ORP-51440
Revision 0

Final Report DM1200 Tests with AZ-101 HLW Simulants

VSL-03R3800-4, Rev. 0, 2/17/04

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

Office of River Protection

P.O. Box 450
Richland, Washington 99352

Final Report DM1200 Tests with AZ-101 HLW Simulants

VSL-03R3800-4, Rev. 0, 2/17/04

K. S. Matlack
Vitreous State Laboratory,
The Catholic University of America

A. A. Kruger
Department of Energy - Office of River Protection

T. Bardakci
N. A. D'Angelo
W. Gong
W. K. Kot
I. L. Pegg
Vitreous State Laboratory,
The Catholic University of America

Date Published
December 2011

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

Office of River Protection

P.O. Box 450
Richland, Washington 99352

Release Approval   Date 12/29/2011

Approved for Public Release;
Further Dissemination Unlimited

VSL-03R3800-4

Final Report

DM1200 Tests with AZ-101 HLW Simulants

prepared by

Keith S. Matlack, Weiliang Gong, Tevfik Bardakci,
Nicholas D'Angelo, Wing K. Kot, and Ian L. Pegg

Vitreous State Laboratory
The Catholic University of America
Washington, DC 20064

for

Duratek, Inc.

and

Bechtel National, Inc.

2/26/04
for W. Tamosaitis
ACCEPTED FOR
WTP PROJECT USE

December 3, 2003

Rev. 0; 2/17/04

Document Title: DM1200 Tests with AZ-101 HLW Simulants
Document Number and Revision: VSL-03R3800-4, Rev. 0
Issue Date: 02/17/04
Performing Organization: Vitreous State Laboratory, The Catholic University of America

Test Specification: 24590-HLW-TSP-RT-02-005, Rev 0
Test Exceptions: 24590-HLW-TEF-RT-02-002
Test Plan: VSL-02T8000-1, 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: Keith Matlack (for) **Date:** 2/16/04
VSL Program Director/Principal Investigator

I. Joseph: Innocent Joseph **Date:** 2/16/04
Duratek Sub-Contract Manager

TABLE OF CONTENTS

List of Tables 4
List of Figures 6
List of Abbreviations 12
SUMMARY OF TESTING 13
SECTION 1.0 INTRODUCTION 22
1.1 Test Objectives 23
1.2 Test Overview 24
1.3 Quality Assurance 25
1.4 Melter System Description 25
1.4.1 Feed System 25
1.4.2 Melter System 26
1.4.3 Off-Gas System 27
SECTION 2.0 WASTE SIMULANT AND GLASS FORMULATIONS 29
2.1 AZ-101 Waste Simulant 29
2.2 AZ-101 Glass and Melter Feed Formulations 30
2.3 Analysis of Feed Samples 30
2.3.1 General Properties 30
2.3.2 Rheology 31
2.3.3 Chemical Composition 32
SECTION 3.0 DM100 OPERATIONS 33
3.1 Melter System Description 33
3.1.1 Feed System 33
3.1.2 Melter System 33
3.1.3 Off-Gas System 34
3.2 Melter Testing 34
3.3 Glass Product Analysis 34
SECTION 4.0 DM1200 OPERATIONS 36
SECTION 5.0 OFF-GAS SYSTEM PERFORMANCE 40
5.1 Off-Gas System Test Results 40
5.1.1 Melter Pressure 41
5.1.2 SBS Performance 43
5.1.3 WESP Performance 50
5.1.4 HEME #1 54
5.1.5 HEPA Filter 55
5.1.6 First Paxton Blower (Blower-701) 55
5.1.7 Thermal Catalytic Oxidizer and Selective Catalytic Reduction Unit 56
5.1.8 Packed Bed Scrubber (PBS) 58
5.1.9 HEME #2 60
5.1.10 Effluent Liquid Treatment System 60
5.2 SBS and WESP Process Fluids 61
5.2.1 SBS Fluids 61
5.2.2 WESP, PBS, and HEME Fluids 63
5.2.3 Estimates of Accumulations in SBS, WESP, and PBS and Fluids 64
SECTION 6.0 GLASS PRODUCT FROM THE DM1200 66
6.1 Compositional Analysis 66
6.2 Glass Density Comparison 67
SECTION 7.0 MONITORED OFF-GAS EMISSIONS 68
7.1 Particulate and Gaseous Emissions 68
7.2 Particle Size Distribution 70
7.3 FTIR Analysis 70
7.4 Hydrogen by Gas Chromatography 71
7.5 Iodine Mass Balance 71
SECTION 8.0 CONCLUSIONS 73
SECTION 9.0 REFERENCES 75

List of Tables

Table 2.1. Compositional Summary of Different Waste Streams and Blended Solids. T-1
Table 2.2. Compositional Summary (Oxide Basis) of the HLW AZ-101 Simulant, Glass Additives, Target Test Glass, and the Corresponding Crucible-Melt Glass (HLW98-77) T-2
Table 2.3. Composition of Melter Feed to Produce One Metric Ton of Target Glass from AZ-101 HLW Simulant (20 wt% total solids) T-3
Table 2.4. Properties of AZ-101 Melter Feed Samples T-4
Table 2.5. XRF Analyzed Compositions for Vitrified DM100 Melter Feed Samples T-6
Table 2.6. XRF Analyzed Compositions for DM1200 Feed Samples T-7
Table 3.1. Summary of DM100 AZ-101 Test Conditions and Results T-12
Table 3.2. Glass Discharged, Masses, and Analysis Performed on DM100 Samples T-13
Table 3.3. XRF Analyzed Compositions for Glass Discharged from DM100 T-14
Table 4.1.a Summary of Test Conditions and Results for Tests 1 and 2 T-16
Table 4.1.b Summary of Test Conditions and Results for Tests 3 and 4 T-17
Table 4.1.c Summary of Test Conditions and Results for Tests 5 and 6 T-18
Table 4.2.a DM1200 Melter System Measured Parameters during Tests 1 and 2 T-19
Table 4.2.b DM1200 Melter System Measured Parameters during Test 3 T-20
Table 4.2.c DM1200 Melter System Measured Parameters during Test 4 T-21
Table 4.2.d DM1200 Melter System Measured Parameters during Test 5 T-22
Table 4.2.e DM1200 Melter System Measured Parameters during Test 6 T-23
Table 5.1 DuraMelter 1200 AZ-101 Bubbling Tests Off Gas System Measured Parameters T-24
Table 5.2 Nitrogen Oxides and Carbon Monoxide Destruction across TCO-SCR Catalytic Unit during Test 3 T-30
Table 5.3 Nitrogen Oxides and Carbon Monoxide Destruction across TCO-SCR Catalytic Unit during Test 4 T-31
Table 5.4 Nitrogen Oxides and Carbon Monoxide Destruction across TCO-SCR Catalytic Unit during Test 5 T-32
Table 5.5 Nitrogen Oxides and Carbon Monoxide Destruction across TCO-SCR Catalytic Unit during Test 6 T-33
Table 5.6 Gas Residence Times in TCO T-34
Table 5.7 Listing of Samples from SBS Blow-Downs T-35
Table 5.8 Analytical Results for Selected SBS Blow-Down Fluids T-41
Table 5.9 Anion Concentrations and Cumulative Masses in SBS Blow-Down Liquids during Test 3C T-44
Table 5.10 Listing of Samples from WESP Blow-Downs T-46
Table 5.11 Listing of Samples from PBS Blow-Downs T-48
Table 5.12 Analytical Results for Dissolved solids in WESP Blow-down Fluids for Test 3C T-50
Table 5.13 Analytical Results for Dissolved solids in Select WESP Blow-Down Fluids T-51
Table 5.14 Anion Concentrations for PBS and HEME Blow-Down Liquids T-52
Table 5.15 Upper Estimates of Accumulations in Off-Gas Liquids from Test 3C T-53
Table 6.1 Listing of Glass Discharged, Masses, and Analysis Performed T-55
Table 6.2 XRF Analyzed Compositions for Glass discharged from DM1200 T-66
Table 6.3 Intrinsic Densities for Discharged Glass Samples from DM1200 Melter Tests T-72
Table 7.1 Summary of Method 29 Particulate Matter Results T-73
Table 7.2 Results from Test 3A Emissions Sampling T-74
Table 7.3 Results from Test 3B Emissions Sampling T-75
Table 7.4 Results from Test 3C Emissions Sampling T-76
Table 7.5 Results from Test 4C Melter Emissions Sampling T-77
Table 7.6 Results from Test 4C SBS Emissions Sampling T-78
Table 7.7 Results from Test 4C WESP Emissions Sampling T-79
Table 7.8 Results from DM 1200 AZ101 Test 6 Melter Emissions Sampling T-80
Table 7.9 Results from Test 5C Melter Emissions Sampling T-81
Table 7.10 Results from Test 5C SBS Emissions Sampling T-82
Table7.11 Results from Test 5C WESP Emissions Sampling T-83
Table 7.12 Particulate DFs for AZ-101, AZ-102 [25], C-106/AY-102 [26] and C-104/AY-101 [27]

Tests at 65 lpm Bubbling T-84
Table 7.13 Particle Size Distribution Results for Test 3 Melter Emissions T-85
Table 7.14 Particle Size Distribution Results for Test 4C Melter Emissions T-86
Table 7.15 Particle Size Distribution Results for Test 5C Melter Emissions T-87
Table 7.16.a Test 3 Average Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy T-88
Table 7.16.b Test 3 Concentration [ppmv] Ranges of Selected Species in Off-Gas Measured by FTIR Spectroscopy T-89
Table 7.17.a Test 4 Average Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy T-90
Table 7.17.b Test 4 Concentration [ppmv] Ranges of Selected Species in Off-Gas Measured by FTIR Spectroscopy T-91
Table 7.18.a Test 5 Average Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy T-92
Table 7.18.b Test 5 Concentration [ppmv] Ranges of Selected Species in Off-Gas Measured by FTIR Spectroscopy T-93
Table 7.19.a Test 6 Average Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy T-94
Table 7.19.b Test 6 Concentration [ppmv] Ranges of Selected Species in Off-Gas Measured by FTIR Spectroscopy T-95
Table 7.20 Average Hydrogen Concentrations [ppmv] Measured by Gas Chromatography at the WESP Outlet T-96
Table 7.21 Iodine Mass Balance Summary T-96
Table 8.1 Completion of Test Objectives T-97

List of Figures

Figure 1.1 Cross-section of the DM1200 melter through the discharge chamber F-1
Figure 1.2 Cross-section through the DM1200 melter showing electrodes F-2
Figure 1.3 Schematic diagram of DM1200 off-gas system F-3
Figure 2.1 Viscosity vs. shear rate of select feed samples F-4
Figure 3.1 Production rates for DM100 test....F-5
Figure 3.2 Glass temperatures and electrode power for DM100 test....F-6
Figure 3.3 Plenum temperatures for DM100 test....F-7
Figure 3.4 Glass pool bubbling for DM100 test....F-8
Figure 3.5 XRF analysis of sodium and silicon oxides in glasses from DM100 ....F-9
Figure 3.6 XRF analysis of selected oxides in glasses from DM100 testing....F-10
Figure 3.7 XRF analysis of oxides decreasing in concentration in glasses from DM100 testing....F-11
Figure 3.8 XRF analysis of oxides increasing in concentration in glasses from DM100 testing....F-12
Figure 4.1.a Test 1 (504 g glass/l) and Test 2 (281 g glass/l) production rates F-13
Figure 4.1.b Production rates for Test 3 ....F-14
Figure 4.1.c Production rates for Test 4 ....F-15
Figure 4.1.d Production rates for Test 5 ....F-16
Figure 4.1.e Production rates for Test 6 ....F-17
Figure 4.2 Production rates vs. bubbling for Test 1 ....F-18
Figure 4.3 Comparison of steady state glass production rates for HLW AZ-101 melter tests F-19
Figure 4.4 Comparison of production rates for tests 1 and 3....F-20
Figure 4.5 Comparison of steady state glass production rates for 20% UDS HLW waste simulant melter tests F-21
Figure 4.6.a Glass temperatures for Test 1 (504 g glass/l) and Test 2 (281 g glass/l)....F-22
Figure 4.6.b Glass temperatures for Test 3 (530 g glass/l)....F-23
Figure 4.6.c Glass temperatures for Test 4 (400 g glass/l)....F-24
Figure 4.6.d Glass temperatures for Test 5 (300 g glass/l)....F-25
Figure 4.6.e Glass temperatures for Test 6 (400 g glass/l)....F-26
Figure 4.7.a Plenum temperatures and electrode power for Test 1 and Test 2....F-27
Figure 4.7.b Plenum temperatures and electrode power for Test 3 ....F-28
Figure 4.7.c Plenum temperatures for Test 4....F-29
Figure 4.7.d Plenum temperatures and electrode power for Test 5 ....F-30
Figure 4.7.e Plenum temperatures and electrode power for Test 6 ....F-31
Figure 4.8.a Electrode temperatures and power for Tests 1 and 2....F-32
Figure 4.8.b Electrode temperatures and power for Test 3 ....F-33
Figure 4.8.c Electrode temperatures and power for Test 4 ....F-34
Figure 4.8.d Electrode temperatures and power for Test 5 ....F-35
Figure 4.8.e Electrode temperatures and power for Test 6 ....F-36
Figure 4.9.a Electrode power and glass resistance for Test 1 and Test 2 ....F-37
Figure 4.9.b Electrode power and glass resistance for Test 3....F-38
Figure 4.9.c Electrode power and glass resistance for Test 4....F-39
Figure 4.9.d Electrode power and glass resistance for Test 5....F-40
Figure 4.9.e Electrode power and glass resistance for Test 6....F-41
Figure 4.10.a Glass density and level for Test 1 and Test 2....F-42
Figure 4.10.b Glass density and level for Test 3 ....F-43
Figure 4.10.c Glass density and level for Test 4 ....F-44
Figure 4.10.d Glass density and level for Test 5 ....F-45
Figure 4.10.e Glass density and level for Test 6 ....F-46
Figure 4.11.a Glass pool bubbling for Test 1 and Test 2....F-47
Figure 4.11.b Glass pool bubbling for Test 3 ....F-48
Figure 4.11.c Glass pool bubbling for Test 4 ....F-49
Figure 4.11.d Glass pool bubbling for Test 5 ....F-50
Figure 4.12 Power usage as a function of bubbling and feed solids content....F-51

Figure 5.1 Average gas temperatures along the DM1200 off-gas train during Test 1 and 2 ....F-52
Figure 5.2 Average gas temperatures along the DM1200 off-gas train during Test 3 ....F-53
Figure 5.3 Average gas temperatures along the DM1200 off-gas train during Test 4 ....F-54
Figure 5.4 Average gas temperatures along the DM1200 off-gas train during Test 5 ....F-55
Figure 5.5 Average gas temperatures along the DM1200 off-gas train during Test 6 ....F-56
Figure 5.6 Transition line
and film cooler differential pressures hourly average values) during Test 1 and Test 2....F-57
Figure 5.7 Melter pressure at instrument port and control air flow rate during Test 1 and Test 2....F-58
Figure 5.8. Transition line and film
cooler differential pressures (hourly average values) during Test 3 ....F-59
Figure 5.9 Melter pressure at instrument port and control air flow rate during Test 3 ....F-60
Figure 5.10 Transition line and
film cooler differential pressures (hourly average values) during Test 4....F-61
Figure 5.11 Melter pressure at instrument port and control air flow rate during Test 4 ....F-62
Figure 5.12 Transition line and film
cooler differential pressures (hourly average values) during Test 5 ....F-63
Figure 5.13a Melter pressure at instrument port and control air flow rate during Test 5 ....F-64
Figure 5.13b Layout of film cooler and transition line sections F-65
Figure 5.14 View of transition line section #1 inlet after Test 5 ....F-66
Figure 5.15 View of deposited solids in the transition line outlet on SBS side after Test 5 ....F-67
Figure 5.16 Another view of the deposited solids in the transition line outlet on SBS side after Test 5 ....F-68
Figure 5.17 Transition line and film
cooler differential pressures (hourly average values) during Test 6 ....F-69
Figure 5.18 Melter pressure at instrument port and control air flow rate during Test 6 ....F-70
Figure 5.19 SBS inlet and outlet gas temperatures during Tests 1 and 2 ....F-71
Figure 5.20 SBS inlet, outlet, and differential pressures (hourly average values) during Test 1 and 2 ....F-72
Figure 5.21 SBS cooling water and bed temperatures (hourly average values) during Tests 1 and 2....F-73
Figure 5.22 SBS jacket, inner coil, and heat exchanger water flow rates (hourly average values) during Tests 1 and 2 ....F-74
Figure 5.23 Calculated heat loads on the cooling jacket and plate heat exchanger (hourly average values) during Tests 1 and 2 ....F-75
Figure 5.24 SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Tests 1 and 2 ....F-76
Figure 5.25 SBS bowl before cleaning after Tests 1 and 2 ....F-77
Figure 5.26 Another view of SBS bowl before cleaning after Tests 1 and 2....F-78
Figure 5.27 Solids deposits in SBS bottom drain pipe after Tests 1 and 2....F-79
Figure 5.28 Bottom view of SBS weir tubes (with rubber plugs installed) before Test 1 ....F-80
Figure 5.29 SBS weir tubes and cooling coil (with plugs) after Tests 1 and 2....F-81
Figure 5.30 Another view of the SBS weir tubes (with plugs) after Tests 1 and 2....F-82
Figure 5.31 View of the SBS weir tubes (with plugs) after Tests 1 and 2 ....F-83
Figure 5.32 View of the SBS downcomer before cleaning after Tests 1 and 2....F-84
Figure 5.33 View of weir tubes at various locations following cleaning after Tests 1 and 2 ....F-85
Figure 5.34 Additional view of weir tubes at various locations following cleaning after Tests 1 and 2 ....F-86
Figure 5.35 View of SBS downcomer after cleaning after Tests 1 and 2....F-87
Figure 5.36 SBS inlet and outlet gas temperatures during Test 3....F-88
Figure 5.37 SBS inlet, outlet, and differential pressures (hourly average values) during Test 3 ....F-89
Figure 5.38 SBS cooling water and bed temperatures (hourly average values) during Test 3 ....F-90
Figure 5.39 SBS jacket, inner coil and heat exchanger water flow rates (hourly average values) during Test 3....F-91
Figure 5.40 Calculated heat loads on the cooling jacket and plate heat exchanger (hourly average values) during Test 3....F-92
Figure 5.41 SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Test 3....F-93
Figure 5.42 Calculated heat load difference between plate heat exchanger and SBS inner coil (hourly

average values) during Test 3 ....F-94
Figure 5.43 SBS inlet and outlet gas temperatures during Test 4 ....F-95
Figure 5.44 SBS inlet, outlet, and differential pressures (hourly average values) during Test 4 ....F-96
Figure 5.45 SBS cooling water and bed temperatures (hourly average values) during Test 4 ....F-97
Figure 5.46 SBS jacket, inner coil and heat exchanger water flow rates (hourly average values) during Test 4 ....F-98
Figure 5.47 Calculated heat loads on the cooling jacket and plate heat exchanger (hourly average values) during Test 4 ....F-99
Figure 5.48 SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Test 4 ....F-100
Figure 5.49 Calculated heat load difference between plate heat exchanger and SBS inner coil (hourly average values) during Test 4 ....F-101
Figure 5.50 SBS inlet and outlet gas temperatures during Test 5 ....F-102
Figure 5.51 SBS inlet, outlet and differential pressures (hourly average values) during Test 5 ....F-103
Figure 5.52 SBS cooling water and bed temperatures (hourly average values) during Test 5 ....F-104
Figure 5.53 SBS jacket, inner coil and heat exchanger water flow rates (hourly average values) during Test 5 ....F-105
Figure 5.54 Calculated heat loads on the cooling jacket and the plate heat exchanger (hourly average values) during Test 5 ....F-106
Figure 5.55 SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Test 5 ....F-107
Figure 5.56 Calculated heat load difference between plate heat exchanger and SBS inner coil (hourly average values) during Test 5 ....F-108
Figure 5.57 SBS bowl before cleaning after Test 5 ....F-109
Figure 5.58 Close-up view of SBS bowl before cleaning after Test 5 ....F-110
Figure 5.59 Another close-up view of SBS bowl before cleaning after Test 5 ....F-111
Figure 5.60 SBS weir tubes and downcomer before cleaning after Test 5 ....F-112
Figure 5.61 SBS downcomer end before cleaning after Test 5 ....F-113
Figure 5.62 View of SBS of downcomer from inlet viewport before cleaning after Test 5 ....F-114
Figure 5.63 Close-up view of SBS downcomer from inlet viewport before cleaning after Test 5 ....F-115
Figure 5.64 SBS bowl after cleaning after Test 5 ....F-116
Figure 5.65 SBS downcomer after first attempt to clean after Test 5 ....F-117
Figure 5.66 SBS downcomer after second cleaning after Test 5 ....F-118
Figure 5.67 SBS inlet and outlet gas temperatures during Test 6 ....F-119
Figure 5.68 SBS inlet, outlet and differential pressures (hourly average values) during Test 6 ....F-120
Figure 5.69 SBS cooling water and bed temperatures (hourly average values) during Test 6 ....F-121
Figure 5.70 SBS jacket, inner coil and heat exchanger water flow rates (hourly average values) during Test 6 ....F-122
Figure 5.71 Calculated heat loads on the cooling jacket and plate exchanger (hourly average values) during Test 6 ....F-123
Figure 5.72 SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Test 6 ....F-124
Figure 5.73 Calculated heat load difference between plate heat exchanger and SBS inner coil (hourly average values) during Test 6 ....F-125
Figure 5.74 WESP inlet and outlet temperatures during Tests 1 and 2 ....F-126
Figure 5.75 WESP differential pressure and outlet gas flow rate (hourly average values) during Tests 1 and 2 ....F-127
Figure 5.76 Accumulated WESP blow-down volume, accumulated fresh spray water and water removed from off-gas during Tests 1 and 2 ....F-128
Figure 5.77 Voltage and current across the WESP during Tests 1 and 2 ....F-129
Figure 5.78 WESP inlet and outlet temperatures during Test 3 ....F-130
Figure 5.79 WESP differential pressure and gas flow rate (hourly average values) during Test 3 ....F-131
Figure 5.80 Accumulated WESP blow-down volume, accumulated fresh spray water, and water removed from off-gas during Test 3 ....F-132
Figure 5.81 Voltage and current across the WESP during Test 3 ....F-133
Figure 5.82 WESP inlet and outlet temperatures during Test 4 ....F-134

Figure 5.83 WESP differential pressure and gas flow rate (hourly average values) during Test 4 .... F-135
Figure 5.84 Accumulated WESP blow-down volume, accumulated fresh spray water, and water removed from off-gas during Test 4 .... F-136
Figure 5.85 Voltage and current across the WESP during Test 4 .... F-137
Figure 5.86 WESP inlet and outlet temperatures during Test 5 .... F-138
Figure 5.87 WESP differential pressure and gas flow rate (hourly average values during Test 5 .... F-139
Figure 5.88 Accumulated WESP blow-down volume, accumulated fresh spray water, and water removed from off-gas during Test 5 .... F-140
Figure 5.89 Voltage and current across the WESP during Test 5 .... F-141
Figure 5.90 WESP inlet and outlet temperatures during Test 6 .... F-142
Figure 5.91 WESP differential pressure and gas flow rate (hourly average values) during Test 6 .... F-143
Figure 5.92 Accumulated WESP blow-down volume, accumulated fresh spray water, and water removed from off-gas during Test 6 .... F-144
Figure 5.93 Voltage and current across the WESP during Test 6 .... F-145
Figure 5.94 WESP overall view of grid after Test 6 .... F-146
Figure 5.95 WESP power supply wire connection after Test 6 .... F-147
Figure 5.96 WESP south grid support after Test 6 .... F-148
Figure 5.97 Outlet temperature and differential pressure for HEME #1 during Tests 1 and 2 .... F-149
Figure 5.98 Outlet temperature and differential pressure for HEME #1 during Test 3 .... F-150
Figure 5.99 Outlet temperature and differential pressure for HEME #1 during Test 4 .... F-151
Figure 5.100 Outlet temperature and differential pressure for HEME #1 during Test 5 .... F-152
Figure 5.101 Outlet temperature and differential pressure for HEME #1 during Test 6 .... F-153
Figure 5.102 Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Tests 1 and 2 .... F-154
Figure 5.103 Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 3 .... F-155
Figure 5.104 Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 4 .... F-156
Figure 5.105 Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 5 .... F-157
Figure 5.106 Outlet temperature and differential pressure for HEPA 31 (hourly average values) during Test 6 .... F-158
Figure 5.107 Paxton 1 outlet temperature (hourly average values) during Tests 1 and 2 .... F-159
Figure 5.108 View of the blower 701 head inlet port before Test 1 .... F-160
Figure 5.109 View of the blower 701 head outlet port before Test 1 .... F-161
Figure 5.110 Post failure view of the blower 701 inlet port after 121.2 hours of operation during Test 1 .... F-162
Figure 5.111 Post failure view of the bower 701 outlet port after 121.2 hours of operation during Test 1 .... F-163
Figure 5.112 Paxton 1 outlet temperature (hourly average values) during Test 3 .... F-164
Figure 5.113 View of the blower 701 intake impeller with mushroomed edges due to friction after Test 3 .... F-165
Figure 5.114 Another view of the blower 701 intake impeller with mushroomed edges due to friction after Test 3 .... F-166
Figure 5.115 Paxton 1 outlet temperature (hourly average values) during Test 4 .... F-167
Figure 5.116 Paxton 1 outlet temperature (hourly average values) during Test 5 .... F-168
Figure 5.117 Paxton 1 outlet temperature (hourly average values) during Test 6 .... F-169
Figure 5.118 TCO/SCR temperatures (hourly average values) during Tests 1 and 2 .... F-170
Figure 5.119 TCO differential pressure (hourly average values) during Test 1 and 2 .... F-171
Figure 5.120 TCO/SCR temperatures (hourly average values) during Test 3 .... F-172
Figure 5.121 TCO/SCR differential pressures (hourly average values) during Test 3 .... F-173
Figure 5.122 TCO/SCR temperatures (hourly average values) during Test 4 .... F-174
Figure 5.123 TCO/SCR differential pressures (hourly average values) during Test 4 .... F-175
Figure 5.124 TCO/SCR temperatures (hourly average values) during Test 5 .... F-176
Figure 5.125 TCO/SCR differential pressures (hourly average values) during Test 5 .... F-177
Figure 5.126 TCO/SCR temperatures (hourly average values) during Test 6 .... F-178
Figure 5.127 TCO/SCR differential pressures (hourly average values) during Test 6 .... F-179
Figure 5.128 Inlet temperature and differential pressure for PBS (hourly average values) during Tests 1 and 2 .... F-180

Figure 5.129 Sump temperature and pH for PBS during Tests 1 and 2 .... F-181
Figure 5.130 Inlet temperature and differential pressure for PBS (hourly average values) during Test 3 .... F-182
Figure 5.131 Sump temperature and pH for PBS during Test 3 .... F-183
Figure 5.132 Inlet temperature and differential pressure for PBS (hourly average values) during Test 4 .... F-184
Figure 5.133 Sump temperature and pH for PBS during Test 4 .... F-185
Figure 5.134 Inlet temperature and differential pressure for PBS (hourly average values) during Test 5 .... F-186
Figure 5.135 Sump temperature and pH for PBS during Test 5 .... F-187
Figure 5.136 Inlet temperature and differential pressure for PBS (hourly average values) during Test 6 .... F-188
Figure 5.137 Sump temperature and pH for PBS during Test 6 .... F-189
Figure 5.138 Inlet and outlet temperatures and differential pressure for HEME #2 during Tests 1 and 2 .... F-190
Figure 5.139 Inlet and outlet temperatures and differential pressure for HEME #2 during Test 3 .... F-191
Figure 5.140 Inlet and outlet temperatures and differential pressure for HEME #2 during Test 4 .... F-192
Figure 5.141 Inlet and outlet temperatures and differential pressure for HEME #2 during Test 5 .... F-193
Figure 5.142 Inlet and outlet temperature and differential pressure for HEME #2 during Test 6 .... F-194
Figure 5.143 pH of SBS blow-down solutions F-195
Figure 5.144 Total suspended and dissolved solids in SBS blow-down solutions in Tests 1 and 2 .... F-196
Figure 5.145 pH plus suspended and dissolved solids in SBS blow-down solutions in Test 3c F-197
Figure 5.146 pH plus suspended and dissolved solids in SBS blow-down solutions in Test 4c F-198
Figure 5.147 Accumulated SBS blow-down volumes and accumulated feed water during Tests 1 and 2 .... F-199
Figure 5.148 Accumulated SBS blow-down volumes and accumulated feed water during Test 3 .... F-200
Figure 5.149 Accumulated SBS blow-down volumes, accumulated feed water and added process water volume during Test 4 .... F-201
Figure 5.150 Accumulated SBS blow down volumes, accumulated feed water and added process water volume during Test 5 .... F-202
Figure 5.151 Accumulated SBS blow down volumes, accumulated feed water and added process Water volume during Test 6 .... F-203
Figure 5.152 Feed composition (excludes oxygen and carbon) F-204
Figure 5.153 Suspended solids composition from SBS sample F-205
Figure 5.154 Dissolved solids composition from SBS sample F-206
Figure 5.155 Accumulation of anions in SBS blow-down solution during Test 3c F-207
Figure 5.156 Dissolved solids composition from WESP sample F-208
Figure 6.1 XRF analysis of sodium and silicon oxides in glasses from DM1200 testing F-209
Figure 6.2 XRF analysis of selected oxides in glasses from DM1200 testing F-210
Figure 6.3 XRF analysis of oxides decreasing in concentration in glasses from DM1200 testing F-211
Figure 6.4 XRF analysis of oxides increasing in concentration in glasses from DM1200 testing F-212
Figure 7.1 Melter emission as a function of glass bubbling rate during Test 3 .... F-213
Figure 7.2 Melter emissions as a function of feed solids content at a glass pool bubbling rate of 65 lpm (Tests 3c, 4c, and 5c) F-214
Figure 7.3 Feed composition (excludes oxygen, nitrogen and carbon compounds F-215
Figure 7.4 Average melter exhaust composition (excludes oxygen, nitrogen and carbon compounds) from Test 3 .... F-216
Figure 7.5 Average SBS exhaust composition (excludes oxygen, nitrogen and carbon compounds) from Test 3 .... F-217
Figure 7.6 Average WESP exhaust composition (excludes oxygen, nitrogen, and carbon compounds) for Test 3 .... F-218
Figure 7.7.a Concentration of NO at various points in the off-gas stream during Test 3 .... F-219
Figure 7.7.b Concentration of NO at various points in the off-gas stream during Test 4 .... F-220
Figure 7.7.c Concentration of NO at various points in the off-gas stream during Test 5 .... F-221
Figure 7.7.d Concentration of NO at various points in the off-gas stream during Test 6 .... F-222
Figure 7.8.a Concentration of NO_2 at various points in the off-gas stream during Test 3 .... F-223
Figure 7.8.b Concentration of NO_2 at various points in the off-gas stream during Test 4 .... F-224
Figure 7.8.c Concentration of NO_2 at various points in the off-gas stream during Test 5 .... F-225
Figure 7.8.d Concentration of NO_2 at various points in the off-gas stream during Test 6 .... F-226
Figure 7.9.a Concentration of CO at various points in the off-gas stream during Test 3 .... F-227
Figure 7.9.b Concentration of CO at various points in the off-gas stream during Test 4 .... F-228
Figure 7.9.c Concentration of CO at various points in the off-gas stream during Test 5 .... F-229

Figure 7.10.a Concentration of CO_2 at various points in the off-gas stream during Test 3 .... F-230
Figure 7.10.b Concentration of CO_2 at various points in the off-gas stream during Test 4 .... F-231
Figure 7.10.c Concentration of CO_2 at various points in the off-gas stream during Test 5 .... F-232
Figure 7.10.d Concentration of CO_2 at various points in the off-gas stream during Test 6 .... F-233
Figure 7.11.a Concentration of water at various points in the off-gas stream during Test 3.................................. F-234
Figure 7.11.b Concentration of water at various points in the off-gas stream during Test 4.................................. F-235
Figure 7.11.c Concentration of water at various points in the off-gas stream during Test 5.................................. F-236
Figure 7.11.d Concentration of water at various points in the off-gas stream during Test..................................... F-237

List of Abbreviations

AA	Atomic Absorption Spectroscopy
ACM	Aspen Custom Modeler
ADS	Air Displacement Slurry
AOD	Air Operated Diaphragm
CFR	Code of Federal Regulation
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
QAPjP	Quality Assurance Project Plan for Testing Programs Generating Environmental Regulatory Data
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

This report documents melter and off-gas performance results obtained on the DM1200 HLW Pilot Melter during processing of simulated HLW AZ-101 feed.

The principal objectives of the DM1200 melter testing were to determine the achievable glass production rates for simulated HLW AZ-101 feed; determine the effect of bubbling rate and feed solids content on production rate; 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 to perform pre- and post test inspections of system components. The test objectives (including test success criteria), along with how they were met, are outlined in the following table. Test objectives are numbered from 1 to 16 and success criteria are listed under "a" through "p".

Test Objective & Success Criteria	Objective Met?	Discussion Section
1. Perform analyses and laboratory testing, as required, to assess and specify "working glass" compositions, glass forming chemicals, and additives utilizing the estimated AZ-101 feed composition in this specification. (a) Recommend working glass compositions for each Phase 1 HLW composition that meets WTP Contract Specification 1. "Working glass" compositions are not expected to be optimized for glass performance properties but would to the extent possible utilize previous glass testing results. For example, minor changes in waste composition may be tolerated using an existing GFC blend and waste oxide -to-GFC oxide ratio.	Yes	Feed formulations and "working glass" compositions are given in Section 2.0..
2. Utilizing the DM1200 melter and associated feed handling and off-gas treatment equipment, design and conduct testing in which representative AZ-101 simulant is processed. The duration of tests shall be sufficient to achieve at least four melter glass inventory turnovers (8 MT) for each composition. (b) Conduct testing in which representative AZ-101 simulants are processed for periods sufficient to obtain meaningful process data while achieving at least four melter glass inventory turnovers (8 to 9 MT).	Yes	Glass production rate data and summary data for melter testing are provided in Table 4.1.
3. Determine the effect of bubbling rate on melter production rate and operating stability for AZ-101 melter feed. (c) Submit data defining the effect of feed concentration on melter production rate and operating stability for AZ-101 melter feed.	Yes	Data provided in Table 4.1 and Figures 4.1 - 4.2.

Test Objective & Success Criteria	Objective Met?	Discussion Section
4. Determine the effect of feed concentration on melter production rate and operating stability for AZ-101 melter feed. (d) Submit data defining the effect of bubbler rate on melter production rate and operating stability for AZ-101 melter feed.	Yes	Data provided in Table 4.1 and Figure 4.3.
5. Fabricate, install and evaluate the performance of the HLW bubbler design and placement recommended by the Duratek design staff. (e) 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 were employed for these tests.
6. Characterize the melter emissions (particulate, aerosol, and gaseous) under nominal steady-state operating conditions for inorganic and organic compounds including the effect of air displacement slurry (ADS) pump operation on feed entrainment. Measurement of organic compounds will be satisfied through the use of Fourier Transform Infrared (FTIR) spectrometry and gas chromatography (including H_2). (f) Obtain, report, and assess melter emissions (particulate, aerosol, and gaseous) data under nominal steady state operating conditions for each test.	Yes	Data and detailed description of melter emissions are given in Section 7.0..
7. Quantify and document the occurrence and associated operating conditions of any melter off-gas volume surging events. (g) Document the occurrence and associated operating conditions of any melter off-gas volume surging events.	Yes	Melter pressure data and control air flow rates during testing are provided in Section 5.0.
8. Characterize the performance of the primary off-gas treatment equipment (submerged bed scrubber (SBS), wet electrostatic precipitator (WESP) and high-efficiency mist eliminator (HEME)) to remove particulate, aerosol and gas phase emissions under steady-state melter conditions. (h) 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	Operational details of off-gas system components are given in Section 5.0. Data and detailed description of SBS and WESP emissions as well as DF values for these components are provided in Section 7.0.

Test Objective & Success Criteria	Objective Met?	Discussion Section
9. Characterize the chemical and physical characteristics of the aqueous streams (feed, SBS, WESP, and caustic scrubber). (i) Measure and document the chemical and physical characteristics of the aqueous streams (feed, SBS, WESP, and caustic scrubber).	Yes	Detailed feed analysis results are provided in Section 2.3. detailed off-gas solution analyses are provided in Section 5.2.
10. Characterize the performance of the secondary off-gas treatment equipment (selective catalytic reduction (SCR) and thermal catalytic oxidizer (TCO) (j) Measure and document the performance of the secondary off-gas treatment equipment (SCR and TCO) to treat NOx under steady state melter conditions. Testing of a small-scale silver mordenite column to capture iodine emissions will be addressed in future test plans conducted under the Test Specification [7].	Yes	Operational details of off-gas system components are given in Section 5.0. SCR/TCO inlet (WESP outlet) and outlet emission data are given in Tables 7.16-7.19 and Figures 7.7-7.11.
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. (k) 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 4.0 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. (l) 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, 4.0, 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. (m) Document pre- and post-test inspections of key equipment and process lines to monitor for solids accumulations and corrosion/erosion of materials.	Yes	Off-gas system inspection information is provided in Section 5.0. Inspection downstream of the SCR was covered in a previous report [29].

Test Objective & Success Criteria	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. (n) 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	Melter pressure data and control air flow rates during testing are discussed in Sections 3.0, 4.0, and 5.0.
15. Operate and evaluate the performance of the air-displacement slurry (ADS) pump under operating conditions that are applicable to expected WTP plant operations. (o) Document the performance of the air-displacement slurry pump under operating conditions that are applicable to expected WTP plant operations. The ADS pump will be installed and used during these tests; however, a separate Test Plan will be issued to address the detailed pump testing outlined in Section 6.0 of the Test Specification [7].	Yes	The ADS pump was employed for these tests and performed flawlessly. (A minor malfunction of the ADS computer system resulted in use of the backup AOD system for one hour in Test 4; however the AOD simulated the ADS pump behavior.)
16. Conduct one of the melter tests with the SBS water circulation tubes (located at the bottom distribution plate) plugged to prevent their use. This test configuration has been requested by Process Engineering to assess the need for these tubes when combined with the perforations in the distribution plate. (p) Document SBS process performance, e.g. pressure drop, pressure drop stability, DF performance, etc. when the water circulation tubes are plugged.	Yes	Tests 1 and 2 of the series were conducted with plugged weir tubes. No effect on SBS process performance was observed. A short discussion is included in Section 5.1.2

B) Test Exceptions

Test Exception	Description
24590-HLW-TEF-RT-02-002	Changed requirement in the Test Plan to have one off-gas emissions sample per test segment (Tests 3, 4, and 5) to instead be three replicate samples in test segments 4C and 5C and none in the other segments in these two tests.

C) R&T Testing Conditions

Testing was performed using a flow-sheet based AZ-101 composition provided by the WTP project, from which a suitable simulant was developed for this work. Supporting glass formulation work was performed to develop a compliant glass formulation. Based on these results, melter feed simulant for these tests was prepared by a chemical vendor. The nominal solids content of the feed was fixed based on the WTP baseline value of 20 wt% undissolved solids from pretreatment, which resulted in a melter feed yielding 530 g glass per liter. Additional tests were conducted with feed diluted to 10 and 15 wt% undissolved solids from pretreatment, which resulted in a melter feeds yielding 300 and 400 g glass per liter, respectively. Screening tests were performed on the DM100-BL melter system as a prerequisite to proceeding to the larger-scale DM1200 tests. Initial large-scale tests determined the amount of bubbling required to produce glass at 400 and 800 kg/m^2/day, as well as to determine the maximum production rates for feeds solid contents of 530 and 300 g glass per liter. Subsequently, DM1200 testing was performed with all three feed solids contents in three contiguous 3-day segments, each at a progressively higher bubbling rate.

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, as compared to 0.108 m^2 for the DM100-BL, 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 were 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; the first Paxton blower; a thermal catalytic oxidation unit (TCO); a NO_X removal system (SCR); a packed-bed caustic scrubber (PBS); and a second HEME followed by the second Paxton blower. 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 [7]:

R&T Test Condition (from Test Plan [7])	**Status**
Melter	--
Bulk glass temperature target - 1150°C (typically allowed to vary ± 25°C before power input changes are initiated).	Satisfied. See Table 4.2.
Bubbling rate will be determined during testing.	Satisfied. Values reported in Table 4.1.

R&T Test Condition (from Test Plan [7])	Status
Plenum temperature - 400°C – 450°C (this is a dependent variable whose actual value is the result of cold cap coverage, air in-leakage and other conditions).	Values were generally higher than the target as reported in Table 4.2.
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 Table 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.	Maintained stable pressure control with some positive pressure spikes as discussed in Section 5.1.1.
--	--
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.	Typical flow rates for the film cooler were about 70 scfm. Air flow was maintained during idling.
SBS	--
The SBS liquid weir tubes in the diffuser plate should be plugged for the first series of tests; their use thereafter will be as directed by the Project.	The weir tubes were plugged for Tests 1 and 2, which were the first series. The remainder of the tests used unplugged conditions.
Tank temperature - 50°C unless condensation downstream requires lowering the temperature. Tank temperature will always be maintained above 40°C.	Average SBS water temperature of approximately 40°C was maintained throughout the tests as reported in Table 5.1. As described in the Test Plan [7], lower temperatures may be required based on 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 will be installed 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.	The average blowdown rate for the total test series was 243 gal per day. Makeup water was added as necessary to maintain daily blowdown rates above 100 gal per day, see Section 5.2.1.
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 blowdowns were via the pick-up wand. The SBS bowl was cleaned after Tests 1 and 2 (the plugged weir tests), and after Test 5 (end of series.)

R&T Test Condition (from Test Plan [7])	**Status**
Inspect off-gas inlet pipe for accumulated solids. Do not remove solids between tests unless accumulations are determined to be increasing from previous observation and, if allowed to continue, could lead to unacceptable SBS performance.	The SBS downcomer pipe was inspected after completion of Test 2 to assess effect of plugged weir tubes. The SBS downcomer pipe was also inspected at the end of the series, after Test 5. See discussion in Section 5.1.2.
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.	Satisfied. Data reported in Section 5.1.3.
Inlet water spray – 2 gph $\pm$ 0.2 gph.	Satisfied. Data reported in Section 5.1.3.
As a part of normal operation the WESP electrodes will be deluged with water from the internal overhead nozzle once a day at the rate of 20 gpm for 2 minutes. This will be done initially at the normal operating voltage and current. In case an internal discharge develops, the voltage across the electrodes will be adjusted to the point at which a discharge disappears. The time delay before reinstating the initial voltage and current settings will be also investigated and determined. This information will be used to determine the preferred protocol for future deluge operations.	The WESP deluge procedure used a nominal 12 gpm spray for 3.3 minutes.
At end of each melter feeding test, inspect WESP internals prior to and after typical wash-down operation.	The WESP was inspected after Tests 2, 3, 4, and 6.
--	--
HEME: Operate with ~1 gph continuous water spray.	No HEME spray used in this test series.
HEPA: 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.	Average temperature at the HEME 1 outlet was about 39°C. Average temperatures at the HEPA filter outlet were about 64-65°C.
SCR	--
Bed temperature – per the catalyst manufacturer's recommendation (350-400°C)	Values reported in Section 5.1.7. Average SCR inlet temperatures ranged from 349 to 382°C.
Ammonia slip (exit concentration) $\leq$ 25 ppm, if possible.	Ammonia was injected in Tests 4 and 5. Slippage data is reported in Section 5.1.7, and values are less than 25 ppm.
--	--
TCO: Bed temperature per the catalyst manufacturer's recommendation and previous test results (approximately 400°C)	TCO bed temperatures are reported in Section 5.1.7. Average TCO inlet temperatures (Table 5.1) ranged from 448 to 497°C.
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 4.2 and 5.1.

D) Results and Performance Against Objectives

Melter tests were conducted on the DM1200 to determine the effects of bubbling rate and feed solids content on glass production rate and off-gas system performance while processing a HLW AZ-101 feed composition. Three nine-day tests each at different feed solids content (530, 400 and 300 g glass per liter) were conducted at three bubbling rates. These tests were preceded by two tests designed to establish bubbling rates required to produce glass at 400 and 800 kg/m^2/day as well as for the maximum production rate. An additional test was added that featured no bubbling to determine the effect of bubbling on the retention of noble metals. About eighty metric tons of feed was processed to produce almost twenty five metric tons of glass. Cold-cap-limited, steady-state production rates of 400, 655 and 900 kg/m^2/day were maintained for test segments with feed having the highest solids content (20 wt% undissolved solids) and bubbling rates of 8, 40, and 65 lpm, respectively. Progressively lower rates were observed in feeds with lower solids contents (15 and 10 wt% undissolved solids), as expected. Some foaming occurred at the lowest bubbling rate and at feeding interruptions but did not prevent the attainment of steady-state conditions.

The general performance of the DM1200 melter and off-gas treatment system was good. The ADS pump itself worked well throughout testing; however, deposits ("stalactites") often formed on the end of feed tube creating feed blockages, which were periodically mechanically removed. The DM1200 test was preceded by a 100-hour DM100 test to ensure that the new glass formulation and melter feed were acceptable for processing in the HLW pilot melter. Extensive sets of process engineering data were collected during both tests. In both cases, the glass product was close to the intended composition at the end of testing.

Isokinetic particulate samples were taken at the outlets of the melter, SBS, and WESP during test segments featuring three bubbling rates (8, 40 and 65 lpm bubbling) and the high feed solids content, as well as the highest bubbling for both lower solids content feeds (10 and 15 wt% undissolved solids). The purpose of these samples was to determine the effects of bubbling and feed solids content on emissions as well as to determine the efficiency of off-gas system components. Particulate carryover from the melter increased with increasing water content and at the highest bubbling rate. Elemental DF values were determined across the melter, SBS, and WESP. Particle size distributions were determined for the melter emissions. The total solids carryover from the melter (0.55% of feed for the highest feed solids content) was lower than that observed for tests with other HLW compositions. Calculated DFs across the SBS were about 48 and were typical of tests with other HLW compositions. The WESP, which is effective in collecting finer particles, removed much of the additional particulate material exiting the SBS. As a result, the cumulative DF (Melter+SBS+WESP) was about 132,838, which is typical of other HLW tests conducted while using the deluge cleaning procedure of the WESP during emission sampling.

The volumes of processing solutions generated in the SBS, WESP, HEME, and PBS were documented during testing and representative samples were subjected to complete 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 concentration was typically about 3000 mg/l, whereas measured TDS values were about 2 times higher. The WESP sump fluid was also in the neutral pH region but had negligible suspended solids. The WESP solutions contained significant concentrations of nitrate, sulfate, and alkali halides. 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 about 80 gallons. The nearly 10,200 gallons of liquid that accumulated in the SBS during testing originated from the condensation of water from the melter feed, except for a small volume of makeup water added to the SBS during the low-bubbling tests.

A good mass balance was achieved for iodine around the melter, SBS, and WESP. Essentially all of the feed iodine was emitted from the melter and no iodine was detected in the glass product.

E) Quality Requirements

This work was conducted under an NQA-1 (1989) and NQA-2a (1990) Part 2.7 based quality assurance program that is in place at the VSL. 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 an HLW AZ-101 simulant with the composition described in Section 2.0; this composition was defined in the BNI Test Specification [6]. Rheological characterization data are presented in Section 2.0. Comparisons to actual waste data are not included in this report and will be done as part of the HLW Rheology Testing Task.

G) Issues

The presently required glass output of each of the WTP HLW melters of 3 Mt/d corresponds to a specific glass production rate of 800 kg/m^2/d. The test employing the highest bubbling rate and feed solids content on the DM1200 melter exceeded this requirement, whereas tests with lower bubbling rates or lower solids contents did not. It should be noted that the full-scale WTP melter has slightly fewer bubblers per unit melt surface area than does the DM1200 (five bubblers in 3.75 m^2 vs. two bubblers in 1.2 m^2), which may lead to lower large-scale glass production rates on a per unit melt surface area basis.

Occlusion of the SBS down-comer pipe near the diffuser plate with solid deposits was again observed in these tests. This issue needs to be understood and resolved in order to establish confidence in the long-term performance of the off-gas system design.

SECTION 1.0
INTRODUCTION

The RPP-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. That system has 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 RPP-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 RPP-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 (400 kg/m^2/d) were possible with bubbling, the baseline rate was not achieved in tests performed without bubblers. None of the variables investigated, which included feed concentration, feed acidification, frit as the glass former additive, variable additions of reductant (sugar), continuous feeding (as opposed to pulsed) and increased glass temperature resulted in production rates approaching the project baseline. 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 (800 kg/m^2/d) required under the revised WTP baseline. Based on these results and Project guidance to include bubblers in the reference design, testing was designed to determine the processing rates for each of the Phase 1 HLW feed compositions in the DM1200 melter with bubbling. The testing is detailed in a Test Specification [6] and a corresponding series of Test Plans issued to address DM1200 testing at a variety of bubbling rates and feed concentrations using AZ-101, AZ-102, C-106/AY-102, and C-104/AY-101 simulants [7-9]. The tests were conducted between 07/02 and 03/03 with summary reports for each test series submitted shortly after the completion of each test [10-13]. This final report addresses DM1200 tests performed over a range of bubbling rates and feed solids contents using the HLW AZ-101 simulant and corresponding melter feed. Separate final reports were issued to cover the other three Phase 1 HLW feed compositions described in the Test Specification [6] and Test Plans [8, 9].

1.1 Test Objectives

As listed in the Test Specification for this work [6], the principal objectives of these tests are identified below. DM1200 testing covered in this final report addresses only AZ-101. Any deviations from the Test Specification are noted below. For traceability to the Test Specification, test objectives are sequential and correspond to the objectives in the referenced Test Specification:

The objectives to be achieved under the Test Specification [6] are:

1. Perform analyses, laboratory and small-melter testing, as required, to assess and specify "working glass" compositions, glass forming chemicals, and additives utilizing the estimated AZ-101 feed composition in this specification.
2. Utilizing the DM1200 melter and associated feed handling and off-gas treatment equipment, design and conduct testing in which representative AZ-101 simulant is processed. The duration of tests shall be sufficient to achieve at least four melter glass inventory turnovers (8 MT) for each composition.
3. Determine the effect of bubbling rate on melter production rate and operating stability for AZ-101 melter feed.
4. Determine the effect of feed concentration on melter production rate and operating stability for AZ-101 melter feed.
5. Fabricate, install and evaluate the performance of the HLW bubbler design and placement recommended by the Duratek design staff.
6. Characterize the melter emissions (particulate, aerosol, and gaseous) under nominal steady-state operating conditions for inorganic and organic compounds including the effect of air displacement slurry (ADS) pump operation on feed entrainment. Measurement of organic compounds will be satisfied through the use of Fourier Transform Infrared (FTIR) spectrometry.
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 (submerged bed scrubber (SBS), wet electrostatic precipitator (WESP) and high-efficiency mist eliminator (HEME)) to remove particulate, aerosol and gas phase emissions under steady-state melter conditions.
9. Characterize the chemical and physical characteristics of the aqueous streams (feed, SBS, WESP, and caustic scrubber).
10. Characterize the performance of the secondary off-gas treatment equipment (selective catalytic reduction (SCR) and thermal catalytic oxidizer (TCO) and small-scale silver mordenite column) to treat NO_X, organics, and iodine under steady-state melter conditions. [Note: Testing of iodine removal by the silver mordenite system was completed under another Test Plan [9].]
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, especially ammonium nitrate downstream of the SCR.
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.
15. Operate and evaluate the performance of the air-displacement slurry (ADS) pump under operating conditions that are applicable to expected WTP plant operations. The ADS pump has been installed and was used during these tests; in addition, a separate Test Plan has been issued to address the detailed pump testing outlined in Section 6.0 of the Test Specification [6].
16. Conduct one of the melter tests with the SBS water circulation tubes (located at the bottom distribution plate) plugged to prevent their use. This test configuration has been requested by Process Engineering to assess the need for these tubes when combined with the perforations in the distribution plate.

1.2 Test Overview

Previous melter testing with HLW simulants was conducted with recipes based on TFCOUP Rev. 1 [14]. The current Test Specification [6] stipulates the use of TFCOUP Rev. 3A [15] and that Sr/TRU precipitation products not be included with the AZ-101 simulant. This change in simulated waste composition required a revised glass formulation and testing at both the crucible and DM100 melter scales prior to use in the DM1200. A 100-hour DM100 melter test was completed prior to the DM1200 melter tests in order to provide the required confidence in the new formulation. Testing parameters such as plenum and glass temperatures mimicked those used in the DM1200 tests.

After successful completion of the DM100 test, a series of tests were conducted on the DM1200 to determine the effect of bubbling rate and feed solids content on production rate. The first test employed progressively higher bubbling rates to determine the amount of bubbling required to produce glass at 400 and 800 $kg/m^2/day$ as well as the maximum production rate for the given bubbler configuration and feed solids content (20 weight percent undissolved solids in the waste simulant). The second test was a continuation of the first to determine the maximum production rate for feed with the lowest solids content (10 weight percent undissolved solids in the waste simulant). Bubbling rates used in the first test to achieve production rates of 400 $kg/m^2/day$, 800 $kg/m^2/day$, and the maximum were identified as "Low," "Medium," and "High" bubbling rates, respectively, for further testing; these tests were performed at variable feed solids content (AZ-101 simulant only) as well as with the other three HLW compositions in the Task Specification at high feed solids (20 weight percent undissolved solids in the waste simulant)[1]. During each test segment, the bubbling rate was fixed to rates determined from the

[1] Note that in the controlling Test Specification for this work the WTP baseline value for the solids content of the waste from pretreatment is 20 weight percent undissolved solids; present WTP expectations are that this value may be closer to 15 wt%.

first test and the feed rate adjusted to attain the desired near-complete cold cap. Each test segment had a nominal duration of three days. Variables that were held constant during each test to the extent possible included melt temperature, plenum temperature, cold cap coverage, the waste simulant composition, glass-forming additives, 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. An additional five-day test was added under a separate Test Plan [16] to evaluate the behavior of noble metals in the melter while melt pool was not bubbled. The Test Plan also added a noble metals spike to one of the bubbled test segments. A variety of processing data were taken throughout the test to document the performance of the feed, melter, and off-gas systems.

1.3 Quality Assurance

This work was conducted under an NQA-1 (1989) and NQA-2a (1990) Part 2.7 based quality assurance program that is in place at the VSL. This program is supplemented by a Quality Assurance Project Plan for RPP-WTP work [17] 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 [18].

This work did not generate data to support waste form quality 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 QAPjP [19] 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 were used to measure additions to and removal from the feed tank and were electronically monitored to determine the feed rate to the melter. The requisite amount of feed is pumped to the feed tank from the mix tank; measured amounts of water were 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 provided 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. The DM1200 is shown schematically 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 [20]. The DuraMelter™ 1200 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. Cross-sectional diagrams of the melter illustrating the discharge chamber and electrode configuration are provided in Figures 1.1 and 1.2.

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 DuraMelter™ 1200 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 were used, located in diagonally opposite corners.

1.4.3 Off-Gas System

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, shown schematically in Figure 1.3, 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; the first Paxton blower; a thermal catalytic oxidation unit (TCO); a NO_x removal system (SCR); a packed-bed caustic scrubber (PBS); and a second HEME followed by the second Paxton blower. The second HEME is used to limit entrained particle carryover into the balance of the VSL ventilation system. Note that the PBS and the second HEME are not part of the WTP off-gas train, which effectively ends at the SCR. Subsequent to the AZ-101 and AZ-102 tests, a silver mordenite column was also installed to obtain engineering data on iodine capture efficiency on a 10% slip stream of the SCR/TCO exhaust. The system can be functionally divided into four subsystems:

<u>Particulate Removal</u>: Components from the submerged bed scrubber (SBS) to the HEPA serve to remove essentially all of the particulate from the gas stream with an estimated removal efficiency of greater than 99.9999% for particles greater than 0.3 μm in size. 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 (TCO) 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 (PBS) to remove remaining acid gases.

Stack System: The emergency/bypass exhaust system, which includes a second HEPA, and the primary off-gas system both feed into the building stack system for exhausting to the atmosphere.

Liquid Processing: Components including the 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.

With minor exceptions noted above, the DM1200 off-gas system processing sequence follows the proposed design for the full-scale WTP HLW melter system.

Initial quenching of the melter exhaust gas stream is effected by the film cooler. Immediately downstream of the film cooler is the injection point for control air, which is used to regulate melter pressure. The gas entering the balance of the off-gas system is at a temperature of about 250 to 350°C and a flow rate of about 100-250 scfm, of which about 10-80 scfm is water vapor. The off-gas is then rapidly quenched by direct liquid water contact in the Submerged Bed Scrubber (SBS), which also effects removal of most of the larger particulates. The piping between the film cooler and SBS has a high superficial gas velocity to minimize particulate deposition. The gas stream leaving the SBS is at a low temperature (typically between 40-50°C). Further mist and particulate removal is effected in the WESP, HEME, and 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 are located in the WESP, flow sheet HEME, PBS, and facility HEME to wash down deposits and dissolved species into their respective collection sumps from which they can be sampled. The system components are fabricated from corrosion resistant materials including AL6XN in the SBS and 316L stainless steel and various plastics in less demanding locations. There are extensive provisions for sampling both the gas and liquid streams throughout the system in order to collect mass balance information and removal efficiency data for each treatment stage.

The off-gas system maintains the melter plenum under slight negative pressure, typically about -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 after the film cooler. The air is supplied by a blower through a diverter valve. The setting of the diverter valve, and therefore the air flow rate, is controlled by a process controller that responds to the signal from a melter pressure transducer. When the plenum pressure becomes more positive, the air injection flow rate is decreased, which tends to restore the pressure to the set-point. Conversely, the flow rate is increased when the plenum pressure becomes more negative.

SECTION 2.0
WASTE SIMULANT AND GLASS FORMULATIONS

The composition of the AZ-101 HLW simulant used for these tests was derived and specified in the BNI Test Specification [6]. The AZ-101 waste data and blending assumptions stipulated in the Test Specification are different than those used previously and therefore new glass formulations were developed and tested to support this work. This Section summarizes the composition of the simulant provided in the Test Specification and describes the corresponding glass formulations selected for melter testing.

2.1 AZ-101 Waste Simulant

Formulation of the AZ-101 waste simulant makes use of inventory data from the TFCOUP Rev. 3A [15], calculated data from ACM modeling, and analytical data on Cs- and Tc-removal eluates from LAW pretreatment [21]. The composition of the AZ-101 Envelope D solids (Stream FRP02) is based on the inventory data found in Revision 3A of the TFCOUP [15]. As seen in Table 3.1, in addition to updated information, Revision 3A of the TFCOUP also provides information on minor components that were not included in earlier revisions [14] and the Best Basis Inventory (BBI) database (e.g., cadmium). The use of other data sources (e.g., HLW Feed Staging Plan [22]) 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., 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 before ultra-filtration to produce the pretreated HLW solids (UFP07). The separation factors due to HLW pretreatment and ultra-filtration are given in Table 2.1.

To complete the simulant formulation, the pretreated HLW solids are 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 was omitted since the current processing schedule indicates that AN-102 (first Envelope C tank) waste will be processed after AZ-101. Analytical data on eluates from Cs- and Tc-removal on an Envelope B sample (AZ-102) [21] 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 incorporation of these streams primarily leads to increase of sodium and nitrate in the HLW simulant.

The calculated composition of the blended HLW solids (HLP09b) is shown in Table 2.1, which lists a total of 53 components. Similar to the approach taken during previous testing, radionuclides, noble metals (including silver), and minor components (< 0.05 wt% oxide basis) are omitted from the simulant formulations. Exceptions include cesium, which is included for analytical purpose, and praseodymium, which is replaced with another rare earth element, neodymium. Iodine is also added for analytical purposes, at an amount equivalent to 0.1 wt% in glass. The resulting HLW simulant formulation, which is given in Table 2.2, consists of 28 components, 24 of which are non-volatile (compared with 32 and 28, respectively, for the previous AZ-101 simulant).

2.2 AZ-101 Glass and Melter Feed Formulations

With the elimination of Sr/TRU pretreatment products from the HLW AZ-101 simulant, new glass formulations were developed and tested at VSL to support these tests. The glass composition selected as the basis for these tests, HLW98-77, is presented in Table 2.2. On an oxide basis, this glass incorporates 24.65 wt% of Envelope D waste and 25.25 wt% of all wastes. These can be compared with the respective values of 27.00 wt% and 30.49 wt% for HLW98-31, the AZ-101 reference glass used in Part B1. The difference is due to the increased limiting component (Al_2O_3+Fe_2O_3+ZrO_2) in the new HLW simulant (84 wt% vs. 79 wt%). The glass HLW98-77 meets the contract specification by incorporating 21.20 wt% of (Al_2O_3+Fe_2O_3+ZrO_2) from Envelope D waste.

Crucible melts of HLW98-77 were prepared and tested to determine that it meets the necessary processing requirements. The measured viscosity and conductivity at 1150°C are 50 P and 0.36 S/cm, respectively. Heat treatment of HLW98-77 at 950°C results in <0.5 vol% of spinel crystals. The target glass formulation for these tests, which is also given in Table 2.2, differs slightly from HLW98-77 by the removal of silver and the addition of small amounts of barium from the projected waste composition.

The additional constituents required to form the target test glass from the AZ-101 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 with direction of the WTP Project. Table 2.3 lists the starting materials and amounts required to produce the target AZ-101 simulant and melter feed. Note that all of the TOC is assumed to be oxalate and that more carbonate (0.429 g/100 g oxide) is present in the simulant than that required per the basis documents (0.106 g/100 g oxide). The small excess in carbonate is not expected to impact the tests since much greater amounts are present in the glass forming additives. The suspended 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 [23]. The theoretical glass yield of the resulting feed is 375 g of glass/kg of feed (about (485-550) g/l of feed, dependent on feed density).

Melter feeds were produced by NOAH Technologies Corporation, the supplier of simulant and feed used in previous tests on the DM-100 and DM-1200 melter systems. Tests that involve feeds of lower solids contents (e.g., 10 wt% and 15 wt%) were prepared at VSL by diluting the feed supplied by NOAH.

2.3 Analysis of Feed Samples

2.3.1 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 2.4. All samples were taken from the feed line immediately upstream of the entrance point to the melter. The exact density of the target feed was not known and therefore the amount of water added to the feed to achieve the target glass yields for the DM100 and Tests 1 and 2 on the DM1200 were estimated. Results from the analysis of these samples indicated the solids contents to be on average up to 6.3 % lower than target and therefore the water additions to feed were refined for subsequent tests. The average measured glass yield for Test 3 was within three percent of the target glass yield of 375 g of glass per kg of feed. Average glass yields for tests targeting lower water contents were all within 4% of the 400 and 300 g glass per liter feed targets; consequently, the target values were used for calculating glass production rates. For each test, all measured parameters, including glass conversion ratio, water content, density, and pH, fall within narrow ranges, confirming the relative consistency of the melter feed within each test. One feed sample, 12Y-F-145A, had a lower measured water content and higher solids content than all the other samples from Test 3. This difference was attributed to sampling bias and therefore the results for this sample were not included in the feed averages. Comparisons of sample analyses from tests with different glass yields followed expected trends; increasing water content with decreasing glass yield as well as decreasing density and pH with decreasing glass yield. Measured pH values were about a tenth of a unit lower for feed samples with the noble metals spike (Test 6 and part of Test 4b) than comparable samples without the spike (Tests 4a and 4c). The measured values for the DM1200 Test 3 and DM100 feed samples were very similar, as expected in light of the shared source and recipe.

2.3.2 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 [24]. 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 [24], which examined a range of temperatures, showed a relatively weak effect of temperature.

Rheograms which show the feed viscosity versus shear rate for the DM1200 and DM100 feeds are presented in Figure 2.1; measured values for viscosity at selected shear rates and the yield stress values are shown in Table 2.4. Comparisons of sample rheology from tests with different glass yields followed expected trends of decreasing yield stress and viscosity with decreasing glass yield. The measured viscosities were comparable to those measured on other HLW feed samples (AZ-102 [25] and C-104/AY-101 [27]) with similar solids contents and slightly higher than those measured on C-106/AY-101 samples [26]. The measured yield stress followed a different trend with the value measured for the AZ-101 samples being comparable to C-106/AY-102 and C-104/AY-101 but being slightly less than that for the AZ-102 samples.

2.3.3 Chemical Composition

Feed samples collected during this test were subjected to chemical analysis using x-ray fluorescence (XRF). The chemical compositions of the feed samples from the test 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 presented in Tables 2.5 - 2.6 and are compared to the target composition.

The compositional analysis results can be discussed by dividing the 23 elements into three categories: major elements with measured oxide concentrations greater than 3%, intermediate elements with measured oxide concentrations between 0.5 and 3%, the remainder being minor elements. The major elements constitute the bulk of the glass and, therefore, largely determine its properties. XRF results for the major elements (Al, Fe, Na, Si, and Zr), except for zirconium, are typically within 10 percent of the target composition for most of the feed samples. The aluminum excess observed in the average of all DM1200 samples was biased high by samples taken during Test 5 which had aluminum concentrations considerably higher than target. This trend was also observed in an increase in aluminum concentration in the product from the latter portion of Test 5 (see Section 6.1) indicating that the last batch of feed received contained excess aluminum. Feed samples from the DM100 tests were derived from the first batch received and therefore are not prone to this bias. A zirconium surplus of about twenty five percent was measured in both the DM1200 and DM100 feed samples as well product glasses (see Sections 3.3 and 6.1) indicating a true surplus in the feed. Both elements in the intermediate concentration range (Ni and Zn) were 5 to 15 % below their target values; however, the absolute deviations were no more than 0.11 wt% and 0.4 wt% for nickel and zinc oxides, respectively. The large number of minor elements (Ba, Ca, Cd, Cu, F, I, K, La, Mg, Mn, Nd, Pb, S, and Sr) 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. As expected, highly volatile elements such as halogens are under-represented in the glasses. Conversely, common elements such as calcium and potassium, which are typical impurities in bulk chemicals, are over-represented when the constituent is a minor component. Titanium and phosphorus, which are not included in glass formulation, were detected at low levels in the feed as impurities. Excess in titanium oxide has been observed in previous studies [20, 25-29], 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 [26, 27, 30]. 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. A similar tiered approach has also been employed with the combination of the DM100-WV and the LAW Pilot Melter for LAW testing. The revised AZ-101 simulant and glass composition had not been tested previously in a melter and, therefore, a DM100 test was conducted to identify any issues with the feed or glass prior to the DM1200 tests. This section presents a description of the DM100-BL system, glass product analysis, and screening level process data from the DM100 test.

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 constantly recirculated except for periodic, momentary interruptions during which the weight is recorded. The way in which the feed is introduced into the melter is designed to mimic the operation 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 mechanical timer-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. The mixed feed enters the melter through a 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. 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 temperatures 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 test was conducted between 7/8/03 and 7/13/03, producing 583 kg 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 100.6 hours. The measured glass production rate is depicted in Figure 3.1 as cumulative and one-hour moving averages. The glass production rate varied about 20% from the steady-state rate of about 1300 kg/m^2/day over the course of the test. 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.

A variety of operational measurements were recorded during these tests, the most important of which are glass temperature (Figure 3.2), electrode power (Figure 3.2), plenum temperature (Figure 3.3), and glass bubbling rate (Figure 3.4). The target glass temperature of 1150°C was successfully maintained for most of the glass pool during the test. Plenum temperatures were higher than the 400 - 500°C target range for the DM1200 as a result of intentional openings in the cold-cap required for prevention of excessive bridging across the melt pool. Electrode power varied by only about 3 kW from an average of about 25 kW. Glass pool bubbling averaged only 8.9 lpm which is about half that required in the C-106/AY-102 and C-104/AY-101 tests [27, 28]. This result is even more surprising considering that the production rates were 15 to 30 percent higher in the AZ-101 tests.

3.3 Glass Product Analysis

Almost 600 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 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 3.3. There was reasonable agreement with the target composition for the majority of oxides and, in particular, for the major oxides, as described for feed samples in Section 2.3.3. Trace amounts of arsenic, antimony, cerium, cesium, phosphorus, tellurium, and titanium remained in the glass product from the previous tests [29]. No iodine was retained in the glass product, consistent with its known volatility.

Compositional trends from the XRF data are plotted for selected elements in Figures 3.5-3.8. The graphs illustrate three trends: elements with oxide concentrations that either did not change as a result of the similarity to the previous AZ-101 composition [4] (silicon in Figure 3.5 and zinc in Figure 3.6), systematically decreased in concentration towards target (Figure 3.7 and aluminum in Figure 3.6), or systematically increased towards target (Figure 3.8, sodium shown in Figure 3.5, and iron in Figure 3.6). The principal compositional changes were the increase in lanthanides and iron at the expense of Sr/TRU removal products (Mn and Sr) and aluminum present in the previous AZ-101 simulant composition (Figure 3.5 and 3.7).

SECTION 4.0
DM1200 OPERATIONS

Six melter tests were conducted on the DM1200 with the HLW AZ-101 simulant between 7/23/02 and 10/24/02, producing about 25 metric tons of glass. The total testing duration, including the time for water feeding and cold-cap burn-off, was 1000 hours during which over 77 metric tons of feed was processed. A summary of the test conditions and results is provided in Table 4.1. Five tests were designed to determine the effects of bubbling rate and feed solids content on glass production rate and off-gas system performance. An additional test was added under a separate Test Plan [16] to determine the effect of noble metals behavior in bubbled and un-bubbled melters. The six tests are summarized as follows:

- Test 1: One- to two-day run segments to determine bubbling rates required for cold-cap-limited glass production rates of 400, 800, and 1000 kg/m^2/day for 530 g glass per liter feed (measured value used for rate calculations was 504 g glass per liter feed). Determine maximum production rate for that feed.
- Test 2: Determine maximum production rates for 300 g glass per liter feed (measured value used for rate calculations was 281 g glass per liter feed).
- Test 3: Determine production rates for 530 g glass per liter feed at 3 bubbling rates (8, 40, 65 lpm) over nine days.
- Test 4: Determine production rates for 400 g glass per liter feed at 3 bubbling rates (8, 40, 65 lpm) over nine days. Noble metals were spiked into the feed during the majority of the middle test segment.
- Test 5: Determine production rates for 300 g glass per liter feed at 3 bubbling rates (8, 40, 65 lpm) over nine days.
- Test 6: Determine production rates for 400 g glass per liter feed with 1 lpm bubbling over five days. Noble metals were spiked into the feed throughout the test.

Tests 1 and 2 were conducted with rubber plugs inserted into the SBS weir tubes; the remainder of the tests did not have the plugs installed. The two configurations were tested in order to assess the need for the SBS water circulation tubes along with the perforation plate holes in the SBS.

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, and a side-to-side electrode firing pattern. Bubbling was provided by two top-entering, "J" bubbling lances located six inches from the melter bottom in corners diagonally across the melt pool. In each test, the cold-cap-limited production rate was determined by visual observations of the cold cap and confirmed by the plenum temperature. Analysis of feed samples from Tests 1 and 2 indicated feed solids contents were 2% bw and therefore minor dilution adjustments were made in subsequent tests to more closely achieve the target solids content. The prototypical feed tube used with the ADS pump is not cooled and has a much greater tendency for stalactite formation on the feed tube tip, which in turn results in feed being directed into the melter in unpredictable and often undesirable directions. As necessary in the case of extreme build ups, stalactites had to be mechanically removed, which was generally accomplished by tapping the external portion of the feed tube with a rubber mallet. This problem was alleviated with a new feed tube design that was put into service during the later C-104/AY-101 tests [27]. Aside from the feed tube issues, the ADS feed system performed well throughout testing. A computer failure in Test 4 at about 140 hours run time resulted in switching to the backup AOD system for the remainder of the test.

The measured glass production rates for the six tests are depicted in Figures 4.1.a – 4.1.e as cumulative and one-hour moving averages for each of the test segments. Steady-state production rates were obtained in Test 1 for production rates of 400, 600, 800, and 1000 kg/m^2/day but not for higher production rates, as shown in Figure 4.1.a. Higher production rates at about 140 and 160 hours run time were not sustainable due to accumulating and poorly distributed amounts of feed on the melt surface. The run time portion after 180 hours in Figure 4.1.a illustrate the maximum sustainable production rate for 300 g glass per liter feed as 500 kg/m^2/day. Bubbling rates used during Test 1 were compared to instantaneous production rates in Figure 4.2 for the purposes of selecting bubbling rates for subsequent tests; based on these results, values of 8, 40, and 65 lpm were selected. Steady-state production rates were achieved for each of the subsequent three-day run segments in Tests 3-5 as well as Test 6, as shown in Figures 4.1.b – 4.1.e. Some foaming occurred on the glass surface at the lower bubbling rates when cold cap coverage became too extensive and gases could not escape (e.g. 61 hours into Test 6, Figure 4.1.e). Once foaming subsided, processing gradually returned to the previous rate. The only significant foaming event that occurred outside of test segments targeting bubbling rates greater than 8 lpm was during a feed interruption in Test 4 to switch to the backup feed system.

A summary of the steady-state production rates given in Figure 4.3 illustrates the expected production rate increases with bubbling and feed solids content. Figure 4.4 illustrates the decrease in production rates from Tests 1 to 3, which is interesting given that the same average bubbling rate and comparable feed solids contents were used. Restricting bubbling to a given rate (Test 3) as opposed to adjusting bubbling to control the changes in the cold cap (Test 1) resulted in a lower production rate even though the average bubbling rates for comparable test segments were the same. Based on the results of these tests, it was recognized that adjusting bubbling between the two lances in response to changing cold cap thickness (skewing) has the potential to increase production rates and therefore was evaluated as a test variable in a subsequent melter Test Plan [31].

The steady-state production rates for all four HLW compositions (20% undissolved solids in the waste simulant) given in the Test Specification [6] are illustrated in Figure 4.5. Notice that production rates for three of the four compositions (AZ-101, AZ-102, and C104/AY101) are virtually identical. The C106/AY102 production rate is lower than the others at the lower bubbling rates (8 and 40 lpm) and higher than the others at the highest bubbling rate (65 lpm). Also of note is that, at the 65 lpm bubbling rate, production rates for all four compositions exceed the present WTP requirement of 800 kg/m^2/day with feed containing 20% undissolved solids in the simulant. Tests with more dilute simulants did not reach this threshold at any tested bubbling rate, as shown Figures 4.1.a, 4.1.c and 4.1.d.

A variety of operational measurements recorded during these tests, including temperatures throughout the melter system, are given in Tables 4.2.a – 4.2.e. The glass temperatures for most of the glass pool were largely between 1140 and 1150°C, slightly below the target of 1150°C, as illustrated in Figures 4.6.a -4.6.e. Glass temperatures on the West side of the melter were typically higher than those on the East side of the melter in the bulk of the glass pool (13" and 15.5" from the floor) but lower than the East side near the melt pool surface (27" from the floor). Bulk glass temperatures were relatively constant throughout the glass pool except near the surface (27" from the floor), where temperatures were lower due to the thermocouples being in or near the cold cap. Other exceptions were temperature spikes caused by foaming events observed in Test 4 at 20 and 140 hours runtime (Figure 4.6.c), as well as in Test 6 at about 10 and 61 hours run time (Figure 4.6.e). Plenum temperatures (Figure 4.7.a – 4.7.e) were typically between 450 - 600°C, with higher temperatures at the beginning of the test during cold cap formation, and downward spikes approaching 400°C during foaming events (e.g. 10 and 50 hours into Test 5, Figure 4.1.d). Plenum temperatures were lowest in Test 6 (Figure 4.7.e) as a result of the lack of bubbling, which constantly breaks and changes the cold cap. Visual observations of the cold cap corroborated the plenum temperature indications that melt pool coverage was nearly complete for the vast majority of the test.

Electrode temperatures averaged below 1150°C throughout testing. The East electrode was about 70°C hotter than the bottom electrode throughout most of testing, as shown in Figures 4.8.a – 4.8.e (note that the bottom electrode was not powered in these tests). The East electrode was about 15 to 35°C hotter than the West electrode during the tests. This small temperature difference between the two sides of the melter has been observed over the lifetime of the DM1200 [3, 4, 20, 25-29]. Curiously, the opposite trend is observed in the majority of the glass pool with the West side being hotter than the East side. Differences between side and bottom electrode temperatures are greater in HLW tests, which do not use the bottom bubbler [4, 25-27], than in the LAW tests, which employ them [20, 28, 29]. The discharge chamber and riser temperatures were largely maintained above 950°C throughout the tests. Gas temperatures after film-cooler dilution typically ranged between 320°C and 380°C but were higher during periods of higher plenum temperatures, such as the beginning of the test as the cold cap was forming, and lower during the periods of water-cleaning of the film cooler (once every 12 hours).

Conditions in the glass pool are illustrated for electrical properties in Figures 4.9.a - 4.9.e, level and density in Figures 4.10.a – 4.10.e, and bubbling in Figures 4.11.a – 4.11.d. Electrode power increased 50 to 60 kW over the course of each test as bubbling and production rates increased, as expected. Decreases in power of about 40 kW were responses to foaming on the glass surface (e.g., at 10 and 50 hours into Test 5, Figure 4.9.d). Glass resistance was relatively constant during testing despite changes in production rates, feed water contents, and glass bubbling rates, as illustrated by the narrow range for test segment averages (0.103 – 0.110 ohms). As with the power changes in response to foaming, foaming also resulted in the expected changes in glass resistance (e.g., 61 hours into Test 6, Figure 4.9.e). The glass level fluctuated over the course of testing from 26.5 to 28.5 inches from the floor. The glass density largely remained between 2.30 and 2.45 g/cc. Density decreases with increasing bubbling were observed, particularly in tests using feeds with higher solids content (e.g., Figures 4.10.a and 4.10.b). The target total bubbling rates of 8, 40 and 65 lpm were held for each three-day segment, as shown in Figure 4.11.b – 4.11.d. The average values for total bubbling for the last two segments given in Table 4.2 are slightly below the target because the time for transitioning up in bubbling rate is included. Lance bubbler flow rates were skewed slightly to prevent buildup of feed on the West side of the melter, particularly for portions of test segments featuring higher bubbling rates and higher water contents. As usual, power per unit glass production decreased with increasing production rate and was similar to previous tests with HLW feeds that had comparable water contents [25-27]; it was, however, much higher than for the previous LAW tests (3.6-5.0 vs. 1.6-2.0 kW/kg glass) [20, 28, 29] due to the higher feed water content and much lower glass production rates. This relationship between bubbling (or production rate), feed solids content, and power usage is apparent from the data collected during these tests, as shown in Figure 4.12. Of particular note is the dramatic increase in power usage when the lance bubblers are removed from the melter and the decrease in the effect of feed solids content at the higher bubbling rates.

SECTION 5.0
OFF-GAS SYSTEM PERFORMANCE

The off-gas treatment system, shown schematically in Figure 1.3 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 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. A silver mordenite column and a sulfur-impregnated activated carbon bed to test a slip stream from the off-gas stream were added after these tests were completed. Data on the off-gas system performance collected during the test with HLW AZ-101 feed are presented and discussed in this section.

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 5.1. The plots of the typical sequence of gas temperatures through the DM 1200 off-gas system at various locations are given in Figures 5.1 through 5.5.

During the course of the above tests, equipment malfunctions resulted in test interruptions or modifications of normal equipment operating parameters several times, as described below. The first interruption occurred during Tests 1 and 2 between 121.2 and 122.9 hours of operation due to failure of Paxton Blower (B-701) bearings whereupon the system was switched to the back-up off-gas system. During Test 3 between 36.3 and 39.0 hours, control air was secured in order to make repairs to its power controller. At about 204 hours into the test, feed was secured and off-gas was diverted to the back-up system to clean the SBS differential pressure sensor port and to clean the SBS down-comer. During Test 3, between 204.9 and 205.8 hours of operation the same Paxton blower (B-701) malfunctioned. This time the head was replaced and the blower was restored to operation. During Test 3, between 136.4 and 136.8 hours of operations, the feed was stopped briefly for cold cap sampling. During Test 4, between 140.7 and 141.7 hours, feeding was switched from the ADS to the AOD system due to malfunctioning of the ADS computer system. During Test 5, after 192.9 hours of operation, the TCO/SCR heater was unable to maintain the set point temperature of 470°C and, therefore, the set point was lowered to 300°C. This was due to failure of a control card in the heater power supply. The system returned to normal operation after the control card was replaced. In order to prevent overheating of the control card in future, a cooling fan was installed. During Test 6, after 48.9

hours of operation the ammonia system was secured because the FTIR gas analyzer was not operational and the TCO/SCR heater set point was lowered to 350°C.

5.1.1 Melter Pressure

Tests 1 and 2

The differential pressures across the transition line and film cooler are given in Figure 5.6. During the early part of the test the film cooler differential pressure was high, probably as a result of solids build-up. At about 24 hours, the film cooler was tapped once with a rubber mallet and its differential pressure decreased sharply. Between 121.2 and 122.9 hours of operations, since the system was switched to the emergency off-gas system during repair of the Paxton blower, the transition line and film cooler differential pressures decreased sharply. An increase in transition line differential pressure was noted in the operational logbook at 8/12/02 10:35, which is 213 hours runtime; however no reason for this increase was noted. The data may indicate a possible partial clogging of the line. Feeding was stopped about 1 hour later without further operational comment on the transition line differential pressure. The transition line was not inspected after this test, but, only after completion of the test series. The next test in this series was started over a month later.

