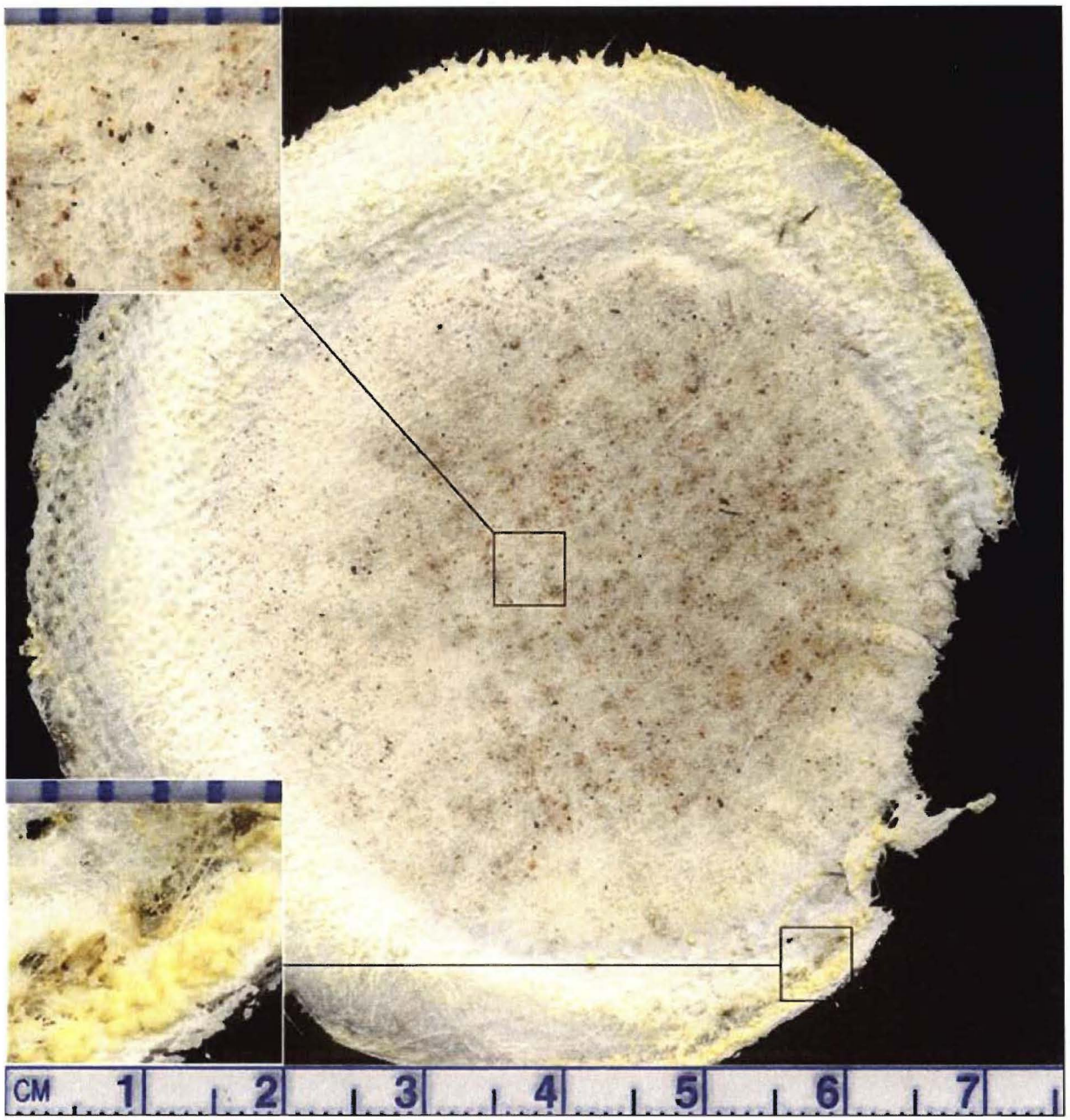

Figure 5.121. Macro image of filter scanned at 1200 dpi (Sample # 1Z2-O-116A , JMGR).

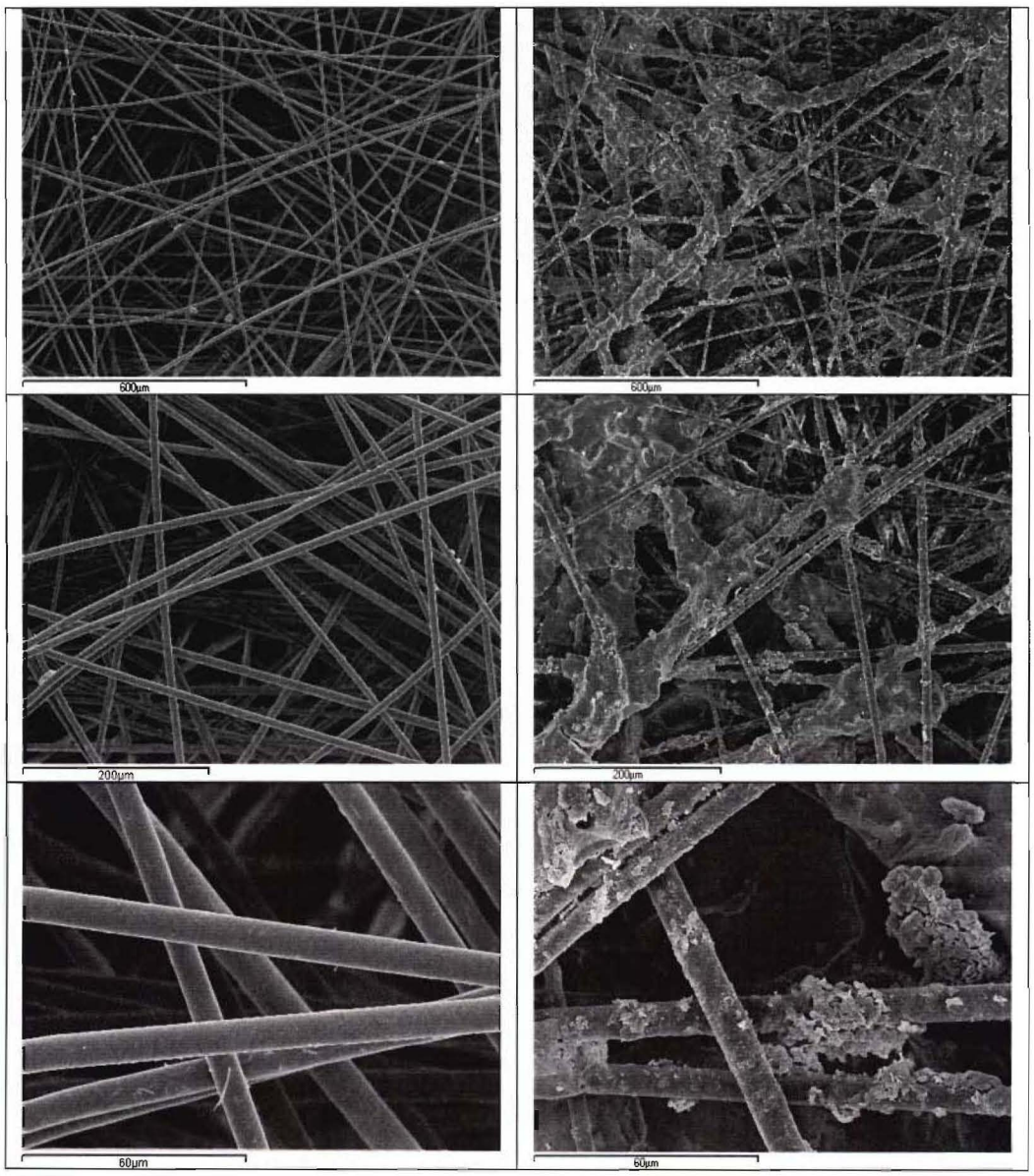

Figure 5.122. Comparative images of original (left) and exposed (right) filters (Sample #1Z2-O-116A, JMGR).

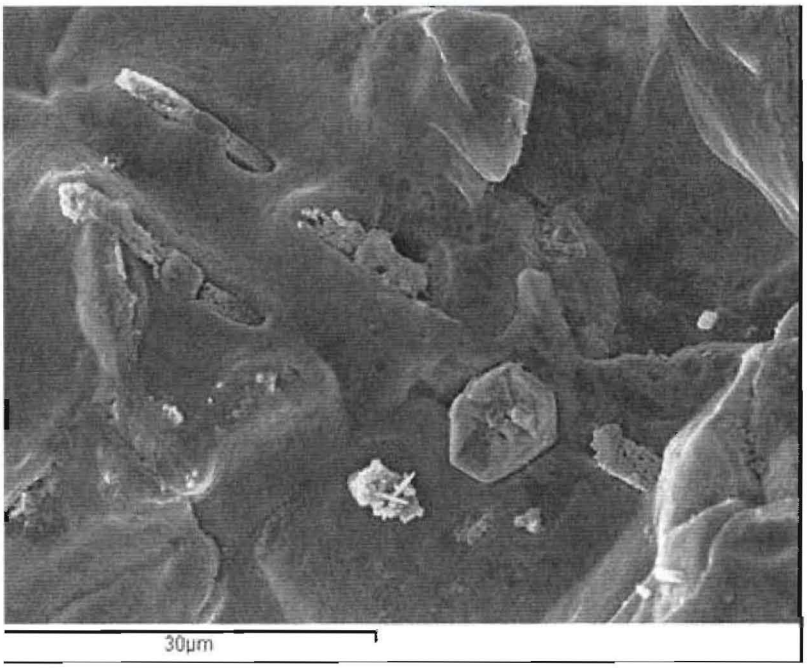

Figure 5.123. Medium magnification SEM micrograph of residue adhered to filter (Sample # 1Z2-O-116A, JMGR).

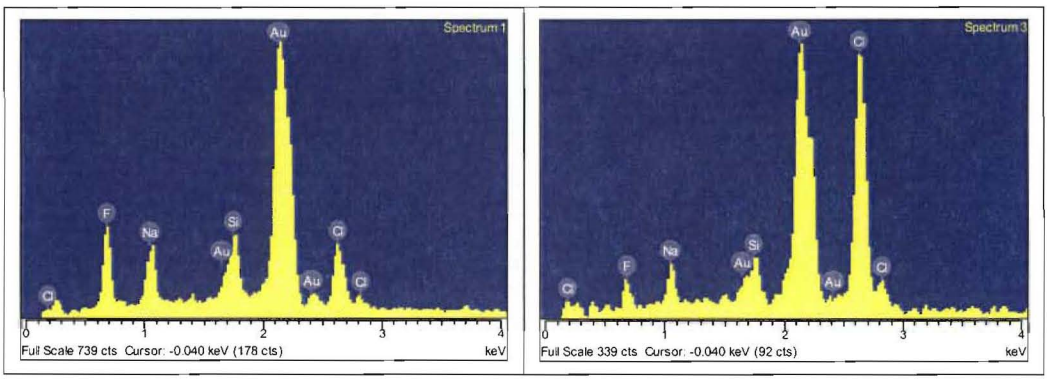

Figure 5.124. Typical EDS spectra from various locations on residue, (Au coating.) (Sample # 1Z2-O-116A, JMGR).

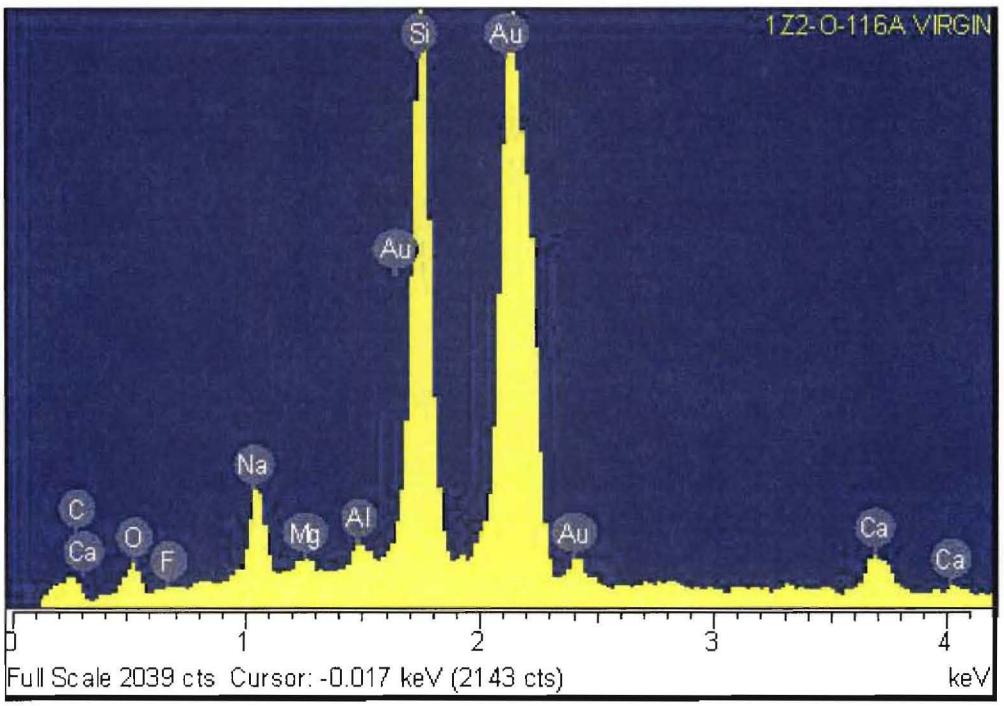

Figure 5.125. EDS spectrum from the original material of sample # 1Z2-O-116A.