The computer logged melter pressures measured at the instrument port and the calculated control air flow rates are plotted in Figure 5.7. A review of the data files showed that only three positive pressure values were recorded. In the first case, at about 5.3 hours of operation, water was purged through the annulus of feed tube at 500 ml/min for about 3-4 minutes to eliminate a stalactite that had formed on the feed tube. This resulted in a positive pressure spike measured at 0.96 in. W.C. The second positive pressure occurred at 121.3 hours when the Paxton blower was secured to replace its head, which resulted in a positive pressure value measured at 0.8 in. W.C. Finally at 214.8 hours, a short positive pressure spike of 0.35 in W.C. was measured while the control air setting was being adjusted. The average melter pressures were -5.1 in. W.C for Test 1 and for Test 2; melter pressures ranged from -6.8 in. W.C. to 1.0 in. W.C. for Test 1, and -6.6 in. W.C. to -0.6 in. W.C. for Test 2.

The control air system was operational and generally effective during these tests. The control air flow rate averaged 32.2 scfm and 28.7 scfm during Test 1 and Test 2, respectively.

Test 3

The differential pressures across the transition line and film cooler are given in Figure 5.8. The effects of securing the control air between 36.3 and 39.0 hours and securing feed because of the Paxton blower maintenance between 204.9 and 205.8 hours of operation resulted in sharply reduced transition line and film cooler differential pressures. Film cooler and transition line sections were not inspected during or after this test.

The computer logged melter pressures measured at the instrument port and calculated control air flow rates are plotted in Figure 5.9. The average melter pressure was -4.4 in. W.C. and melter pressure ranged from -6.6 in. W.C. to 5.8 in. W.C. The control air system was operational and effective during this test and its flow rate averaged 40.5 scfm. Between 36.3 and 39.0 hours, control air was secured for a controller power supply repair. A review of the data files showed that three positive pressure values were recorded. The first of these was measured at 0.2 in. W.C. and occurred when feed mounded under the feed tube, which likely resulted in sudden steam release during incorporation into the melt. The second occurred when the control air was secured and the system was being switched to the emergency off-gas line. The third, measured at 5.8 in. W.C., occurred at about 205 hours as a result of the failure of the Paxton blower. The blower head was replaced and it was restored to operation, as mentioned above in Section 5.1.

Test 4

The differential pressures across the transition line and film cooler are given in Figure 5.10. Film cooler and transition line sections were not inspected during or after this test.

The computer logged melter pressures measured at the instrument port and calculated control air flow rates are plotted in Figure 5.11. The average melter pressure was -4.2 in. W.C and ranged from -7.7 in. W.C. to 1.4 in. W.C. The control air system was operational during this test and its flow rate averaged 39.5 scfm. A review of the data files showed that three positive pressure values were recorded, as shown on Figure 5.11. The first of these, measured at 0.1 in. W.C. occurred during cold cap sampling. The second positive pressure reading, measured at 0.3 in. W.C., occurred when melter feeding was switched from the ADS to the AOD system, as described in Section 5.1. The third spike, at 1.4 in W.C. occurred at about 167 hours of run time, shortly after switching to the alternate feed tube due to clogging of a pinch valve in the primary line. However the cause of this spike was not identified.

Test 5

The differential pressures across the transition line and film cooler are given in Figure 5.12.

The computer logged melter pressures measured at the instrument port and calculated control air flow rates are plotted in Figure 5.13a. The average melter pressure was -4.2 in. W.C and melter pressure ranged from -7.8 in. W.C. to 0.4 in. W.C. The control air system was operational and effective during this test. The control air flow rate averaged 31.1.scfm. A review of the data files showed that two positive pressure values of 0.4 and 0.06 in. W.C. were recorded. The first spike, of unknown cause, was at 16.8 hours. The second positive pressure spike occurred at 207.5 hours when a large piece of cold-cap dislodged and came suddenly in contact with the hot glass-melt.

At the end of test 5 the transition line was inspected and cleaned. The general layout of the film cooler and transition line sections is shown in Figure 5.13b. The film cooler is shown on the right hand side of the photograph. Transition line section #1 is located on the right, above the film cooler, and has a Y shape. Transition line section #2 is a long and slightly curved portion following transition line section #1. Transition line section #3 is a shorter straight part following section #2. The transition line bellows is a short section located as the last section in Figure 5.4. The transition line SBS inlet, which is not shown in Figure 5.13.a, has a similar shape to transition line section #1 and connects the transition line bellows to the SBS. A photograph of the solids deposits at the inlet of transition line #1 is provided in Figure 5.14. Photographs of solids deposits at the transition line outlet on SBS side are given in Figures 5.15 and 5.16. The solids deposits in the transition line, as well as in the transition line bellows, were cleaned at the end of Test 5.

Test 6

The differential pressures across the transition line and film cooler are given in Figure 5.17. Film cooler and transition line sections were not inspected during or after this test.

The computer logged melter pressures measured at the instrument port and calculated control air flow rates are plotted in Figure 5.18. The average melter pressure was -4.8 in. W.C and melter pressure ranged from -8.9 in. W.C. to 0.01 in. W.C. The control air system was operational and effective during this test with the control air flow rate averaging 42.2 scfm. A review of the data files showed that one positive pressure value of 0.01in. W.C. was recorded at 37.0 hours, which probably resulted from a large piece of cold-cap dislodging and suddenly coming in contact with the hot glass-melt. After the feed was stopped at the end of the test, a melter pressure reading of 0.1 in. W.C. was recorded during cold cap sampling.

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 test. The amounts of heat removed by the SBS jacket cooling water and the plate heat exchanger/SBS inner cooling coil were calculated from the measured data.

Data on the performance of the SBS regarding solids removal from the off-gas stream are presented and discussed in Section 7.0. Results from the analysis of fluids accumulated in the SBS are presented and discussed in Section 5.2

Test 1

SBS operations data for Tests 1 and 2 are presented in the same figures. Test 1 run time was from zero to 179.8 hours, and Test 2 run time was from 180.3 to 218.2 hours. The SBS inlet and outlet gas temperatures are plotted in Figure 5.19. The inlet gas temperature peaked at 465°C and averaged 265°C; the outlet gas temperature peaked at 51.8°C and averaged 39.5°C. The downward spikes in SBS inlet gas temperatures are due to periodic cleaning of the film cooler with water. The inlet, outlet, and differential pressures are shown in Figure 5.20. The inlet gas pressure averaged -8.2 in. W.C., the outlet pressure averaged -51.3 in. W.C., and the pressure drop across the SBS averaged about 43.5 in. W.C. The discontinuities in the plots between 121.2 and 122.9 hours of operations are due to the Paxton blower (701) failure and resultant feed stoppage. The pressure drop across the SBS increased by about 4.9 in. W.C. over 179.8 hours of testing with HLW AZ 101 feed.

Water temperatures in the SBS, SBS chilled cooling water supply temperature, water cooling jacket outlet temperature, and water outlet temperature from the plate heat exchanger, are shown in Figure 5.21. There was an average of about 0.7°C difference in water temperatures measured at four depths (48, 60, 72 and 78 inches) within the SBS. The liquid in the SBS was heated to a maximum temperature of 52.9°C during the initial period of water feeding, while the average SBS sump temperature was 39.9°C.

The SBS jacket, inner coil, and heat exchanger water flow rates are plotted in Figure 5.22. Average SBS jacket, inner coil and heat exchanger water flow rates were 29.2, 25.0 and 23.3 gpm respectively. The amounts of heat removed by the SBS cooling jacket and the plate heat exchanger are shown in Figure 5.23. The heat load data for SBS cooling jacket and plate heat exchanger are calculated based on hourly averaged cooling water temperature increases (outlet temperature minus supply temperature) across the cooling jacket and plate heat exchanger multiplied by the time-averaged flow rate through each. For this test, heat removal averaged 86.8 kW by the plate heat exchanger and 46.4 kW by the cooling jacket. About 65% of the heat load to the SBS was removed by the plate heat exchanger and about 35% by the cooling jacket. The SBS inner coil and plate exchanger water temperatures are plotted in Figure 5.24. The heat load difference between plate heat exchanger and SBS inner cooling coil was not calculated because of the large fluctuations in cooling water flow rates.

At the end of Test 1, the SBS was not blown down. Test 2 began at 180.3 hours, approximately 30 minutes after Test 1 was finished.

Test 2

The SBS inlet and outlet gas temperatures are plotted in Figure 5.19. The inlet gas temperature peaked at 325°C and averaged 273°C; the outlet gas temperature peaked at 47.0°C and averaged 39.9°C. The downward spikes in SBS inlet gas temperatures are due to periodic cleaning of the film cooler with water. The inlet, outlet, and differential pressures are shown in Figure 5.20. The inlet gas pressure averaged -8.6 in. W.C., the outlet pressure averaged –53.2 in. W.C., and the pressure drop across the SBS averaged about 46.8 in. W.C. At 212.2 hours, SBS inlet and outlet pressures dropped while the control air flow rate was adjusted. The pressure drop across the SBS increased by about 2.2 in. W.C. over 38 hours of testing with HLW AZ 101 feed during Test 2.

Water temperatures in the SBS, SBS chilled cooling water supply temperature, water cooling jacket outlet temperature, and water outlet temperature from the plate heat exchanger, are shown in Figure 5.21. There was an average of about 0.5°C difference in water temperatures measured at four depths (48, 60, 72 and 78 inches) within the SBS. The liquid in the SBS was heated to a maximum temperature of 47.8°C, while the average SBS sump temperature was 40.1°C.

The SBS jacket, inner coil and heat exchanger water flow rates are plotted in Figure 5.22. Average SBS jacket, inner coil and heat exchanger water flow rates were 21.6, 24.9 and 36.0 gpm respectively. The amounts of heat removed by the SBS cooling jacket and the plate heat exchanger are shown in Figure 5.23. The heat load data for SBS cooling jacket and plate heat exchanger are calculated based on hourly averaged cooling water temperature increases (outlet temperature minus supply temperature) across the cooling jacket and plate heat exchanger multiplied by the time-averaged flow rate through each. For this test, heat removal averaged 120.0 kW by the plate heat exchanger and 45.8 kW by the cooling jacket. About 72% of the heat load to the SBS was removed by the plate heat exchanger and about 28% by the cooling jacket. The SBS inner coil and plate exchanger water temperatures are plotted in Figure 5.24.

At the end of Test 2, the SBS was totally blown down and the SBS bowl was lowered for inspection and cleaning. When the bottom flange was removed, the 2" pipe at the bottom was found to be filled with solids from the flange to the 90° elbow. The length of 2" pipe from the flange to the elbow below is about 7 inches, and the length of the pipe above the flange to the bottom of the SBS bowl is about 4 inches. Figures 5.25 and 5.26 show two views of the wet solids at the bottom of the SBS bowl. About 2.5 gallons of wet solids were removed from the SBS bowl (about 17 kg of wet solids assuming a density of 1.75 g/cc). Another 1.05 kg of solids were removed from the pipe at the bottom of SBS bowl. A photograph of the solids in the bottom pipe is given in Figure 5.27. A bottom view of the SBS weir tubes with rubber plugs that were installed before Test 1, is shown in Figure 5.28. After Test 2, all of the installed rubber stoppers were in place, as shown in Figures 5.29 and 5.30. A view of the solids inside the weir tubes following the removal of the plugs is given in Figure 5.31. About 16 kg of solids were removed from the weir tubes after the plugs were removed. Solids build-up was observed inside the SBS down-comer, as can be seen in Figure 5.32. Post-cleaning views of the weir tubes are given in Figures 5.33 and 5.34. A post-cleaning photograph of the SBS down-comer is given in Figure 5.35.

Test 3

For Test 3 and the remaining tests the rubber stoppers were removed from the SBS weir tubes. The SBS inlet and outlet gas temperatures are plotted in Figure 5.36. Between 204.9 and 205.8 hours of operation, the feed was turned off, the effect of which can be seen in decreased inlet and outlet gas temperatures. The inlet gas temperature peaked at 413°C and averaged 242°C; the outlet gas temperature peaked at 47.2°C and averaged 37.8°C. The downward spikes in SBS inlet gas temperatures are due to periodic cleaning of the film cooler with water. The inlet, outlet, and differential pressures are shown in Figure 5.37. The inlet gas pressure averaged -10.8 in. W.C., the outlet pressure averaged –53.1 in. W.C., and the pressure drop across the SBS averaged about 40.6 in. W.C. until 46.2 hours. The differential pressure data beyond 46.2 hours is not accurate because of clogging of the sensor. At about 204 hours, while feed was secured and off-gas was diverted to the back-up system, the SBS down-comer was cleaned using a brush. Water temperatures in the SBS, SBS chilled cooling water supply temperature, water cooling jacket outlet temperature, and water outlet temperature from the plate heat exchanger, are shown in Figure 5.38. There was about 1.1°C difference in average water temperatures measured at four depths (48, 60, 72 and 78 inches) within the SBS. The liquid in the SBS was heated to a maximum temperature of 50.3°C during the initial period of water feeding, while the average SBS sump temperature was 40.2°C.

The SBS jacket, inner coil, and heat exchanger water flow rates are plotted in Figure 5.39. The average SBS jacket, inner coil, and heat exchanger water flow rates were 5.7, 24.4 and 9.9 gpm, respectively. The amounts of heat removed by the SBS cooling jacket and the plate heat exchanger are shown in Figure 5.40. The heat load data for SBS cooling jacket and plate heat exchanger are calculated based on hourly averaged cooling water temperature increases (outlet temperature minus supply temperature) across the cooling jacket and plate heat exchanger multiplied by the time-averaged flow rate through each. For this test, heat removal averaged 39.6 kW by the plate heat exchanger and 10.7 kW by the cooling jacket. About 78.7% of the heat load to the SBS was removed by the plate heat exchanger and about 21.3% by the cooling jacket. The SBS inner coil and plate exchanger water temperatures are plotted in Figure 5.41. The heat load data for SBS inner coil was also calculated based on hourly averaged cooling coil water temperature increases (coil water outlet minus its inlet temperature) multiplied by the hourly averaged flow rate of inner cooling coil water. The average SBS inner coil heat load was 40.8 kW. The heat load difference between SBS inner coil and plate heat exchanger is plotted in Figure 5.42 and, on average, it is only about -1.2 kW. Independently calculated SBS inner coil heat load and plate heat exchanger heat load values were thus very close to each other showing that, as expected, the heat removed from the SBS by the cooling coil matches the primary to secondary heat transfer in the plate heat exchanger.

At the end of Test 3, the SBS was blown down and 40.24 gallons of liquid were removed.

Test 4

The SBS inlet and outlet gas temperatures are plotted in Figure 5.43. The inlet gas temperature peaked at 336°C and averaged 267°C; the outlet gas temperature peaked at 43.2°C and averaged 39.0°C. The downward spikes in SBS inlet gas temperatures are due to periodic cleaning of the film cooler with water. Between 140.7 and 141.7 hours, the ADS feed system malfunctioned so feeding was switched over to the AOD system. Inlet and outlet gas temperatures decreased during the time period when feeding was stopped. The inlet, outlet, and differential pressures are shown in Figure 5.44. The inlet gas pressure averaged -6.9 in. W.C., the outlet pressure averaged –45.3 in. W.C., and the pressure drop across the SBS averaged about 43.2 in. W.C. At around 136.4 hours, feeding was secured for 22 minutes for cold cap sampling.

Inlet and outlet pressures increased slightly during this time. The pressure drop across the SBS increased by about 5.2 in. W.C. over nine days of testing with HLW AZ 101 feed.

Water temperatures in the SBS, SBS chilled cooling water supply temperature, water cooling jacket outlet temperature, and water outlet temperature from the plate heat exchanger, are shown in Figure 5.45. There was an average of about 0.8°C difference in water temperatures measured at four depths (48, 60, 72 and 78 inches) within the SBS. The liquid in the SBS was heated to a maximum temperature of 46.2°C, while the average SBS sump temperature was 40.1°C.

The SBS jacket, inner coil, and heat exchanger water flow rates are plotted in Figure 5.46. The average SBS jacket, inner coil and heat exchanger water flow rates were 6.5, 24.5 and 9.4 gpm, respectively. The amounts of heat removed by the SBS cooling jacket and the plate heat exchanger are shown in Figure 5.47. The heat load data for SBS cooling jacket and plate heat exchanger are calculated based on hourly averaged cooling water temperature increases (outlet temperature minus supply temperature) across the cooling jacket and plate heat exchanger multiplied by the time-averaged flow rate through each. For this test, heat removal averaged 40.8 kW by the plate heat exchanger and 18.0 kW by the cooling jacket. About 69.4% of the heat load to the SBS was removed by the plate heat exchanger and about 30.6% by the cooling jacket. The SBS inner coil and plate exchanger water temperatures are plotted in Figure 5.48. The heat load data for SBS inner coil was also calculated based on hourly averaged cooling coil water temperature increases (coil water outlet minus its inlet temperature) multiplied by the hourly averaged flow rate of inner cooling coil water. The average SBS inner coil heat load was 42.2 kW. The heat load difference between SBS plate heat exchanger and inner coil is plotted in Figure 5.49 and, on average, it is only about 1.4 kW. Independently calculated SBS inner coil heat load and plate heat exchanger heat load values were thus very close to each other showing that, as expected, the heat removed from the SBS liquid by the cooling coil matches the primary to secondary heat transfer in the plate heat exchanger. At the end of the HLW AZ-101 Test 4, the SBS was not blown down.

Test 5

The SBS inlet and outlet gas temperatures are plotted in Figure 5.50. The inlet gas temperature peaked at 390.6°C and averaged 271°C; the outlet gas temperature peaked at 50.7°C and averaged 39.3°C. The downward spikes in SBS inlet gas temperatures are due to periodic cleaning of the film cooler with water. The inlet, outlet, and differential pressures are shown in Figure 5.51. The inlet gas pressure averaged -7.4 in. W.C., the outlet pressure averaged –51.7 in. W.C., and the pressure drop across the SBS averaged about 44.1 in. W.C. The pressure drop across the SBS increased by about 2.4 in. W.C. over nine days of testing with HLW AZ 101 feed.

Water temperatures in the SBS, SBS chilled cooling water supply temperature, water cooling jacket outlet temperature, and water outlet temperature from the plate heat exchanger, are shown in Figure 5.52. There was an average of about 0.5°C difference in water temperatures measured at four depths (48, 60, 72 and 78 inches) within the SBS. The liquid in the SBS was heated to a maximum temperature of 53.2°C, while the average SBS sump temperature was 40.3°C.

The SBS jacket, inner coil and heat exchanger water flow rates are plotted in Figure 5.53. The average SBS jacket, inner coil and heat exchanger water flow rates were 6.1, 24.4 and 11.5 gpm, respectively. The amounts of heat removed by the SBS cooling jacket and the plate heat exchanger are shown in Figure 5.54. The heat load data for SBS cooling jacket and plate heat exchanger are calculated based on hourly averaged cooling water temperature increases (outlet temperature minus supply temperature) across the cooling jacket and plate heat exchanger multiplied by the time-averaged flow rate through each. For this test, heat removal averaged 47.8 kW by the plate heat exchanger and 14.4 kW by the cooling jacket. About 76.8% of the heat load to the SBS was removed by the plate heat exchanger and about 23.2% by the cooling jacket. SBS inner coil and plate exchanger water temperatures are plotted in Figure 5.55. The heat load data for SBS inner coil was also calculated based on hourly averaged cooling coil water temperature increases (coil water outlet minus its inlet temperature) multiplied by the hourly averaged flow rate of inner cooling coil water. The average SBS inner coil heat load was 49.9 kW. The heat load difference between SBS plate heat exchanger and inner coil is plotted in Figure 5.56 and, on average, it is only about -1.2 kW. Independently calculated SBS inner coil heat load and plate heat exchanger heat load values were thus very close to each other showing that, as expected, the heat removed from the SBS liquid by the cooling coil matches the primary to secondary heat transfer in the plate heat exchanger.

At the end of the Test 5, the SBS was completely blown down and 7.3 gallons of liquid were removed. The SBS overflow tank contained solids to a height of about 2" from the bottom. About 2.1 kg of wet solids (with some left-over ceramic packing) were removed from the bowl after draining the SBS. Figure 5.57 shows a photograph of the SBS bowl with the solids. Pieces of the original ceramics packing are clearly visible in Figures 5.58 and 5.59. Another 480 grams of solids were removed from the SBS down-comer at the end of the test. Figure 5.60 and Figure 5.61 provide views looking upward from the bottom of the SBS down-comer showing rings of solids deposited about 8 in. above the bottom of SBS inlet pipe. About 70% of the cross sectional area of the pipe was occluded by solids. During earlier tests with the down-comer in place, solids build-up was observed inside the down-comer close to the vertical location of the diffuser plate. Views of solids from the inlet view-port of SBS down comer are given in Figure 5.62 and Figure 5.63. There are solids deposits at different distances from the bottom of the SBS inlet pipe. A view of the SBS bowl after cleaning is given in Figure 5.64. Photographs of the SBS down-comer after the first attempt to clean it and after the second and final attempt to clean it are given in Figures 5.65 and Figure 5.66, respectively. In both cases the deposited material was manually scraped off with a wire brush.

Test 6

The SBS inlet and outlet gas temperatures are plotted in Figure 5.67. The inlet gas temperature peaked at 386°C and averaged 223°C; the outlet gas temperature peaked at 48.7°C and averaged 39.4°C. The downward spikes in SBS inlet gas temperatures are due to periodic cleaning of the film cooler with water. The inlet, outlet, and differential pressures are shown in Figure 5.68. The inlet gas pressure averaged -6.8 in. W.C., the outlet pressure averaged –48.2 in. W.C., and the pressure drop across the SBS averaged about 41.3 in. W.C. The pressure drop across the SBS increased by about 2.1 in. W.C. over five days of testing with HLW AZ 101 feed.

Water temperatures in the SBS, SBS chilled cooling water supply temperature, water cooling jacket outlet temperature, and water outlet temperature from the plate heat exchanger, are shown in Figure 5.69. There was an average of about 0.6°C difference in water temperatures measured at four depths (48, 60, 72 and 78 inches) within the SBS. The liquid in the SBS was heated to a maximum temperature of 53.0°C during the initial period of water feeding, while the average SBS sump temperature was 40.1°C.

The SBS jacket, inner coil, and heat exchanger water flow rates are plotted in Figure 5.70. Average SBS jacket, inner coil and heat exchanger water flow rates were 6.2, 24.0 and 2.9 gpm, respectively. Somewhere between 66.2 and 68.5 hours, the inner cooling water pump was turned off; it was turned on again at 68.5 hours. The amounts of heat removed by the SBS cooling jacket and the plate heat exchanger are shown in Figure 5.71. The heat load data for SBS cooling jacket and plate heat exchanger are calculated based on hourly averaged cooling water temperature increases (outlet temperature minus supply temperature) across the cooling jacket and plate heat exchanger multiplied by the time-averaged flow rate through each. For this test, heat removal averaged 17.0 kW by the plate heat exchanger and 10.6 kW by the cooling jacket. About 61.6% of the heat load to the SBS was removed by the plate heat exchanger and about 38.4% by the cooling jacket. SBS inner coil and plate exchanger water temperatures are plotted in Figure 5.72. The heat load data for SBS inner coil was also calculated based on hourly averaged cooling coil water temperature increases (coil water outlet minus its inlet temperature) multiplied by the hourly averaged flow rate of inner cooling coil water. The average SBS inner coil heat load was 12.4 kW. The heat load difference between SBS inner coil and plate heat exchanger is plotted in Figure 5.73. Independently calculated SBS inner coil heat load and plate heat exchanger heat load values were very close to each other showing that, as expected, the heat removed from the SBS liquid by the cooling coil matches the primary to secondary heat transfer in the plate heat exchanger.

Effect of Weir Tube Plugging

During Tests 1 and 2 rubber stoppers were used to plug the SBS weir tubes. The intent was to determine what effect, if any, these plugs had on SBS performance and thereby assess the need for the water circulation tubes in the SBS in addition to the holes in the perforation plate. No significant differences are apparent when comparing the SBS inlet, outlet, and differential pressures from Tests 1 and 2 (Figure 5.20) with those from the other tests (Figures 5.37, 5.44, 5.51, and 5.68). The plugged tubes provided locations for the settling of solids as evidenced by the 16 kg of solids removed from the weir tubes after Test 2.

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 during the test while the WESP current and voltage were recorded manually.

Data on the performance of WESP regarding solids removal from the off-gas stream are presented and discussed in Section 7.0. Results of the analysis of fluids that accumulated in the WESP are presented and discussed in Section 5.2.

Test 1

WESP operating data for Tests 1 and 2 are presented in the same figures. Test 1 run time was from zero to 179.8 hours and Test 2 run time was from 180.3 to 218.2 hours. The WESP inlet and outlet gas temperatures are plotted in Figure 5.74. The WESP inlet gas temperature averaged 40.0°C and the outlet temperature averaged 41.4°C, indicating a 1.4°C temperature increase across the WESP during this test. The downward spikes in the WESP outlet temperatures are a result of the daily deluge of the WESP. WESP differential pressure and gas flow rate out of the WESP are plotted in Figure 5.75. The pressure drop across the WESP averaged 2.6 in. W.C. The average WESP gas flow rate was 210.0 scfm.

The amount of liquid accumulated in the WESP is plotted as a function of run time in Figure 5.76 where it is compared to 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 ≈ 2.03 gph. As evident from Figure 5.76, spray water accounts for the majority of the liquid accumulation in the WESP. The difference between accumulated liquid and fresh water sprayed is the liquid removed from the off-gas, which is also plotted in Figure 5.76. The WESP electrodes were deluged daily with water at a nominal rate of 12 gpm for 3.33 minutes, as planned. At the end of the test the WESP was not blown down.

The WESP voltage and current are plotted as a function of run time in Figure 5.77. For Tests 1-2, the average operating voltage and current were about 28.7 kV and 17.1 mA, respectively. The voltage and current remained steady throughout the test. WESP current and voltage were very stable when compared to previous tests [25 - 27]. The time to restore power to the WESP after a deluge was not requested by the WTP or recorded for this test; this information was collected for later tests after being requested by the WTP.

Test 2

Test 2 run time was from 180.3 to 218.2 hours. The WESP inlet and outlet gas temperatures are plotted in Figure 5.74. The WESP inlet gas temperature averaged 40.6°C and the outlet temperature averaged 42.0°C, indicating a 1.4°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 differential pressure and outlet gas flow rate are plotted in Figure 5.75. The pressure drop across the WESP averaged 2.5 in. W.C. The average WESP gas flow rate was 207.4 scfm.

The amount of liquid accumulated in the WESP is plotted as a function of run time in Figure 5.76 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 ≈ 2.06 gph. As evident from Figure 5.76, spray water accounts for the majority of the liquid accumulation in the WESP. The difference between accumulated liquid and fresh water sprayed is the liquid removed from the off-gas, which is also plotted in Figure 5.76. The WESP electrodes were deluged daily with water at a nominal rate of 12 gpm for 3.33 minutes, as planned.

At the end of the test, a total of 19.1 gallons of liquid was blown down and inspections of the WESP were conducted. No solids deposits were visible on the ionizing rods and collector plates and the electrode and collector plates were clean.

Test 3

The WESP inlet and outlet gas temperatures are plotted in Figure 5.78. The WESP inlet gas temperature averaged 39.2°C and the outlet temperature averaged 41.1°C, indicating a 1.9°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 differential pressure and outlet gas flow rate are plotted in Figure 5.79. The pressure drop across the WESP averaged 2.3 in. W.C. The average WESP gas flow rate was 211.3 scfm. As stated earlier, between 36.3 and 39.0 hours, control air was secured to make repairs to its power controller. The effect can be seen in Figure 5.79 as a downward spike in both the gas flow rate and differential pressure. Between 204.9 and 205.8 hours of operation, the feed was turned off to repair the Paxton blower. The second minimum in the gas flow rate and the differential pressure corresponds to that time.

The amount of liquid accumulated in the WESP is plotted as a function of run time in Figure 5.80, 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 ≈ 2.02 gph. As evident from Figure 5.80, spray water accounts for the majority of the liquid accumulation in the WESP. The difference between accumulated liquid and fresh water sprayed is the liquid removed from the off-gas, which is also plotted in Figure 5.80. The WESP electrodes were deluged daily with water at a nominal rate of 12 gpm for 3.33 minutes, as planned.

The WESP voltage and current are plotted as a function of run time in Figure 5.81. The average operating voltage and current were about 28.4 kV and 17.1 mA, respectively. The voltage and current remained steady throughout the test. WESP current and voltage were very stable as compared to previous tests. The time to restore power to the WESP after a deluge was not requested by the WTP or recorded for this test.

At the end of the test a total of 24.0 gallons of liquid was blown down and inspections of the WESP were conducted. Ionizing rods and collector plates were very clean, with only spots of solids deposits evident.

Test 4

The WESP inlet and outlet gas temperatures are plotted in Figure 5.82. The WESP inlet gas temperature averaged 39.8°C and the outlet temperature averaged 41.1°C, indicating a 1.3°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. WESP differential pressure and gas flow rate out of the WESP are plotted in Figure 5.83. The decrease in the gas flow rate and differential pressure at about 70 hours into the test is most likely due to a decrease in the control air flow rate to the melter. The pressure drop across the WESP averaged 2.3 in. W.C.. The average WESP gas flow rate was 206.9 scfm. At about 141 hours into the test, feeding was changed from the ADS to the AOD system. The discontinuities in the gas flow rate and differential pressure seen in Figure 5.83 are probably a result of this change.

The amount of liquid accumulated in the WESP is plotted as a function of run time in Figure 5.84 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 ≈ 2.03 gph. As evident from Figure 5.84, spray water accounts for the majority of the liquid accumulation in the WESP. The difference between accumulated liquid and fresh water sprayed is the liquid removed from the off-gas, which is also plotted in Figure 5.84. The WESP electrodes were deluged daily with water at a nominal rate of 12 gpm for 3.33 minutes, as planned.

The WESP voltage and current are plotted as a function of run time in Figure 5.85. The average operating voltage and current were about 28.0 kV and 17.0 mA, respectively. The voltage and current remained steady throughout the test. WESP current and voltage were very stable as compared to previous tests. The time to restore power to the WESP after a deluge was not requested by the WTP or recorded for this test.

At the end of the test all the liquid in the WESP was blown down and a video inspection was conducted. Ionizing rods and collector plates were observed to be clean both before and after the post-test deluge. Very small pockets of solids were observed in some locations. Upon completion of the WESP deluge, some black solids were collected from the bottom of the WESP.

Test 5

The WESP inlet and outlet gas temperatures are plotted in Figure 5.86. The WESP inlet gas temperature averaged 39.7°C and the outlet temperature averaged 40.3°C, indicating a 0.6°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 differential pressure and outlet gas flow rate are plotted in Figure 5.87. The pressure drop across the WESP averaged 2.4 in. W.C. The average WESP gas flow rate was 208.2 scfm.

The amount of liquid accumulated in the WESP is plotted as a function of run time in Figure 5.88 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 ≈ 2.03 gph. As evident from Figure 5.88, spray water accounts for the majority of the liquid accumulation in the WESP. The difference between accumulated liquid and fresh water sprayed is the liquid removed from the off-gas, which is also plotted in Figure 5.88. The WESP electrodes were deluged daily with water at a nominal rate of 12 gpm for 3.33 minutes, as planned.

The WESP voltage and current are plotted as a function of run time in Figure 5.89. The average operating voltage and current were about 28.2 kV and 17.0 mA, respectively. The voltage and current remained steady throughout the test. WESP current and voltage were very stable when compared with previous tests. The time to restore power to the WESP after a deluge was not requested by the WTP or recorded for this test.

At the end of the test, 18.91 gallons of liquid was initially blown down. After a deluge, an additional 40.9 gallons of liquid were removed. The WESP was not inspected after Test 5.

Test 6

The WESP inlet and outlet gas temperatures are plotted in Figure 5.90. The WESP inlet gas temperature averaged 39.6°C and the outlet temperature averaged 40.4°C, indicating a 0.8°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. WESP differential pressure and gas flow rate out of the WESP are plotted in Figure 5.91. The pressure drop across the WESP averaged 2.6 in. W.C. The average WESP gas flow rate was 218.1 scfm.

The amount of liquid accumulated in the WESP is plotted as a function of run time in Figure 5.92 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 ≈ 2.03 gph. As evident from Figure 5.92, spray water accounts for the majority of the liquid accumulation in the WESP. The difference between accumulated liquid and fresh water sprayed is the liquid removed from the off-gas, which is also plotted in Figure 5.92. The WESP electrodes were deluged daily with water at a nominal rate of 12 gpm for 3.33 minutes, as planned.

The WESP voltage and current are plotted as a function of run time in Figure 5.93. The average operating voltage and current were about 27.8 kV and 17.0 mA, respectively. The voltage and current remained steady throughout the test. The WESP current and voltage were very stable as compared to previous tests. The time to restore power to the WESP after a deluge was not requested by the WTP or recorded for this test.

At the end of the test, 22.3 gallons of liquid was blown down from the WESP. After a deluge, another 41.1 gallons of liquid was removed. After Test 6, the WESP was opened and inspected. Figures 5.94 and 5.95 show that the WESP grid and power supply connections appeared normal. The WESP grid supports were intact, as shown in Figure 5.96.

As a general observation of WESP behavior for the six tests, after each deluge the voltage starts at a high value and then decreases, as shown in Figures 5.77, 5.81, 5.85, 5.89 and 5.93. This behavior is similar to that previously reported for C106/AY102 and C104-AY101 tests [26, 27].

5.1.4 HEME #1

The 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 Tests 1 and 2, the outlet gas temperature and differential pressure are plotted in Figure 5.97. The average HEME #1 gas outlet temperature was 40.1°C for Test 1 and 40.5 °C for Test 2. The average pressure drop across HEME #1 was 2.6 in. W.C. for Test 1 and 2.5 in. W.C. for Test 2. At the end of Tests 1 and 2, no liquids were blown-down from HEME #1.

For Test 3, the outlet gas temperature and differential pressure are plotted in Figure 5.98. The average HEME #1 gas outlet temperature was 39.9 °C. The average pressure drop across HEME #1 was 2.5 in. W.C. At the end of the test, no liquids were blown-down from HEME #1.

For Test 4, the outlet gas temperature and differential pressure are plotted in Figure 5.99. The average HEME #1 gas outlet temperature was 39.6 °C. The average pressure drop across HEME #1 was 2.4 in. W.C. At the end of the test, no liquids were blown-down from HEME #1.

For Test 5, the outlet gas temperature and differential pressure are plotted in Figure 5.100. The average HEME #1 gas outlet temperature was 38.3 °C. The average pressure drop across HEME #1 was 2.7 in. W.C. The average differential pressure was slightly higher as compared to the previous tests. At the end of the test, 14.66 gallons of liquid was blown-down from HEME #1.

For Test 6, the outlet gas temperature and differential pressure are plotted in Figure 5.101. The average HEME #1 gas outlet temperature was 39.0°C. The average pressure drop across HEME #1 was 1.7 in. W.C. At the end of the test, 7.40 gallons of liquid was blown-down from HEME #1.

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 are given in Figures 5.102 through Figure 5.106 for Test 1-2 through Test 6, respectively.

For the six tests the average HEPA #1 outlet temperature was between 61.0°C and 65.4°C. The average differential pressure across HEPA #1 was between 0.1 and 0.3 in. W.C. The small differential pressure observed throughout the tests indicates that no significant particulate loading or moisture blinding of HEPA #1 filter occurred.

5.1.6 First Paxton Blower (Blower-701)

For Tests 1 and 2, the Paxton blower (blower 701) gas outlet inlet temperature is plotted in Figure 5.107. The blower outlet gas temperature averaged 87.8°C for Test 1 and 86.8°C for Test 2. Pre-test views of the blower head inlet and outlet ports are given in Figures 5.108 and 5.109, respectively. After 121.2 hours into Test 1, the blower bearings failed and off-gas flow was diverted to the back-up system while repairs were completed. Post-failure views of the inlet and outlet ports are given in Figures 5.110 and 5.111, respectively. A light coating of solids seen in the figures was too thin to allow collection of samples for analysis. In addition to the miniscule fraction of material that might pass through the HEPA filter, solids deposition can result from condensation processes or chemical reactions such as corrosion, or in this case, material generated during the blower bearing failure.

For Test 3, the blower gas outlet temperature is plotted in Figure 5.112. The outlet gas temperature averaged 88.5°C. At 204.9 hours, the Paxton blower (blower 701) failed and the off-gas flow was diverted to the back-up system. Inspection showed damage to the impeller fins due to impact with the outside casing, as shown in Figures 5.113 and 5.114. The head was replaced and the blower was restored to operation.

Before Test 4, the other Paxton blower (blower 801) head was removed and flushed with hot water to dissolve solids and clean the impeller. Blower 801 is located downstream of HEME #2. For Test 4, Paxton blower (blower 701) gas outlet temperature is plotted in Figure 5.115. The outlet gas temperature averaged 83.1°C.

For Test 5, Paxton blower (blower 701) gas outlet temperature is plotted in Figure 5.116. The outlet gas temperature averaged 82.4°C.

For Test 6, Paxton blower (blower 701) gas outlet temperature is plotted in Figure 5.117. The outlet gas temperature averaged 81.3°C.

5.1.7 Thermal Catalytic Oxidizer and Selective Catalytic Reduction 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

TCO inlet, SCR inlet and outlet, and post SCR temperatures during the test are plotted in Figure 5.118. The average TCO inlet gas temperature was 497°C, while the average SCR inlet gas temperature was 382°C. The average SCR outlet gas temperatures were 361°C and 327°C at two locations, one foot apart, at the outlet of the SCR. The average temperature after the SCR was 318°C. The test plan requirement for a SCR bed temperature of 350 – 400 °C was satisfied.

The differential pressure across the TCO is plotted in Figure 5.119. The average differential pressure was 3.3 in. W.C. Gas concentrations were not measured and ammonia injection was not done during Test 1. Gas residence time in the TCO during Test 1 is given in Table 5.6 and averaged 0.20 seconds.

Test 2

The TCO inlet, SCR inlet and outlet, and post SCR temperatures during the test are plotted in Figure 5.118. The average TCO inlet gas temperature was 497°C, while the average SCR inlet gas temperature was 382°C. The average SCR outlet gas temperatures were 361°C and 330°C at two locations, one foot apart, at the outlet of the SCR. The average temperature after the SCR was 320°C.

The differential pressure across the TCO is plotted in Figure 5.119. The average differential pressures was 3.3 in. W.C.. Gas concentrations were not measured and ammonia injection was not done during Test 2. Gas residence time in the TCO during Test 2 is given in Table 5.6 and was 0.20 seconds.

Data for differential pressures across the SCR and TCO/SCR are not presented for Tests 1 and 2 due to instrument malfunction. The instruments were operational and data are presented for the remaining tests.

Test 3

The TCO inlet, SCR inlet and outlet, and post SCR temperatures during the test are plotted in Figure 5.120. The average TCO inlet gas temperature was 448°C, while the average SCR inlet gas temperature was 349°C. The average SCR outlet gas temperatures were 333°C and 304°C at two locations, one foot apart, at the outlet of the SCR. The average temperature after the SCR was 298°C.

The differential pressures across the TCO, SCR and TCO/SCR are plotted in Figure 5.121. Average differential pressures were 3.2 in. W.C., 6.5 in. W.C. and 10.1 in. W.C., respectively.

Information on NO_X and CO removal in the TCO/SCR is provided in Table 5.2. During test segments A, B, and C, carbon monoxide removals were >29.5%, >46.8%, and 63.1%, respectively. During test segments A, B, and C, nitrogen oxide removals were about 6.7%, 19.8%, and 27.1%, respectively. Gas residence time in the TCO during Test 3 are given in Table 5.6 and averaged 0.21 seconds. Ammonia was not used during this test.

Test 4

The TCO inlet, SCR inlet and outlet, and post SCR temperatures during the test are plotted in Figure 5.122. The average TCO inlet gas temperature was 458°C, while the average SCR inlet gas temperature was 353°C. The average SCR outlet gas temperatures were 339°C and 308°C at two locations, one foot apart, at the outlet of the SCR. The average temperature after the SCR was 302°C.

The differential pressures across the TCO, SCR, and TCO/SCR are plotted in Figure 5.123. Average differential pressures were 3.1 in. W.C., 6.3 in. W.C., and 9.8 in. W.C., respectively.

Information on NO_X and CO removal in the TCO/SCR is provided in Table 5.3. During test segments A, B, and C, carbon monoxide removals were >18.2%, >37.3%, and 53.0%, respectively. During test segments A, B, and C, nitrogen oxide removals were about 96%, 68.8%, and 66.6%, respectively. Gas residence time in the TCO during Test 4 are given in Table 5.6 and averaged 0.21 seconds. Average ammonia injections into the SCR during test segments A, B and C were 0.035, 0.097, and 0.095 lbs/hr, respectively. NH_3 slippages also are shown in Table 5.3. Ammonia slippages during test segments A, B and C were about 9.8%, 6.8% and 3.3%, respectively Average ammonia concentrations after the SCR unit, during test segments A, B and C, were 6 ppm, 12 ppm, and 5.9 ppm, respectively. They are much lower than the maximum planned ammonia slippage of 25 ppm.

Test 5

The TCO inlet, SCR inlet and outlet, and post SCR temperatures during the test are plotted in Figure 5.124. The average TCO inlet gas temperature was 473°C, while the average SCR inlet gas temperature was 361°C. The average SCR outlet gas temperatures were 343°C and

315°C at two locations, one foot apart, at the outlet of the SCR. The average temperature after the SCR was 309°C. A sharp decrease in the temperatures at about 193 hours into the test can be seen in Figure 5.124. The heater was unable to maintain the set point temperature of 470°C because of the failure of a control card in the TCO/SCR heater power supply. The set point temperature was, therefore, lowered to 300°C. The system returned to normal operation after the control card was replaced.

The differential pressures across the TCO, SCR, and TCO/SCR are plotted in Figure 5.125. Average differential pressures were 3.3 in. W.C., 6.6 in. W.C., and 9.6 in. W.C., respectively.

Information on NO_X and CO removal in the TCO/SCR is provided in Table 5.4. Data collected before the heater malfunction only were used in the following analysis. During test segments B and C, nitrogen oxide removals were >85.9%, and >65.6%, respectively. Gas residence time in the TCO during Test 5 are given in Table 5.6 and averaged 0.21 seconds. Average ammonia injections into the SCR during test segments A, B, and C were 0.035, 0.084 and 0.108 lbs/hr, respectively. Ammonia slippages during the test segments A, B, and C were 4.8%, 4.2% and 3.6%, respectively. Average ammonia concentration after the SCR unit, during test segments A, B and C, were 3 ppm, 6.1 ppm, and 6.9 ppm, respectively.

Test 6

The TCO inlet, SCR inlet and outlet, and post SCR temperatures during the test are plotted in Figure 5.126. The average TCO inlet gas temperature was 461°C, while the average SCR inlet gas temperature was 356°C. The average SCR outlet gas temperatures were 339°C and 310°C at two locations, one foot apart, at the outlet of the SCR. The average temperature after the SCR was 305°C. After about 49 hours into the test the heater set point was reduced to 350°C and ammonia injection was stopped because of a malfunction of the FTIR gas analyzer.

The differential pressures across the TCO, SCR, and TCO/SCR are plotted in Figure 5.127. Average differential pressures were 3.3 in. W.C., 6.6 in. W.C., and 10.2 in. W.C., respectively.

Information on NO_X and CO removal in the TCO/SCR is provided in Table 5.5. Gas residence time in the TCO during Test 5 is given in Table 5.6 and averaged 0.20 seconds.

Inspection of the off-gas system components after the TCO/SCR for ammonium nitrate deposition is reported in the DM 1200 LAW Sub-Envelope B1 Test Report [29].

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 solids content and pH of the scrubber liquid.

For Test 1, the inlet gas temperature and the pressure drop across the PBS are shown in Figure 5.128. The average PBS differential pressure was 2.7 in. W.C. The discontinuities in the plots correspond to the time when Paxton blower (blower 701) failed and off-gas was diverted to the back-up system. The PBS was not blown down at the end of Test 1. The average PBS inlet gas temperature for this test was 299.9°C. The PBS sump temperature and pH are plotted in Figure 5.129 and averaged 26.2°C and 9.3, respectively.

For Test 2, the inlet gas temperature and the pressure drop across the PBS are shown in Figure 5.128. The average PBS differential pressure was 2.7 in. W.C. The PBS was not blown down at the end of Test 2. The average PBS inlet gas temperature for this test was 302.0°C. The PBS sump temperature and pH are plotted in Figure 5.129 and averaged 26.9°C and 9.2, respectively.

For Test 3, the inlet gas temperature and the pressure drop across the PBS are shown in Figure 5.130. The average PBS differential pressure was 2.7 in. W.C. The downward spike in the plot at about 205 hours corresponds to the time when Paxton blower (blower 701) failed and off-gas was diverted to the back-up system. About 41.21 gallons of liquid was blown down from the PBS. The average PBS inlet temperature for this test was 281.0°C. The PBS sump temperature and pH are plotted in Figure 5.131 and averaged 24.6°C and 8.9, respectively.

For Test 4, the inlet gas temperature and the pressure drop across the PBS are shown in Figure 5.132. The average PBS differential pressure was 4.8 in. W.C. The PBS was not blown down at the end of Test 4. The average PBS inlet temperature was 285°C. The PBS sump temperature and pH are plotted in Figure 5.133 and averaged 25.5°C and 8.9, respectively.

The inlet gas temperature and the pressure drop across the PBS during Test 5 are shown in Figure 5.134. The average PBS differential pressure was 3.6 in. W.C. The PBS was not blown down at the end of Test 5. The average PBS inlet temperature was 289.3°C. The PBS sump temperature and pH are plotted in Figure 5.135 and averaged 25.4°C and 8.8, respectively. The pH sensor connected to the data acquisition system was not operational during this test up to 92.8 hours. The pH values were, therefore, measured and recorded manually.

For Test 6, the inlet gas temperature and the pressure drop across the PBS are shown in Figure 5.136. The average PBS differential pressure was 3.5 in. W.C. The PBS was blown down and 19.1 gallons of liquid was removed. The average PBS inlet temperature was 286°C. The PBS sump temperature and pH are plotted in Figure 5.137 and averaged 24.5 and 8.6°C, respectively. The pH sensor connected to the data acquisition system was not operational during this test up to 84.0 hours and after 114.0 hours. The pH values were, therefore, measured and recorded manually. During this test the pH was controlled in the range of 9 ± 0.5.

5.1.9 HEME #2

The 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.

For Test 1, inlet and outlet gas temperatures and differential pressure are plotted in Figure 5.138. The average HEME # 2 gas inlet temperature was 30.8°C, and the average outlet temperature was 32.6°C. The average pressure drop across HEME # 2 was 3.2 in. W.C. At the end of the test, no liquids were blown-down from HEME # 2.

For Test 2, inlet and outlet gas temperatures and differential pressure are plotted in Figure 5.138. The average HEME # 2 gas inlet temperature was 30.7°C, and the average outlet temperature was 32.7°C. The average pressure drop across HEME # 2 was 3.5 in. W.C. At the end of the test, no liquids were blown-down from HEME # 2.

For Test 3, inlet and outlet gas temperatures and differential pressure are plotted in Figure 5.139. The average HEME # 2 gas inlet temperature was 28.8°C, and the average outlet temperature was 31.0°C. The average pressure drop across HEME # 2 was 3.3 in. W.C. At the end of the test, no liquids were blown down.

For Test 4, inlet and outlet gas temperatures and differential pressure are plotted in Figure 5.140. The average HEME # 2 gas inlet temperature was 27.0°C, and the average outlet temperature was 29.4°C. The average pressure drop across HEME # 2 was 3.0 in. W.C. At the end of the test, no liquids were blown down.

For Test 5, inlet and outlet gas temperatures and differential pressure are plotted in Figure 5.141. The average HEME # 2 gas inlet temperature was 26.6°C, and the average outlet temperature was 28.6°C. The average pressure drop across HEME # 2 was 3.5 in. W.C. At the end of the test, no liquids were blown down.

For Test 6, inlet and outlet gas temperatures and differential pressure are plotted in Figure 5.142. The average HEME # 2 gas inlet temperature was 25.4°C, and the average outlet temperature was 26.9°C. The average pressure drop across HEME # 2 was 3.1 in. W.C. At the end of the test, no liquids were blown down.

5.1.10 Effluent Liquid Treatment System

Effluent liquids from the SBS, WESP, PBS, 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."

The various effluent liquid sampling and storage tanks were visually monitored during periodic operator rounds, and effluent liquid transfers were made as needed. The only parameter of the effluent liquid treatment system monitored by the computer data acquisition system during this test was the pH of the storage tank.

5.2 SBS and WESP 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, atomic absorption (AA) for cesium, 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. The only anions determined in the filtered solids were sulfate and iodide due to interference from the acids required to dissolve the filtered solids.

All of the SBS sump samples that were taken throughout the DM1200 tests are listed in Table 5.7; 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 during each of the test segments are provided in Table 5.8. The pH values for the SBS liquids are plotted in Figure 5.143. Notice that the solution pH varies by only one pH unit, between 8 and 9, during testing. The highest pH values were recorded during Test 6 when the water condensation rate was the lowest, allowing dissolved constituents to become more concentrated. The lowest pH values were measured during Test 3 and were bracketed by values measured in comparable HLW AZ-102 [25] and C-104/AY-101 [27] tests (8.1-8.8 and 7.8 – 8.3 vs. 8 – 8.3) but slightly higher than values from the comparable C-106/AY-102 [26] tests (6.8 – 8). This near-neutral pH is partly due to the low feed concentrations of nitrates, nitrites, halides, and sulfates, which form acid gases in the melter and decrease the SBS sump pH when scrubbed.

The concentration of TSS and TDS measured in SBS blow down solutions was relatively constant during testing once a steady state was achieved in the SBS sump. Typical steady-state concentrations were about 1500 and 3000 mg/l, TDS and TSS respectively. The sump solution was exchanged with tap water prior to Tests 1 and 3 and, therefore, solution chemistry was evolving during these tests. Data depicted in Figure 5.144 show the solids increasing in Test 1 as production rate, and therefore solids emission rate, increased over course of the test. Solids concentrations decreased during Test 2 as the production rate decreased and the water content of the feed was increased by about 30%. Solids concentrations had not come to steady state in Test 3C, as shown in Figure 5.145 by the continuing increases in solids concentration. Conversely, solids concentrations during Test 4B (Figure 5.146) were relatively constant indicating the process had reached equilibrium with respect to rates of water condensation, water removal, and solids carry-over from the melter. Also, notice in all three figures that the 2:1 ratio of TDS: TSS is constant irrespective of the water content or processing rate indicating the uniformity of particulate chemistry throughout testing.

Figures 5.147 – 5.151 compare the amount of water fed to the total volumetric accumulations in the SBS over the course of the test. Included is the water fed to cool the melter plenum at the start of the 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). Also included is water added to meet the Test Specification requirement of a minimum of 100 gallons of liquid blow down from the SBS daily. This “makeup” water was required at the beginning of Tests 4 and 5 (about 40 gallons in each test) as well as extensively in Test 6 (434 gallons). There is close agreement between water quantities at the beginning of the tests, followed by increasing divergence as the testing progressed and production rates increased. Notice that the change in water feed rate as a result of increased bubbling is reflected in an increase in the water accumulation rate in the SBS (Figures 5.148 – 5.150). Another change in accumulation rate is shown in Figure 5.147 during the transition from Test 1 (504 g glass per liter feed) to Test 2 (281 g glass per liter feed) as glass production rate decreases. Production rates, and therefore water accumulation rates, were constant throughout Test 6 (Figure 5.151) due to constant operating conditions, which included no bubbling. By the end of the tests, the amount of water fed into the melter less the amount condensed in the SBS was as follows: Tests 1 and 2 – 114 gallons, Test 3 – 634 gallons, Test 4 – 661 gallons, and Test 5 – 699 gallons. This difference is dependent on the SBS sump temperature set-point of 40°C (lower temperatures would decrease this difference) and the feed rate of water into the SBS. More water was blown down from the SBS than fed into the melter during Test 6, the difference being compensated for by 434 gallons of makeup water added directly to the SBS overflow container. Previous testing with HLW AZ-101 feed [3, 4] showed that a near-room-temperature SBS sump condensed virtually all of the feed water, whereas a sump temperature of 40°C resulted in a portion of feed water being emitted. SBS water condensation plots from LAW tests (Sub-Envelope C1 [20], A1 [27], and B1 [28]) and HLW tests [25 - 27] that used a sump temperature of 40°C are very similar.

Figures 5.152 - 5.154 compare the feed composition to the SBS dissolved and suspended fractions from a sample taken during the last test segment of Test 5 (G12-S-140A). As might be expected, the dissolved solids consist mainly of species such as halogens, boron, and alkali metals. 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 (27-29). Nitrite and ammonia, which constitute greater than half the dissolved SBS solids in the LAW melter tests [20, 28, 29], are present only in very small quantities due to very low feed concentrations of nitrate/nitrite and the lack of sugar additions. The suspended solids more closely resemble the feed and consist primarily of iron, silicon, zirconium, aluminum, and sodium. Iodide was present only in the dissolved fraction. The composition depicted in Figures 5.153 and 5.154 is representative of other SBS solutions, as shown in the detailed analysis of SBS samples taken from the end of each segment given in Table 5.8. This uniformity in composition indicates uniform chemistry of solids carryover from the melter.

Detailed anion analysis for all samples from Test 3C is provided in Table 5.9. The data provide an opportunity to closely track the accumulation of anions in the SBS blow down solutions as depicted in Figure 5.155. The uniform rate of increase in accumulation suggests the process is steady with respect to emissions and blow down rate.

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 test. All of the WESP and PBS sump samples that were taken throughout the test are listed in Tables 5.10 and 5.11; 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. About 80 gallons were blown down from the WESP daily: the first 40 gallons from the previous day's accumulation of water from spraying and condensation (sample with suffix "A" in name) and the second from the 40-gallon deluge (sample with suffix "B" in name). The PBS was blown down as required to maintain constant volume. Little liquid accumulated in the HEME immediately downstream of the WESP (HEME #1) during testing. Liquid was removed and sampled from HEME #1 at the end of Test 6 (7.40 gallons) and Test 5 (14.66 gallons). Prior to these two blow downs, no liquid was ever removed from HEME #1.

Results from the analysis of sump samples from the WESP taken before and after the deluge are given in Tables 5.12 for Test 3C and other tests in Table 5.13. The chemical composition of a representative sample is illustrated in Figure 5.156. The WESP solution pH values were higher (7 to 9 vs. 2 to 7) than for the previous HLW tests [6] due to dilution from the added deluge and higher than for the previous LAW Sub-Envelope B1 tests [29] (7 to 9 vs. 2 to 4) due to the lower concentrations of nitrates/nitrites in the feed. Values were comparable to more recent HLW tests that also employed a daily deluge for cleaning the WESP elements [25 - 27]. A near total absence of suspended material was measured in both the pre- and post-deluge blow-down solutions. The principal constituents in the WESP solutions were volatile salts (alkali halides, boron) carried over from the SBS and residual sulfate from previous tests or feed impurities. This confirms 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. The concentrations of elements are higher in the solutions prior to the deluge, although the relative proportion of elements is very similar. The measured concentrations of elements from samples taken near the end of Test 3 – 6 are similar, as expected given that the same composition glass is produced in each test. One outlier is the high nitrate concentration in a sample from Test 6 where a heavy metals spike high in nitrates was used.

Anion analysis of the PBS and HEME 1 blow-down solutions taken at the end of Test 3 - 6 is given in Table 5.14. The pH of the PBS sump is maintained between 9 and 10 during testing by the addition of 25% sodium hydroxide solution. Conversely, the pH of HEME solutions is a result of constituents removed from the exhaust stream. It is important to note that while relatively high concentrations of iodine and to a lesser extent other anions such as nitrite were measured in the PBS solutions, they certainly are not removed quantitatively in the PBS in the 9 to 10 pH range. Significant concentrations of several anions including ammonium, sulfate, and nitrate were measured in HEME solutions; however, the HEME plays only a small role in the mass balance as a result of the small volumes of liquids collected.

The high concentrations of both ammonium and nitrate, however, merit special consideration given the concern over the potential accumulation of ammonium nitrate deposits. The HEME housing was installed prior to the first LAW test in December 2001 [20]; however, the hard-piped bypass was not installed. The bypass for the first LAW test was accomplished by not installing the filter in the housing or any liquids in the unit and directing the exhaust stream through the empty HEME housing. As a result, exhaust high in nitrates, volatile organic compounds, and possibly ammonia had an opportunity to deposit on the cold internals of the HEME housing. Prior to the second set of LAW tests, a hard-piped bypass was installed, which prevented the HEME internals from being exposed to further exhaust from LAW vitrification. In the turnover to a HLW glass and the subsequent tests described in this report, no water was introduced into the HEME by spraying or any other means and therefore any liquid present in the HEME sump is from the condensation of melter exhaust. The volumes collected during these tests were small (7.4 and 14.7 gallons from Tests 6 and 5, respectively) particularly considering the large amount of glass produced (about 47 metric tons). The total amount of ammonium nitrate in the HEME solutions was about three kilograms. Samples taken in subsequent HLW tests [25-27] had ammonium concentrations 20 times less than in the samples from these tests and therefore the origin of the ammonium is probably residual material from the LAW test.

5.2.3 Estimates of Accumulations in SBS, WESP, and PBS and Fluids

Estimates of elemental accumulations in the SBS, WESP, and PBS blow-down solutions for Test 3C are provided in Table 5.15. The accumulation totals are the product of the analyses given in Tables 5.8, 5.9, 5.12, and 5.14 and the total accumulated liquids given in Tables 5.7, 5.10 and 5.11. Single sample concentrations from the end of the test segment for SBS and PBS were used for the estimates except for anions in the SBS solutions where a rigorous calculation was conducted from almost all the SBS samples from the test segment. The accumulations given therefore are mostly upper estimates since the concentration values were taken near the end of test segment and the concentrations certainly increased over the course of the test segment. They do not include the solids in the SBS bowl or down-comer that were removed at the end of the test (see Section 5.1.2). The accumulations estimated from blow-down data are also compared to estimates calculated from emissions data as percent of feed. The equivalent of almost three kilograms of sodium, two kilograms of boron, about one and a half kilograms of iodine and sulfate, as well as hundreds of grams of aluminum, iron, lithium, zinc, fluorine, and nitrate/nitrite are estimated to have accumulated in the SBS liquids during the test segment. However, the SBS liquids constitute a significant proportion of the elemental mass balance only for sulfur and halogens, with about 44 percent of these feed constituents reporting to the SBS fluids. Although a significant percentage of feed iodine accumulated in the SBS, less accumulated than in LAW Sub-Envelope tests [20, 28, 29] (43 vs. > 50-90%) and more than in other HLW tests [26, 27] (43 vs. 11-15%) due presumably to the difference in the SBS solution composition or the speciation of iodine in the melter emissions. Estimates of accumulations in WESP solutions are the equivalent of about a quarter of a kilogram of sulfur, 88 grams of sodium, as well as ten to thirty five grams of boron, calcium, magnesium, fluorine, nitrite and nitrate over the course of the test. The WESP liquids constitute a significant proportion of the elemental mass balance only for the feed sulfur. Agreement between the two methods for estimating accumulations in the SBS was not as good as in the C-106/AY-102 test [26] and similar for many elements to the AZ-102 and C-104/AY-101 tests [25, 27]. Emissions data suggest that two to five times more of some elements (Al, Ca, Cd, Cu, Fe, Mn, Ni, Si, Sr, Zn, and Zr) should be present in SBS solutions. Differences are much smaller or nonexistent for elements that constitute the bulk of emissions, such as alkali metals, boron, halogens, and sulfur. A difference between the two estimations is that solids on the bottom of the SBS bowl or down-comer were not included in the estimate based on blow-down solutions but were certainly derived from melter emissions. This may be why agreement is much better for the soluble than insoluble elements. Both estimation methods indicate little feed accumulation in the WESP. Some of the calcium, fluorine, and magnesium in the WESP solutions originated from city water used to constantly spray the WESP and conduct the deluge, which would not be reflected in the exhaust sampling estimates. Finally, as expected, the PBS sump fluids account for only a modest percentage of feed anions.

SECTION 6.0
GLASS PRODUCT FROM THE DM1200

Almost twenty five 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 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 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 2.3. Both zirconium and zinc had about the same deviation from target in the discharged glass as in the feed samples, whereas aluminum was closer to the target. Oxides of cerium, chromium, cesium, antimony, selenium, tellurium, and titanium remained in the glass pool from the previous AZ-101 formulation [4] and decreased systematically over the course of the test. Chromium and titanium oxides remained in the glass at very low levels even after three melt pool turnovers due to leaching of chromium from melter components and the ubiquity of titanium as a contaminant in the glass forming additives. Cerium, palladium, rhodium, ruthenium, and yttrium were introduced as a spike in Tests 4B and 6 to trace the behavior of these elements in melt pool and, therefore, they are observed in the results for these tests and the tests immediately thereafter. Note, however, that with respect to these elements, data of much higher sensitivity and precision were obtained from a separate set of analyses that was reported previously [32]. Consistent with previous melter tests using lower alkali glass [4, 20, 25-27, 29], no measurable feed iodine was retained in the glass product.

Compositional trends from the XRF data are plotted for selected elements in Figures 6.1-6.4. The figures illustrate many of the points apparent in the tabular summaries of the data: good agreement with target for all oxides after the melt pool has experienced three turnovers (~6000 kg of glass produced), a lack of compositional change due to the similarity between the former and present AZ-101 compositions, and the increase in lanthanides at the expense of Sr/TRU products. The figures also illustrate the three compositional trends that occurred: elements with oxide concentrations that either did not change as a result of the similarity to the previous AZ-101 composition [4] (e.g., zirconium and zinc in Figure 6.2), systematically decreased in concentration towards target (e.g., Sr/TRU products and calcium in Figure 6.3 and aluminum in Figure 6.2), or systematically increased towards target (e.g., lanthanides and nickel in Figure 6.4, silicon in Figure 6.1, and iron in Figure 6.2). The principal compositional changes were the increase in lanthanides and iron at the expense of Sr/TRU removal products (Mn and Sr) and aluminum present in the previous AZ-101 simulant composition. All of these trends closely parallel those observed in the DM100 test, described in Section 3. One trend unique to the DM1200 tests is the drop in silicon and rise in aluminum in the latter half of Test 5. This trend is also observed in the feed samples from end of the same test, confirming the glass analysis.

Two glass samples were analyzed by colorimetric methods for iron redox state. Analysis results showed 3.0% (for sample C12-G-108A) and 2.6% (for sample C12-G-20A) of the total iron measured as Fe^{+2} indicating that, as expected, without the addition of reductants to the feed, there is no appreciable reduced iron in the glass.

6.2 Glass Density Comparison

Measurements were made on several drums of poured glass to permit the calculation of glass bulk density; the results of which have been previously reported [33]. Also included in that report were measurements of the intrinsic glass density on small bubble-free shards of glass (5 – 10 g) removed from the top of each drum using a pycnometric water displacement procedure (ASTM D854-83). Table 6.3 compares these intrinsic densities to those measured on glasses generated from melter tests on the other three compositions given in the Test Specification. As expected, the densities of the AZ-101 and AZ-102 glasses are nearly identical due to the similarity of the two compositions. Values measured for the C-106/AY-102 and C-104/AY-101 were higher due perhaps to either the incorporation of Sr/TRU and high concentration of zirconia, respectively.

SECTION 7.0
MONITORED OFF-GAS EMISSIONS

7.1 Particulate and Gaseous Emissions

Seven exhaust samples were taken from the melter and various off-gas system components using 40-CFR-60 Methods 3, 5, and 29 to examine particulate and certain gaseous fluxes. All samples were taken during the steady-state portion of the third test segment. Sampling durations were one to three hours for the melter and SBS exhaust, whereas a 24-36 hour sample was required for the WESP exhaust due to the low particle concentration. The WESP was deluged during the exhaust sample. 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. An additional procedure was required for particulate samples containing ruthenium (Tests 4C, 6 and 5C). Undissolved ruthenium particles were filtered from the nitric/hydrofluoric acid digestate, fused with sodium hydroxide, and dissolved with hydrochloric acid. A list of all inorganic isokinetic samples taken is provided in Table 7.1, including sampling location, air sample volume, air flow rates, particulate emission rates, and air moisture. All samples were within 10% of isokinetic. The Test Plan [7] specified one sample per test segment (Tests 3, 4, and 5) but this was later changed by Test Exception [34] to three replicate samples in Test segments 4C and 5C and none in the other segments in these two tests.

Elemental emission rates and DFs obtained during the tests are provided in Tables 7.2-7.11 for the melter, SBS, and WESP. Notice the distinction that is made between constituents sampled as particles and as "gas". The "gaseous" constituents are operationally defined as those species that are scrubbed in the impinger solutions after the air stream has passed through a 0.45 μm heated filter. Samples from the three segments of Test 3 were intended to show the effect of bubbling on melter emissions and the triplicate samples for Tests 5C and 6 were intended to address the variability of emissions for a given condition. Despite expectations, no clear trend of emissions with bubbling rate was observed in Test 3 when the data are normalized to feed rate, even though emissions did increase substantially at the highest bubbling rate, as shown in Figure 7.1. The percent solids carryover from the melter for the intermediate segment was less than half of the carryover of the two segments with both higher and lower bubbling rates. This may be due to the inherent variability in melter emissions as a result of continuing changes in the cold cap. One of the three triplicate melter emission samples from Test 5C is about three times the other two and one of the three triplicate samples from Test 6 is about half the other two. Less variability was observed in the SBS triplicate samples, as would be expected. A trend of increasing particulate carryover with increasing feed water content is observed during Test 5C, as shown in Figure 7.2. This comports with the expectation that increased steam generation in the cold cap region can lead to increased entrainment of feed particulates.

A comparison of melter system DF values for all four HLW compositions given in the Test Specification [6] is shown in Table 7.12. All of the values shown are for the highest feed solids content (20% UDS) and the highest bubbling rate (65 lpm). The measured solids carry-over from the melter was lower for the AZ-101 composition (0.55 percent of feed solids) than for any of the other compositions. This performance is probably not due to compositional differences given the similarity between the feeds with lowest (AZ-101) and highest (AZ-102) melter emission rates but due to changing conditions in the melter as the samples are being taken. The SBS performance for the AZ-101 was typical for the HLW feeds at about 98 percent of particulate in the melter emissions being removed. Except for one low outlier, SBS DF values for the various AZ-101 test segments were between 40 and 50. Lower DF values were obtained for HLW C-106/AY-102 [26] tests due to the higher concentrations of constituents that form fine particles such a halides and selenium; higher DF values were obtained for the HLW AZ-102 tests due to higher melter carryover in those tests. The SBS performance was generally better for HLW tests than for the LAW Sub-Envelope tests [20, 28, 29] due to melter emissions being relatively higher in glass formers such as silica that form coarser particulate that is efficiently captured by the SBS as opposed to fine alkali particulate which is not as effectively removed from exhaust streams. The AZ-101 DF values for the WESP were the lowest of all four compositions, perhaps due to the lower concentration of particles in the SBS exhaust during the AZ-101 test. During the AZ-101 tests, WESP efficiency increased as melter bubbling increased (comparison of Tests 3A, 3B and 3C) and as feed water content increased (comparison of Tests 3C, 4C and 5C). This is probably due to increased alkali emissions as a result of either increased bubbling or increased feed water content. The AZ-101 cumulative DF value, which is calculated from feed fluxes into the melter and emissions from the WESP, was 132,838 and bracketed by those measured on the other three HLW compositions.

The average composition of feed, melter emissions, SBS, and WESP emissions (excluding oxygen, carbon, nitrate, and nitrite) for samples taken during Test 3 are displayed in Figures 7.3-7.6, respectively. Notice that the relative percentages of volatiles, such as halides, increase downstream as the major constituents decrease. Iodine constitutes the majority of WESP emissions as the result of no retention in the glass and poor iodine removal in the SBS and WESP. The composition of the particles and gases in the melter, SBS, and WESP exhaust is very similar for each bubbling and feed solid contents tested. Melter emissions for the AZ-101 tests are similar to those from the other HLW tests with a few exceptions. The C-106/AY-102 formulation is the only one of the four containing the volatile element selenium and, therefore, emissions from this test are uniquely enriched in selenium. Likewise, the C-104/AY-101 formulation contained significant amounts of fluorine, resulting in emissions containing significant concentrations of fluorine. The AZ-102 tests had a higher proportion of feed entrainment into the off gas system and, therefore, particles had a higher proportion of the most abundant constituent, silica. SBS emissions, and to a greater extent WESP emissions, are high in iodine, sulfur, and alkali metals and depleted in major feed constituents, such as silicon, aluminum, and iron. This compositional trend was observed for the other three HLW compositions with the addition of other volatiles such as selenium and fluorine that are present in select compositions. Impinger solutions from off-gas sampling were analyzed for all of the elements in the feed but only iodine, boron, and sulfur were detected. The presence of these elements in the gas fraction is consistent with observations from previous studies [3, 4, 25-29].

7.2 Particle Size Distribution

Samples were taken using a University of Washington cascade impactor, which separates particles into particle size ranges, enabling the determination of particle size distributions. The melter exhaust stream was sampled once during each test segment during Test 3 and in triplicate during the third steady-state test segment of Tests 4 and 5. Data for the particle size distributions are provided in Tables 7.13 – 7.15. From 51 to 88 percent of the total particulate mass was observed in the coarsest size fraction (> 14.7-16.1 μm) with the remainder being spread out over the remaining seven finer size fractions. No obvious trend of changing particle size was observed with bubbling rate (comparison of Tests 3A, 3B and 3C) or feed water content (comparison of Tests 3C, 4C and 5C).

7.3 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 during each test segment in Tests 3-6 for a set of selected species over discrete time intervals at specified off-gas system locations. Tables 7.16 – 7.19 display summaries of the average and range of analyte concentrations measured over the course of the tests. Real-time concentrations of NO, NO_2, CO, CO_2, and water are presented in Figures 7.7-7.11. Only NO, CO_2, and water had average concentrations greater than 10 ppmv as a result of the lack of carbon and nitrogen compounds in the feed. Concentrations of NO_2 in the downstream portion of off-gas system are an exception due to oxidation of NO, as well as throughout the system during Test 6 (Figure 7.8.d) as a result of the use of the nitrate-rich noble metals spike. As expected, concentrations increased as feed rates increased over the course of Tests 3 - 5. The low nitrogen monoxide concentrations were reduced downstream of the TCO/SCR (see Section 5.1.7). Nitrogen oxide emissions could have further been reduced by increasing the amount of ammonia supplied to the catalyst unit at the expense of increased ammonia slippage. Nitrogen dioxide concentrations actually increased across the catalyst unit even though the total NO_x emissions decreased. Another aspect of the emissions is the high degree of variation during testing, as can be observed in the figures and the tables, which give the concentration ranges. Notice that, even over short periods of time, NO_X and CO_2 emissions can vary by factors of 2 to 100. This variation exists even after the catalyst, attesting to the difficulty of removing NO_X from a highly variable exhaust stream without incurring a higher ammonia slippage. Moisture percentages determined at the melter, SBS, and WESP were comparable to those measured using the stack sampling methods, as shown in Table 7.1. Average water percentages determined by FTIR were lower at the melter outlet as a result of stack samples being taken near the end of test segments when production rates are at their highest. The moisture data also indicate that measurable condensation occurs only in the SBS, as intended.

7.4 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 provided in Table 7.20. As expected, hydrogen concentrations were low. Slightly higher concentrations were observed in Test 3, which used a feed with the highest solids content. The average concentration for the Test segment was about a third of that measured in the comparable HLW C-106/AY-102 tests [26], a fifth of what was measured in the LAW Sub-Envelope B1 tests [29] and a twentieth of what was measured in LAW Sub-Envelope A1 tests [28]; this trend is consistent with the progressively increasing carbon content of these feeds.

7.5 Iodine Mass Balance

Iodine mass balance closure has been an objective of a large number of melter runs. Deficits of iodine occurred in many tests due to the neutralization of basic impinger solutions and inability of off-gas system components to quantitatively remove iodine from the exhaust stream. This test provided a good opportunity to measure iodine emission rates due to the low concentrations of acid gases in the exhaust stream, which tend to neutralize basic impinger solutions. A detailed iodine mass balance for Test 3C and a summary of iodine emission rates is presented in Table 7.21 in terms of percent feed iodine. Notice that despite the lack of iodine in the glass, excellent mass closure around the melter was achieved as either melter emissions (102%) or the sum of SBS blow-down solutions and SBS emissions (45 + 58 = 103%). The iodine mass balance closure across the WESP for Test 3C is not as good as that across the melteras can be seen in Table 7.21.The amount of iodine detected in the WESP emissions is higher than in many previous studies that featured less efficient sampling [4, 20, 28], comparable to the C-104/AY-101 tests [27], but less than other more recent HLW tests [25, 26]. The recent HLW tests support the long-held assumption that the WESP removes little or no iodine and, therefore, the amount of iodine entering and exiting the WESP are equal. Clearly, however, a large proportion of the feed iodine is exiting the WESP and a significant proportion of that is exiting the PBS. The summary of all emission samples shows the range of measured emission rates, even though the lack of iodine retention in the glass product is constant. No iodine was detected in the particulate and only about 2 percent of iodine was detected in the acidic impinger catch, indicating that the iodine is emitted predominantly as a molecular gas (I_2) as opposed to HI or particles.

SECTION 8.0
CONCLUSIONS

Melter tests were conducted on the DM1200 to determine the effects of bubbling rate and feed solids content on glass production rate and off-gas system performance while processing a HLW AZ-101 feed composition. Three nine-day tests, each at different feed solids content (530, 400 and 300 g glass per liter), were conducted at three bubbling rates. These tests were preceded by two tests designed to establish the bubbling rate values required to produce glass at ~400 and ~800 kg/m^2/day as well as for the maximum production rate. An additional test was added that featured no bubbling to determine the effect of bubbling on the retention of noble metals. About eighty metric tons of feed was processed to produce almost twenty five metric tons of glass. Cold-cap-limited, steady-state production rates of 400, 655 and 900 kg/m^2/day were maintained for test segments with feed having the highest solids content (20 wt% undissolved solids) and bubbling rates of 8, 40, and 65 lpm, respectively. Progressively lower rates were observed in feeds with lower solids contents (15 and 10 wt% undissolved solids), as expected. Some foaming occurred at the lowest bubbling rate and during feeding interruptions but did not prevent the attainment of steady-state conditions. The presently required glass output of each of the WTP HLW melters of 3 Mt/d corresponds to a specific glass production rate of 800 kg/m^2/d. The test employing the highest bubbling rate and feed solids content on the DM1200 melter exceeded this requirement whereas tests with lower bubbling rates or solids contents did not. It should be noted that the full-scale WTP melter has slightly fewer bubblers per unit melt surface area than does the DM1200 (five bubblers in 3.75 m^2 vs. two bubblers in 1.2 m^2), which may lead to lower large-scale glass production rates on a per unit melt surface area basis.

The general performance of the DM1200 melter and off-gas treatment system was good. The ADS pump itself worked well throughout testing but feed deposits ("stalactites") often formed on the end of feed tube creating feed blockages, which were periodically mechanically removed. The DM1200 test was preceded by a 100-hour DM100 test to ensure that the new glass formulation and melter feed were acceptable for processing in the HLW pilot melter. Extensive sets of process engineering data were collected during both tests. The glass product was close to the intended composition once the melt inventory was turned over.

Isokinetic particulate samples were taken at the outlets of the melter, SBS, and WESP during test segments featuring three bubbling rates (8, 40 and 65 lpm bubbling) and the high feed solids content, as well as at the highest bubbling rate for both lower solids content feeds (10 and 15 wt% undissolved solids). The purpose of these samples was to illustrate the effects of bubbling and feed solids content on emissions as well as to determine the efficiency of off-gas system components. Particulate carryover from the melter increased with increasing water content and at the highest bubbling rate. Elemental DF values were determined across the melter, SBS, and WESP. Particle size distributions were determined for the melter emissions. The total solids carryover from the melter (0.55% of feed for the highest feed solids content) was lower than that observed for tests with other HLW compositions. Calculated DFs across the SBS were about 48 and typical of tests with other HLW compositions. The WESP, which is effective in collecting finer particles, removed much of the additional particulate material exiting the SBS.

As a result, the cumulative DF (Melter+SBS+WESP) was about 132,838 and typical of other HLW tests conducted while using the deluge cleaning procedure of the WESP during emission sampling.

During Tests 1 and 2 rubber stoppers were used to plug the SBS weir tubes. The intent was to determine what effect, if any, these plugs had on SBS performance and thereby assess the need for the water circulation tubes in the SBS in addition to the holes in the perforation plate. No significant differences were apparent for the SBS inlet, outlet, and differential pressures from Tests 1 and 2 when compared to the other tests.

The volumes of processing solutions generated in the SBS, WESP, HEME, and PBS were documented during testing and representative samples were subjected to complete 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 concentration was typically about 3000 mg/l, whereas measured TDS values were about 2 times higher. The WESP sump fluid was also in the neutral pH region but had negligible suspended solids. The WESP solutions contained significant concentrations of nitrate, sulfate, and alkali halides. The WESP was sprayed continuously during this test and was deluged with 40 gallons of water once daily, resulting in a daily blow-down volume of about 80 gallons. The nearly 10,200 gallons of liquid that accumulated in the SBS during testing originated from the condensation of water from the melter feed except for a small volume of makeup water added to the SBS during low-bubbling-rate tests.

A good mass balance was achieved for iodine around the melter, SBS, and WESP. Essentially all of the feed iodine was emitted from the melter and no iodine was detected in the glass product.

The completion of the Test Objectives for this work is summarized in Table 8.1.

SECTION 9.0
REFERENCES

[1] "Determination of Processing Rate of RPP-WTP HLW Simulants using a DuraMelter™ 1000 Vitrification System," K.S. Matlack, W.K. Kot, F. Perez-Cardenas, and I.L. Pegg, VSL-00R2590-2, Rev. 0, 8/21/00.

[2] "Design and Installation of a Prototypical Off-Gas Treatment System for the DM1200 RPP-WTP HLW Pilot Melter," R.T. Anderson, M. Brandys, and R. Jung, Final Report, VSL-01R2510-1, Rev. 0, 2/22/01.

[3] "Start-Up and Commissioning Tests on the DM1200 HLW Pilot Melter System Using AZ-101 Waste Simulants," K.S. Matlack, M. Brandys, and I.L. Pegg, Final Report, VSL-01R0100-2, Rev.1, 10/31/01.

[4] "Tests on the DuraMelter 1200 HLW Pilot Melter System Using AZ-101 HLW Simulants," K.S. Matlack, W.K. Kot, T. Bardakci, T.R. Schatz, W. Gong, and I.L. Pegg, Final Report, VSL-02R0100-2, Rev. 0, 6/11/02.

[5] "Research & Technology Recommendation on the Requirement of Bubblers in the HLW Melter," Perez, J.M. 24590-HLW-RPT-RT-01-003, River Protection Project, Waste Treatment Plant, 3000 George Washington Way, Richland, WA 99352, 2002.

[6] "Integrated DM1200 Testing of HLW Compositions Using Bubblers," J.M. Perez, RPP-WTP Test Specification, 24590-HLW-TSP-RT-02-005, Rev 0, 4/1/02.

[7] "Integrated DM1200 Melter Testing of HLW AZ-101 Compositions Using Bubblers," K.S. Matlack, M. Brandys, W.K. Kot, and I.L. Pegg, VSL-02T8000-1, Rev. 0, 6/17/02.

[8] "Integrated DM1200 Melter Testing of HLW AZ-102 Compositions Using Bubblers," K.S. Matlack, M. Brandys, W.K. Kot, and I.L. Pegg, VSL-02T8000-3, Rev. 0, 9/12/02.

[9] "Integrated DM1200 Melter Testing of HLW C-106/AY-102 and C-104/AY-101 Compositions Using Bubblers," K.S. Matlack and I.L. Pegg, Test Plan, VSL-02T8000-4, Rev. 0, 12/11/02.

[10] "Integrated DM1200 Melter Testing of HLW AZ-101 Compositions Using Bubblers," K.S. Matlack and I.L. Pegg, Data Summary Report, VSL-02S8800-5, Rev. 0, 12/16/02.

[11] "Integrated DM1200 Melter Testing of HLW AZ-102 Compositions Using Bubblers," K.S. Matlack and I.L. Pegg, Data Summary Report, VSL-03S3800-1, Rev. 0, 1/14/03.

[12] "Integrated DM1200 Melter Testing of HLW C-106/AY-102 Compositions Using Bubblers," K.S. Matlack and I.L. Pegg, Data Summary Report, VSL-03S3800-2, Rev. 0, 3/4/03.

75

[13] "Integrated DM1200 Melter Testing of HLW C-104/AY-101 Compositions Using Bubblers," K.S. Matlack and I.L. Pegg, Data Summary Report, VSL-03S3800-3, Rev. 0, 3/28/03.

[14] "Tank Waste Remediation System Operation and Utilization Plan to Support Waste Feed Delivery," R.A. Kirkbride, G.K. Allen, R.M. Orme, R.S. Wittman, J.H. Baldwin, T.W. Crawford, J. Jo, L.J. Fergestrom, G.T. MacLean and D.L. Penwell, Volume I,. HNF-SD-WM-SP-012, Revision 1 (Draft), February 1999.

[15] "Tank Farm Contractor Operation and Utilization Plan," R.A. Kirkbride, et al., CH2M Hill Hanford Group Inc., Richland, WA, HNF-SD-SP-012, Rev. 3A, 12/12/01.