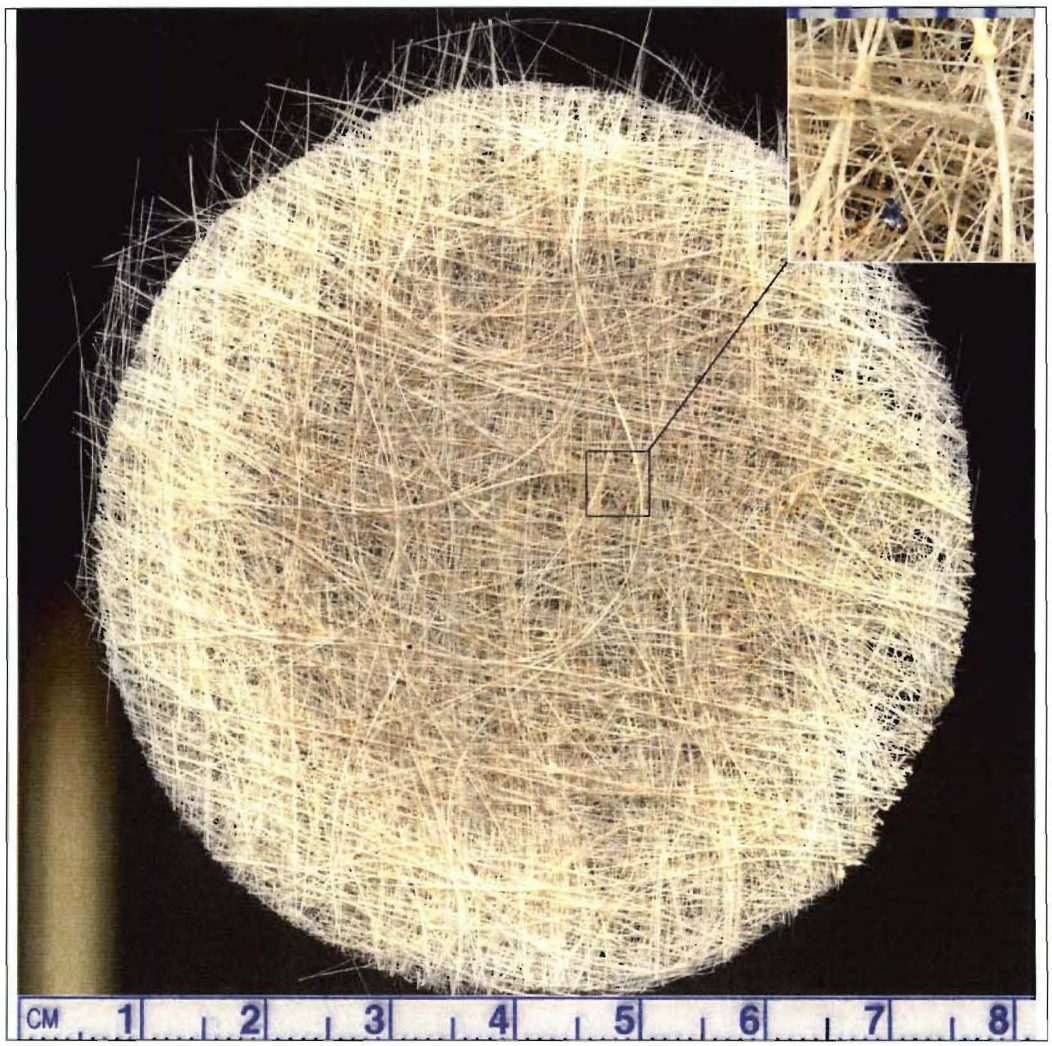

Figure 5.126. Macro image of filter scanned at 1200 dpi (Sample # 1Z2-O-116B, HGFGM).

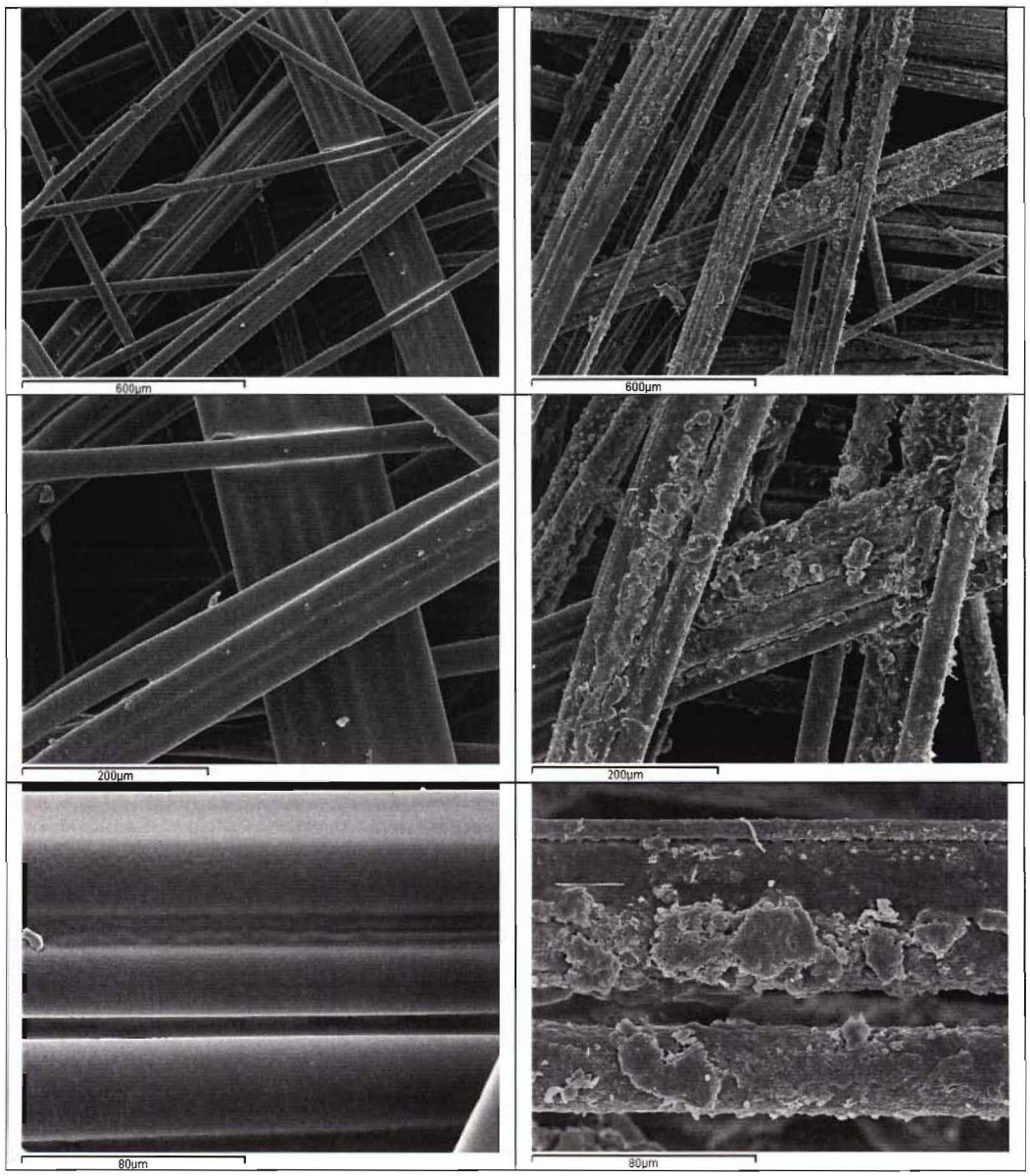

Figure 5.127. Comparative secondary electron images of original (left) and exposed (right) filters (Sample # 1Z2-O-116B, HGFGM).

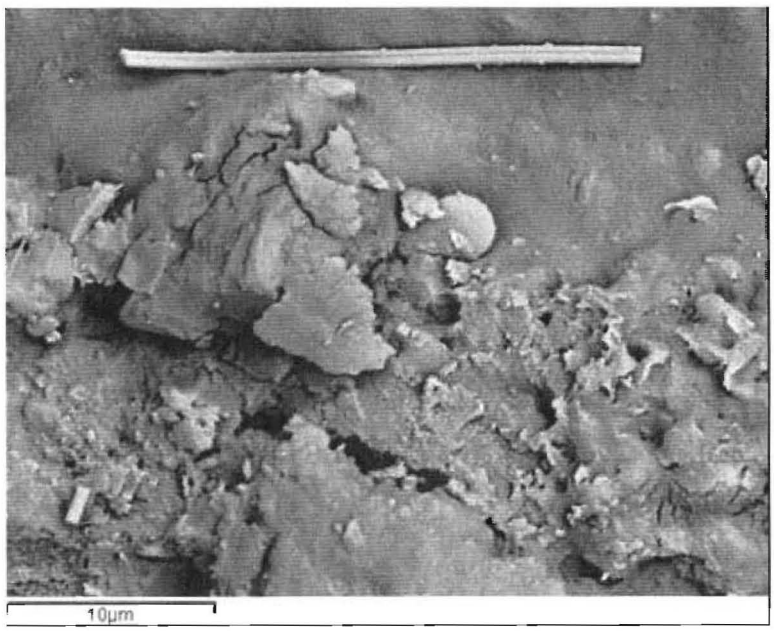

Figure 5.128. Medium magnification SEM micrograph of residue adhered to filter (Sample # 1Z2-O-116B, HGFGM).

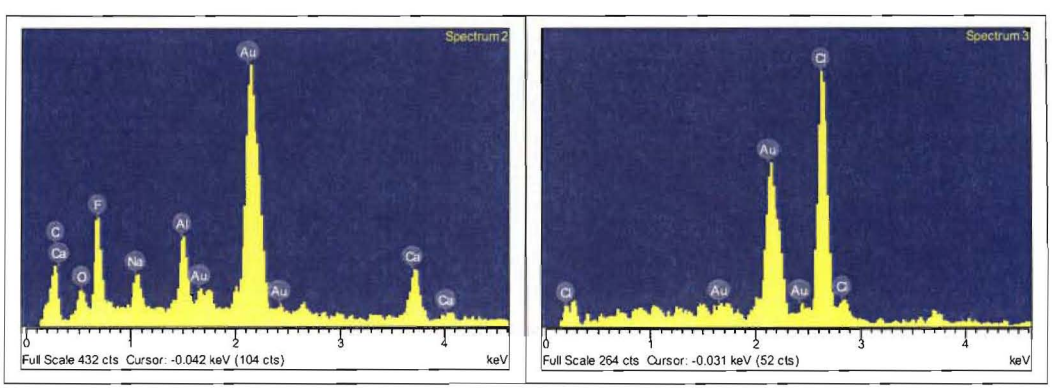

Figure 5.129. Typical EDS spectra from various locations on residue, (Au coating.) (Sample # 1Z2-O-116B, HGFGM).

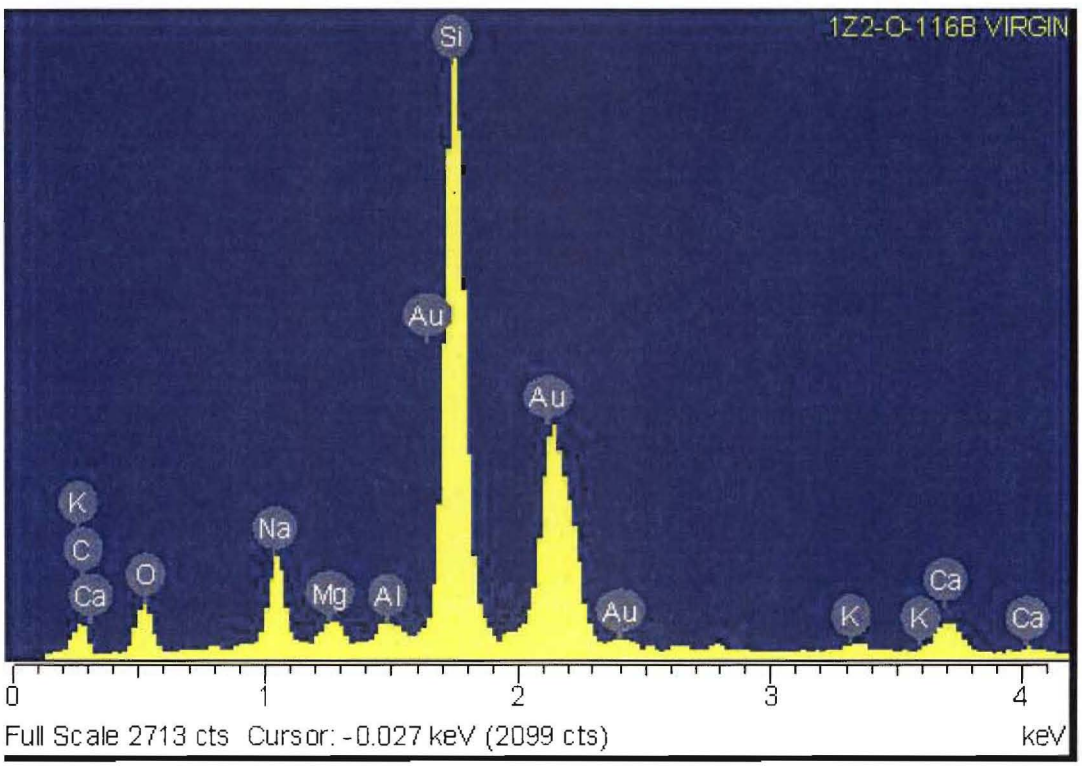

Figure 5.130. EDS spectrum from the original material of sample # 1Z2-O-116B.

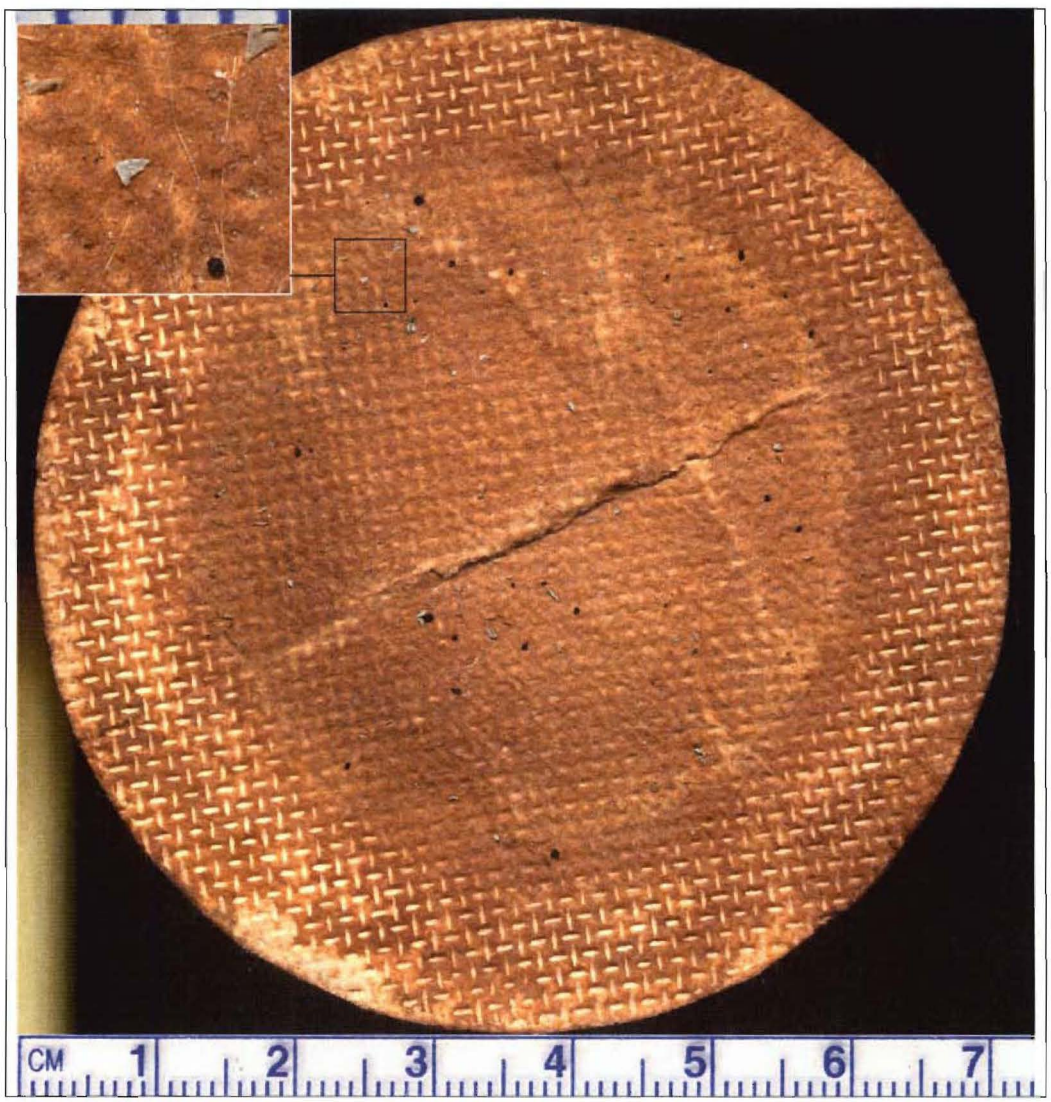

Figure 5.131. Macro image of filter scanned at 1200 dpi (Sample # 1Z2-O-116C, FLND700).

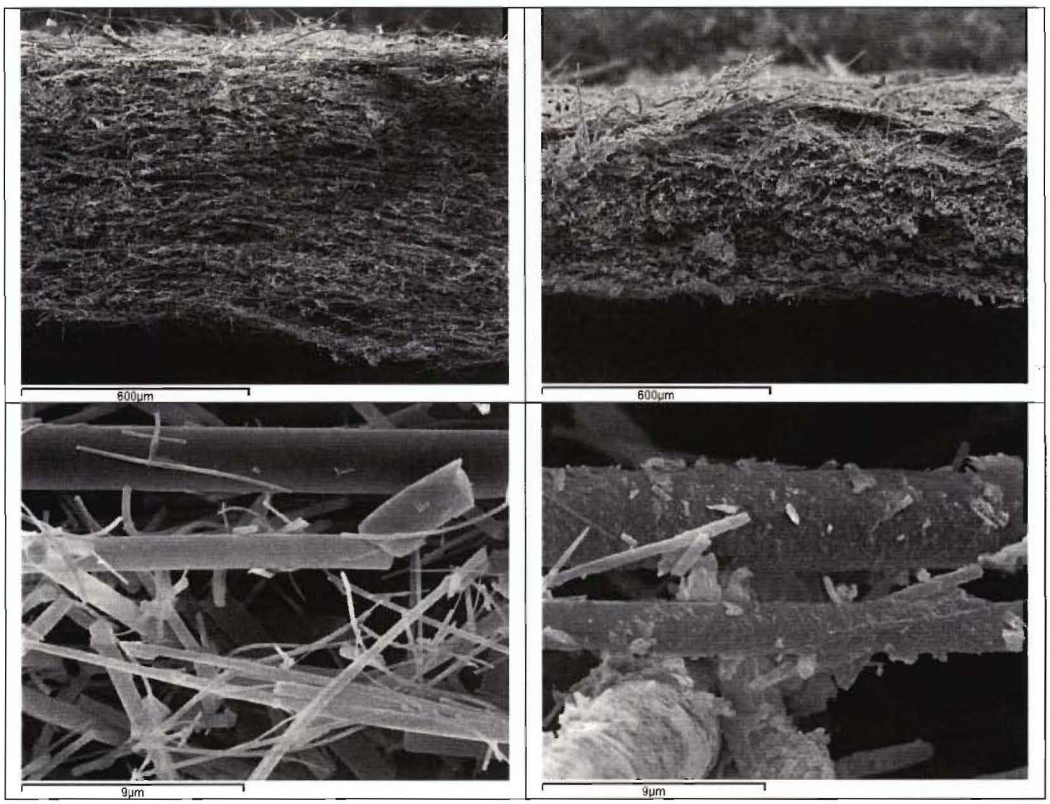

Figure 5.132. Comparative secondary electron images of original (left) and exposed (right) filters in cross section (Sample # 1Z2-O-116C, FLND700).

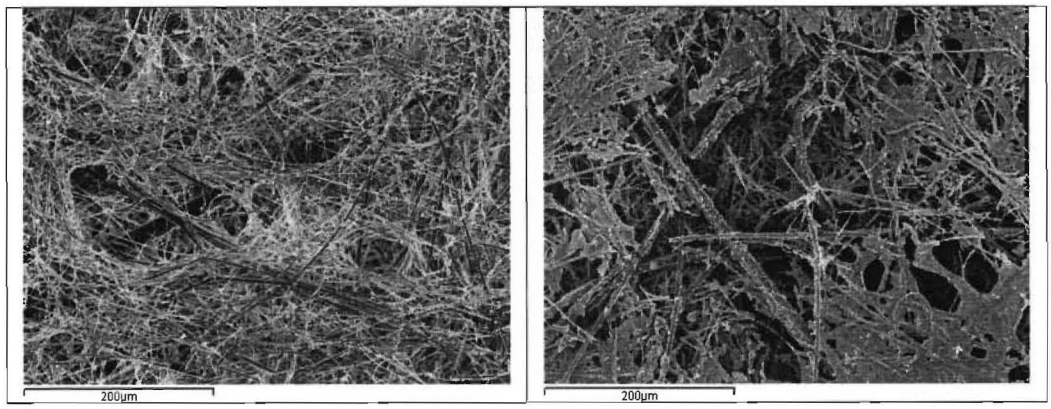

Figure 5.133. Comparative secondary electron images of flat surface of original (left) and exposed (right) (Sample # 1Z2-O-116C, FLND700).

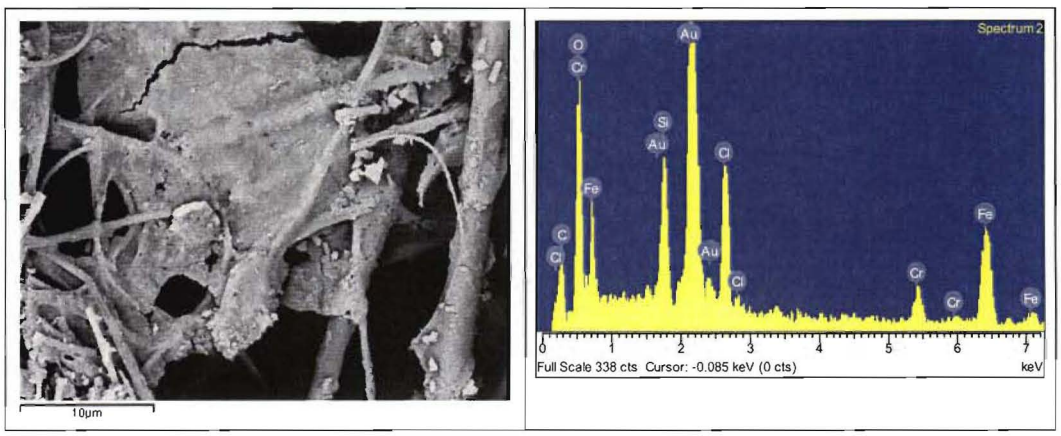

Figure 5.134. Medium magnification SEM micrograph of residue adhered to filter and corresponding EDS spectrum (Sample # 1Z2-O-116C, FLND700).

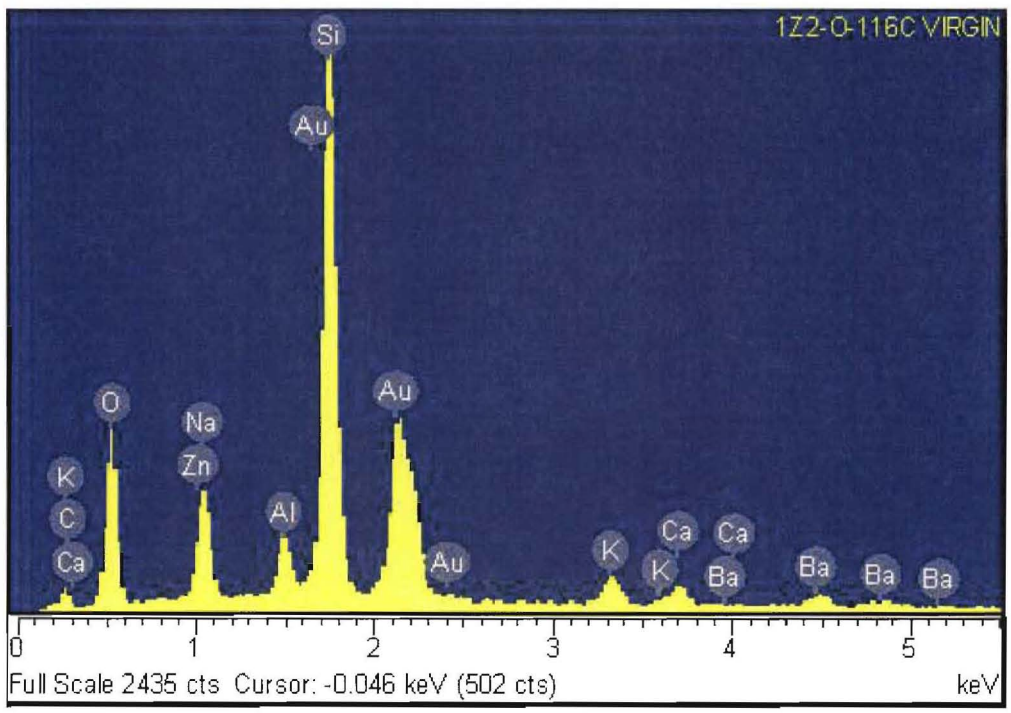

Figure 5.135. EDS spectrum of the original material of sample # 1Z2-O-116C.