[16] "Noble Metals Testing to Support RPP-WTP HLW Vitrification: Gradient Furnace, Crucible, and Melter Testing," W. Lutze, W. Gong, and I.L. Pegg, VSL-02T7400-1, Rev. 0, 9/23/02.

[17] "Quality Assurance Project Plan for RPP-WTP Support Activities Conducted by VSL," Vitreous State Laboratory, QAPP Rev. 4, 8/2/2001.

[18] "Master List of Controlled VSL Manuals and Standard Operating Procedures in Use," QA-MLCP, Rev. 5, November 7, 2002.

[19] D. B. Blumenkranz, "Quality Assurance Project Plan for Testing Programs Generating Environmental Regulatory Data," PL-24590-QA00001, Rev. 0, Bechtel National Inc., Richland, WA, June 7, 2001.

[20] "Integrated Off-Gas System Tests on the DM1200 Melter with RPP-WTP LAW Sub-Envelope C1 Simulants," K.S. Matlack, W. Gong, T. Bardakci, N. D'Angelo, and I.L. Pegg, Final Report, VSL-02R8800-1, Rev. 0, 7/25/02.

[21] "Small-Scale Ion Exchange Removal of Cesium and Technetium from Envelope B Hanford Tank 241-AZ-102," W.D. King, WSRC-TR-2000-00419 (SRT-RPP-2000-00036), 02/15/2001.

[22] "Phase I High-Level Waste Pretreatment and Feed Staging Plan," A.F. Manuel, S.L. Lambert and G.E. Stegen, WHC-SD-WM-ES-370, Rev. 1, September 1996.

[23] "Tank Characterization for Double-Shell Tank 241-AZ-102," R.D. Schreiber, WHC-SD-WM-ER-411, Rev. 0, Westinghouse Hanford Company, Richland, WA, July 1995.

[24] "Physical and Rheological Properties of Waste Simulants and Melter Feeds for RPP-WTP HLW Vitrification," Final Report, K. Kot, H. Gan, and I.L. Pegg, VSL-00R2520-1, Rev. 0, 10/31/01.

[25] "Integrated DM1200 Melter Testing of HLW AZ-102 Compositions Using Bubblers," K.S. Matlack, W. Gong, T. Bardakci, N. D'Angelo, W. Kot and I.L. Pegg, Final Report, VSL-03R3800-2, Rev. 0, 9/24/03.

[26] "Integrated DM1200 Melter Testing of HLW C-106/AY-102 Compositions Using Bubblers," K.S. Matlack, W. Gong, T. Bardakci, N. D'Angelo, W. Kot and I.L. Pegg, Final Report, VSL-03R3800-1, Rev. 0, 9/15/03.

[27] "Integrated DM1200 Melter Testing of HLW C-104/AY-101 Compositions Using Bubblers," K.S. Matlack, W. Gong, T. Bardakci, N. D'Angelo, W. Kot and I.L. Pegg, Final Report, VSL-03R3800-3, Rev. 0, 11/24/03.

[28] "Integrated Off-Gas System Tests on the DM1200 Melter with RPP-WTP LAW Sub-Envelope A1 Simulants," K.S. Matlack, W. Gong, T. Bardakci, D'Angelo, and I.L. Pegg, VSL-02R8800-2, Rev. 0, 9/03/02.

[29] "Integrated Off-Gas System Tests on the DM1200 Melter with RPP-WTP LAW Sub-Envelope B1 Simulants," K.S. Matlack, W. Gong, T. Bardakci, D'Angelo, and I.L. Pegg, VSL-03R3851-1, Rev. 0, 10/17/03.

[30] "Melt Tests with HLW AZ-101 Simulant Using a DuraMelter 100 Vitrification System," K.S. Matlack, W. Kot, and I.L. Pegg, Final Report, VSL-01R10N0-1, Rev. 1, 2/25/01.

[31] "Integrated DM1200 Melter Testing of Bubbler Configuration and Flow Sheet Changes Using HLW AZ-101 and C-106/AY-102 Compositions," K.S. Matlack, W.K. Kot, and I.L. Pegg, Test Plan, VSL-03T3800-1, Rev. 0, 4/18/03.

[32] "Noble Metals Testing on the DM1200 Pilot Melter System with AZ-101 HLW Simulants," W. Lutze, W. Gong, and I.L. Pegg, VSL-03R3740-2, Rev. A, 10/03/03.

[33] "Gas Bubbles in DM1200 Glass Produced From AZ-101 HLW Simulants," W. Gong, K.S. Matlack, and I.L. Pegg, Letter Report, VSL-03L3800-1, Rev. 0, 1/31/03.

[34] WTP Test Exception, 24590-HLW-TEF-RT-02-002, J.M. Perez, River Protection Project, Waste Treatment Plant, 3000 George Washington Way, Richland, WA 99352, 9/19/02.

Table 2.1. Compositional Summary of Different Waste Streams and Blended Solids.

-	AZ-101 Solids	Recycle Stream	Separation Factor	Cs-Eluate	Tc-Eluate	Blended Solids
-	FRP02	PWD01	-	CNP12	TEP12	HLP09b
-	(lb/day)	(lb/day)	(fraction remained)	(lb/day)	(lb/day)	(lb/day)
Ag	4.66E+00	4.17E-21	1.00E+00	-	-	4.66E+00
Al	1.49E+03	1.77E+00	4.20E-01	5.27E-01	2.11E-02	6.26E+02
As	1.43E+00	1.21E-01	1.00E+00	-	-	1.56E+00
B	6.44E+00	3.11E+00	1.00E+00	6.60E-01	6.80E-02	1.03E+01
Ba	1.58E+01	1.64E-04	2.42E-01	1.71E-03	1.33E-04	3.82E+00
Be	2.24E-01	0.00E+00	1.00E+00	-	-	2.24E-01
Bi	1.49E+00	2.34E-04	1.00E+00	-	-	1.49E+00
Ca	4.60E+01	8.14E-02	9.88E-01	3.75E-02	2.29E-03	4.56E+01
Cd	1.54E+02	6.19E-04	8.27E-02	5.12E-03	-	1.27E+01
Ce	1.88E+01	5.88E+00	7.72E-02	-	-	1.90E+00
Cl	1.15E+00	9.42E-02	7.95E-02	-	1.28E-02	1.12E-01
Co	1.00E+00	0.00E+00	1.00E+00	-	-	1.00E+00
Carbonate	4.46E+01	2.24E+00	1.31E-01	-	-	6.12E+00
Cr	7.33E+00	2.15E-01	1.52E-01	6.31E-02	3.18E-03	1.21E+00
Cs	7.06E-01	0.00E+00	1.15E-01	2.80E-01	-	3.61E-01
Cu	5.20E+00	2.37E-44	1.00E+00	2.94E-01	-	5.50E+00
F	1.01E+02	1.27E+00	8.25E-02	-	-	8.42E+00
Fe	1.96E+03	1.41E+00	9.94E-01	1.28E-01	2.22E-02	1.95E+03
Hg	4.55E-02	1.90E-05	1.00E+00	-	-	4.55E-02
K	4.64E+01	6.82E-01	9.29E-02	1.86E+00	4.16E-02	6.28E+00
La	8.02E+01	1.80E-02	9.85E-01	-	-	7.90E+01
Li	1.45E+00	8.15E-01	1.00E+00	-	-	2.26E+00
Mg	1.46E+01	7.28E-06	1.00E+00	-	2.98E-04	1.46E+01
Mn	2.44E+01	8.20E-02	9.99E-01	1.71E-03	2.98E-04	2.45E+01
Mo	1.25E+00	0.00E+00	1.00E+00	-	-	1.25E+00
Na	1.18E+03	3.59E+02	1.15E-01	**1.71E+01**	**3.32E-01**	1.94E+02
Nd	4.88E+01	0.00E+00	1.00E+00	-	-	4.88E+01
Ni	1.11E+02	1.07E-01	9.83E-01	2.61E-01	2.65E-03	1.10E+02
Nitrite	3.04E+02	2.56E-01	7.84E-02	-	-	2.38E+01
Nitrate	2.03E+02	8.21E+02	7.77E-02	4.92E+01	-	1.29E+02
Hydroxide	1.85E+03	3.16E+01	5.97E-01	-	-	1.12E+03
Hydroxide(Bound)	4.15E+03	0.00E+00	7.68E-02	-	-	3.19E+02
Pb	7.00E+00	2.00E-02	1.00E+00	1.14E-01	-	7.14E+00
Pd	0.00E+00	1.95E-09	1.00E+00	-	-	1.95E-09
Phosphate	5.10E+00	5.01E-03	2.20E-01	-	-	1.16E+00
Pr	1.16E+01	0.00E+00	1.00E+00	-	-	1.16E+01
Rb	3.18E-01	0.00E+00	1.00E+00	-	-	3.18E-01
Rh	3.85E+00	0.00E+00	1.00E+00	-	-	3.85E+00
Sb	1.76E-01	0.00E+00	*	-	-	0.00E+00
Se	6.48E-01	0.00E+00	-	-	-	0.00E+00
Si	3.60E+01	6.46E+00	9.97E-01	4.57E-01	9.29E-02	4.29E+01
Sulfate	2.36E+02	2.46E+01	7.86E-02	-	-	2.05E+01
Sr	6.46E+00	0.00E+00	9.58E-01	-	-	6.18E+00
Ta	1.76E-01	0.00E+00	-	-	-	0.00E+00
Te	1.93E+00	0.00E+00	-	-	-	0.00E+00
Th	6.35E+00	0.00E+00	-	-	-	0.00E+00
Ti	7.84E-01	1.39E-03	1.00E+00	-	-	7.85E-01
Tl	1.76E-01	0.00E+00	-	-	-	0.00E+00
TOC	7.02E+01	0.00E+00	7.67E-02	-	-	5.39E+00
U	1.34E+02	0.00E+00	-	6.13E-01	-	6.13E-01
V	7.13E-01	0.00E+00	-	-	-	0.00E+00
Zn	2.09E+00	4.71E-01	1.00E+00	5.29E-02	2.32E-04	2.61E+00
Zr	6.42E+02	3.13E-01	9.99E-01	-	-	6.41E+02
TOTAL	**1.30E+04**	**1.26E+03**[#]	-	7.16E+01	5.99E-01	5.50E+03

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

Table 2.2. Compositional Summary (Oxide Basis) of the HLW AZ-101 Simulant, Glass Additives, Target Test Glass, and the Corresponding Crucible-Melt Glass (HLW98-77).

-	HLW Simulant	Glass Former (as wt% of glass)	Melter Test Target Glass	HLW98-77
Ag_2O	-	-	-	0.02%
Al_2O_3	20.56%	-	5.19%	5.20%
B_2O_3	0.58%	11.75%	11.90%	11.91%
BaO	0.07%	-	0.02%	-
CaO	1.11%	-	0.28%	0.28%
CdO	0.25%	-	0.06%	0.06%
Cs_2O	0.01%	-	< 0.01%	-
CuO	0.12%	-	0.03%	0.03%
F	0.15%	-	0.04%	0.04%
Fe_2O_3	48.37%	-	12.21%	12.22%
I	0.40%	-	0.10%	-
K_2O	0.13%	-	0.03%	0.03%
La_2O_3	1.61%	-	0.41%	0.41%
Li_2O	0.08%	3.50%	3.52%	3.53%
MgO	0.42%	-	0.11%	0.11%
MnO	0.67%	-	0.17%	0.17%
Na_2O	4.54%	10.50%	11.65%	11.66%
Nd_2O_3	1.22%	-	0.31%	0.31%
NiO	2.43%	-	0.61%	0.61%
PbO	0.13%	-	0.03%	0.03%
SiO_2	1.60%	47.00%	47.40%	47.45%
SO_3	0.30%	-	0.07%	0.08%
SrO	0.13%	-	0.03%	0.03%
ZnO	0.06%	2.00%	2.01%	2.02%
ZrO_2	15.06%	-	3.80%	3.81%
TOTAL	100.00%	74.75%	100.00%	100.00%
Volatiles (g/100 g oxide)	-	-	-	-
Carbonate	0.106	-	-	-
Nitrite	0.414	-	-	-
Nitrate	2.237	-	-	-
TOC	0.093	-	-	-

"-" Empty data field

Table 2.3. Composition of Melter Feed to Produce One Metric Ton of Target Glass from AZ-101 HLW Simulant (20 wt% total solids).

AZ-101 HLW Simulant		Glass-Forming Additives	
Starting Materials	Target Weight (kg)	Starting Materials	Target Weight (kg)
-	-	-	-
$Al(OH)_3$	83.61	-	-
H_3BO_3	2.63	$Na_2B_4O_7 \cdot 10H_2O$	325.08
$Ba(OH)_2 \cdot 8H_2O$	0.37	-	-
$Ca(OH)_2$	3.78	-	-
CdO	0.64	-	-
CsOH (solution)	0.05	-	-
CuO	0.31	-	-
NaF	0.84	-	-
$Fe(OH)_3$ (13% slurry)	1257.25	-	-
NaI	1.22	-	-
KNO_3	0.71	-	-
$La(OH)_3 \cdot 3H_2O$	6.15	-	-
Li_2CO_3	0.51	Li_2CO_3	88.78
$Mg(OH)_2$	1.55	-	-
MnO_2	2.09	-	-
NaOH	13.32	Na_2CO_3	91.03
Nd_2O_3	3.11	-	-
$Ni(OH)_2$	7.89	-	-
PbO	0.33	-	-
SiO_2	4.08	SiO_2	474.75
Na_2SO_4	1.36	-	-
$Sr(OH)_2 \cdot 8H_2O$	0.86	-	-
ZnO	0.15	ZnO	20.20
$Zr(OH)_4 \cdot xH_2O$	98.27	-	-
$NaNO_2$	1.61	-	-
$NaNO_3$	7.19	-	-
$H_2C_2O_4 \cdot 2H_2O$	1.24	-	-
Water	286.50	-	-
-	-	-	-
TOTAL	1787.62	TOTAL	999.84
-	-	FEED TOTAL	2787.46
-	-	-	-

"-" Empty data field

Table 2.4. Properties of AZ-101 Melter Feed Samples.

Melter Type	Test	Date	Name	% Water	Density (g/ml)	Glass Yield (kg/kg)	Glass Yield (g/l)	pH	Yield Stress	Viscosity (Poise) @1/s	Viscosity (Poise) @10/s	Viscosity (Poise) @100/s
DM1200	#1	7/24/02	12X-F-19A	51.6	1.36	0.374	509	10.49	5.5	33.70	4.75	0.66
		7/26/02	12X-F-65A	55.3	1.33	0.382	508	10.41	NA	NA	NA	NA
		7/27/02	12X-F-103A	55.8	1.35	0.374	504	10.56	NA	NA	NA	NA
		7/28/02	12X-F-126A	55.3	1.36	0.366	497	10.52	NA	NA	NA	NA
		7/29/02	12Y-F-21A	55.3	1.35	0.370	499	10.47	NA	NA	NA	NA
		7/30/02	12Y-F-47A	55.8	1.34	0.380	509	10.51	NA	NA	NA	NA
		7/30/02	12Y-F-71A	56.6	1.32	0.376	496	10.48	NA	NA	NA	NA
		7/31/02	12Y-F-75A	55.9	1.34	0.378	506	10.51	NA	NA	NA	NA
		Average		55.2	1.34	0.375	504	10.49	5.5	33.70	4.75	0.66
	#2	7/31/02	12Y-F-106A	73.6	1.22	0.221	269	10.16	1.1	1.87	0.38	0.09
		8/1/02	12Y-F-131A	72.1	1.23	0.238	292	10.13	NA	NA	NA	NA
		Average		72.8	1.23	0.229	281	10.15	1.1	1.87	0.38	0.09
	#3	9/9/02	12Y-F-145A	51.4	1.44	0.414	596	10.79	NA	NA	NA	NA
		9/10/02	12Z-F-24A	55.2	1.38	0.379	522	10.58	NA	NA	NA	NA
		9/11/02	12Z-F-65A	55.4	1.40	0.393	550	10.63	NA	NA	NA	NA
		9/12/02	12Z-F-96A	55.8	1.38	0.373	515	10.63	NA	NA	NA	NA
		9/13/02	12Z-F-142A	55.3	1.39	0.381	529	10.55	NA	NA	NA	NA
		9/14/02	A12-F-30A	56.0	1.38	0.378	522	10.59	NA	NA	NA	NA
		9/15/02	A12-F-57A	55.9	1.40	0.379	531	10.59	NA	NA	NA	NA
		9/16/02	A12-F-94A	56.0	1.38	0.384	530	10.59	NA	NA	NA	NA
		9/17/02	A12-F-128A	56.0	1.38	0.375	517	10.64	NA	NA	NA	NA
		9/18/02	B12-F-12A	56.1	1.40	0.381	533	10.71	6.1	38.20	5.49	0.74
		Average		55.3	1.39	0.383	534	10.63	6.1	38.20	5.49	0.74
	#4	9/24/02	B12-F-112A	64.2	1.33	0.306	407	10.43	2.3	13.03	1.48	0.25
		9/25/02	B12-F-142A	62.8	1.33	0.312	415	10.45	NA	NA	NA	NA
		9/26/02	C12-F-25A	63.5	1.33	0.310	412	10.46	NA	NA	NA	NA
		9/27/02	C12-F-38A	63.5	1.33	0.313	416	10.47	NA	NA	NA	NA
		9/28/02	C12-F-77A	63.3	1.34	0.304	407	10.42	NA	NA	NA	NA
		9/29/02	C12-F-106A	63.5	1.34	0.304	407	10.40	0.8	9.12	1.24	0.21
		9/30/02	D12-F-22A	63.2	1.33	0.291	387	10.48	NA	NA	NA	NA

NA – Not analyzed

Table 2.4. Properties of AZ-101 Melter Feed Samples (continued).

Melter Type	Test	Date	Name	% Water	Density	Glass Yield		pH	Yield Stress	Viscosity (Poise)		
					(g/ml)	(kg/kg)	(g/l)		(Pa)	@1/s	@10/s	@100/s
DM1200	#4	10/1/02	D12-F-28A	66.1	1.33	0.283	376	10.36	NA	NA	NA	NA
		10/10/02	D12-F-48A	64.1	1.32	0.302	399	10.54	NA	NA	NA	NA
		10/2/02	D12-F-69A	63.3	1.34	0.316	423	10.51	2.5	15.44	2.08	0.32
		Average		63.7	1.33	0.304	405	10.45	1.9	12.53	1.60	0.26
	#6	10/8/02	D12-F-149A	64.5	1.33	0.297	395	10.34	NA	NA	NA	NA
		10/11/03	E12-F-80A	64.3	1.30	0.298	387	10.36	1.9	12.10	1.52	0.25
		10/12/02	E12-F-104A	64.1	1.32	0.301	397	10.36	NA	NA	NA	NA
		Average		64.3	1.32	0.298	393	10.35	1.9	12.10	1.52	0.25
	#5	10/15/03	E12-F-145A	72.2	1.24	0.226	281	10.26	NA	NA	NA	NA
		10/16/03	F12-F-22A	71.8	1.24	0.236	293	10.30	NA	NA	NA	NA
		10/17/02	F12-F-47A	71.8	1.24	0.235	291	10.17	NA	NA	NA	NA
		10/18/02	F12-F-88A	71.9	1.25	0.230	287	10.19	NA	NA	NA	NA
		10/19/02	F12-F-121A	70.9	1.25	0.239	299	10.19	NA	NA	NA	NA
		10/20/02	F12-F-136A	70.8	1.25	0.250	313	10.27	NA	NA	NA	NA
		10/20/02	G12-F-6A	72.3	1.25	0.238	298	10.26	NA	NA	NA	NA
		10/21/02	G12-F-40A	71.5	1.24	0.231	286	10.23	NA	NA	NA	NA
		10/22/02	G12-F-77A	71.3	1.25	0.237	296	10.28	NA	NA	NA	NA
		10/23/02	G12-F-94A	72.1	1.24	0.221	275	10.21	NA	NA	NA	NA
		10/24/02	G12-F-124A	72.3	1.23	0.232	286	10.28	NA	NA	NA	NA
		10/24/02	G12-F-141A	73.4	1.25	0.223	279	10.25	1.1	1.00	0.21	0.07
		Average		71.9	1.24	0.233	290	10.24	1.1	1.00	0.21	0.07
DM100BL		7/8/2002	BLE-F-126A	51.20	1.43	0.370	529	10.52	NA	NA	NA	NA
		7/8/2002	BLE-F-136A	54.93	1.47	0.374	550	10.42	NA	NA	NA	NA
		7/9/2002	BLE-F-151A	54.51	1.42	0.390	554	10.34	NA	NA	NA	NA
		7/10/2002	BLE-F-19A	53.81	1.40	0.369	516	10.57	NA	NA	NA	NA
		7/11/2002	BLE-F-37A	53.42	1.44	0.382	549	10.44	NA	NA	NA	NA
		7/12/2002	BLE-F-46A	53.74	1.38	0.385	532	10.52	NA	NA	NA	NA
		7/12/2002	BLE-F-58A	53.94	1.40	0.385	539	10.49	NA	NA	NA	NA
		Average		53.65	1.42	0.379	538	10.47	NC	NC	NC	NC

NA – Not analyzed
NC – Not calculated

Table 2.5. XRF Analyzed Compositions for Vitrified DM100 Melter Feed Samples (wt%).

Element	Target	BLD-F-129A	BLD-F-136A	BLD-F-151A	BLE-F-19A	BLE-F-37A	BLE-F-46A	BLE-F-58A	Average	%Dev.
Al_2O_3	5.19	5.75	5.48	5.59	5.78	5.63	5.66	5.92	5.69	9.59
B_2O_3*	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	NC	NC
BaO	0.02	0.07	0.06	0.05	0.05	0.05	0.05	0.06	0.06	NC
CaO	0.28	0.36	0.37	0.36	0.38	0.36	0.34	0.35	0.36	NC
CdO	0.06	0.07	0.07	0.07	0.06	0.06	0.07	0.07	0.07	NC
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	NC
F	0.04	NA	NA	NA	NA	NA	NA	NA	0.00	NC
Fe_2O_3	12.21	11.65	11.60	11.59	11.43	11.34	11.66	11.53	11.54	-5.48
I	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
K_2O	0.03	0.14	0.15	0.14	0.13	0.12	0.13	0.14	0.13	NC
La_2O_3	0.41	0.41	0.41	0.41	0.39	0.39	0.40	0.40	0.40	-2.00
Li_2O*	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	-0.02
MgO	0.11	0.07	0.08	0.12	0.08	0.09	0.07	0.11	0.09	NC
MnO	0.17	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	NC
Na_2O	11.65	11.48	11.30	11.33	11.55	11.61	11.84	11.22	11.48	-1.51
Nd_2O_3	0.31	0.28	0.30	0.30	0.30	0.29	0.30	0.30	0.29	-5.24
NiO	0.61	0.57	0.56	0.57	0.54	0.54	0.56	0.55	0.56	-8.88
P_2O_5	§	0.02	0.03	<0.01	0.03	0.03	0.02	0.02	0.02	NC
PbO	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	NC
SiO_2	47.41	46.43	46.90	46.81	46.95	47.18	46.45	47.00	46.82	-1.25
SO_3	0.07	0.06	0.06	0.06	0.07	0.07	0.08	0.06	0.07	NC
SrO	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	NC
TiO_2	§	0.11	0.10	0.10	0.11	0.10	0.09	0.10	0.10	NC
ZnO	2.01	1.86	1.86	1.85	1.78	1.74	1.78	1.75	1.80	-10.29
ZrO_2	3.80	4.98	4.97	4.95	4.69	4.70	4.79	4.73	4.83	27.10
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	NC

* Target values
NA – Not analyzed
NC – Not calculated
§ Not a target constituent

Table 2.6. XRF Analyzed Compositions for DM1200 Feed Samples (wt%).

Test		**1**									**2**	
Element	Target	12X-F-19A	12X-F-65A1	12X-F-65A2	12X-F-103A	12X-F-126A	12Y-F-21A	12Y-F-47A	12Y-F-71A	12Y-F-75A	12Y-F-106A	12Y-F-131A1
Al_2O_3	5.19	5.73	5.55	5.82	5.88	5.51	5.41	5.65	5.64	5.80	5.83	5.81
B_2O_3*	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90
BaO	0.02	0.06	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05
CaO	0.28	0.35	0.34	0.37	0.34	0.35	0.34	0.34	0.34	0.34	0.35	0.35
CdO	0.06	0.06	0.06	0.06	0.06	0.07	0.05	0.05	0.05	0.06	0.06	0.06
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	11.42	11.49	11.69	11.46	11.64	11.61	11.60	11.52	11.47	11.87	11.66
I	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.00	0.01	<0.01	<0.01	<0.01
K_2O	0.03	0.15	0.12	0.14	0.14	0.12	0.12	0.12	0.14	0.14	0.15	0.14
La_2O_3	0.41	0.40	0.40	0.41	0.41	0.40	0.40	0.40	0.39	0.39	0.42	0.41
Li_2O*	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52
MgO	0.11	0.08	0.10	0.05	0.05	0.06	0.08	0.07	0.05	0.10	0.08	0.05
MnO	0.17	0.34	0.21	0.21	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0.17
Na_2O	11.65	11.33	11.44	10.93	11.01	10.96	11.32	11.39	11.06	10.88	10.12	10.06
Nd_2O_3	0.31	0.28	0.31	0.31	0.32	0.32	0.32	0.31	0.30	0.31	0.32	0.32
NiO	0.61	0.54	0.53	0.54	0.52	0.54	0.54	0.55	0.54	0.54	0.57	0.55
P_2O_5	§	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
PbO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03
PdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Rh_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RuO_2	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SiO_2	47.41	47.03	47.12	47.02	47.50	47.53	47.42	48.20	47.71	47.59	47.58	48.24
SO_3	0.07	0.06	0.07	0.07	0.05	0.07	0.05	0.06	0.06	0.06	0.07	0.06
SrO	0.03	0.08	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.03
TiO_2	§	0.10	0.09	0.10	0.09	0.10	0.10	0.09	0.09	0.10	0.09	0.09
Y_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ZnO	2.01	1.83	1.79	1.83	1.76	1.79	1.78	1.80	1.76	1.75	1.83	1.77
ZrO_2	3.80	4.65	4.74	4.83	4.63	4.78	4.70	3.60	4.59	4.71	4.89	4.66
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values
NA – Not analyzed
§ Not a target constituent. In Tests 4B and 6, melter feed was spiked with Ce, Y, Pd, Rh, and Ru.

Table 2.6. XRF Analyzed Compositions for DM1200 Feed Samples (wt%) (continued).

Test		2	3A				3B			3C		
Element	Target	12Y-F131A2	12Y-F-145A	12Z-F-24A	12Z-F-65A	12Z-F-96A	12Z-F-142A	A12-F-30A	A12-F-57A	A12-F-94A	A12-F-128A	B12-F-12A
Al_2O_3	5.19	6.02	5.75	5.63	5.69	5.57	5.59	5.61	5.68	5.87	5.77	5.57
B_2O_3*	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90
BaO	0.02	0.06	0.05	0.07	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.05
CaO	0.28	0.35	0.40	0.36	0.37	0.37	0.38	0.35	0.37	0.35	0.36	0.36
CdO	0.06	0.06	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.07	0.06	0.07
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	11.52	11.50	11.51	11.78	11.61	11.37	10.38	11.11	10.64	11.30	10.76
I	0.10	<0.01	0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
K_2O	0.03	0.16	0.13	0.12	0.13	0.12	0.12	0.13	0.13	0.14	0.13	0.13
La_2O_3	0.41	0.41	0.39	0.40	0.42	0.43	0.42	0.38	0.40	0.38	0.40	0.40
Li_2O*	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52
MgO	0.11	0.08	0.09	0.11	0.09	0.11	0.07	0.07	0.06	0.08	0.08	0.09
MnO	0.17	0.17	0.17	0.17	0.18	0.17	0.17	0.16	0.17	0.16	0.17	0.16
Na_2O	11.65	10.46	10.48	10.97	10.50	11.37	11.27	11.69	11.53	11.34	11.32	11.61
Nd_2O_3	0.31	0.31	0.33	0.32	0.31	0.31	0.31	0.30	0.30	0.30	0.31	0.29
NiO	0.61	0.55	0.54	0.55	0.57	0.57	0.55	0.48	0.53	0.50	0.54	0.50
P_2O_5	§	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	0.02
PbO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.03	0.03
PdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Rh_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RuO_2	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SiO_2	47.41	47.75	47.85	47.41	47.38	46.90	47.55	48.99	47.70	48.53	47.47	48.37
SO_3	0.07	0.08	0.09	0.07	0.08	0.08	0.08	0.07	0.07	0.07	0.07	0.08
SrO	0.03	0.03	0.01	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
TiO_2	§	0.09	0.11	0.10	0.11	0.10	0.09	0.09	0.09	0.10	0.09	0.09
Y_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ZnO	2.01	1.76	1.78	1.79	1.81	1.80	1.77	1.56	1.70	1.61	1.74	1.63
ZrO_2	3.80	4.66	4.76	4.80	4.93	4.83	4.62	4.10	4.52	4.28	4.63	4.34
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values
NA – Not analyzed
§ Not a target constituent. In Tests 4B and 6, melter feed was spiked with Ce, Y, Pd, Rh, and Ru.

Table 2.6. XRF Analyzed Compositions for DM100 Feed Samples (wt%) (continued).

Test		4A			4B			4C			6
Element	Target	B12-F-112A	B12-F-142A	C12-F-25A	C12-F-38A	C12-F-77A	C12-F-106A	D12-F-22A	D12-F-48A	D12-F-69A	D12-F-149A	E12-F-80A
Al_2O_3	5.19	5.72	5.59	5.78	5.66	5.58	5.68	5.71	5.97	5.70	5.58	5.79
B_2O_3*	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90
BaO	0.02	0.05	0.06	0.05	0.06	0.05	0.06	0.06	0.05	0.05	0.05	0.05
CaO	0.28	0.36	0.37	0.35	0.36	0.38	0.36	0.39	0.39	0.36	0.39	0.37
CdO	0.06	0.06	0.08	0.06	0.06	0.06	0.06	0.07	0.06	0.06	0.07	0.07
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	0.09	0.08	<0.01	0.08	<0.01	<0.01	0.07
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	10.81	10.75	10.65	11.17	11.00	10.70	11.33	11.45	11.08	11.50	11.20
I	0.10	<0.01	<0.01	0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
K_2O	0.03	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.16	0.13	0.12	0.15
La_2O_3	0.41	0.38	0.41	0.40	0.42	0.37	0.36	0.42	0.39	0.42	0.45	0.38
Li_2O*	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52
MgO	0.11	0.11	0.12	0.08	0.08	0.12	0.05	0.11	0.10	0.14	0.10	0.11
MnO	0.17	0.14	0.17	0.15	0.15	0.17	0.16	0.17	0.16	0.15	0.17	0.17
Na_2O	11.65	12.10	11.98	12.10	11.40	11.28	11.81	11.10	11.14	12.37	10.98	10.78
Nd_2O_3	0.31	0.30	0.31	0.29	0.30	0.32	0.30	0.32	0.30	0.30	0.32	0.33
NiO	0.61	0.50	0.50	0.50	0.53	0.52	0.50	0.54	0.54	0.52	0.55	0.53
P_2O_5	§	0.02	0.02	0.02	0.03	<0.01	0.01	0.02	<0.01	0.02	0.02	0.01
PbO	0.03	0.02	0.03	0.00	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.03
PdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Rh_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01
RuO_2	§	<0.01	<0.01	<0.01	<0.01	0.02	0.02	0.00	0.02	<0.01	<0.01	0.02
SiO_2	47.41	47.70	47.97	48.00	47.84	48.16	48.12	47.53	47.09	46.88	47.49	48.02
SO_3	0.07	0.08	0.08	0.07	0.09	0.08	0.08	0.08	0.11	0.07	0.07	0.08
SrO	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
TiO_2	§	0.08	0.08	0.08	0.09	0.07	0.07	0.09	0.08	0.09	0.10	0.08
Y_2O_3	§	<0.01	<0.01	<0.01	<0.01	0.10	0.09	<0.01	0.09	<0.01	<0.01	0.08
ZnO	2.01	1.64	1.63	1.61	1.70	1.67	1.62	1.76	1.76	1.70	1.80	1.73
ZrO_2	3.80	4.30	4.26	4.17	4.42	4.33	4.22	4.67	4.53	4.44	4.73	4.45
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values
NA – Not analyzed
§ Not a target constituent. In Tests 4B and 6, melter feed was spiked with Ce, Y, Pd, Rh, and Ru.

Table 2.6. XRF Analyzed Compositions for DM1200 Feed Samples (wt%) (continued).

Test		**6**	**5**									
Element	Target	E12-F-104A	E12-F-145A	F12-F-22A	F12-F-47A	F12-F-88A	F12-F-121A	F12-F-136A	G12-F-6A	G12F-40A	G12-F-77A	G12-F-94A
Al_2O_3	5.19	5.29	5.32	5.80	5.79	6.01	5.92	5.84	5.53	7.07	8.48	7.94
B_2O_3*	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90
BaO	0.02	0.06	0.06	0.06	0.05	0.06	0.06	0.07	0.06	0.06	0.09	0.08
CaO	0.28	0.39	0.40	0.40	0.40	0.38	0.39	0.39	0.40	0.40	0.39	0.40
CdO	0.06	0.07	0.07	0.07	0.07	0.06	0.08	0.07	0.06	0.06	0.07	0.08
Ce_2O_3	§	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.05	0.05
CuO	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.04
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	12.25	12.70	11.64	11.69	11.80	11.31	11.53	12.95	12.87	11.19	12.83
I	0.10	0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01	0.01	<0.01	0.01	0.01
K_2O	0.03	0.11	0.12	0.13	0.15	0.15	0.16	0.15	0.12	0.11	0.15	0.11
La_2O_3	0.41	0.39	0.44	0.44	0.43	0.43	0.42	0.42	0.46	0.44	0.43	0.43
Li_2O*	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52
MgO	0.11	0.10	0.05	0.12	0.07	0.09	0.08	0.09	0.09	0.06	0.07	0.08
MnO	0.17	0.19	0.19	0.18	0.16	0.16	0.18	0.17	0.16	0.25	0.28	0.28
Na_2O	11.65	11.08	10.34	11.05	10.30	10.61	10.93	10.85	10.94	10.75	10.99	10.98
Nd_2O_3	0.31	0.36	0.36	0.34	0.36	0.35	0.34	0.36	0.38	0.38	0.35	0.37
NiO	0.61	0.61	0.65	0.55	0.56	0.57	0.54	0.55	0.66	0.67	0.53	0.66
P_2O_5	§	0.01	<0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	<0.01	0.02
PbO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
PdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Rh_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RuO_2	§	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SiO_2	47.41	46.56	46.62	47.00	47.74	47.11	47.68	47.45	45.43	44.31	45.06	42.90
SO_3	0.07	0.05	0.07	0.06	0.05	0.05	0.04	0.04	0.04	0.06	0.07	0.06
SrO	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04	0.04	0.04
TiO_2	§	0.08	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.08	0.08
Y_2O_3	§	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ZnO	2.01	1.83	1.91	1.79	1.79	1.80	1.73	1.75	1.94	1.93	1.71	1.94
ZrO_2	3.80	4.88	5.09	4.74	4.75	4.73	4.53	4.66	5.15	4.90	4.49	5.16
Sum	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Target values
NA – Not analyzed
§ Not a target constituent. In Tests 4B and 6, melter feed was spiked with Ce, Y, Pd, Rh, and Ru.

Table 2.6. XRF Analyzed Compositions for DM1200 Feed Samples (wt%) (continued).

Test		5		Average of all samples	% Dev. from Target
Element	Target	G12-F-124A	G12-F-141A		
Al_2O_3	5.19	7.47	8.12	5.92	14.09
B_2O_3*	11.90	11.90	11.90	NC	NC
BaO	0.02	0.07	0.07	0.06	NC
CaO	0.28	0.41	0.41	0.37	NC
CdO	0.06	0.07	0.08	0.06	NC
Ce_2O_3	§	0.01	0.04	0.01	NC
CuO	0.03	0.04	0.04	0.03	NC
F	0.04	NA	NA	NC	NC
Fe_2O_3	12.21	12.00	12.01	11.52	-5.66
I	0.10	<0.01	<0.01	<0.01	NC
K_2O	0.03	0.14	0.13	0.13	NC
La_2O_3	0.41	0.43	0.43	0.41	-0.17
Li_2O*	3.52	3.52	3.52	NC	NC
MgO	0.11	0.12	0.11	0.09	NC
MnO	0.17	0.21	0.26	0.18	NC
Na_2O	11.65	10.53	10.93	11.09	-4.82
Nd_2O_3	0.31	0.37	0.38	0.32	NC
NiO	0.61	0.58	0.58	0.55	NC
P_2O_5	§	0.03	0.02	0.02	NC
PbO	0.03	0.25	0.03	0.03	NC
PdO	§	<0.01	<0.01	<0.01	NC
Rh_2O_3	§	<0.01	<0.01	<0.01	NC
RuO_2	§	<0.01	<0.01	<0.01	NC
SiO_2	47.41	44.95	43.95	47.17	-0.50
SO_3	0.07	0.05	0.10	0.07	NC
SrO	0.03	0.04	0.04	0.03	NC
TiO_2	§	0.10	0.09	0.09	NC
Y_2O_3	§	<0.01	<0.01	0.01	NC
ZnO	2.01	1.84	1.86	1.76	-12.30
ZrO_2	3.80	4.87	4.92	4.63	21.75
Sum	100.00	100.00	100.00	NC	NC

* Target values calculated based on simple well-stirred tank model.
NA – Not analyzed
NC – Not calculated
§ Not a constituent. In Tests 4B and 6, melter feed was spiked with Ce, Y, Pd, Rh, and Ru.

Table 3.1. Summary of DM100 AZ-101 Test Conditions and Results.

Time	Feed Start	7/8/02, 22:04
	Feed End	7/13/02, 02:37
	Interval	100.6 hr
Water Feeding for Cold Cap		0.55 hr
Slurry Feeding		100.1 hr
Average Bubbling Rate		8.9 lpm
Melt Pool Surface Area		0.108 m^2
Feed	Used	1541 kg
	Glass yield#	530 g/l
		0.375 kg/kg
	Average Rate	15.4 kg/hr
Glass Produced	Poured	583.4 kg
	Average Rate$	1295 $kg/m^2/day$
	Average Rate*	1283 $kg/m^2/day$

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

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

Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
07/09/02	BLD-G-137A	-	23.5	23.5
	BLD-G-141A	XRF		
	BLD-G-147A	-	20.9	44.4
	BLD-G-149A	XRF		
	BLD-G-150A	-	30.7	75.1
	BLD-G-151A	XRF		
	BLD-G-151B	-	24.3	99.4
	BLE-G-7A	XRF		
	BLE-G-7B	-	38.1	137.5
07/10/02	BLE-G-11A	XRF		
	BLE-G-13A	XRF	23.9	161.4
	BLE-G-15A	-	22.8	184.2
	BLE-G-17A	XRF		
	BLE-G-19A	-	23.9	208.1
	BLE-G-22A	XRF		
	BLE-G-22B	-	33.9	22.0
	BLE-G-23A	XRF		
	BLE-G-24A	-	37.9	279.9
07/11/02	BLE-G-24B	XRF		
	BLE-G-30A	-	26.9	306.8
	BLE-G-31A	XRF		
	BLE-G-32A	-	25.6	332.4
	BLE-G-34A	XRF		
	BLE-G-36A	-	31.7	364.1
	BLE-G-37A	XRF		
	BLE-G-40A	-	28.0	392.1
	BLE-G-40B	XRF		
	BLE-G-43A	-	35.1	427.2
07/12/02	BLE-G-46A	XRF		
	BLE-G-48A	-	26.4	453.6
	BLE-G-49A	XRF		
	BLE-G-53A	-	38.5	492.1
	BLE-G-53B	XRF		
	BLE-G-55A	XRF	27.4	519.5
	BLE-G-58A	-	24.5	544.0
	BLE-G-58B	XRF		
	BLE-G-60A	-	37.5	581.4
07/13/02	BLE-G-61A	XRF		
	BLE-G-70A	XRF	1.9	583.4

"-" Empty data field

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

Glass Mass (kg)		23.5	44.4	75.1	99.4	137.5	161.4	184.2	208.1	242.0	279.9	306.8
-	Target	BLD-G-141A	BLD-G-149A	BLD-G-151A	BLE-G-7A	BLE-G-11A	BLE-G-13A	BLE-G-17A	BLE-G-22A	BLE-G-23A	BLE-G-24B	BLE-G-31A
Al_2O_3	5.19	8.00	7.63	7.79	7.34	7.18	7.00	6.94	6.87	6.68	6.69	6.41
As_2O_3	§	0.03	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	<0.01	<0.01
B_2O_3*	11.90	10.23	10.42	10.65	10.81	11.01	11.12	11.22	11.30	11.40	11.50	11.55
BaO	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CaO	0.28	0.53	0.51	0.47	0.46	0.44	0.43	0.43	0.42	0.40	0.39	0.38
CdO	0.06	0.40	0.33	0.30	0.25	0.24	0.22	0.19	0.17	0.16	0.14	0.13
Ce_2O_3	§	0.06	0.06	0.04	0.03	0.02	0.01	0.02	0.01	<0.01	<0.01	<0.01
Cr_2O_3	§	0.11	0.11	0.10	0.09	0.08	0.08	0.07	0.07	0.06	0.06	0.06
Cs_2O	§	0.08	0.06	0.06	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	9.30	9.78	9.72	10.19	10.20	10.31	10.59	10.53	10.88	10.58	10.99
I	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K_2O	0.03	0.28	0.26	0.28	0.26	0.25	0.24	0.23	0.22	0.21	0.21	0.19
La_2O_3	0.41	0.23	0.25	0.29	0.27	0.30	0.29	0.34	0.32	0.34	0.35	0.36
Li_2O*	3.52	5.70	5.46	5.15	4.95	4.68	4.53	4.41	4.30	4.17	4.04	3.97
MgO	0.11	0.90	0.79	0.75	0.59	0.54	0.47	0.44	0.36	0.35	0.29	0.28
MnO	0.17	2.49	2.21	1.88	1.67	1.43	1.29	1.17	1.06	0.92	0.80	0.74
Na_2O	11.65	7.84	8.12	8.71	9.10	9.37	9.80	9.92	10.11	10.03	10.72	10.17
Nd_2O_3	0.31	0.02	0.06	0.09	0.12	0.15	0.17	0.18	0.19	0.21	0.21	0.22
NiO	0.61	0.32	0.37	0.39	0.44	0.44	0.46	0.49	0.49	0.52	0.51	0.53
P_2O_5	0.00	0.25	0.23	0.19	0.17	0.14	0.13	0.11	0.11	0.10	0.08	0.08
PbO	0.03	0.12	0.11	0.10	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05
Sb_2O_3	§	0.16	0.13	0.12	0.10	0.09	0.08	0.06	0.06	0.05	0.04	0.03
SiO2	47.41	44.87	45.14	45.34	45.54	46.03	46.07	45.93	46.25	46.30	46.60	46.91
SO_3	0.07	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
SrO	0.03	1.89	1.64	1.39	1.18	0.99	0.89	0.79	0.70	0.60	0.48	0.44
TeO_2	§	0.07	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.01	<0.01	0.01
TiO_2	§	0.17	0.17	0.16	0.14	0.14	0.13	0.13	0.12	0.12	0.11	0.11
ZnO	2.01	1.79	1.81	1.75	1.76	1.74	1.72	1.75	1.72	1.77	1.68	1.74
ZrO_2	3.80	4.08	4.21	4.11	4.27	4.28	4.32	4.39	4.41	4.53	4.34	4.51
Sum	100.00	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.
NA – Not analyzed
§ Not a target constituent
"-" Empty data field

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

Glass Mass (kg)		332.4	364.1	392.1	427.2	453.6	492.1	519.5	544.0	581.5	583.4	544-583 kg	
-	Target	BLE-G-34A	BLE-G-37A	BLE-G-40B	BLE-G-46A	BLE-G-49A	BLE-G-53B	BLE-G-55A	BLE-G-58B	BLE-G-61A	BLE-G-70A	Avg.	%Dev
Al_2O_3	5.19	5.99	6.29	5.75	6.03	5.85	5.80	5.80	5.68	5.66	5.68	5.67	9.24
As_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
B_2O_3*	11.90	11.60	11.65	11.68	11.72	11.75	11.78	11.79	11.81	11.82	11.83	NC	NC
BaO	0.02	0.06	<0.01	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	NC
CaO	0.28	0.38	0.37	0.37	0.37	0.37	0.35	0.36	0.36	0.35	0.35	0.35	NC
CdO	0.06	0.13	0.12	0.12	0.11	0.10	0.10	0.10	0.10	0.10	0.09	0.09	NC
Ce_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
Cr_2O_3	§	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.04	0.05	0.05	NC
Cs_2O	§	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	<0.01	0.01	0.01	NC
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	NC
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NC	NC
Fe_2O_3	12.21	11.18	10.94	11.38	11.30	11.53	11.51	11.48	11.56	11.65	11.39	11.53	-5.57
I	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
K_2O	0.03	0.16	0.19	0.14	0.15	0.15	0.15	0.14	0.13	0.14	0.14	0.14	NC
La_2O_3	0.41	0.36	0.36	0.37	0.37	0.39	0.38	0.39	0.39	0.39	0.38	0.39	-5.85
Li_2O*	3.52	3.91	3.85	3.80	3.75	3.72	3.68	3.66	3.64	3.62	3.62	3.63	2.97
MgO	0.11	0.26	0.26	0.23	0.23	0.19	0.17	0.18	0.11	0.13	0.09	0.11	NC
MnO	0.17	0.69	0.64	0.61	0.56	0.51	0.46	0.44	0.40	0.38	0.37	0.39	NC
Na_2O	11.65	10.88	10.97	11.22	11.02	10.94	11.07	11.28	11.08	10.98	11.48	11.18	-4.05
Nd_2O_3	0.31	0.23	0.23	0.25	0.26	0.27	0.26	0.27	0.27	0.27	0.27	0.27	-12.01
NiO	0.61	0.57	0.56	0.59	0.58	0.60	0.59	0.59	0.58	0.58	0.57	0.58	-5.32
P_2O_5	0.00	0.07	0.06	0.05	0.06	0.04	0.05	0.04	0.04	0.04	0.04	0.04	NC
PbO	0.03	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.04	0.03	0.03	0.03	NC
Sb_2O_3	§	0.04	0.03	0.03	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	NC
SiO_2	47.41	46.35	46.64	46.25	46.49	46.45	46.60	46.45	46.73	46.74	46.84	46.77	-1.35
SO_3	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	NC
SrO	0.03	0.39	0.34	0.31	0.27	0.24	0.21	0.20	0.18	0.16	0.15	0.16	NC
TeO_2	§	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
TiO_2	0.00	0.11	0.11	0.10	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	NC
ZnO	2.01	1.76	1.69	1.76	1.74	1.78	1.75	1.76	1.76	1.78	1.74	1.76	-12.39
ZrO_2	3.80	4.66	4.48	4.71	4.62	4.73	4.73	4.74	4.81	4.88	4.66	4.78	25.86
Sum	100.00	100.00	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.
NA – Not analyzed
NC – Not calculated
§ Not a target constituent
"-" Empty data field

Table 4.1.a. Summary of Test Conditions and Results for Tests 1 and 2.

Test		1					2
		A	B	C	D	E	
Time	Feed Start	7/23/02 13:12	7/25/02 14:25	7/26/02 14:26	7/27/02 14:27	7/28/02 16:16	7/31/02 01:39
	Feed End	7/25/02 14:25	7/26/02 14:26	7/27/02 14:27	7/28/02 14:26	7/31/02 00:59	8/01/02 15:25
	Interval	49.2 hr	24 hr	24 hr	24 hr	56.7 hr	36.2 hr
Water Feeding for Cold Cap		1.2 hr	NA	NA	NA	NA	NA
Slurry Feeding		48 hr	24 hr	24 hr	24 hr	56.7 hr	33.8 hr
Cold Cap Burn		NA	NA	NA	NA	NA	2.4 hr
Bubbling Rate (lpm)	Average	7.5	26	43	65	73	69
	Range	6.0 - 11	10 - 33	29 - 54	49 - 74	11 - 107	23 - 99
Feed	Used	2634 kg	2032 kg	2586 kg	3199 kg	7209 kg	3506 kg
	Glass Yield#	504 g/l	504 g/l	504 g/l	504 g/l	504 g/l	281 g/l
		0.37 kg/kg	0.37 kg/kg	0.37 kg/kg	0.37 kg/kg	0.37 kg/kg	0.23 kg/kg
	Average Rate	54.9 kg/hr	84.7 kg/hr	107.8 kg/hr	133.3 kg/hr	127.1 kg/hr	103.7 kg/hr
Glass Produced	Poured	879.4 kg	688.9 kg	1055.4 kg	1198.4 kg	2732.0 kg	863.5 kg
	Average Rate$	366 $kg/m^2/day$	574 $kg/m^2/day$	880 $kg/m^2/day$	999 $kg/m^2/day$	964 $kg/m^2/day$	510 $kg/m^2/day$
	Average Rate*	406 $kg/m^2/day$	627 $kg/m^2/day$	797 $kg/m^2/day$	986 $kg/m^2/day$	941 $kg/m^2/day$	477 $kg/m^2/day$
	Steady State Rate*	400 $kg/m^2/day$	630 $kg/m^2/day$	800 $kg/m^2/day$	1000 $kg/m^2/day$	Not Achieved	500 $kg/m^2/day$
	Average Power Use	4.9 kW.hr/ kg glass	4.0 kW.hr/ kg glass	3.6 kW.hr/ kg glass	3.3 kW.hr/ kg glass	3.3 kW.hr/ kg glass	6.2 kW.hr/ kg glass

- Average measured values.
$ - 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 4.1.b. Summary of Test Conditions and Results for Tests 3 and 4.

Test		3			4		
		A	B	C	A	B	C
Time	Feed Start	9/09/02 19:46	9/12/02 20:59	9/15/02 21:00	9/23/02 16:02	9/26/02 19:01	9/29/02 19:02
Time	Feed End	9/12/02 20:58	9/15/02 20:59	9/18/02 21:01	9/26/02 19:00	9/29/02 19:01	10/02/02 21:30
Time	Interval	73.2 hr	72 hr	74.9 hr	75 hr	72 hr	74.5 hr
Water Feeding for Cold Cap		1.2 hr	NA	NA	3.0 hr	NA	NA
Slurry Feeding		72 hr	72 hr	72 hr	72 hr	72 hr	72 hr
Cold Cap Burn		NA	NA	2.9 hr	NA	NA	2.5 hr
Bubbling Rate		8 lpm	40 lpm	65 lpm	8 lpm	40 lpm	65 lpm
Feed	Used	3955 kg	6220 kg	8399 kg	3099 kg	5506 kg	8120 kg
Feed	Glass Yield#	530 g/l	530 g/l	530 g/l	400 g/l	400 g/l	400 g/l
Feed	Glass Yield#	0.375 kg/kg	0.375 kg/kg	0.375 kg/kg	0.315 kg/kg	0.315 kg/kg	0.315 kg/kg
Feed	Average Rate	54.9 kg/hr	86.4 kg/hr	116.7 kg/hr	43.0 kg/hr	76.5 kg/hr	112.8 kg/hr
Glass Produced	Poured	1502.6 kg	2356.5 kg	3116.1 kg	1032.6 kg	1710.4 kg	2491.8 kg
Glass Produced	Average Rate$	417 $kg/m^2/day$	655 $kg/m^2/day$	866 $kg/m^2/day$	287 $kg/m^2/day$	475 $kg/m^2/day$	692 $kg/m^2/day$
Glass Produced	Average Rate*	412 $kg/m^2/day$	648 $kg/m^2/day$	875 $kg/m^2/day$	271 $kg/m^2/day$	481 $kg/m^2/day$	709 $kg/m^2/day$
Glass Produced	Steady State Rate*	400 $kg/m^2/day$	655 $kg/m^2/day$	900 $kg/m^2/day$	270 $kg/m^2/day$	500 $kg/m^2/day$	750 $kg/m^2/day$
Glass Produced	Average Power Use	4.8 kW.hr/ kg glass	3.9 kW.hr/ kg glass	3.4 kW.hr/ kg glass	7.0 kW.hr/ kg glass	5.2 kW.hr/ kg glass	4.3 kW.hr/ kg glass

- Target values.
$ - 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 4.1.c. Summary of Test Conditions and Results for Tests 5 and 6.

Test		5			6
		A	B	C	
Time	Feed Start	10/15/02 13:30	10/18/02 14:31	10/21/02 14:32	10/07/02 12:49
	Feed End	10/18/02 14:30	10/21/02 14:31	10/24/02 17:30	10/12/02 20:30
	Interval	73 hr	72 hr	75 hr	127.7 hr
Water Feeding for Cold Cap		1 hr	NA	NA	1.5 hr
Slurry Feeding		72 hr	72 hr	72 hr	122.7 hr
Cold Cap Burn		NA	NA	3 hr	3.5 hr
Bubbling Rate		8 lpm	40 lpm	65 lpm	< lpm
Feed	Used	3410 kg	6816 kg	9726 kg	3453 kg
	Glass Yield#	300 g/l	300 g/l	300 g/l	400 g/l
		0.249 kg/kg	0. 249 kg/kg	0. 249 kg/kg	0.315 kg/kg
	Average Rate	47.4 kg/hr	94.7 kg/hr	135.1 kg/hr	28.1 kg/hr
Glass Produced	Poured	825.6 kg	1508.0 kg	2098.9 kg	1049.2 kg
	Average Rate$	229 kg/m^2/day	419 kg/m^2/day	583 kg/m^2/day	171 kg/m^2/day
	Average Rate*	235 kg/m^2/day	471 kg/m^2/day	672kg/m^2/day	177 kg/m^2/day
	Steady State Rate*	250 kg/m^2/day	450 kg/m^2/day	550 kg/m^2/day	190 kg/m^2/day
	Average Power Use	8.5 kW.hr/ kg glass	5.5 kW.hr/ kg glass	4.4 kW.hr/ kg glass	9.1 kW.hr/ kg glass

- Target Values.
$ - 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.a. DM1200 Melter System Measured Parameters during Tests 1 and 2.

-			Test 1															Test 2		
			A			B			C			D			E			2		
			Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
TEMPERATURE (°C)	Glass	1" from floor E	1135	1109	1161	1143	1123	1159	1158	1143	1169	1159	1148	1170	1149	1126	1165	1148	1127	1163
		13" from floor E	1149	1122	1164	1146	1114	1157	1143	1129	1158	1143	1124	1156	1134	1101	1166	1137	1112	1167
		18" from floor E	1150	1128	1174	1150	1114	1165	1149	1120	1171	1150	1126	1170	1142	1111	1179	1140	1111	1169
		27" from floor E	727	380	907	781	597	974	780	517	941	788	549	926	821	289	1075	844	411	1025
		9" from floor W	1137	1110	1161	1140	1127	1150	1142	1132	1154	1145	1128	1167	1155	1110	1175	1157	1134	1183
		18" from floor W	1156	1124	1178	1156	1138	1168	1153	1141	1168	1149	1128	1161	1152	1113	1174	1161	1126	1186
		24" from floor W	928	776	1035	958	873	1072	966	842	1066	915	807	1044	938	674	1115	989	826	1141
		30" from floor W	579	348	793	630	475	745	623	489	779	571	422	765	599	229	925	657	268	958
	Plenum	8" below ceiling	545	462	767	489	439	544	489	439	569	492	466	543	505	454	665	519	428	599
		17" below ceiling	531	450	761	504	460	561	496	436	554	496	462	567	495	423	673	507	427	590
		Exposed	540	301	740	494	423	556	499	442	615	502	460	574	517	441	700	561	435	676
	Discharge	TC 1	1015	652	1069	1049	954	1077	1064	1047	1083	1028	862	1094	999	602	1056	1014	988	1047
		TC 2	1043	684	1090	1072	1028	1090	1082	1064	1101	1055	959	1099	999	713	1047	1004	982	1034
		Air Flow	201	156	244	201	185	237	204	184	237	201	174	231	187	145	218	182	173	209
		Riser	1080	1017	1139	1093	1075	1145	1109	1084	1148	1123	1111	1151	1103	1076	1150	1081	1057	1144
	Electrode	East	1102	1091	1113	1109	1097	1118	1127	1108	1137	1139	1129	1146	1132	1088	1145	1120	1102	1133
		West	1072	1035	1099	1086	1066	1097	1107	1085	1120	1117	1102	1124	1107	1075	1125	1097	1069	1122
		Bottom	1053	1014	1067	1060	1048	1071	1075	1067	1082	1078	1070	1085	1067	1054	1077	1068	1056	1084
	Film Cooler Outlet		342	69	582	348	68	404	361	71	415	374	75	421	371	72	459	368	70	429
Glass	Density (g/cc)		2.35	2.29	2.42	2.31	2.27	2.36	2.29	2.23	2.33	2.26	2.18	2.32	2.24	2.13	2.37	2.27	2.18	2.36
	Level (" from floor)		27.9	26.8	29.4	28.6	27.7	29.8	28.7	27.7	29.5	28.6	27.3	29.6	28.8	26.7	30.8	28.9	27.6	30.3
	Resistance (ohms)		0.103	0.098	0.111	0.105	0.100	0.110	0.104	0.100	0.108	0.106	0.103	0.110	0.110	0.101	0.120	0.109	0.100	0.118
Differential Pressure (inches water)		Transition Line	1.69	1.06	3.72	1.59	1.20	2.98	1.87	1.31	3.74	2.04	1.07	5.34	2.17	1.00	6.17	2.31	1.29	4.50
		Film Cooler	1.75	0.99	3.87	1.30	0.95	2.37	1.40	1.03	2.70	1.51	1.06	4.24	1.44	0.72	4.74	1.49	0.93	2.27
Electrodes	Current (A)		986.7	897.5	1231.4	1095.9	1016.6	1114.2	1176.3	1087.3	1215.4	1231.6	1177.3	1240.1	1193.9	837.1	1239.5	1163.7	1065.7	1218.9
	Voltage (V)		101.8	94.5	136.2	114.7	109.2	119.5	122.0	111.4	126.5	130.8	123.0	135.0	131.0	88.9	148.1	126.8	120.0	134.7
	Power (kW)		100.4	84.9	167.7	125.7	111.0	133.1	143.5	121.2	153.7	161.1	144.8	167.4	156.4	74.4	183.6	147.5	127.9	164.1
Lance Bubblers	1	Rate (lpm)	1.9	1.0	4.6	12.3	3.5	20.7	19.1	13.1	25.3	30.6	23.1	35.0	34.8	4.1	52.1	31.0	15.1	60.0
		Temp. (°C)	1161	1132	1177	1146	1115	1159	1140	1116	1162	1112	1090	1131	1095	1043	1160	1108	1051	1165
	2	Rate (lpm)	2.5	1.4	6.0	10.6	3.4	15.2	20.3	12.9	25.3	30.7	23.0	36.1	35.3	3.9	52.0	35.3	19.9	59.9
		Temp. (°C)	1155	1117	1175	1147	1134	1158	1143	1125	1156	1125	1107	1149	1107	1054	1151	1104	1058	1160
Total Bubbling (lpm)			7.5	6.0	10.6	26.1	10.1	33.4	42.6	29.1	53.6	64.5	49.3	74.2	73.4	11.1	107.2	68.5	23.2	98.9

"-" Empty data field

Table 4.2.b. DM1200 Melter System Measured Parameters during Test 3.

-			A			B			C		
			Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
TEMPERATURE (°C)	Glass	13" from floor E	1147	1135	1166	1142	1117	1173	1146	1116	1178
		15.5" from floor E	1140	1126	1174	1135	1103	1170	1135	1097	1172
		18" from floor E	1149	1132	1192	1147	1107	1184	1145	1101	1181
		27" from floor E	1040	814	1196	981	800	1114	950	552	1110
		13" from floor W	1159	1130	1174	1157	1129	1177	1153	1125	1186
		15.5" from floor W	1156	1128	1179	1155	1125	1177	1150	1121	1186
		18" from floor W	1151	1127	1183	1157	1115	1181	1149	1112	1183
		27" from floor W	1089	930	1154	1088	957	1171	1043	910	1168
	Plenum	8" below ceiling	516	448	708	481	425	549	508	448	644
		17" below ceiling	493	445	707	485	427	550	516	461	638
		Exposed	504	423	700	476	397	583	521	434	716
	Discharge	TC 1	997	934	1057	995	864	1057	1002	837	1057
		TC 2	1037	980	1093	1037	1000	1094	1047	961	1097
		Air Flow	169	145	197	171	160	196	166	87	192
		Riser	996	912	1054	1054	1004	1130	1089	1049	1155
	Electrode	East	1109	1076	1136	1137	1114	1145	1147	1117	1162
		West	1093	1038	1110	1104	1078	1122	1111	1085	1126
		Bottom	1043	1025	1054	1066	1038	1078	1072	1057	1082
	Film Cooler Outlet		324	66	501	351	72	411	372	62	444
Glass	Density (g/cc)	-	2.36	2.12	2.43	2.33	2.27	2.39	2.30	2.22	2.41
	Level (" from floor)	-	27.9	27.1	30.2	27.7	26.8	28.6	27.8	26.9	28.9
	Resistance (ohms)	-	0.109	0.103	0.122	0.106	0.101	0.115	0.107	<0.001	0.114
Differential Pressure (inches water)		Transition Line	5.36	-2.50	8.57	6.68	3.71	10.04	6.26	<0.01	10.05
		Film Cooler	0.91	-2.50	2.24	1.07	0.46	1.75	1.17	<0.01	2.86
Electrodes	Current (A)		948.0	723.3	1042.8	1087.7	987.8	1126.6	1181.2	<0.1	1203.6
	Voltage (V)		103.5	76.8	124.4	115.7	107.4	124.3	126.2	<0.1	132.1
	Power (kW)		98.1	55.6	129.7	125.8	106.1	140.0	149.1	<0.1	159.0
Lance Bubblers	1	Rate (lpm)	3.1	1.5	7.1	19.5	7.1	25.6	29.5	5.1	36.7
		Temp. (°C)	1159	1110	1177	1131	1111	1162	1112	1074	1184
	2	Rate (lpm)	3.4	1.4	7.8	19.0	7.7	24.2	31.6	4.9	38.0
		Temp. (°C)	1155	1117	1170	1148	1120	1168	1129	1105	1177
Total Bubbling (lpm)			7.6	3.9	15.9	39.5	15.8	40.2	62.0	11.0	65.6

"-" Empty data field

Table 4.2.c. DM1200 Melter System Measured Parameters during Test 4.

-			A			B			C		
			Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
TEMPERATURE (°C)	Glass	13" from floor E	1152	1102	1203	1145	1109	1190	1147	1117	1173
		15.5" from floor E	1141	1089	1202	1133	1095	1194	1134	1095	1168
		18" from floor E	1146	1098	1215	1142	1102	1209	1144	1107	1182
		27" from floor E	1019	858	1205	967	753	1211	949	630	1127
		13" from floor W	1156	1104	1207	1152	1114	1199	1152	1131	1173
		15.5" from floor W	1154	1102	1209	1150	1108	1201	1150	1124	1172
		18" from floor W	1149	1099	1222	1146	1101	1209	1146	1118	1172
		27" from floor W	978	684	1211	948	614	1217	920	668	1117
	Plenum	8" below ceiling	558	442	690	564	461	636	552	498	640
		17" below ceiling	549	438	643	564	429	634	547	494	632
		Exposed	555	257	661	576	459	658	585	500	682
	Discharge	TC 1	988	882	1062	1001	945	1049	1022	1002	1061
		TC 2	1030	913	1099	1044	991	1089	1062	1041	1097
		Air Flow	166	153	194	169	110	194	168	152	190
		Riser	1019	941	1122	1066	1016	1164	1092	1057	1152
	Electrode	East	1108	1072	1160	1123	1082	1156	1138	1108	1154
		West	1069	1031	1149	1087	1052	1131	1098	1072	1121
		Bottom	1039	1023	1075	1050	1030	1076	1068	1037	1082
	Film Cooler Outlet		357	62	451	397	69	481	383	74	439
Glass	Density (g/cc)		2.37	2.13	2.46	2.33	2.05	2.41	2.32	2.24	2.38
	Level (" from floor)		27.7	26.1	29.2	27.3	25.87	43.5	27.7	26.8	28.6
	Resistance (ohms)		0.107	0.093	0.122	0.109	<0.001	0.121	0.105	0.096	0.113
Differential Pressure (inches water)		Transition Line	1.80	0.54	3.41	1.71	0.52	3.55	1.95	0.83	3.92
		Film Cooler	0.86	-0.09	2.16	1.10	-0.49	2.77	1.39	0.39	3.07
Electrodes	Current (A)		942.8	697.1	1031.4	1073.7	<0.1	1142.0	1206.9	1099.8	1219.7
	Voltage (V)		100.2	66.8	109.6	116.5	<0.1	124.7	127.1	119.0	132.4
	Power (kW)		94.4	46.5	113.1	125.1	<0.1	142.4	153.3	130.8	161.4
Lance Bubblers	1	Rate (lpm)	2.8	0.9	4.9	18.2	1.5	25.1	27.6	11.5	39.4
		Temp. (°C)	1159	1110	1207	1136	1098	1186	1129	1103	1156
	2	Rate (lpm)	3.9	1.4	4.9	18.0	1.4	29.5	34.4	23.4	42.6
		Temp. (°C)	1148	1096	1207	1136	1090	1186	1111	1075	1144
Total Bubbling (lpm)			7.8	4.0	8.0	37.2	4.0	41.1	63.0	40.0	67.0

"-" Empty data field

Table 4.2.d. DM1200 Melter System Measured Parameters during Test 5.

-			A			B			C		
			Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
TEMPERATURE (°C)	Glass	13" from floor E	1146	1107	1176	1142	1114	1157	1136	1088	1156
TEMPERATURE (°C)	Glass	15.5" from floor E	1135	1093	1170	1143	569	1178	1153	1110	1176
TEMPERATURE (°C)	Glass	18" from floor E	1140	1101	1184	1140	1099	1158	1137	1083	1166
TEMPERATURE (°C)	Glass	27" from floor E	991	667	1179	934	655	1102	928	652	1107
TEMPERATURE (°C)	Glass	13" from floor W	1150	1113	1180	1147	1111	1173	1147	1114	1176
TEMPERATURE (°C)	Glass	15.5" from floor W	1149	1112	1183	1145	1110	1170	1147	1115	1173
TEMPERATURE (°C)	Glass	18" from floor W	1145	1103	1195	1141	1106	1163	1145	1102	1173
TEMPERATURE (°C)	Glass	27" from floor W	948	595	1178	891	614	1075	939	743	1122
TEMPERATURE (°C)	Plenum	8" below ceiling	565	452	703	516	432	609	514	445	590
TEMPERATURE (°C)	Plenum	17" below ceiling	553	427	692	498	425	571	517	434	594
TEMPERATURE (°C)	Plenum	Exposed	569	434	688	529	431	625	532	445	626
TEMPERATURE (°C)	Discharge	TC 1	1007	833	1055	998	826	1058	1015	940	1065
TEMPERATURE (°C)	Discharge	TC 2	1055	975	1094	1048	976	1103	1062	1034	1111
TEMPERATURE (°C)	Discharge	Air Flow	165	142	193	163	146	185	165	150	185
TEMPERATURE (°C)	Discharge	Riser	1026	878	1131	1075	1034	1140	1088	1062	1156
TEMPERATURE (°C)	Electrode	East	1099	1065	1125	1115	1088	1133	1137	1106	1151
TEMPERATURE (°C)	Electrode	West	1064	996	1119	1088	1057	1112	1106	1078	1130
TEMPERATURE (°C)	Electrode	Bottom	1021	949	1057	1050	1033	1066	1072	1056	1085
TEMPERATURE (°C)	Film Cooler Outlet		384	68	499	361	71	417	379	73	445
Glass	Density (g/cc)		2.37	2.16	2.45	2.34	2.22	2.40	2.34	2.24	2.41
Glass	Level (" from floor)		27.5	26.6	28.8	27.5	26.5	28.5	27.5	26.3	28.5
Glass	Resistance (ohms)		0.109	0.098	0.129	0.108	0.100	0.114	0.105	0.098	0.117
Differential Pressure (inches water)	Transition Line		1.75	0.40	3.88	2.02	0.67	3.42	2.12	0.61	4.49
Differential Pressure (inches water)	Film Cooler		1.13	0.27	3.38	1.26	0.13	2.53	1.40	0.23	3.45
Electrodes	Current (A)		962.3	714.3	948.3	1097.9	1019.5	1116.5	1190.9	1109.3	1225.9
Electrodes	Voltage (V)		104.2	74.8	119.7	118.4	106.7	125.0	124.7	114.4	131.2
Electrodes	Power (kW)		100.2	53.4	113.5	130.0	108.8	139.6	148.5	126.9	160.8
Lance Bubblers	1	Rate (lpm)	2.8	1.4	5.0	14.7	2.9	30.0	31.2	13.8	49.9
Lance Bubblers	1	Temp. (°C)	1150	1112	1184	1141	1102	1164	1108	1047	1158
Lance Bubblers	2	Rate (lpm)	3.9	1.2	5.6	21.0	2.8	30.2	30.1	13.4	49.9
Lance Bubblers	2	Temp. (°C)	1136	-70	1178	1131	1098	1171	1122	1073	1162
Total Bubbling (lpm)			7.7	3.6	8.4	36.7	11.7	42.9	62.3	41.7	72.0

"-" Empty data field

Table 4.2.e. DM1200 Melter System Measured Parameters during Test 6.

-			Avg.	Min.	Max.
TEMPERATURE (°C)	Glass	13" from floor E	1148	1092	1184
		15.5" from floor E	1140	1088	1183
		18" from floor E	1151	1089	1195
		27" from floor E	956	450	1166
		13" from floor W	1152	1116	1193
		15.5" from floor W	1149	1111	1191
		18" from floor W	1151	1110	1195
		27" from floor W	914	553	1188
	Plenum	8" below ceiling	497	389	685
		17" below ceiling	488	378	674
		Exposed	505	297	680
	Discharge	TC 1	989	929	1040
		TC 2	1031	978	1081
		Air Flow	159	142	190
		Riser	1007	935	1133
	Electrode	East	1089	1070	1131
		West	1074	1058	1133
		Bottom	1011	988	1039
	Film Cooler Outlet		323	61	470
Glass	Density (g/cc)		2.39	2.27	2.46
	Level (" from floor)		27.4	26.2	28.4
	Resistance (ohms)		0.107	0.096	0.122
Differential Pressure (inches water)	Transition Line		1.62	0.28	4.27
	Film Cooler		0.91	0.05	3.26
Electrodes	Current (A)		869.0	650.8	974.7
	Voltage (V)		93.0	65.1	104.6
	Power (kW)		80.8	42.3	102.0

Table 5.1. DuraMelter 1200 AZ-101 Bubbling Tests Off-Gas System Measured Parameters.

Test #		1A			1B			1C		
-		Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Melter	Pressure at Level Detector Port ("water)	-5.0	-6.4	1.0	-5.0	-6.5	-3.3	-5.0	-6.3	-2.7
	Pressure at Instrument Port ("water)	-5.1	-6.6	0.6	-5.2	-6.6	-3.4	-5.1	-6.6	-2.6
SBS	Differential Pressure ("water)	41.5	38.1	44.1	42.1	39.6	44.3	42.8	40.1	46.0
	Inlet Gas Pressure ("water)	-8.1	-11.0	-5.2	-7.7	-10.4	-5.9	-8.0	-9.8	-6.5
	Outlet Gas Pressure ("water)	-49.9	-54.3	-47.4	-50.3	-53.6	-47.7	-51.2	-55.8	-48.1
	Inlet Gas Temp. (°C)	262	131	465	254	135	291	262	154	294
	Outlet Gas Temp. (°C)	39.3	32.9	51.8	39.4	35.1	42.6	40.0	38.0	43.3
	Chilled Water Inlet Temp (°C)	14.4	12.1	18.5	14.7	11.4	17.3	15.1	12.4	16.8
	Chilled Water Outlet Temp (°C)	27.3	18.5	42.9	27.9	18.4	38.8	20.4	18.1	30.2
	Submerged 48" Temp (°C)	39.5	32.4	52.9	39.9	35.6	43.7	40.4	38.1	43.6
	Submerged 60" Temp (°C)	39.5	32.2	52.8	39.9	35.0	43.5	40.4	38.1	43.7
	Submerged 72" Temp (°C)	40.1	32.5	52.9	40.6	35.8	44.4	41.0	38.4	45.6
	Submerged 78" Temp (°C)	39.5	32.2	52.8	40.0	35.3	44.1	40.4	38.3	44.4
	Recirc. Pump Discharge Temp (°C)	38.7	31.5	47.9	38.9	34.9	41.0	39.3	37.6	42.1
	Heat Exchanger Outlet Temp (°C)	34.0	20.6	43.2	31.9	24.0	38.3	33.6	31.4	37.2
	Chilled Water Flow (gal/min)	11.4	3.2	49.9	7.8	3.2	53.4	49.8	8.9	53.4
	Heat Exchanger Flow (gal/min)	13.3	0.5	44.9	21.0	6.4	42.5	15.8	11.8	17.8
	Recirc. Pump Discharge Pressure	37.9	30.7	40.1	38.2	31.1	40.2	38.3	31.2	40.4
	Inner C. Coil W. Inlet Temp (°C)	30.3	16.9	46.7	26.3	18.9	35.7	28.3	25.5	32.5
	Inner C. Coil W. Outlet Temp(°C)	35.1	25.3	47.1	33.4	27.4	39.1	34.5	32.3	38.3
	Inner C. Coil W. Flow (gal/min)	25.2	24.3	25.9	25.0	24.3	25.6	25.1	24.5	25.8
WESP	Differential Pressure ("water)	2.6	2.2	3.0	2.6	2.3	3.0	2.6	2.0	2.9
	Inlet Gas Temp. (°C)	40.1	36.0	54.5	39.5	35.8	42.4	40.0	38.0	42.2
	Outlet Gas Temp. (°C)	41.1	32.4	50.5	41.1	33.9	43.3	41.5	32.4	44.1
HEME #1, Outlet Gas Temp. (°C)		40.4	36.0	50.6	39.7	36.9	42.1	40.2	36.6	42.1
HEPA 1	Differential Pressure ("water)	0.3	0.2	0.3	0.3	0.2	0.3	0.3	0.2	2.4
	Outlet Gas Temp. (°C)	65.5	64.4	67.2	65.3	64.4	66.0	65.5	64.9	66.1
PAXTON 1 Outlet Gas Temp. (°C)		88.1	87.3	89.8	87.9	87.0	88.5	88.1	87.5	89.3
TCO	Inlet Gas Temp. (°C)	496	444	504	497	490	504	497	492	503
	Differential Pressure ("water)	3.3	2.8	3.5	3.3	3.2	3.5	3.3	3.1	3.4
SCR	Inlet Gas Temp. (°C)	382	352	384	382	378	384	383	380	385
	Outlet Gas Temp. Right (°C)	360	330	363	360	357	366	360	357	363
	Outlet Gas Temp. Left (°C)	327	293	331	326	323	333	324	319	329
	Differential Pressure ("water)	4.8	4.8	4.9	4.8	4.8	4.9	4.8	4.8	4.9
	Post Outlet Gas Temp. (°C)	317	288	320	317	315	322	316	313	319
PBS	Inlet Gas Temp. (°C)	299	272	302	299	298	301	299	296	301
	PBS Sump Temp. (°C)	24.5	22.5	29.3	24.7	23.1	27.7	26.5	24.8	27.4
	Differential Pressure ("water)	2.6	1.5	4.2	2.5	2.0	2.9	2.5	2.2	3.0
HEME #2	Inlet Gas Temp. (°C)	30.3	26.6	38.8	29.6	28.3	36.7	30.9	28.5	32.4
	Outlet Gas Temp. (°C)	32.1	28.9	39.7	31.3	29.9	37.9	32.7	30.8	34.4
Exhaust Stack Absolute Pressure ("water)		-7.3	-7.5	-7.1	-7.4	-7.6	-6.1	-7.3	-7.4	-7.1

"-" Empty data field

Table 5.1. DuraMelter 1200 AZ-101 Bubbling Tests Off-Gas System Measured Parameters (continued).

Test #		1D			1E			2		
	-	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Melter	Pressure at Level Detector Port ("water)	-5.0	-6.7	-1.8	-5.0	-6.6	-2.5	-5.0	-6.4	-0.6
	Pressure at Instrument Port ("water)	-5.1	-6.8	-1.9	-5.1	-6.5	-2.6	-5.1	-6.6	-0.8
SBS	Differential Pressure ("water)	43.7	40.6	50.0	46.0	43.1	49.6	46.8	43.4	51.3
	Inlet Gas Pressure ("water)	-8.5	-11.6	-4.7	-8.4	-13.5	-6.5	-8.6	-11.7	-4.9
	Outlet Gas Pressure ("water)	-52.5	-57.7	-49.2	-52.4	-61.0	-48.5	-53.2	-57.7	-49.2
	Inlet Gas Temp. (°C)	275	132	303	270	167	320	273	170	325
	Outlet Gas Temp. (°C)	39.8	36.7	45.3	39.4	22.4	45.2	39.9	34.0	47.0
	Chilled Water Inlet Temp (°C)	15.9	13.9	19.8	15.7	12.6	25.0	15.7	13.5	23.6
	Chilled Water Outlet Temp (°C)	20.3	18.4	24.2	23.7	15.6	38.2	26.3	19.2	44.4
	Submerged 48" Temp (°C)	40.2	37.0	45.9	39.6	19.1	47.7	40.0	33.7	47.8
	Submerged 60" Temp (°C)	40.1	36.6	45.9	39.5	19.1	47.5	39.9	33.7	47.8
	Submerged 72" Temp (°C)	40.8	37.2	47.1	40.1	19.8	47.6	40.4	34.0	47.8
	Submerged 78" Temp (°C)	40.2	36.9	45.9	39.7	19.1	47.2	40.1	33.8	47.8
	Recirc. Pump Discharge Temp (°C)	39.1	36.4	43.8	38.6	19.7	43.1	39.1	33.9	44.1
	Heat Exchanger Outlet Temp (°C)	29.9	25.4	42.5	28.5	15.8	41.2	28.5	24.0	42.0
	Chilled Water Flow (gal/min)	52.6	50.3	53.4	34.7	6.4	53.4	21.6	3.2	53.4
	Heat Exchanger Flow (gal/min)	29.7	3.2	42.3	33.3	0.6	44.9	36.0	8.5	44.9
	Recirc. Pump Discharge Pressure	38.5	31.0	40.7	38.8	30.9	41.0	38.9	31.6	41.0
	Inner C. Coil W. Inlet Temp (°C)	24.0	19.8	41.2	22.9	14.9	44.5	22.2	19.2	37.2
	Inner C. Coil W. Outlet Temp(°C)	32.4	29.0	43.6	31.7	17.1	44.5	31.7	26.5	43.0
	Inner C. Coil W. Flow (gal/min)	24.9	24.1	25.8	24.9	24.1	26.1	24.9	24.3	25.6
WESP	Differential Pressure ("water)	2.6	1.1	3.3	2.6	1.5	3.0	2.5	2.0	3.2
	Inlet Gas Temp. (°C)	40.2	37.5	44.7	40.0	24.6	44.4	40.6	35.8	46.4
	Outlet Gas Temp. (°C)	41.9	31.3	45.9	41.6	30.4	45.1	42.0	32.3	46.6
HEME #1, Outlet Gas Temp. (°C)		40.1	35.7	43.6	40.1	29.6	43.6	40.5	36.4	44.3
HEPA 1	Differential Pressure ("water)	0.3	0.2	0.4	0.3	0.2	0.3	0.3	0.2	0.3
	Outlet Gas Temp. (°C)	65.5	64.4	66.4	64.0	59.2	64.9	64.0	63.1	64.8
PAXTON 1 Outlet Gas Temp. (°C)		89.3	87.9	92.8	86.8	76.8	87.9	86.8	86.3	87.6
TCO	Inlet Gas Temp. (°C)	497	491	504	497	491	523	497	493	502
	Differential Pressure ("water)	3.3	2.8	3.7	3.3	2.5	3.4	3.3	3.1	3.4
SCR	Inlet Gas Temp. (°C)	382	376	387	383	308	388	382	375	384
	Outlet Gas Temp. Right (°C)	360	352	366	362	280	368	361	354	364
	Outlet Gas Temp. Left (°C)	324	314	336	330	259	339	330	325	334
	Differential Pressure ("water)	4.8	4.8	4.9	4.8	4.8	4.9	4.8	4.8	4.9
	Post Outlet Gas Temp. (°C)	316	309	324	321	231	326	320	316	323
PBS	Inlet Gas Temp. (°C)	299	292	306	302	186	307	302	297	304
	PBS Sump Temp. (°C)	28.1	25.5	32.7	27.3	16.1	33.8	26.9	24.7	31.9
	Differential Pressure ("water)	2.9	2.2	7.5	2.7	1.8	3.5	2.7	2.2	3.2
HEME #2	Inlet Gas Temp. (°C)	32.1	30.2	36.3	31.0	19.8	37.2	30.7	28.4	35.5
	Outlet Gas Temp. (°C)	33.9	32.2	37.5	32.9	22.2	38.5	32.7	30.7	36.8
Exhaust Stack Absolute Pressure ("water)		-7.2	-7.4	-6.9	-7.2	-7.5	-7.1	-7.3	-7.4	-7.2

"-" Empty data field

Table 5.1. DuraMelter 1200 AZ-101 Bubbling Tests Off-Gas System Measured Parameters (continued).