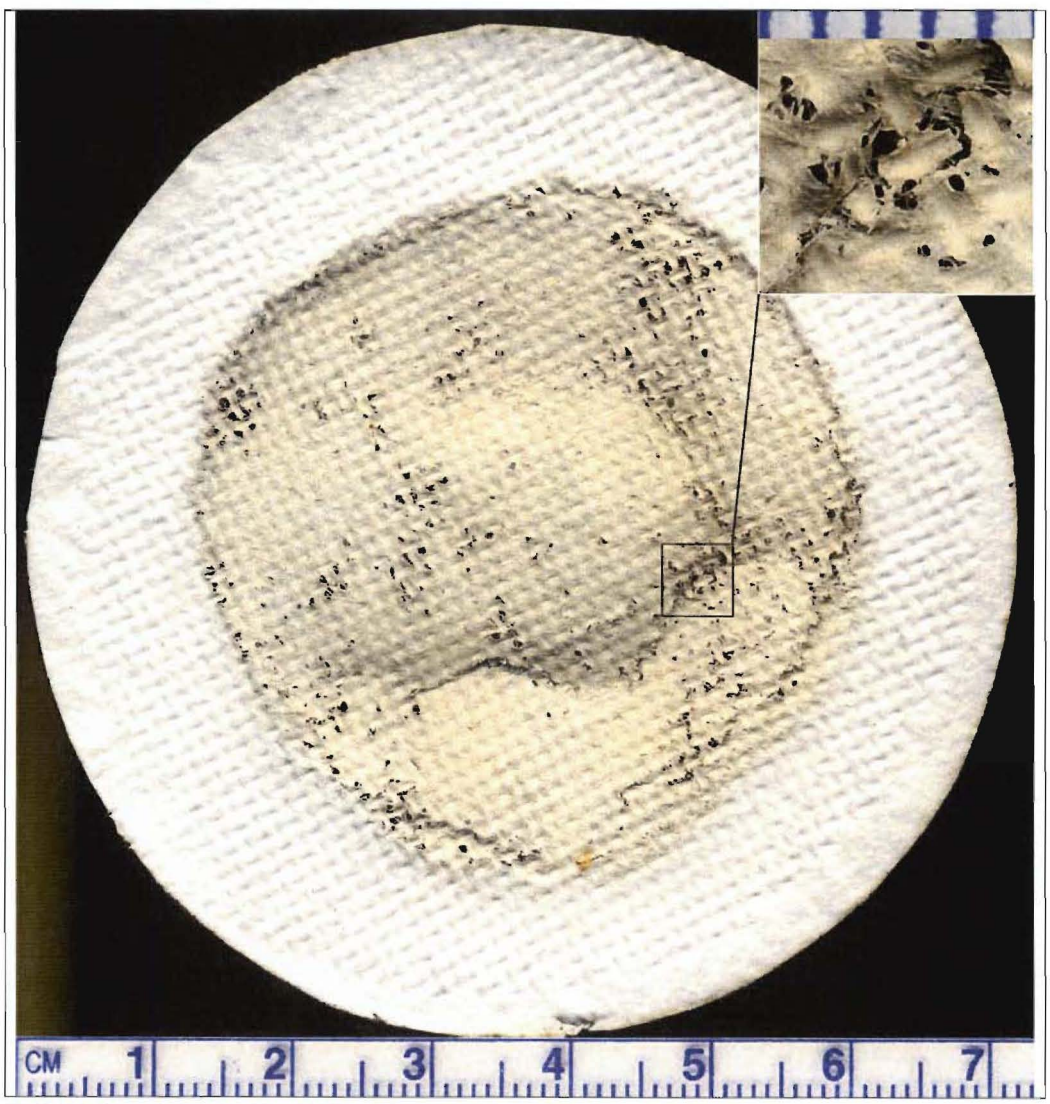

Figure 5.136. Macro image of filter scanned at 1200 dpi (Sample # 1Z2-O-116D, FLND713).

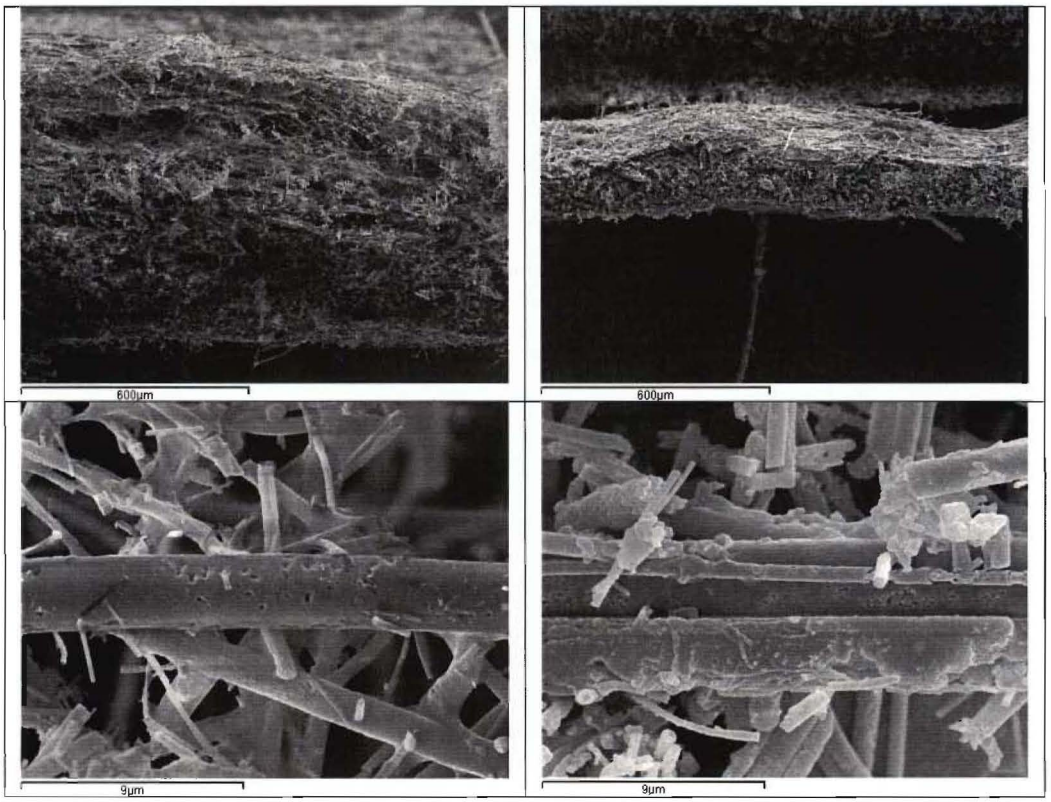

Figure 5.137. Comparative secondary electron images of original (left) and exposed (right) filters in cross section (Sample # 1Z2-O-116D, FLND713).

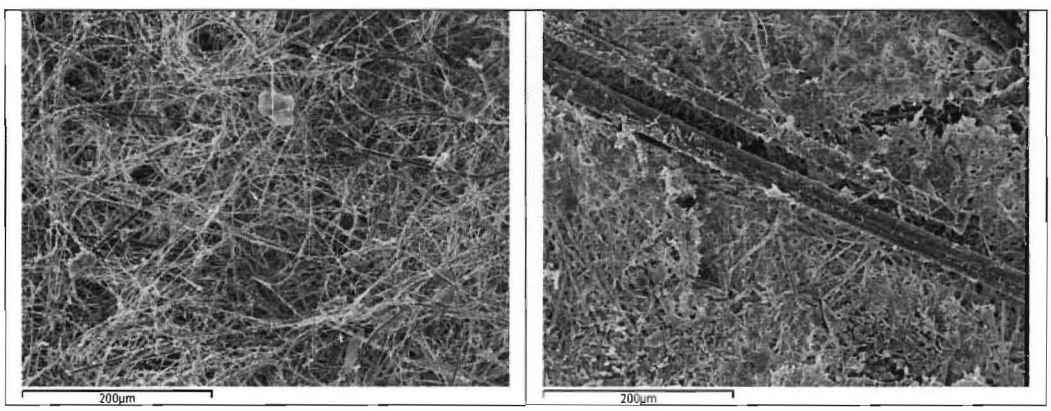

Figure 5.138. Comparative SEM micrographs of flat surface of original (left) and exposed (right) (Sample # 1Z2-O-116D, FLND713).

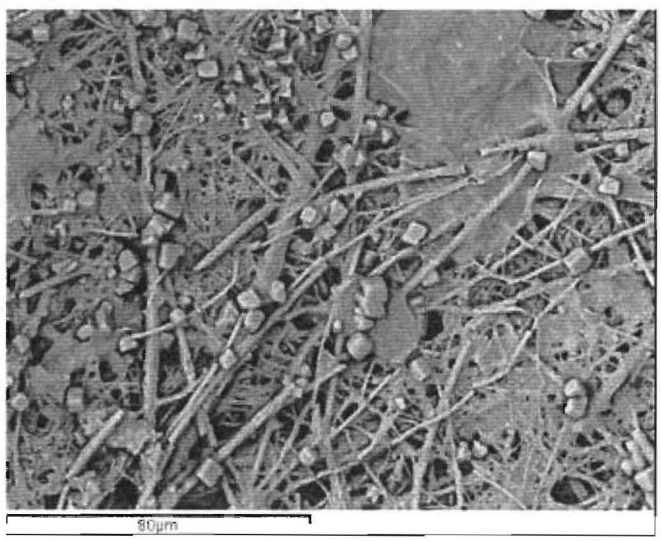

Figure 5.139. SEM micrograph of residue and precipitate adhered to filter (Sample # 1Z2-O-116D, FLND713).

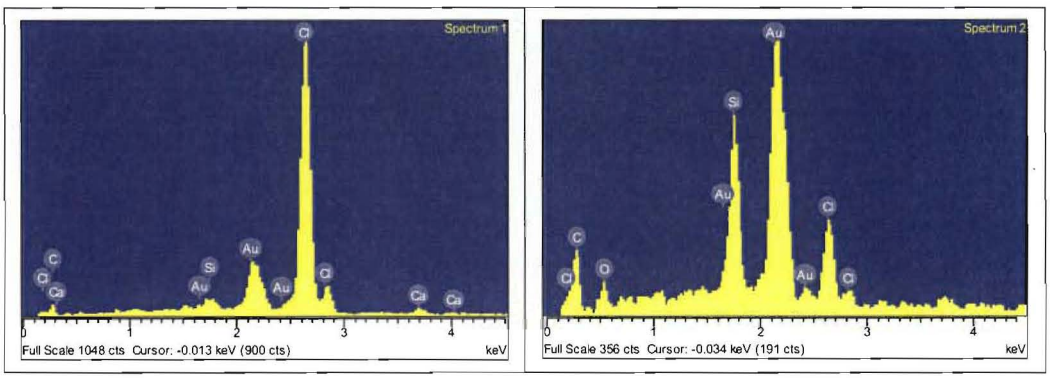

Figure 5.140. Spectrum 1 from precipitate evident in Figure 5.139 image and spectrum from general residue (Sample # 1Z2-O-116D, FLND713).

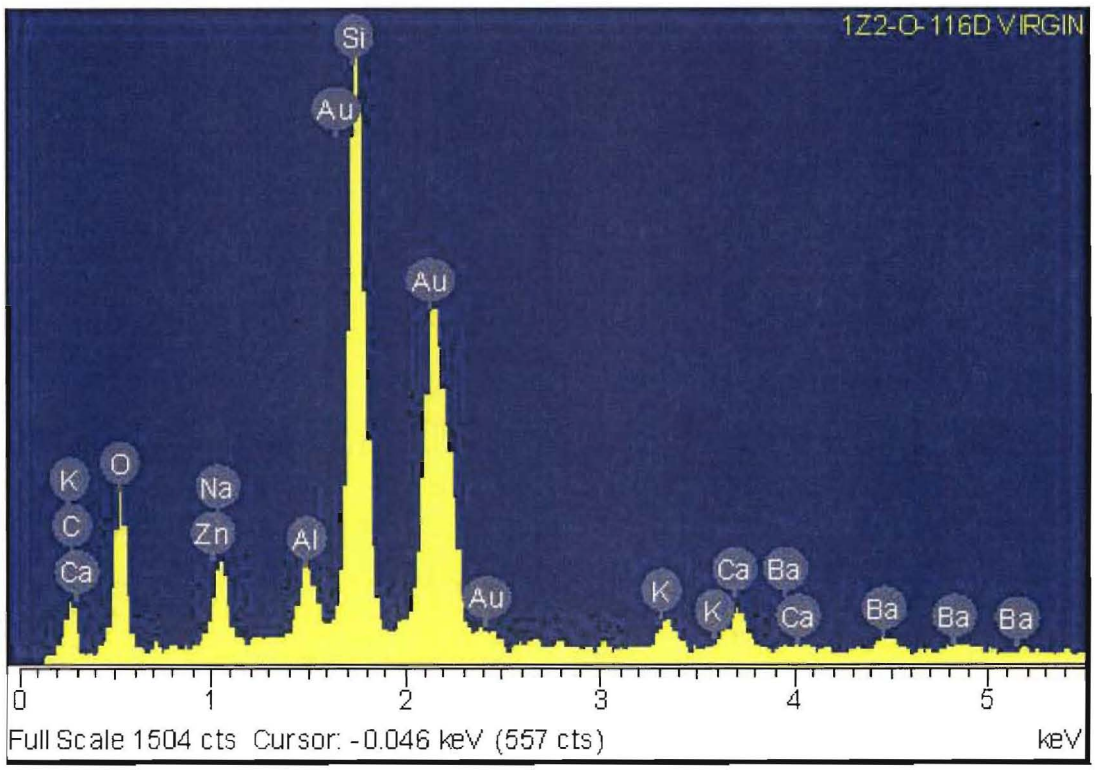

Figure 5.141. EDS spectrum from the original material of sample # 1Z2-O-116D.