Test #		3A			3B			3C		
-		Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Melter	Pressure at Level Detector Port ("water)	-3.9	-6.0	1.1	-4.1	-5.5	-2.6	-3.7	-5.4	0.5
	Pressure at Instrument Port ("water)	-4.4	-6.1	0.4	-5.1	-6.4	-3.6	-4.9	-6.6	0.4
SBS	Differential Pressure ("water)	40.6	20.9	45.9	-	-	-	-	-	-
	Inlet Gas Pressure ("water)	-10.1	-16.0	1.2	-11.6	-14.5	-8.6	-10.9	-18.3	0.1
	Outlet Gas Pressure ("water)	-51.0	-56.8	-18.7	-53.8	-56.9	-51.0	-55.1	-62.2	-40.4
	Inlet Gas Temp. (°C)	232	106	413	235	114	272	260	47	303
	Outlet Gas Temp. (°C)	38.6	30.5	47.2	38.9	36.1	42.8	38.6	23.1	44.1
	Chilled Water Inlet Temp (°C)	14.2	10.7	27.7	15.6	10.7	27.1	16.2	11.9	29.8
	Chilled Water Outlet Temp (°C)	20.9	18.2	34.8	22.7	19.5	39.2	24.8	15.5	39.5
	Submerged 48" Temp (°C)	39.7	31.1	49.2	40.3	37.0	44.1	39.9	23.7	45.8
	Submerged 60" Temp (°C)	39.6	31.1	49.1	40.3	37.0	43.7	39.9	23.7	45.8
	Submerged 72" Temp (°C)	40.7	32.3	50.3	41.4	37.8	45.9	40.9	24.9	46.8
	Submerged 78" Temp (°C)	39.7	31.1	49.2	40.4	37.0	44.0	40.0	23.7	45.8
	Recirc. Pump discharge Temp (°C)	38.3	30.2	44.2	38.6	36.0	41.6	38.2	22.8	42.8
	Heat Exchanger Outlet Temp (°C)	34.9	20.4	44.0	33.3	26.7	37.6	30.5	17.9	40.2
	Chilled Water Flow (gal/min)	5.5	2.4	16.7	3.4	2.0	11.4	8.0	1.6	22.4
	Heat Exchanger Flow (gal/min)	4.5	0.6	15.0	9.7	4.5	21.2	14.7	1.9	35.8
	Recirc. Pump Discharge Pressure	37.7	30.7	41.3	37.5	30.7	40.2	37.5	29.6	40.3
	Inner C. Coil W. Inlet Temp (°C)	31.7	16.5	45.1	27.3	20.6	32.9	24.0	15.2	37.9
	Inner C. Coil W. Outlet Temp(°C)	35.9	24.7	45.1	34.5	30.2	38.9	32.8	18.9	40.4
	Inner C. Coil W. Flow (gal/min)	24.5	23.8	25.3	24.4	23.3	25.1	24.3	22.8	25.1
WESP	Differential Pressure ("water)	2.5	0.0	3.2	2.8	2.2	3.3	2.5	1.6	4.7
	Inlet Gas Temp. (°C)	39.4	33.6	49.1	38.9	36.2	42.5	39.1	26.0	44.3
	Outlet Gas Temp. (°C)	40.9	30.8	45.2	41.3	30.2	43.8	41.3	31.2	45.0
HEME #1, Outlet Gas Temp. (°C)		40.0	35.3	47.4	39.9	35.1	42.6	39.7	30.9	43.6
HEPA 1	Differential Pressure ("water)	0.1	-0.2	0.3	0.1	-0.1	0.2	0.1	-0.2	0.2
	Outlet Gas Temp. (°C)	65.6	63.7	67.3	65.6	64.3	66.6	65.1	59.5	66.9
PAXTON 1 Outlet Gas Temp. (°C)		87.5	85.2	102	89.1	87.7	89.9	88.8	83.2	91.5
TCO	Inlet Gas Temp. (°C)	448	416	463	448	443	452	449	404	485
	Differential Pressure ("water)	3.1	1.1	3.5	3.3	3.1	3.5	3.2	2.6	3.9
SCR	Inlet Gas Temp. (°C)	350	336	368	349	345	364	348	260	366
	Outlet Gas Temp. Right (°C)	333	322	347	334	330	346	333	229	349
	Outlet Gas Temp. Left (°C)	303	293	322	303	299	317	305	213	327
	Differential Pressure ("water)	6.3	1.4	7.0	6.7	6.3	7.1	6.5	5.6	8.0
	Post Outlet Gas Temp. (°C)	297	288	309	298	294	310	298	208	313
PBS	Inlet Gas Temp. (°C)	280	271	290	282	278	293	281	185	294
	PBS Sump Temp. (°C)	23.2	21.1	32.7	24.9	22.5	33.0	25.7	18.8	35.7
	Differential Pressure ("water)	2.5	1.1	5.7	2.9	2.4	3.5	2.6	1.8	4.1
HEME #2	Inlet Gas Temp. (°C)	27.0	24.1	36.4	29.3	26.9	37.7	30.1	22.5	40.5
	Outlet Gas Temp. (°C)	29.4	26.8	38.0	31.5	28.7	39.0	32.1	24.9	41.8
Exhaust Stack Absolute Pressure ("water)		-7.7	-8.4	-7.2	-7.7	-8.0	-7.5	-7.7	-7.9	-7.1

"-" Empty data field

Table 5.1. DuraMelter 1200 AZ-101 Bubbling Tests Off-Gas System Measured Parameters (continued).

Test #		4A			4B			4C		
	-	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Melter	Pressure at Level Detector Port ("water)	-3.7	-7.2	-0.2	-4.0	-6.2	0.3	-3.8	-6.3	1.4
	Pressure at Instrument Port ("water)	-4.1	-7.7	-0.3	-4.9	-6.9	0.0	-4.8	-6.8	0.7
SBS	Differential Pressure ("water)	41.4	37.7	51.0	42.9	6.8	47.0	45.4	40.8	49.3
	Inlet Gas Pressure ("water)	-6.5	-10.3	-3.2	-7.0	-10.1	-2.2	-7.2	-10.0	-3.0
	Outlet Gas Pressure ("water)	-48.0	-52.9	-45.3	-50.1	-55.6	-46.3	-52.7	-57.6	-47.4
	Inlet Gas Temp. (°C)	234	103	323	277	134	336	290	158	327
	Outlet Gas Temp. (°C)	39.1	32.0	43.2	38.9	31.3	41.9	39.2	34.0	43.2
	Chilled Water Inlet Temp (°C)	14.0	10.0	18.4	14.6	10.4	19.2	15.4	11.9	25.7
	Chilled Water Outlet Temp (°C)	27.7	18.4	33.2	25.9	21.3	30.5	24.2	19.3	31.8
	Submerged 48" Temp (°C)	39.7	32.7	43.9	39.7	29.6	44.4	40.0	33.8	44.9
	Submerged 60" Temp (°C)	39.7	32.7	43.9	39.7	29.6	44.2	40.0	33.7	44.9
	Submerged 72" Temp (°C)	40.5	34.0	46.2	40.6	29.8	45.8	40.7	34.7	45.9
	Submerged 78" Temp (°C)	39.8	32.7	44.5	40.3	29.8	44.6	40.5	34.7	45.2
	Recirc. Pump Discharge Temp (°C)	38.6	28.1	42.7	38.1	31.1	40.7	38.5	33.8	41.9
	Heat Exchanger Outlet Temp (°C)	36.2	22.0	42.7	33.0	27.0	38.4	29.8	24.1	36.8
	Chilled Water Flow (gal/min)	4.8	2.6	17.0	5.9	2.4	10.8	8.7	2.6	38.8
	Heat Exchanger Flow (gal/min)	3.8	0.5	20.0	8.8	0.6	18.0	15.6	5.6	33.7
	Recirc. Pump Discharge Pressure	38.1	31.2	40.6	38.1	30.8	40.6	38.0	30.9	40.7
	Inner C. Coil W. Inlet Temp (°C)	33.4	18.2	42.6	27.2	23.6	39.2	23.0	17.7	31.8
	Inner C. Coil W. Outlet Temp(°C)	36.8	25.4	42.6	34.1	27.2	39.5	32.5	28.5	37.8
	Inner C. Coil W. Flow (gal/min)	24.6	23.8	25.3	24.4	23.1	25.0	24.3	22.9	24.9
WESP	Differential Pressure ("water)	2.6	1.7	3.4	2.2	-0.2	3.3	2.2	1.6	2.9
	Inlet Gas Temp. (°C)	40.1	34.8	43.5	39.7	33.2	41.9	39.8	35.8	43.1
	Outlet Gas Temp. (°C)	41.5	29.3	43.8	40.8	29.4	42.7	41.0	29.3	43.9
HEME #1, Outlet Gas Temp. (°C)		40.4	34.8	43.1	39.2	33.7	46.0	39.3	34.2	42.3
HEPA 1	Differential Pressure ("water)	0.1	0.0	0.2	0.1	-0.1	0.2	0.2	0.0	0.3
	Outlet Gas Temp. (°C)	62.0	60.8	63.1	61.6	58.0	66.2	63.2	62.6	64.0
PAXTON 1 Outlet Gas Temp. (°C)		82.4	80.7	84.5	82.3	80.8	125	84.6	83.5	85.4
TCO	Inlet Gas Temp. (°C)	458	451	469	458	394	488	458	452	465
	Differential Pressure ("water)	3.3	2.9	3.5	3.1	2.9	3.5	3.0	2.8	3.4
SCR	Inlet Gas Temp. (°C)	356	341	364	352	331	367	352	347	362
	Outlet Gas Temp. Right (°C)	341	323	348	338	317	353	337	333	345
	Outlet Gas Temp. Left (°C)	310	292	318	307	285	321	307	301	320
	Differential Pressure ("water)	6.6	5.8	7.2	6.2	5.8	7.2	6.1	5.6	6.9
	Post Outlet Gas Temp. (°C)	304	290	310	301	285	311	301	297	309
PBS	Inlet Gas Temp. (°C)	287	281	293	284	273	293	283	281	288
	PBS Sump Temp. (°C)	25.2	22.8	27.8	25.2	23.5	28.6	26.2	24.1	33.0
	Differential Pressure ("water)	5.6	3.9	8.6	4.5	0.6	6.6	4.4	3.8	5.4
HEME #2	Inlet Gas Temp. (°C)	27.1	25.0	29.2	26.6	24.8	29.7	27.4	25.7	33.9
	Outlet Gas Temp. (°C)	29.5	27.5	31.7	29.0	27.2	32.1	29.7	28.1	35.3
Exhaust Stack Absolute Pressure ("water)		-7.7	-8.0	-6.5	-7.7	-8.7	-7.4	-7.8	-8.2	-6.9

"-" Empty data field

Table 5.1. DuraMelter 1200 AZ-101 Bubbling Tests Off-Gas System Measured Parameters (continued).

Test #		5A			5B			5C		
-		Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
Melter	Pressure at Level Detector Port ("water)	-4.4	-7.6	0.4	-4.0	-6.2	-0.5	-4.0	-7.2	0.1
	Pressure at Instrument Port ("water)	-4.6	-7.8	-0.3	-4.1	-6.3	-0.5	-4.1	-7.3	-0.1
SBS	Differential Pressure ("water)	43.1	37.4	47.6	44.2	39.8	47.1	45.0	40.5	47.7
	Inlet Gas Pressure ("water)	-7.1	-12.0	-3.0	-7.3	-11.1	-4.2	-7.8	-14.7	-2.7
	Outlet Gas Pressure ("water)	-50.4	-55.5	-45.9	-51.8	-57.0	-47.7	-52.9	-62.6	-46.2
	Inlet Gas Temp. (°C)	270	154	391	264	156	306	279	175	327
	Outlet Gas Temp. (°C)	39.6	34.1	50.7	38.8	36.0	42.7	39.5	35.9	44.8
	Chilled Water Inlet Temp (°C)	14.1	8.7	28.5	14.8	11.3	26.5	15.1	11.2	26.1
	Chilled Water Outlet Temp (°C)	20.8	16.7	30.8	24.6	19.3	32.7	25.1	21.8	32.9
	Submerged 48" Temp (°C)	40.0	34.2	52.0	39.6	36.3	43.7	40.4	36.2	46.9
	Submerged 60" Temp (°C)	40.0	34.0	52.0	39.6	36.4	43.7	40.4	36.4	46.9
	Submerged 72" Temp (°C)	40.6	34.8	53.2	40.1	37.3	44.6	40.8	36.4	47.1
	Submerged 78" Temp (°C)	40.5	34.8	53.2	40.0	37.1	44.2	40.8	36.4	47.1
	Recirc. Pump Discharge Temp (°C)	39.0	33.7	45.3	38.4	35.5	41.4	39.0	36.5	43.0
	Heat Exchanger Outlet Temp (°C)	35.4	24.4	43.1	31.6	27.9	39.4	29.7	25.6	37.0
	Chilled Water Flow (gal/min)	5.5	2.3	31.7	5.4	2.6	12.0	7.4	2.7	15.9
	Heat Exchanger Flow (gal/min)	6.0	0.1	22.0	11.9	2.6	33.9	16.5	10.7	35.6
	Recirc. Pump Discharge Pressure	37.7	30.6	40.7	38.0	30.7	40.3	37.9	30.6	40.5
	Inner C. Coil W. Inlet Temp (°C)	31.3	18.1	43.8	24.9	21.0	37.9	22.7	18.8	32.2
	Inner C. Coil W. Outlet Temp(°C)	36.2	27.6	43.8	33.3	30.2	40.3	32.6	29.1	38.8
	Inner C. Coil W. Flow (gal/min)	24.5	21.2	25.4	24.4	23.7	25.1	24.3	23.7	24.9
WESP	Differential Pressure ("water)	2.5	1.2	3.2	2.4	1.8	3.2	2.3	1.7	3.4
	Inlet Gas Temp. (°C)	40.3	36.0	52.0	38.9	36.2	42.8	39.8	37.2	44.7
	Outlet Gas Temp. (°C)	40.3	27.7	46.8	39.8	26.0	42.7	40.7	26.2	44.7
HEME #1, Outlet Gas Temp. (°C)		38.8	33.4	43.7	37.9	32.0	40.4	38.3	31.6	42.3
HEPA 1	Differential Pressure ("water)	0.1	-0.2	0.4	0.1	0.1	0.2	0.2	-0.2	0.3
	Outlet Gas Temp. (°C)	61.1	60.2	62.6	61.0	59.9	61.6	61.0	60.0	62.2
PAXTON 1 Outlet Gas Temp. (°C)		82.3	78.4	83.7	82.5	81.8	83.1	82.3	81.4	85.1
TCO	Inlet Gas Temp. (°C)	473	465	479	473	469	477	472	402	478
	Differential Pressure ("water)	3.3	2.3	3.5	3.3	3.1	3.5	3.2	2.9	3.6
SCR	Inlet Gas Temp. (°C)	363	319	367	361	358	365	357	315	363
	Outlet Gas Temp. Right (°C)	345	300	349	343	340	347	339	299	346
	Outlet Gas Temp. Left (°C)	316	274	320	314	311	318	314	272	317
	Differential Pressure ("water)	6.6	4.5	7.1	6.6	6.1	7.0	6.5	5.7	7.5
	Post Outlet Gas Temp. (°C)	310	272	313	309	306	311	308	274	311
PBS	Inlet Gas Temp. (°C)	290	255	294	289	288	292	288	262	291
	PBS Sump Temp. (°C)	24.8	21.7	36.5	25.6	23.8	33.7	26.1	23.9	33.7
	Differential Pressure ("water)	3.6	1.9	5.4	3.7	3.1	4.3	3.6	3.0	4.7
HEME #2	Inlet Gas Temp. (°C)	25.9	23.4	36.5	26.7	25.3	34.0	27.4	25.6	33.8
	Outlet Gas Temp. (°C)	28.1	26.2	38.4	28.7	27.1	35.3	29.2	27.5	35.3
Exhaust Stack Absolute Pressure ("water)		-7.9	-8.3	-6.5	-7.9	-8.2	-7.7	-8.0	-8.2	-7.8

"-" Empty data field

Table 5.1. DuraMelter 1200 AZ-101 Bubbling Tests Off-Gas System Measured Parameters (continued).

Test #		6		
-		Avg.	Min.	Max.
Melter	Pressure at Level Detector Port ("water)	-4.6	-8.8	0.0
	Pressure at Instrument Port ("water)	-4.9	-8.9	-0.6
SBS	Differential Pressure ("water)	41.3	34.2	45.9
	Inlet Gas pressure ("water)	-6.8	-12.5	-2.5
	Outlet Gas pressure ("water)	-48.2	-56.4	-42.4
	Inlet Gas Temp. (°C)	223	93	386
	Outlet Gas Temp. (°C)	39.4	31.6	48.7
	Chilled Water Inlet Temp (°C)	13.4	8.3	25.6
	Chilled Water Outlet Temp (°C)	20.8	15.4	38.8
	Submerged 48" Temp (°C)	39.9	31.7	51.8
	Submerged 60" Temp (°C)	39.9	31.9	51.8
	Submerged 72" Temp (°C)	40.4	32.5	53.0
	Submerged 78" Temp (°C)	40.3	32.2	53.0
	Recirc. Pump Discharge Temp (°C)	39.0	31.3	46.2
	Heat Exchanger Outlet Temp (°C)	37.1	24.1	43.6
	Chilled Water Flow (gal/min)	6.2	1.0	32.2
	Heat Exchanger Flow (gal/min)	2.9	-1.0	44.9
	Recirc. Pump Discharge Pressure	37.6	30.1	41.2
	Inner C. Coil W. Inlet Temp (°C)	36.2	18.7	45.1
	Inner C. Coil W. Outlet Temp(°C)	38.1	27.6	45.1
	Inner C. Coil W. Flow (gal/min)	24.0	1.0	25.5
WESP	Differential Pressure ("water)	2.6	1.4	3.6
	Inlet Gas Temp. (°C)	39.6	32.7	48.3
	Outlet Gas Temp. (°C)	40.4	28.2	47.1
HEME #1, Outlet Gas Temp. (°C)		39.0	31.5	47.7
HEPA 1	Differential Pressure ("water)	0.2	-0.2	0.4
	Outlet Gas Temp. (°C)	61.1	60.0	62.5
PAXTON 1 Outlet Gas Temp. (°C)		81.3	79.6	83.3
TCO	Inlet Gas Temp. (°C)	461	421	480
	Differential Pressure ("water)	3.3	2.9	3.6
SCR	Inlet Gas Temp. (°C)	356	341	381
	Outlet Gas Temp. Right (°C)	339	325	361
	Outlet Gas Temp. Left (°C)	310	296	332
	Differential Pressure ("water)	6.6	5.8	7.2
	Post Outlet Gas Temp. (°C)	305	293	325
PBS	Inlet Gas Temp. (°C)	286	276	304
	PBS Sump Temp. (°C)	24.5	22.3	31.7
	Differential Pressure ("water)	3.5	2.5	4.3
HEME #2	Inlet Gas Temp. (°C)	25.4	23.4	32.0
	Outlet Gas Temp. (°C)	26.9	24.9	33.0
Exhaust Stack Absolute Pressure ("water)		-7.9	-8.2	-7.3

Note: For Test 5, after 193.4 hours, heater 801 could not maintain 470°C; heater set point was loweredto 300°C. Consequently, for the TCO and subsequent units, the listed statistics were calculated only up to 193.4 hours. For Test 6, after 48.9 hours, the ammonia system was shut down; heater 801 set point was reduced to 350°C; for the TCO and subsequent units, the statistics are for the period up to 48.9 hours.
"-" Empty data field

Table 5.2. Nitrogen Oxides, Carbon Monoxide, and Ammonia Destruction Across TCO-SCR Catalytic Unit During Test 3.

Test Number	Gaseous Species		Conc. at Melter Outlet (ppmv)	Conc. At SBS Outlet (ppmv)	Flux at WESP outlet (mol/hr)	Flux at TCO-SCR outlet (mol/hr)	NO_x, CO, NH_3 removal* (%)	DF
3A	N_2O		1.5	1.7	0.022	0.020	-	-
	NO		130	140	1.753	1.051	-	-
	NO_2		5.1	5.2	0.102	0.680	-	-
	Total NOx				1.877	1.751	6.7	1.1
	CO		1.3	1.4	0.022	<0.016	>29.5	>1.4
	CO_2		4000	3700	49.7	46.4	-	-
	NH_3	exhaust	2.3	3.3	0.026	-	-	-
		injected	-	-	0.000	-	-	-
		Total	-	-	0.026	0.056	-111.7	0.5
3B	N_2O		1.7	2.1	0.031	0.026	-	-
	NO		200	220	3.250	1.812	-	-
	NO_2		4.1	7.8	0.201	0.955	-	-
	Total NOx		-	-	3.482	2.793	19.8	1.2
	CO		2.0	2.1	0.031	<0.016	>46.8	>1.9
	CO_2		5300	5200	78.9	69.2	-	-
	NH_3	exhaust	<1.0	1.7	0.026	-	-	-
		injected	-	-	0.000	-	-	-
		Total	-	-	0.026	0.035	-31.5	0.8
3C	N_2O		2.0	2.3	0.035	0.028	-	-
	NO		260	280	4.209	2.329	-	-
	NO_2		6.7	8.8	0.290	0.916	-	-
	Total NOx		-	-	4.534	3.273	27.1	1.4
	CO		2.6	2.7	0.042	0.016	63.1	2.7
	CO_2		6800	6500	98.7	80.7	-	-
	NH_3	exhaust	<1.0	1.7	0.017	-	-	-
		injected	-	-	0.000	-	-	-
		Total	-	-	0.017	<0.016	>10.9	>1.1

"-" Empty data field
* Negative values indicate an increase in the flux from the WESP to the TCO-SCR outlets.

Table 5.3. Nitrogen Oxides, Carbon Monoxide, and Ammonia Destruction Across TCO-SCR Catalytic Unit During Test 4.

Test Number	Gaseous Species		Conc. At Melter Outlet (ppmv)	Conc. At SBS Outlet (ppmv)	Flux at WESP Outlet (mol/hr)	Flux at TCO-SCR Outlet (mol/hr)	NO_x, CO, NH_3 Removal* (%)	DF
4A	N_2O		<1.0	<1.0	<0.016	<0.017	-	-
	NO		63	94	1.134	<0.017	-	-
	NO_2		4.0	5.3	0.099	<0.017	-	-
	Total NOx		-	-	<1.249	<0.050	>95.9	>24.4
	CO		1.1	1.4	0.020	<0.017	>18.2	>1.2
	CO_2		2500	2800	35.7	33.1	-	-
	NH_3	exhaust	2.8	3.2	0.067	-	-	-
		injected	-	-	0.944	-	-	-
		Total	-	-	1.011	0.099	90.2	10.2
4B	N_2O		1.3	1.6	0.023	0.024	-	-
	NO		200	210	2.988	0.713	-	-
	NO_2		13	9.4	0.270	0.288	-	-
	Total NOx		-	-	3.281	1.025	68.8	3.2
	CO		1.8	1.7	0.024	<0.015	>37.3	>1.6
	CO_2		4500	4400	55.5	50.0	-	-
	NH_3	exhaust	6.3	6.8	0.101	-	-	-
		injected	-	-	2.594	-	-	-
		Total	-	-	2.695	0.182	93.2	14.8
4C	N_2O		1.1	1.2	0.032	0.027	-	-
	NO		120	250	3.478	0.817	-	-
	NO_2		4.0	12	0.264	0.416	-	-
	Total NOx		-	-	3.774	1.259	66.6	3.0
	CO		1.9	2.1	0.035	0.016	53.0	2.1
	CO_2		4300	5900	80.7	69.8	-	-
	NH_3	exhaust	4.6	3.1	0.075	-	-	-
		injected	-	-	2.544	-	-	-
		Total	-	-	2.619	0.088	96.7	29.9

"-" Empty data field

* Negative values indicate an increase in the flux from the WESP to the TCO-SCR outlets.

Table 5.4. Nitrogen Oxides, Carbon Monoxide, and Ammonia Destruction Across TCO-SCR Catalytic Unit During Test 5.

Test Number	Gaseous Species		Conc. at Melter Outlet (ppmv)	Conc. at SBS Outlet (ppmv)	Flux at WESP Outlet (mol/hr)	Flux at TCO-SCR Outlet (mol/hr)	NO_x, CO, NH_3 Removal* (%)	DF
5A	N_2O		<1.0	<1.0	<0.015	<0.016	-	-
	NO		62	67	0.878	0.206	-	-
	NO_2		2.7	2.8	0.054	0.222	-	-
	Total NOx		-	-	<0.947	<0.444	-	-
	CO		<1.0	<1.0	<0.015	<0.016	-	-
	CO_2		2700	2300	34.2	28.6	-	-
	NH_3	exhaust	2.3	4.6	0.055	-	-	-
		injected	-	-	0.944	-	-	-
		Total	-	-	0.999	0.048	95.2	21.0
5B	N_2O		<1.0	1.3	0.016	<0.016	-	-
	NO		100	150	1.618	0.188	-	-
	NO2		2.6	3.8	0.091	0.039	-	-
	Total NOx		-	-	1.726	<0.243	>85.9	>7.1
	CO		<1.0	<1.0.	<0.015	<0.016	-	-
	CO_2		3800	3800	48.5	34.5	-	-
	NH_3	exhaust	5.9	4.9	0.062	-	-	-
		injected	-	-	2.229	-	-	-
		Total	-	-	2.291	0.096	95.8	23.9
5C	N_2O		<1.0	1.5	0.019	<0.015	-	-
	NO		98	190	2.297	0.706	-	-
	NO_2		2.8	4.4	0.109	0.114	-	-
	Total NOx		-	-	2.425	<0.835	>65.6	>2.9
	CO		3.6	1.5	<0.014	<0.015	-	-
	CO_2		4100	4700	60.3	46.0	-	-
	NH_3	exhaust	3.7	3.2	0.049	-	-	-
		injected	-	-	2.888	-	-	-
		Total	-	-	2.937	0.106	96.4	27.7

"-" Empty data field
* Negative values indicate an increase in the flux from the WESP to the TCO-SCR outlets.

Table 5.5. Nitrogen Oxides and Carbon Monoxide Destruction Across TCO-SCR Catalytic Unit During Test 6.

Test Number	Gaseous Species		Conc. at Melter Outlet (ppmv)	Conc. at SBS Outlet (ppmv)	Flux at WESP outlet (mol/hr)	Flux at TCO-SCR outlet (mol/hr)
6	N_2O		<1.0	<1.0	<0.015	<0.016
	NO		110	110	1.534	1.023
	NO_2		29	28	0.399	0.390
	Total NOx		-	-	<1.949	<1.429
	CO		<1.0	<1.0	<0.015	<0.016
	CO_2		2300	2100	30.7	26.0
	NH_3	exhaust	1.8	1.6	0.017	-
		injected	-	-	0.000	-
		Total	-	-	0.017	0.047

"-" Empty data field

Table 5.6. Gas Residence Times in TCO.

Test Number	Residence Time (seconds)
1A	0.20
1B	0.20
1C	0.20
1D	0.20
1E	0.20
2	0.20
3A	0.21
3B	0.20
3C	0.21
4A	0.20
4B	0.22
4C	0.22
5A	0.20
5B	0.21
5C	0.21
6	0.20

Table 5.7. Listing of Samples from SBS Blow-Downs.

Test	Date	Name	TSS (mg/l)	TDS (mg/l)	pH	Blow-Down Volume (gal)	Cumulative Volume (gal)
1	7/23/02	12W-S-115A	480	468	7.45	40.02	40.0
		12W-S-118A	512	584	7.81	39.99	80.0
	7/24/02	12W-S-123A	604	872	7.99	40.01	120.0
		12W-S-136A	640	1266	8.13	39.98	160.0
		12W-S-150A	608	1422	8.07	40.20	200.2
	7/25/02	12W-S-155A	598	1474	8.07	39.86	240.1
		12X-S-22A	684	1722	8.35	40.00	280.1
		12X-S-27A	732	1818	8.28	40.04	320.1
		12X-S-33A	766	1886	8.25	40.10	360.2
	7/26/02	12X-S-35A	830	1856	8.37	40.16	400.4
		12X-S-46A	764	1852	8.34	40.02	440.4
		12X-S-51A	1004	2206	8.26	40.00	480.4
		12X-S-61A	967	2187	8.28	39.49	519.9
		12X-S-65A	668	2442	8.28	40.22	560.1
		12X-S-68A	1158	2616	8.31	50.19	610.3
	7/27/02	12X-S-70A	1400	2702	8.31	40.00	650.3
		12X-S-81A	1430	2844	8.36	39.86	690.1
		12X-S-91A	1784	2934	8.36	40.02	730.2
		12X-S-95A	1468	2976	8.45	39.99	770.2
		12X-S-98A	1472	2142	8.41	40.01	810.2
		12X-S-101A	1468	3084	8.35	39.86	850.0
		12X-S-104A	1565	3195	8.38	50.09	900.1
		12X-S-106A	1702	3220	8.31	40.05	940.2
		12X-S-108A	1550	3280	8.25	40.09	980.3
	7/28/02	12X-S-110A	1821	3088	8.42	40.03	1020.3
		12X-S-118A	1738	3260	8.61	40.01	1060.3
		12X-S-121A	1804	3354	8.39	39.89	1100.2
		12X-S-122A	1890	3308	8.10	40.01	1140.2
		12X-S-125A	1862	3438	8.39	40.00	1180.2
		12X-S-137A	1884	3500	8.43	40.00	1220.2
		12X-S-140A	1770	3480	8.46	39.93	1260.1
		12X-S-141A	1460	3752	8.22	39.94	1300.1
		12X-S-145A	1540	4044	8.22	40.02	1340.1
	7/29/02	12X-S-147A	1692	3696	8.30	40.07	1380.2
		12Y-S-16A	1864	3920	8.34	40.17	1420.3
		12Y-S-19A	1976	3936	8.38	39.87	1460.2
		12Y-S-22A	2124	4012	8.40	40.18	1500.4
		12Y-S-24A	2308	4260	8.44	40.00	1540.4
		12Y-S-27A	2292	4012	8.32	40.02	1580.4
		12Y-S-29A	2036	4116	8.31	40.01	1620.4
		12Y-S-31A	2172	3760	8.24	40.00	1660.4
		12Y-S-34A	2140	3892	8.31	40.16	1700.6
		12Y-S-35A	1620	4148	8.32	39.97	1740.5

Table 5.7. Listing of Samples from SBS Blow-Downs (continued).

Test	Date	Name	TSS (mg/l)	TDS (mg/l)	pH	Blow-Down Volume (gal)	Cumulative Volume (gal)
1	7/30/02	12Y-S-38A	1944	3728	8.27	40.01	1780.5
		12Y-S-47A	1976	3624	8.27	40.08	1820.6
		12Y-S-50A	2100	3820	8.32	40.03	1860.7
		12Y-S-53A	2204	3764	8.32	39.74	1900.4
		12Y-S-57A	2112	4048	8.34	39.98	1940.4
		12Y-S-69A	2106	3946	8.26	40.13	1980.5
		12Y-S-70A	2140	3896	8.42	39.93	2020.4
		12Y-S-71A	2096	3696	8.39	39.94	2060.4
		12Y-S-73A	2484	3740	8.41	39.18	2099.6
		12Y-S-74A	1928	3868	8.30	40.05	2139.6
	7/31/02	12Y-S-87A	2244	3740	8.34	39.96	2179.6
2		12Y-S-89A	1888	3496	8.48	40.15	2219.7
		12Y-S-90A	1964	3476	8.53	40.06	2259.8
		12Y-S-93A	1856	3320	8.51	39.00	2298.8
		12Y-S-95A	1740	3200	8.46	40.08	2338.9
		12Y-S-105A	1668	3244	8.48	39.95	2378.8
		12Y-S-106A	1632	3220	8.56	39.97	2418.8
		12Y-S-108A	1684	3264	8.56	40.00	2458.8
		12Y-S-117A	1542	3072	8.52	40.03	2498.8
		12Y-S-118A	1564	3104	8.37	40.01	2538.8
	8/1/02	12Y-S-121A	1464	3068	8.31	40.10	2578.9
		12Y-S-125A	1324	2920	8.29	40.15	2619.1
		12Y-S-129A	1384	2928	8.31	80.29	2699.4
		12Y-S-144A	1016	2844	8.37	39.96	2739.3
3A	9/9/02	12Z-S-20A	NA	NA	8.28	41.98	2781.3
	9/10/02	12Z-S-23A	NA	NA	8.36	38.05	2819.3
		12Z-S-42A	NA	NA	8.24	35.31	2854.7
		12Z-S-47A	NA	NA	8.27	35.27	2889.9
		12Z-S-50A	NA	NA	8.32	40.02	2929.9
	9/11/02	12Z-S-64A	NA	NA	8.31	40.37	2970.3
		12Z-S-78A	NA	NA	8.16	39.13	3009.4
	9/12/02	12Z-S-91A	NA	NA	8.13	40.03	3049.5
		12Z-S-106A	492	1272	8.12	40.12	3089.6
#3B		12Z-S-114A	NA	NA	8.13	30.16	3119.8
	9/13/02	12Z-S-118A	NA	NA	8.13	40.00	3159.8
		12Z-S-132A	NA	NA	8.13	40.00	3199.8
		12Z-S-143A	NA	NA	8.22	40.49	3240.2
		12Z-S-144A	NA	NA	8.13	40.41	3280.7
		12Z-S-147A	NA	NA	8.19	39.21	3319.9
		12Z-S-150A	NA	NA	8.16	40.19	3360.1
	9/14/02	12Z-S-154A	NA	NA	8.19	39.80	3399.9
		A12-S-8A	NA	NA	8.18	40.01	3439.9
		A12-S-19A	NA	NA	8.17	40.10	3480.0

NA- Not analyzed

Table 5.7. Listing of Samples from SBS Blow-Downs (continued).

Test	Date	Name	TSS (mg/l)	TDS (mg/l)	pH	Blow-Down Volume (gal)	Cumulative Volume (gal)
3B	7/30/02	12Y-S-38A	1944	3728	8.27	40.01	1780.5
		A12-S-29A	NA	NA	8.27	39.87	3519.8
		A12-S-31A	NA	NA	8.26	39.97	3559.8
	9/15/02	A12-S-42A	NA	NA	8.29	39.99	3599.8
		A12-S-44A	NA	NA	8.18	40.00	3639.8
		A12-S-49A	NA	NA	8.21	40.03	3679.8
		A12-S-51A	NA	NA	8.26	40.02	3719.8
		A12-S-53A	NA	NA	8.22	40.17	3760.0
		A12-S-57A	1300	2796	8.26	42.65	3802.7
3C	9/16/02	A12-S-68A	1388	2692	8.13	46.01	3848.7
		A12-S-71A	1568	2888	8.25	40.01	3888.7
		A12-S-76A	1572	2872	8.22	40.13	3928.8
		A12-S-85A	1484	3056	8.18	39.97	3968.8
		A12-S-88A	1700	3132	8.06	40.01	4008.8
		A12-S-91A	1788	3020	8.13	38.42	4047.2
		A12-S-93A	1800	3092	8.12	38.93	4086.1
		A12-S-104A	1816	3224	8.19	40.47	4126.6
	9/17/02	A12-S-105A	1912	3228	8.18	39.98	4166.6
		A12-S-107A	1764	3160	8.19	40.05	4206.6
		A12-S-109A	1832	3192	8.14	41.01	4247.7
		A12-S-112A	1900	3112	8.23	40.17	4287.8
		A12-S-121A	1928	3136	8.26	40.12	4327.9
		A12-S-123A	2040	3372	8.21	37.75	4365.7
		A12-S-125A	1792	3144	8.19	39.26	4405.0
		A12-S-128A	1992	3736	8.02	40.83	4445.8
		A12-S-137A	1716	3384	8.11	40.12	4485.9
		A12-S-138A	1980	3376	8.03	39.93	4525.8
	9/18/02	A12-S-142A	1976	3216	8.06	41.04	4566.9
		A12-S-143A	1972	3428	8.10	40.21	4607.1
		A12-S-146A	2444	3552	8.27	39.93	4647.0
		A12-S-155A	2364	3068	8.38	40.00	4687.0
		B12-S-10A	2288	3548	8.29	40.02	4727.0
		B12-S-13A	2144	3640	8.24	38.86	4765.9
		B12-S-15A	2424	3472	8.29	40.29	4806.2
		B12-S-18A	2404	3652	8.25	40.76	4846.9
	9/19/02	B12-S-48A	760	3716	8.35	40.24	4887.2
4A	9/23/02	B12-S-77A	NA	NA	8.39	41.04	4928.2
	9/24/02	B12-S-83A	NA	NA	8.39	38.96	4967.2
		B12-S-100A	NA	NA	8.47	40.02	5007.2
	9/25/02	B12-S-124A	NA	NA	8.42	40.28	5047.5
		B12-S-138A	NA	NA	8.41	39.74	5087.2
	9/26/02	B12-S-145A	NA	NA	8.43	39.96	5127.2
		C12-S-20A	1580	3296	8.79	40.16	5167.3

NA – Not analyzed

Table 5.7. Listing of Samples from SBS Blow-Downs (continued).

Test	Date	Name	TSS (mg/l)	TDS (mg/l)	pH	Blow-Down Volume (gal)	Cumulative Volume (gal)
4B	9/27/02	C12-S-28A	1596	3284	8.67	40.30	5207.6
		C12-S-38A	NA	NA	8.67	40.00	5247.6
		C12-S-41A	NA	NA	8.59	40.00	5287.6
		C12-S-44A	NA	NA	8.37	40.00	5327.6
		C12-S-46A	NA	NA	8.44	40.01	5367.7
		C12-S-57A	NA	NA	8.64	40.00	5407.7
	9/28/02	C12-S-60A	1516	2988	8.51	40.00	5447.7
		C12-S-61A	NA	NA	8.35	40.13	5487.8
		C12-S-74A	NA	NA	8.27	40.04	5527.8
		C12-S-76A	NA	NA	8.27	40.01	5567.8
		C12-S-79A	1228	3092	8.37	30.00	5597.8
		C12-S-83A	NA	NA	8.23	39.34	5637.2
		C12-S-92A	NA	NA	8.08	40.03	5677.2
	9/29/02	C12-S-94A	NA	NA	8.20	40.07	5717.3
		C12-S-97A	1212	2856	8.19	40.00	5757.3
		C12-S-107A	NA	NA	8.13	40.15	5797.4
		C12-S-116A	NA	NA	8.32	38.20	5835.6
		C12-S-128A	1320	2660	8.22	39.90	5875.5
4C		C12-S-132A	NA	NA	8.21	39.90	5915.4
	9/30/02	C12-S-134A	1604	2636	8.15	39.92	5955.3
		C12-S-136A	1564	2868	8.23	40.65	5996.0
		C12-S-145A	1702	2908	8.36	40.13	6036.1
		C12-S-148A	2000	2948	8.26	40.01	6076.1
		D12-S-6A	1836	2864	8.24	40.03	6116.2
		D12-S-8A	1524	3172	8.28	39.65	6155.8
		D12-S-21A	1810	3068	8.34	40.03	6195.8
		D12-S-22A	1956	2932	8.35	40.08	6235.9
		D12-S-24A	1840	2768	8.29	40.33	6276.3
	10/1/02	D12-S-24B	1896	2760	8.35	39.03	6315.3
		D12-S-27A	NA	NA	8.31	41.13	6356.4
		D12-S-28A	1864	2868	8.32	40.15	6396.6
		D12-S-30A	1912	3400	8.33	40.00	6436.6
		D12-S-32A	1876	2632	8.40	40.18	6476.7
		D12-S-34A	1632	2872	8.34	40.09	6516.8
		D12-S-35A	1912	2896	8.39	40.07	6556.9
		D12-S-46A	1940	2796	8.48	40.02	6596.9
		D12-S-47A	1932	2904	8.45	40.01	6636.9
		D12-S-48A	2116	2996	8.46	39.96	6676.9
	10/2/02	D12-S-51A	2040	3000	8.44	40.25	6717.1
		D12-S-60A	1928	2748	8.44	38.14	6755.3
		D12-S-62A	1868	2784	8.37	40.37	6795.7
		D12-S-64A	1872	2748	8.29	40.00	6835.7
		D12-S-65B	1892	2884	8.30	40.00	6875.7

NA – Not analyzed

Table 5.7. Listing of Samples from SBS Blow-Downs (continued).

Test	Date	Name	TSS (mg/l)	TDS (mg/l)	pH	Blow-Down Volume (gal)	Cumulative Volume (gal)
4C	10/2/02	D12-S-66A	1780	2944	8.37	40.00	6915.7
		D12-S-67A	1812	2808	8.31	40.35	6956.0
		D12-S-70A	1852	2968	8.4	40.06	6996.1
		D12-S-72A	1808	3288	8.26	40.14	7036.2
6	10/7/02	D12-S-119A	NA	NA	8.62	20.00	7056.2
		No sample	NA	NA	NA	25.13	7081.3
	10/8/02	D12-S-126A	2724	2952	8.63	40.15	7121.5
		D12-S-130A	NA	NA	8.69	40.01	7161.5
		D12-S-149A	NA	NA	8.78	39.92	7201.4
	10/9/02	D12-S-151A	1356	2636	8.82	40.87	7242.3
		D12-S-155A	NA	NA	8.80	40.37	7282.7
		E12-S-20A	NA	NA	8.82	39.76	7322.4
	10/10/02	E12-S-35A	NA	NA	8.87	40.59	7363.0
		E12-S-40A	1292	2952	8.95	40.01	7403.0
		E12-S-51A	NA	NA	8.77	39.34	7442.4
	10/11/02	E12-S-63A	NA	NA	8.85	40.14	7482.5
		E12-S-67A	NA	NA	8.82	40.02	7522.5
		E12-S-80A	NA	NA	8.78	39.81	7562.3
	10/12/02	E12-S-92A	NA	NA	8.84	30.51	7592.8
		E12-S-95A	NA	NA	8.94	40.00	7632.8
		E12-S-110A	2784	2620	8.93	7.32	7640.2
5A	10/15/02	E12-S-141A	NA	NA	9.13	40.04	7680.2
		E12-S-144A	NA	NA	8.73	40.00	7720.2
	10/16/02	E12-S-153A	NA	NA	8.88	40.32	7760.5
		F12-S-15A	NA	NA	8.87	40.00	7800.5
		F12-S-22A	NA	NA	8.84	39.76	7840.3
	10/17/02	F12-S-33A	NA	NA	8.76	40.04	7880.3
		F12-S-38A	NA	NA	8.75	40.00	7920.3
		F12-S-49A	NA	NA	8.85	39.99	7960.3
	10/18/02	F12-S-64A	NA	NA	8.80	40.68	8001.0
		F12-S-78A	1900	2660	8.69	39.46	8040.4
5B		F12-S-83A	NA	NA	8.67	40.01	8080.5
		F12-S-88A	NA	NA	8.63	40.00	8120.5
	10/19/02	F12-S-97A	NA	NA	8.55	40.50	8161.0
		F12-S-102A	NA	NA	8.53	40.14	8201.1
		F12-S-104A	NA	NA	8.53	40.01	8241.1
		F12-S-105A	NA	NA	8.43	40.00	8281.1
		F12-S-115A	NA	NA	8.40	40.03	8321.1
		F12-S-118A	NA	NA	8.55	40.01	8361.1
		F12-S-120A	NA	NA	8.47	40.01	8401.2
		F12-S-123A	NA	NA	8.46	40.00	8441.2
	10/20/02	F12-S-131A	NA	NA	8.56	39.11	8480.3
		F12-S-134A	NA	NA	8.40	40.62	8520.9

NA – Not analyzed

Table 5.7. Listing of Samples from SBS Blow-Downs (continued).

Test	Date	Name	TSS (mg/l)	TDS (mg/l)	pH	Blow-Down Volume (gal)	Cumulative Volume (gal)
5A	10/20/02	F12-S-136A	NA	NA	8.55	40.22	8561.1
		F12-S-140A	1292	2300	8.40	50.07	8611.2
		F12-S-151A	NA	NA	8.55	40.00	8651.2
		F12-S-153A	NA	NA	8.53	40.02	8691.2
		F12-S-155A	NA	NA	8.55	40.01	8731.2
		G12-S-10A	NA	NA	8.54	40.02	8771.2
	10/21/02	G12-S-18A	NA	NA	8.53	40.00	8811.2
		G12-S-21A	NA	NA	8.49	39.03	8850.3
		G12-S-23A	NA	NA	8.52	40.01	8890.3
		G12-S-25A	NA	NA	8.35	40.01	8930.3
		G12-S-35A	1292	2278	8.37	40.00	8970.3
5C		G12-S-38A	NA	NA	8.46	40.03	9010.3
		G12-S-39A	NA	NA	8.37	39.98	9050.3
		G12-S-42A	NA	NA	8.49	40.06	9090.3
	10/22/02	G12-S-51A	NA	NA	8.47	41.07	9131.4
		G12-S-53A	NA	NA	8.42	38.35	9169.8
		G12-S-55A	NA	NA	8.42	40.97	9210.7
		G12-S-58A	NA	NA	8.46	40.03	9250.8
		G12-S-60A	NA	NA	8.37	40.00	9290.8
		G12-S-77A	NA	NA	8.35	40.35	9331.1
		G12-S-78A	NA	NA	8.42	40.02	9371.1
		G12-S-80A	NA	NA	8.44	30.02	9401.2
		G12-S-81A	NA	NA	8.45	40.02	9441.2
		G12-S-85A	NA	NA	8.40	40.09	9481.3
		G12-S-87A	NA	NA	8.39	41.13	9522.4
	10/23/02	G12-S-88A	NA	NA	8.31	36.99	9559.4
		G12-S-91A	NA	NA	8.42	39.89	9599.3
		G12-S-93A	NA	NA	8.48	54.73	9654.0
		G12-S-96A	NA	NA	8.27	40.09	9694.1
		G12-S-104A	NA	NA	8.36	40.00	9734.1
		G12-S-109A	NA	NA	8.35	40.00	9774.1
		G12-S-110A	NA	NA	8.57	40.01	9814.1
		G12-S-112A	NA	NA	8.55	39.73	9853.8
		G12-S-113A	NA	NA	8.47	39.76	9893.6
		G12-S-114A	NA	NA	8.43	40.28	9933.9
	10/24/02	G12-S-124A	NA	NA	8.36	40.32	9974.2
		G12-S-127A	NA	NA	8.48	40.04	10014.2
		G12-S-128A	NA	NA	8.42	39.98	10054.2
		G12-S-130A	NA	NA	8.39	40.21	10094.4
		G12-S-139A	NA	NA	9.39	40.01	10134.4
		G12-S-140A	1292	2300	8.54	40.02	10174.5

NA – Not analyzed

Table 5.8. Analytical Results for Selected SBS Blow-Down Fluids (mg/l).

Test	**1**			**2**			**3A**			**3B**		
Sample ID	12Y-S-87A			12Y-S-144A			12Z-S-106A			A12-S-57A		
Glass (kg)	6607.2			7425.0			8800.8			11310.1		
pH	8.34			8.37			8.12			8.26		
-	Sus*	Dis.#	Total	Sus*	Dis.#	Total	Sus*	Dis.#	Total	Sus*	Dis.#	Total
Total	2244	3740	5984	1016	2844	3860	492	1272	1764	1300	2796	4096
Al	96.57	2.13	98.70	42.79	0.574	43.36	20.94	0.26	21.19	58.97	1.61	60.58
B	29.00	584.57	613.57	10.90	279.15	290.05	5.85	183.15	189.00	11.40	417.06	428.47
Ba	0.46	0.02	0.48	0.21	0.014	0.23	0.10	0.02	0.13	0.27	0.02	0.29
Ca	6.32	2.04	8.36	3.02	4.341	7.36	1.41	13.13	14.54	4.37	1.71	6.08
Cd	2.12	0.00	2.12	1.05	<0.01	1.05	0.45	0.01	0.46	1.34	0.03	1.37
Cu	0.49	0.02	0.50	0.21	<0.01	0.21	0.11	0.01	0.12	0.34	0.01	0.34
Fe	440.61	0.53	441.15	212.52	0.171	212.69	93.93	0.04	93.98	251.50	3.12	254.62
K	1.09	5.57	6.66	0.57	4.001	4.57	0.24	3.25	3.49	0.73	3.83	4.55
La	NA	0.18	0.18	NA	<0.03	NC	NA	NA	NC	NA	NA	NC
Li	4.70	58.10	62.80	2.64	27.762	30.41	1.18	16.97	18.15	2.22	35.82	38.04
Mg	3.56	2.56	6.12	1.70	4.038	5.74	0.79	4.76	5.55	2.15	2.00	4.15
Mn	1.14	0.08	1.21	0.52	0.039	0.56	0.27	0.01	0.28	0.74	0.03	0.76
Na	53.21	688.27	741.48	21.86	291.10	312.95	11.07	196.64	207.71	20.45	404.87	425.32
Ni	20.59	0.15	20.75	9.86	0.14	10.00	4.56	0.07	4.62	11.76	0.21	11.97
Pb	1.20	1.04	2.24	0.58	0.21	0.79	0.27	0.31	0.58	0.70	0.67	1.37
Si	303.95	6.99	310.94	131.99	5.726	137.72	64.94	7.84	72.78	175.13	9.29	184.43
Sr	0.87	0.12	0.98	0.48	0.176	0.66	0.20	0.49	0.69	0.29	0.06	0.36
Zn	75.27	0.23	75.50	35.55	0.067	35.61	16.32	0.14	16.46	42.90	0.70	43.59
Zr	25.19	0.12	25.31	7.92	0.041	7.96	5.41	0.01	5.42	18.38	0.24	18.62
F	NA	143.56	143.56	NA	68.26	68.26	NA	39.24	39.24	NA	118.64	118.64
Cl	NA	79.50	79.50	NA	53.21	53.21	NA	38.16	38.16	NA	76.71	76.71
I	<0.1	284.89	284.89	<0.1	195.80	195.80	<0.1	99.54	99.54	<0.1	330.02	330.02
NH_4^+	NA	4.60	4.60	NA	10.60	10.60	NA	12.10	12.10	NA	14.30	14.30
Nitrate	NA	4.53	4.53	NA	6.46	6.46	NA	5.16	5.16	NA	6.17	6.17
Nitrite	NA	83.88	83.88	NA	63.16	63.16	NA	47.70	47.70	NA	76.36	76.36
Sulfate	0.81	255.41	256.22	1.84	168.06	169.90	0.26	108.34	108.60	0.29	238.87	239.16

NA – Not analyzed
NC – Not calculated
* Suspended Solids
# Dissolved Solids
"-" Empty data field

Table 5.8. Analytical Results for Selected SBS Blow-Down Fluids (mg/l) (continued).

Test	3C			4A			4B			4C		
Sample ID	B12-S-48A			C12-S-20A			C12-S-128A			D12-S-72A		
Glass (kg)	14468.4			15450.0			17175.5			19678.0		
pH	8.35			8.79			8.22			8.26		
-	Sus*	Dis.#	Total	Sus*	Dis.#	Total	Sus*	Dis.#	Total	Sus*	Dis.#	Total
Total	760	3716	4476	1580	3296	4876	1320	2660	3980	1808	3288	5096
Al	35.69	2.70	38.39	72.57	0.78	73.35	61.12	1.09	62.21	89.54	1.72	91.26
B	8.71	477.75	486.46	10.76	444.07	454.83	9.87	393.11	402.98	15.74	493.26	509.00
Ba	0.17	0.025	0.19	0.36	0.01	0.37	0.25	0.011	0.26	0.34	0.01	0.35
Ca	2.71	2.041	4.75	6.71	4.21	10.92	4.11	2.678	6.79	5.35	2.43	7.77
Cd	0.80	<0.01	0.80	1.24	<0.01	1.24	0.18	<0.01	0.18	1.80	<0.01	1.80
Cu	0.20	0.01	0.21	0.40	<0.01	0.40	0.34	<0.01	0.34	0.49	<0.01	0.49
Fe	142.51	1.12	143.63	309.80	0.21	310.01	239.51	0.222	239.73	306.37	0.08	306.45
K	0.57	7.16	7.73	1.30	6.07	7.37	0.83	3.775	4.61	0.90	9.73	10.64
La	NA	0.56	0.56	NA	<0.03	NC	NA	<0.03	NC	NA	<0.03	NC
Li	1.55	58.401	59.96	3.09	62.50	65.59	2.51	44.766	47.28	3.73	50.85	54.58
Mg	1.27	2.59	3.86	3.03	3.74	6.77	2.06	2.509	4.57	2.74	2.67	5.41
Mn	0.46	0.08	0.54	1.04	0.07	1.11	0.79	0.103	0.90	1.27	0.10	1.37
Na	17.57	696.23	713.80	25.05	552.23	577.28	20.91	458.26	479.17	34.28	656.18	690.46
Ni	6.65	0.23	6.88	14.40	0.23	14.64	11.65	0.213	11.86	15.29	0.18	15.48
Pb	0.42	0.98	1.40	0.74	0.37	1.11	0.65	0.306	0.96	0.94	0.35	1.29
Si	104.85	7.53	112.38	237.55	8.40	245.95	199.55	8.671	208.22	287.48	6.37	293.85
Sr	0.28	0.12	0.40	0.60	0.13	0.73	0.38	0.123	0.50	0.55	0.10	0.65
Zn	24.71	0.45	25.16	52.79	0.07	52.86	41.00	0.237	41.24	55.12	0.07	55.19
Zr	10.99	0.34	11.33	26.33	0.12	26.45	23.89	0.117	24.01	37.17	0.13	37.30
F	NA	128.13	128.13	NA	113.29	113.29	NA	104.23	104.23	NA	118.78	118.78
Cl	NA	97.43	97.43	NA	79.08	79.08	NA	80.04	80.04	NA	81.16	81.16
I	<0.1	341.87	341.87	<0.1	257.48	257.48	<0.1	240.19	240.19	<0.1	190.36	190.36
NH_4^+	NA	580.30	580.30	NA	13.40	13.40	NA	5.00	5.00	NA	8.00	8.00
Nitrate	NA	4.21	4.21	NA	8.14	8.14	NA	11.76	11.76	NA	87.81	87.81
Nitrite	NA	63.67	63.67	NA	77.46	77.46	NA	91.41	91.41	NA	131.56	131.56
Sulfate	0.20	322.85	323.05	1.15	255.03	256.18	2.46	284.90	287.36	0.77	226.69	227.46

NA – Not analyzed
NC – Not calculated
* Suspended Solids
# Dissolved Solids
"-" Empty field

Table 5.8. Analytical Results for Selected SBS Blow-Down Fluids (mg/l) (continued).

Test	6			5A			5B			5C		
Sample ID	E12-S-110A			F12-S-78A			G12-S-35A			G12-S-140A		
Glass (kg)	20705.1			21535.6			23024.0			24894.5		
pH	8.93			8.69			8.37			8.54		
-	Sus*	Dis.#	Total	Sus*	Dis.#	Total	Sus*	Dis.#	Total	Sus*	Dis.#	Total
Total	2784	2620	5404	1900	2660	4560	1292	2278	3570	1292	2300	3592
Al	129.02	1.20	130.22	92.37	1.06	93.43	74.78	1.08	75.86	81.15	1.34	82.49
B	24.66	334.56	359.22	13.01	364.50	377.52	10.83	340.05	350.88	11.69	381.85	393.54
Ba	0.70	0.01	0.71	0.41	0.01	0.42	0.37	0.01	0.37	0.46	0.01	0.47
Ca	21.12	4.87	25.99	11.12	3.14	14.26	5.21	2.30	7.51	4.58	2.58	7.16
Cd	2.49	<0.01	2.49	1.39	<0.01	1.39	1.18	<0.01	1.18	1.33	<0.01	1.33
Cu	1.05	<0.01	1.05	0.51	<0.01	0.51	0.38	<0.01	0.38	0.42	<0.01	0.42
Fe	320.18	0.11	320.29	355.30	0.08	355.38	239.32	0.14	239.46	216.21	0.25	216.47
K	2.85	9.16	12.00	1.72	7.48	9.20	0.85	4.35	5.20	0.89	4.54	5.42
La	NA	<0.03	NC	NA	<0.03	NC	NA	<0.03	NC	NA	<0.03	NC
Li	5.12	58.15	63.26	4.06	73.72	77.78	3.43	53.55	56.99	3.72	57.32	61.04
Mg	5.94	3.76	9.70	4.36	3.95	8.31	2.35	1.53	3.88	2.04	1.42	3.46
Mn	3.59	0.06	3.65	1.18	0.06	1.24	1.16	0.06	1.22	1.35	0.07	1.42
Na	42.83	498.44	541.27	26.58	466.95	493.53	22.47	334.76	357.23	23.88	353.47	377.35
Ni	0.00	0.12	0.12	16.69	0.13	16.81	11.34	0.14	11.48	10.64	0.09	10.73
Pb	1.82	0.22	2.04	0.87	0.24	1.11	0.68	0.24	0.91	0.70	0.26	0.96
Si	527.71	4.51	532.22	299.65	7.76	307.42	186.86	5.19	192.04	172.36	4.21	176.57
Sr	1.29	0.24	1.53	0.76	0.18	0.94	0.48	0.09	0.57	0.50	0.08	0.58
Zn	58.34	0.05	58.39	62.43	0.06	62.49	42.42	0.12	42.53	37.36	0.76	38.12
Zr	157.30	0.06	157.36	38.14	0.10	38.23	24.17	0.08	24.25	24.05	0.06	24.12
F	NA	55.56	55.56	NA	74.23	74.23	NA	93.68	93.68	NA	99.50	99.50
Cl	NA	61.57	61.57	NA	57.91	57.91	NA	61.42	61.42	NA	67.92	67.92
I	<0.1	162.70	162.70	<0.1	166.62	166.62	<0.1	126.50	126.50	<0.1	128.97	128.97
NH_4^+	NA	<5.1	NC	NA	<5.1	NC	NA	5.70	5.70	NA	6.5	6.50
Nitrate	NA	100.28	100.28	NA	41.90	41.90	NA	8.98	8.98	NA	14.42	14.42
Nitrite	NA	235.56	235.56	NA	117.51	117.51	NA	55.79	55.79	NA	43.36	43.36
Sulfate	<0.1	163.33	163.33	1.98	127.95	129.94	0.39	127.14	127.53	2.95	161.28	164.23

NA – Not analyzed
NC – Not calculated
* Suspended Solids
# Dissolved Solids
"-" Empty field

Table 5.9. Anion Concentrations and Cumulative Masses in SBS Blow-Down Liquids During Test 3C.

Sample I.D.		A12-S-68A	A12-S-71A	A12-S-76A	A12-S-85A	A12-S-88A	A12-S-91A	A12-S-93A	A12-S-104A	A12-S-105A	A12-S-107A	A12-S-109A	A12-S-112A	A12-S-121A	A12-S-123A
TSS (mg/l)		1388	1568	1572	1484	1700	1788	1800	1816	1912	1764	1832	1900	1928	2040
TDS (mg/l)		2692	2888	2872	3056	3132	3020	3092	3224	3228	3160	3192	3112	3136	3372
Total (mg/l)		4080	4456	4444	4540	4832	4808	4892	5040	5140	4924	5024	5012	5064	5412
pH		8.13	8.25	8.22	8.18	8.06	8.13	8.12	8.19	8.18	8.19	8.14	8.23	8.26	8.21
Blow-Down (gal)		46.01	40.01	40.13	39.97	40.01	38.42	38.93	40.47	39.98	40.05	41.01	40.17	40.12	37.75
Glass (kg)		11514.5	11617.0	11770.8	11873.3	11975.8	12078.4	12232.6	12386.8	12489.6	12591.6	12743.4	12844.6	12945.8	13104.1
Concentration (mg/l)	Cs	0.37	0.36	0.37	0.32	0.36	0.28	0.34	0.28	0.30	0.30	0.28	0.27	0.27	0.27
	F	121.13	123.81	134.17	135.07	135.54	135.54	137.36	141.00	137.36	138.27	135.34	132.67	137.12	148.70
	Cl	74.19	76.48	78.52	82.10	83.05	82.53	82.01	83.57	85.14	85.14	80.31	81.61	81.35	82.39
	I	334.62	340.27	354.38	360.03	361.17	352.40	353.87	352.40	359.71	368.48	335.90	340.16	334.48	345.85
	NH_4^+	14.30	14.30	13.80	13.20	12.20	12.20	11.30	10.90	11.30	10.40	9.60	5.30	5.80	5.00
	NO_2^-	5.82	5.98	5.90	5.74	5.67	5.35	5.30	5.18	5.10	4.81	4.73	4.41	4.57	4.32
	NO_3^-	73.26	74.75	76.23	74.75	76.70	73.63	74.15	75.17	76.70	76.19	71.89	71.39	70.88	74.43
	SO_4^{2-}	237.34	239.71	241.26	254.44	259.90	255.08	247.86	262.31	262.31	257.49	251.08	260.64	259.84	259.05
Cumulative Mass (g)	F	24.58	47.07	81.71	103.45	124.70	144.49	167.30	193.97	209.85	232.14	249.23	265.82	292.82	329.99
	Cl	9.52	24.28	39.05	56.42	70.34	81.68	93.10	108.09	123.17	136.13	142.03	156.27	168.32	181.56
	I	64.80	124.26	197.60	260.02	316.49	355.94	410.30	462.48	527.13	595.21	602.98	660.74	703.96	769.13
	NH_4^+	2.50	4.67	6.09	7.28	7.77	9.55	9.99	11.12	13.38	13.73	14.13	9.06	10.63	10.25
	NO_2^-	0.54	1.67	2.46	3.11	3.88	4.22	4.94	5.57	6.23	6.57	7.20	7.43	8.35	8.62
	NO_3^-	8.57	21.97	35.62	44.95	59.28	65.83	77.51	90.46	104.21	115.11	120.43	130.64	140.75	156.28
	SO_4^{2-}	39.40	79.09	118.00	174.68	221.66	252.31	279.10	339.21	379.06	411.65	442.01	494.87	533.39	569.47

Table 5.9. Anion Concentrations and Cumulative Masses in SBS Blow-Down Liquids During Test 3C (continued).

Sample I.D.		A12-S-125A	A12-S-128A	A12-S-137A	A12-S-138A	A12-S-142A	A12-S-143A	A12-S-146A	A12-S-155A	B12-S-10A	B12-S-13A	B12-S-15A	B12-S-18A
TSS (mg/l)		1792	1992	1716	1980	1976	1972	2444	2364	2288	2144	2424	2404
TDS (mg/l)		3144	3736	3384	3376	3216	3428	3552	3068	3548	3640	3472	3652
Total (mg/l)		4936	5728	5100	5356	5192	5400	5996	5432	5836	5784	5896	6056
pH		8.19	8.02	8.11	8.03	8.06	8.10	8.27	8.38	8.29	8.24	8.29	8.25
Blow-Down (gal)		39.26	40.83	40.12	39.93	41.04	40.21	39.93	40.00	40.02	38.86	40.29	40.76
Glass (kg)		13161.1	13275.2	13446.4	13503.4	13712.5	13763.1	13915.1	13965.7	14067.0	14201.4	14291.1	14425.5
Concentration (mg/l)	Cs	0.30	0.25	0.29	0.27	0.23	0.29	1.03	0.97	0.91	0.88	0.80	0.82
	F	146.03	137.75	148.56	152.17	154.87	157.57	150.55	154.09	155.85	147.47	150.09	128.25
	Cl	86.54	83.23	82.71	85.80	80.14	86.83	102.09	103.88	101.51	101.05	95.65	102.41
	I	360.05	337.69	345.99	345.99	355.67	359.82	326.90	332.46	339.41	330.02	331.37	331.37
	NH_4^+	5.30	6.10	12.20	11.30	10.10	9.70	10.10	5.80	8.60	8.30	8.60	12.10
	NO_2^-	4.49	4.17	4.01	4.17	4.25	4.09	4.78	4.70	5.02	4.73	4.41	4.49
	NO_3^-	76.46	72.62	72.10	72.10	76.72	78.26	68.25	72.80	71.29	68.44	66.46	65.96
	SO_4^{2-}	274.98	266.57	260.23	272.90	245.18	267.36	321.89	326.37	317.12	316.75	311.48	317.80
Cumulative Mass (g)	F	348.12	358.17	395.60	423.63	451.48	479.25	492.49	520.75	546.86	557.17	583.74	573.73
	Cl	200.15	208.53	220.43	237.68	242.43	264.85	301.22	319.46	331.65	345.94	353.20	378.31
	I	842.27	864.07	928.17	980.67	1049.38	1110.04	1114.61	1172.75	1233.87	1269.76	1322.34	1373.66
	NH_4^+	11.45	13.49	23.70	24.18	24.11	25.05	27.13	22.13	27.27	28.08	29.81	36.47
	NO_2^-	9.53	9.74	10.13	10.98	11.75	12.16	13.83	14.43	15.63	15.94	16.17	16.98
	NO_3^-	170.47	176.48	186.76	197.70	215.99	230.05	226.71	244.00	252.78	258.99	266.45	275.99
	SO_4^{2-}	632.29	662.14	693.14	751.88	752.20	823.39	946.83	1002.57	1038.14	1084.41	1124.89	1182.76

Table 5.10. Listing of Samples from WESP Blow-Downs.

Test	Date	Name	TSS	TDS	pH	BLD Vol. (gal)	Cumulative BLD Vol. (gal)
1	7/24/02	12W-W-136A	NA	NA	NA	9.97	9.97
		12W-W-138A	NA	NA	NA	80.35	90.32
	7/25/02	12X-W-21A	NA	NA	NA	51.30	141.62
		12X-W-21B	NA	NA	NA	42.90	184.52
	7/26/02	12X-W-51A	NA	NA	NA	53.47	237.99
		12X-W-51B	NA	NA	NA	41.14	279.13
	7/27/02	12X-W-96A	NA	NA	NA	62.84	341.97
		12X-W-98A	NA	NA	NA	41.90	383.87
	7/28/02	12X-W-125A	NA	NA	NA	52.25	436.12
		12X-W-126A	NA	NA	NA	38.78	474.90
	7/29/02	12Y-W-25A	NA	NA	NA	57.43	532.33
		12Y-W-26A	NA	NA	NA	40.02	572.35
	7/30/02	12Y-W-56A	NA	NA	NA	51.70	624.05
		12Y-W-56B	NA	NA	NA	42.92	666.97
2	7/31/02	12Y-W-94A	NA	NA	NA	59.82	726.79
		12Y-W-94B	NA	NA	NA	43.57	770.36
	8/1/02	12Y-W-130A	<1	620	NA	57.61	827.97
		12Y-W-130B	NA	NA	NA	44.69	872.66
		12Y-W-144A	NA	NA	NA	19.10	891.76
3	9/10/02	12Z-W-43A	NA	NA	8.03	39.65	931.41
		12Z-W-43B	NA	NA	7.80	45.89	977.30
	9/11/02	12Z-W-73A	NA	NA	7.92	53.36	1030.66
		12Z-W-73B	NA	NA	7.93	40.09	1070.75
	9/12/02	12Z-W-104A	NA	NA	7.83	55.33	1126.08
		12Z-W-104B	NA	NA	7.76	40.41	1166.49
	9/13/02	12Z-W-143A	NA	NA	7.84	54.40	1220.89
		12Z-W-143B	NA	NA	7.52	40.32	1261.21
	9/14/02	A12-W-19A	NA	NA	7.66	48.11	1309.32
		A12-W-19B	NA	NA	7.52	39.89	1349.21
	9/15/02	A12-W-50A	NA	NA	7.77	95.21*	1349.21
		A12-W-50B	NA	NA	7.42		1444.42
	9/16/02	A12-W-88A	6	642	7.66	55.10	1499.52
		A12-W-88B	10	408	7.30	44.62	1544.14
	9/17/02	A12-W-123A	<1	876	7.42	49.93	1594.07
		A12-W-123B	6	374	7.33	39.95	1634.02
	9/18/02	B12-W-12A	<1	686	7.37	54.97	1688.99
		B12-W-12B	<1	368	7.31	42.43	1731.42
	9/19/02	B12-W-19A	NA	NA	7.70	24.01	1755.43
4	9/24/02	B12-W-95A	NA	NA	NA	58.58	1814.01
		B12-W-95B	NA	NA	NA	41.49	1855.50
	9/25/02	B12-W-127A	NA	NA	7.94	48.89	1904.39
		B12-W-127B	NA	NA	7.78	43.47	1947.86
	9/26/02	C12-W-9A	NA	NA	8.02	50.70	1998.56
		C12-W-9B	NA	NA	8.00	40.43	2038.99

*Combined value for two blow-downs; NA – Not analyzed

Table 5.10. Listing of Samples from WESP Blow-Downs (continued).

Test	Date	Name	TSS	TDS	pH	BLD Vol. (gal)	Cumulative BLD Vol. (gal)
4	9/27/02	C12-W-42A	NA	NA	8.02	52.55	2091.54
		C12-W-42B	NA	NA	7.79	40.32	2131.86
	9/28/02	C12-W-76A	NA	NA	8.05	51.88	2183.74
		C12-W-76B	12	28	7.69	40.81	2224.55
	9/29/02	C12-W-110A	<1	844	7.69	56.59	2281.14
		C12-W-110B	6	488	7.69	40.91	2322.05
	9/30/02	C12-W-148A	6	692	7.76	50.28	2372.33
		C12-W-148B	NA	NA	7.53	42.17	2414.50
	10/1/02	D12-W-32A	14	840	7.75	51.29	2465.79
		D12-W-32B	60	448	7.62	47.56	2513.35
	10/2/02	D12-W-65A	19	987	8.39	50.41	2563.76
		D12-W-65B	76	766	7.32	40.00	2603.76
6	10/8/02	D12-W-131A	NA	NA	8.27	50.54	2654.30
		D12-W-131B	NA	NA	8.16	42.34	2696.64
	10/9/02	E12-W-6A	2	262	8.32	54.17	2750.81
		E12-W-6B	4	330	8.30	44.85	2795.66
	10/10/02	E12-W-40A	8	214	8.26	53.59	2849.25
		E12-W-40B	4	566	8.30	45.03	2894.28
	10/11/02	E12-W-67A	<1	334	8.26	50.13	2944.41
		E12-W-67B	2	284	7.53	41.14	2985.55
	10/12/02	E12-W-95A	NA	NA	8.94	55.12	3040.67
		E12-W-95B	NA	NA	8.29	42.60	3083.27
		E12-W-110A	<1	488	7.55	22.30	3105.57
		E12-W-110B	<1	240	8.24	41.11	3146.68
5	10/15/02	E12-W-144A	NA	NA	8.21	36.26	3182.94
	10/16/02	F12-W-15A	NA	NA	8.23	45.16	3228.10
		F12-W-15B	NA	NA	8.35	43.08	3271.18
	10/17/02	F12-W-46A	NA	NA	8.05	50.00	3321.18
		F12-W-46B	NA	NA	7.89	40.74	3361.92
	10/18/02	F12-W-79A	NA	NA	8.15	54.42	3416.34
		F12-W-79B	NA	NA	7.90	41.82	3458.16
	10/19/02	F12-W-113A	NA	NA	7.95	48.77	3506.93
		F12-W-113B	NA	NA	7.66	44.50	3551.43
	10/20/02	F12-W-149A	NA	NA	8.00	55.47	3606.90
		F12-W-149B	NA	NA	7.84	51.50	3658.40
	10/21/02	G12-W-34A	NA	NA	7.97	56.75	3715.15
		G12-W-34B	NA	NA	7.87	39.10	3754.25
	10/22/02	G12-W-61A	NA	NA	7.87	54.60	3808.85
		G12-W-61B	NA	NA	7.82	40.60	3849.45
	10/23/02	G12-W-106A	NA	NA	8.08	56.56	3906.01
		G12-W-106B	NA	NA	7.96	42.26	3948.27
	10/24/02	G12-W-140A	9	665	7.96	40.00	3988.27
		G12-W-140B	28	514	8.12	42.38	4030.65
		G12-W-141A	NA	NA	8.30	18.91	4049.56
		G12-W-142A	NA	NA	NA	40.94	4090.50

Table 5.11. Listing of Samples from PBS Blow-Downs.

Test	Date	Name	pH	BLD Vol. (gal)	Cumulative BLD Vol. (gal)
1	07/24/02	12W-P-132A	8.97	23.15	23.15
		12W-P-149A	9.34	23.90	47.05
	07/25/02	12W-P-155A	ND	37.60	84.65
	07/26/02	12X-P-51A	9.76	39.82	124.47
	07/27/02	12X-P-91A	9.40	34.52	158.99
	07/28/02	12X-P-120A	8.93	28.42	187.41
		12X-P-141A	8.80	24.01	211.42
	07/29/02	12Y-P-25A	8.81	44.51	255.93
	07/30/02	12Y-P-54A	8.81	40.60	296.53
		12Y-P-73A	8.78	17.03	313.56
2	07/31/02	12Y-P-106A	8.88	23.87	337.43
	08/01/02	12Y-P-126A	8.82	38.30	375.73
3	09/10/02	12Z-P-42A	8.72	38.22	413.95
	09/11/02	12Z-P-54A	9.05	41.54	455.49
		12Z-P-78A	8.76	41.88	497.37
	09/12/02	12Z-P-94A	8.81	36.58	533.95
		12Z-P-111A	8.88	44.88	578.83
	09/13/02	12Z-P-122A	8.97	49.76	628.59
		12Z-P-148A	9.01	32.16	660.75
	09/14/02	A12-P-8A	9.34	38.29	699.04
		A12-P-34A	9.21	29.01	728.05
	09/15/02	A12-P-52A	8.90	56.05	784.10
	09/16/02	A12-P-73A	8.98	42.38	826.48
	09/17/02	A12-P-108A	9.09	29.78	856.26
		A12-P-138A	8.81	17.95	874.21
	09/18/02	B12-P-13A	9.00	31.24	905.45
	09/19/02	B12-P-31A	ND	41.21	946.66
4	09/23/02	B12-P-79A	ND	N/A	946.66
	09/24/02	B12-P-83A	ND	N/A	946.66
		B12-P-97A	ND	0.61	947.27
	09/25/02	B12-P-123A	ND	N/A	947.27*
		B12-P-138A	8.95	21.24	968.51
	09/26/02	B12-P-145A	8.83	36.16	1004.67
		C12-P-20A	9.53	22.33	1027.00
	09/27/02	C12-P-30A	9.28	33.56	1060.56
		C12-P-46A	9.03	27.41	1087.97
	09/28/02	C12-P-73A	9.23	28.40	1116.37
		C12-P-92A	9.10	28.66	1145.03
	09/29/02	C12-P-116A	9.32	38.20	1183.23
	09/30/02	C12-P-136A	9.07	32.89	1216.12
		D12-P-21A	8.96	28.29	1244.41
	10/01/02	D12-P-34A	8.96	37.98	1282.39
	10/02/02	D12-P-62A	9.02	33.46	1315.85

ND – Not determined; N/A – Not available due to failure in totalizer readout
*It is estimated that about 120 gallons of PBS liquid was blown down during the totalizer failure. Accumulated totals do not reflect this estimate.

Table 5.11. Listing of Samples from PBS Blow-Downs (continued).

Test	Date	Name	pH	BLD Vol. (gal)	Cumulative BLD Vol. (gal)
6	10/08/02	D12-P-126A	9.47	31.91	1347.76
		D12-P-150A	9.54	38.18	1385.94
	10/09/02	E12-P-7A	9.42	36.48	1422.42
		E12-P-21A	9.56	19.75	1442.17
	10/10/02	E12-P-35A	9.33	30.54	1472.71
		E12-P-51A	9.32	29.12	1501.83
	10/11/02	E12-P-61A	9.07	32.16	1533.99
		E12-P-77A	8.96	25.65	1559.64
	10/12/02	E12-P-82A	9.26	31.11	1590.75
		E12-P-95A	9.56	35.89	1626.64
		E12-P-110A	9.09	19.10	1645.74
5	10/15/02	E12-P-144A	9.40	24.55	1670.29
	10/16/02	F12-P-15A	9.33	37.20	1707.49
		F12-P-31A	9.06	17.01	1724.50
	10/17/02	F12-P-36A	9.03	41.27	1765.77
		F12-P-52A	9.12	20.72	1786.49
	10/18/02	F12-P-65A	10.11	32.36	1818.85
		F12-P-83A	9.50	19.49	1838.34
	10/19/02	F12-P-97A	9.43	27.38	1865.72
		F12-P-117A	9.10	29.00	1894.72
	10/20/02	F12-P-134A	9.44	26.81	1921.53
		F12-P-154A	9.19	24.40	1945.93
	10/21/02	G12-P-21A	9.06	27.58	1973.51
		G12-P-40A	9.00	18.98	1992.49
	10/22/02	G12-P-54A	9.12	27.36	2019.85
		G12-P-80A	9.11	15.53	2035.38
	10/23/02	G12-P-91A	8.86	26.70	2062.08
		G12-P-110A	9.19	18.94	2081.02
		G12-P-114A	8.87	29.41	2110.43
	10/24/02	G12-P-139A	9.31	34.67	2145.10

Table 5.12. Analytical Results for Dissolved solids in WESP Blow-Down Fluids for Test 3C. (mg/l)

Sample ID	A12-W-88A	A12-W-88B	A12-W-123A	A12-W-123B	B12-W-12A	B12-W-12B	B12-W-19A
Glass (kg)	11976	11976	13104	13104	14112	14112	14426
pH	7.66	7.30	7.42	7.33	7.37	7.31	7.70
Al	0.87	0.72	1.10	0.92	1.09	0.94	0.93
B	21.73	6.46	31.86	9.19	27.90	8.45	24.06
Ba	0.05	0.05	0.06	0.05	0.06	0.05	0.06
Ca	34.89	36.34	34.12	36.85	35.32	35.38	35.70
Cd	0.11	0.15	0.20	0.13	0.21	0.12	0.11
Cu	0.07	0.01	0.08	0.01	0.08	0.01	0.07
Fe	0.02	0.02	0.01	0.03	0.02	0.01	0.05
K	6.92	5.00	8.63	6.60	7.97	5.53	6.62
La	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Li	8.26	4.84	7.76	4.99	8.88	4.06	6.83
Mg	10.95	10.88	9.03	11.67	11.58	10.85	11.58
Mn	0.04	0.02	0.03	0.03	0.04	0.03	0.03
Na	106.50	54.59	133.96	65.10	127.34	56.87	96.87
Ni	0.15	0.13	0.24	0.07	0.19	0.09	0.14
Pb	0.09	<0.02	0.06	0.05	0.04	0.03	0.06
Si	2.27	1.74	2.94	1.79	2.71	1.58	2.22
Sr	0.34	0.32	0.39	0.36	0.40	0.33	0.35
Zn	0.23	0.28	0.82	0.24	0.69	0.24	0.42
Zr	0.01	0.01	0.01	<0.01	0.02	0.01	0.01
F	12.36	11.38	17.50	15.96	14.96	13.96	11.87
Cl	60.91	46.31	64.65	46.77	64.30	47.83	59.83
I	6.21	2.68	7.76	2.59	6.59	2.97	5.83
NH_4^+	12.30	10.40	20.50	10.40	10.80	12.90	5.70
Nitrate	7.17	18.60	7.18	17.83	7.78	18.67	6.74
Nitrite	24.11	6.56	28.87	6.17	28.51	5.17	15.34
Sulfate	262.37	157.15	346.94	166.11	300.79	162.24	263.66

Table 5.13. Analytical Results for Dissolved Solids in Select WESP Blow-Down Fluids (mg/l).

Test	4		6		5	
Sample ID	D12-W-65A	D12-W-65B	E12-W-110A	E12-W-110B	G12-W-140A	G12-W-140B
Glass (kg)	19434	19434	20696	20696	24895	24895
pH	8.39	7.32	7.55	8.24	7.96	8.12
Al	0.37	0.33	0.29	0.21	0.51	0.26
B	22.60	9.46	14.93	<0.03	15.03	<0.03
Ba	0.02	<0.01	0.05	0.03	0.03	0.01
Ca	33.73	35.20	43.84	25.43	37.14	40.77
Cd	0.04	0.02	0.55	0.03	0.04	0.03
Cu	0.04	<0.01	0.03	0.01	0.03	<0.01
Fe	0.04	0.02	0.02	0.02	<0.01	<.0066
K	6.52	5.86	11.16	5.94	8.66	6.68
La	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Li	8.03	5.38	2.65	0.55	8.29	5.62
Mg	11.27	11.18	10.08	10.05	8.69	8.65
Mn	0.03	0.03	<0.01	0.01	0.05	0.02
Na	115.06	79.73	53.45	19.53	120.35	65.80
Ni	0.07	0.08	0.06	0.08	<0.01	0.01
Pb	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Si	1.85	1.59	1.75	1.40	3.09	3.18
Sr	0.31	0.28	0.30	0.25	0.25	0.25
Zn	0.14	0.03	0.14	0.01	0.04	0.07
Zr	<0.01	0.02	0.01	0.01	0.01	<0.01
F	9.94	11.85	3.67	1.98	10.44	13.59
Cl	49.21	43.76	56.43	31.12	52.56	41.74
I	9.78	6.09	4.49	<0.1	13.13	4.83
NH_4^+	14.00	8.60	288.50	5.50	9.40	4.80
Nitrate	14.40	22.65	1302.6	25.57	44.26	46.27
Nitrite	25.32	10.07	21.77	0.95	41.45	18.23
Sulfate	380.08	254.85	125.70	80.27	276.59	149.75

Table 5.14. Anion Concentrations for PBS and HEME Blow-Down Liquids (mg/l).