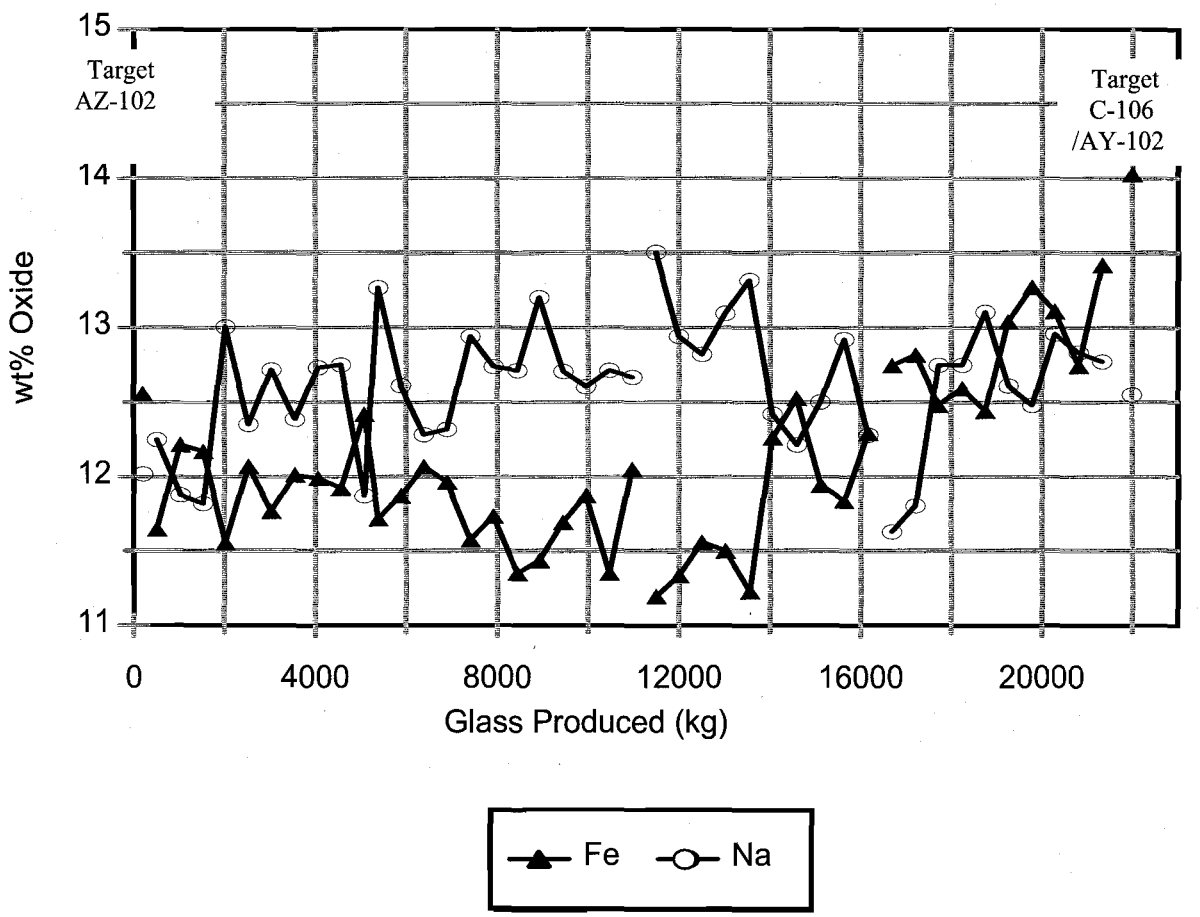

Figure 6.1. XRF analysis of iron and sodium oxides in discharged glasses. Note: the target depicted for the C-106/AY-102 is for the high waste loading formulation.

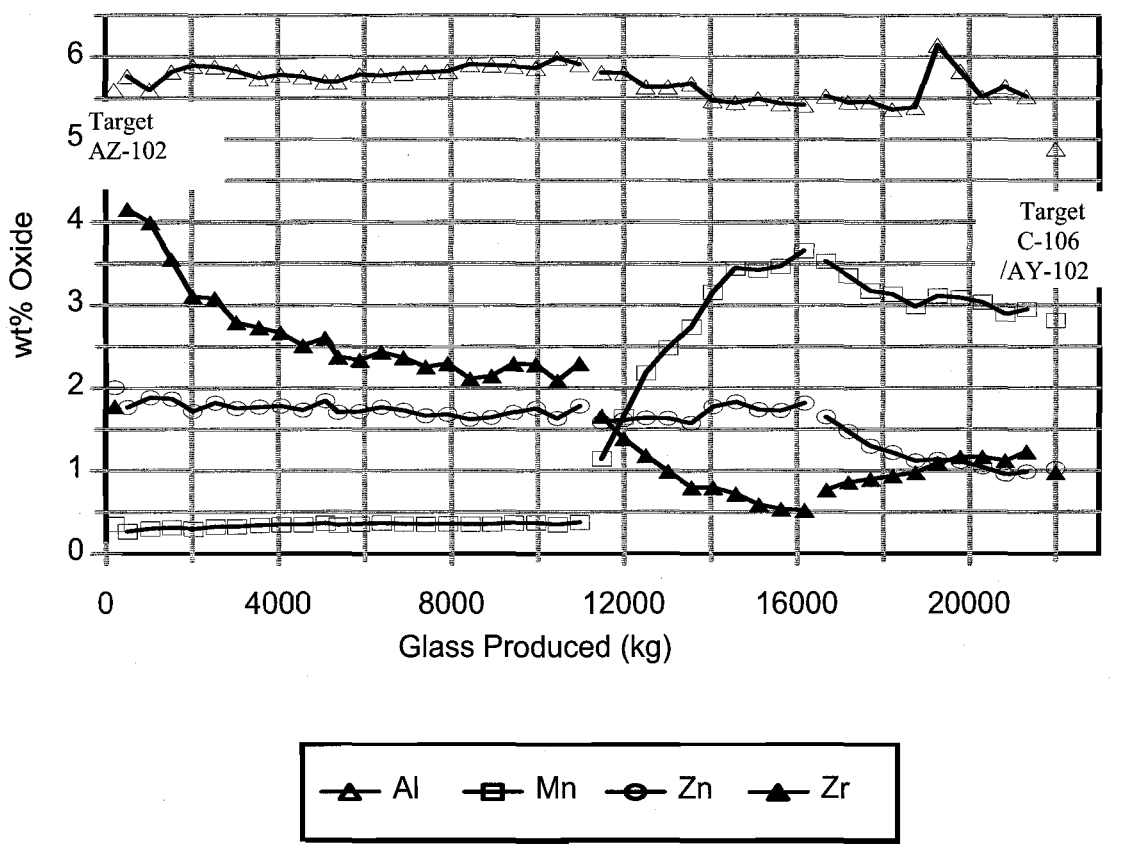

Figure 6.2. XRF analysis of selected major oxides in discharged glasses. Note: the target depicted for the C-106/AY-102 is for the high waste loading formulation.

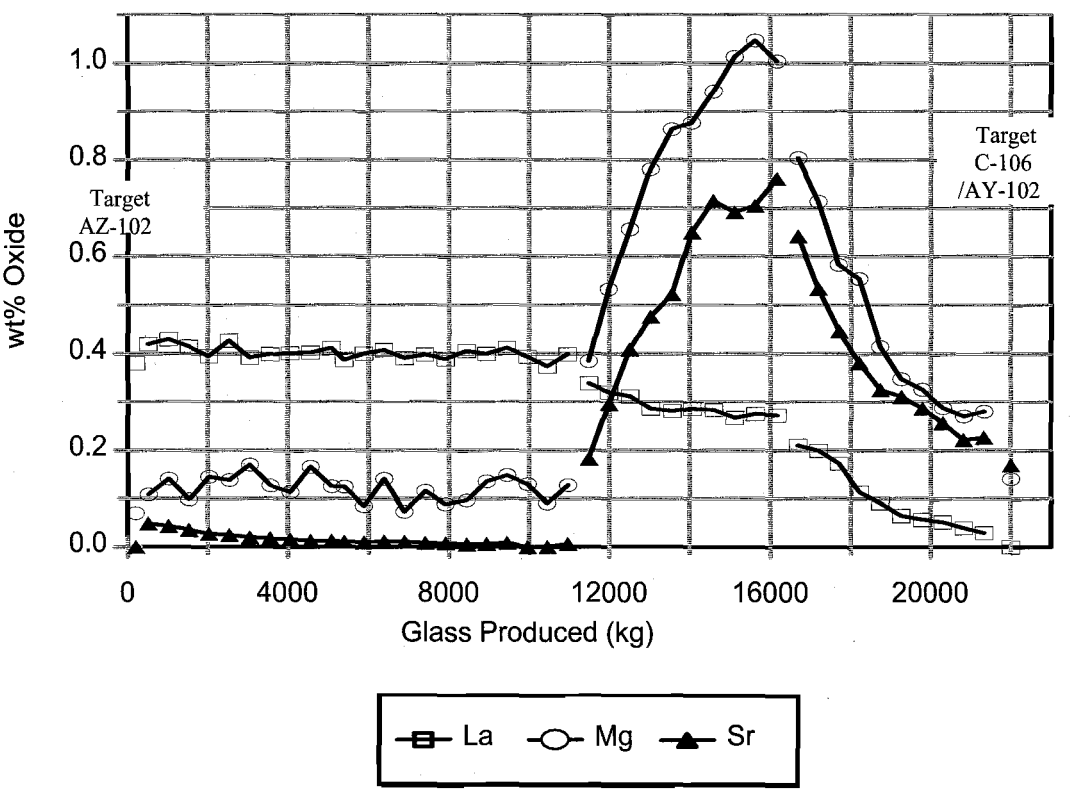

Figure 6.3. XRF analysis of select minor oxides in discharged glasses. Note: the target depicted for the C-106/AY-102 is for the high waste loading formulation.

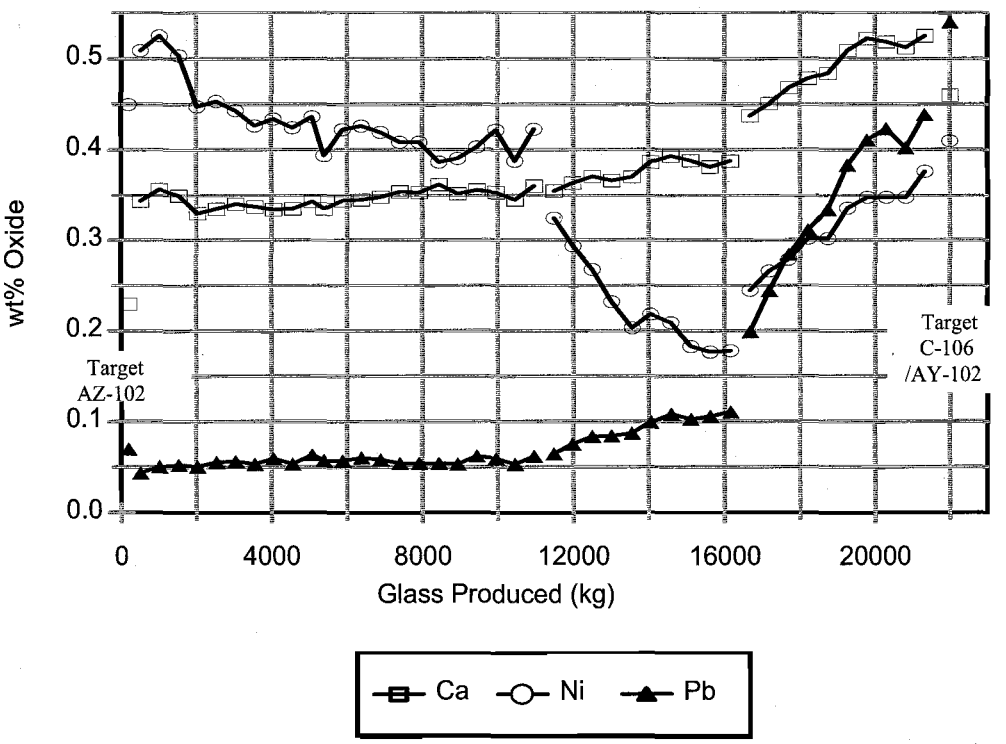

Figure 6.4. XRF analysis of oxides in discharged glasses increasing in concentration during the high waste loading C-106/AY-102 formulation. Note: the target depicted for the C-106/AY-102 is for the high waste loading formulation.

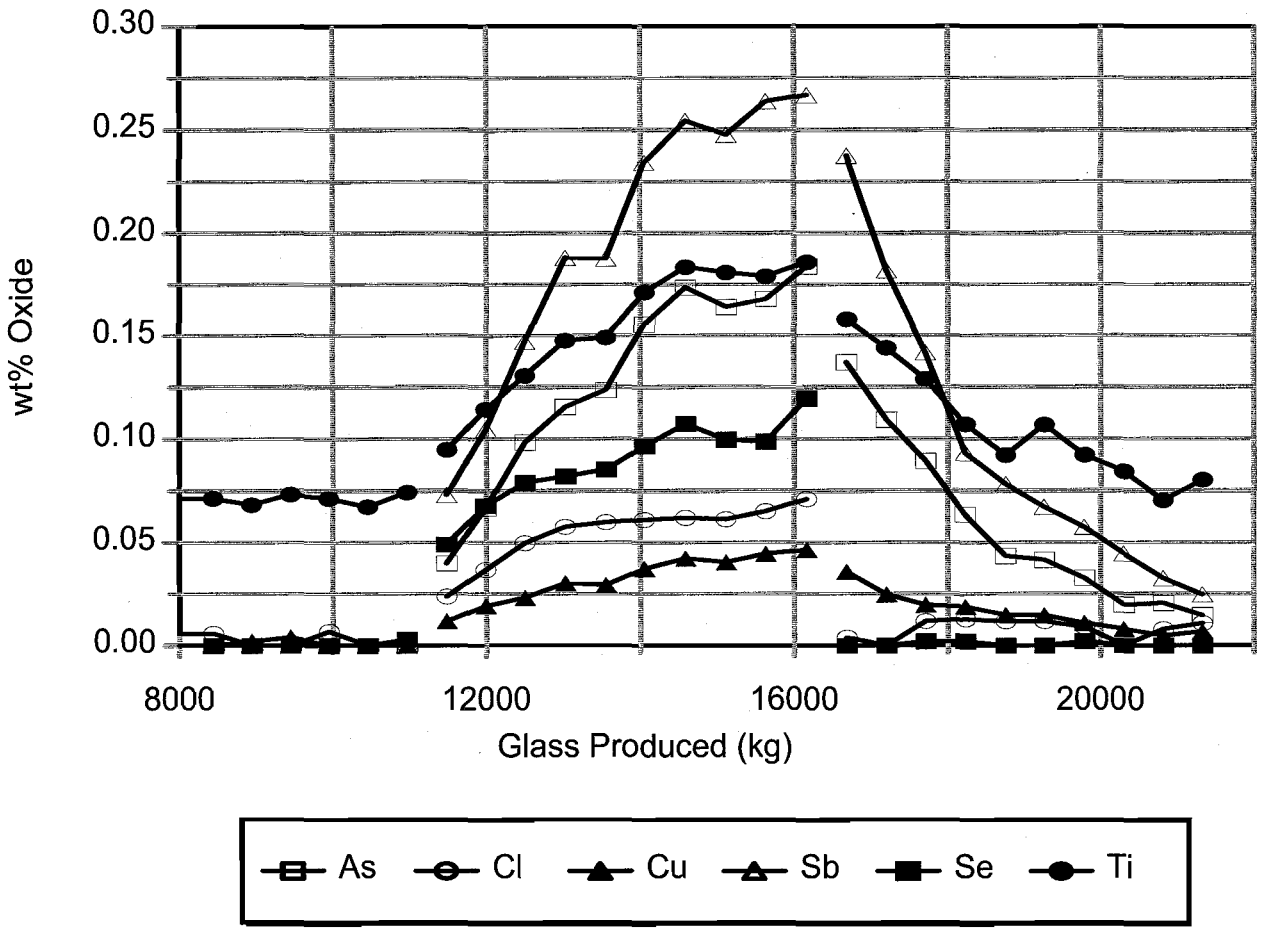

Figure 6.5. XRF analysis of oxides from the adjusted rheology C-106/AY-102 formulation in discharged glasses.

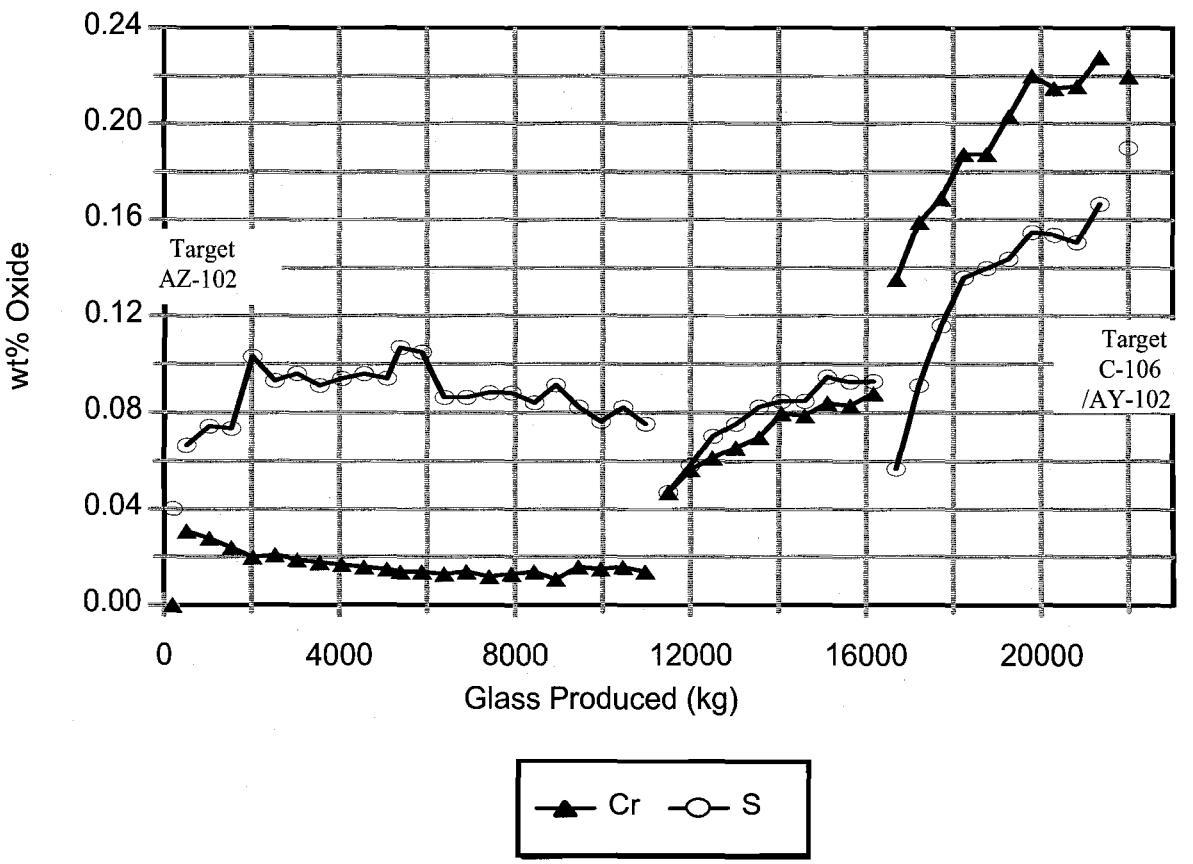

Figure 6.6. XRF analysis of chromium and sulfur oxide in discharged glasses.

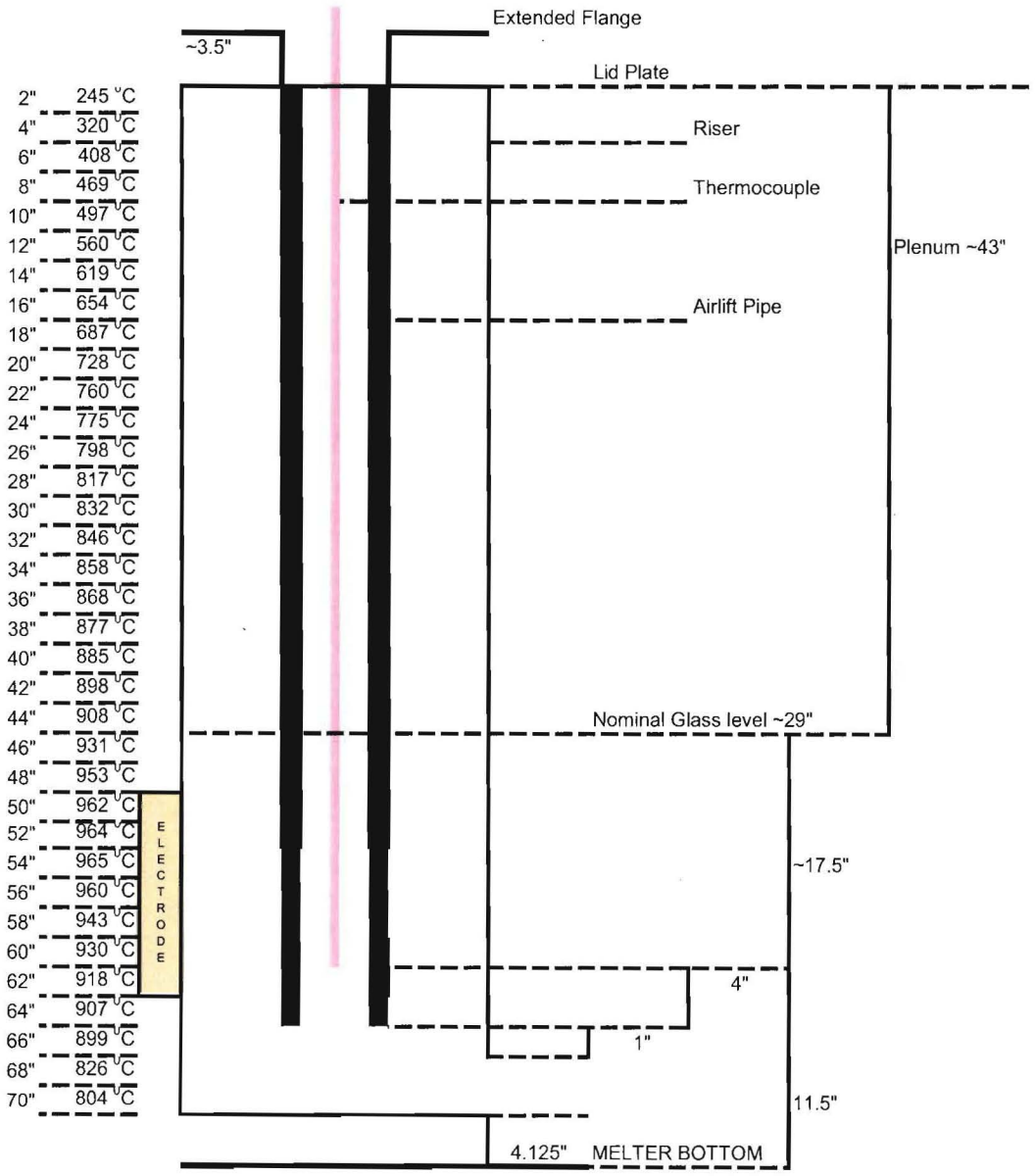

Figure 6.7. DM1200 discharge riser temperature profile. Note: Measurements made at an average glass temperature of 1087°C and discharge chamber temperature of 941-975 ^{0}C.

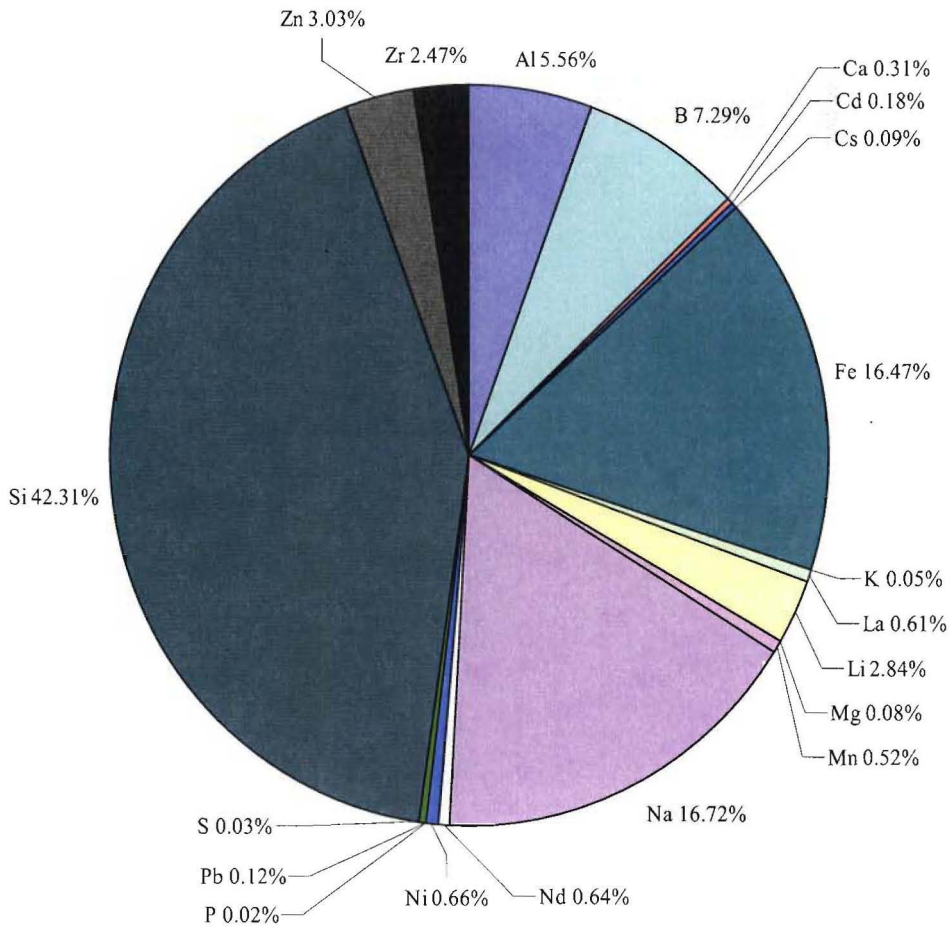

Figure 7.1. AZ-102 feed composition (excludes oxygen, nitrogen and carbon compounds).

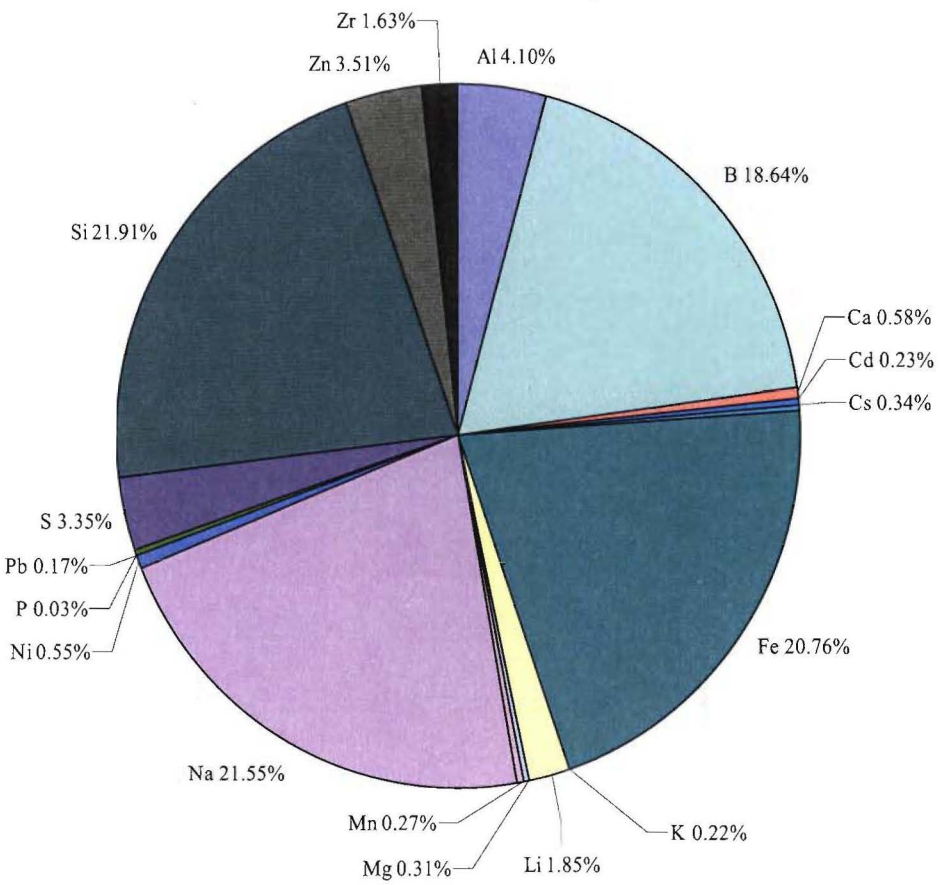

Figure 7.2. Melter exhaust composition (excludes oxygen, nitrogen and carbon compounds) from Test 1A.