Sample Type	Test	ID	pH	F	Cl	I	NH_4^+	Nitrate	Nitrite	Sulfate
PBS	3	B12-P-31A	NA	11.75	37.03	278.7	<5.6	44.73	560.9	6.29
	4	D12-P-62A	9.02	9.29	30.87	247.0	13.6	14.16	163.7	1.37
	6	E12-P-110A	9.09	4.54	16.18	62.48	<6.5	65.77	229.1	5.61
	5	G12-P-139A	9.31	6.34	28.54	163.2	8.6	16.23	135.4	2.04
HEME 1	6	E12-H1-110A	4.52	36.01	1102	9.90	11688	51404	<0.1	823.9
	5	G12-H1-141A	6.11	13.47	452.5	20.99	4062	18692	243.2	1660

NA – Not analyzed

Table 5.15. Upper Estimates of Accumulations in Off-Gas Liquids from Test 3C.

Analyte	Feed (kg)	SBS			WESP			PBS	
		Mass (g)	% Feed	% Feed calculated from emissions data	Mass (g)	% Feed	% Feed calculated from emissions data	Mass (g)	% Feed
Al	86.5	158	0.2	0.6	0.9	< 0.1	< 0.1	NA	NA
B	116	2005	1.7	1.7	17.0	< 0.1	< 0.1		
Ba	0.6	0.8	0.1	1.0	0.1	< 0.1	< 0.1		
Ca	6.3	19.6	0.3	0.9	34.5	0.5	< 0.1		
Cd	1.7	3.3	0.2	0.8	0.1	< 0.1	< 0.1		
Cu	0.8	0.9	0.1	0.5	< 0.1	< 0.1	< 0.1		
Fe	269	591.9	0.2	0.8	< 0.1	< 0.1	< 0.1		
K	0.8	31.9	4.1	2.7	6.6	0.8	0.2		
La	11.0	2.3	< 0.1	NA	< 0.1	< 0.1	NA		
Li	51.5	247.1	0.5	0.4	6.3	< 0.1	< 0.1		
Mg	2.1	15.9	0.8	1.4	10.5	0.5	< 0.1		
Mn	4.2	2.2	0.1	0.4	< 0.1	< 0.1	< 0.1		
Na	272	2942	1.1	0.7	88.3	< 0.1	< 0.1		
Nd	19.5	NA	NA	NA	NA	NA	NA		
Ni	15.1	28.4	0.2	0.8	0.1	< 0.1	< 0.1		
Pb	0.9	5.8	0.7	1.2	< 0.1	< 0.1	< 0.1		
Si	698	463	0.1	0.3	2.1	< 0.1	< 0.1		
Sr	0.8	1.7	0.2	0.7	0.3	< 0.1	< 0.1		
Zn	50.9	103.7	0.2	0.7	0.4	< 0.1	< 0.1		
Zr	88.6	46.7	0.1	0.4	< 0.1	< 0.1	< 0.1		
F	1.3	574	44.0	20.6	14.0	1.1	NC	5.3	0.4
I	3.2	1374	43.0	43.9	4.7	0.2	29.3	127	4.0
Sulfate	2.7	1183	44.0	47.7	226	8.7	0.4	2.9	0.1
Nitrite + Nitrate	22.3	293	1.3	NC	28.6	0.1	NA	275	1.2

NA – Not analyzed, NC – Not calculated

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed.

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
1A	No	7/23/02	12W-G-117A	-	517.5	517.5
			12W-G-120A	-		
			12W-G-121A	-		
		7/24/02	12W-G-124A	-		
			12W-G-124B	-		
			12W-G-132A	-		
			12W-G-138A	-		
			12W-G-139A	-		
			12W-G-148A	XRF		
			12W-G-150A	-	517.0	1034.5
			12W-G-152A	-		
		7/25/02	12W-G-154A	-		
			12X-G-14A	-		
			12X-G-15A	-		
			12X-G-18A	-		
			12X-G-21A	-		
1B			12X-G-22A	-		
			12X-G-24A	-		
			12X-G-26A	XRF		
			12X-G-27A	-	477.5	1512.0
			12X-G-31A	-		
			12X-G-33A	-		
		7/26/02	12X-G-34A	-		
			12X-G-35A	-		
			12X-G-44A	-		
			12X-G-45A	-		
			12X-G-48A	XRF		
			12X-G-49A	-	506.5	2018.5
			12X-G-53A	-		
1C			12X-G-61A	-		
			12X-G-64A	-		
			12X-G-64B	-		
			12X-G-65A	-		
			12X-G-66A	-		
			12X-G-68A	-		
			12X-G-68B	XRF		
			12X-G-69A	-	-	-
		7/27/02	12X-G-70A	-		
			12X-G-72A	-		
			12X-G-81A	-		
			12X-G-89A	-		
			12X-G-89B	-		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
1C	No	7/27/02	12X-G-90A	-	501.5	2520.0
			12X-G-91A	-		
			12X-G-93A	XRF		
			12X-G-96A	-	498.0	3018.0
			12X-G-96B	-		
			12X-G-98A	-		
1D			12X-G-101A	-		
			12X-G-103A	-		
			12X-G-103B	-		
			12X-G-104A	-		
			12X-G-105A	-		
			12X-G-105B	XRF		
			12X-G-106A	-	466.5	3484.5
			12X-G-106B	-		
			12X-G-108A	-		
		7/28/02	12X-G-110A	-		
			12X-G-118A	-		
			12X-G-118B	-		
			12X-G-120A	-		
			12X-G-121A	XRF		
			12X-G-121B	-	517.5	4002.0
			12X-G-124A	-		
			12X-G-124B	-		
			12X-G-125A	-		
			12X-G-126A	-		
			12X-G-134A	-		
			12X-G-137A	-		
1E			12X-G-139A	-		
			12X-G-141A	XRF		
			12X-G-141B	-	507.0	4509.0
			12X-G-143A	-		
			12X-G-143B	-		
		7/29/02	12X-G-145A	-		
			12X-G-147A	-		
			12X-G-155A	-		
			12Y-G-16A	-		
			12Y-G-17A	-		
			12Y-G-17B	XRF		
			12Y-G-20A	-	-	-
			12Y-G-20B	-		
			12Y-G-21A	-		
			12Y-G-22A	-		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
1E	No	7/29/02	12Y-G-26A	-	504.0	5013.0
			12Y-G-27A	-		
			12Y-G-29A	XRF		
			12Y-G-31A	-	509.5	5522.5
			12Y-G-32A	-		
			12Y-G-32B	-		
			12Y-G-34A	-		
			12Y-G-34B	-		
			12Y-G-36A	-		
		7/30/02	12Y-G-36B	-		
			12Y-G-38A	-		
			12Y-G-46A	XRF		
			12Y-G-47A	-	530.5	6053.0
			12Y-G-50A	-		
			12Y-G-51A	-		
			12Y-G-52A	-		
			12Y-G-52B	-		
			12Y-G-53A	-		
			12Y-G-56A	-		
			12Y-G-59A	XRF		
			12Y-G-69A	-	508.5	6561.5
			12Y-G-69B	-		
			12Y-G-70A	-		
			12Y-G-70B	-		
			12Y-G-71A	-		
			12Y-G-73A	-		
			12Y-G-73B	-		
			12Y-G-74A	-		
		7/31/02	12Y-G-75A	XRF		
2			12Y-G-88A	-	499.0	7060.5
			12Y-G-90A	-		
			12Y-G-90B	-		
			12Y-G-94A	-		
			12Y-G-95A	-		
			12Y-G-105A	-		
			12Y-G-106A	-		
			12Y-G-109A	-		
			12Y-G-117A	-		
			12Y-G-118A	XRF		
		8/1/02	12Y-G-120A	-	-	-
			12Y-G-120B	-		
			12Y-G-124A	-		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
2	No	8/1/02	12Y-G-125A	-	364.5	7425.0
			12Y-G-127A	-		
			12Y-G-131A	-		
			12Y-G-132A	XRF		
3A		9/9/02	12Z-G-20A	-	513.0	7938.0
		9/10/02	12Z-G-23A	-		
			12Z-G-24A	-		
			12Z-G-26A	-		
			12Z-G-27A	-		
			12Z-G-27B	-		
			12Z-G-42A	-		
			12Z-G-45A	-		
			12Z-G-46A	-		
			12Z-G-47A	XRF, density		
			12Z-G-49A	-	514.5	8452.5
		9/11/02	12Z-G-50A	-		
			12Z-G-52A	-		
			12Z-G-54A	-		
			12Z-G-55A	-		
			12Z-G-65A	-		
			12Z-G-73A	-		
			12Z-G-75A	-		
			12Z-G-76A	-		
			12Z-G-78A	XRF, density		
			12Z-G-88A	-	497.5	8950.0
		9/12/02	12Z-G-89A	-		
			12Z-G-91A	-		
			12Z-G-94A	-		
			12Z-G-95A	-		
			12Z-G-104A	-		
			12Z-G-106A	-		
			12Z-G-107A	-		
			12Z-G-108A	-		
			12Z-G-111A	XRF, density		
3B			12Z-G-112A	-	520.0	9470.0
			12Z-G-115A	-		
		9/13/02	12Z-G-117A	-		
			12Z-G-120A	-		
			12Z-G-121A	-		
			12Z-G-124A	-		
			12Z-G-133A	-		
			12Z-G-134A	-		
			12Z-G-134B	XRF, density		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
3B	No	9/13/02	12Z-G-143A	-	513.0	9983.0
			12Z-G-144A	-		
			12Z-G-146A	-		
			12Z-G-146B	-		
			12Z-G-147A	-		
			12Z-G-148A	-		
			12Z-G-150A	-		
			12Z-G-151A	-		
		9/14/02	12Z-G-153A	-		
			12Z-G-154A	XRF, density		
			A12-G-6A	-	494.5	10477.5
			A12-G-8A	-		
			A12-G-9A	-		
			A12-G-17A	-		
			A12-G-19A	-		
			A12-G-28A	-		
			A12-G-29A	-		
			A12-G-29B	-		
			A12-G-30A	-		
			A12-G-31A	XRF, density		
			A12-G-32A	-	526.0	11003.5
			A12-G-34A	-		
			A12-G-42A	-		
		9/15/02	A12-G-42B	-		
			A12-G-43A	-		
			A12-G-44A	-		
			A12-G-46A	-		
			A12-G-48A	-		
			A12-G-49A	-		
			A12-G-50A	XRF		
			A12-G-51A	-	511.0	11514.5
			A12-G-52A	-		
			A12-G-53A	-		
			A12-G-54A	-		
			A12-G-54B	-		
			A12-G-57A	-		
3C			A12-G-58A	-		
			A12-G-66A	-		
		9/16/02	A12-G-67A	-		
			A12-G-68A	XRF		
			A12-G-70A	-	-	-
			A12-G-71A	-		
			A12-G-71B	-		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
3C	No	9/16/02	A12-G-73A	-	512.5	12027.0
			A12-G-76A	-		
			A12-G-84A	-		
			A12-G-86A	-		
			A12-G-86B	-		
			A12-G-88A	-		
			A12-G-89A	XRF		
			A12-G-91A	-	514.0	12541.0
			A12-G-91B	-		
			A12-G-92A	-		
			A12-G-93A	-		
			A12-G-93B	-		
			A12-G-94A	-		
			A12-G-104A	-		
			A12-G-104B	-		
			A12-G-105A	-		
		9/17/02	A12-G-106A	XRF		
			A12-G-107A	-	506.0	13047.0
			A12-G-107B	-		
			A12-G-108A	-		
			A12-G-109A	-		
			A12-G-111A	-		
			A12-G-112A	-		
			A12-G-112B	-		
			A12-G-121A	-		
			A12-G-121B	-		
			A12-G-122A	XRF		
			A12-G-123A	-	513.5	13560.5
			A12-G-125A	-		
			A12-G-125B	-		
			A12-G-128A	-		
			A12-G-136A	-		
			A12-G-136B	-		
			A12-G-137A	-		
			A12-G-138A	-		
			A12-G-139A	XRF		
		9/18/02	A12-G-139B	-	-	-
			A12-G-140A	-		
			A12-G-142A	-		
			A12-G-143A	-		
			A12-G-143B	-		
			A12-G-144A	-		
			A12-G-145A	-		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
3C	No	9/18/02	B12-G-8A	-	506.5	14067.0
			B12-G-8B	-		
			B12-G-10A	XRF		
			B12-G-12A	-	358.5	14425.5
			B12-G-12B	-		
			B12-G-13A	-		
			B12-G-14A	-		
			B12-G-15A	-		
			B12-G-16A	-		
			B12-G-16B	-		
			B12-G-18A	XRF		
4A		9/19/02	B12-G-48A	-	514.5	14940.0
		9/23/02	B12-G-78A	-		
			B12-G-79A	-		
		9/24/02	B12-G-81A	-		
			B12-G-83A	-		
			B12-G-92A	-		
			B12-G-93A	-		
			B12-G-102A	-		
			B12-G-110A	-		
			B12-G-112A	-		
		9/25/02	B12-G-114A	-		
			B12-G-115A	XRF		
			B12-G-124A	-	510.0	15450.0
			B12-G-125A	-		
			B12-G-137A	-		
			B12-G-138A	-		
			B12-G-138B	-		
			B12-G-142A	-		
			B12-G-143A	-		
		9/26/02	B12-G-144A	-		
			B12-G-145A	-		
			C12-G-7A	-		
			C12-G-10A	-		
			C12-G-20A	XRF, Fe^{+2}		
4B			C12-G-24A	-	409.5	15859.5
			C12-G-26A	-		
		9/27/02	C12-G-28A	-		
			C12-G-29A	-		
			C12-G-30A	-		
			C12-G-39A	-		
			C12-G-42A	XRF		
			C12-G-43A	-	22.0	15881.5

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
4B	No	9/27/02	C12-G-43B	-	405.5	16287.0
			C12-G-45A	-		
			C12-G-55A	-		
			C12-G-58A	-		
	Yes		C12-G-59A	-		
		9/28/02	C12-G-60A	-		
			C12-G-61A	-		
			C12-G-62A	XRF		
			C12-G-73A	-	235.0	16522.0
			C12-G-74A	-		
			C12-G-75A	-		
			C12-G-77A	XRF		
			C12-G-82A	-	260.5	16782.5
			C12-G-83A	-		
			C12-G-91A	-		
			C12-G-92A	-		
			C12-G-93A	XRF		
		9/29/02	C12-G-96A	-	245.0	17027.5
			C12-G-97A	-		
			C12-G-97B	-		
			C12-G-106A	-		
			C12-G-108A	XRF, Fe^{+2}		
	No		C12-G-111A	-	414.0	17441.5
			C12-G-116A	-		
			C12-G-128A	-		
			C12-G-129A	SEM, density		
			C12-G-132A	-		
			C12-G-133A	-		
			C12-G-133B	-		
4C		9/30/02	C12-G-134A	-		
			C12-G-135A	XRF		
			C12-G-136A	-	401.5	17843.0
			C12-G-144A	-		
			C12-G-145A	-		
			C12-G-147A	-		
			C12-G-148A	-		
			D12-G-6A	-		
			D12-G-7A	-		
			D12-G-8A	XRF		
			D12-G-9A	-	-	-
			D12-G-21A	-		
			D12-G-22A	-		
			D12-G-23A	-		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
4C	No	9/30/02	D12-G-23B	-	419.5	18262.5
			D12-G-24A	-		
		10/1/02	D12-G-26A	-		
			D12-G-26B	XRF		
			D12-G-28A	-	412.0	18674.5
			D12-G-28B	-		
			D12-G-29A	-		
			D12-G-30A	-		
			D12-G-32A	-		
			D12-G-33A	-		
			D12-G-33B	-		
			D12-G-34A	XRF		
			D12-G-35A	-	418.0	19092.5
			D12-G-45A	-		
			D12-G-46A	-		
			D12-G-47A	-		
			D12-G-48A	-		
			D12-G-50A	-		
			D12-G-50B	-		
		10/2/02	D12-G-51A	XRF		
			D12-G-59A	-	390.0	19482.5
			D12-G-60A	-		
			D12-G-62A	-		
			D12-G-63A	-		
			D12-G-64A	-		
			D12-G-64B	-		
			D12-G-65A	-		
			D12-G-66A	XRF		
			D12-G-67A	-	195.5	19678.0
			D12-G-69A	-		
			D12-G-70A	-		
			D12-G-72A	XRF		
6	No	10/7/02	D12-G-120A	-	406.0	20084.0
			D12-G-121A	-		
		10/8/02	D12-G-126A	-		
			D12-G-127A	-		
	Yes		D12-G-130A	-		
			D12-G-148A	-		
		10/9/02	D12-G-150A	-		
			D12-G-154A	XRF		
			E12-G-6A	-	-	-
			E12-G-8A	-		
			E12-G-21A	-		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
6	Yes	10/10/02	E12-G-36A	-	409.0	20493.0
			E12-G-48A	-		
		10/11/02	E12-G-61A	-		
			E12-G-63A	-		
			E12-G-78A	XRF		
		10/12/02	E12-G-82A	-	202.5	20695.5
			E12-G-92A	-		
			E12-G-93A	-		
			E12-G-104A	XRF		
5A	No	10/15/02	E12-G-129A	-	400.0	21095.5
			E12-G-129B	-		
			E12-G-142A	-		
			E12-G-143A	-		
			E12-G-144A	-		
		10/16/02	E12-G-153A	-		
			E12-G-155A	-		
			F12-G-17A	-		
			F12-G-22A	-		
			F12-G-32A	XRF		
		10/17/02	F12-G-34A	-	391.0	21486.5
			F12-G-37A	-		
			F12-G-46A	-		
			F12-G-49A	-		
			F12-G-54A	-		
		10/18/02	F12-G-65A	-		
			F12-G-68A	-		
			F12-G-68B	XRF		
5B			F12-G-79A	-	392.5	21879.0
			F12-G-83A	-		
			F12-G-84A	-		
			F12-G-88A	-		
		10/19/02	F12-G-98A	-		
			F12-G-99A	-		
			F12-G-102A	-		
			F12-G-104A	XRF		
			F12-G-105A	-	411.5	22290.5
			F12-G-113A	-		
			F12-G-115A	-		
			F12-G-118A	-		
			F12-G-120A	-		
			F12-G-121A	-		
			F12-G-123A	-		
		10/20/02	F12-G-131A	XRF		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
5B	No	10/20/02	F12-G-135A	-	274.5	22565.0
			F12-G-136A	-		
			F12-G-139A	-		
			F12-G-140A	-		
			F12-G-150A	XRF		
			F12-G-154A	-	407.0	22972.0
			F12-G-155A	-		
			G12-G-10A	-		
		10/21/02	G12-G-18A	-		
			G12-G-19A	-		
			G12-G-21A	-		
			G12-G-23A	-		
			G12-G-25A	XRF		
5C			G12-G-35A	-	416.0	23388.0
			G12-G-37A	-		
			G12-G-38A	-		
			G12-G-40A	-		
			G12-G-41A	-		
			G12-G-42A	-		
		10/22/02	G12-G-53A	-		
			G12-G-54A	XRF		
			G12-G-55A	-	402.0	23790.0
			G12-G-56A	-		
			G12-G-60A	-		
			G12-G-61A	-		
			G12-G-78A	-		
			G12-G-79A	-		
			G12-G-80A	-		
			G12-G-84A	XRF		
			G12-G-87A	-	424.0	24214.0
		10/23/02	G12-G-88A	-		
			G12-G-88B	-		
			G12-G-89A	-		
			G12-G-93A	-		
			G12-G-94A	-		
			G12-G-96A	-		
			G12-G-96B	XRF		
			G12-G-106A	-	-	-
			G12-G-110A	-		
			G12-G-111A	-		
			G12-G-112A	-		
			G12-G-113A	XRF		

"-" Empty data field

Table 6.1. Listing of Glass Discharged, Masses, and Analysis Performed (continued).

Test	Metals Spike	Date	Name	Analysis	Mass (kg)	Cumulative Mass (kg)
5C	No	10/23/02	G12-G-122A	-	407.0	24621.0
		10/24/02	G12-G-124A	-		
			G12-G-125A	XRF		
			G12-G-128A	-	273.5	24894.5
			G12-G-129A	-		
			G12-G-130A	-		
			G12-G-139A	-		
			G12-G-140A	XRF		

"-" Empty data field

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

Test		1									
Glass Prod. (kg)		517.5	1034.5	1512.0	2018.5	2520.0	3018.0	3484.5	4002.0	4509.0	5013.0
-	Target	12W-G-148A	12X-G-26A	12X-G-48A	12X-G-68B	12X-G-93A	12X-G-105B	12X-G-121A	12X-G-141A	12Y-G-17B	12Y-G-29A
Al_2O_3	5.19	6.95	6.62	6.85	6.39	5.99	6.12	6.01	6.10	6.03	6.03
B_2O_3*	11.90	10.20	10.60	10.88	11.12	11.30	11.43	11.53	11.62	11.68	11.73
BaO	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.05	0.05	0.06
CaO	0.28	0.70	0.62	0.56	0.51	0.44	0.48	0.42	0.41	0.39	0.38
CdO	0.06	0.26	0.22	0.19	0.16	0.13	0.14	0.12	0.10	0.09	0.08
Ce_2O_3	§	0.03	0.02	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Cr_2O_3	§	0.06	0.05	0.04	0.03	0.02	0.03	0.02	0.02	0.02	0.01
Cs_2O	§	0.08	0.06	0.06	0.05	0.03	0.04	0.02	0.02	0.02	0.01
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	10.05	10.40	10.18	10.54	11.09	10.95	10.81	11.35	11.20	11.42
I	0.10	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K_2O	0.03	0.27	0.24	0.26	0.22	0.17	0.19	0.18	0.20	0.18	0.18
La_2O_3	0.41	0.16	0.24	0.28	0.29	0.35	0.33	0.35	0.39	0.36	0.38
Li_2O*	3.52	4.01	3.89	3.81	3.74	3.69	3.65	3.63	3.60	3.58	3.57
MgO	0.11	0.89	0.73	0.53	0.48	0.33	0.35	0.27	0.23	0.16	0.15
MnO	0.17	1.71	1.37	1.10	0.91	0.63	0.77	0.53	0.46	0.39	0.34
Na_2O	11.65	10.84	11.04	11.08	11.28	11.08	11.45	11.60	10.75	10.95	10.69
Nd_2O_3	0.31	0.06	0.12	0.15	0.19	0.24	0.21	0.25	0.27	0.29	0.29
NiO	0.61	0.41	0.45	0.44	0.46	0.50	0.49	0.49	0.52	0.52	0.53
P_2O_5	§	0.16	0.13	0.10	0.08	0.06	0.08	0.05	0.05	0.04	0.03
PbO	0.03	0.08	0.07	0.06	0.05	0.05	0.05	0.04	0.04	0.03	0.03
PdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Rh_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
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	§	0.11	0.09	0.07	0.05	0.03	0.04	0.02	<0.01	<0.01	<0.01
SeO_2	§	0.02	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SiO_2	47.41	44.49	44.85	45.80	45.97	46.38	45.62	46.53	46.57	47.18	47.28
SO_3	0.07	0.18	0.15	0.15	0.12	0.10	0.10	0.09	0.08	0.09	0.07
SrO	0.03	1.32	1.02	0.78	0.62	0.42	0.53	0.32	0.26	0.21	0.17
TeO_2	§	0.08	0.06	0.05	0.03	0.02	0.02	<0.01	<0.01	<0.01	<0.01
TiO_2	§	0.54	0.44	0.36	0.29	0.22	0.27	0.19	0.17	0.15	0.14
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	2.14	2.08	1.93	1.93	1.94	1.96	1.84	1.92	1.79	1.82
ZrO_2	3.80	4.16	4.39	4.25	4.44	4.74	4.64	4.60	4.80	4.57	4.57
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.
NA – Not analyzed
"-" Empty data cell
§ Not in target composition. Melter feed was spiked with Ce, Y, Pd, Rh, and Ru during Tests 4B and 6.

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

Test		1			2		3				
Glass (kg) prod.		5522.5	6053.0	6561.5	7060.5	7425.0	7938.0	8452.5	8950.0	9470.0	9983.0
-	Target	12Y-G-46A	12Y-G-59A	12Y-G-75A	12Y-G-118A	12Y-G-132A	12Z-G-47A	12Z-G-78A	12Z-G-111A	12Z-G-134B	12Z-G-154A
Al_2O_3	5.19	5.99	5.87	5.70	5.66	5.86	6.30	5.51	5.50	5.54	5.59
B_2O_3*	11.90	11.77	11.80	11.83	11.84	11.85	11.86	11.87	11.88	11.88	11.89
BaO	0.02	0.05	0.06	0.06	0.05	0.05	0.05	0.05	0.06	0.06	0.06
CaO	0.28	0.37	0.36	0.36	0.35	0.35	0.36	0.36	0.36	0.36	0.36
CdO	0.06	0.08	0.07	0.08	0.08	0.07	0.07	0.08	0.08	0.07	0.07
Ce_2O_3	§	<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	0.02	0.02	0.02	0.01	0.01
Cs_2O	§	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	11.48	11.26	11.31	11.21	11.23	10.92	11.53	11.39	11.30	11.25
I	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K_2O	0.03	0.17	0.17	0.16	0.15	0.16	0.16	0.12	0.13	0.13	0.12
La_2O_3	0.41	0.39	0.40	0.39	0.40	0.40	0.40	0.42	0.41	0.42	0.41
Li2O*	3.52	3.56	3.55	3.54	3.54	3.53	3.53	3.53	3.53	3.52	3.52
MgO	0.11	0.14	0.11	0.13	0.11	0.11	0.11	0.09	0.11	0.07	0.06
MnO	0.17	0.30	0.27	0.25	0.23	0.22	0.20	0.21	0.20	0.20	0.19
Na_2O	11.65	10.58	11.18	10.99	11.20	11.46	10.82	11.07	11.30	11.29	11.18
Nd_2O_3	0.31	0.29	0.30	0.30	0.31	0.30	0.30	0.31	0.31	0.31	0.32
NiO	0.61	0.54	0.52	0.52	0.52	0.52	0.50	0.54	0.53	0.54	0.53
P_2O_5	§	0.04	0.03	0.03	0.02	0.03	0.03	0.02	0.02	0.02	0.03
PbO	0.03	0.03	0.03	0.03	0.03	0.00	0.03	0.03	0.03	0.01	0.03
PdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Rh_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RuO_2	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SiO_2	47.41	47.41	47.38	47.64	47.67	47.27	48.01	47.42	47.41	47.59	47.77
SO_3	0.07	0.08	0.07	0.08	0.07	0.08	0.06	0.06	0.07	0.08	0.07
SrO	0.03	0.14	0.11	0.09	0.08	0.07	0.06	0.06	0.05	0.04	0.04
TiO_2	§	0.13	0.11	0.11	0.11	0.10	0.12	0.11	0.10	0.10	0.10
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	1.81	1.76	1.76	1.74	1.73	1.68	1.82	1.77	1.76	1.74
ZrO_2	3.80	4.59	4.55	4.61	4.59	4.58	4.39	4.74	4.71	4.65	4.64
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.
NA – Not analyzed
"-" Empty data field
§ Not in target composition. Melter feed was spiked with Ce, Y, Pd, Rh, and Ru during Tests 4B and 6.

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

Test		3									4A
Glass (kg) prod.		10477.5	11003.5	11514.5	12027.0	12541.0	13047.0	13560.5	14067.0	14425.5	14940.0
-	Target	A12-G-31A	A12-G-50A	A12-G-68A	A12-G-89A	A12-G-106A	A12-G-122A	A12-G-139A	B12-G-10A	B12-G-18A	B12-G-115A
Al_2O_3	5.19	5.69	5.69	5.45	5.88	5.51	5.38	5.44	5.74	5.77	5.31
B_2O_3*	11.90	11.89	11.89	11.89	11.90	11.90	11.90	11.90	11.90	11.90	11.90
BaO	0.02	0.06	0.06	0.06	0.05	0.06	0.05	0.05	0.06	0.05	0.06
CaO	0.28	0.36	0.37	0.37	0.37	0.37	0.37	0.39	0.37	0.38	0.37
CdO	0.06	0.07	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08
Ce_2O_3	§	<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	0.01	0.14
Cs_2O	§	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	11.02	11.23	11.44	11.12	11.52	11.21	11.55	11.22	11.10	11.49
I	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K_2O	0.03	0.12	0.13	0.12	0.13	0.13	0.12	0.13	0.13	0.14	0.11
La_2O_3	0.41	0.40	0.41	0.42	0.42	0.42	0.41	0.41	0.41	0.41	0.42
Li_2O*	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52
MgO	0.11	0.08	0.07	0.10	0.09	0.06	0.07	0.09	0.10	0.08	0.10
MnO	0.17	0.17	0.18	0.18	0.17	0.18	0.17	0.17	0.17	0.17	0.17
Na_2O	11.65	11.78	11.04	11.25	10.87	11.23	11.91	11.21	10.95	11.33	11.44
Nd_2O_3	0.31	0.31	0.32	0.32	0.32	0.32	0.31	0.32	0.32	0.32	0.32
NiO	0.61	0.51	0.54	0.54	0.54	0.56	0.54	0.55	0.54	0.53	0.57
P_2O_5	§	0.02	0.02	0.02	0.01	0.02	0.02	<0.01	0.03	0.02	0.02
PbO	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03
PdO	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Rh_2O_3	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RuO_2	§	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SiO_2	47.41	47.57	47.80	47.43	48.03	47.24	47.34	47.34	47.77	47.63	47.33
SO_3	0.07	0.08	0.07	0.08	0.08	0.07	0.08	0.08	0.07	0.08	0.08
SrO	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.03
TiO_2	§	0.10	0.10	0.10	0.10	0.10	0.09	0.10	0.10	0.10	0.09
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	1.68	1.73	1.78	1.71	1.80	1.74	1.80	1.74	1.72	1.73
ZrO_2	3.80	4.46	4.64	4.75	4.51	4.84	4.61	4.79	4.69	4.59	4.66
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.
NA – Not analyzed
"-" Empty data field
§ Not in target composition. Melter feed was spiked with Ce, Y, Pd, Rh, and Ru during Tests 4B and 6.

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

Test		4A	4B					4C			
Glass (kg) prod.		15450.0	15859.5	16287.0	16522.0	16782.5	17027.5	17441.5	17843.0	18262.5	18674.5
-	Target	C12-G-20A	C12-G-42A	C12-G-62A	C12-G-77B	C12-G-93A	C12-G-108A	C12-G-135A	D12-G-8A	D12-G-26B	D12-G-34A
Al_2O_3	5.19	5.58	5.73	5.48	5.52	5.53	5.79	5.85	5.53	5.50	5.68
B_2O_3*	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90
BaO	0.02	0.06	0.06	0.07	0.05	0.06	0.05	0.06	0.06	0.06	0.05
CaO	0.28	0.36	0.37	0.37	0.38	0.37	0.37	0.36	0.37	0.37	0.37
CdO	0.06	0.07	0.07	0.07	0.07	0.08	0.07	0.07	0.07	0.08	0.07
Ce_2O_3	§	<0.01	<0.01	<0.01	0.02	0.06	0.07	0.06	0.05	0.03	0.03
Cr_2O_3	§	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	<0.01	0.01
Cs_2O	§	0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CuO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	10.33	11.22	10.98	11.12	10.96	10.91	10.73	11.03	11.15	11.16
I	0.10	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
K_2O	0.03	0.13	0.16	0.13	0.13	0.13	0.16	0.17	0.13	0.12	0.15
La_2O_3	0.41	0.39	0.41	0.40	0.40	0.39	0.37	0.37	0.39	0.39	0.42
Li_2O*	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52
MgO	0.11	0.07	0.09	0.07	0.05	0.10	0.07	0.07	0.04	0.07	0.08
MnO	0.17	0.15	0.18	0.16	0.17	0.17	0.16	0.16	0.17	0.17	0.17
Na_2O	11.65	12.58	11.03	11.24	11.14	11.54	10.88	11.34	11.37	11.52	11.04
Nd_2O_3	0.31	0.31	0.32	0.31	0.31	0.31	0.31	0.30	0.32	0.32	0.33
NiO	0.61	0.48	0.54	0.51	0.50	0.51	0.52	0.51	0.53	0.53	0.53
P_2O_5	§	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
PbO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
PdO	§	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
Rh_2O_3	§	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
RuO_2	§	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
SiO_2	47.41	48.08	47.79	48.32	48.09	47.88	48.38	48.23	47.96	47.59	47.91
SO_3	0.07	0.09	0.08	0.09	0.08	0.08	0.07	0.07	0.07	0.07	0.07
SrO	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
TiO_2	§	0.08	0.09	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.08
Y_2O_3	§	<0.01	<0.01	0.02	0.04	0.06	0.08	0.07	0.06	0.05	0.04
ZnO	2.01	1.56	1.73	1.67	1.72	1.67	1.68	1.63	1.71	1.73	1.72
ZrO_2	3.80	4.14	4.58	4.48	4.55	4.46	4.42	4.32	4.52	4.63	4.56
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.
NA – Not analyzed
"-" Blank cell
§ Not in target composition. Melter feed was spiked with Ce, Y, Pd, Rh, and Ru during Tests 4B and 6.

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

Test		4C			6			5			
Glass (kg)		19092.5	19482.5	19678.0	20084.0	20493.0	20695.5	21095.5	21486.5	21879.0	22290.5
-	Target	D12-G-51A	D12-G-66A	D12-G-72A	D12-G-154A	E12-G-78A	E12-G-104A	F12-G-32A	F12-G-68B	F12-G-104A	F12-G-131A
Al_2O_3	5.19	5.67	5.76	5.35	5.48	5.78	5.48	5.37	5.32	5.57	5.64
B_2O_3*	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90
BaO	0.02	0.05	0.05	0.06	0.06	0.06	0.05	0.06	0.06	0.06	0.05
CaO	0.28	0.37	0.37	0.38	0.39	0.39	0.38	0.38	0.39	0.40	0.38
CdO	0.06	0.07	0.07	0.08	0.08	0.07	0.07	0.08	0.08	0.08	0.08
Ce_2O_3	§	0.03	0.02	0.01	0.04	0.06	0.07	0.07	0.05	0.05	0.04
Cr_2O_3	§	<0.01	0.01	0.16	0.01	0.01	0.01	0.18	0.15	0.01	0.01
Cs_2O	§	0.01	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CuO	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.04	0.03	0.03
F	0.04	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fe_2O_3	12.21	10.95	10.86	11.91	11.54	10.84	11.38	11.75	11.96	11.77	11.46
I	0.10	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
K_2O	0.03	0.14	0.15	0.11	0.12	0.13	0.12	0.12	0.11	0.13	0.13
La_2O_3	0.41	0.40	0.39	0.42	0.43	0.38	0.39	0.38	0.41	0.40	0.41
Li_2O*	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52
MgO	0.11	0.07	0.06	0.05	0.09	0.12	0.08	0.07	0.07	0.04	0.12
MnO	0.17	0.17	0.17	0.19	0.18	0.17	0.17	0.18	0.18	0.18	0.18
Na_2O	11.65	11.40	11.44	11.25	11.01	11.26	11.03	11.17	11.04	10.61	10.99
Nd_2O_3	0.31	0.32	0.31	0.33	0.32	0.31	0.32	0.33	0.34	0.34	0.35
NiO	0.61	0.53	0.51	0.62	0.55	0.52	0.54	0.60	0.61	0.57	0.56
P_2O_5	§	0.01	0.01	0.01	<0.01	0.03	<0.01	0.01	<0.01	0.01	<0.01
PbO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
PdO	§	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01
Rh_2O_3	§	0.01	0.01	0.01	<0.01	0.01	0.01	0.01	0.01	<0.01	0.01
RuO_2	§	0.01	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.01	<0.01
SiO_2	47.41	47.95	48.08	46.82	47.44	48.04	47.64	47.06	46.85	47.32	47.31
SO_3	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.07	0.07	0.07
SrO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
TiO_2	§	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.08	0.09	0.09
Y_2O_3	§	0.03	0.02	0.02	0.04	0.07	0.09	0.08	0.07	0.06	0.05
ZnO	2.01	1.70	1.67	1.82	1.78	1.68	1.78	1.76	1.80	1.84	1.78
ZrO_2	3.80	4.47	4.39	4.74	4.76	4.35	4.67	4.64	4.82	4.89	4.76
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.
NA – Not analyzed
"-" Empty data field
§ Not in target composition. Melter feed was spiked with Ce, Y, Pd, Rh, and Ru during Tests 4B and 6.

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

Test		5								
Glass (kg)		22565.0	22972.0	23388.0	23790.0	24214.0	24621.0	24894.5	12000-25000 kg glass	
-	Target	F12-G-150A	G12-G-25A	G12-G-54A	G12-G-84A	G12-G-96B	G12-G-125A	G12-G-140A	Average	% Dev.
Al_2O_3	5.19	5.58	5.47	5.74	6.23	6.73	6.71	6.68	5.70	9.80
B_2O_3*	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	11.90	NC
BaO	0.02	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.06	NC
CaO	0.28	0.40	0.39	0.39	0.40	0.39	0.39	0.40	0.38	NC
CdO	0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.01	0.07	NC
Ce_2O_3	§	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	NC
Cr_2O_3	§	0.01	0.19	0.20	0.16	0.13	0.18	0.18	0.06	NC
Cs_2O	§	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	NC
CuO	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.03	NC
F	0.04	NA	NA	NA	NA	NA	NA	NA	NC	NC
Fe_2O_3	12.21	11.79	12.26	11.95	12.10	11.94	12.00	12.14	11.39	-6.71
I	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
K_2O	0.03	0.13	0.11	0.12	0.11	0.12	0.11	0.11	0.13	NC
La_2O_3	0.41	0.43	0.43	0.40	0.41	0.42	0.41	0.40	0.40	-1.36
Li_2O*	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	NC
MgO	0.11	0.08	0.07	0.09	0.06	0.08	0.06	0.09	0.08	NC
MnO	0.17	0.18	0.20	0.21	0.23	0.24	0.24	0.25	0.18	NC
Na_2O	11.65	10.43	10.99	11.81	11.49	11.14	11.09	11.07	11.23	-3.62
Nd_2O_3	0.31	0.35	0.35	0.35	0.34	0.36	0.35	0.36	0.33	5.09
NiO	0.61	0.57	0.62	0.62	0.63	0.60	0.61	0.62	0.55	-9.16
P_2O_5	§	0.01	<0.01	0.02	<0.01	0.02	<0.01	0.02	0.01	NC
PbO	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	NC
PdO	§	0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.01	NC
Rh_2O_3	§	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NC
RuO_2	§	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	NC
SiO_2	47.41	47.32	46.31	45.76	45.28	45.32	45.38	45.12	47.29	-0.25
SO_3	0.07	0.06	0.06	0.05	0.06	0.06	0.06	0.05	0.07	NC
SrO	0.03	0.04	0.03	0.03	0.04	0.03	0.03	0.03	0.03	NC
TiO_2	§	0.09	0.09	0.08	0.08	0.08	0.09	0.08	0.09	NC
Y_2O_3	§	0.04	0.04	0.03	0.02	0.02	0.01	0.01	0.03	NC
ZnO	2.01	1.83	1.84	1.78	1.83	1.82	1.80	1.83	1.75	-13.18
ZrO_2	3.80	4.97	4.88	4.73	4.87	4.83	4.82	4.92	4.64	22.15
Sum	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.
NA – Not analyzed
NC – Not analyzed
"-" Empty data field
§ Not in target composition. Melter feed was spiked with Ce, Y, Pd, Rh, and Ru during Tests 4B and 6.

Table 6.3. Intrinsic Densities for Discharged Glass Samples from DM1200 Melter Tests.

Waste Type	Date	Name	Density (g/cm^3)
DM1200 AZ-101	09/10/02	12Z-G-47A	2.637
	09/11/02	12Z-G-78A	2.670
	09/12/02	12Z-G-111A	2.672
	09/13/02	12Z-G-134B	2.607
	09/14/02	Z12-G-154A	2.655
	09/14/02	A12-G-31A	2.655
	09/15/02	A12-G-50A	2.602
	09/29/02	C12-G-129A	2.687
	Average		2.648
DM1200 AZ-102	11/26/02	L12-G-66B	2.650
DM1200 C-106/AY-102	01/30/03	N12-G-155A	2.730
DM1200 C-104/AY-101	02/25/03	P12-G-124A	2.740
	02/28/03	Q12-G-136A	2.784

Table 7.1. Summary of Method 29 Particulate Matter Results.

-	Outlet Location/ Run	Sampling Interval	Total wt. gain (mg)	Meter Volume (dscf)	Conc. (mg/dscf)	Flow Rate (dscfm)	Emission Rate (mg/min)	Moisture (% Vol.)	% Isokinetic
Test 3	Melter	09/12/02 0946 – 1046	411.5	51.584	8.0	204.77	1634	11.7	101.7
	Melter	09/14/02 0847 - 0947	271.4	48.363	5.6	198.80	1116	16.2	98.2
	Melter	09/17/02 0831 – 0931	1349	53.870	25.0	199.07	4987	24.1	109.2
	SBS	09/11/02 0825 – 1105	22.2	132.796	0.17	201.19	33.6	7.58	104.8
	SBS	09/15/02–1249 - 1549	62.8	183.758	0.34	247.51	84.6	7.14	104.7
	SBS	09/17/02 1439 – 1729	73.6	157.486	0.47	222.62	104.0	7.27	105.7
	WESP	09/10/02 0815 – 09/12/02 1835	60.0	1545.857	0.04	231.73	9.0	7.01	102.9
	WESP	09/13/02 0639 – 09/15/02 1841	58.8	1676.654	0.04	246.88	8.7	6.93	103.9
	WESP	09/16/02 0636 – 09/18/02 2023	45.6	1591.836	0.03	243.03	6.8	6.88	103.1
Test 4C	Melter	10/01/02 0737 – 0837	1694	47.055	36.0	181.46	6534	26.6	106.3
	Melter	10/01/02 1403 – 1503	1253	45.142	27.8	182.41	5062	25.5	101.5
	Melter	10/02/02 0745 – 0845	1162	42.347	27.4	174.56	4789	27.1	99.5
	SBS	10/01/02 1003 – 1303	105.5	153.148	0.69	211.98	146.0	7.11	101.9
	SBS	10/01/02 1606 – 1806	69.4	103.423	0.67	217.21	145.8	6.92	100.8
	SBS	10/02/02 0508 – 0708	58.6	102.673	0.57	213.07	121.6	8.15	102.0
	WESP	09/30/02 1631 – 10/02/02 0455	34.4	1386.539	0.02	214.50	5.3	7.17	98.9
Test 5C	Melter	10/23/02 1054 – 1154	1011	33.762	29.9	128.69	3853	26.2	107.6
	Melter	10/23/02 1502 – 1602	1037	35.688	29.1	137.34	3992	25.7	106.6
	Melter	10/24/02 0354 – 0454	2538	41.706	60.9	175.56	10684	26.1	99.8
	SBS	10/23/02 0732 – 0932	55.0	99.819	0.55	216.22	119	7.55	97.7
	SBS	10/23/02 1240 – 1424	55.4	61.151	0.91	216.07	196	7.63	89.9
	SBS	10/23/02 1647 – 1856	45.9	79.135	0.58	216.36	125	7.48	82.9
	WESP	10/22/02 1647 – 10/24/02 0515	20.7	1378.316	0.02	215.39	3.0	7.39	97.9
Test 6	Melter	10/11/02 0921 – 1021	420	35.713	11.8	209.99	2471	8.02	93.7
	Melter	10/11/02 1110 – 1210	243	38.597	6.6	212.03	1405	9.18	95.1
	Melter	10/11/02 1300 - 1400	496	38.530	12.9	210.63	2711	9.25	100.8

"-" Empty data field

Table 7.2. Results from Test 3A Emissions Sampling.

-		Feed Flux (mg/min)	Emissions (mg/min)			Percent of Feed in Emissions			DF Across Component			
			Melter	SBS	WESP	Melter	SBS	WESP	Melter	SBS	WESP	Cumulative
Particulate	Total$	396400	1634	33.6	9.0	0.41	0.01	< 0.01	243	48.6	3.7	44044
	Al	8847	21.6	0.12	< 0.10	0.24	< 0.01	< 0.01	410	180	> 1.2	> 88470
	B	11900	59.3	0.38	< 0.10	0.50	< 0.01	< 0.01	201	156	> 3.8	> 119000
	Ba	58	0.18	< 0.10	< 0.10	0.31	< 0.17	< 0.17	322	> 1.8	NC	> 580
	Ca	645	3.67	0.21	< 0.10	0.57	0.033	< 0.02	176	17.5	> 2.1	> 6450
	Cd	173	0.59	< 0.10	< 0.10	0.34	< 0.06	< 0.06	293	> 5.9	NC	> 1730
	Cl*	0	40.4	NA	NA	NC	NC	NC	NC	NA	NA	NA
	Cu	77	0.28	< 0.10	< 0.10	0.36	< 0.13	< 0.13	275	> 2.8	NC	> 770
	F*	129	12.6	NA	NA	9.75	NA	NA	10.3	NA	NA	NA
	Fe	27510	71.89	0.26	< 0.10	0.26	< 0.01	< 0.01	383	277	> 2.6	> 275100
	I*	322	< 0.10	NA	NA	< 0.03	NA	NA	> 3220	NA	NA	NA
	K	80	1.00	0.47	0.61	1.25	0.59	0.763	80.0	2.1	0.8	131.1
	Li	5269	9.62	0.50	< 0.10	0.18	0.01	< 0.01	548	19.2	> 5.0	> 52690
	Mg	214	1.53	< 0.10	< 0.10	0.72	< 0.05	< 0.05	140	> 15.3	NC	> 2140
	Mn	424	0.84	0.19	1.17	0.20	0.05	0.276	505	4.4	0.2	362.4
	Na	27851	115	5.30	0.19	0.41	0.02	< 0.01	243	21.7	27.9	146584
	Ni	1545	3.94	< 0.10	< 0.10	0.26	< 0.01	< 0.01	392	> 39.4	NC	> 15450
	Pb	90	0.20	< 0.10	< 0.10	0.22	< 0.11	< 0.11	450	> 2.0	NC	> 900
	S*	90	18.3*	NA	NA	20.3	NA	NA	4.9	NA	NA	NA
	Si	71396	87.7	< 0.10	< 0.10	0.12	< 0.01	< 0.01	814	> 877	NC	> 713960
	Sr	82	0.21	< 0.10	< 0.10	0.26	< 0.12	< 0.12	391	> 2.1	NC	> 820
	Zn	5203	29.9	0.11	0.61	0.57	< 0.01	0.01	174	271.5	0.2	8530
	Zr	9064	13.7	< 0.10	< 0.10	0.15	< 0.01	< 0.01	662	> 137	NC	> 90640
Gas	B	11900	46.2	0.76	0.25	0.39	< 0.01	< 0.01	258	60.7	3.0	47600
	Cl	0	< 0.10	< 0.10	< 0.10	NC	NC	NC	NC	NC	NC	NC
	F	129	16.9	< 0.10	< 0.10	13.1	< 0.08	< 0.08	7.6	> 169	NC	> 1290
	I	322	302	308	260	93.6	95.8	80.7	1.1	1.0	1.2	1.2
	S	90	8.15	0.54	0.20	9.06	0.60	0.22	11.0	15.1	2.7	450.0

$ - From gravimetric analysis of filters and front-half rinse dry-down
* - From water dissolution of filter particulate
"-" Empty data field

Table 7.3. Results from Test 3B Emissions Sampling.

-		Feed Flux (mg/min)	Emission Rate (mg/min)			Percent of Feed in Emissions			DF Across Component			
			Melter	SBS	WESP	Melter	SBS	WESP	Melter	SBS	WESP	Cumulative
Particulate	Total$	625700	1116	84.6	8.7	0.18	0.01	< 0.01	561	13.2	9.7	71919.5
	Al	13965	26.0	0.10	< 0.10	0.19	< 0.01	< 0.00	537	260.1	> 1.0	> 139650
	B	18784	65.1	0.67	< 0.10	0.35	< 0.01	< 0.00	288	97.2	> 6.7	> 187840
	Ba	91	0.51	< 0.10	< 0.10	0.56	< 0.11	< 0.11	178	> 5.1	NC	> 910
	Ca	1018	3.17	< 0.10	< 0.10	0.31	< 0.01	< 0.01	321	> 31.7	NC	> 10180
	Cd	273	1.04	< 0.10	< 0.10	0.38	< 0.04	< 0.04	263	> 10.4	NC	> 2730
	Cl*	0	27.2	NA	NA	NC	NC	NC	NC	NA	NA	NA
	Cu	122	0.28	< 0.10	< 0.10	0.23	< 0.08	< 0.08	436	> 2.8	NC	> 1220
	F*	203	17.9	NA	NA	8.80	NA	NA	11.4	NA	NA	NA
	Fe	43425	121	0.50	< 0.10	0.28	< 0.01	< 0.01	360	242	> 5.0	> 434250
	I*	509	< 0.10	NA	NA	< 0.02	NA	NA	> 5090	NA	NA	NA
	K	127	1.17	0.44	< 0.10	0.92	0.35	< 0.08	109	2.7	> 4.4	> 1270
	Li	8317	11.6	2.01	0.13	0.14	0.02	< 0.01	720	5.8	15.5	63977
	Mg	337	1.73	< 0.10	< 0.10	0.51	< 0.03	< 0.03	195	> 17.3	NC	> 3370
	Mn	670	1.12	0.41	< 0.10	0.17	0.06	< 0.01	598	2.7	> 4.1	> 6700
	Na	43963	133	17.71	1.67	0.30	0.04	< 0.01	332	7.5	10.6	26325
	Ni	2438	5.77	0.11	< 0.10	0.24	< 0.01	< 0.01	423	52.5	> 1.1	> 24380
	Pb	142	0.46	< 0.10	< 0.10	0.32	< 0.07	< 0.07	309	> 4.6	NC	> 1420
	S*	143	27.9	NA	NA	19.5	NA	NA	5.1	NA	NA	NA
	Si	112699	142	0.14	< 0.10	0.13	< 0.01	< 0.01	792	1016	> 1.4	> 1126990
	Sr	129	0.22	< 0.10	< 0.10	0.17	< 0.08	< 0.08	586	> 2.2	NC	> 1290
	Zn	8213	25.0	0.22	< 0.10	0.30	< 0.01	< 0.01	329	114	> 2.2	> 82130
	Zr	14308	21.7	< 0.10	< 0.10	0.15	< 0.01	< 0.01	661	> 217	NC	> 143080
Gas	B	18784	92.8	3.94	0.80	0.49	0.02	< 0.01	203	23.5	4.9	23480
	Cl	0	< 0.10	< 0.10	< 0.10	NC	NC	NC	NC	NC	NC	NC
	F	203	43.4	< 0.10	< 0.10	21.4	< 0.05	< 0.05	4.7	> 434	NC	> 2030
	I	509	417	291	239	81.9	57.3	46.9	1.2	1.4	1.2	2.1
	S	143	28.6	0.45	0.16	20.0	0.32	0.11	5.0	63.5	2.8	894

$ - From gravimetric analysis of filters and front-half rinse dry-down
* - From water dissolution of filter particulate
"-" Empty data field

Table 7.4. Results from Test 3C Emissions Sampling.

-		Feed Flux (mg/min)	Emission Rate (mg/min)			Percent of Feed in Emissions			DF Across Component			
			Melter	SBS	WESP	Melter	SBS	WESP	Melter	SBS	Wesp	Cumulative
Particulate	Total[$]	903300	4987	104.0	6.8	0.55	0.01	< 0.01	181	48.0	15.3	132838
	Al	20159	127	0.15	< 0.10	0.63	< 0.01	< 0.01	159	847	> 1.5	> 201590
	B	27116	264	1.22	< 0.10	0.97	< 0.01	< 0.01	103	216	> 12.2	> 271160
	Ba	132	1.45	< 0.10	< 0.10	1.10	< 0.08	< 0.08	91	> 14.5	NC	> 1320
	Ca	1470	12.8	< 0.10	< 0.10	0.87	< 0.01	< 0.01	115	> 128	NC	> 14700
	Cd	394	3.38	< 0.10	< 0.10	0.86	< 0.03	< 0.03	117	> 33.8	NC	> 3940
	Cl*	0	95.3	NA	NA	NC	NC	NC	NC	NA	NA	NA
	Cu	176	0.97	< 0.10	< 0.10	0.55	< 0.06	< 0.06	181	> 9.7	NC	> 1760
	F*	294	261	NA	NA	88.8	NA	NA	1.1	NA	NA	NA
	Fe	62688	492	1.06	< 0.10	0.79	< 0.01	< 0.01	127	464	> 10.6	> 626880
	I*	734	< 0.10	NA	NA	< 0.01	NA	NA	> 7340	NA	NA	NA
	K	183	5.37	0.47	< 0.10	2.93	0.26	< 0.05	34	11.4	> 4.7	> 1830
	Li	12006	43.9	2.21	0.15	0.37	0.02	< 0.01	273	19.9	14.7	80040
	Mg	487	6.89	< 0.10	< 0.10	1.42	< 0.02	< 0.02	71	> 68.9	NC	> 4870
	Mn	967	4.28	< 0.10	< 0.10	0.44	< 0.01	< 0.01	226	> 42.8	NC	> 9670
	Na	63464	476	22.53	1.74	0.75	0.04	< 0.01	133	21.1	12.9	36474
	Ni	3520	27.35	< 0.10	< 0.10	0.78	< 0.01	< 0.01	129	> 274	NC	> 35200
	Pb	204	2.54	< 0.10	< 0.10	1.25	< 0.05	< 0.05	80	> 25.4	NC	> 2040
	S*	206	116	NA	NA	56.3	NA	NA	1.8	NA	NA	NA
	Si	162690	463	0.47	< 0.10	0.29	< 0.01	< 0.01	351	986	> 4.7	> 1626900
	Sr	186	1.38	< 0.10	< 0.10	0.74	< 0.05	< 0.05	135	> 13.8	NC	> 1860
	Zn	11857	87.86	0.37	< 0.10	0.74	< 0.01	< 0.01	135	238	> 3.7	> 118570
	Zr	20655	76.78	< 0.10	< 0.10	0.37	< 0.01	< 0.01	269	> 768	NC	> 206550
Gas	B	27116	193.07	4.28	1.17	0.71	0.02	< 0.01	140	45.1	3.7	23176
	Cl	0	< 0.10	< 0.10	< 0.10	NC	NC	NC	NC	NC	NC	NC
	F	294	60.57	< 0.10	0.42	20.60	< 0.03	0.14	4.9	> 606	NC	700
	I	734	748	426	211	102	58.0	28.7	1.0	1.8	2.0	3.5
	S	206	33.3	0.46	0.20	16.2	0.22	0.10	6.2	72.3	2.3	1030

$ - From gravimetric analysis of filters and front-half rinse dry-down
* - From water dissolution of filter particulate
"-" Empty data field

Table 7.5. Results from Test 4C Melter Emissions Sampling.

	-	Average Feed Flux (mg/min)	Run 1 (mg/min)	Run 2 (mg/min)	Run 3 (mg/min)	Average (mg/min)	Percent of Feed	DF Across Melter
Particulate	Total[$]	703600	6534	5062	4789	5462	0.78	129
	Al	17092	202	145	169	172	1.01	99
	B	22991	353	277	250	293	1.28	78
	Ba	112	1.95	1.27	1.24	1.49	1.33	75
	Ca	1246	19.1	13.3	11.9	14.8	1.19	84
	Cd	334	4.01	3.24	3.28	3.51	1.05	95
	Cl*	0	86.3	79.5	117	94.4	NC	NC
	Cu	149	1.26	0.81	0.97	1.01	0.68	147
	F*	249	229	129	188	182	73.1	1.4
	Fe	53151	689	562	495	582	1.10	91
	I*	623	< 0.10	< 0.10	< 0.10	< 0.10	< 0.02	> 6230
	K	155	5.88	4.60	3.81	4.76	3.07	33
	Li	10179	66.6	51.3	44.7	54.2	0.53	188
	Mg	413	9.58	7.28	7.08	7.98	1.93	52
	Mn	820	4.73	2.82	3.29	3.61	0.44	227
	Na	53809	636	519	449	534	0.99	101
	Ni	2984	39.0	29.4	26.8	31.7	1.06	94
	Pb	173	3.38	2.58	2.52	2.83	1.63	61
	Pd[#]	0	< 0.10	< 0.10	< 0.10	< 0.10	NC	NC
	Rh[#]	0	0.67	0.60	0.41	0.56	NC	NC
	Ru[#]	0	25.5	31.8	15.5	24.3	NC	NC
	S*	175	82.7	81.1	67.9	77.3	44.2	2
	Si	137940	579	471	477	509	0.37	271
	Sr	158	2.43	1.71	1.47	1.87	1.18	84
	Zn	10053	117	92.5	84.9	98.2	0.98	102
	Zr	17513	93.2	47.0	90.2	76.8	0.44	228
Gas	B	22991	179	177	175	177	0.77	130
	Cl	< 1	12.8	9.55	10.6	11.0	NC	NC
	F	249	44.5	44.2	47.0	45.2	18.2	6
	I	623	499	554	503	518	83.2	1
	S	175	12.4	12.4	17.6	14.1	8.06	12

$ - From gravimetric analysis of filters and front-half rinse dry-down
* - From water dissolution of filter particulate
\# - From combination of standard HF:HNO_3 digestion and NaOH:Ru fusion in HCl
"-" Empty data field

Table 7.6. Results from Test 4C SBS Emissions Sampling.

-		Average Melter Flux (mg/min)	Run 1 (mg/min)	Run 2 (mg/min)	Run 3 (mg/min)	Average (mg/min)	Percent of Melter Emissions	DF Across SBS
Particulate	Total[$]	5461.7	146.0	145.8	121.6	137.6	2.52	40
	Al	172	0.47	0.4	0.33	0.40	0.23	430
	B	293	1.14	0.97	0.82	0.98	0.33	300
	Ba	1.49	< 0.10	< 0.10	< 0.10	< 0.10	< 6.71	> 14.9
	Ca	14.8	0.35	0.33	0.35	0.34	2.32	43
	Cd	3.51	< 0.10	< 0.10	< 0.10	< 0.10	< 2.85	> 35.1
	Cl	94.4	NA	NA	NA	NA	NA	NA
	Cu	1.01	< 0.10	< 0.10	< 0.10	< 0.10	< 9.9	> 10.1
	F	182	NA	NA	NA	NA	NA	NA
	Fe	582	1.56	0.9	0.79	1.08	0.19	537
	I	< 0.10	NA	NA	NA	NA	NA	NA
	K	4.76	0.51	0.46	0.4	0.46	9.59	10
	Li	54.2	2.22	2.02	2.15	2.13	3.93	25
	Mg	7.98	< 0.10	0.13	0.13	0.13	1.63	61
	Mn	3.61	0.25	< 0.10	< 0.10	0.25	6.92	14
	Na	534	27.11	26	22.47	25.2	4.72	21
	Ni	31.7	< 0.10	< 0.10	< 0.10	< 0.10	< 0.32	> 317
	Pb	2.83	< 0.10	< 0.10	< 0.10	< 0.10	< 3.53	> 28.3
	Pd[#]	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	NC	NC
	Rh[#]	0.56	< 0.10	< 0.10	< 0.10	< 0.10	< 17.9	> 5.6
	Ru[#]	24.3	4.85	8.66	6.81	6.77	27.9	3.6
	S	77.3	24.0	24.4	20.5	23.0	29.7	3
	Si	509	1.04	0.92	0.73	0.90	0.18	568
	Sr	1.87	< 0.10	< 0.10	< 0.10	< 0.10	< 5.35	> 18.7
	Zn	98.2	1.58	0.34	0.34	0.75	0.77	130
	Zr	76.8	< 0.10	< 0.10	< 0.10	< 0.10	< 0.13	> 768
Gas	B	177	3.98	3.61	4.12	3.90	2.21	45
	Cl	11.0	3.00	3.72	2.80	3.17	28.8	3.5
	F	45.2	0.94	0.66	0.38	0.66	1.46	69
	I	518	391	420	418	410	79.1	1
	S	14.1	0.84	0.77	0.55	0.72	5.11	20

$ - From gravimetric analysis of filters and front-half rinse dry-down
# - From combination of standard HF:HNO_3 digestion and NaOH:Ru fusion in HCl
"-" Empty data field

Table 7.7. Results from Test 4C WESP Emissions Sampling.

-		Average Feed Flux (mg/min)	Average SBS Flux (mg/min)	WESP Run 1 (mg/min)	DF Across WESP	Percent of Feed	Cumulative DF
Particulate	Total[$]	703600	138	5.3	26.0	< 0.01	132755
	Al	17092	0.40	< 0.10	> 4.0	< 0.01	> 170920
	B	22991	0.98	< 0.10	> 9.8	< 0.01	> 229910
	Ba	112	< 0.10	< 0.10	NC	< 0.09	> 1120
	Ca	1246	0.34	< 0.10	>3.4	< 0.01	> 12460
	Cd	334	< 0.10	< 0.10	NC	0.03	> 3340
	Cl	< 1	NA	NA	NA	NA	NA
	Cu	149	< 0.10	< 0.10	NC	< 0.07	> 1490
	F	249	< 0.10	NA	NA	NA	NA
	Fe	53151	1.08	< 0.10	> 10.8	< 0.01	> 531510
	I	623	NA	NA	NA	NA	NA
	K	155	0.46	< 0.10	> 4.6	< 0.06	> 1550
	Li	10179	2.13	< 0.10	> 21.3	< 0.01	> 101790
	Mg	413	0.13	< 0.10	> 1.3	< 0.02	> 4130
	Mn	820	0.25	< 0.10	> 2.5	< 0.01	> 8200
	Na	53809	25.2	0.94	26.8	< 0.01	57244
	Ni	2984	< 0.10	< 0.10	NC	< 0.01	> 29840
	Pb	173	< 0.10	< 0.10	NC	< 0.06	> 1730
	Pd	0	< 0.10	< 0.10	NC	NC	NC
	Rh	0	< 0.10	< 0.10	NC	NC	NC
	Ru	0	6.05	< 0.10	> 60	NC	NC
	S	175	23.0	1.24	18.5	0.71	141
	Si	137940	0.90	< 0.10	9.0	< 0.01	> 1379400
	Sr	158	< 0.10	< 0.10	NC	< 0.06	> 1580
	Zn	10053	0.75	< 0.10	7.5	< 0.01	>100530
	Zr	17513	< 0.10	< 0.10	NC	< 0.01	> 175130
Gas	B	22991	3.90	0.75	5.2	< 0.01	30655
	Cl	< 1	3.17	0.48	6.6	NC	NC
	F	249	0.66	0.79	0.8	0.32	315
	I	623	410	140	2.9	22.5	4
	S	175	0.72	0.15	4.8	0.09	1167

$ - From gravimetric analysis of filters and front-half rinse dry-down
"-" Empty data field

Table 7.8. Results from DM1200 AZ-101 Test 6 Melter Emissions Sampling.

-		Average Feed Flux (mg/min)	Run 1 (mg/min)	Run 2 (mg/min)	Run 3 (mg/min)	Average (mg/min)	Percent of Feed	DF Across Melter
Particulate	Total$	185392	2471	1405	2711	2196	1.18	84
	Al	4431	83.2	34.0	17.5	44.9	1.01	99
	B	5961	108	49.6	103	86.9	1.46	69
	Ba	29	0.77	0.24	0.30	0.44	1.51	66
	Ca	323	6.13	3.48	5.30	4.97	1.54	65
	Cd	87	1.14	0.74	0.99	0.96	1.10	91
	Cl*	< 1	5.2	4.4	6.0	5.2	NC	NC
	Cu	39	0.56	0.25	0.39	0.40	1.04	98
	F*	65	26.9	37.7	60.2	41.6	64	1.6
	Fe	13780	262	144	69.5	159	1.15	87
	I*	161	< 0.10	< 0.10	< 0.10	< 0.10	< 0.07	> 1610
	K	40	1.25	0.72	0.89	0.95	2.38	42
	Li	2639	19.5	10.11	18.7	16.1	0.61	160
	Mg	107	3.27	1.84	1.92	2.34	2.19	46
	Mn	212	1.56	0.74	0.77	1.02	0.48	210
	Na	13951	211	113	216	180	1.29	78
	Ni	774	12.8	6.98	4.86	8.22	1.06	94
	Pb	45	1.24	0.46	0.88	0.86	1.91	52
	Pd	66	0.78	0.62	1.11	0.84	1.27	79
	Rh	37	1.31	0.76	0.90	0.99	2.68	37
	Ru	104	3.89	2.94	2.83	3.22	3.10	32
	S*	45	5.2	5.3	8.1	6.2	14	7.3
	Si	35763	304	151	64.1	173	0.48	207
	Sr	41	0.65	0.35	0.61	0.54	1.31	76
	Zn	2606	42.9	25.3	45.0	37.7	1.45	69
	Zr	4540	66.6	26.2	5.37	32.7	0.72	139
Gas	B	5961	10.7	14.0	5.8	10.2	0.17	584
	Cl	< 1	16.3	17.2	9.0	14.2	NC	NC
	F	65	< 0.10	< 0.10	< 0.10	< 0.10	< 0.02	> 650
	I	161	119	93.9	67.7	93.5	58.1	2.8
	S	45	2.98	2.50	1.85	2.44	5.42	18

$ - From gravimetric analysis of filters and front-half rinse dry-down
* - From water dissolution of filter particulate
"-" Empty data field

Table 7.9. Results from Test 5C Melter Emissions Sampling.

-		Average Feed Flux (mg/min)	Run 1 (mg/min)	Run 2 (mg/min)	Run 3 (mg/min)	Average (mg/min)	Percent of Feed	DF Across Melter
Particulate	Total$	509541	3853	3992	10684	6176	1.21	82.5
	Al	12378	159	121	367	216	1.74	57.4
	B	16650	197	201	533	311	1.87	53.6
	Ba	81	1.17	1.46	4.26	2.30	2.84	35.3
	Ca	902	8.73	10.8	30.7	16.8	1.86	53.9
	Cd	242	2.61	2.48	6.17	3.75	1.55	64.5
	Cl*	0	103	99.4	123	108	NC	NC
	Cu	108	0.92	0.83	2.43	1.39	1.29	77.5
	F*	180	116	99.8	176	131	72.6	1.4
	Fe	38491	348	298	837	495	1.28	77.8
	I*	451	< 0.10	< 0.10	< 0.10	< 0.10	< 0.03	> 4510
	K	112	2.39	3.16	7.38	4.31	3.85	26.0
	Li	7372	40.2	50.6	138	76.3	1.03	96.7
	Mg	299	4.48	5.15	12.5	7.38	2.47	40.5
	Mn	594	3.16	3.29	12.3	6.24	1.05	95.2
	Na	38968	324	341	841	502	1.29	77.6
	Ni	2161	17.4	16.6	47.5	27.2	1.26	79.5
	Pb	126	1.88	1.77	5.04	2.90	2.30	43.5
	Pd#	0	< 0.10	< 0.10	0.17	< 0.12	NC	NC
	Rh#	0	0.21	0.18	0.43	0.27	NC	NC
	Ru#	0	3.17	3.38	4.36	3.64	NC	NC
	S*	126	113	107	151	124	98.4	1
	Si	99895	386	284	841	504	0.50	198
	Sr	114	1.12	1.40	4.40	2.31	2.02	49.4
	Zn	7280	63.2	61.2	158	94.0	1.29	77.5
	Zr	12683	73.1	41.6	184	99.5	0.78	128
Gas	B	16650	117	114	134	122	0.73	137
	Cl	0	11.4	< 0.10	11.9	< 7.8	NC	NC
	F	180	22.2	20.8	14.5	19.2	10.6	9.4
	I	451	254	242	291	262	58.2	1.7
	S	126	12.4	12.0	11.1	11.8	9.40	10.6

$ - From gravimetric analysis of filters and front-half rinse dry-down
* - From water dissolution of filter particulate
# - From combination of standard HF:HNO_3 Digestion and NaOH:Ru fusion in HCl
"-" Empty data field

Table 7.10. Results from Test 5C SBS Emissions Sampling.

-		Average Melter Flux (mg/min)	Run 1 (mg/min)	Run 2 (mg/min)	Run 3 (mg/min)	Average (mg/min)	Percent of Melter Emissions	DF Across SBS
Particulate	Total[$]	6176	119	196	125	147	2.37	42.1
	Al	216	0.56	2.31	0.55	1.14	0.53	189
	B	311	1.11	3.17	1.33	1.87	0.60	166
	Ba	2.30	< 0.10	< 0.10	< 0.10	< 0.10	< 4.35	> 23
	Ca	16.8	0.37	0.40	0.22	0.33	1.97	51
	Cd	3.75	< 0.10	< 0.10	< 0.10	< 0.10	< 2.7	38
	Cl	108	NA	NA	NA	NA	NA	NA
	Cu	1.39	< 0.10	< 0.10	< 0.10	< 0.10	< 7.2	14
	F	131	NA	NA	NA	NA	NA	NA
	Fe	495	2.63	6.22	7.49	5.45	1.10	91
	I	< 0.10	NA	NA	NA	NA	NA	NA
	K	4.31	0.44	0.44	0.46	0.45	10.4	9.7
	Li	76.3	2.20	2.31	1.92	2.14	2.81	36
	Mg	7.38	0.12	0.16	0.10	0.13	1.72	58
	Mn	6.24	< 0.10	0.21	0.12	0.17	2.64	38
	Na	502	22.2	24.25	21.57	22.67	4.52	22
	Ni	27.2	< 0.10	0.37	0.16	0.27	0.98	103
	Pb	2.90	< 0.10	< 0.10	< 0.10	< 0.10	< 3.4	> 29
	Pd	< 0.12	< 0.10[#]	< 0.10	< 0.10	< 0.10	NC	NC
	Rh	0.27	< 0.10[#]	< 0.10	< 0.10	< 0.10	< 37	> 2.7
	Ru	3.64	2.81[#]	1.72	0.79	1.77	48.6	2.1
	S	124	8.26	15.93	13.87	12.69	26	3.8
	Si	504	1.43	9.07	2.54	4.35	0.86	116
	Sr	2.31	< 0.10	< 0.10	< 0.10	< 0.10	< 4.3	> 23
	Zn	94.0	0.65	1.37	0.55	0.86	0.91	110
	Zr	99.5	< 0.10	2.46	0.70	1.58	1.59	63
Gas	B	122	2.49	2.78	2.60	2.62	2.16	46
	Cl	< 7.8	3.59	7.48	5.71	5.59	> 72	1.4
	F	19.2	< 0.10	< 0.10	< 0.10	< 0.10	< 0.52	192
	I	262	340	320	279	313	119	0.84
	S	11.8	2.12	1.84	1.43	1.80	15.2	6.6

$ - From gravimetric analysis of filters and front-half rinse dry-down
# - From combination of standard HF:HNO_3 digestion and NaOH:Ru fusion in HCl
"-" Empty data field

Table7.11. Results from Test 5C WESP Emissions Sampling.

-		Average Feed Flux (mg/min)	Average SBS Flux (mg/min)	Run 1 (mg/min)	Percent of Feed	DF Across WESP	Cumulative DF
Particulate	Total[$]	509541	147	3.0	< 0.01	48.9	169847
	Al	12378	1.14	< 0.10	< 0.01	> 11	> 123780
	B	16650	1.87	< 0.10	< 0.01	> 19	> 166500
	Ba	81	< 0.10	< 0.10	< 0.12	NC	> 810
	Ca	902	0.33	< 0.10	< 0.01	> 3.3	> 9020
	Cd	242	< 0.10	< 0.10	< 0.04	NC	> 2420
	Cl	0	NA	NA	NC	NA	NC
	Cu	108	< 0.10	< 0.10	< 0.09	NC	> 1080
	F	180	NA	NA	NA	NA	NA
	Fe	38491	5.45	0.39	< 0.01	14	98695
	I	451	NA	NA	NA	NA	NA
	K	112	0.45	< 0.10	0.09	> 4.5	> 1120
	Li	7372	2.14	< 0.10	< 0.01	> 21	> 73720
	Mg	299	0.13	< 0.10	< 0.03	> 1.3	> 2990
	Mn	594	0.17	< 0.10	< 0.02	> 1.7	> 5940
	Na	38968	22.7	0.57	< 0.01	40	6836491
	Ni	2161	0.27	< 0.10	< 0.01	> 2.7	> 21610
	Pb	126	< 0.10	< 0.10	< 0.08	NC	>1260
	Pd	0	< 0.10	< 0.10[#]	NC	NC	NC
	Rh	0	< 0.10	< 0.10[#]	NC	NC	NC
	Ru	0	1.77	0.13[#]	NC	14	NC
	S	126	12.7	0.35	0.28	36	360
	Si	99895	4.35	< 0.10	< 0.01	> 44	> 998950
	Sr	114	< 0.10	< 0.10	0.09	NC	> 1140
	Zn	7280	0.86	< 0.10	< 0.01	> 8.6	> 72800
	Zr	12683	1.58	< 0.10	< 0.01	> 16	> 126830
Gas	B	16650	2.62	0.56	< 0.01	4.7	29732
	Cl	0	5.59	< 0.10	NC	> 56	NC
	F	180	< 0.10	< 0.10	< 0.06	NC	> 1800
	I	451	313	204	45.3	1.5	2.2
	S	126	1.80	0.36	0.29	5.0	350

$ - From gravimetric analysis of filters and front-half rinse dry-down
# - From combination of standard HF:HNO_3 digestion and NaOH:Ru fusion in HCl
"-" Empty data field

Table 7.12 Particulate DFs for AZ-101, AZ-102 [25], C-106/AY-102 [26] and C-104/AY-101 [27] Tests at 65 lpm Bubbling.

	AZ-101	**AZ-102**	**C-106/AY-102**	**C-104/AY-101**
Feed Solids Content (g/l)	530	550	550	528
Melter DF	181	49	148	138
SBS DF	48	75	12	47
WESP DF	15	19	60	47
Cumulative DF	132,838	112,667	104,797	301,960

Table 7.13. Particle Size Distribution Results for Test 3 Melter Emissions.

Test Segment	Cutpoint (μm)	Net Weight (mg)	Concentration (mg/dscf)	Mass Fraction
A	> 15.6	5.21	2.738	70.8
	11.8 - 15.6	0.390	0.205	5.3
	4.6 - 11.8	0.210	0.110	2.9
	2.3 - 4.6	0.570	0.300	7.8
	1.3 - 2.3	0.240	0.126	3.3
	0.7 - 1.3	0.260	0.140	3.5
	0.4 - 0.7	0.100	0.053	1.4
	< 0.4	0.370	0.194	5.0
B	> 14.7	15.7	10.880	73.6
	11.1 - 14.7	0.870	0.603	4.08
	4.3 -11.1	1.050	0.728	4.92
	2.2 - 4.3	1.330	0.922	6.23
	1.2 - 2.2	0.900	0.624	4.22
	0.7 - 1.2	0.490	0.340	2.3
	0.41 - 0.7	0.280	0.194	1.31
	< 0.41	0.710	0.492	3.32
C	> 14.9	15.2	14.371	69.2
	11.3 - 14.9	1.260	1.192	5.74
	4.4 - 11.3	1.390	1.315	6.33
	2.2 - 4.4	1.660	1.570	7.56
	1.3 - 2.2	0.820	0.776	3.74
	0.7 - 1.3	0.600	0.568	2.73
	0.41 - 0.7	0.390	0.369	1.78
	< 0.41	0.640	0.605	2.92

Table 7.14. Particle Size Distribution Results for Test 4C Melter Emissions.

-	Cutpoint (μm)	Net Weight (mg)	Concentration (mg/dscf)	Mass Fraction
Sample 1	> 15.5	8.60	14.03	62.5
	11.7 - 15.5	1.07	1.75	7.78
	4.5 - 11.7	1.53	2.50	11.1
	2.3 - 4.5	1.09	1.78	7.93
	1.3 - 2.3	0.60	0.98	4.36
	0.7 - 1.3	0.12	0.20	0.87
	0.3 - 0.7	0.13	0.21	0.95
	< 0.3	0.61	1.00	4.44
Sample 2	> 14.8	5.68	5.80	58.3
	11.1 - 14.8	0.49	0.50	5.03
	4.3 - 11.1	0.58	0.59	5.95
	2.2 - 4.3	0.67	0.68	6.87
	1.2 - 2.2	0.62	0.62	6.37
	0.7 - 1.2	0.83	0.85	8.52
	0.4 - 0.7	0.22	0.23	2.26
	< 0.4	0.65	0.66	6.67
Sample 3	> 14.9	13.1	9.94	51.5
	11.2 -14.9	1.92	1.46	7.54
	4.3 - 11.2	3.43	2.60	13.5
	2.2 - 4.3	2.86	2.17	11.2
	1.3 - 2.2	1.51	1.15	5.93
	0.7 - 1.3	0.88	0.67	3.46
	0.4 - 0.7	0.41	0.31	1.61
	< 0.4	1.34	1.02	5.27

"-" Empty data field

Table 7.15. Particle Size Distribution Results for Test 5C Melter Emissions.

-	Cutpoint (µm)	Net Weight (mg)	Concentration (mg/dscf)	Mass Fraction
Sample 1	> 14.7	182.4	89.85	87.4
	11.1 - 14.7	7.08	3.49	3.39
	4.3-11.1	4.91	2.42	2.35
	2.2- 4.3	6.21	3.06	2.98
	1.2 - 2.2	2.93	1.44	1.4
	0.69 - 1.2	1.95	0.96	0.93
	0.41 - 0.69	1.10	0.54	0.53
	< 0.41	2.13	1.05	1.02
Sample 2	> 14.8	20.06	15.38	71.6
	11.1 - 14.8	1.32	1.01	4.71
	4.31 - 11.1	1.88	1.44	6.71
	2.17 - 4.31	1.80	1.38	6.42
	1.25 - 2.17	0.93	0.71	3.31
	0.7 - 0.42	0.91	0.70	3.25
	0.42 - 0.7	0.22	0.17	0.78
	< 0.42	0.91	0.70	3.25
Sample 3	> 16.1	10.89	19.91	59.2
	12.1 - 16.1	1.06	1.94	5.8
	4.68 - 12.1	1.87	3.42	10.2
	2.36 - 4.68	1.52	2.78	8.3
	1.35 - 2.36	0.58	1.06	3.2
	0.76 - 1.35	0.65	1.19	3.5
	0.45 - 0.76	0.44	0.80	2.4
	< 0.45	1.40	2.56	7.6

"-" Empty data field

Table 7.16.a. Test 3 Average Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy.

Port	**Melter Outlet**			**SBS Outlet**			**WESP Outlet**			**TCO Outlet**		
Test	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
N_2O	1.5	1.7	2.0	1.7	2.1	2.3	1.5	2.0	2.4	1.3	1.6	1.8
NO	130	200	260	140	220	280	120	210	290	68	110	150
NO_2	5.1	4.1	6.7	5.2	7.8	8.8	7.0	13	20	44	58	59
NH_3	2.3	< 1.0	< 1.0	3.3	1.7	1.1	1.8	1.7	1.2	3.6	2.1	< 1.0
H_2O [%]	15	20	22	7.7	8.0	7.2	7.3	7.4	7.0	6.1	6.3	5.7
CO_2	4000	5300	6800	3700	5200	6500	3400	5100	6800	3000	4200	5200
HCN	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
CO	1.3	2.0	2.6	1.4	2.1	2.7	1.5	2.0	2.9	< 1.0	< 1.0	1.0
HCl	< 1.0	< 1.0	1.3	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
HF	3.6	< 1.0	1.1	2.4	< 1.0	< 1.0	1.7	< 1.0	< 1.0	2.1	< 1.0	< 1.0

Table 7.16.b. Test 3 Concentration [ppmv] Ranges of Selected Species in Off-Gas Measured by FTIR Spectroscopy.

Port	Melter Outlet			SBS Outlet			WESP Outlet			TCO Outlet		
Test	A	B	C	A	B	C	A	B	C	A	B	C
N_2O	1.1 – 2.2	< 1.0 – 2.4	1.0 – 2.4	1.0 – 2.3	1.0 – 2.9	1.5 – 3.7	1.0 – 2.3	< 1.0 – 2.6	1.6 – 3.4	< 1.0 – 2.8	< 1.0 – 3.5	< 1.0 – 3.6
NO	90 – 183	29 – 316	182 – 367	78 – 183	130 – 298	174 – 437	73 – 203	122 – 300	196 – 411	< 1.0 – 134	1.0 – 230	< 1.0 – 323
NO_2	2.9 – 7.5	< 1.0 – 15.6	< 1.0 – 13.0	1.7 – 12.6	3.4 – 18.7	< 1.0 – 24.0	2.9 – 15.4	3.5 – 23.8	< 1.0 – 35.5	< 1.0 – 80	< 1.0 – 108.2	< 1.0 – 157.9
NH_3	< 1.0 – 5.0	< 1.0 – 1.8	< 1.0 – 15.0	< 1.0 – 6.0	< 1.0 – 3.9	< 1.0 – 2.4	< 1.0 – 6.4	< 1.0 – 3.5	< 1.0 – 2.7	< 1.0 – 474	< 1.0 – 5376	< 1.0 – 3.3
H_2O [%]	11.0 – 21.0	2.6 – 28.7	14 – 55	5.6 – 9.5	6.9 – 9.4	6.4 – 8.6	6.1 – 14.3	6.8 – 10.3	6.4 – 11.4	3.1 – 8.1	5.7 – 15.3	2.1 – 7.1
CO_2	3200 – 4800	700 – 7400	3100 – 9300	2900 – 4700	3700 – 7100	4400 – 9200	2400 – 5100	3300 – 7000	5000 – 9400	800 – 5300	3100 – 7800	400 - 10000
HNO_2	< 1.0	< 1.0	< 1.0 – 1.2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0 – 1.4	< 1.0	< 1.0 – 8.1	< 1.0 – 1.1
HNO_3	< 1.0	< 1.0	1.0 – 7.	< 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	< 1.0	< 1.0	< 1.0
CO	< 1.0 – 1.9	< 1.0 – 4.2	1.4 – 3.9	< 1.0 – 2.2	< 1.0 – 3.6	1.7 – 4.6	< 1.0 – 2.6	1.2 – 3.0	1.6 – 4.9	< 1.0 – 3.6	< 1.0 – 2.3	< 1.0 – 3.2
HCl	< 1.0	< 1.0	< 1.0 – 12.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0 – 1.0	< 1.0	< 1.0 – 3.7	< 1.0 – 2.4
HF	2.8 – 5.2	< 1.0 – 1.9	< 1.0 – 8.6	1.9 – 3.8	< 1.0	< 1.0	< 1.0 – 4.4	< 1.0	< 1.0	< 1.0 – 3.7	< 1.0 – 1.7	< 1.0 – 1.1

Table 7.17.a. Test 4 Average Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy.