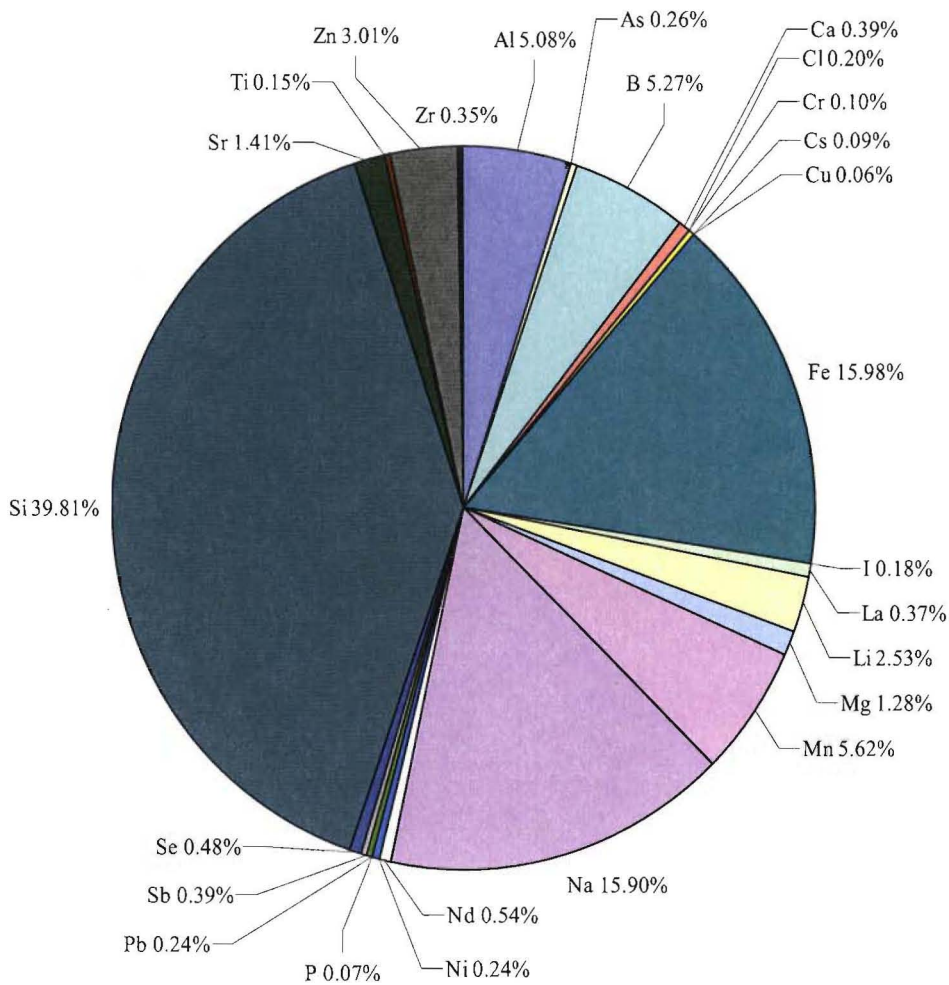

Figure 7.3. C-106/AY-102 feed composition (excludes oxygen, nitrogen and carbon compounds).

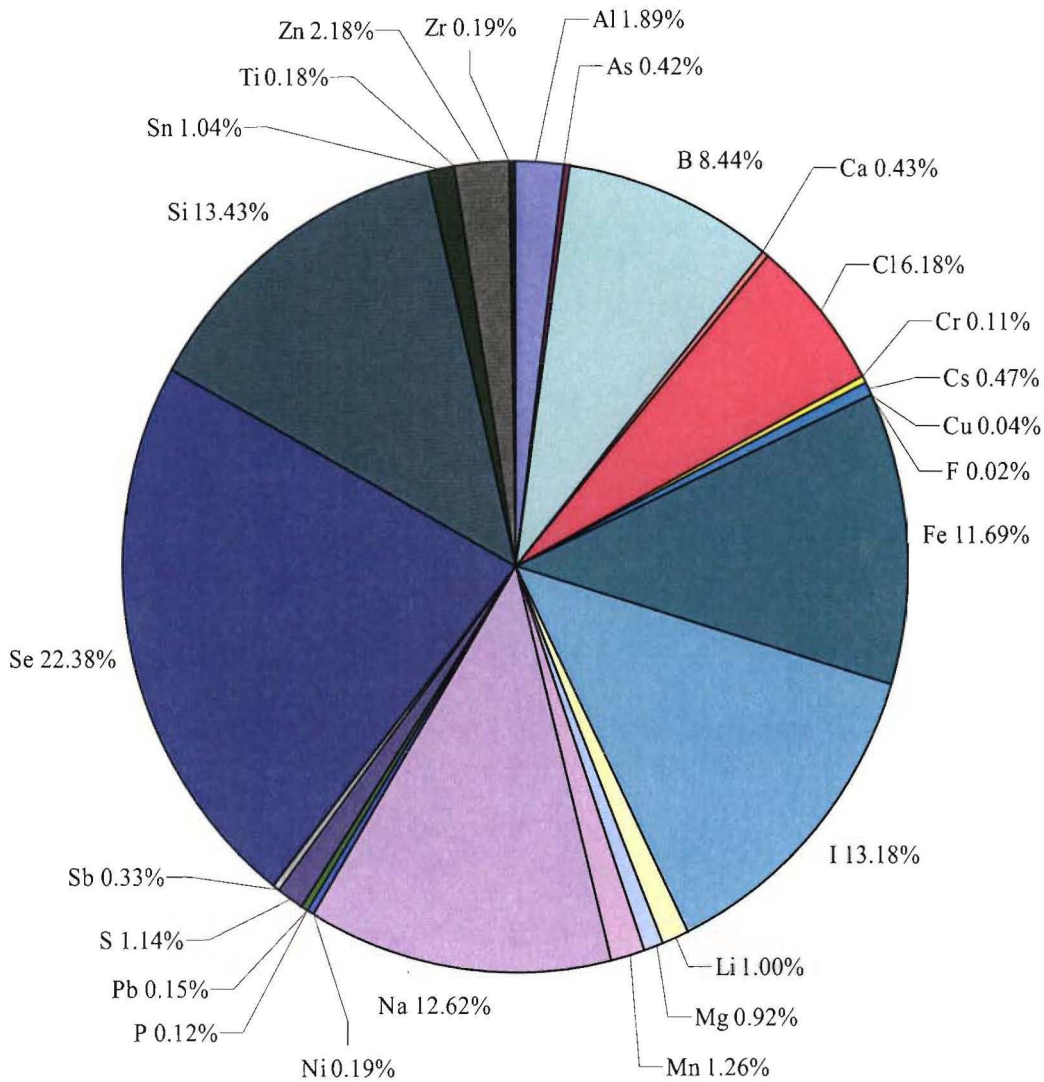

Figure 7.4. Melter exhaust composition (excludes oxygen, nitrogen and carbon compounds) from Test 2A.

R&T Subcontractor Document Review Record

1) To Be Completed by Cognizant R&T Personnel		
Document Number VSL-05R5800-1	Revision A	Document Title Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification
Test Spec: 24590-HLW-TSP-RT-02-015		Scoping Statement(s): VH-4, VHO-3, VHO-2, VH-5

R&T Contact:	L. Petkus	MS5-L	371-3258	May 16, 2005
	Name (Print)	MSIN	Telephone Number	Date

Review Distribution			
Organization	**Contact**	**MSIN**	**Required?**
Process Operations	D McLaughlin	MS4-B2	Yes ☒ No ☐
Quality Assurance	M Mitchell	MS14-4B	Yes ☐ No ☒
Environmental and Nuclear Safety	E Sauceda	MS4-C1	Yes ☐ No ☒
Commissioning and Training	K Vacca	MS12-B	Yes ☐ No ☒
Engineering	M Ongpin	MS4-A2	Yes ☒ No ☐
R&T Functional Manager	S. Barnes	MS5-L	Yes ☒ No ☐
HLW Area	Phil Schuetz	MS5-I	Yes ☐ No ☒
			Yes ☐ No ☐
			Yes ☐ No ☐
			Yes ☐ No ☐

Comments Due By: June 1, 2005

Required Reviewers are required to respond to the R&T Contact.

2) To be Completed by Reviewer			
Reviewer _____ (Name (Print))	_____ (Organization)		_____ (Date)
☐ Accepted, No Comments	☐ Accepted, Comments Not Significant	☐ Significant Comments, Form 24590-MGT-F00006 Attached	☐ Significant Comments, Comments Marked on Document

3) To be Completed by Reviewer*

My significant comments have been addressed.

Acceptance: _____ (*Print/Type Name*) _____ (*Signature*) _____ (*Date*)

** An e-mail to the R&T contact stating that significant comments are addressed can substitute for this acceptance.*

Petkus, Lawrence

From: Eager, Kevin
Sent: Thursday, July 21, 2005 1:53 PM
To: Petkus, Lawrence
Subject: RE: Comment Responses on VSL-05R5800-1, "Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Sim: HLW Simult. Verification"

The subject document has been reviewed and comments have been incorporated; therefore, Engineering gives its concurrence on the subject document.

Kevin Eager
371-3255

-----Original Message-----
From: Petkus, Lawrence
Sent: Thursday, July 21, 2005 11:03 AM
To: Eager, Kevin
Subject: FW: Comment Responces on VSL-05R5800-1, "Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Sim: HLW Simult. Verification"

Kevin,
I never got final engineering concurrence with this report. Can you provide? E-mail history attached. Thank you

Larry Petkus
<< Message: RE: Review of VSL-05R5800-1 "Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification" >>

-----Original Message-----
From: Carl, Daniel
Sent: Thursday, June 16, 2005 7:51 AM
To: Petkus, Lawrence; Yorgesen, Jack
Cc: Eaton, William; Larson, Andrew; Peters, Richard D (WTP); 'rmeigs@duratekinc.com'
Subject: FW: Comment Responces on VSL-05R5800-1, "Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Sim: HLW Simult. Verification"

Larry, Bret,
Responses are acceptable.

Dan

-----Original Message-----
From: Petkus, Lawrence
Sent: Thursday, June 16, 2005 7:35 AM
To: Carl, Daniel; Smith, Gary L
Subject: Comment Responces on VSL-05R5800-1, "Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Sim: HLW Simult. Verification"

Dan, Gary
Attached are the CRFs with responces from VSL from the review of the subject document. Please review the responces and let me know if they are acceptable. thank you.

Larry Petkus
R&T, Main L-179
Ph. 371-3258
<< File: DM1200rheologycom-dc.doc >> << File: DM1200rheologycom-GS.doc >>

Petkus, Lawrence

From: Yorgesen, Jack
Sent: Monday, June 06, 2005 12:02 PM
To: Petkus, Lawrence
Subject: RE: Review of VSL-05R5800-1 "Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification"

Dan Carl's comments are the only comments from Engineering.

No comments from Process Ops
JY

-----Original Message-----
From: Petkus, Lawrence
Sent: Thursday, June 02, 2005 3:09 PM
To: Mclaughlin, Doris; Mitchell, Michelle; Sauceda, Ermelinda; Ongpin, Maria; Schuetz, Phillip
Cc: Gimpel, Rod; Damerow, Frederick; Yorgesen, Jack; Rouse, James
Subject: RE: Review of VSL-05R5800-1 "Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification"

This is a reminder that comments are due for the subject document.

Larry Petkus

-----Original Message-----
From: Petkus, Lawrence
Sent: Monday, May 16, 2005 4:57 PM
To: Mclaughlin, Doris; Mitchell, Michelle; Sauceda, Ermelinda; Vacca, Karen; Ongpin, Maria; Barnes, Steven M; Schuetz, Phillip
Cc: Perez, Joseph; Kelly, Sam; Carl, Daniel; Gimpel, Rod; Damerow, Frederick; Knighton, David; Yorgesen, Jack; Rouse, James; Perez, Jameilyn M
Subject: Review of VSL-05R5800-1 "Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification"

All,
VSL has submitted a draft of the final report VSL-05R5800-1 "Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification." Melter tests were conducted on the DM1200 to determine the effects of feed rheology, feed solids content, and bubbler configuration on glass production rate and off-gas system performance while processing the HLW AZ-101 and C-106/AY-102 feed compositions. Please have the appropriate staff review this document and return comments to Larry Petkus by June 1, 2005.

The document, the Subcontractor Document Review Record, and Comment Resolution Form are located at the following link:.

<\\Wtps0166\R&T\Vitrification\HLW Mltr Tstg\DM1200\Phase III Testing>

Larry Petkus
R&T, Main L-179
Ph. 371-3258

COMMENT RESOLUTION FORM

Return to: L. Petkus

Comments Due: June 1, 2005

Document Title: Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification		Document No. VSL-05R5800-1		Revision: A	Date: May 16, 2005
Reviewer: Gary L. Smith	Date: 06/06/05	Response by:	Date:	Comments Resolved:	Date: 7/27/05

Item No.	Section/ Paragraph	Comment	Significance[a]	"M" Comment Justification[B]	Response	Resolution
1	Page 2	Test Exceptions listed have incorrect alphanumeric designations. [Note: There are three (3) test exceptions listed; however, Test Exception 24590-WTP-TEF-RT-00028 states as part of the "Resolutions:" section, last statement, that there are four (4) test exceptions.]	M		R&T can only find 3 test exceptions related to this work. There was an additional TE on the Test Spec, but not this Test Plan. Test Exception numbering will be checked and corrected as necessary.	
2	Throughout	From Test Specification 24590-HLW-TSP-RT-02-015, Rev 0, Section 6.1 Variability Parameters, No. 5 "Simulant vs. precipitated hydroxide recipe methods on melt rate and/or throughput" has the simulant testing and evaluation related to 'straight' hydroxide vs. precipitated hydroxide preparation procedures; not "nominal rheology" (for which there is no definition provided in the report) and "rheology-adjusted". There needs to be a much better discussion of this "Test Condition" and outcomes than provided in the report, e.g. there is no discussion, preparation procedure, etc. of how the two simulants are produced and what is the relevance. {Note for example: Last sentence of Section 2.6	M		Agreed. The report will be reviewed and nomenclature for describing simulant generation will be made consistent. Descriptions will be clearly linked to those in the Test Plan and Test Specification. Objective 5 of the Test Spec. as described in the Test Plan and report is only partially achieved. Continued testing in the DM100 and elsewhere provides the full answer. R&T will [illegible]	

COMMENT RESOLUTION FORM

Item No.	Section/ Paragraph	Comment	Significance[a]	"M" Comment Justification[B]	Response	Resolution
		"High Waste Loading C-106/AY-102 Glass and Melter Feed Formulation" states "These melter feeds were produced by NOAH Technologies Corporation, the supplier of simulant and feeed samples used in previous testing on the DM1200 melter system." is insufficient information to take care of test conditions request in Test Specification.]			the testing elements needed to document a final answer, separately. (9) GLS 7/27/05 Simulant description is limited because of confidentiality agreement with NOAH. See Issues summary (8).	
3	Throughout	From Test Specification 24590-HLW-TSP-RT-02-015, Rev 0, Section 3 Objectives, No. 10, Section 4 Success Criteria, No. 5, and Section 7 Reporting, third from the last bullet of the section, the chemical, physical, and rheological properties of the simulants were to be tested and reported per guideline document 24590-WTP-GPG-RTD-001. Can not find all the required data reporting per the guidelines document.	M		That was not a requirement of the Test Plan for this work. The Test Plan is one of several in response to the cited Test Specification and the scope of the latter is broader than that of the former. Consequently, any given Test Plan may or may not fulfill all of the requirements of the governing Test Specification. Rheology work completed and reported by SRTC. Results have been tabulated by PNNL. See Issues summary (7)	
4	Section 4.0 DM1200 Operations	The failure of the pump reason is not clearly stated and placed into context of what the actual WTP Plant might encounter. Include "justification" from the test exception (high yield stress) in the report, rather than just a reference. A guess was promulgated in regard to why the pump failed to pump relating to LAW Sub-Envelope B1 feed, was this verified? Similar questions in regard to removal of blockages from the film cooler? How is this being addressed for the WTP Plant?	M		R&T: VSL is asked to report on equipment reliability, but not to make hardware recommendations to the plant Description of events provided in sec. 4. Conclusions are provided in the summary. More added in Issues summary (6)	

COMMENT RESOLUTION FORM

[a] **Significance**: M = Mandatory; I = Improvement. Definitions for these terms are provided at the end of the form instructions and in Appendix B of procedure "WTP Document Administration".

[b] Justification required for Mandatory Comments.

COMMENT RESOLUTION FORM

Return to: L. Petkus

Comments Due: June 1, 2005

Document Title:	Document No.	Revision:	Date:
Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification	VSL-05R5800-1	A	May 16, 2005

Reviewer:	Date:	Response by:	Date:	Comments Resolved:	Date:
Larry Petkus				L Petkus	

Item No.	Section/ Paragraph	Comment	Significance[a]	"M" Comment Justification[B]	Response	Resolution
1	5.1.1	Relative to film cooler deposits. It is reported that there were heavier deposits durring high air flow through the bubblers. Are the characteristics of the deposits different at high deposition rates as opposed to low rates?	I		We did not observe any difference in the characteristics of the deposits.	
2	5.1.7, Figs 5.72 and 5.73	It looks like heater damage is localized near the lid. 1) Is this true? 2) Can you speculate as to a cause / mitigation. Add text as applicable	I		Damage to the one heater occurred near the lid. Since only one heater failed, it is difficult to pin point the cause (do not have sufficient data to establish a trend).	
3	Fig 1.7	Add lables to identify heaters 701 and 801	I		Agreed.	
4	5.1	Temperature drop due to WESP deluge cascades through the system at least to the carbon bed (Test 2B). Is this normal or does it indicate mal-operation of HEME and or heater 701. This seems to indicate water carry over. Please add discussion	M	Posible equipmnet malfunction	We expect that with a WESP deluge of 40 gallons over 3 minutes, the gas stream itself gets quenched. The WESP temperature drop of about 15C reduces to about 10C in the HEME and diminishes to about 1C in the HEPA. We believe that this is normal.	
5	5.1.11	Were samples of the EOG build up taken or analyzed	M	Asess nature of build up and effect on reliability	Samples of EOG solids were taken and archived. They have	

COMMENT RESOLUTION FORM

Item No.	Section/ Paragraph	Comment	Significance[a]	"M" Comment Justification[B].	Response	Resolution
					not been analyzed. Form their appearance, they look like feed carryover with somewhat higher concentrations of more volatile components such as sulfur, and alkali and boron oxides.	
6	Table 6.3	Target values and calculated valves for Boron are different. For the purpose of this table, the values should be the same. that is analytical target is the glass produced at the time.	M	needed for assessment of the different analytical methods	The table will be modified as indicated.	
7	1.1	Add description to differentiate between adjusted rheology and precipitated hydroxide simulant. So that test spec objectives are better understood. Provide shot overview of the group of tests and reports that impact the objectives.	M	this work needs to be put in context of other work in simulant validation	Agreed. The report will be reviewed and nomenclature for describing simulant generation will be made consistent. Descriptions will be clearly linked to those in the Test Plan and Test Specification.	

[a] **Significance**: M = Mandatory; I = Improvement. Definitions for these terms are provided at the end of the form instructions and in Appendix B of procedure "WTP Document Administration".
[b] Justification required for Mandatory Comments.

R&T Technology Issues Summary

Test Report Title: VSL-05R5800-1

Test Report Number: Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification

Prepared By: Lawrence Petkus **Date:** July 27, 2005

Signature: Lawrence Petkus 7/27/05

Does the Testing or Report reveal any new discoveries, technology issues, or suggest potential follow-on work?	**Yes**	**No**
	☒	☐

If yes, describe the suggested activity.

R&T Technology Issues Summary

Test Report Title: VSL-05R5800-1

Test Report Number: Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification

1) Although the rheology-adjusted feeds processed at or above the rates previously attained with the corresponding less-viscous waste simulants, the observed differences in processing rates for different waste compositions for adjusted rheology feeds and lower solids content feeds challenge the previously held notion that all HLW waste streams can be processed at approximately the same rate under similar conditions.

2) These and previous tests showed that significant improvements in glass production rates could be achieved by employing modified bubbler configurations. These improvements appear to be sufficient to more than make up for the production rate short-fall brought about by the reduction in the solids content in the feed from pretreatment from 20 wt% to 15 wt% undissolved solids. However, attainment of the target rate was not possible for all simulants after further reduction in solids content. Attempts to achieve the target rate with low solids content feed resulted in unstable melter conditions and frequent blockages of the film cooler.

3) The modified SBS design appeared to show less tendency for clogging than did the previous design, but longer test durations are needed to confirm this.

4) Film cooler clogging continued to be a significant operational problem; their frequency appeared to increase with bubbling rate and glass production rate.

5) Maintaining a cold cap limited feed rate during DM1200 tests is dependent on frequent visual monitoring of conditions in the melter plenum. The planned operation of the WTP melters based on only non-visual data, such as plenum temperature, could lead to either under feeding of the melter resulting in lower than attainable production rates or over feeding of the melter resulting in excessive cold-cap buildup as well as other operational difficulties. Testing under such conditions is therefore recommended to determine whether the required glass production rates can be achieved without the artificial visual data.

	Yes	No
If appropriate, is a Request for Technology Development attached.	☐	☒

Additional comments (include researcher recommendations):

R&T Technology Issues Summary

Test Report Title: VSL-05R5800-1

Test Report Number: Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification

1) The results of these tests show that the testing done to date provides a conservative estimate of the processing rates we can expect during actual operation.

2) The project is aware that feed from pretreatment that is below 15 wt% solids may not be able to be processed at the target production rate.

3) Test durations with the new SBS were equivelent to previous testing when SBS blockages were prevelent. Tests with the WTP prototypic design did not indicate solids accumulation characteristic of the previous design. The SBS was also used in the four MACT tests in FY 05, to be reported later. The plant off gas jumper includes provisions for a clean out device, if needed.

4) Film cooler plugging does increase with bubbler flow, which puts a limit on the production gains possible with the bubblers. Current attained production rates are aceptable with additional gains possible if bubbler flow is increased only for the bubblers positioned away from the film cooler. The DM1200 film cooler was also known to have degraded (pluggage of a majority of the leading edge slots) and did not possess slots along the outer body as in the WTP design. The outer slots will improve performance. Finally, a cleanout device is being designed for routine use, as needed.

5) Visual monitoring has been recommended by R&T for the cold commissioning period so that experience can be gained prior to "blind" operation. R&T agrees that viewing capability will support optimum operations.

6) The ADS pump would not operate with high viscosity feeds during one test. In test 1a, the AZ-102 simulant from Noah over shot the target viscosity so that the yield strength of the material was 59 Pa. The feed would not pass through the ADS pump inlet screen. When the feed was diluted from 20 wt% waste solids basis to a 17 wt% waste solids basis, the yield strength dropped to 28 Pa, and the ADS Pump could move the slurry to the melter. The bounding yield strength for HLW Melter feed is 30 Pa.

Continued next page

R&T Technology Issues Summary

Test Report Title: VSL-05R5800-1

Test Report Number: Integrated DM1200 Melter Testing Using AZ-102 and C-106/AY-102 HLW Simulants: HLW Simulant Verification

7) Additional rheologic measurements were made on the simulants and resultant feeds by SRNL and reported in WSRC-TC-2005-00035, "Physical Characterization of Vitreous State Laboratory AY102/C106 and AZ102 High Level Waste Melter Feed Simulants." This report is the primary basis for 'simulant validation' against actual wastes. The data is tabulated for comparison with other HLW data in WTP-RPT-112 rev. A "Final Report: Technical Basis for HLW Vitrification Stream Physical and Rheological Property Bounding Conditions".

8) A key component of this work was the manufacture of "adjusted rheology" feeds. The metal hydroxide formations were modified by Noah Chemical through a propriatary process. The feeds are chemically the same, but the rheology is different. VSL signed a confidentiality agreement not to disclose the process so that they could review the modifications and agree that the resulting glass was unaffected. VSL has limited the description of the feeds in this report because of the confidentiality agreement. The fact that a feed prepared by Noah is this manner had similar processing characteristics to the SRNL SIPP feed provides confidence that the preparation methodology did not result in any obvious anomilies.

9) Objective 5 in the Test Specification 24590-HLW-TSP-RT-02-015 requires the examination of "simulant vs precipitated hydroxide reciepe methods on melt rate and/or through put." This test provides part of the testing required to complete this objective. R&T will combine the results of this and various other tests in a separate document to complete this objective.

Miller, Leslie

From: Damerow, Frederick (WGI)
Sent: Wednesday, November 10, 2010 2:04 PM
To: WTP Submittal Coordinator
Subject: Revision to VSL-05R5800-1, 24590-101-TSA-W000-0009-144-00006

We discovered that a few pages are missing from the subject document. I've put a PDF copy of the document that has all of the pages in the FTP folder /rntenergysolutions/To_BNI-formal_submission. Please issue it as the next revision to add the missing pages.

Thanks,
Fred Damerow
R&T Systems and Pretreatment Manager
fwdamero@bechtel.com
off 509-371-3613
cell 509-531-5538
MPF B268

Miller, Leslie

From: Damerow, Frederick (WGI)
Sent: Wednesday, November 10, 2010 2:04 PM
To: WTP Submittal Coordinator
Subject: Revision to VSL-05R5800-1, 24590-101-TSA-W000-0009-144-00006

We discovered that a few pages are missing from the subject document. I've put a PDF copy of the document that has all of the pages in the FTP folder /rntenergysolutions/To_BNI-formal_submission. Please issue it as the next revision to add the missing pages.

Thanks,
Fred Damerow
R&T Systems and Pretreatment Manager
fwdamero@bechtel.com
off 509-371-3613
cell 509-531-5538
MPF B268