Port	Melter Outlet			SBS Outlet			WESP Outlet			TCO Outlet		
Test	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
N_2O	< 1.0	1.3	1.1	< 1.0	1.6	2.2	< 1.0	1.6	2.3	< 1.0	1.6	1.8
NO	63	200	120	94	210	250	73	210	250	< 1.0	47	55
NO_2	4.0	13	4.0	5.3	9.4	12	6.4	19	19	< 1.0	19	28
NH_3	2.8	6.3	4.6	3.2	6.8	3.1	4.3	7.1	4.8	6.0	12	5.9
H_2O [%]	11	18	18	7.1	7.2	7.1	6.8	6.6	7.0	5.9	5.9	5.9
CO_2	2500	4500	4300	2800	4400	5900	2300	3900	5800	2000	3300	4700
HCN	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
CO	1.1	1.8	1.9	1.4	1.7	2.1	1.3	1.7	2.5	< 1.0	< 1.0	1.1
HCl	< 1.0	< 1.0	< 1.0	< 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	< 1.0	< 1.0	< 1.0

Table 7.17.b. Test 4 Concentration [ppmv] Ranges of Selected Species in Off-Gas Measured by FTIR Spectroscopy.

Port	Melter Outlet			SBS Outlet			WESP Outlet			TCO Outlet		
Test	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
N_2O	< 1.0 – 1.2	< 1.0 – 2.8	< 1.0 – 2.1	< 1.0 – 2.4	< 1.0 – 2.7	< 1.0 – 5.1	< 1.0 – 1.1	< 1.0 – 3.3	< 1.0 – 4.1	< 1.0 – 3.2	< 1.0 – 3.9	< 1.0 – 3.7
NO	25 – 140	56 – 519	40 – 287	56 – 232	132 – 360	63 – 605	46 – 109	1.0 – 634.0	71 – 485	< 1.0 – 65.0	< 1.0 – 238	< 1.0 – 256.8
NO_2	< 1.0 – 15.0	1.3 – 46.1	< 1.0 – 13.9	1.3 – 17.1	1.2 – 33.2	1.2 – 39.7	1.8 – 18.0	1.0 – 87.0	2.4 – 51.2	< 1.0 – 47.5	< 1.0 – 98	< 1.0 – 102.5
NH_3	1.7 – 5.4	4.4 – 14.2	1.3 – 9.9	1.8 – 3.9	3.2 – 8.8	1.5 – 7.7	2.4 – 6.9	3.3 – 12.5	1.5 – 8.2	<1.0 – 22	1.1 - 45	< 1.0 – 18
H_2O [%]	6.7 – 19.5	8.7 – 27.5	4.9 – 36.3	6.4 – 9.2	6.0 - 9.2	5.6 – 8.2	5.0 – 9.3	5.2 – 11.5	1.8 – 10.0	3.2 – 7.5	4.6 – 6.7	4.6 – 6.7
CO_2	1400 – 3800	2900 – 6500	1600 – 7700	2000 – 4900	2500 – 6400	2000 - 13700	1700 – 3000	700 – 7200	1800 – 10300	300 – 3200	1400 – 5400	2900 – 9000
HNO_2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0 – 5.5	< 1.0	< 1.0 – 13.0
HNO_3	< 1.0	< 1.0	< 1.0 – 1.1	< 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	< 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	< 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	< 1.0 – 1.7	< 1.0	< 1.0 – 3.4
CO	< 1.0 – 2.1	< 1.0 – 2.5	< 1.0 – 4.4	< 1.0 – 2.8	< 1.0 – 3.1	< 1.0 – 5.8	< 1.0 – 1.9	< 1.0 – 2.7	< 1.0 – 5.2	< 1.0 – 9.4	< 1.0 – 2.4	< 1.0 – 3.4
HCl	< 1.0	< 1.0	< 1.0	< 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	< 1.0 – 2.5	< 1.0	< 1.0 – 2.3

Table 7.18.a. Test 5 Average Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy.

Port	Melter Outlet			SBS Outlet			WESP Outlet			TCO Outlet		
Test	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
N_2O	< 1.0	< 1.0	< 1.0	< 1.0	1.3	1.5	< 1.0	1.1	1.3	< 1.0	< 1.0	< 1.0
NO	62	100	98	67	150	190	59	110	160	13	12	46
NO_2	2.7	2.6	2.8	2.8	3.8	4.4	3.6	6.2	7.6	14	2.5	7.4
NH_3	2.3	5.9	3.7	4.6	4.9	3.2	3.7	4.2	3.4	3.0	6.1	6.9
H_2O [%]	13	19	19	7.5	6.7	7.7	7.1	6.6	7.1	5.4	4.3	4.8
CO_2	2700	3800	4100	2300	3800	4700	2300	3300	4200	1800	2200	3,000
HCN	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
CO	< 1.0	< 1.0	3.6	< 1.0	< 1.0	1.5	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
HCl	< 1.0	< 1.0	< 1.0	< 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	< 1.0	< 1.0	< 1.0

Table 7.18.b. Test 5 Concentration [ppmv] Ranges of Selected Species in Off-Gas Measured by FTIR Spectroscopy.

Port	**Melter Outlet**			**SBS Outlet**			**WESP Outlet**			**TCO Outlet**		
Test	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
N_2O	< 1.0 – 1.1	< 1.0 – 1.9	< 1.0 – 1.4	< 1.0 – 1.3	< 1.0 – 2.0	1.0 – 3.3	< 1.0 – 1.0	< 1.0 – 2.0	< 1.0 – 2.7	< 1.0 – 3.0	< 1.0 – 2.0	< 1.0 – 2.4
NO	26 – 95	10 – 329	27 – 192	12 – 141	98 – 194	130 – 410	<1.0 – 118.3	48 – 210	98 – 388	< 1.0 – 65.6	<1.0 – 122.3	< 1.0 – 214.8
NO_2	< 1.0 – 6.1	< 1.0 – 8.5	< 1.0 – 6.1	< 1.0 – 7.7	1.8 – 6.9	< 1.0 – 21.1	< 1.0 – 8.1	2.2 – 14.7	3.8 – 30.9	< 1.0 – 51.2	< 1.0 – 46.3	< 1.0 – 34.7
NH_3	<1.0 – 5.2	< 1.0 – 66.5	< 1.0 – 7.7	1.3 – 13.5	3.1 – 6.7	< 1.0 – 6.9	< 1.0 – 5.2	2.9 – 5.6	< 1.0 – 8.4	< 1.0 – 30.4	< 1.0 – 22.9	< 1.0 27.8
H_2O [%]	5.9 – 23.1	1.8 – 37.5	4.7 – 32.0	6.4 – 9.1	6.2 – 8.0	6.5 – 9.3	0.0 – 10.2	4.9 – 9.4	4.8 – 10.3	4.1 – 7.2	2.9 – 5.0	3.6 – 5.6
CO_2	1900- 3500	800 – 9500	1100 – 6500	900 – 3700	2900 - 4500	3500 – 9000	40 – 3500	1800 - 5200	3000 – 8800	< 1.0 - 7700	1200 - 8200	1600 - 7200
HNO_2	< 1.0	< 1.0	< 1.0	< 1.0.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
HNO_3	< 1.0	< 1.0 – 1.1	< 1.0 – 1.0	< 1.0.	< 1.0 – 2.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0 – 1.7	< 1.0	< 1.0
HCN	< 1.0	< 1.0	< 1.0	< 1.0.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
acetonitrile	< 1.0	< 1.0	< 1.0 – 2.9	< 1.0.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0 – 2.8	< 1.0	< 1.0 – 1.8
acrylonitrile	< 1.0	< 1.0	< 1.0	< 1.0.	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0 – 1.4	< 1.0	< 1.0
CO	< 1.0	<1.0 – 10.9	1.0 – 11.2	< 1.0.	< 1.0 – 1.0	< 1.0 – 3.3	< 1.0	< 1.0	< 1.0 – 3.0	< 1.0	< 1.0	< 1.0 – 1.8
HCl	< 1.0	< 1.0 – 4.9	< 1.0	< 1.0.	< 1.0 – 30	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0 – 7.2	< 1.0	< 1.0
HF	< 1.0	< 1.0 – 1.2	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0 – 6.3	< 1.0	< 1.0

Table 7.19.a. Test 6 Average Concentrations [ppmv] of Selected Species in Off-Gas Measured by FTIR Spectroscopy.

Port	Melter Outlet	SBS Outlet	WESP Outlet	TCO Outlet
N_2O	< 1.0	< 1.0	< 1.0	< 1.0
NO	110	110	100	63
NO_2	29	28	26	24
NH_3	1.8	1.6	1.1	2.9
H_2O [%]	9.4	7.1	7.2	5.2
CO_2	2300	2100	2000	1600
HNO_2	< 1.0	< 1.0	< 1.0	< 1.0
HNO_3	< 1.0	< 1.0	< 1.0	< 1.0
HCN	< 1.0	< 1.0	< 1.0	< 1.0
CO	< 1.0	< 1.0	< 1.0	< 1.0
HCl	< 1.0	< 1.0	< 1.0	< 1.0
HF	< 1.0	< 1.0	< 1.0	< 1.0

Table 7.19.b. Test 6 Concentration [ppmv] Ranges of Selected Species in Off-Gas Measured by FTIR Spectroscopy.

Port	Melter Outlet	SBS Outlet	WESP Outlet	TCO Outlet
N_2O	< 1.0 – 1.3	< 1.0 – 1.2	< 1.0 – 1.2	< 1.0 – 1.1
NO	59 – 187	53 - 166	65 - 169	35 - 130
NO_2	15 – 54	15 – 47	13 – 53	15 – 43
NH_3	< 1.0 – 3.8	< 1.0 – 4.4	1.0 – 1.4	< 1.0 – 5.6
H_2O [%]	3.2 – 23.2	4.4 – 7.9	5.0 – 10.0	4.4 – 5.7
CO_2	1200 – 3500	1100 – 2800	1600 – 2800	1000 – 2200
HNO_2	< 1.0	< 1.0	< 1.0	< 1.0
HNO_3	< 1.0	< 1.0	< 1.0	< 1.0
Acetonitrile	< 1.0	< 1.0	< 1.0	< 1.0
Acrylonitrile	< 1.0	< 1.0	< 1.0	< 1.0
CO	< 1.0	< 1.0	< 1.0	< 1.0
HCN	< 1.0	< 1.0	< 1.0	< 1.0
HCl	< 1.0	< 1.0	< 1.0	< 1.0
HF	< 1.0	< 1.0	< 1.0	< 1.0

Table 7.20. Average Hydrogen Concentrations [ppmv] Measured by Gas Chromatography at the WESP Outlet.

Test 3			Test 4			Test 5		
A	B	C	A	B	C	A	B	C
10	13	13	8	6	7	8	ND	8

ND – Not Determined

Table 7.21. Iodine Mass Balance Summary.

Location:	Product Glass	Melter Emissions	SBS Blow-Down Solutions	SBS Emissions	WESP Blow-Down Solutions	WESP Emissions	PBS Blow-Down Solutions
% Feed Iodine, Test 3C	< 1%	102%	45%	58%	< 1%	29%	4%
All Emission Samples	NA	58 -102%	NA	57 – 96%	NA	23 – 81%	NA

NA – Not applicable

Table 8.1. Completion of Test Objectives.

Test Objective	Objective Met?	Discussion Section
Perform analyses and laboratory testing, as required, to assess and specify "working glass" compositions, glass forming chemicals, and additives utilizing the estimated AZ-101 feed composition in this specification.	Yes	Section 2.0 provides "working glass" compositions and feed formulations.
Utilizing the DM1200 melter and associated feed handling and off-gas treatment equipment, design and conduct testing in which representative AZ-101 simulant is processed. The duration of tests shall be sufficient to achieve at least four melter glass inventory turnovers (8 MT) for each composition.	Yes	Table 4.1 provides glass production rate data and summary data for melter testing.
Determine the effect of bubbling rate on melter production rate and operating stability for AZ-101 melter feed.	Yes	Data provided in Table 4.1 and Figures 4.1 - 4.2.
Determine the effect of feed concentration on melter production rate and operating stability for AZ-101 melter feed.	Yes	Data provided in Table 4.1 and Figure 4.3.
Fabricate, install and evaluate the performance of the HLW bubbler design and placement recommended by the Duratek design staff.	Yes	The recommended bubbler design and placement was employed for these tests.
Characterize the melter emissions (particulate, aerosol, and gaseous) under nominal steady-state operating conditions for inorganic and organic compounds including the effect of air displacement slurry (ADS) pump operation on feed entrainment. Measurement of organic compounds will be satisfied through the use of Fourier Transform Infrared (FTIR) spectrometry and gas chromatography (including H_2).	Yes	Section 7.0 provides data and detailed description of melter emissions.
Quantify and 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.
Characterize the performance of the primary off-gas treatment equipment (submerged bed scrubber (SBS), wet electrostatic precipitator (WESP) and high-efficiency mist eliminator (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. Section 7.0 provides data and detailed description of SBS and WESP emissions as well as DF values for these components.
Characterize the chemical and physical characteristics of the aqueous streams (feed, SBS, WESP, and caustic scrubber).	Yes	Section 2.3 provides detailed feed analysis. Section 5.2 provides detailed off-gas solution analysis.
Characterize the performance of the secondary off-gas treatment equipment (selective catalytic reduction (SCR) and thermal catalytic oxidizer (TCO)	Yes	Section 5.0 provides operational details of off-gas system components. Tables 7.16-7.19 and Figures 7.7-7.11 provide SCR/TCO inlet (WESP outlet) and outlet emission data
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.	Yes	Data for measured melter parameters is provided in Section 4.0 and data for measured off-gas parameters is in Section 5.0.
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, 4.0, and 5.0.
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.	Yes	Off-gas system inspection information is provided in Section 5.0. Inspection downstream of the SCR was covered in a previous report [29].

Table 8.1. Completion of Test Objectives (continued).

Test Objective	Objective Met?	Discussion Section
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.	Yes	Sections 3.0, 4.0, and 5.0 discuss melter pressure data and control air flow rates during testing.
Operate and evaluate the performance of the air-displacement slurry (ADS) pump under operating conditions that are applicable to expected WTP plant operations.	Yes	The ADS pump was employed for these tests and performed flawlessly.
Conduct one of the melter tests with the SBS water circulation tubes (located at the bottom distribution plate) plugged to prevent their use. This test configuration has been requested by Process Engineering to assess the need for these tubes when combined with the perforations in the distribution plate.	Yes	Tests 1 and 2 of the series were conducted with plugged weir tubes. No effect on SBS process performance was observed. A short discussion is included in Section 5.1.2

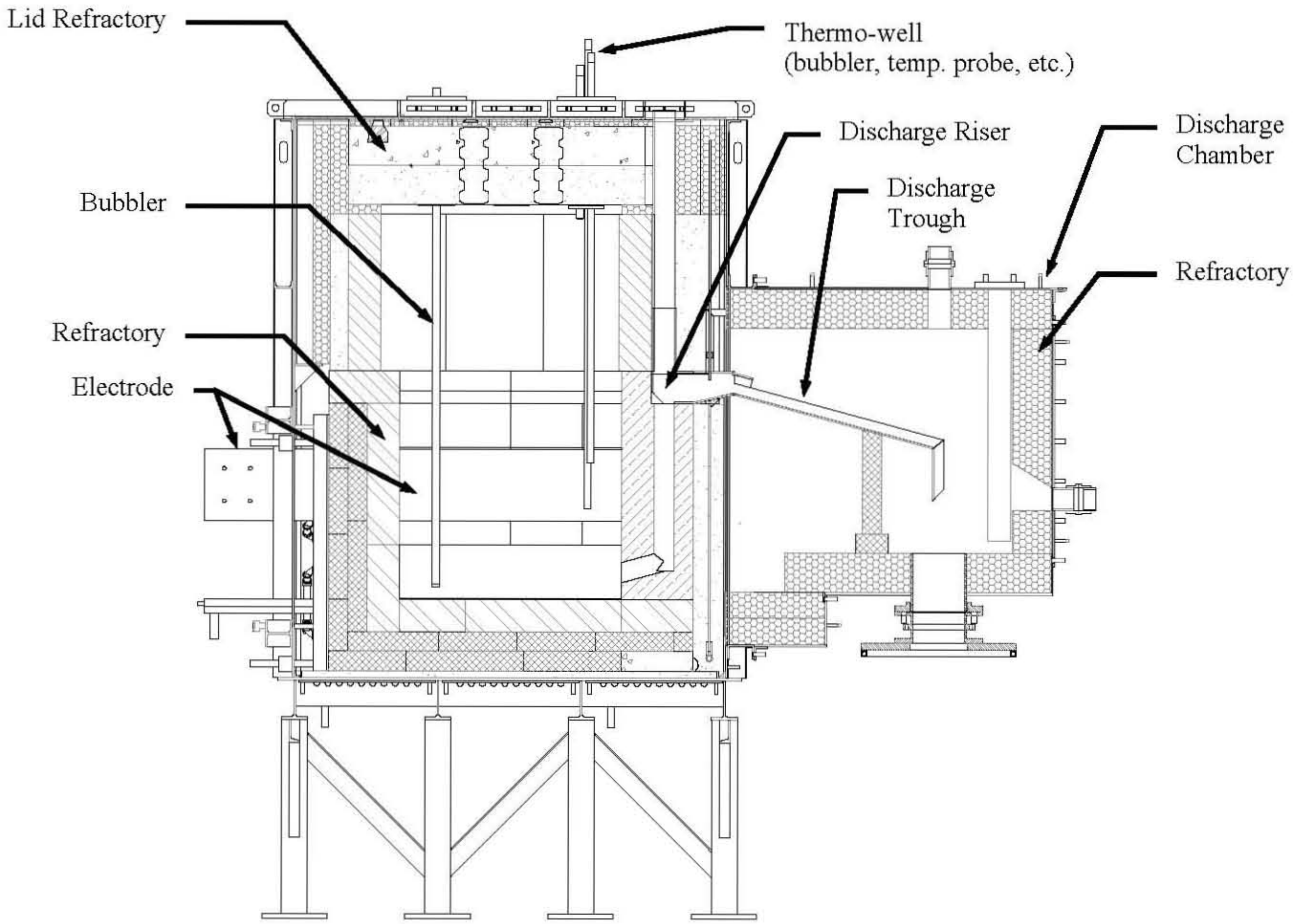

Figure 1.1. Cross-section of the DM1200 melter through the discharge chamber.

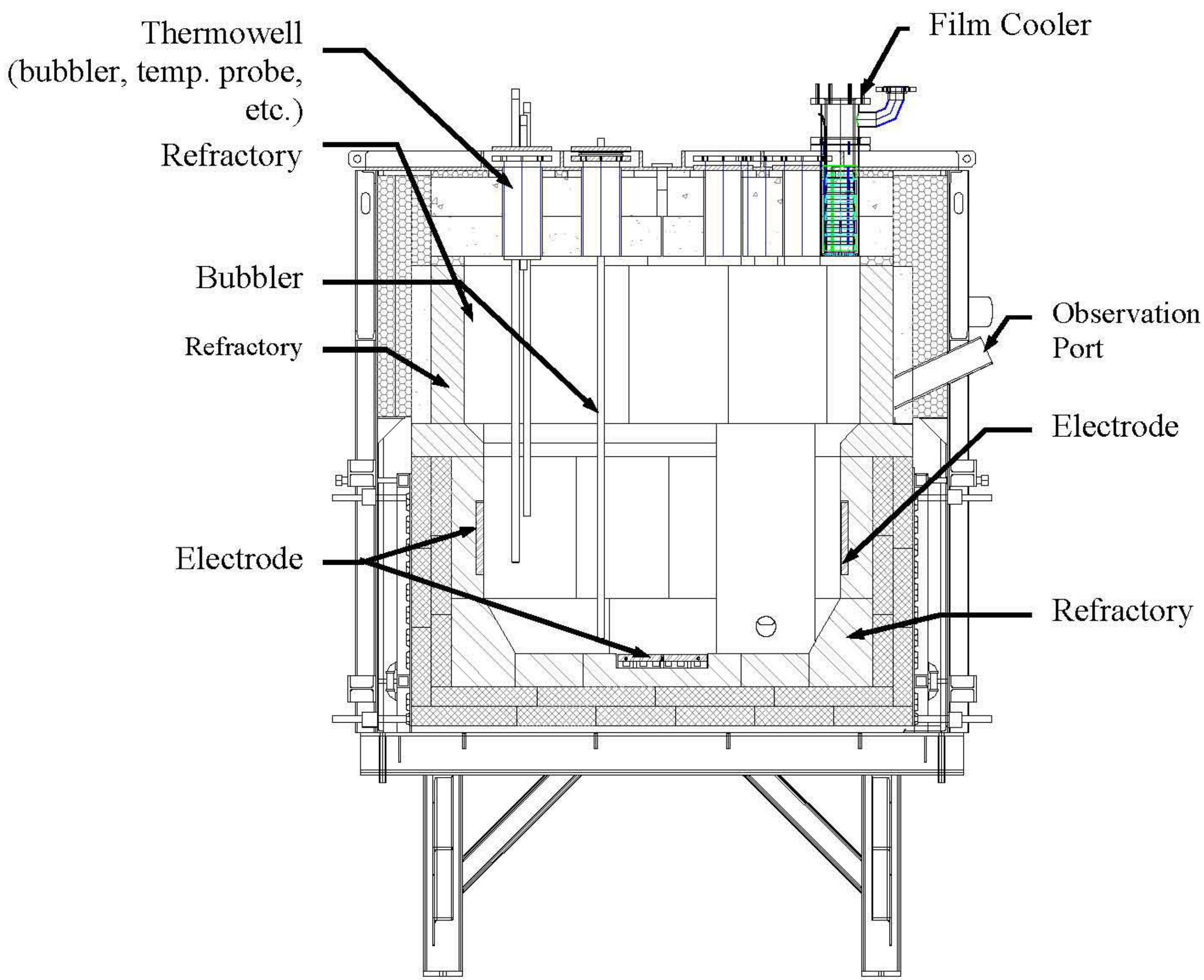

Figure 1.2. Cross-section through the DM1200 melter showing electrodes.

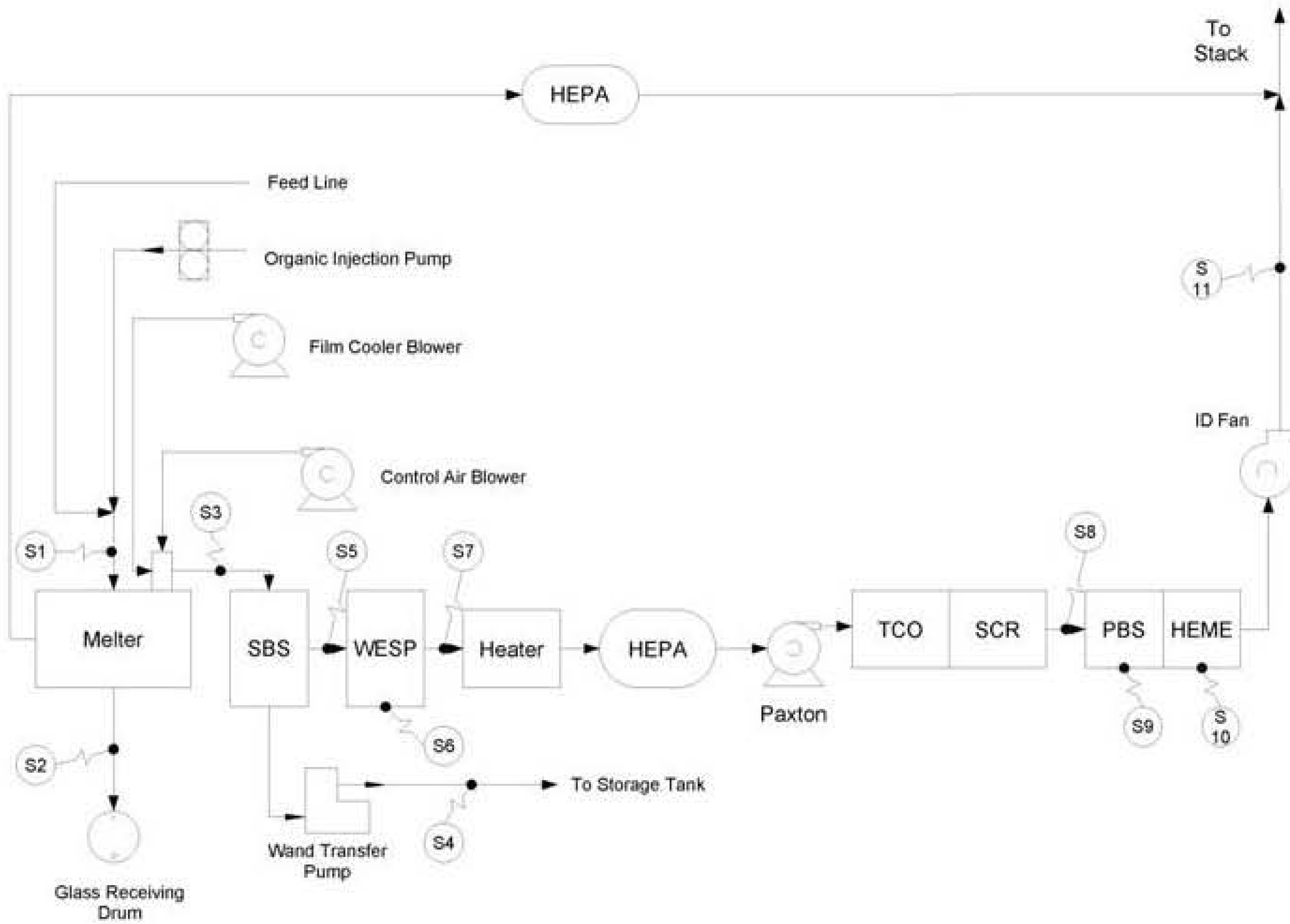

Figure 1.3. Schematic diagram of DM1200 off-gas system. "Sx" indicates sampling point.

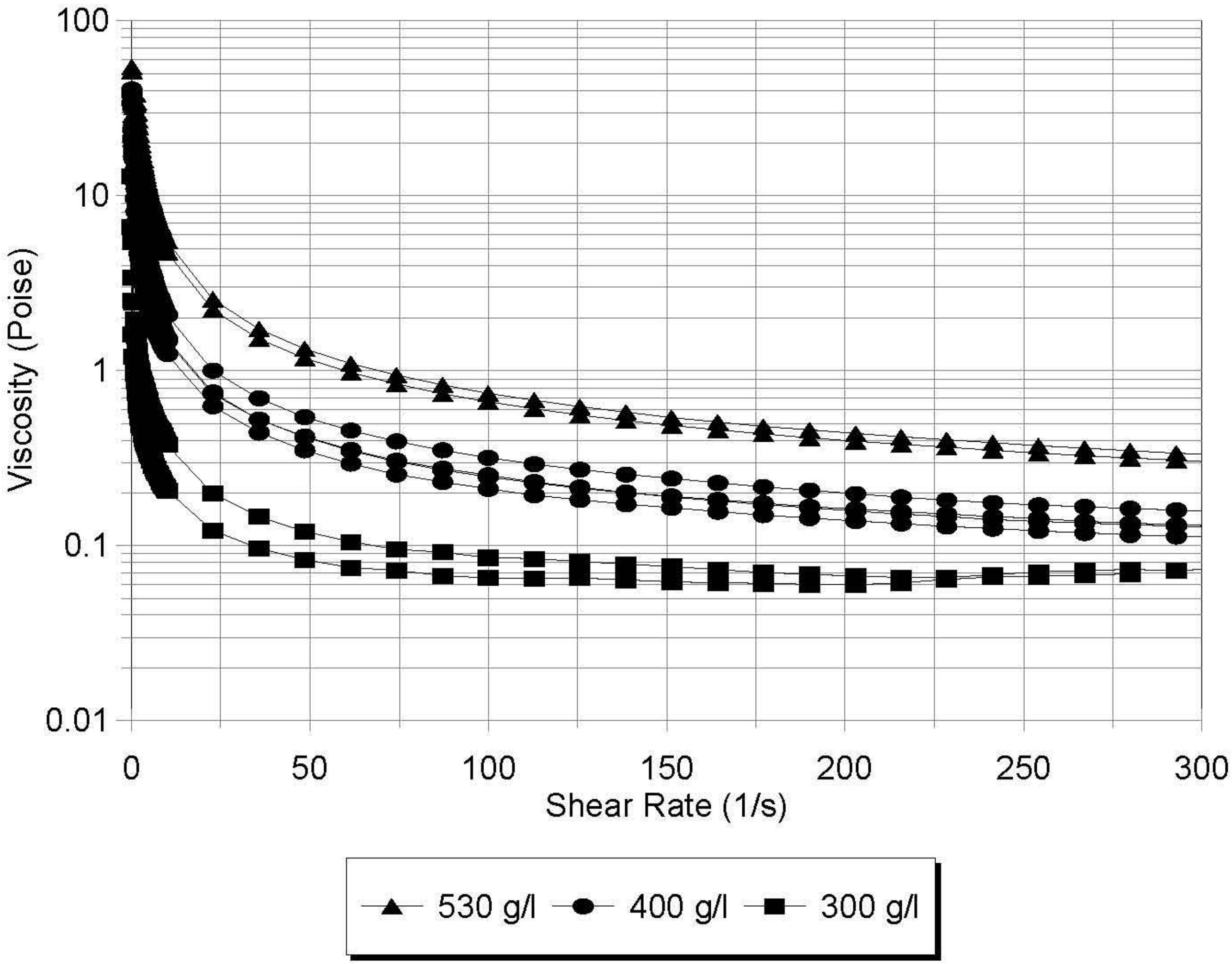

Figure 2.1. Viscosity vs. shear rate of select feed samples.

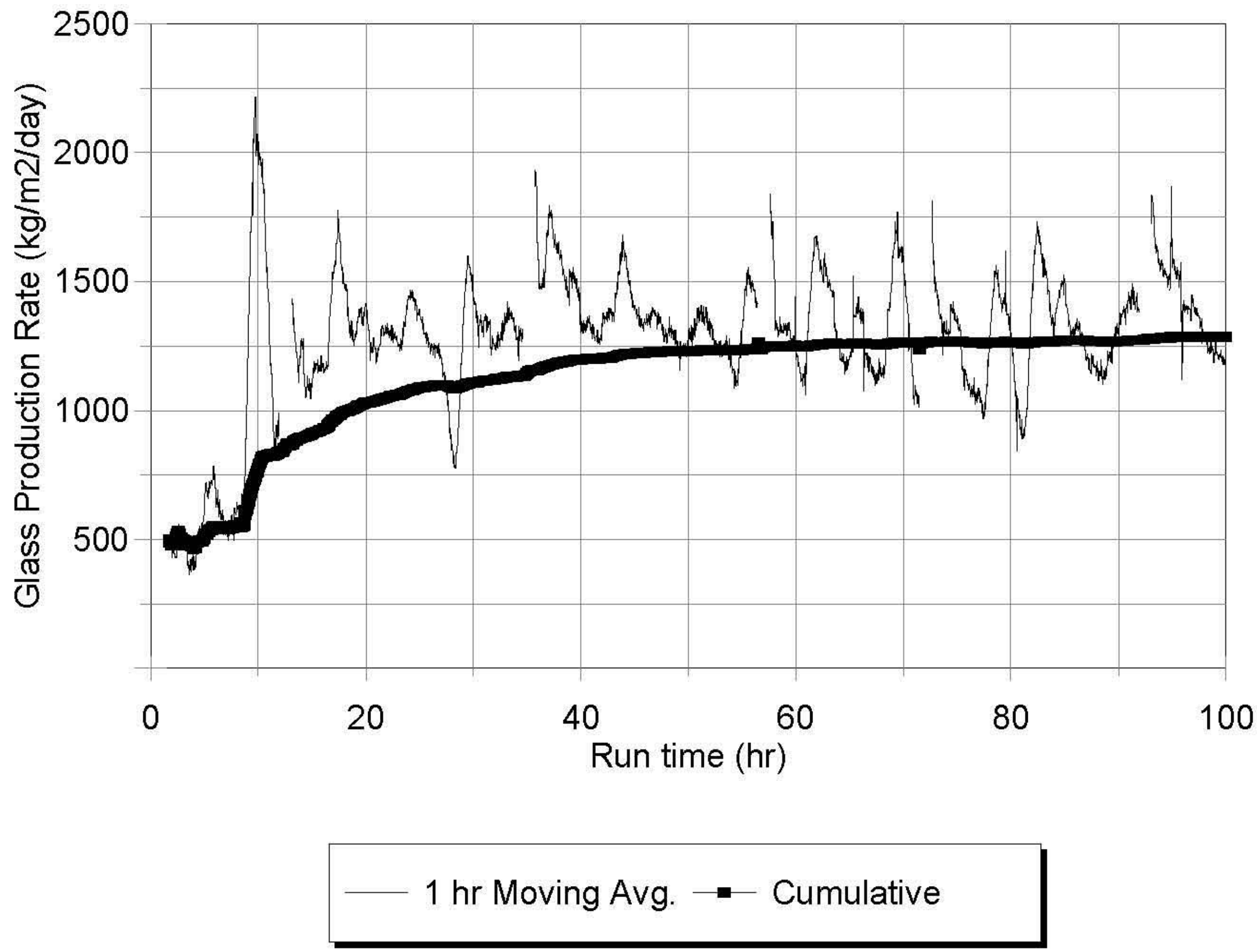

Figure 3.1. Production rates for DM100 test.

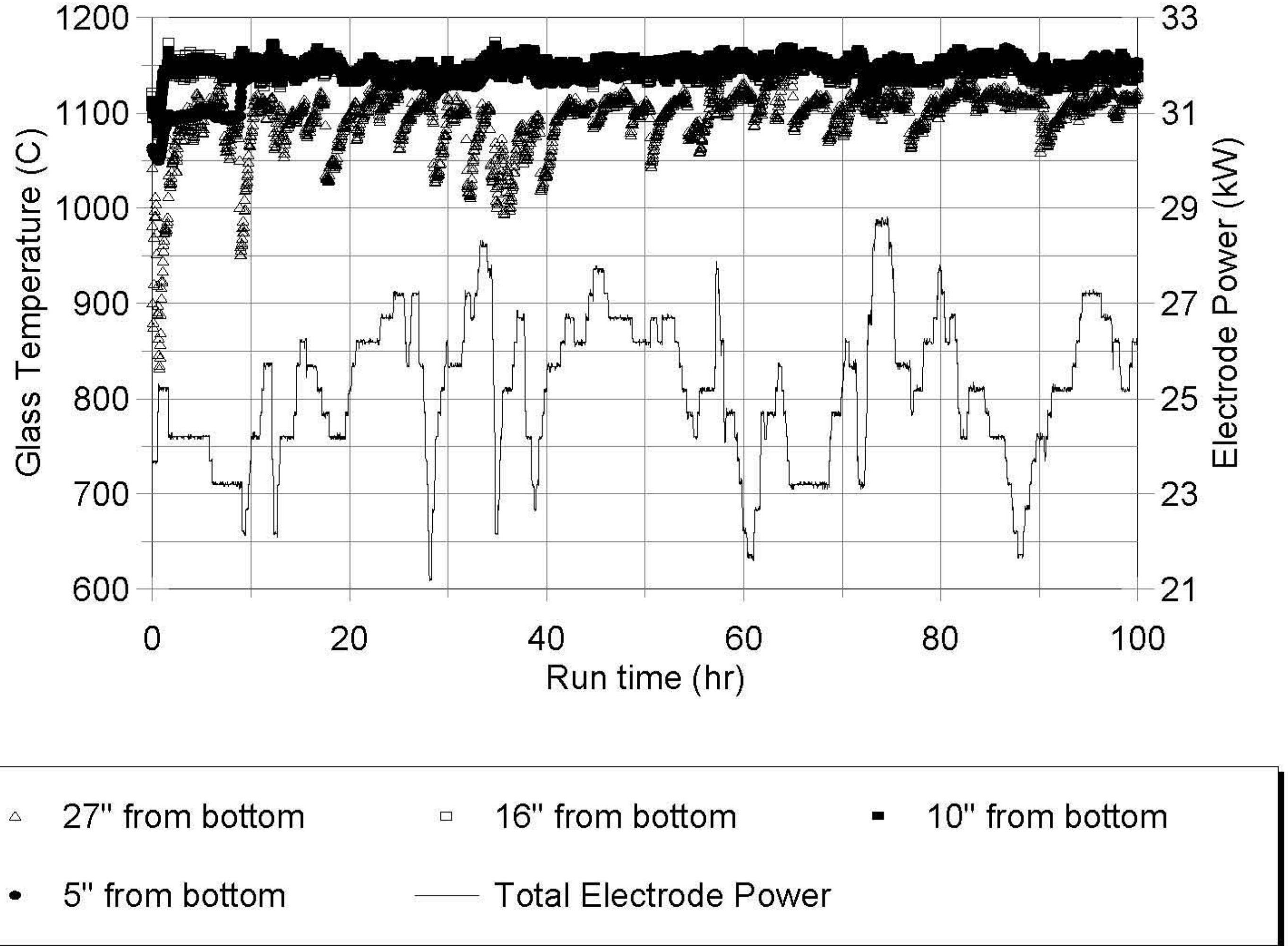

Figure 3.2. Glass temperatures and electrode power for DM100 test.

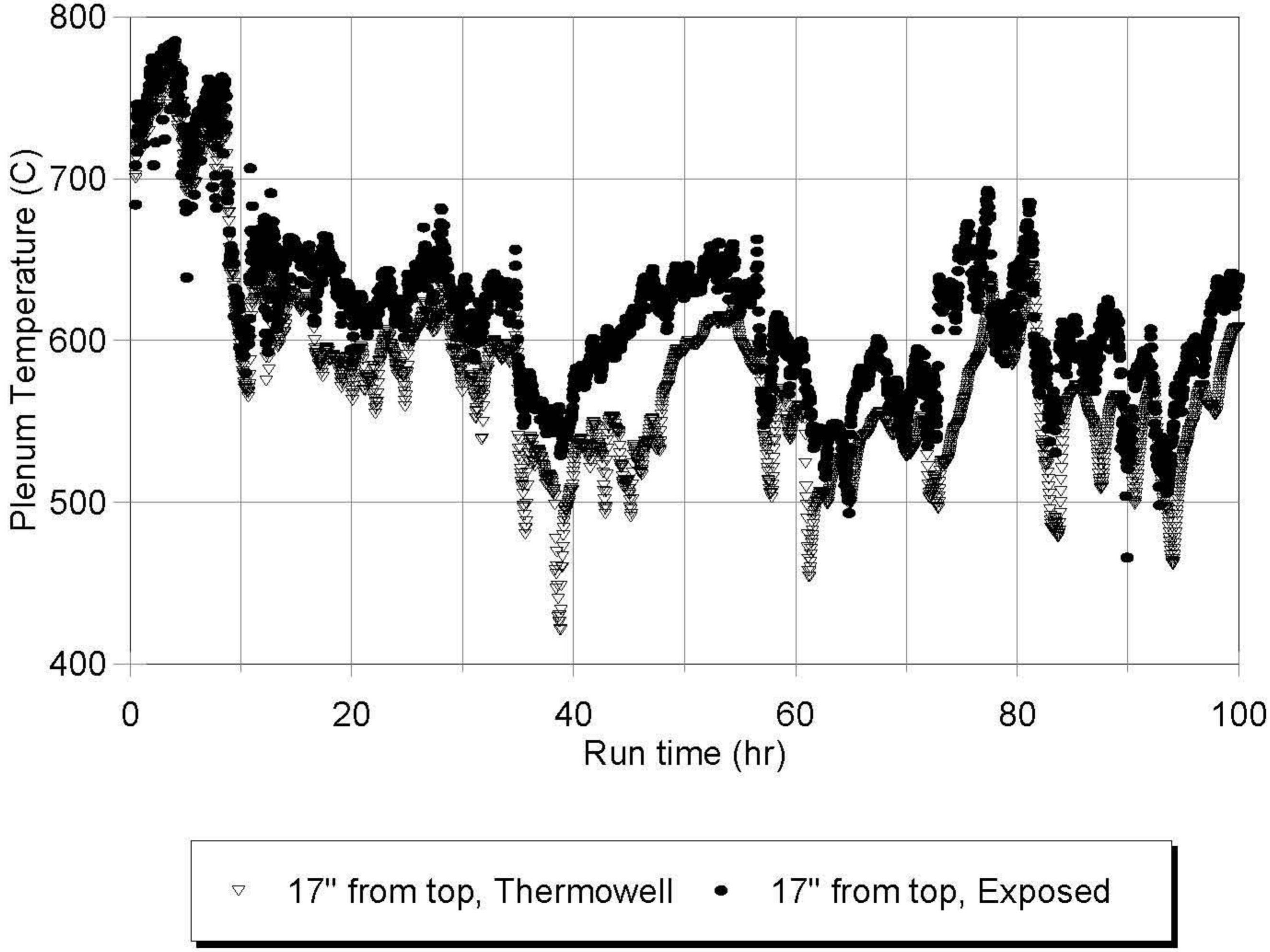

Figure 3.3. Plenum temperatures for DM100 test.

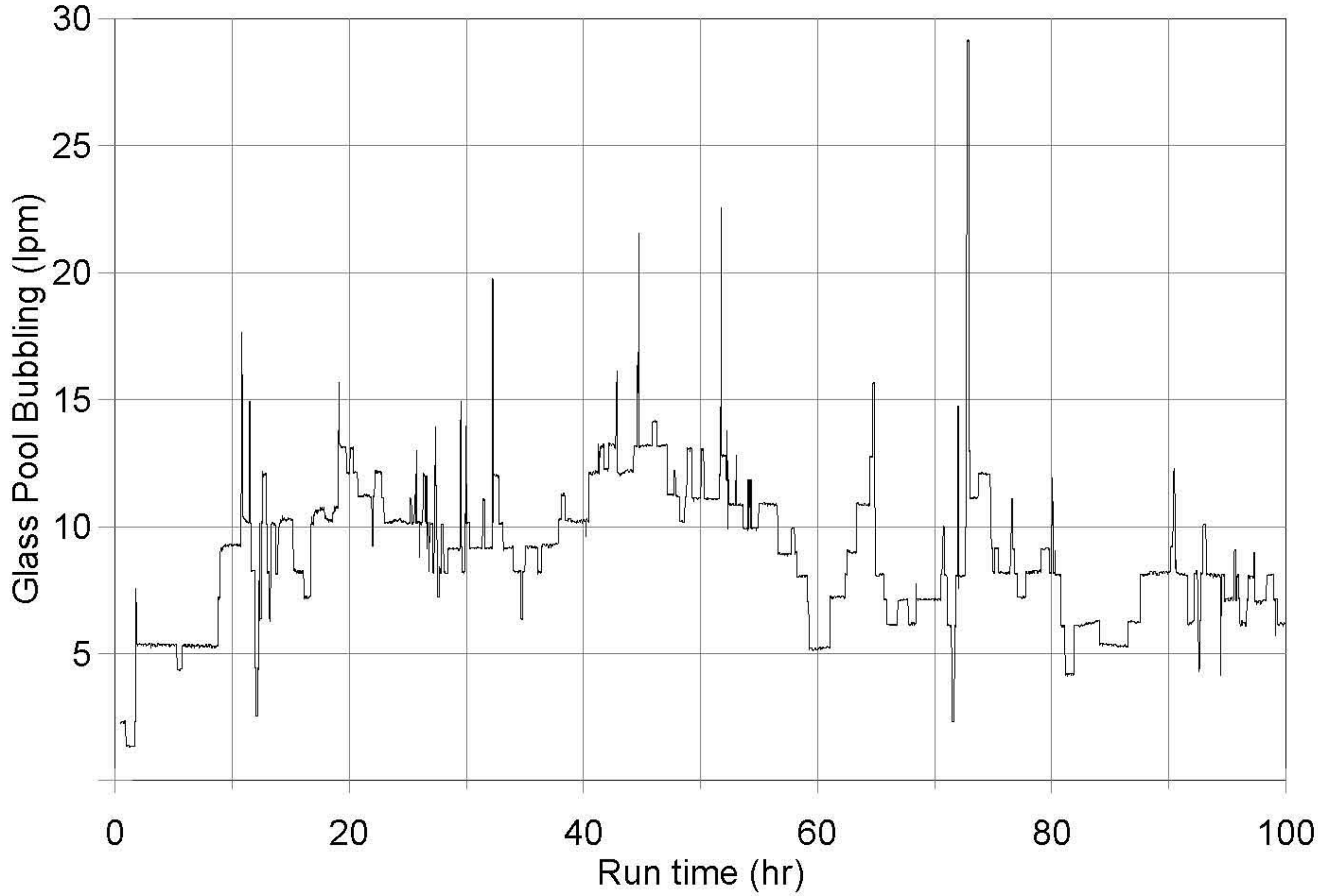

Figure 3.4. Glass pool bubbling for DM100 test.

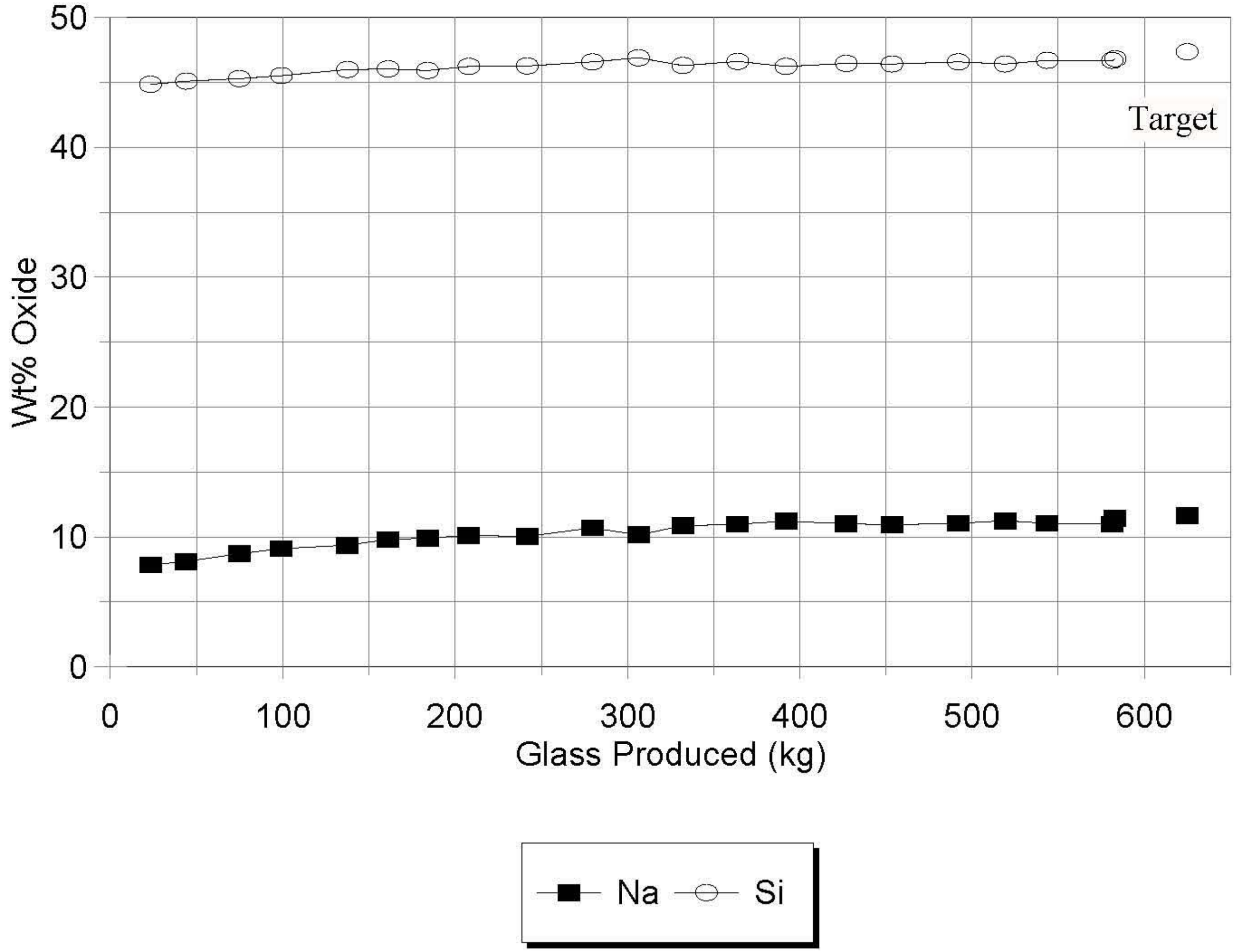

Figure 3.5. XRF analysis of sodium and silicon oxides in glasses from DM100 testing.

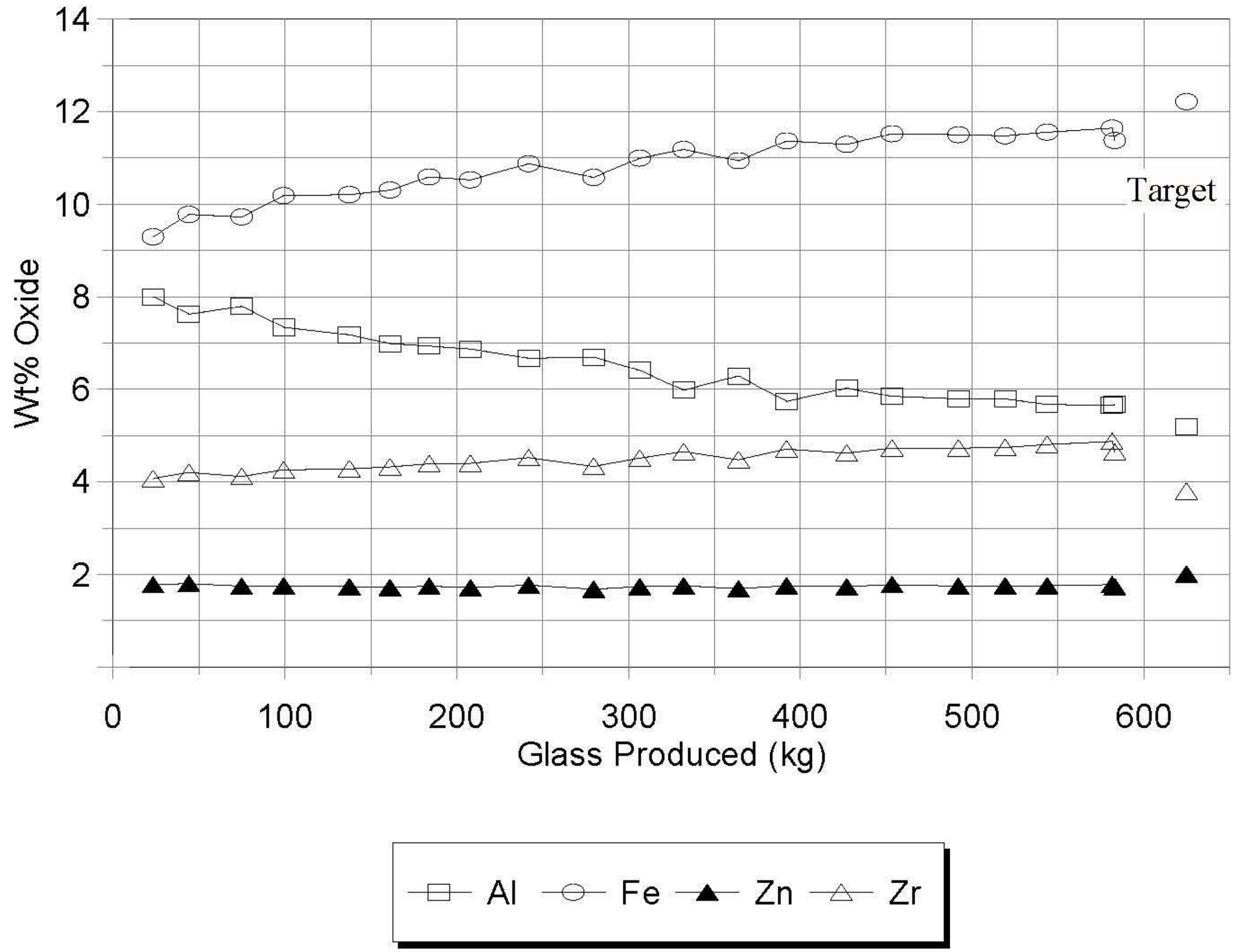

Figure 3.6. XRF analysis of selected oxides in glasses from DM100 testing.

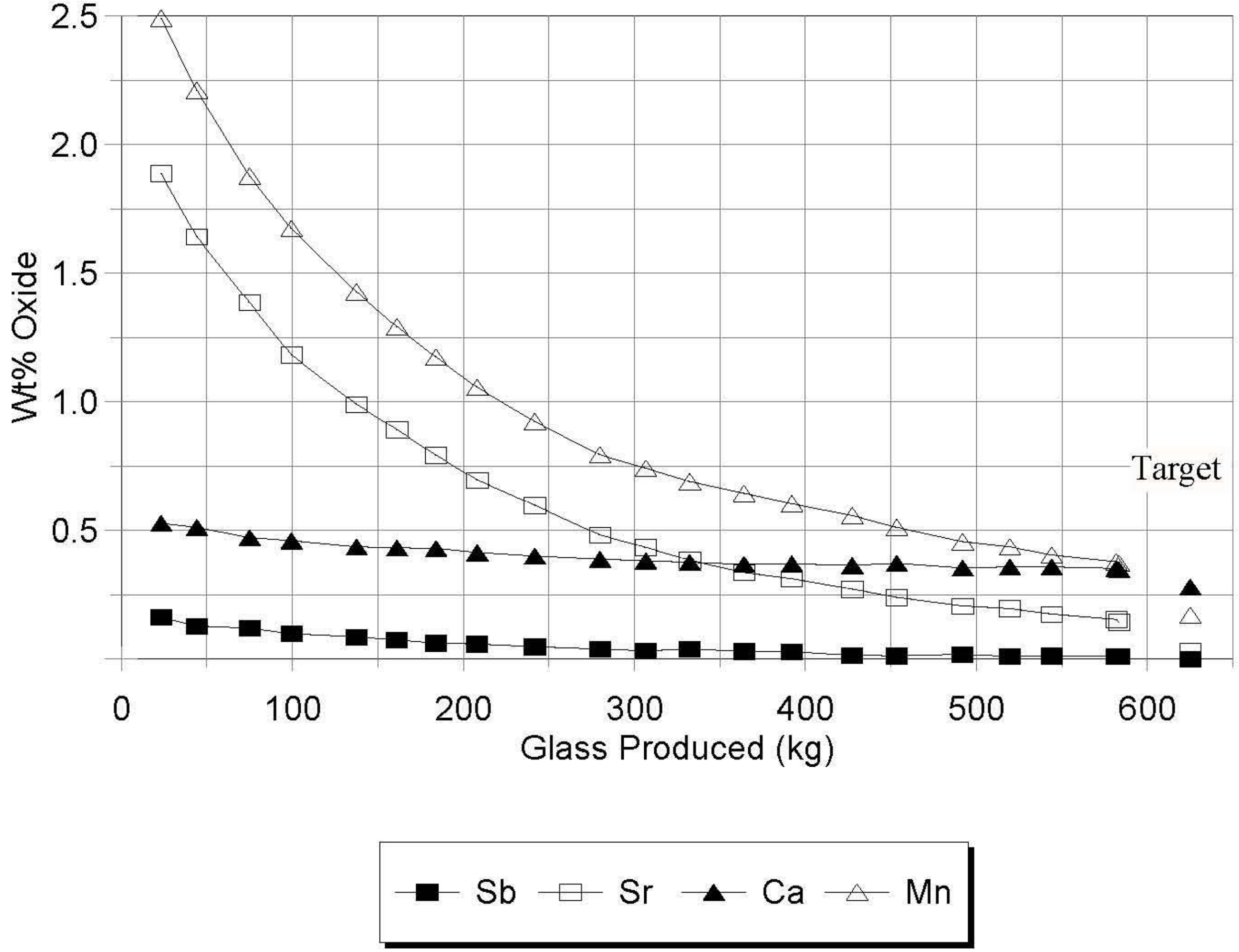

Figure 3.7. XRF analysis of oxides decreasing in concentration in glasses from DM100 testing.

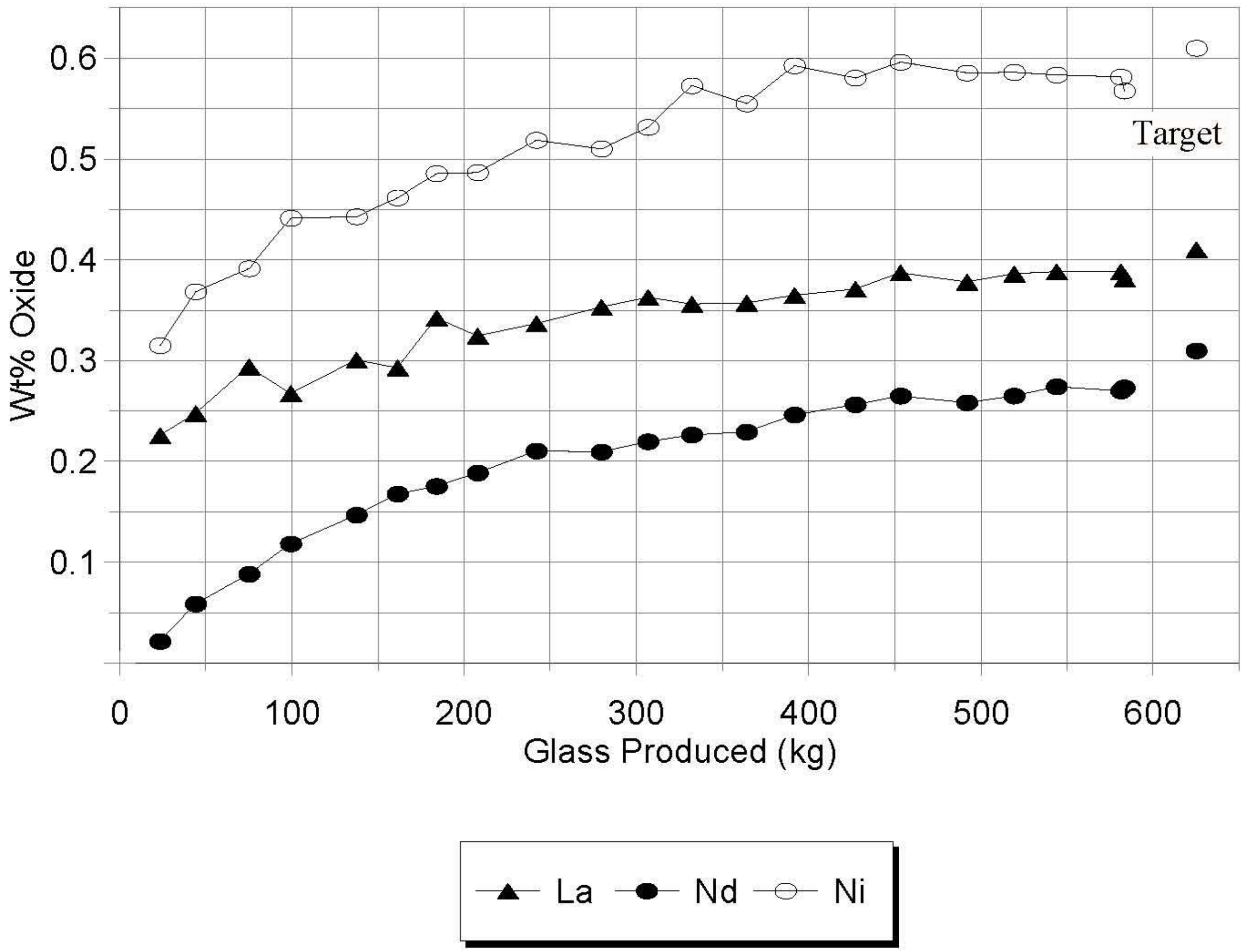

Figure 3.8. XRF analysis of oxides increasing in concentration in glasses from DM100 testing.

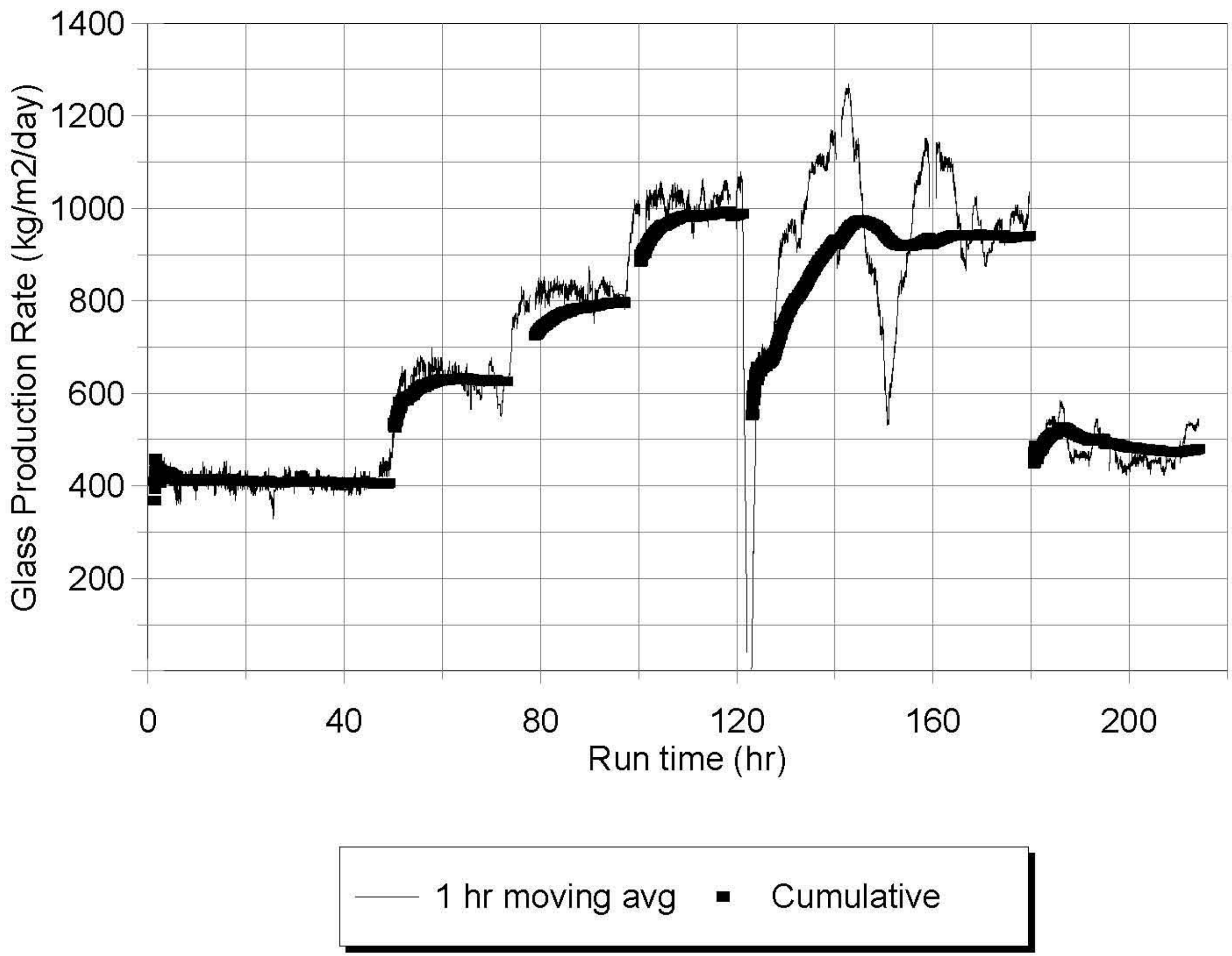

Figure 4.1.a. Test 1 (504 g glass/l) and Test 2 (281 g glass/l) production rates.

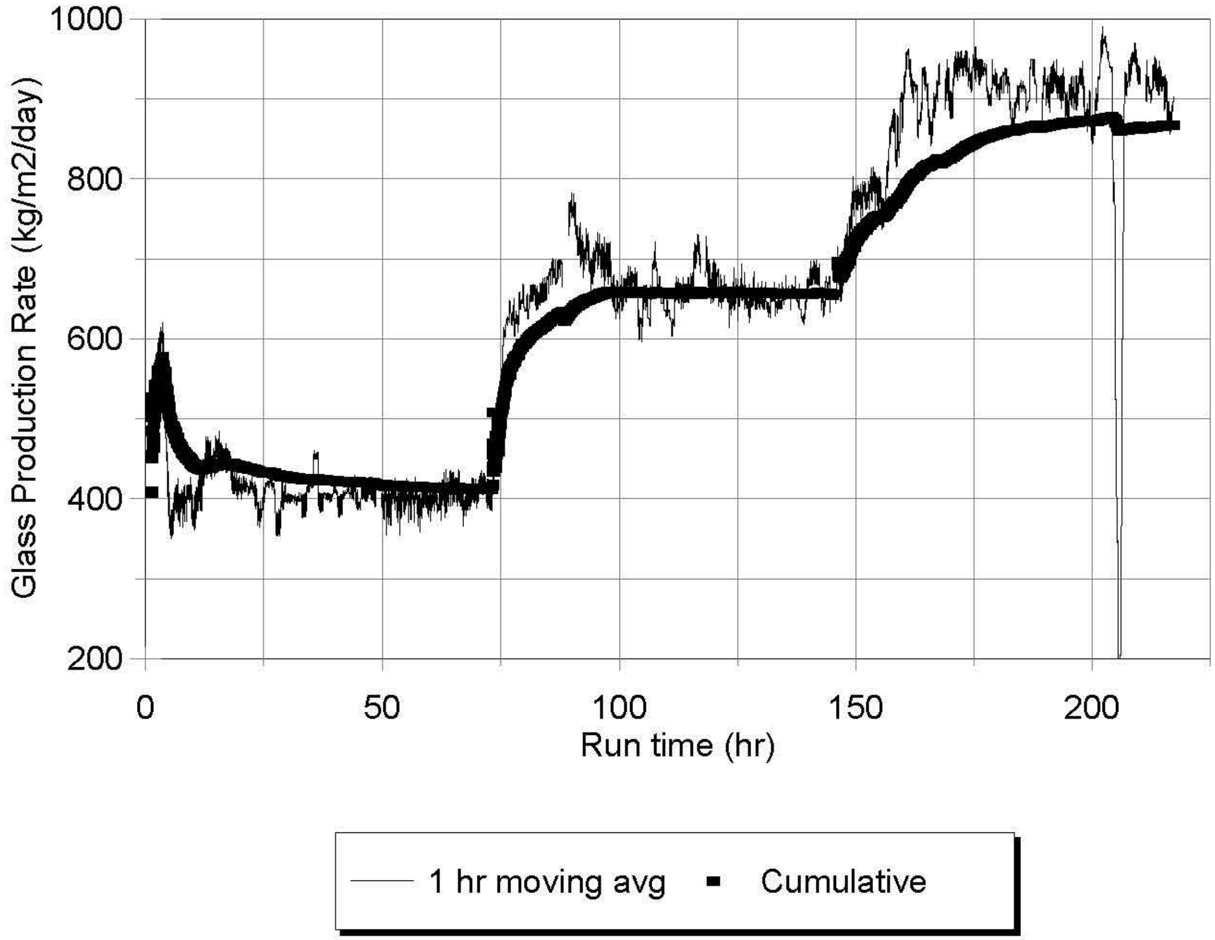

Figure 4.1.b. Production rates for Test 3 (530 g glass/l).

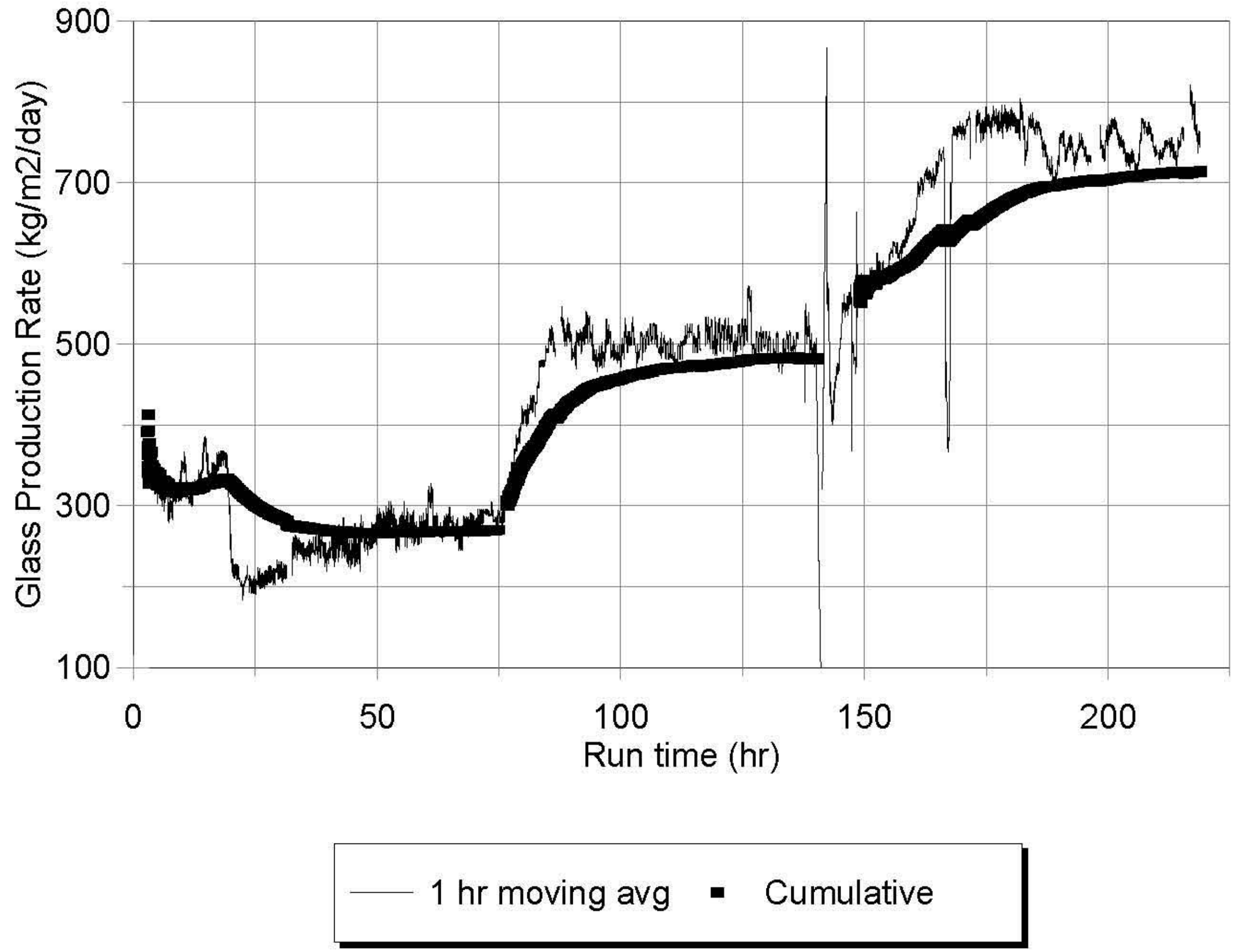

Figure 4.1.c. Production rates for Test 4 (400 g glass/l).

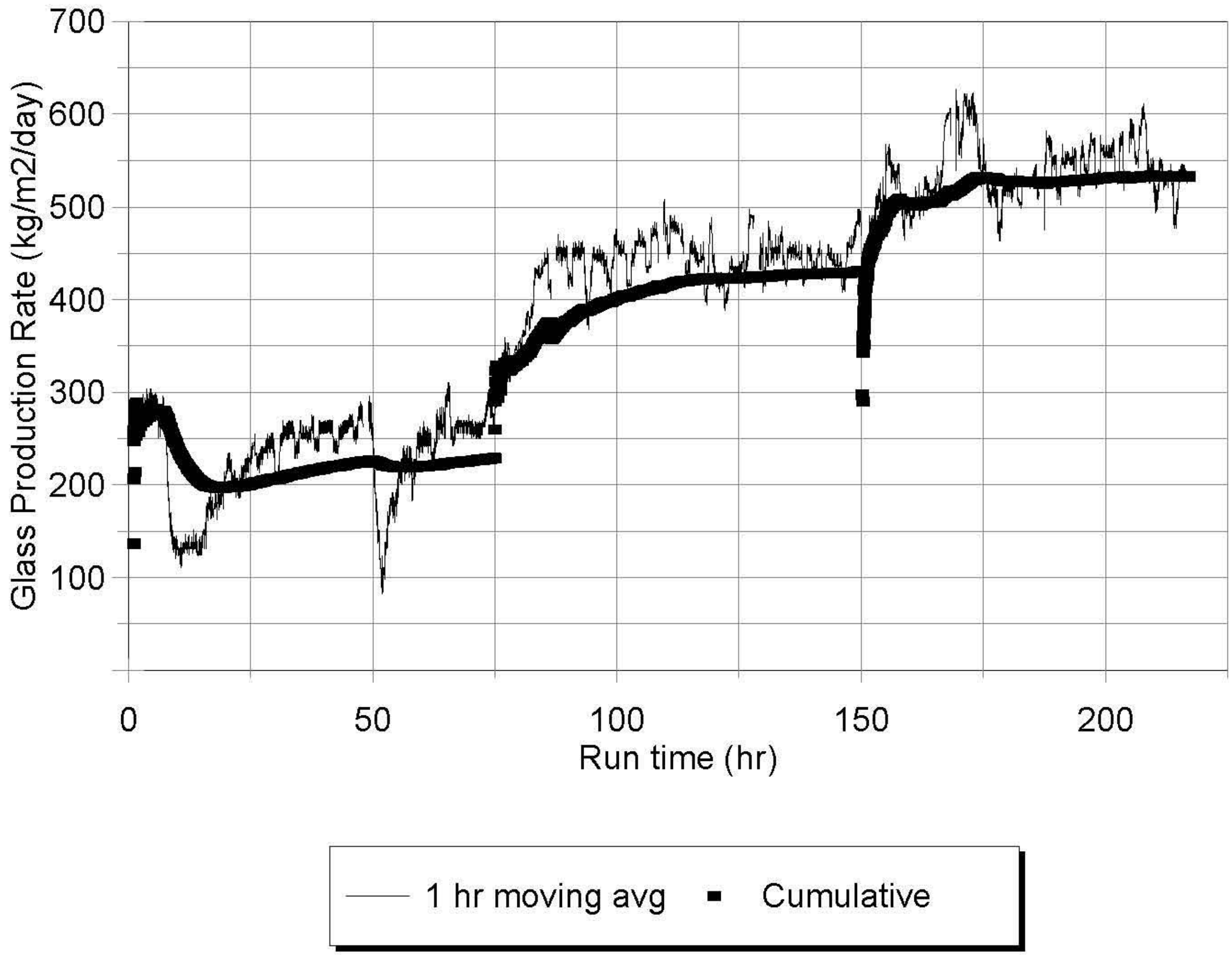

Figure 4.1.d. Production rates for Test 5 (300 g glass/l).

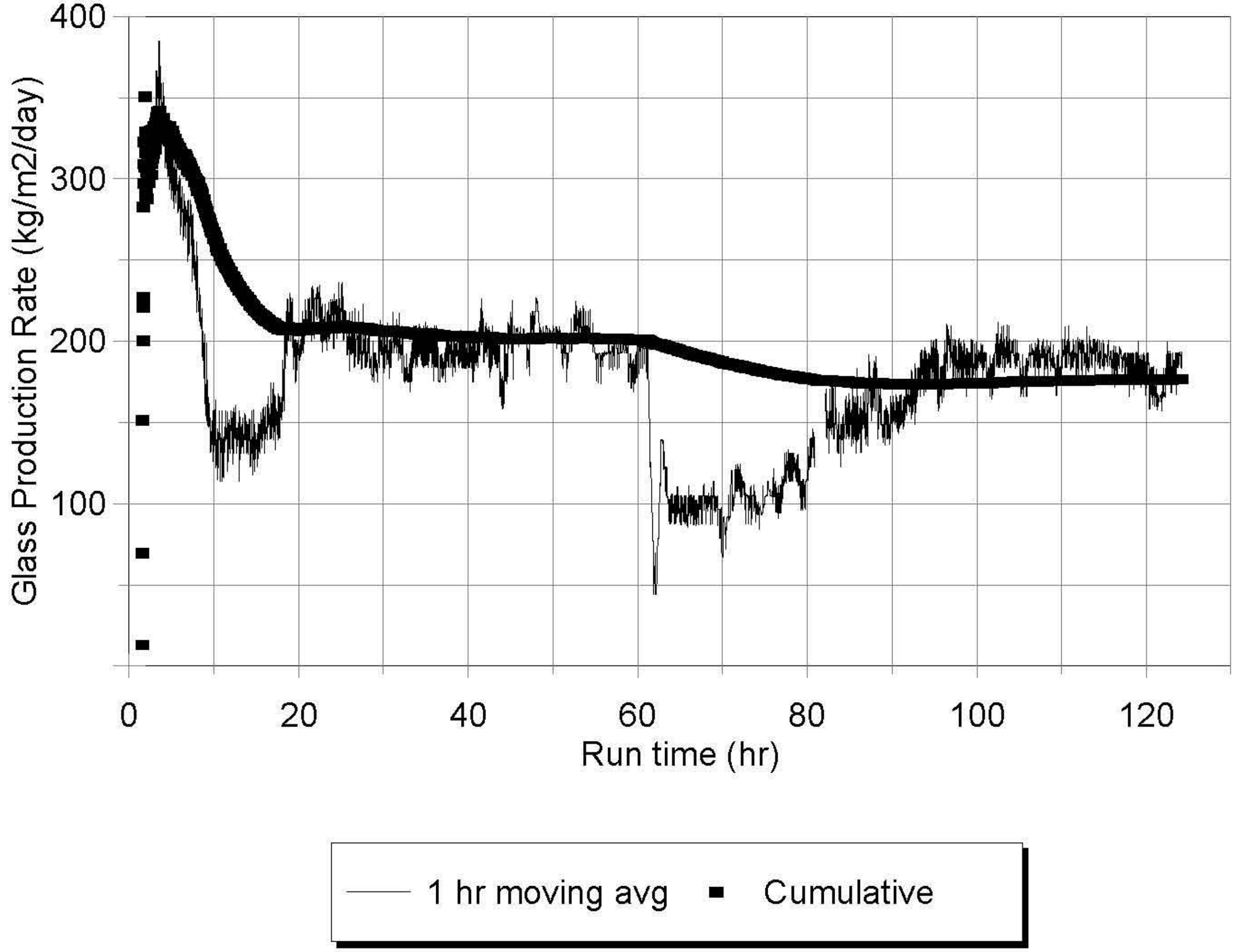

Figure 4.1.e. Production rates for Test 6 (400 g glass/l, 1 lpm bubbling).

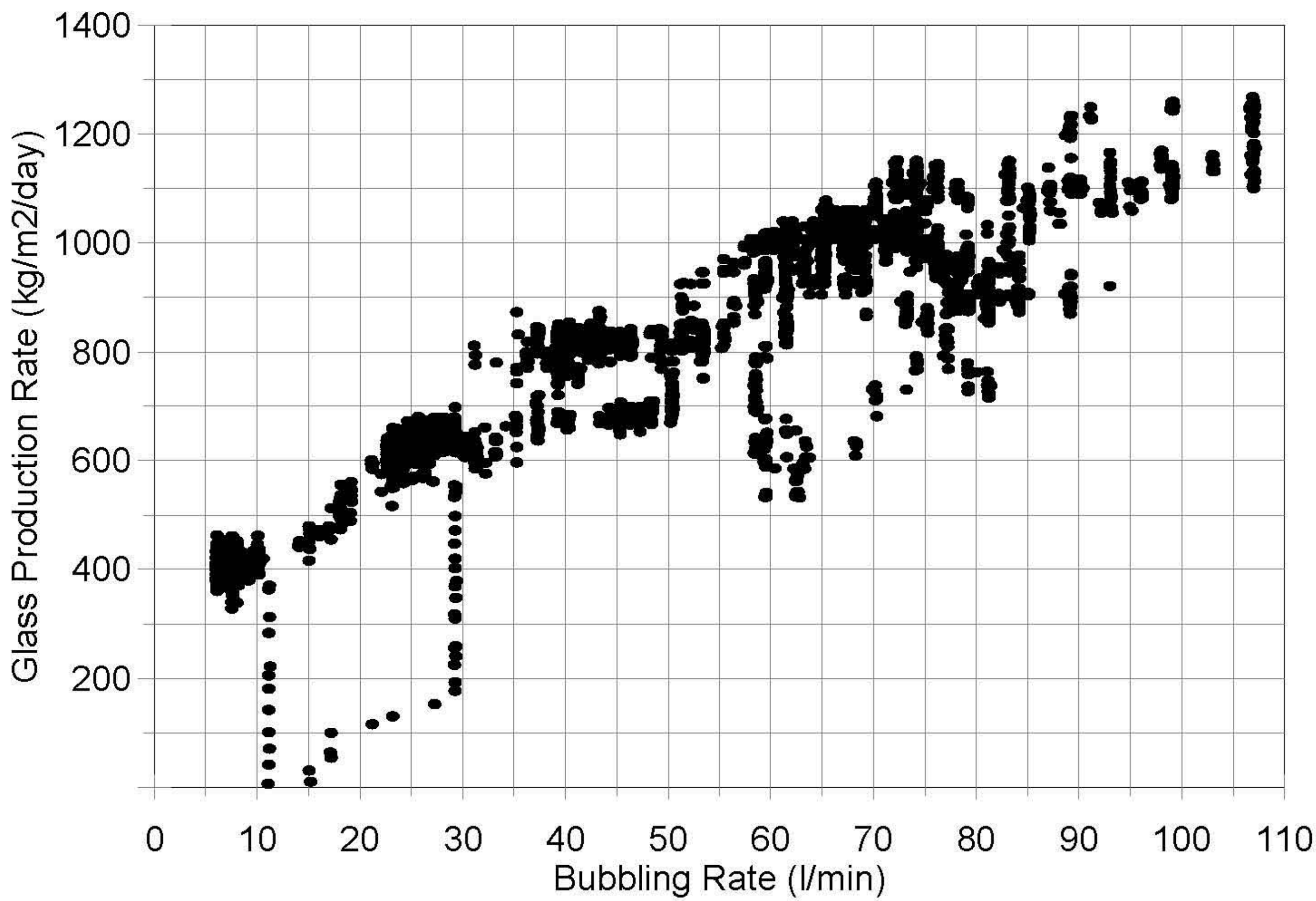

Figure 4.2. Production rates vs. bubbling for Test 1 (504 g glass/l).
Note: On ths plot, many points relate to non steady-state conditions.

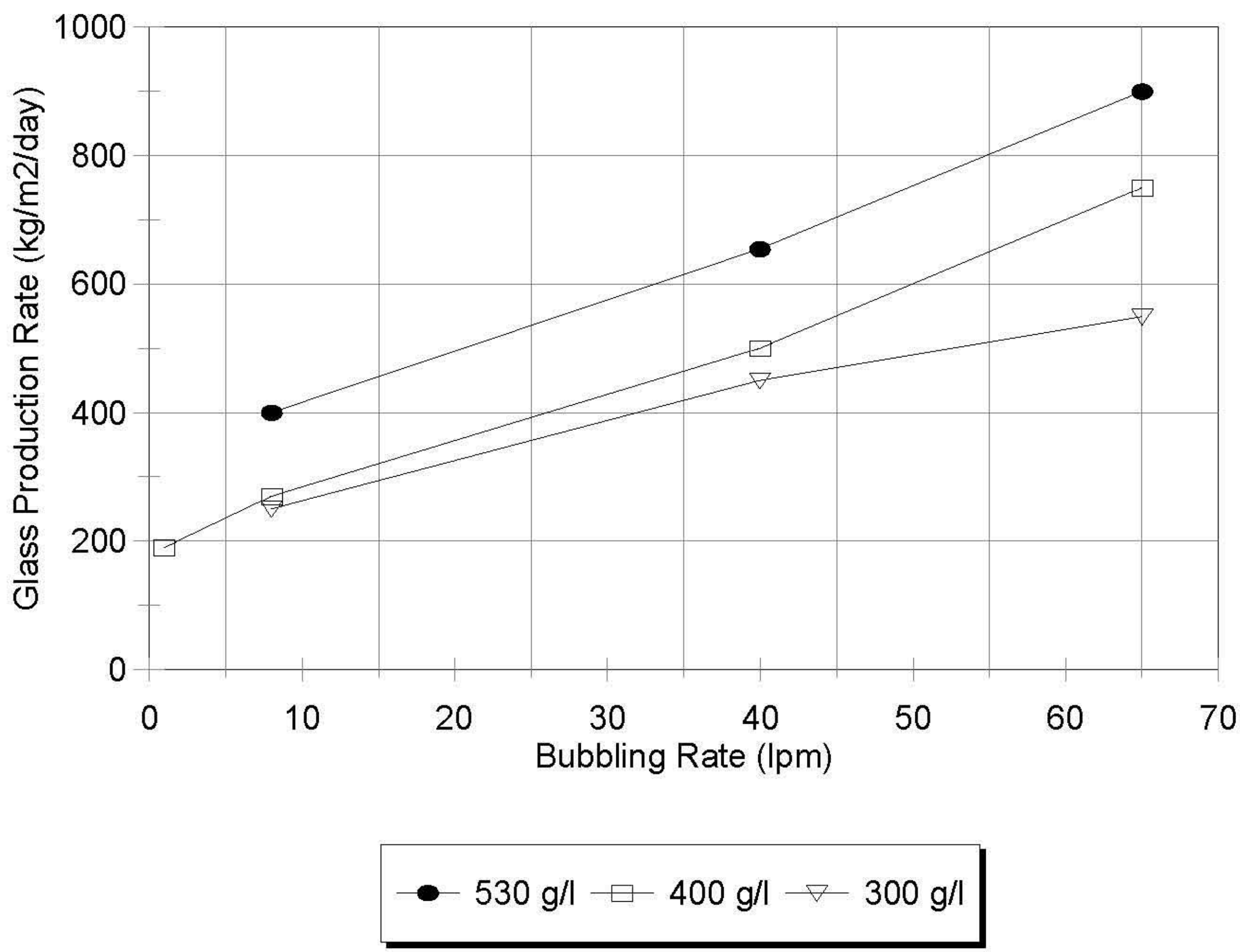

Figure 4.3. Comparison of steady state glass production rates for HLW AZ-101 melter tests.

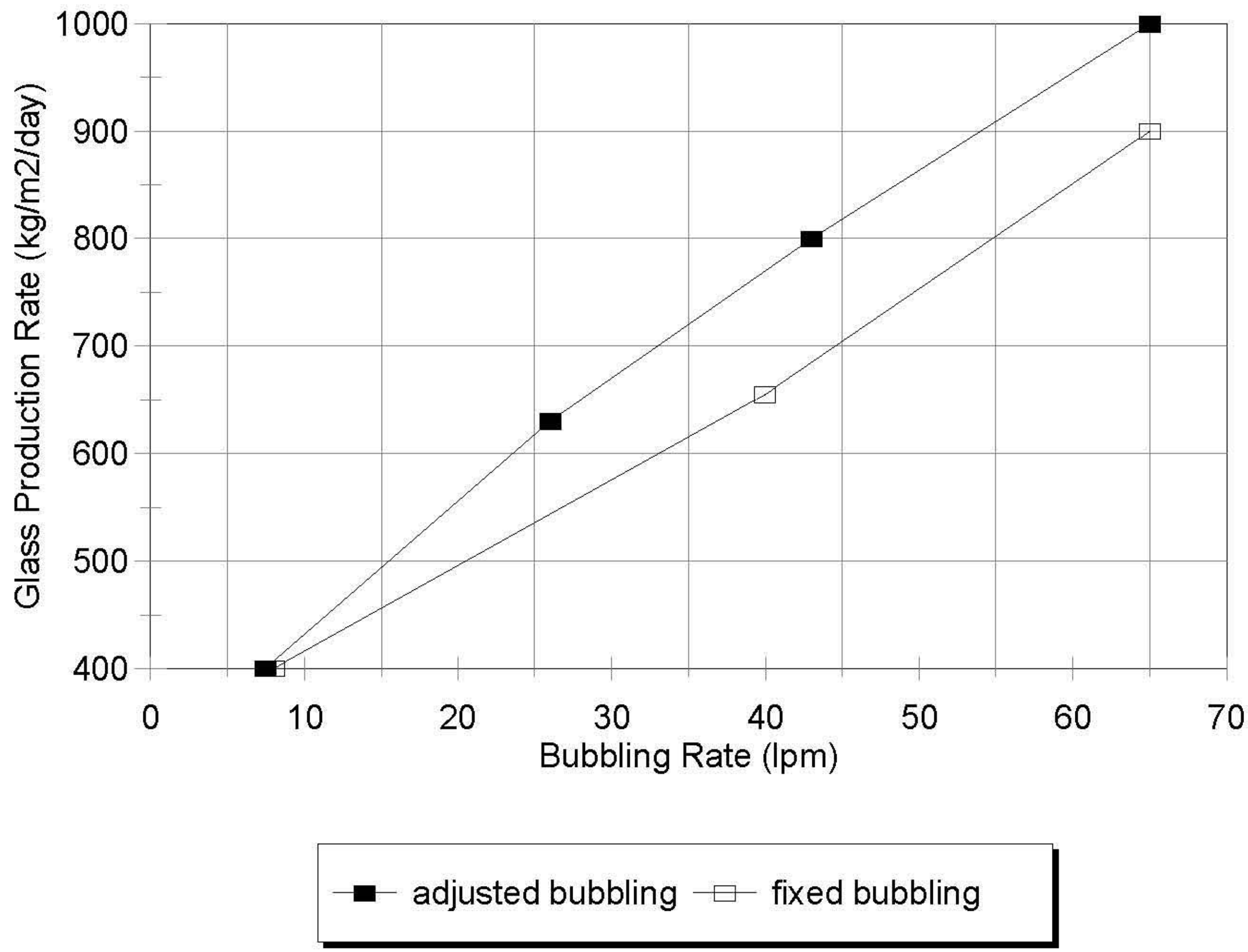

Figure 4.4. Comparison of production rates for Tests 1 and 3.

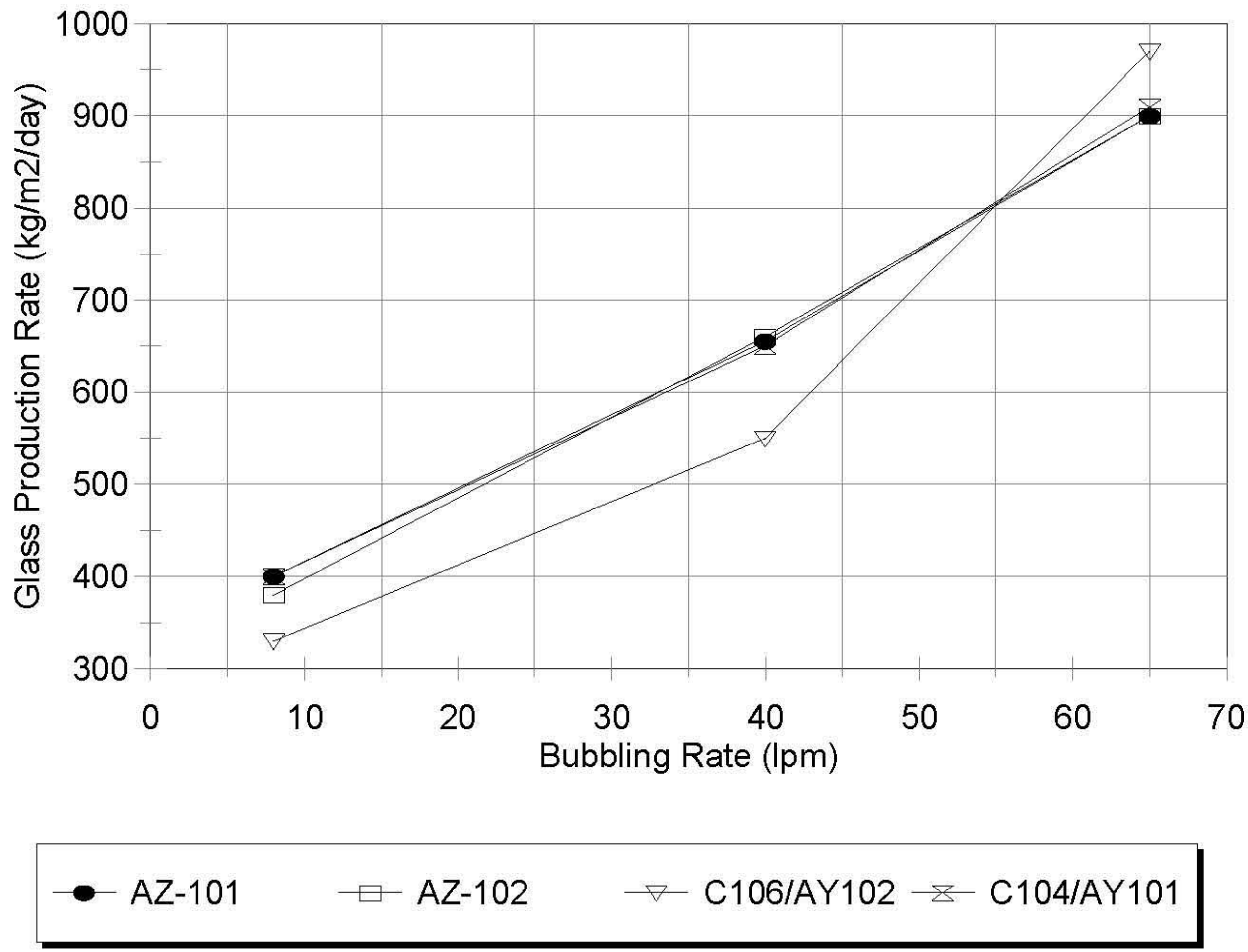

Figure 4.5. Comparison of steady state glass production rates for 20% UDS HLW waste simulant melter tests.

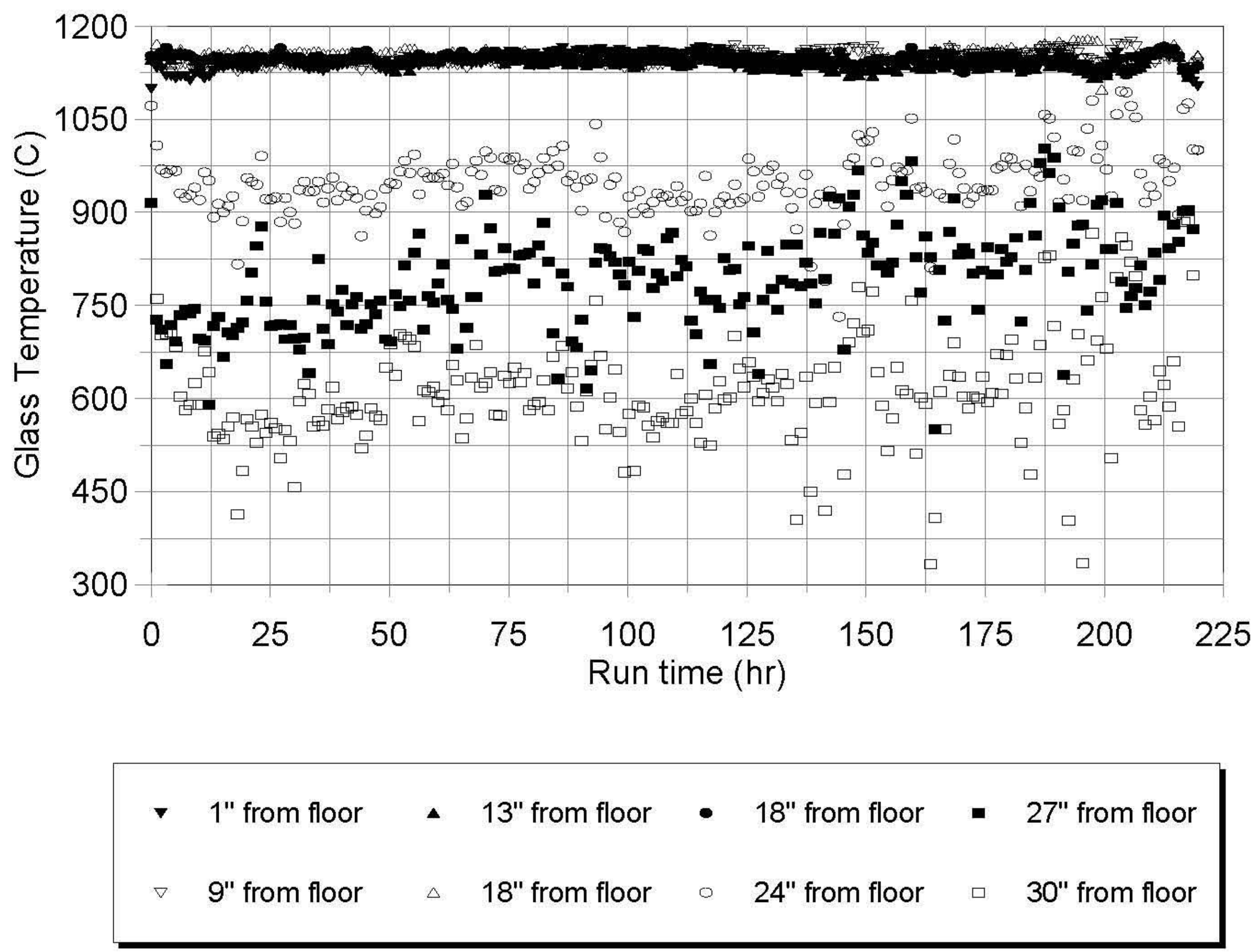

Figure 4.6.a. Glass temperatures for Test 1 (504 g glass/l) and Test 2 (281 g glass/l).

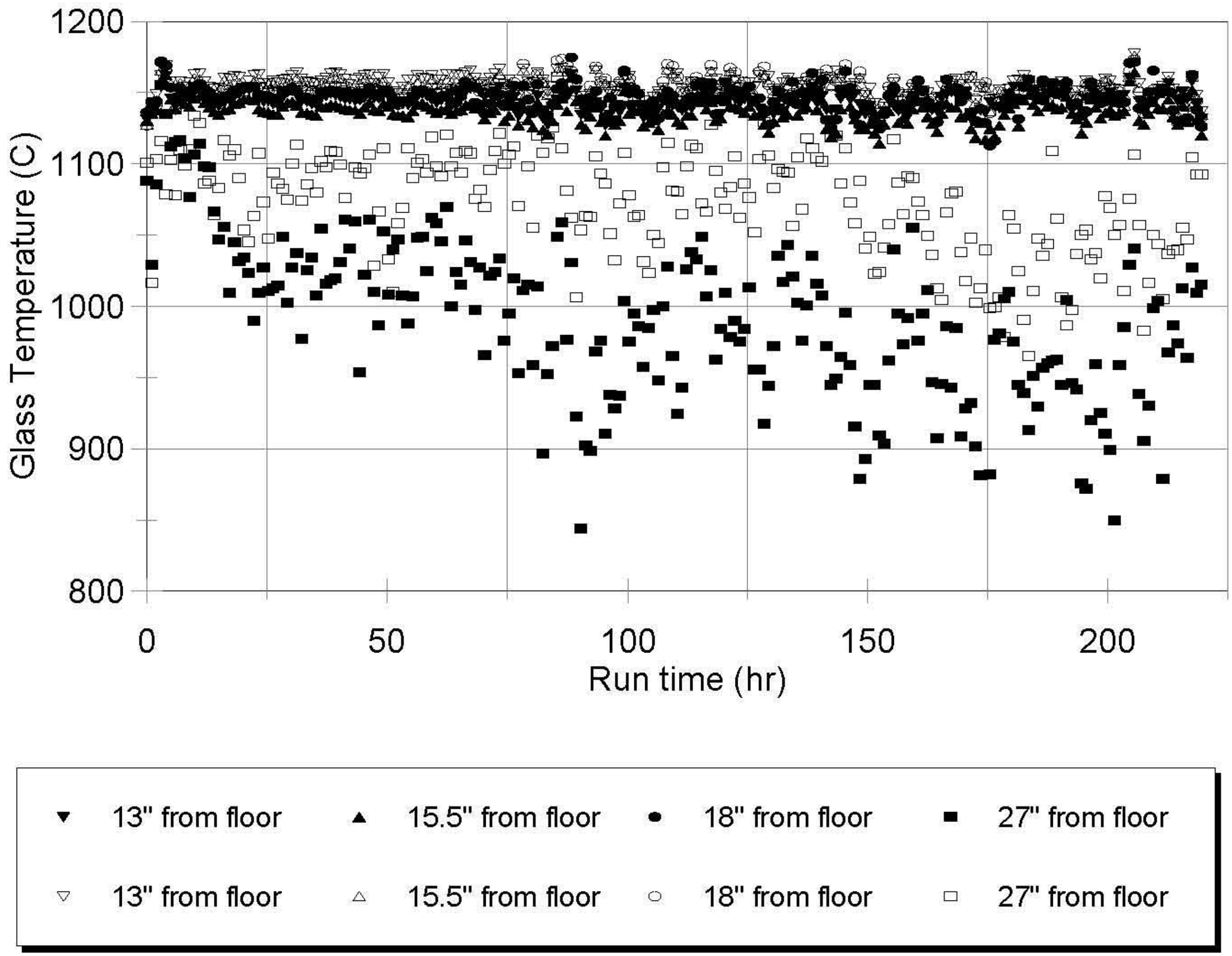

Figure 4.6.b. Glass temperatures for Test 3 (530 g glass/l).

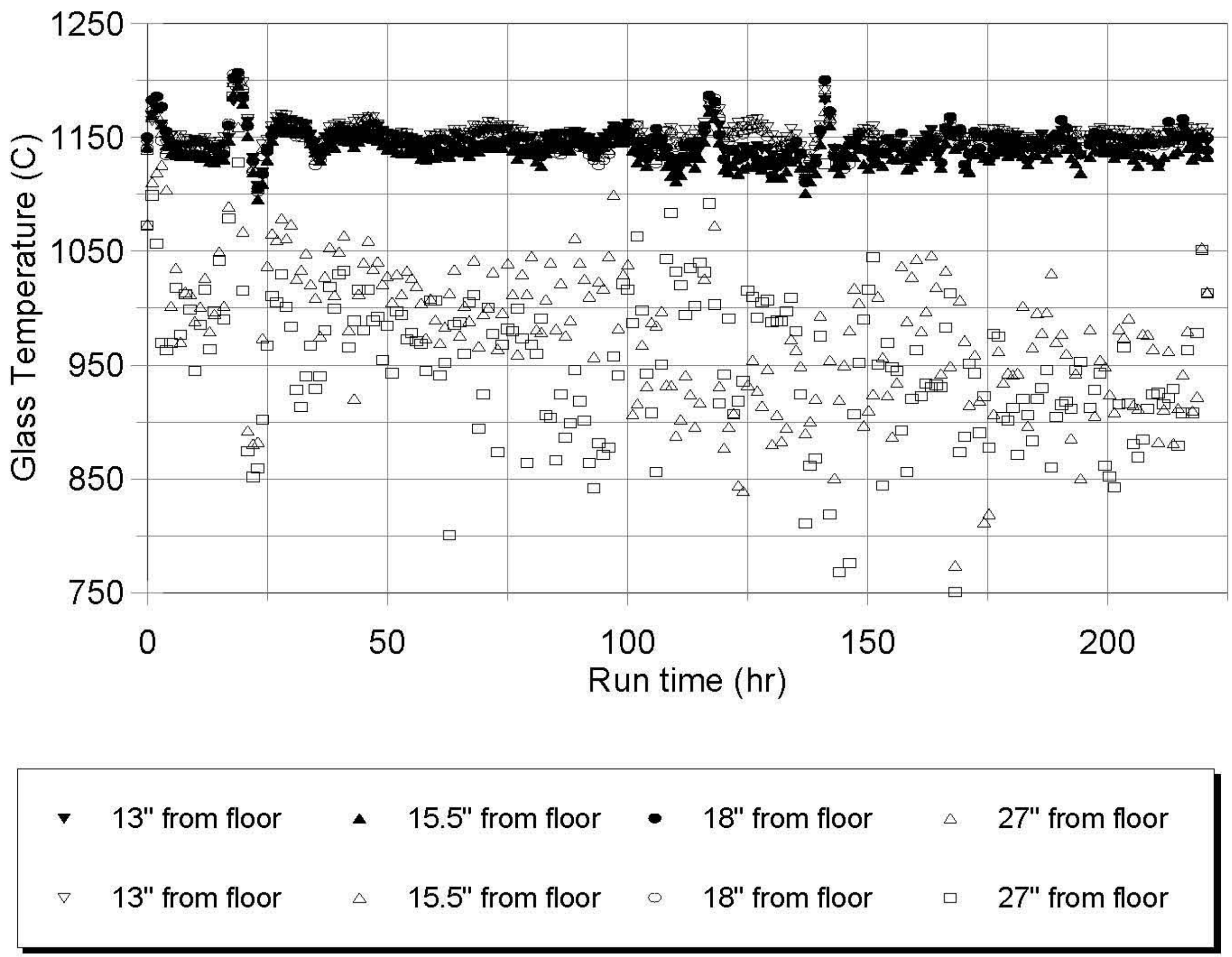

Figure 4.6.c. Glass temperatures for Test 4 (400 g glass/l).

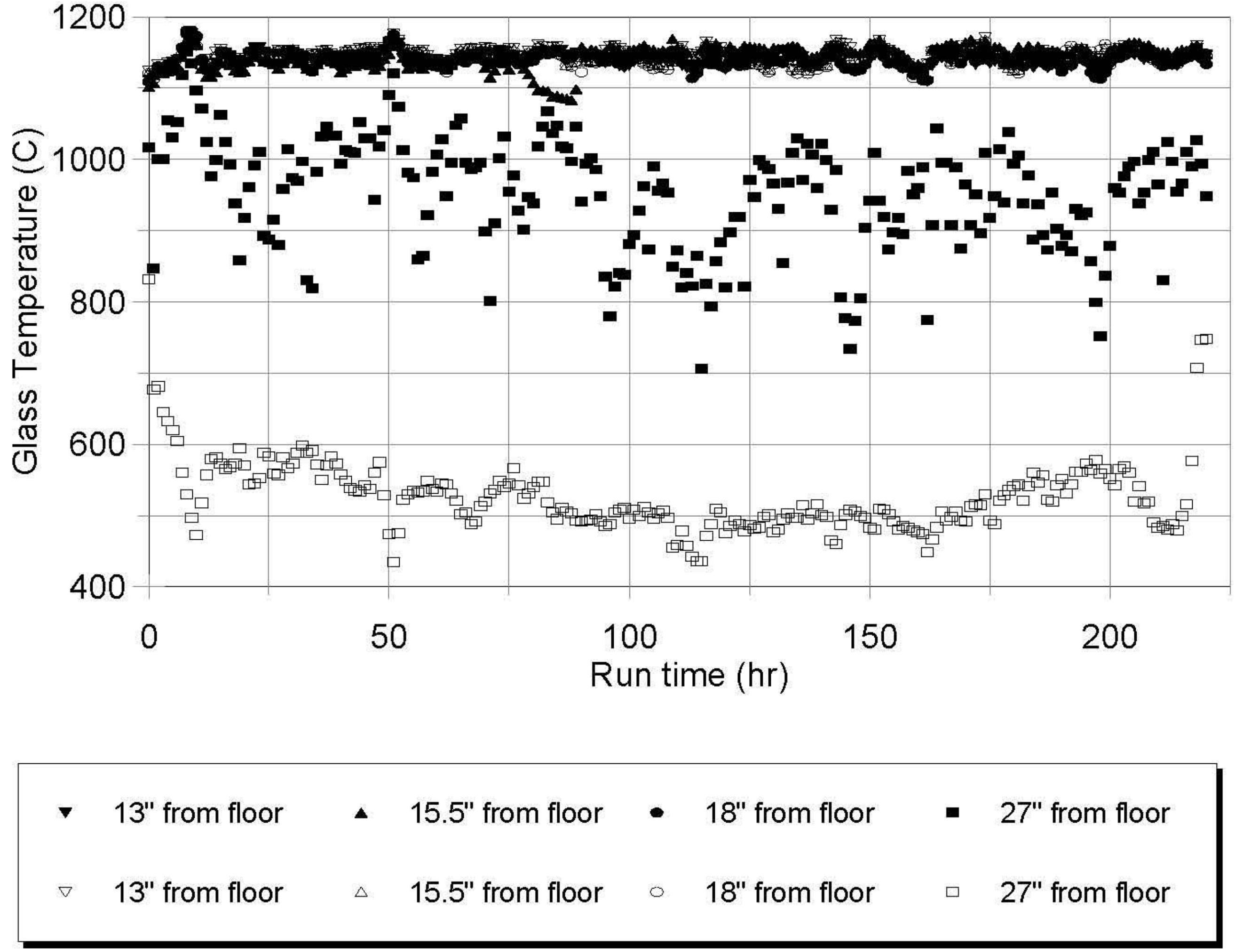

Figure 4.6.d. Glass temperatures for Test 5 (300 g glass/l).

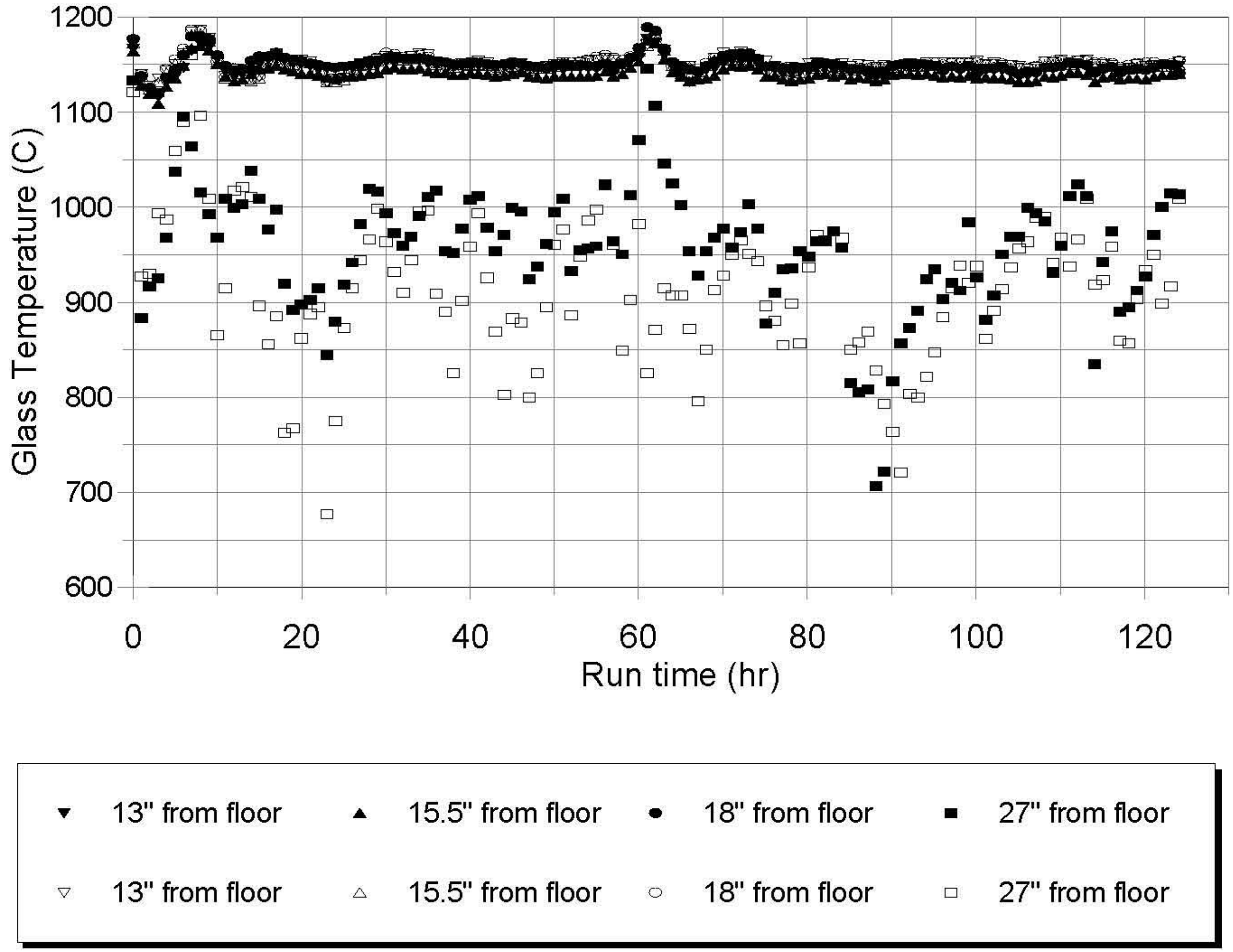

Figure 4.6.e. Glass temperatures for Test 6 (400 g glass/l, 1 lpm bubbling).

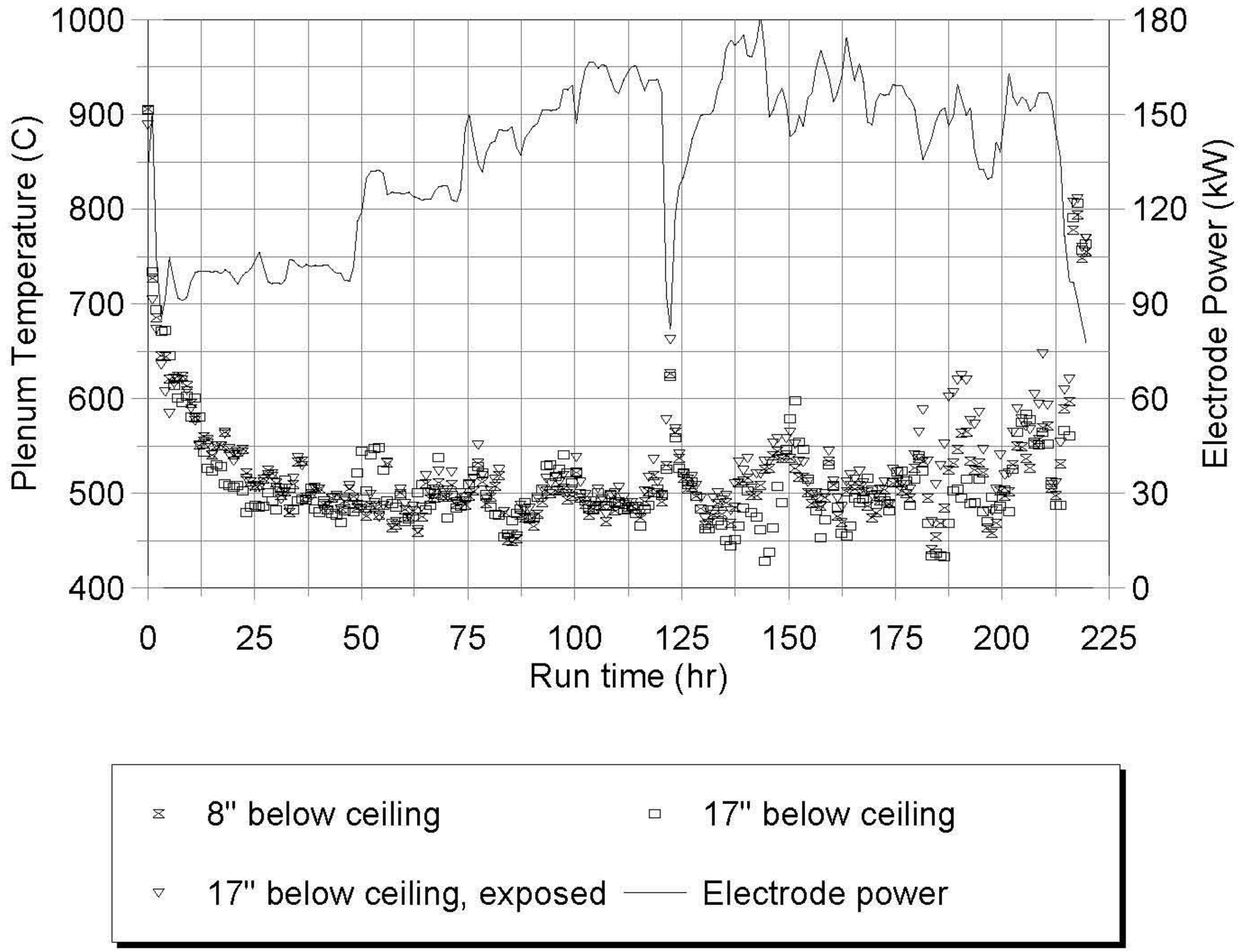

Figure 4.7.a. Plenum temperatures and electrode power for Test 1 (504 g glass/l) and Test 2 (281 g glass/l).

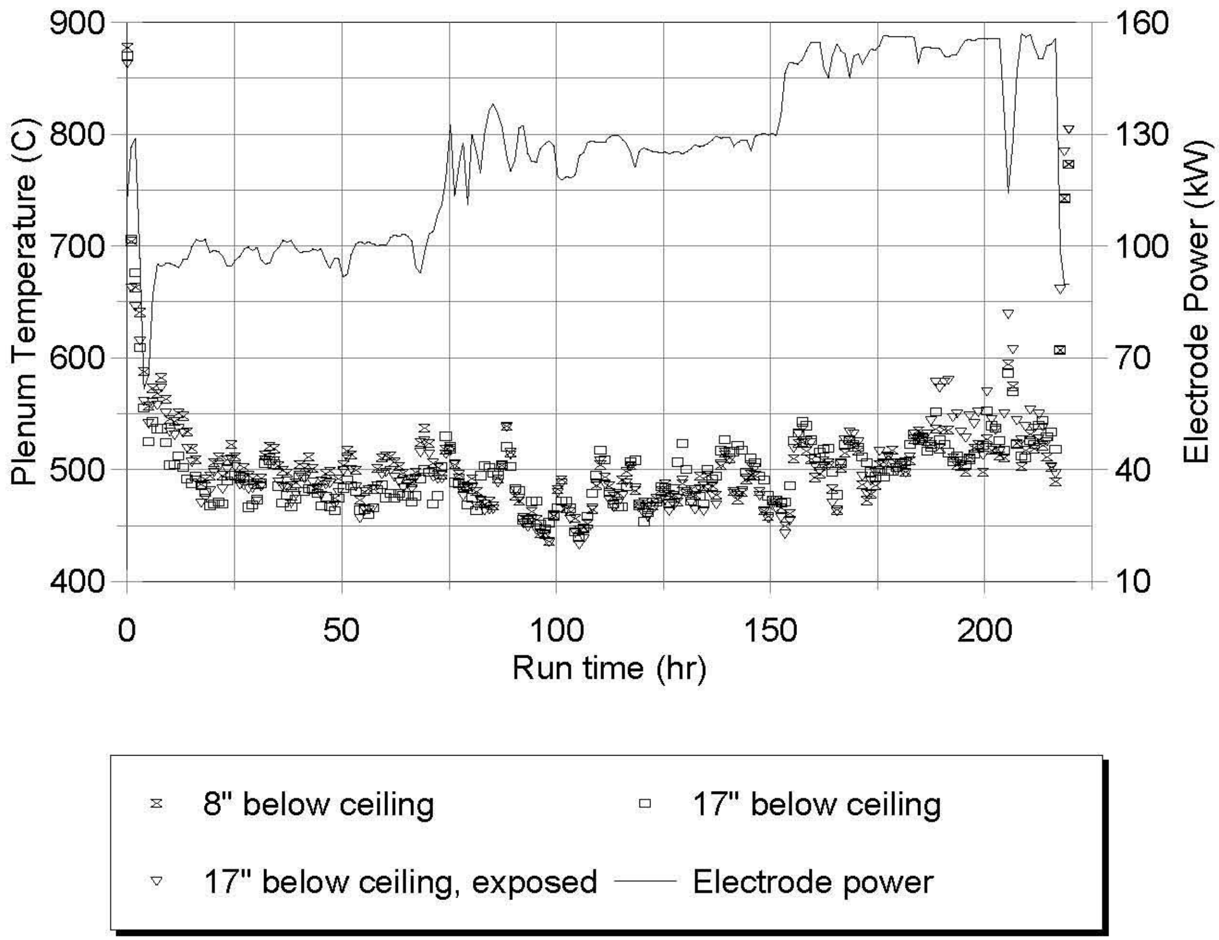

Figure 4.7.b. Plenum temperatures and electrode power for Test 3 (530 g glass/l).

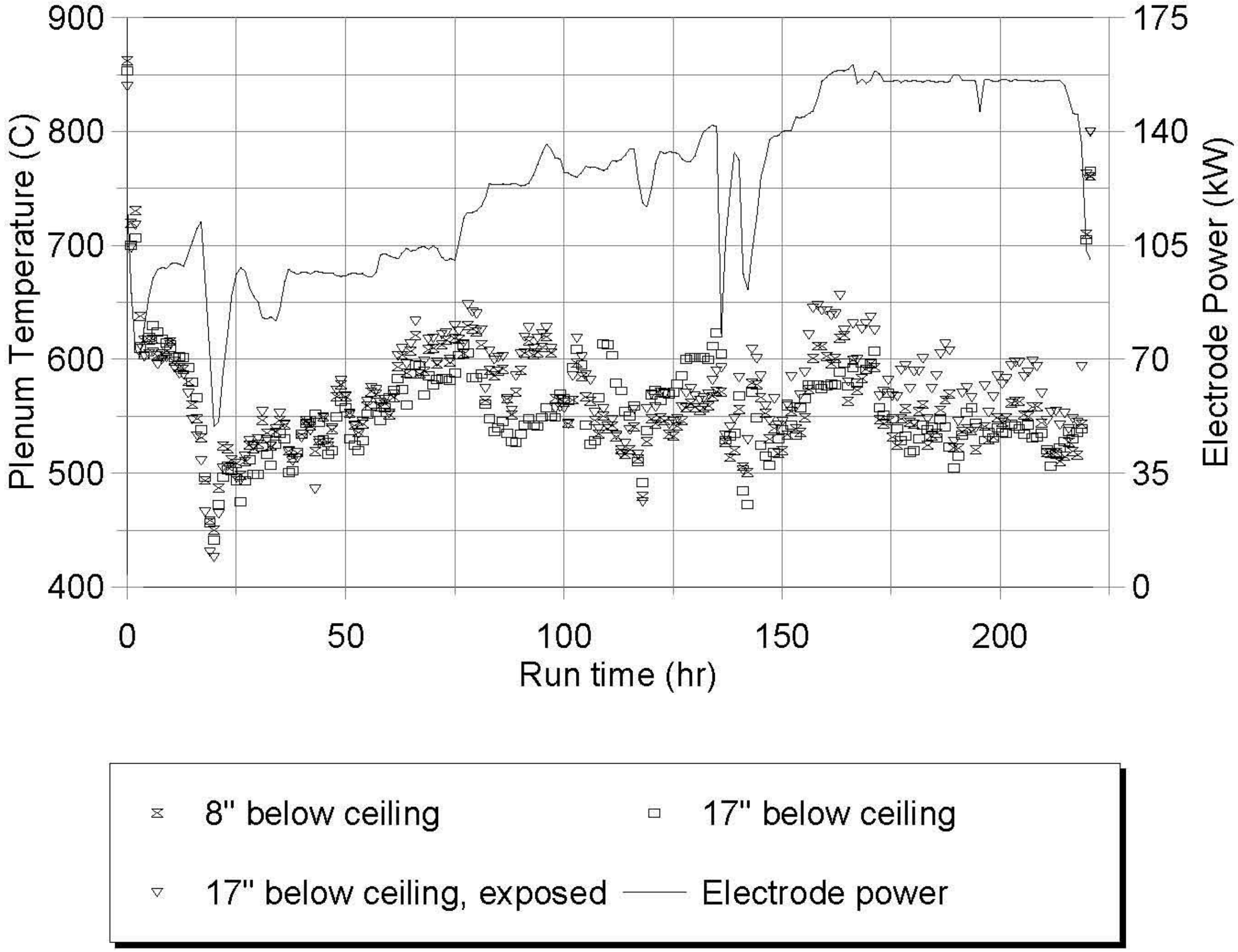

Figure 4.7.c. Plenum temperatures for Test 4 (400 g glass/l).

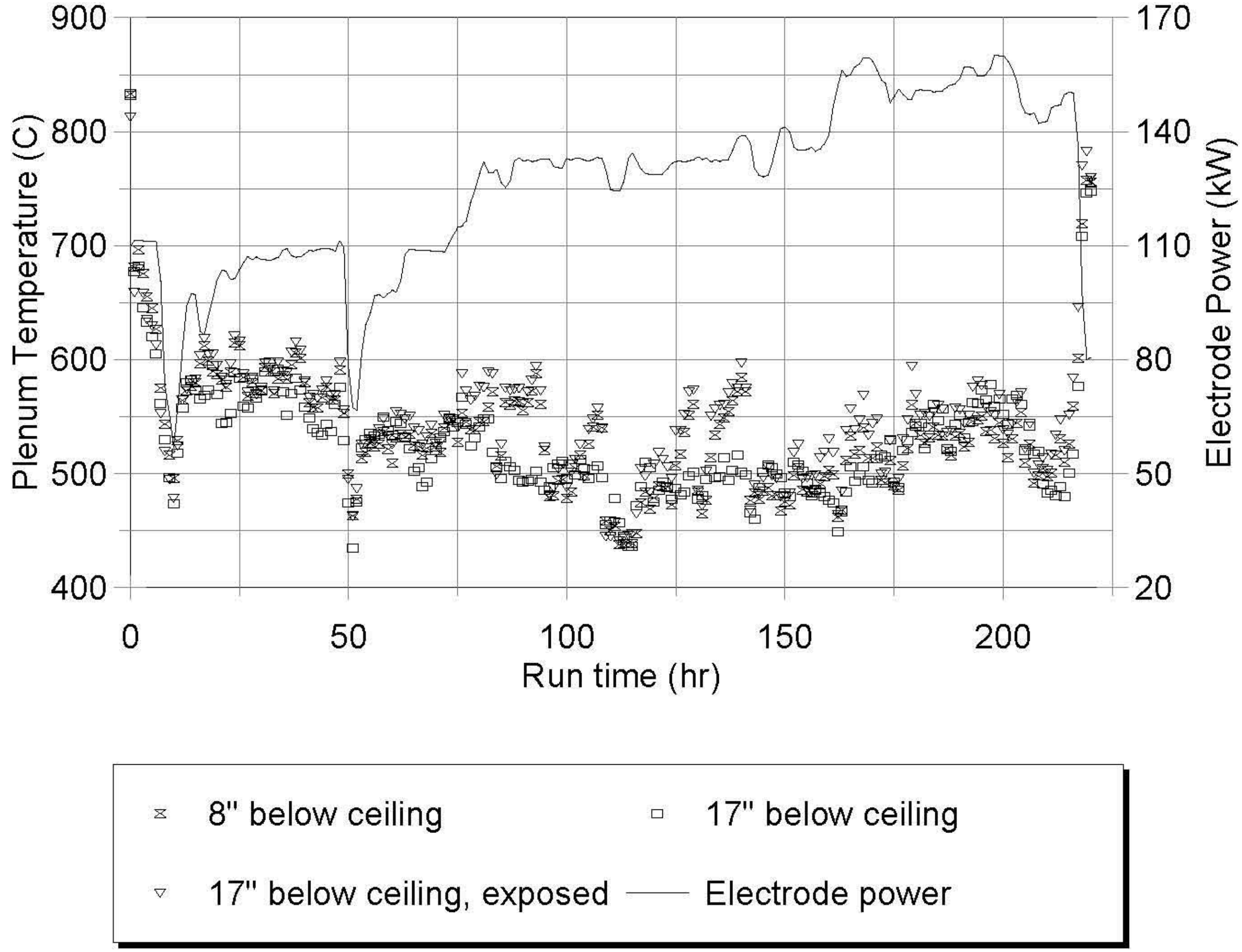

Figure 4.7.d. Plenum temperatures and electrode power for Test 5 (300 g glass/l).

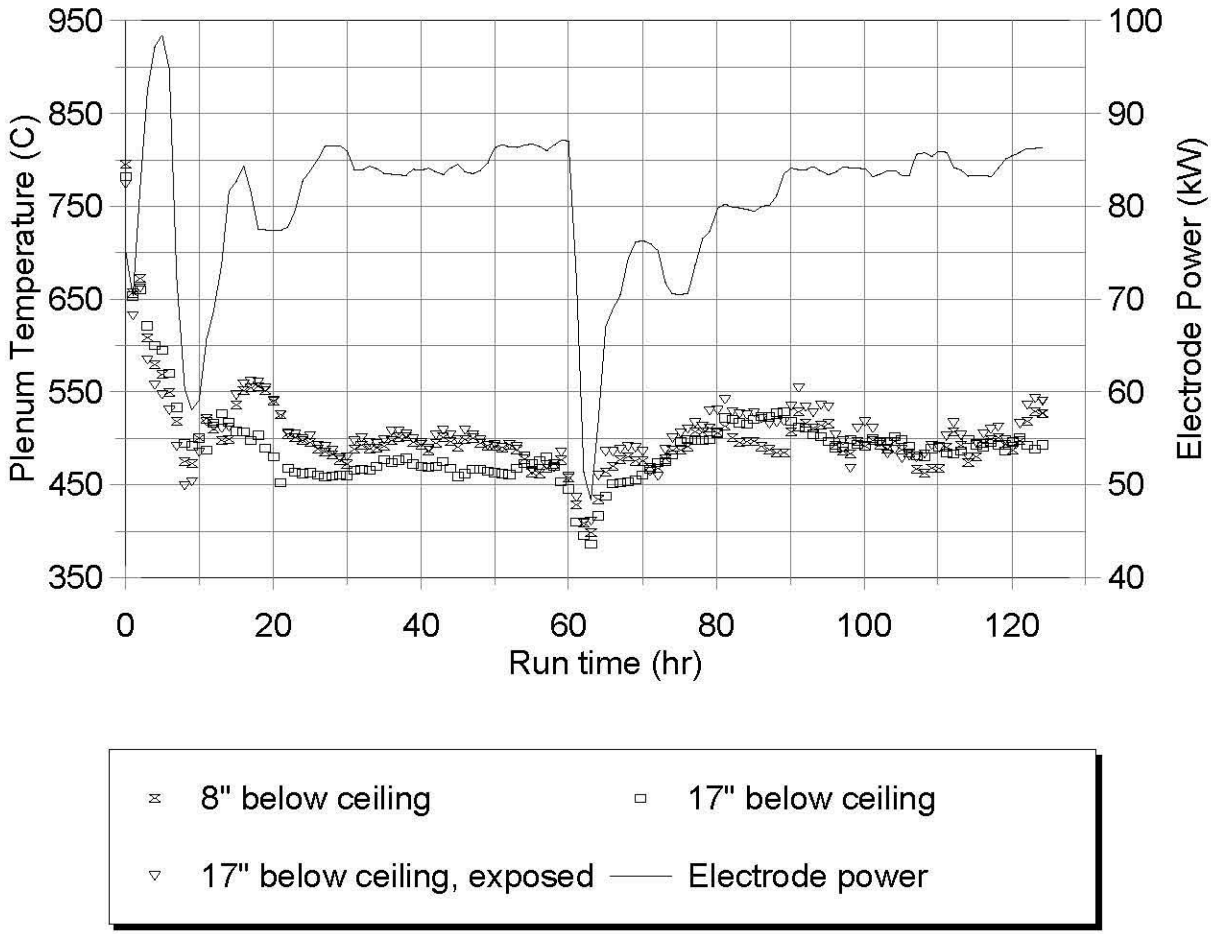

Figure 4.7.e. Plenum temperatures and electrode power for Test 6 (400 g glass/l, 1 lpm bubbling).

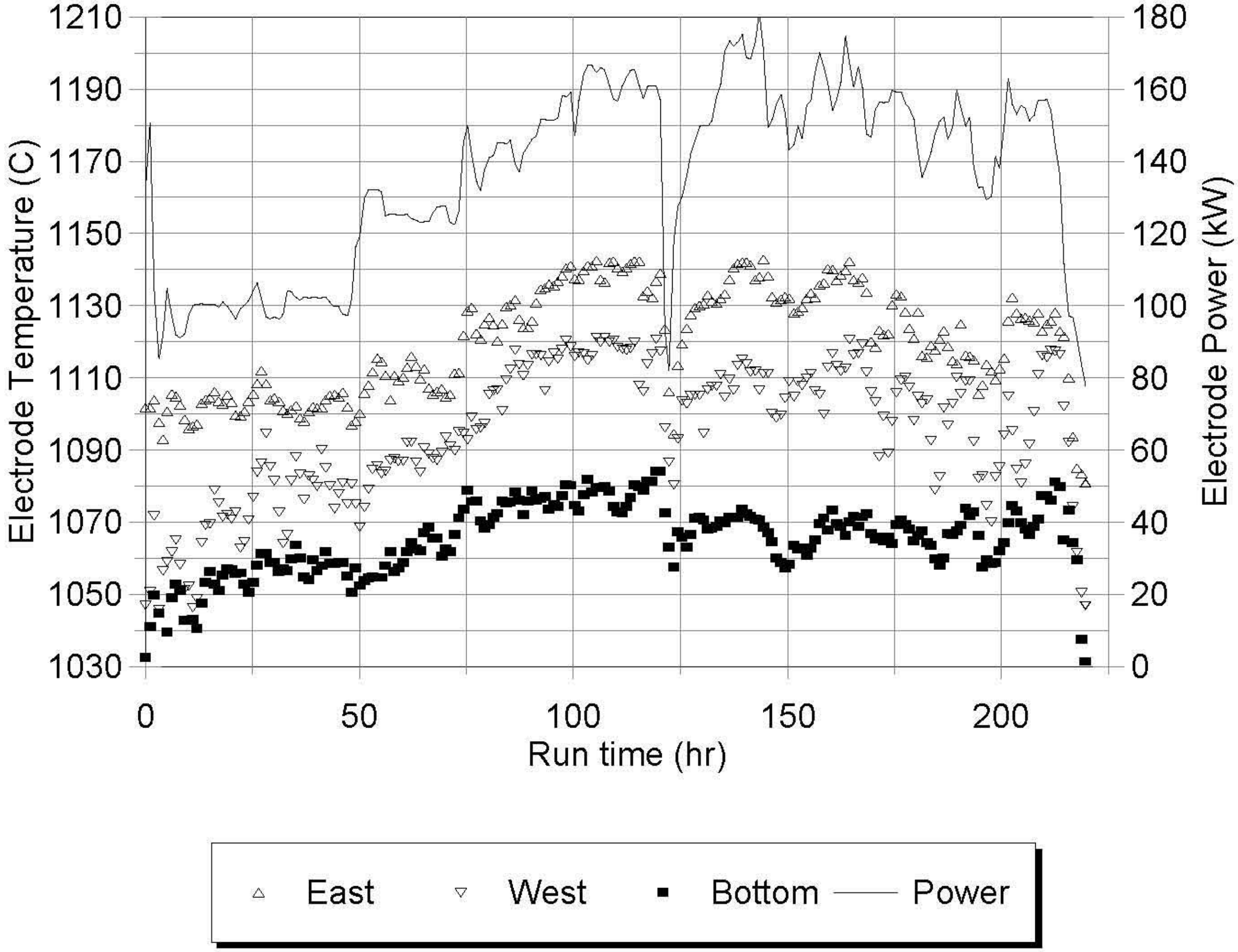

Figure 4.8.a. Electrode temperatures and power for Tests 1 and 2 (504 and 281 g glass/l).

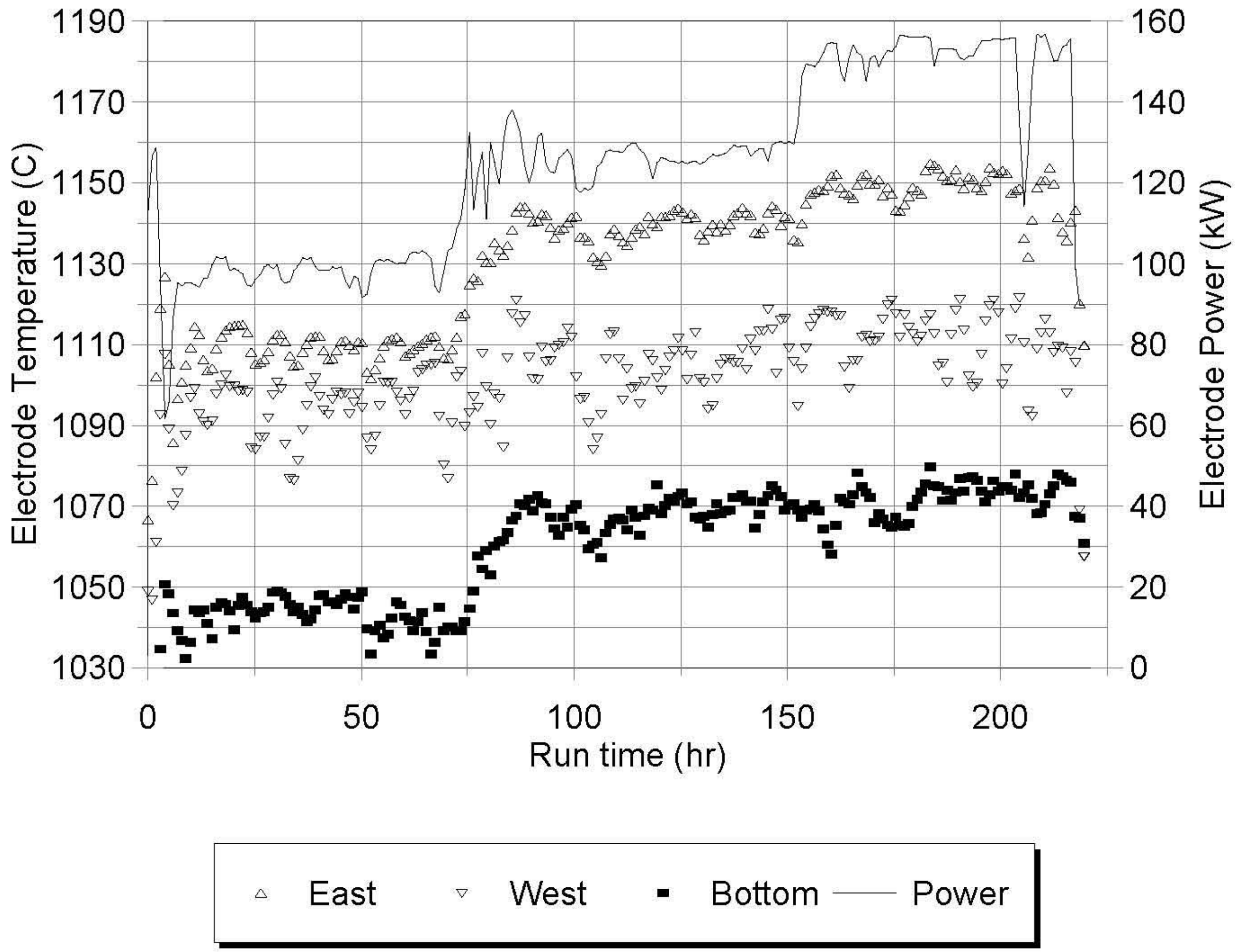

Figure 4.8.b. Electrode temperatures and power for Test 3 (530 g glass/l).

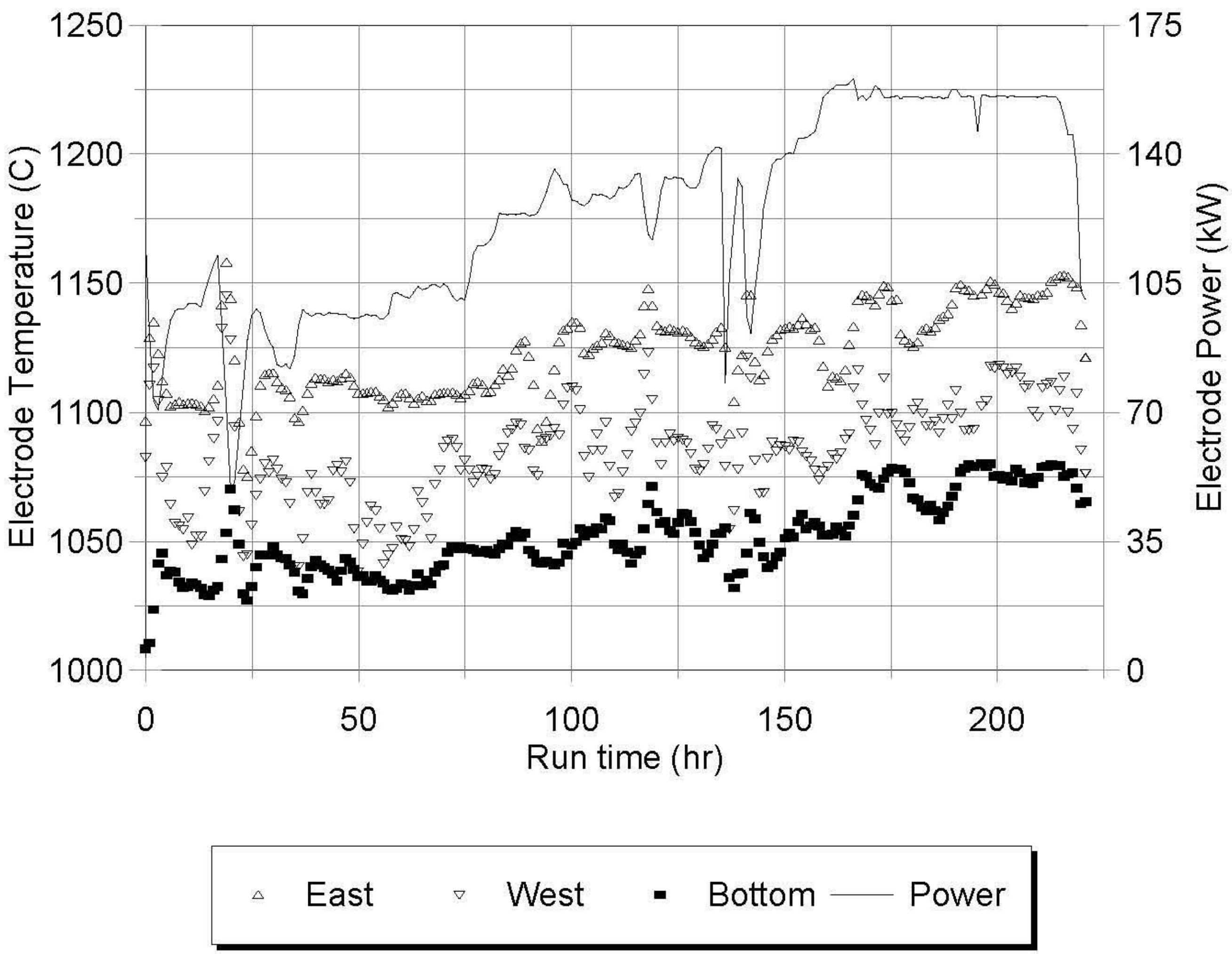

Figure 4.8.c. Electrode temperatures and power for Test 4 (400 g glass/l).

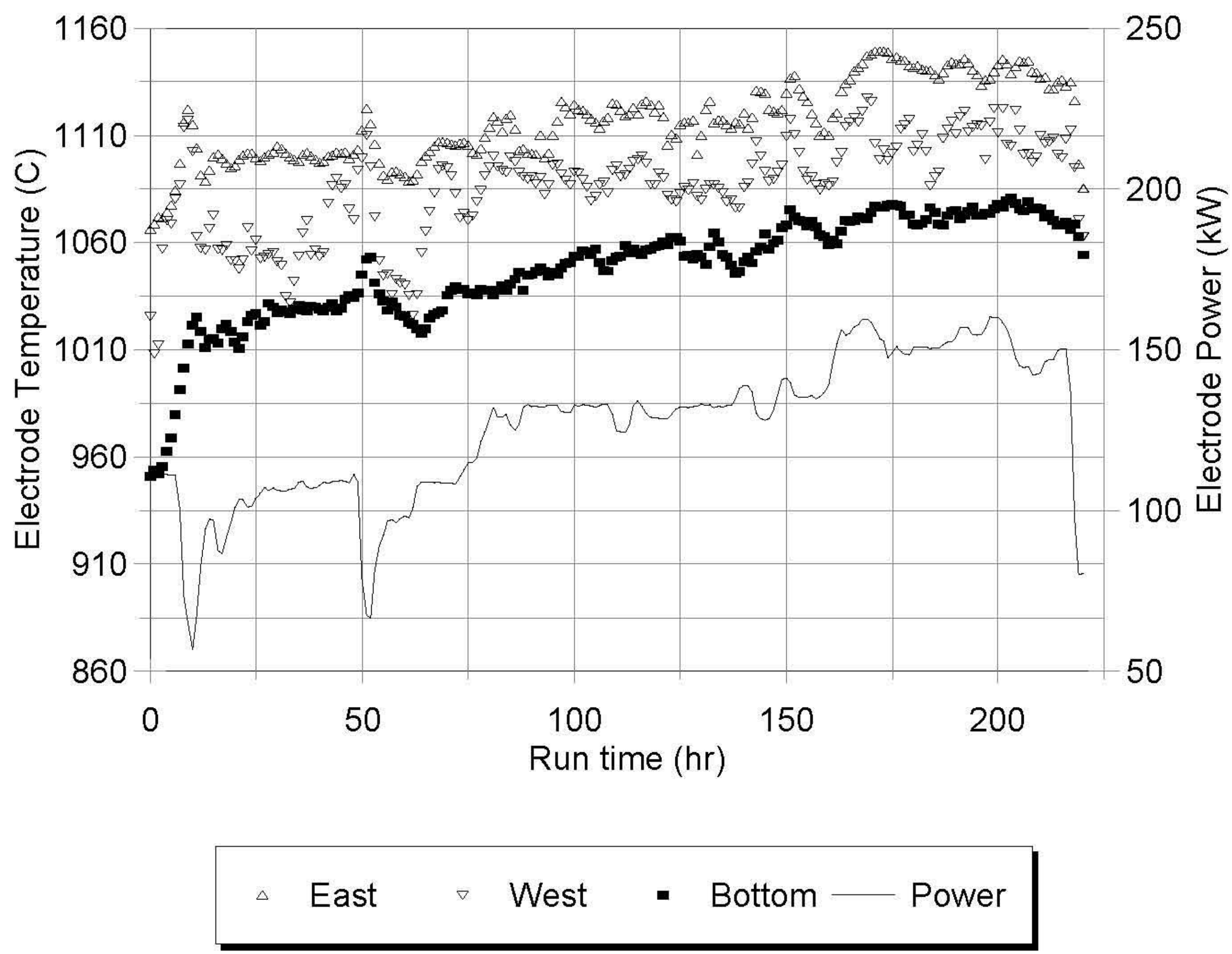

Figure 4.8.d. Electrode temperatures and power for Test 5 (300 g glass/l).

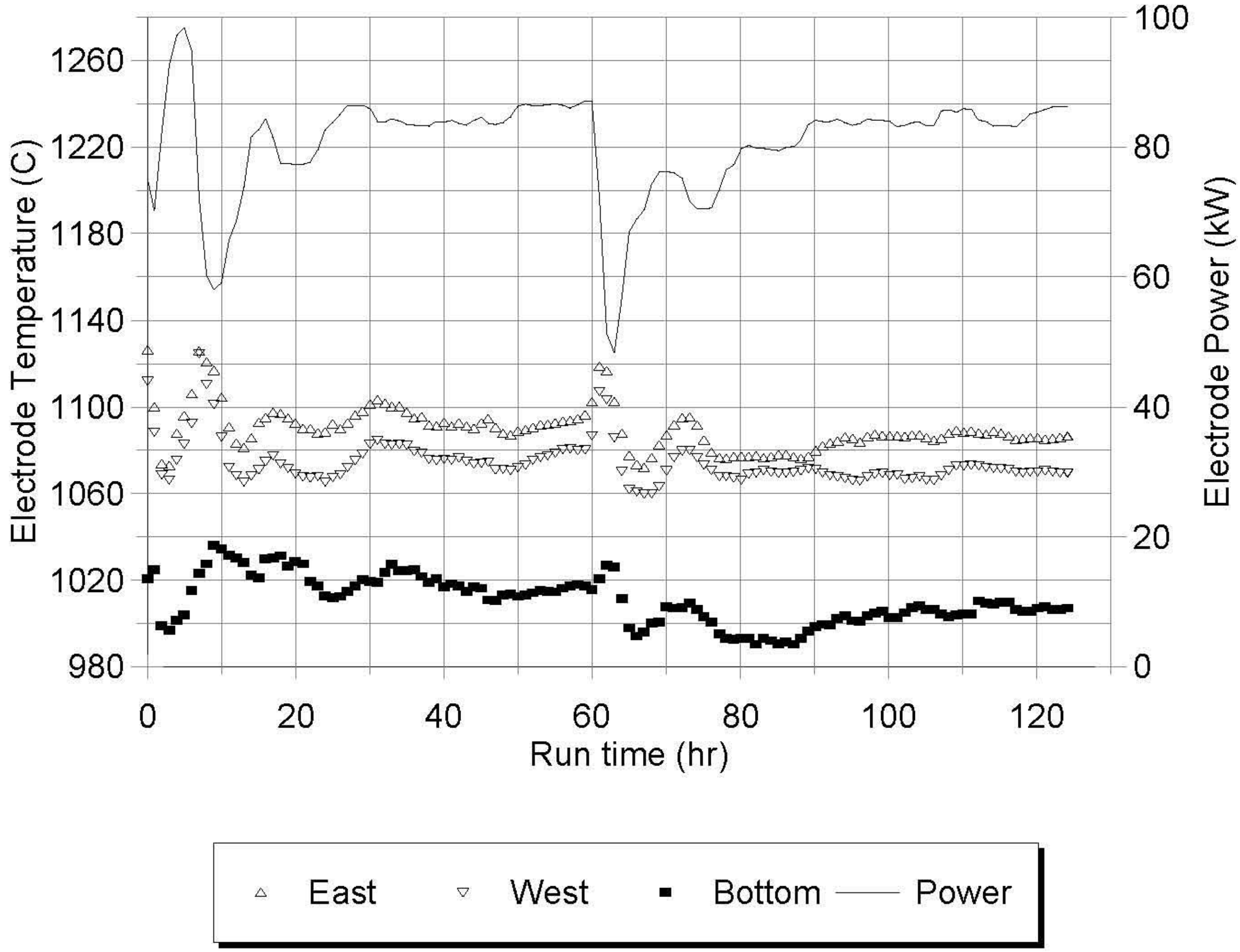

Figure 4.8.e. Electrode temperatures and power for Test 6 (400 g glass/l, 1 lpm bubbling).

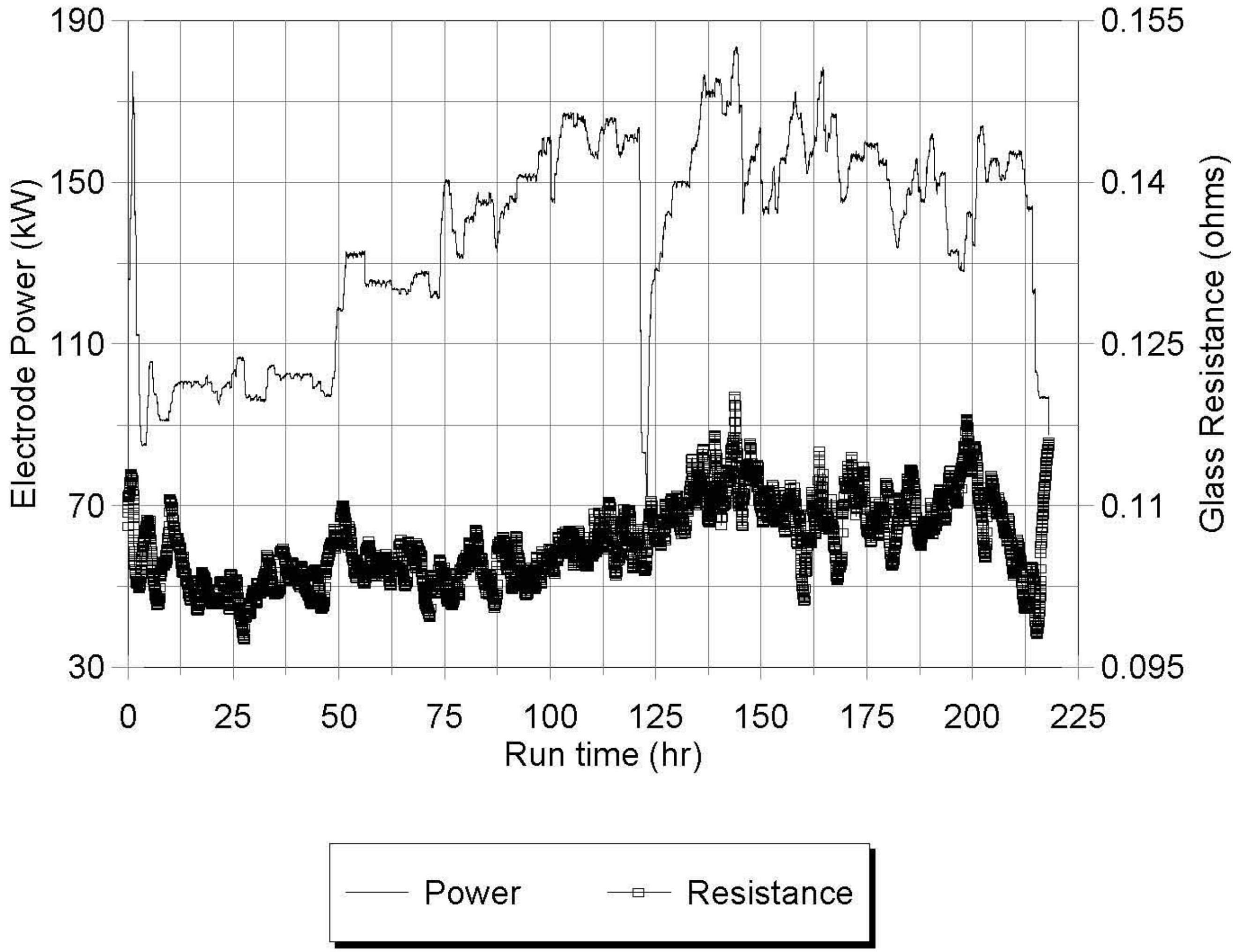

Figure 4.9.a. Electrode power and glass resistance for Test 1 (504 g glass/l) and Test 2 (281 g glass/l).

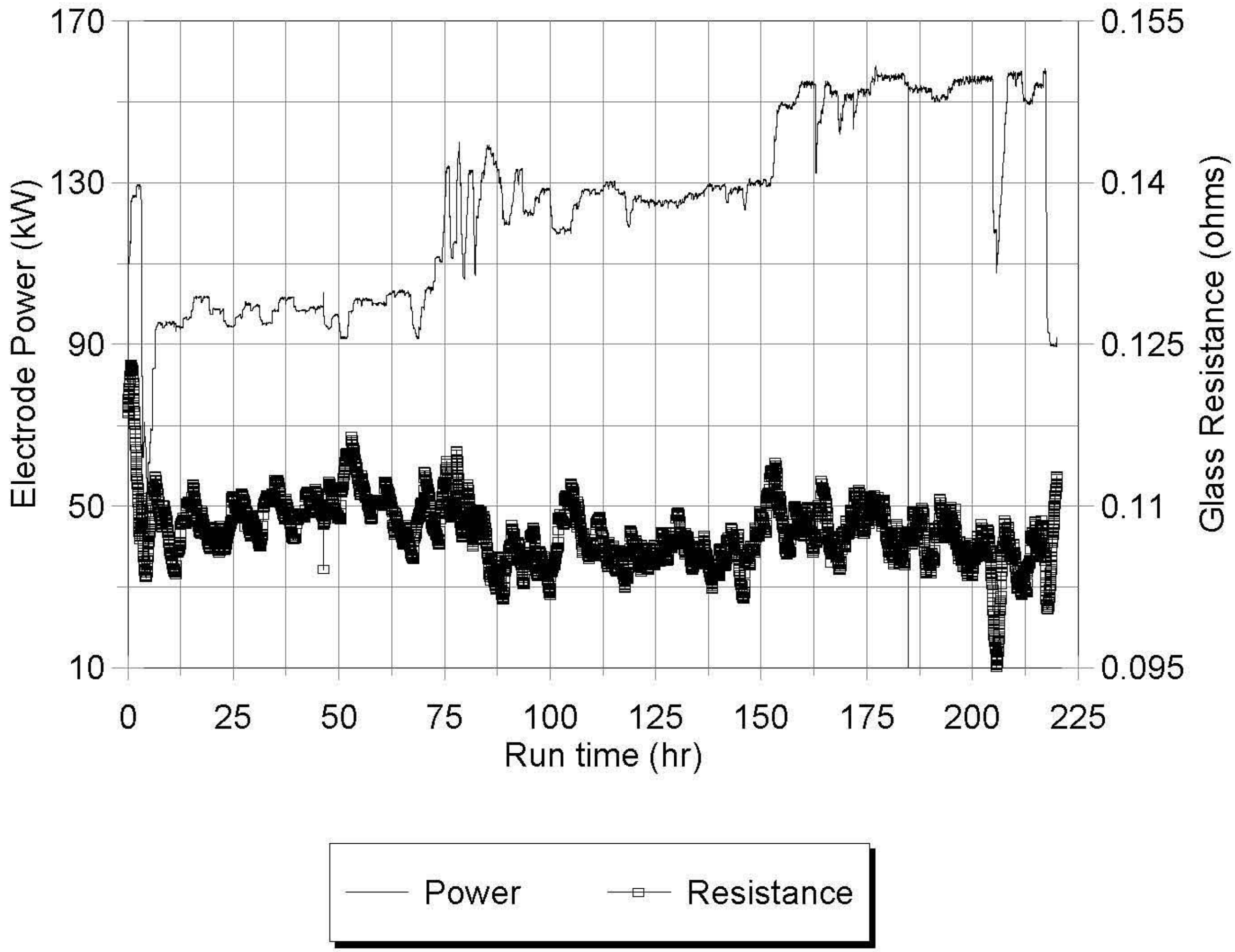

Figure 4.9.b. Electrode power and glass resistance for Test 3 (530 g glass/l).

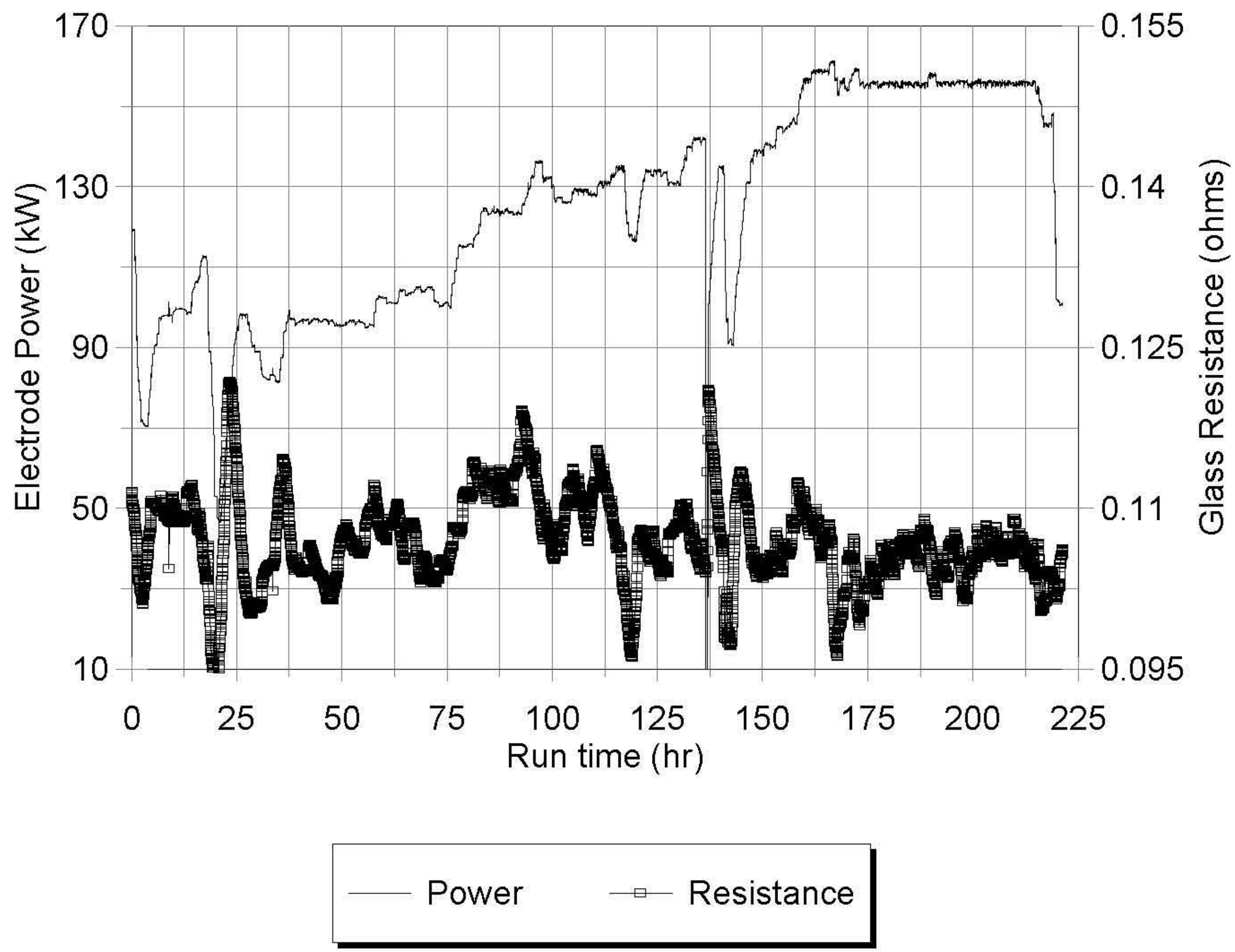

Figure 4.9.c. Electrode power and glass resistance for Test 4 (400 g glass/l).

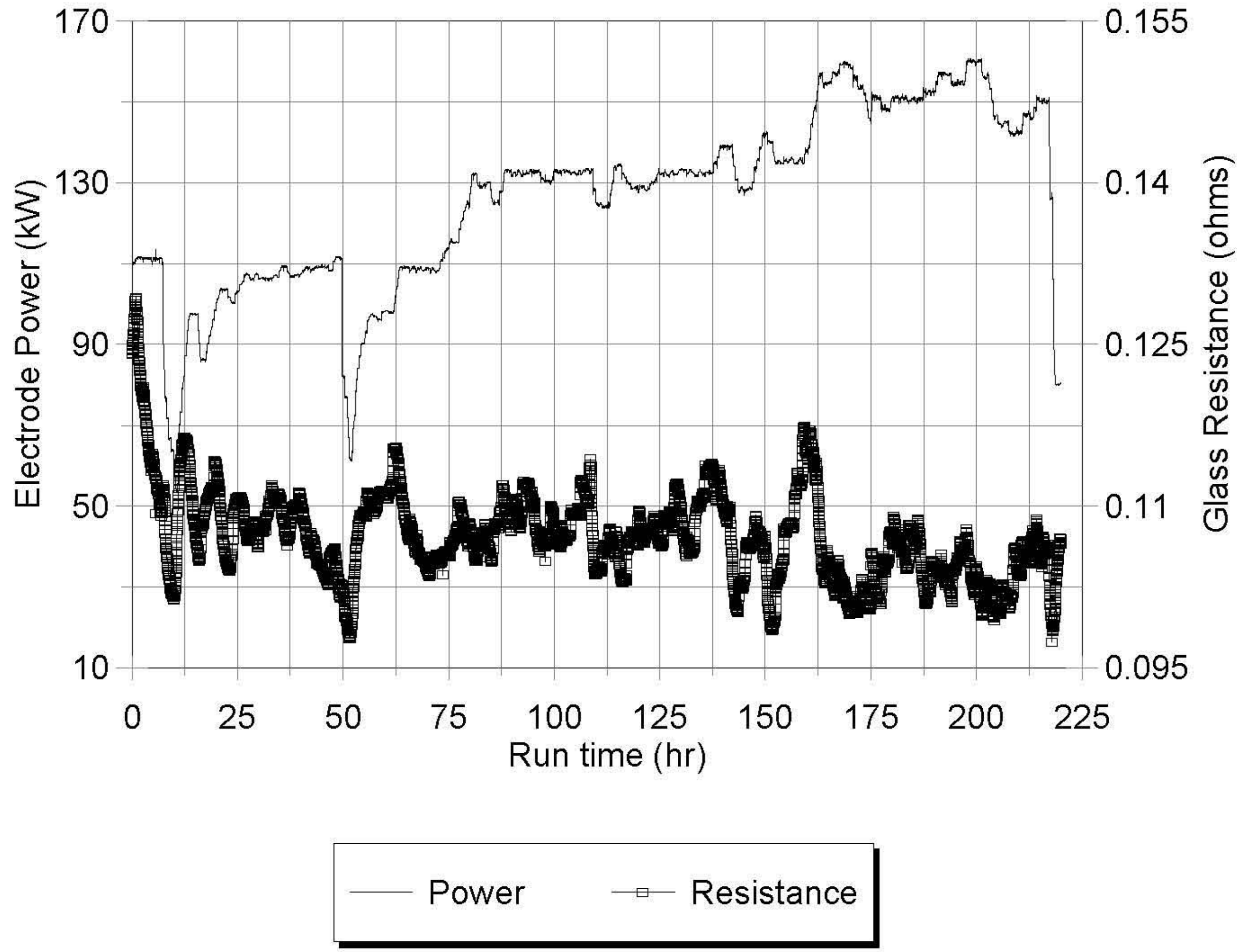

Figure 4.9.d. Electrode power and glass resistance for Test 5 (300 g glass/l).

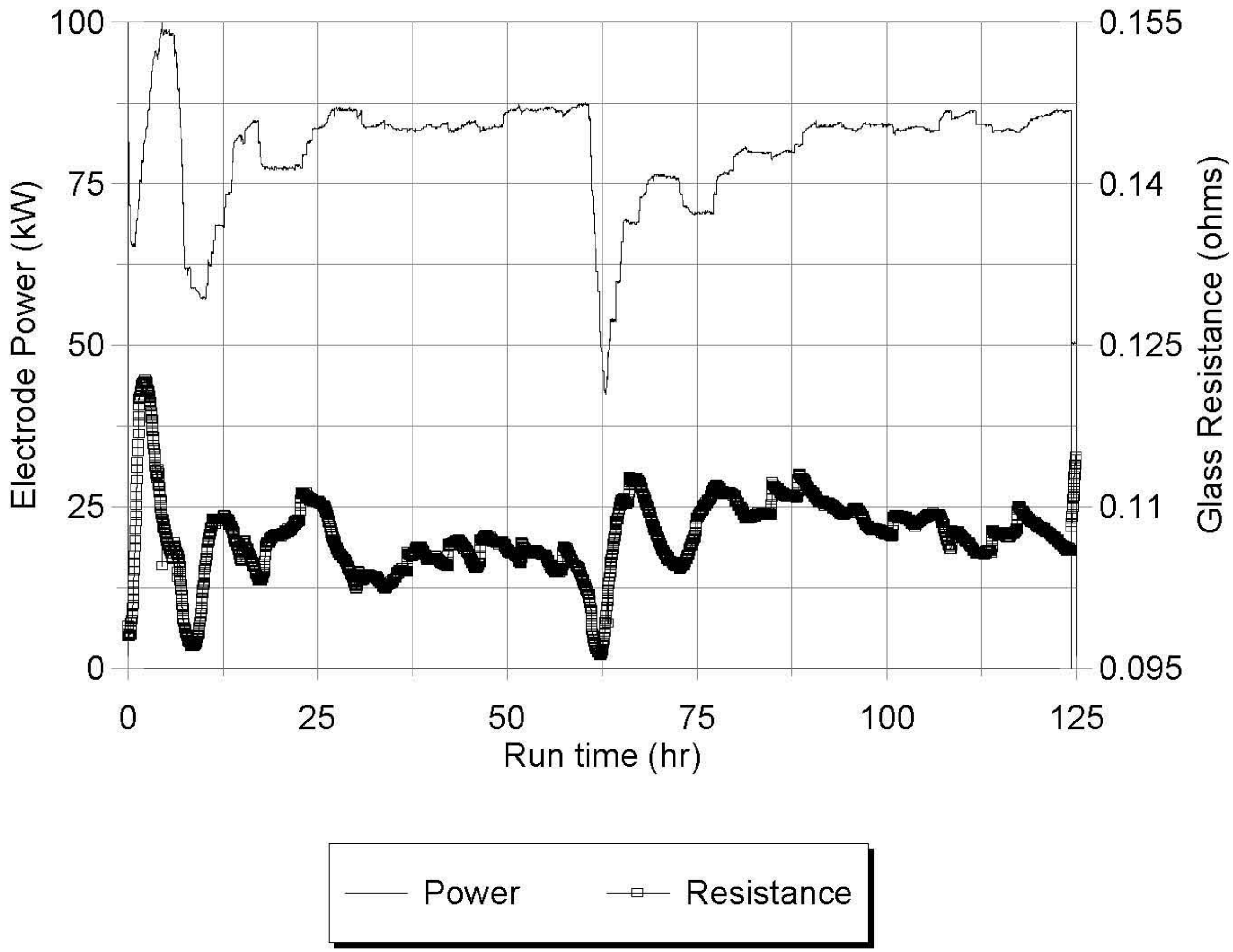

Figure 4.9.e. Electrode power and glass resistance for Test 6 (400 g glass/l and bubbling and < 1 lpm).

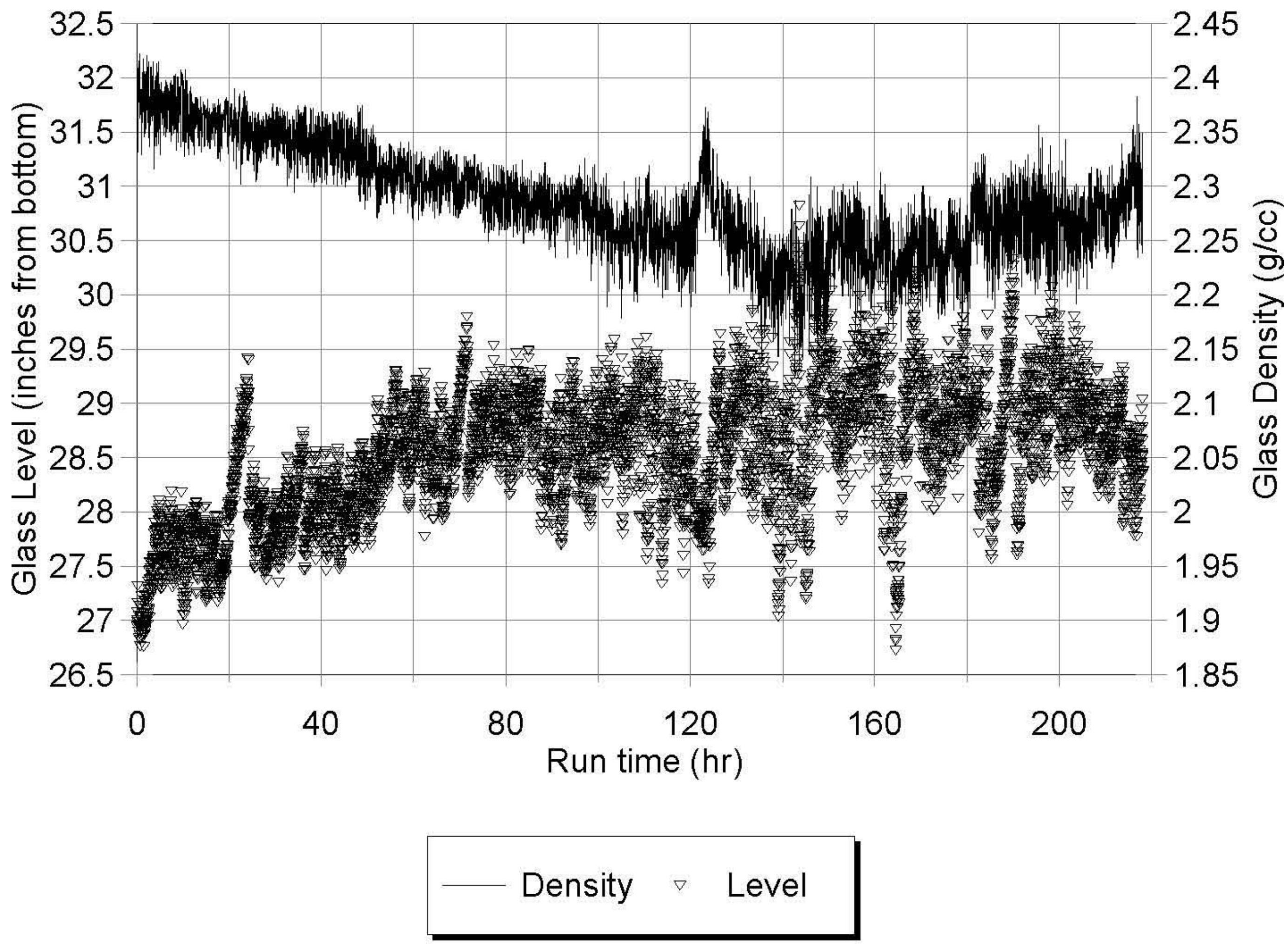

Figure 4.10.a. Glass density and level for Test 1 (504 g glass/l) and Test 2 (281 g glass/l).

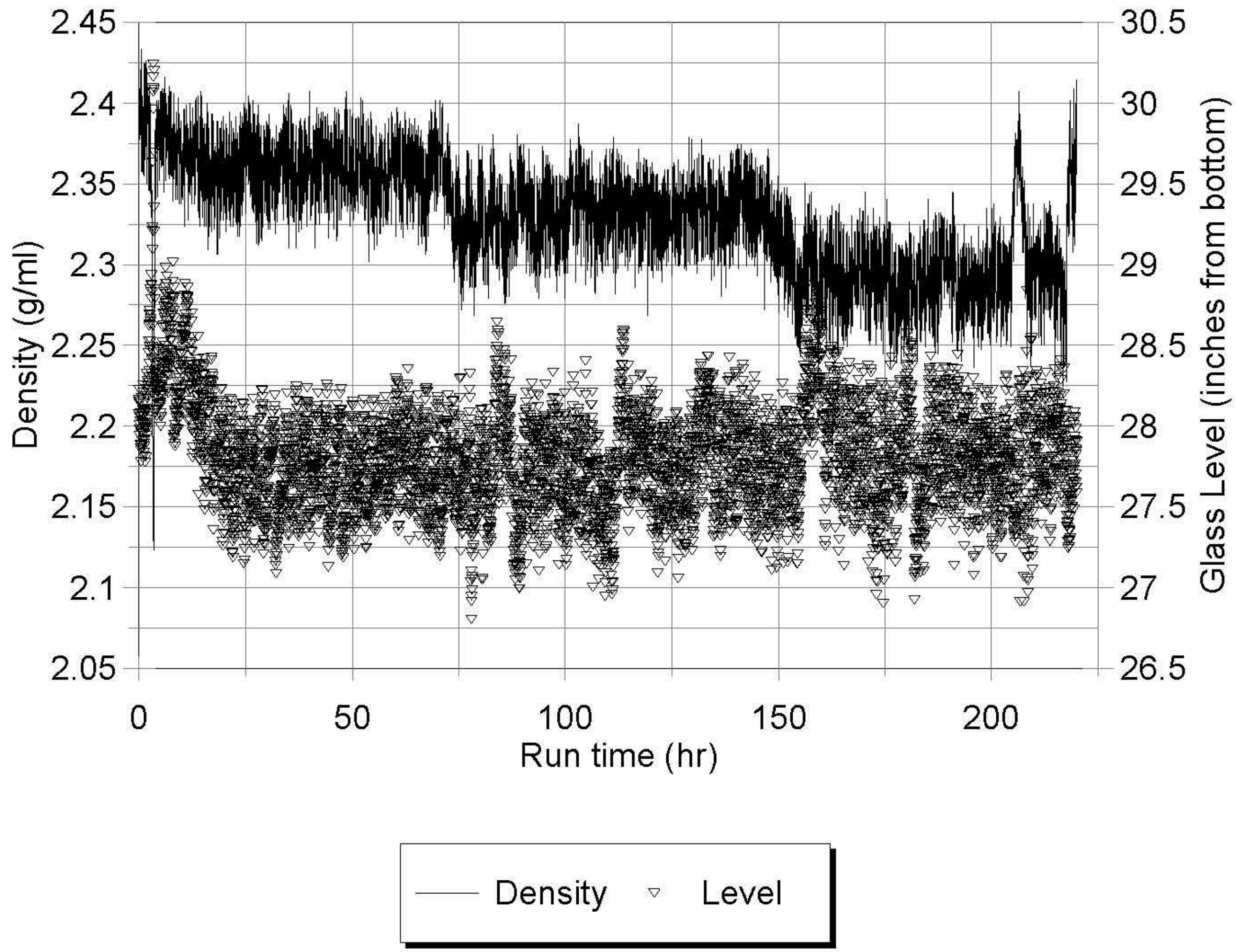

Figure 4.10.b. Glass density and level for Test 3 (530 g glass/l).

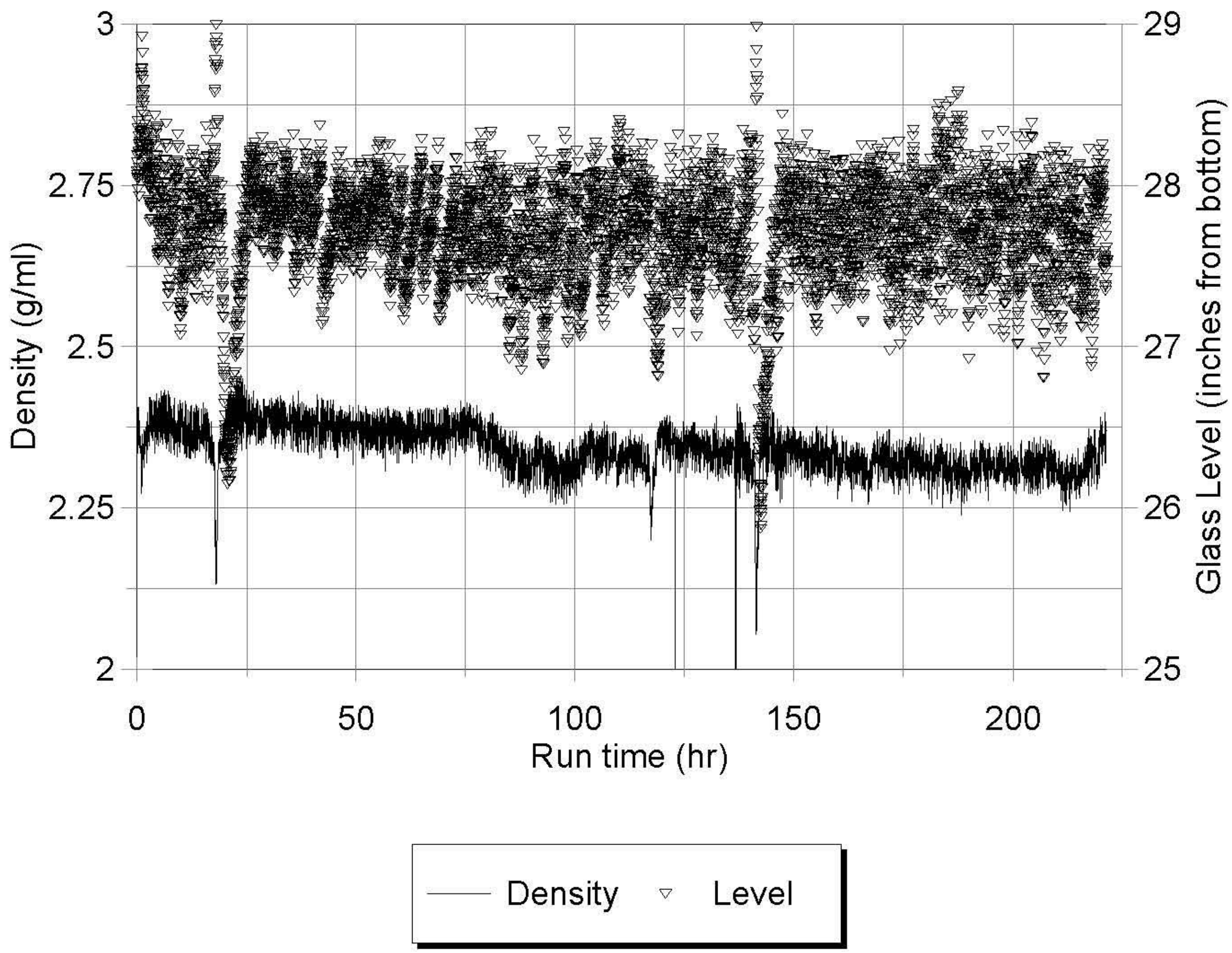

Figure 4.10.c. Glass density and level for Test 4 (400 g glass/l).

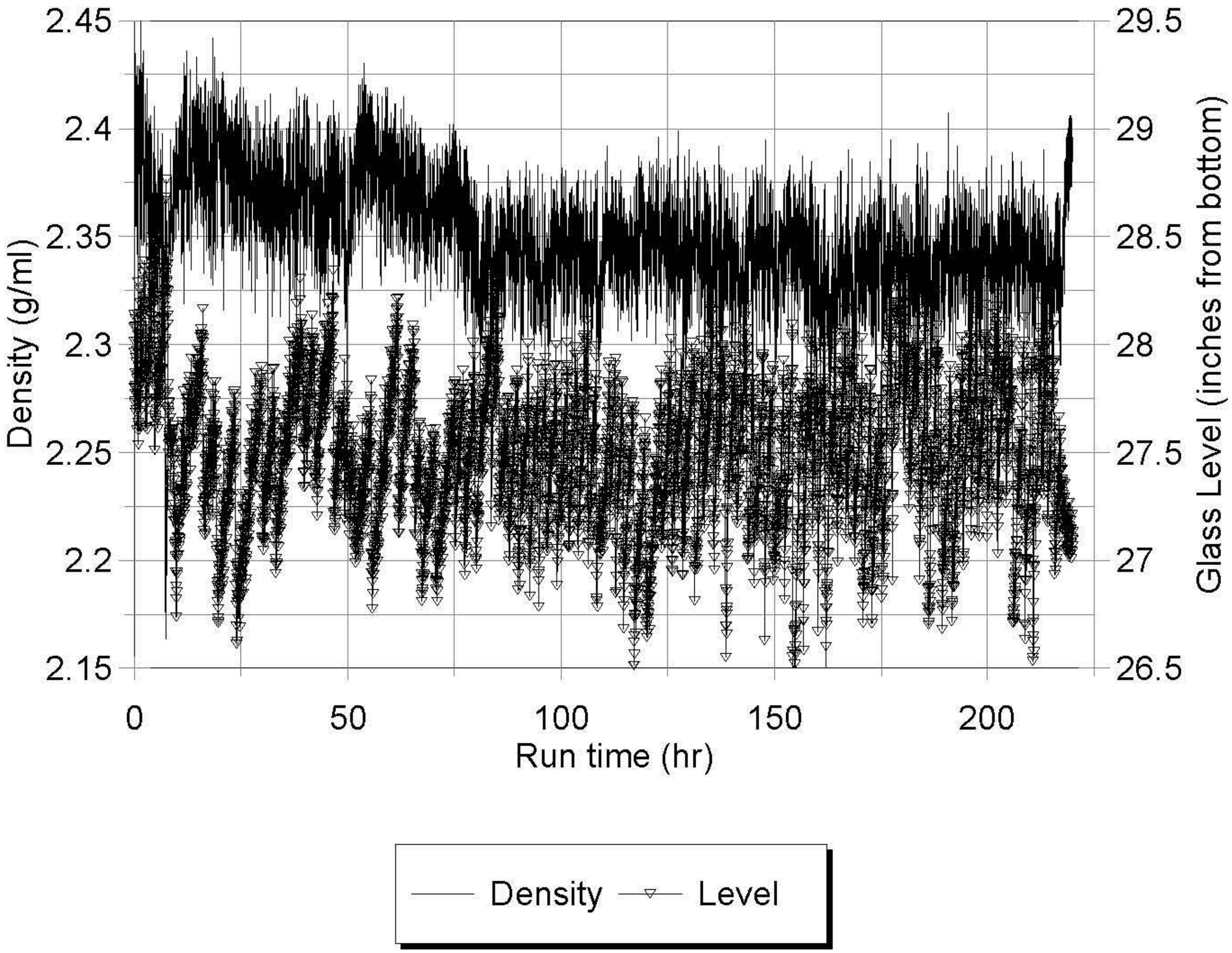

Figure 4.10.d. Glass density and level for Test 5 (300 g glass/l).

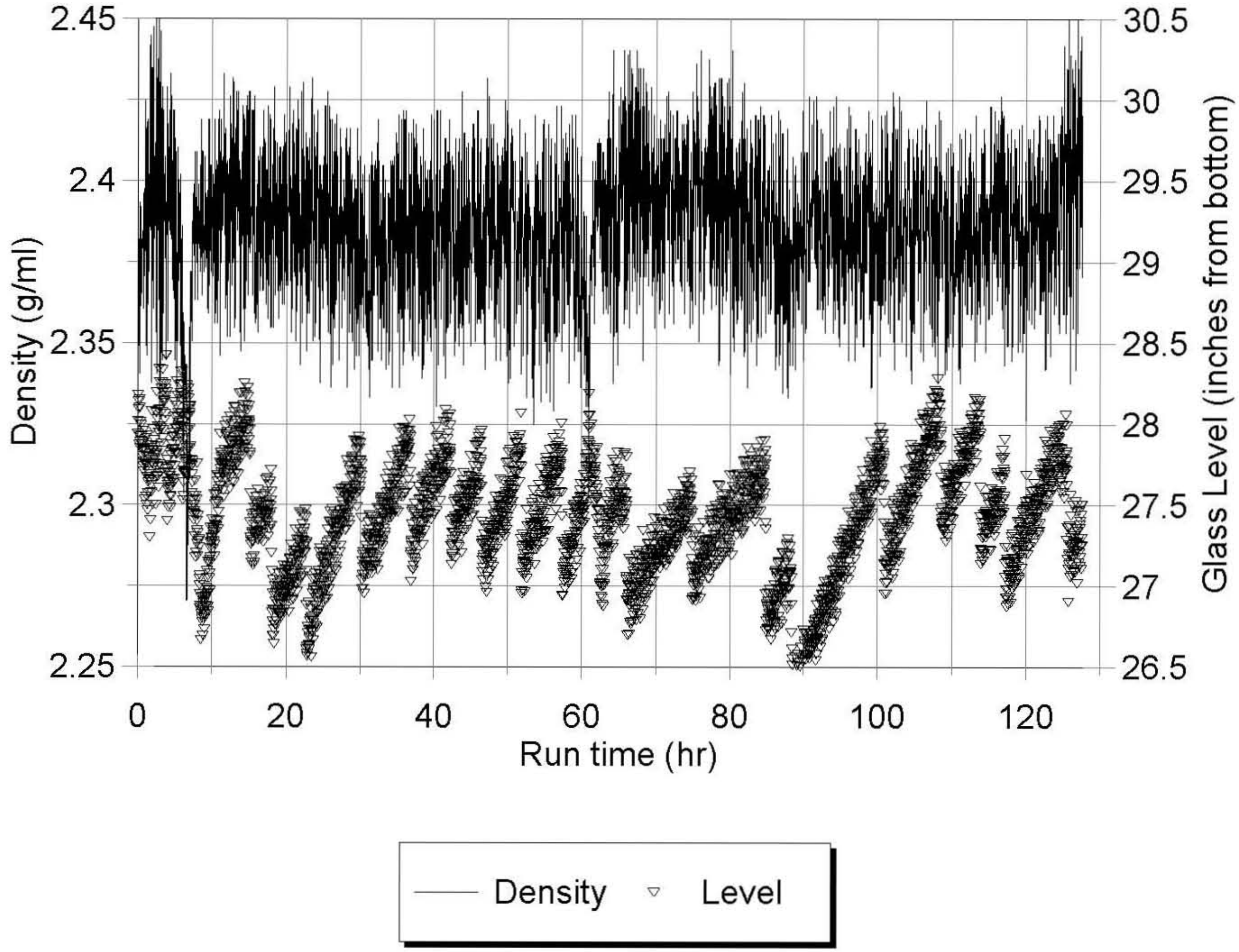

Figure 4.10.e. Glass density and level for Test 6 (400 g glass/l 1 lpm bubbling).

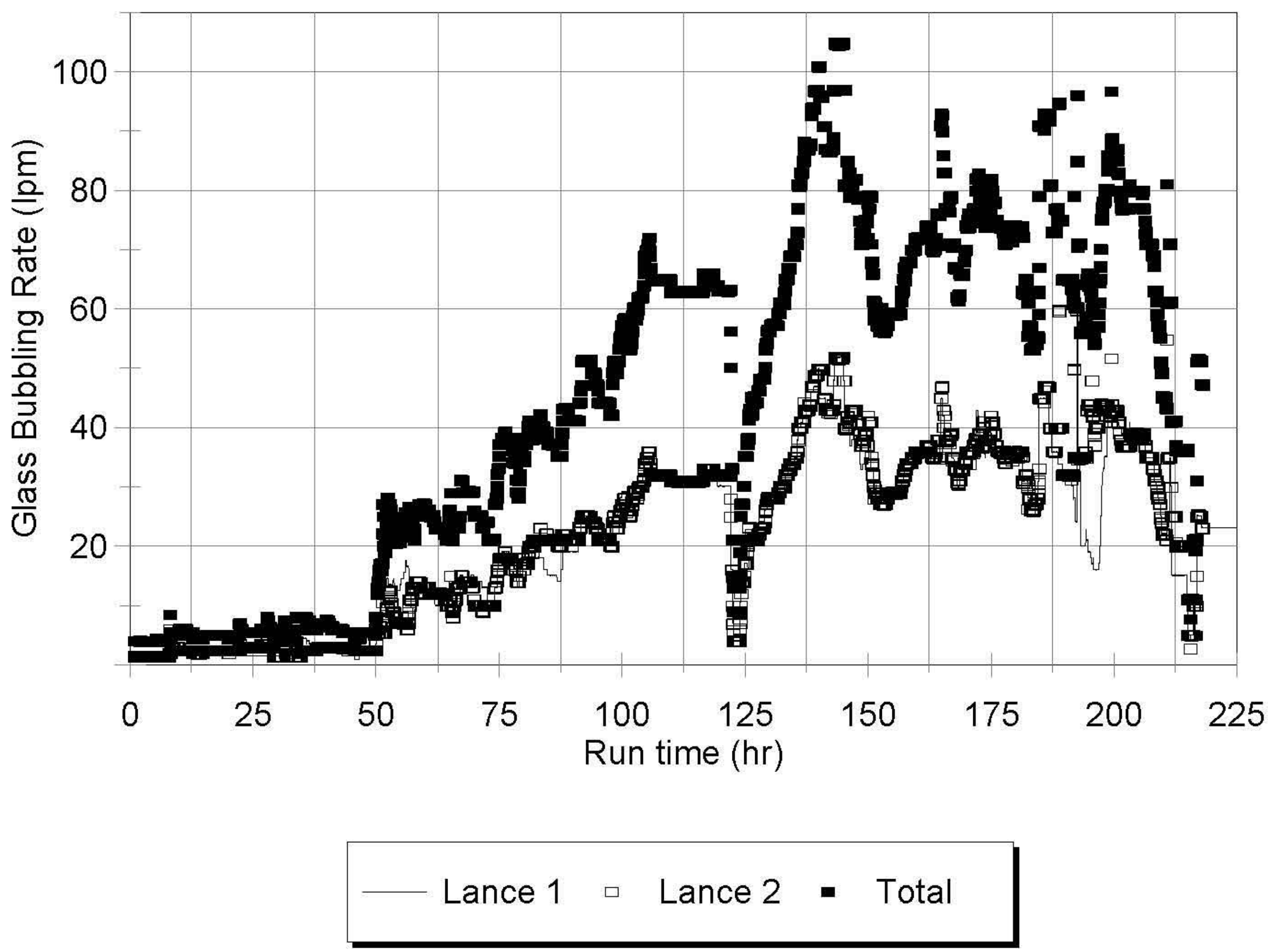

Figure 4.11.a. Glass pool bubbling for Test 1 (504 g glass/l) and Test 2 (281 g glass/l).

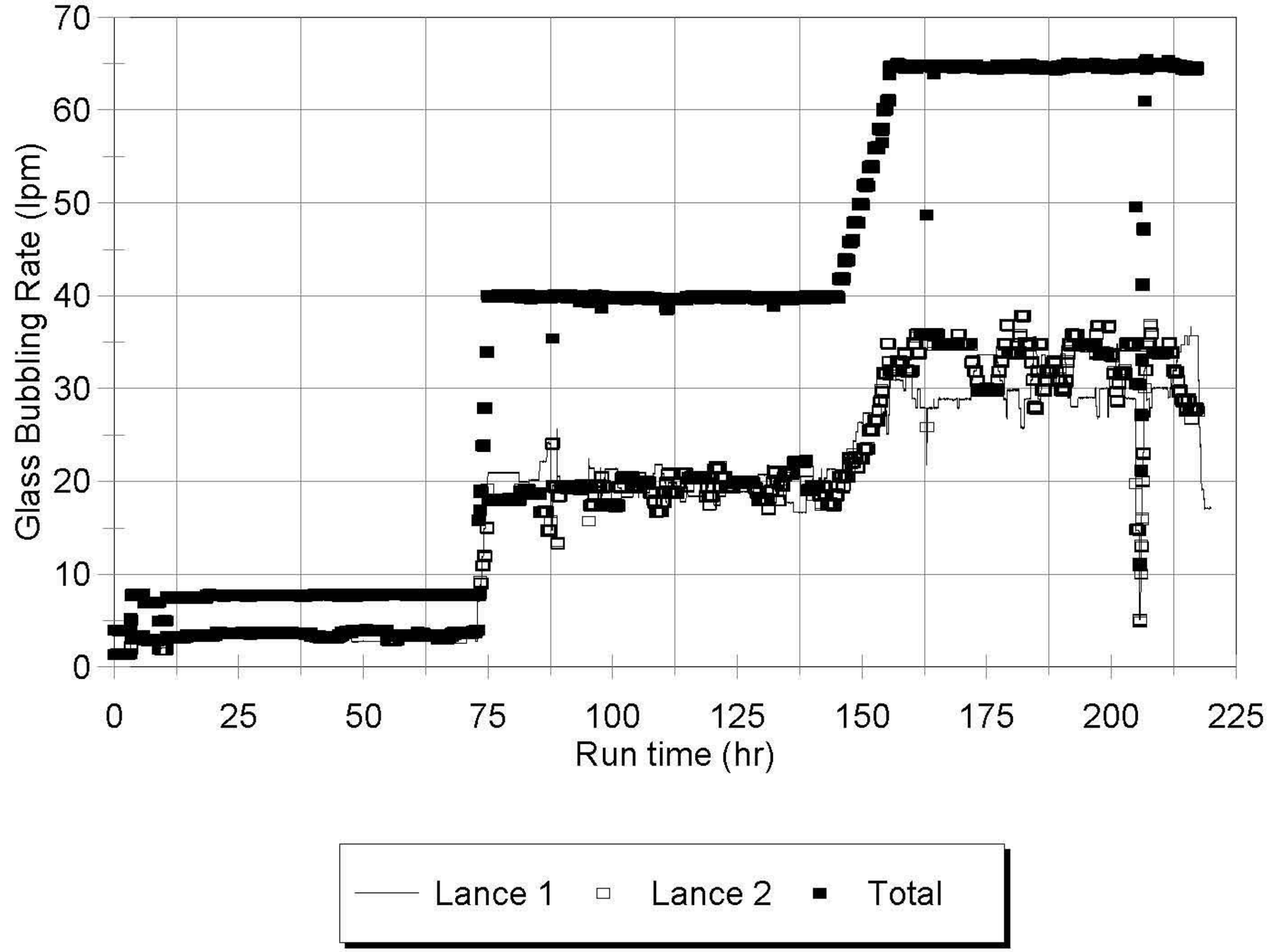

Figure 4.11.b. Glass pool bubbling for Test 3 (530 g glass/l)

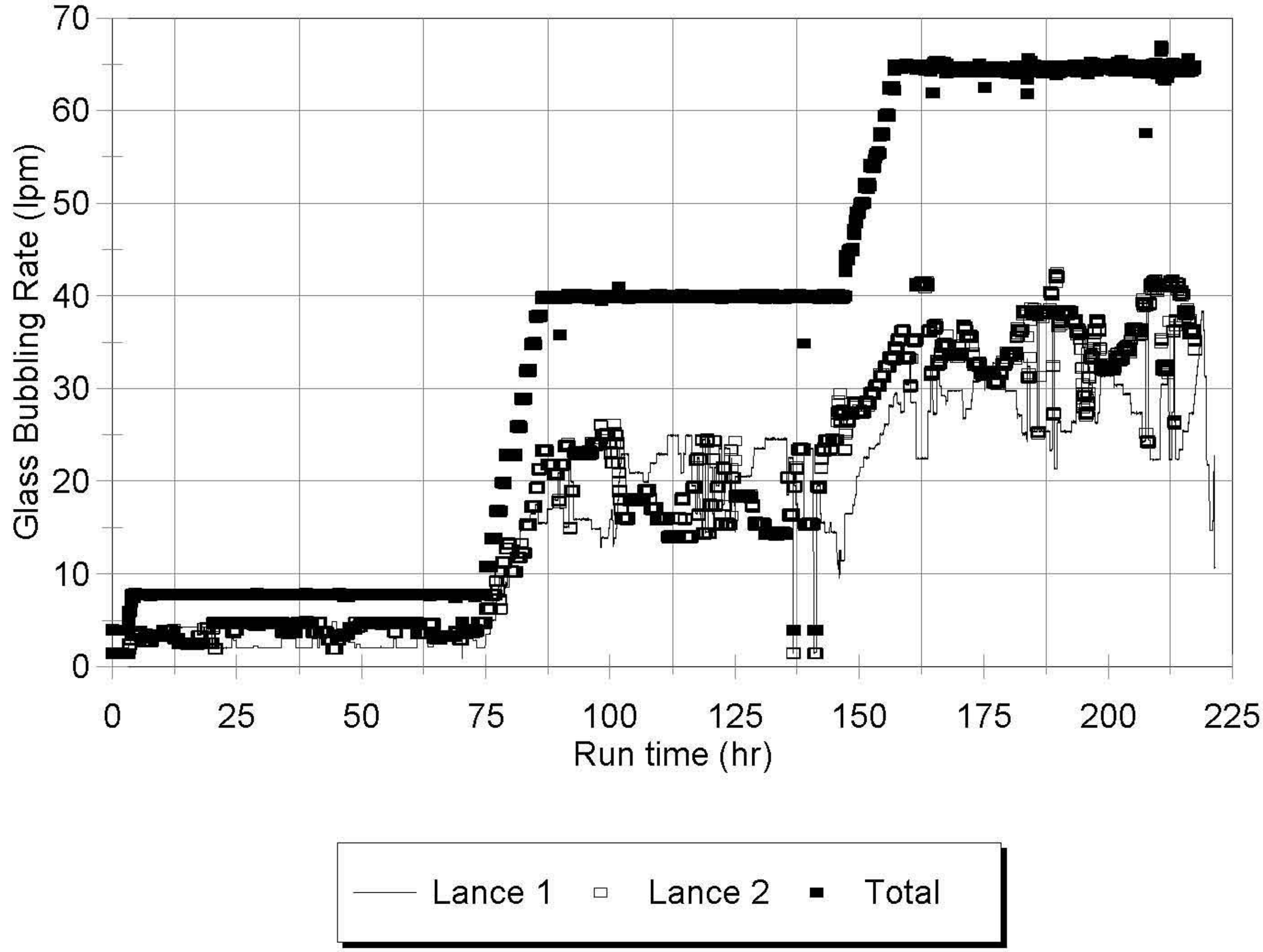

Figure 4.11.c. Glass pool bubbling for Test 4 (400 g glass/l).

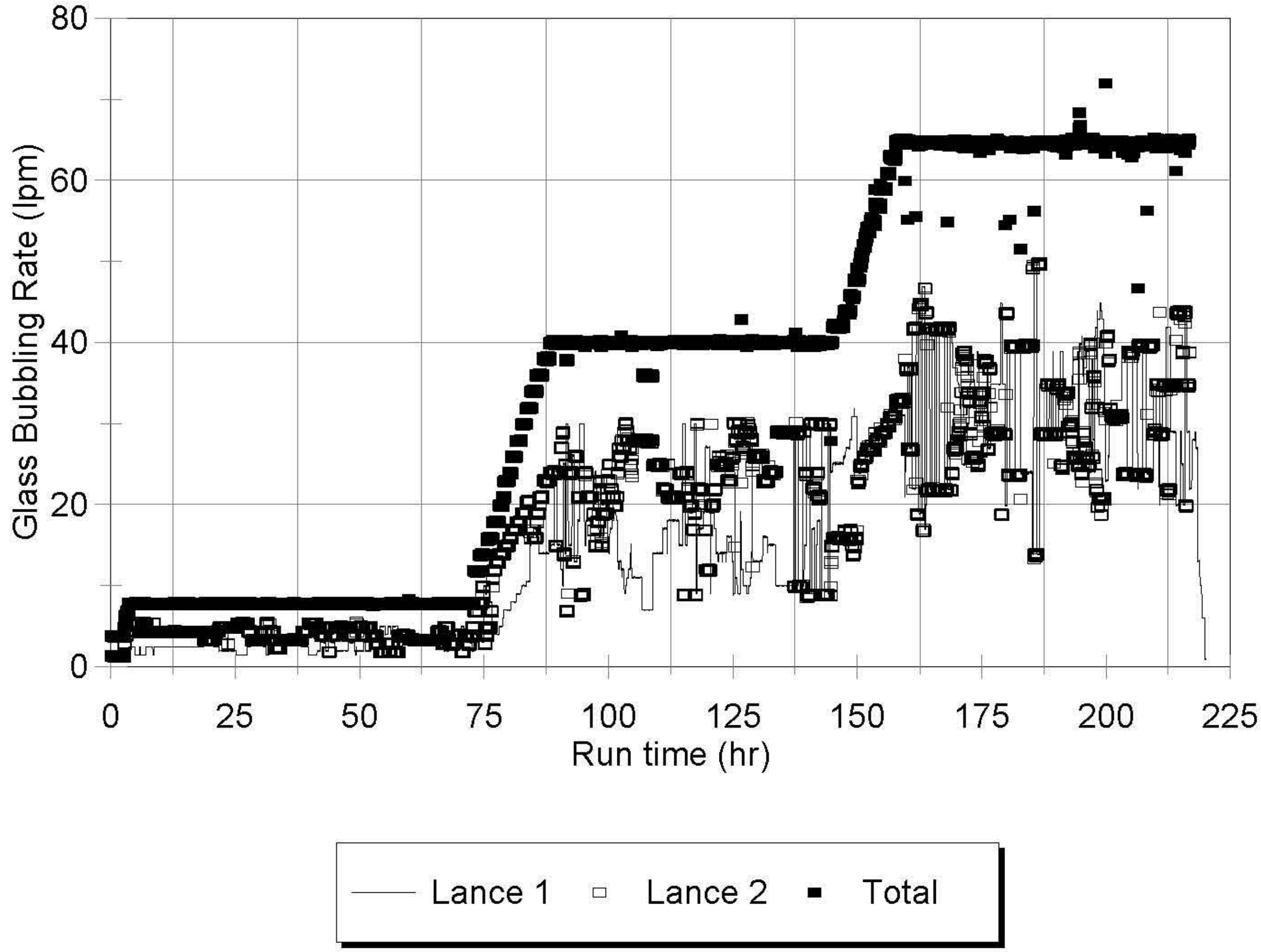

Figure 4.11.d. Glass pool bubbling for Test 5 (300 g glass/l).

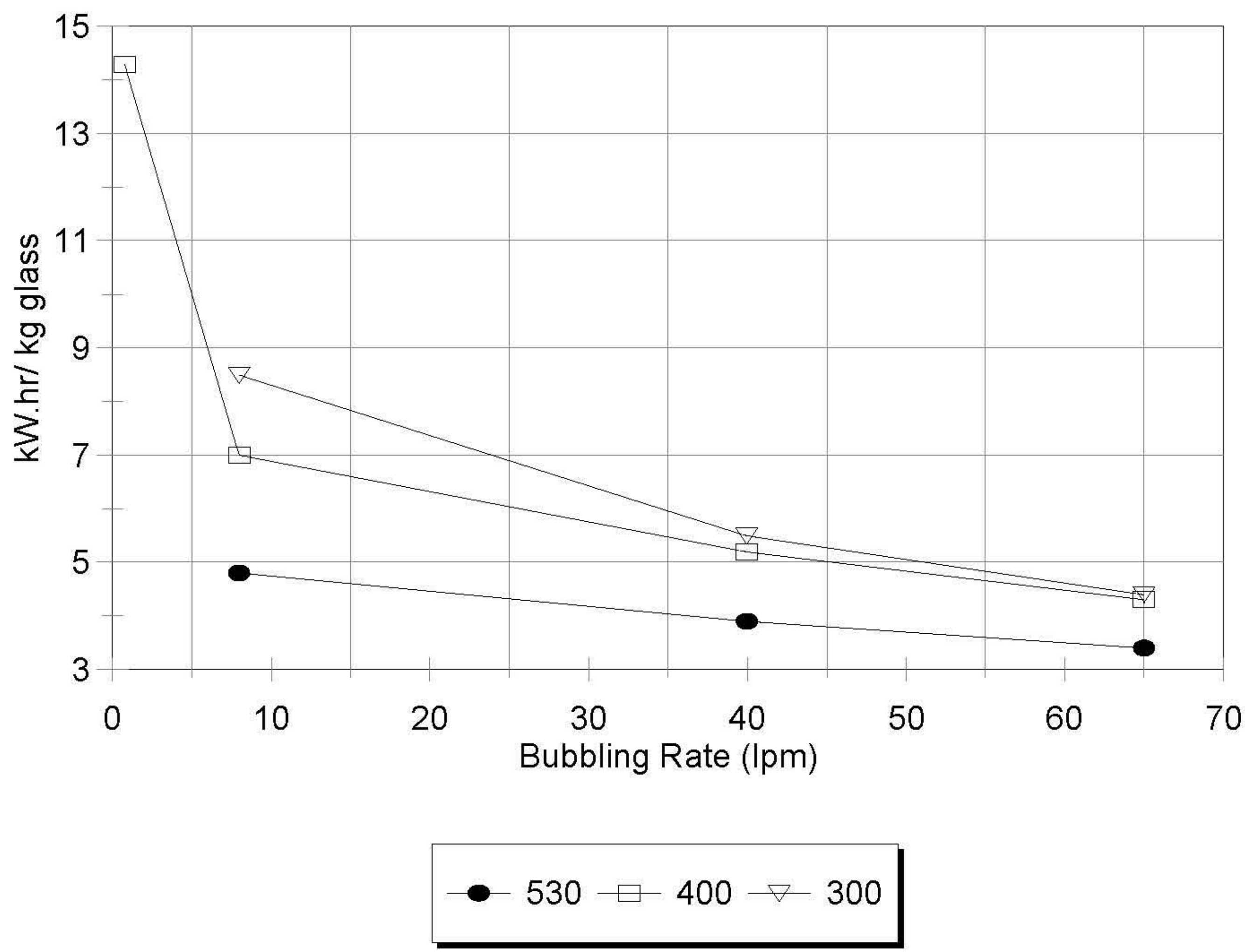

Figure 4.12. Power usage as a function of bubbling and feed solids content (g/l).

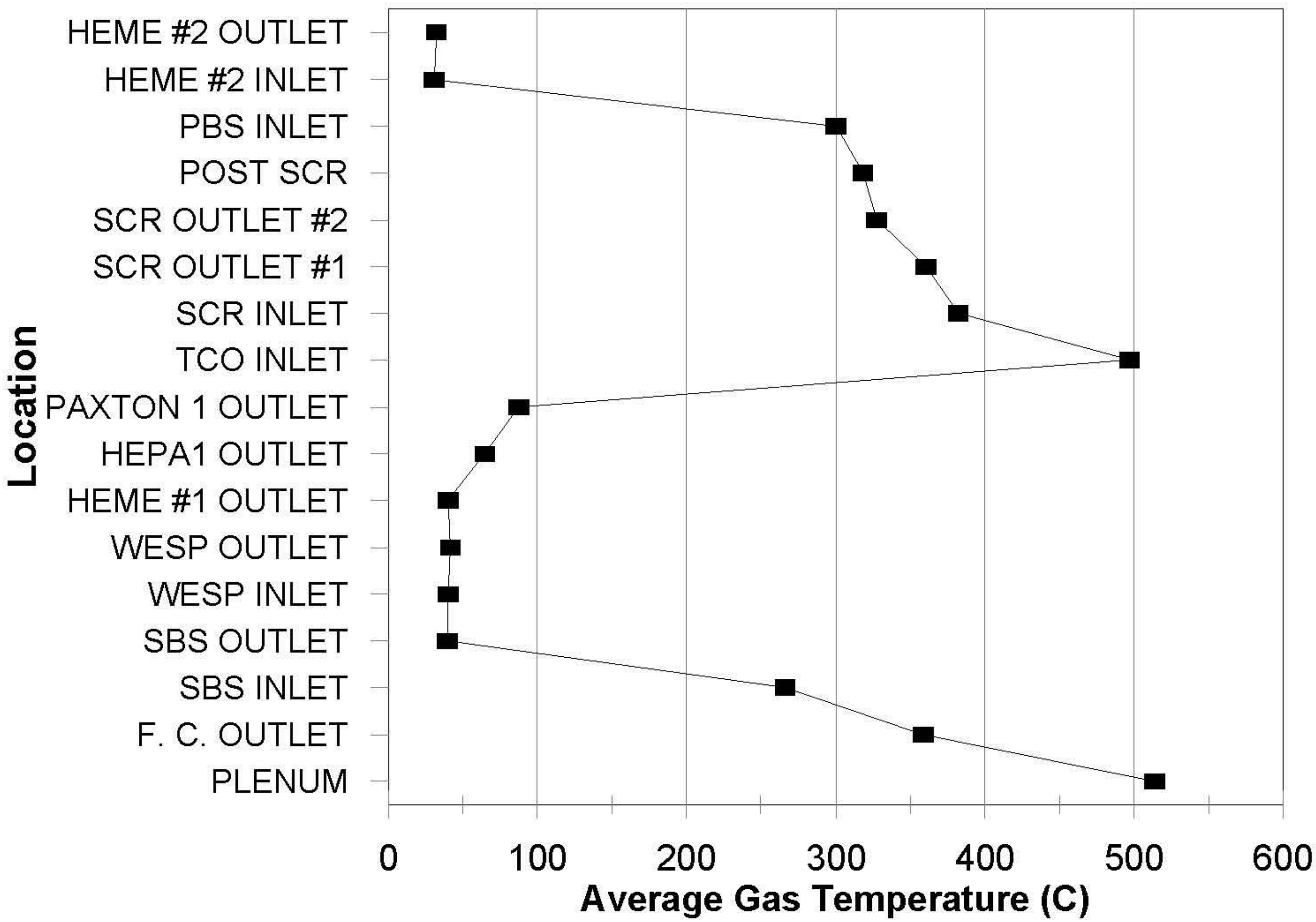

Figure 5.1. Average gas temperatures along the DM1200 off-gas train during Tests 1 and 2.

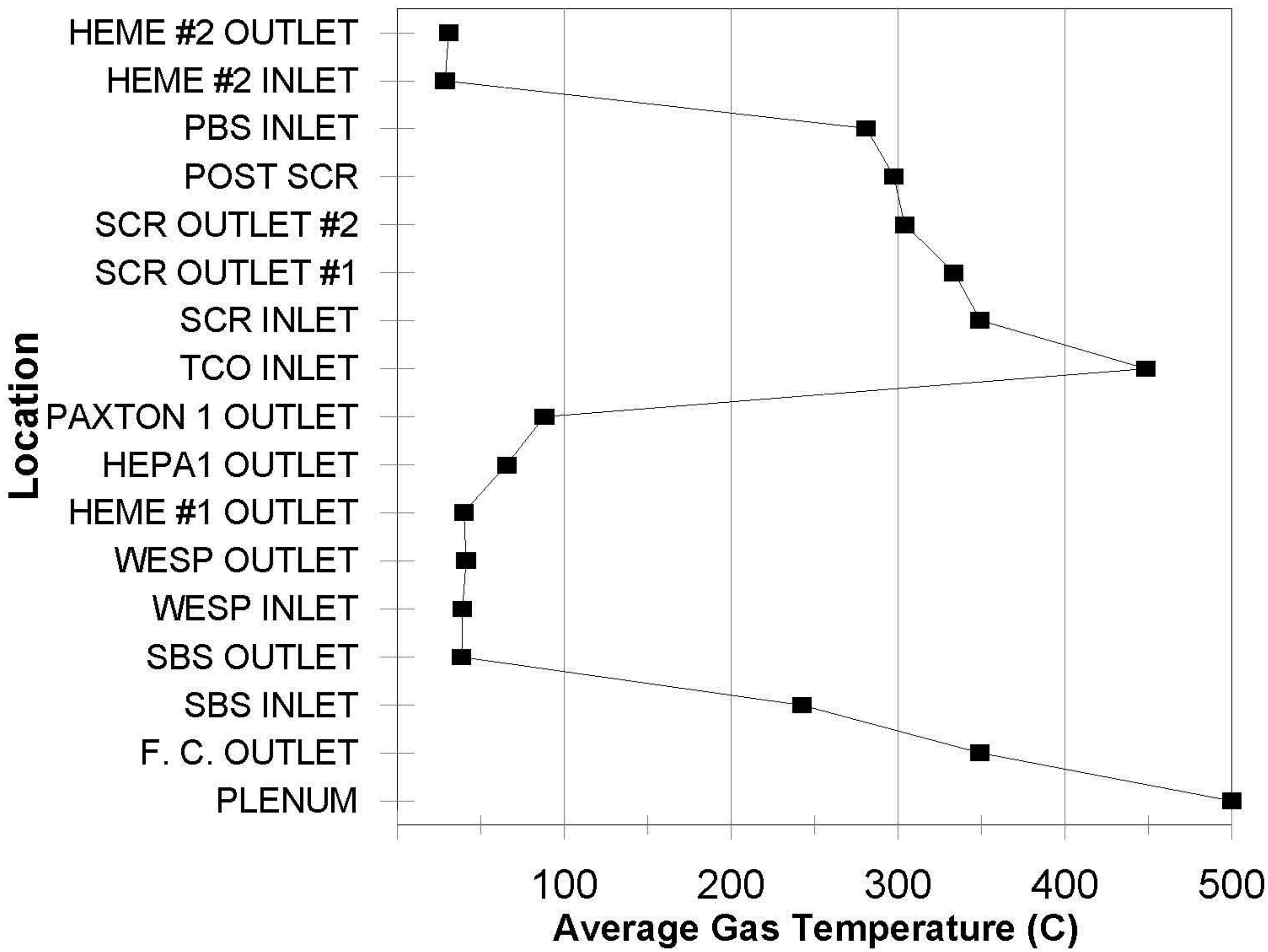

Figure 5.2. Average gas temperatures along the DM1200 off-gas train during Test 3.

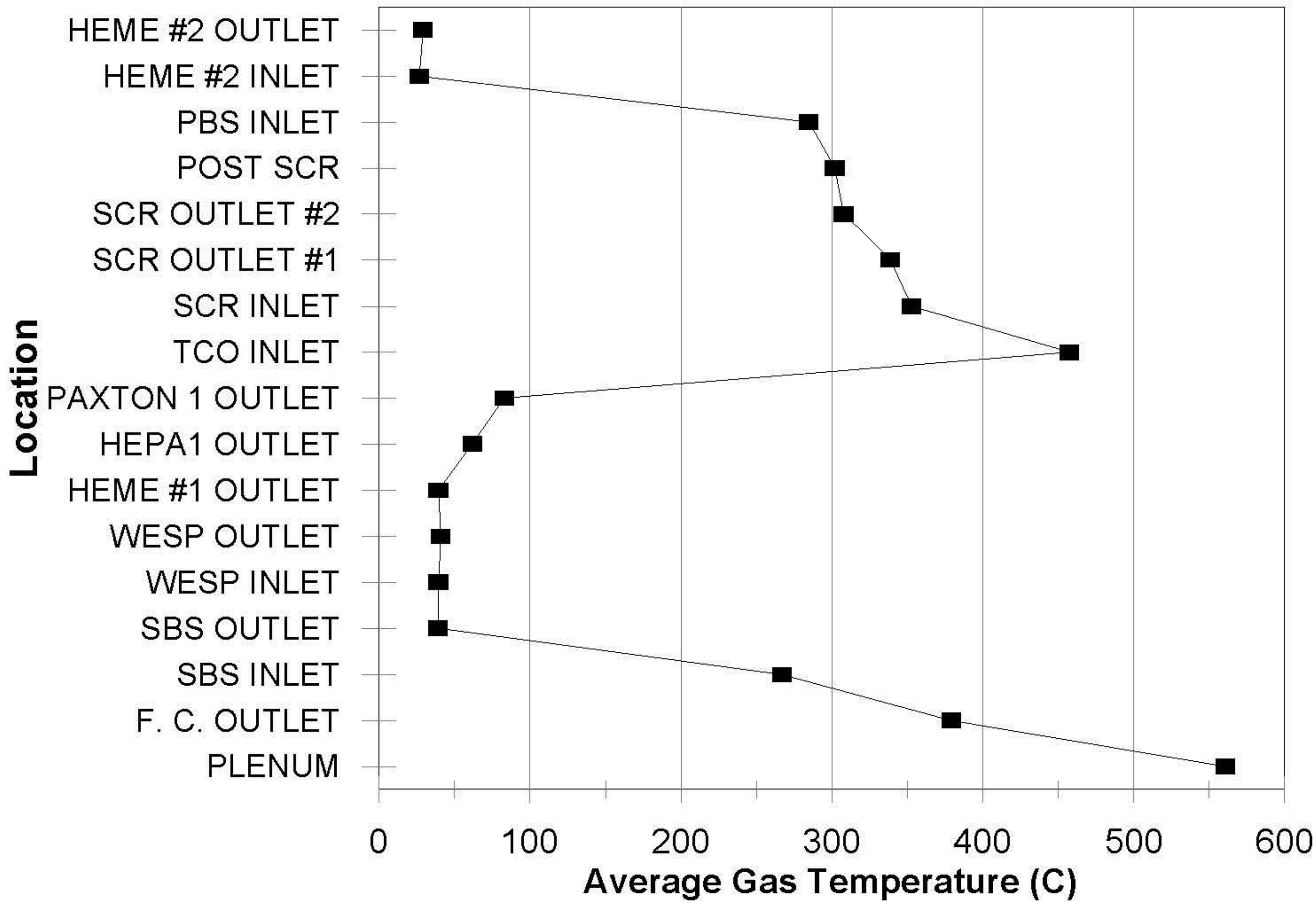

Figure 5.3. Average gas temperatures along the DM1200 off-gas train during Test 4.

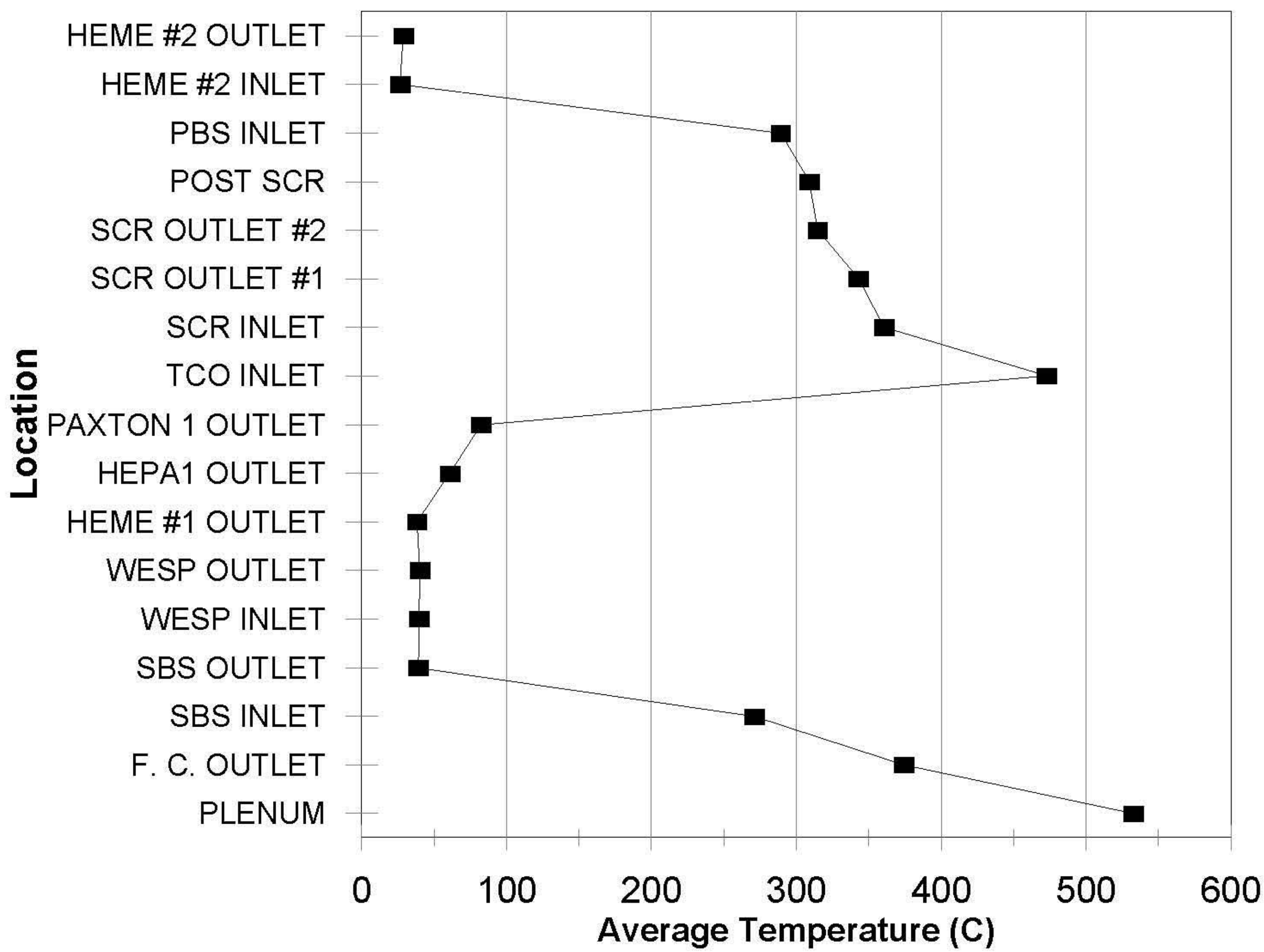

Figure 5.4. Average gas temperatures along the DM1200 off-gas train during Test 5.

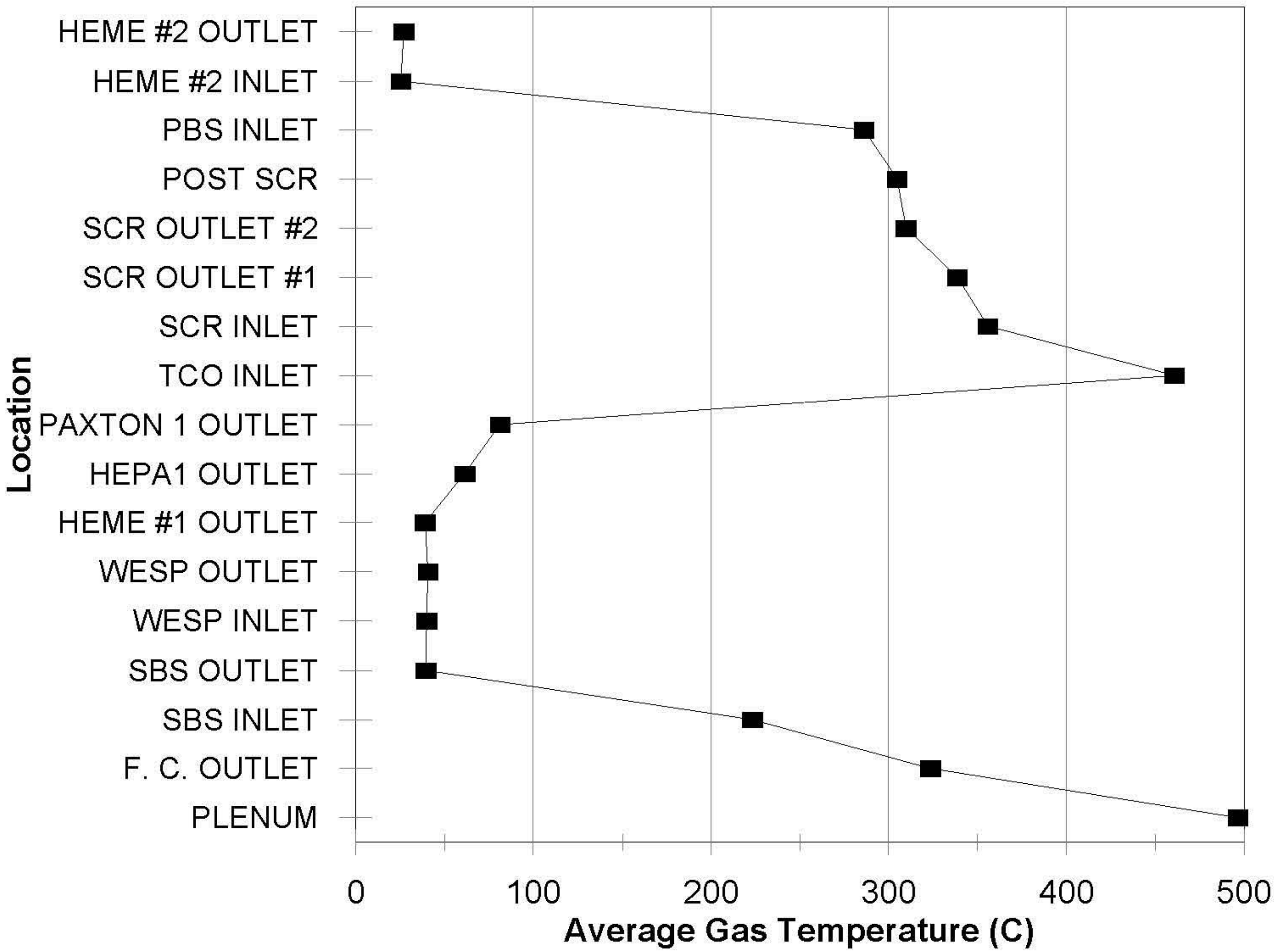

Figure 5.5. Average gas temperatures along the DM1200 off-gas train during Test 6.

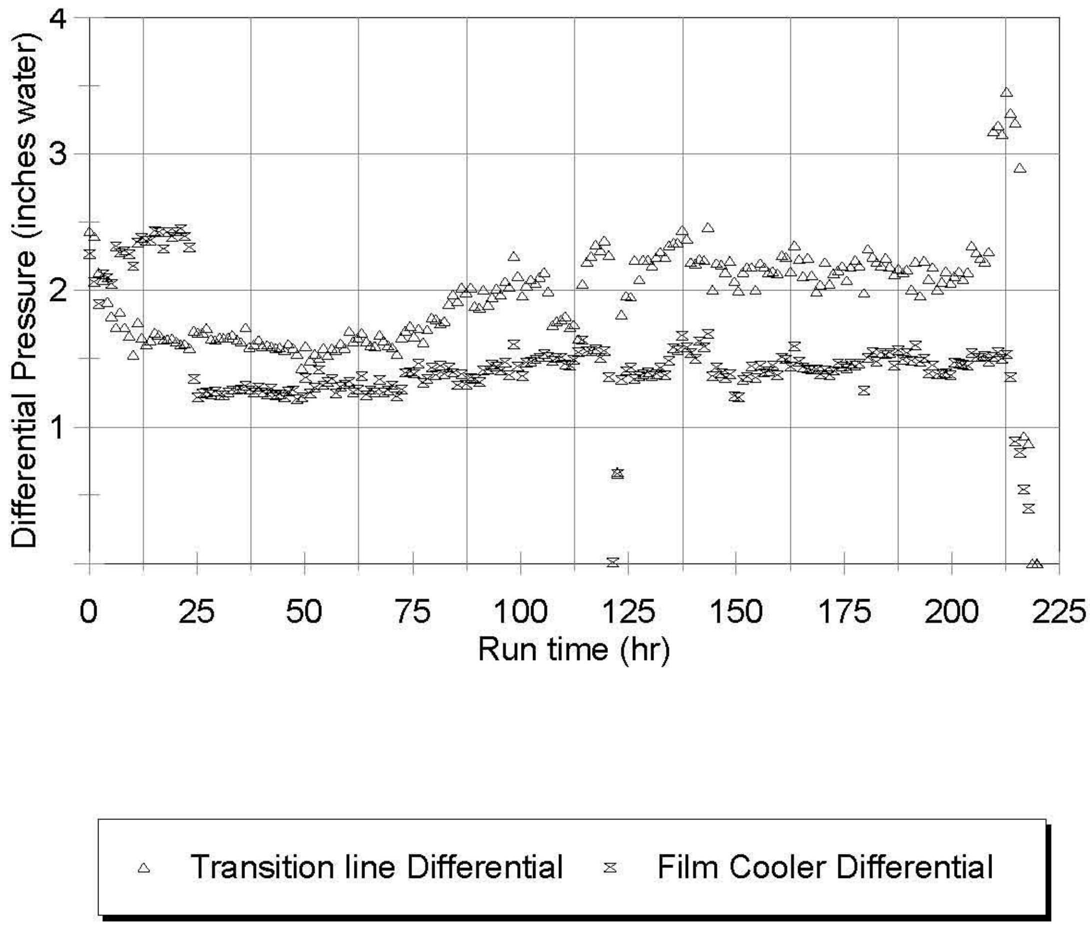

Figure 5.6.Transition line and film cooler differential pressures (hourly average values) during Test 1 and Test 2.

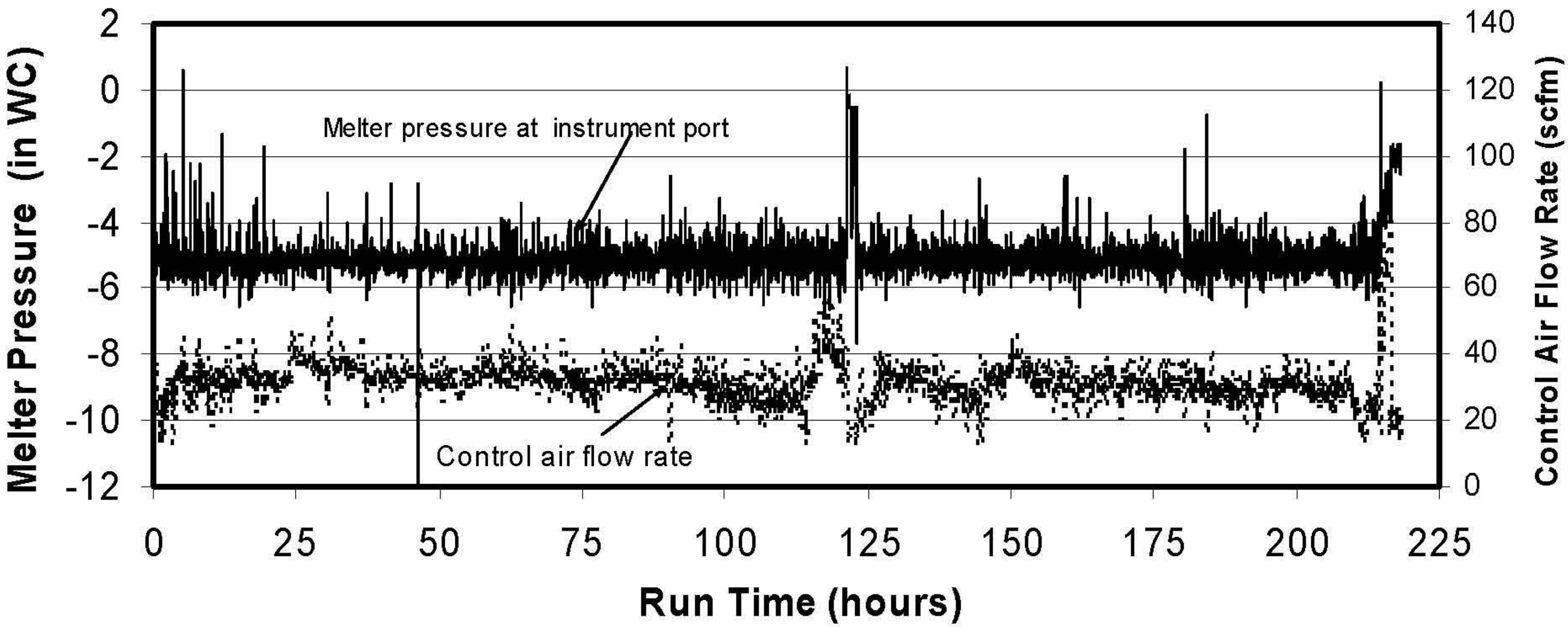

Figure 5.7. Melter pressure at instrument port and control air flow rate during Test 1 and Test 2. (Note: Test interruption occurred between 121.2 and 122.9 hours.)

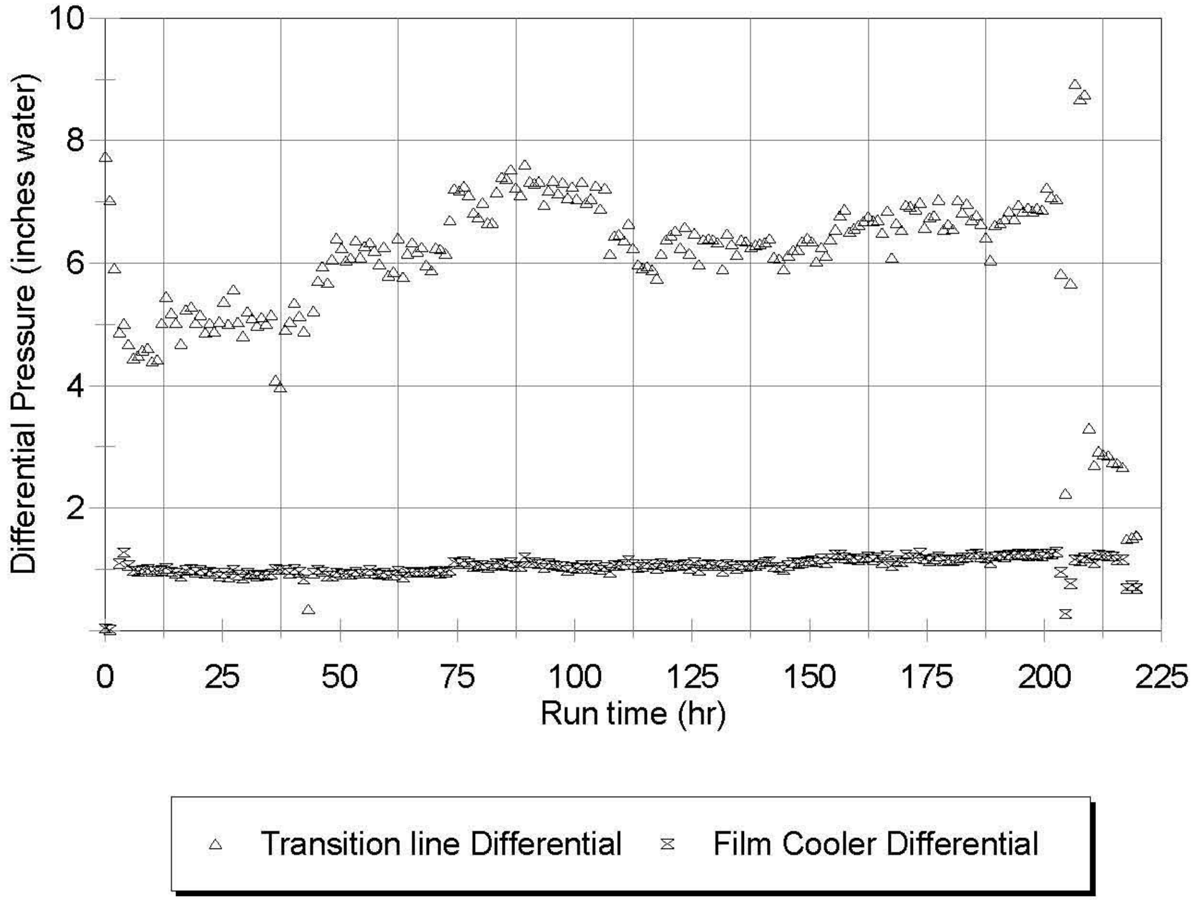

Figure 5.8. Transition line and film cooler differential pressures (hourly average values) during Test 3.

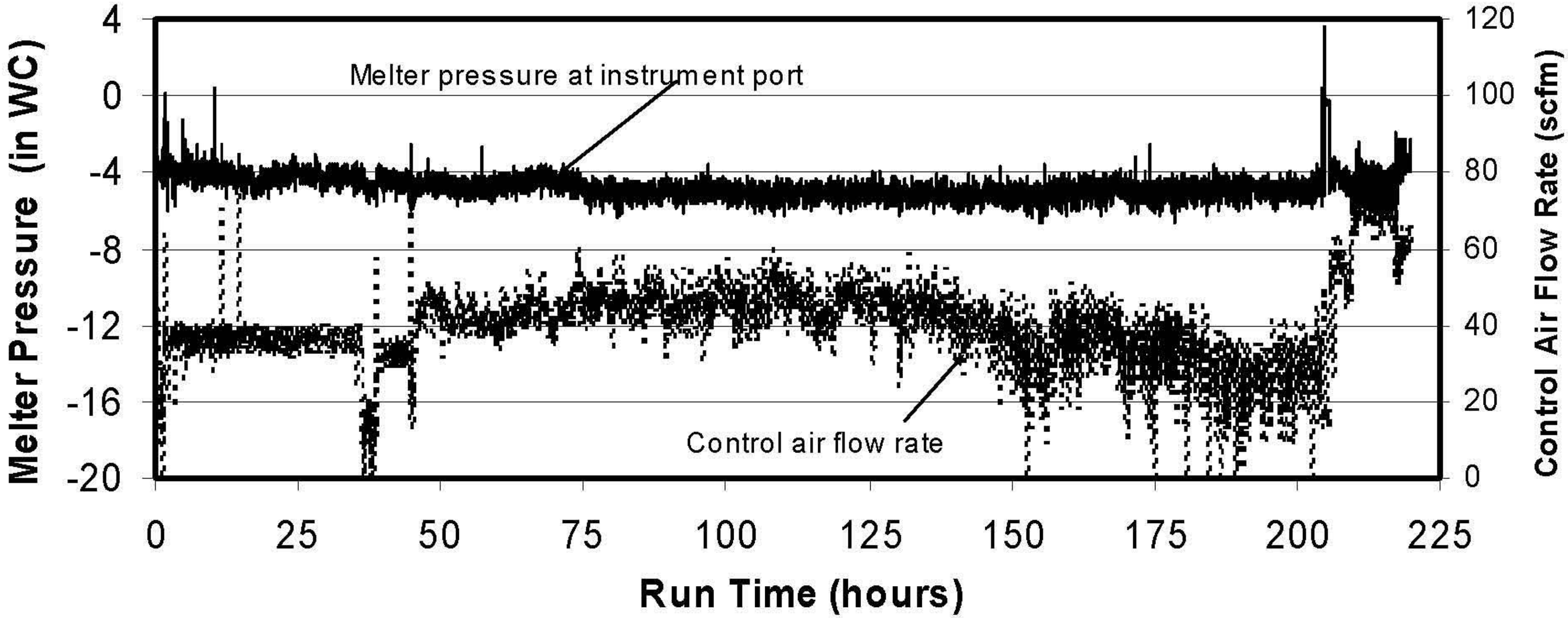

Figure 5.9. Melter pressure at instrument port and control air flow rate during Test 3.

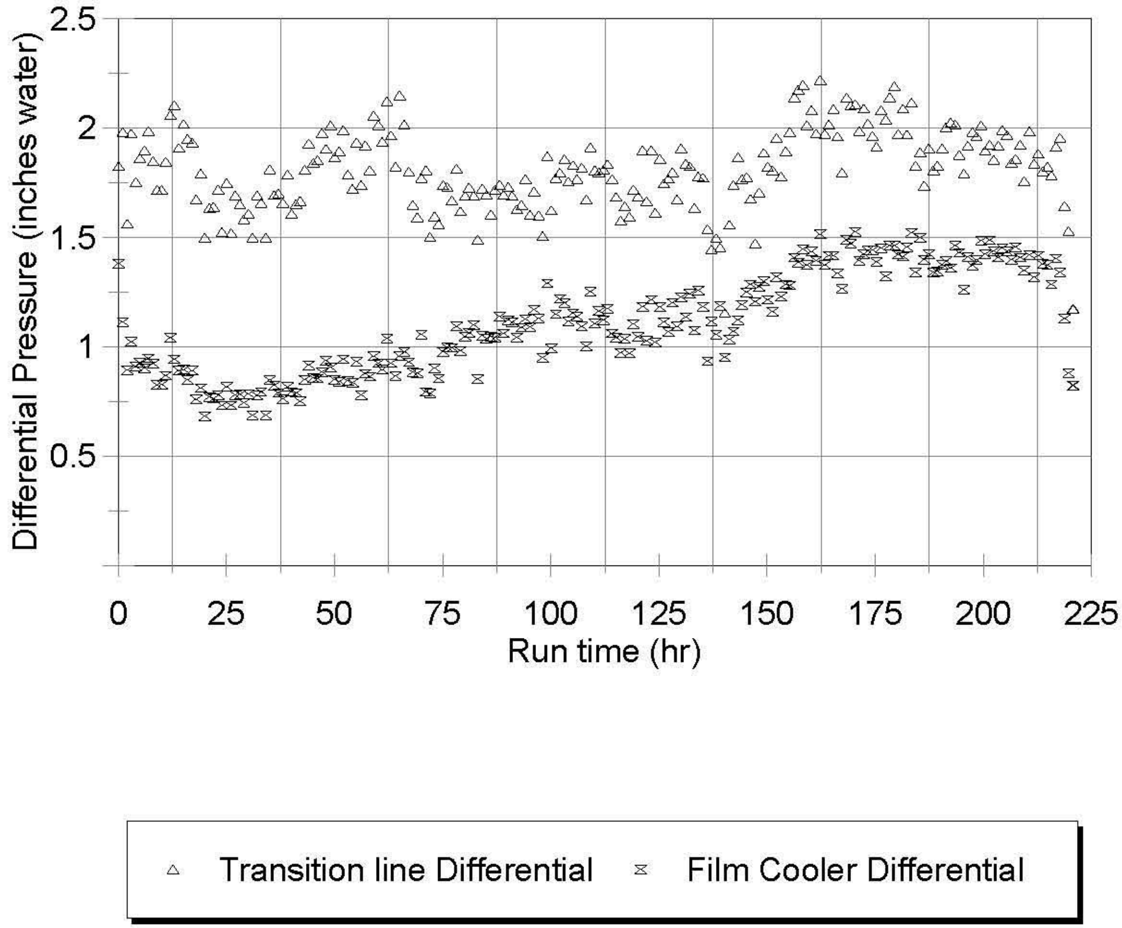

Figure 5.10. Transition line and film cooler differential pressures (hourly average values) during Test 4.

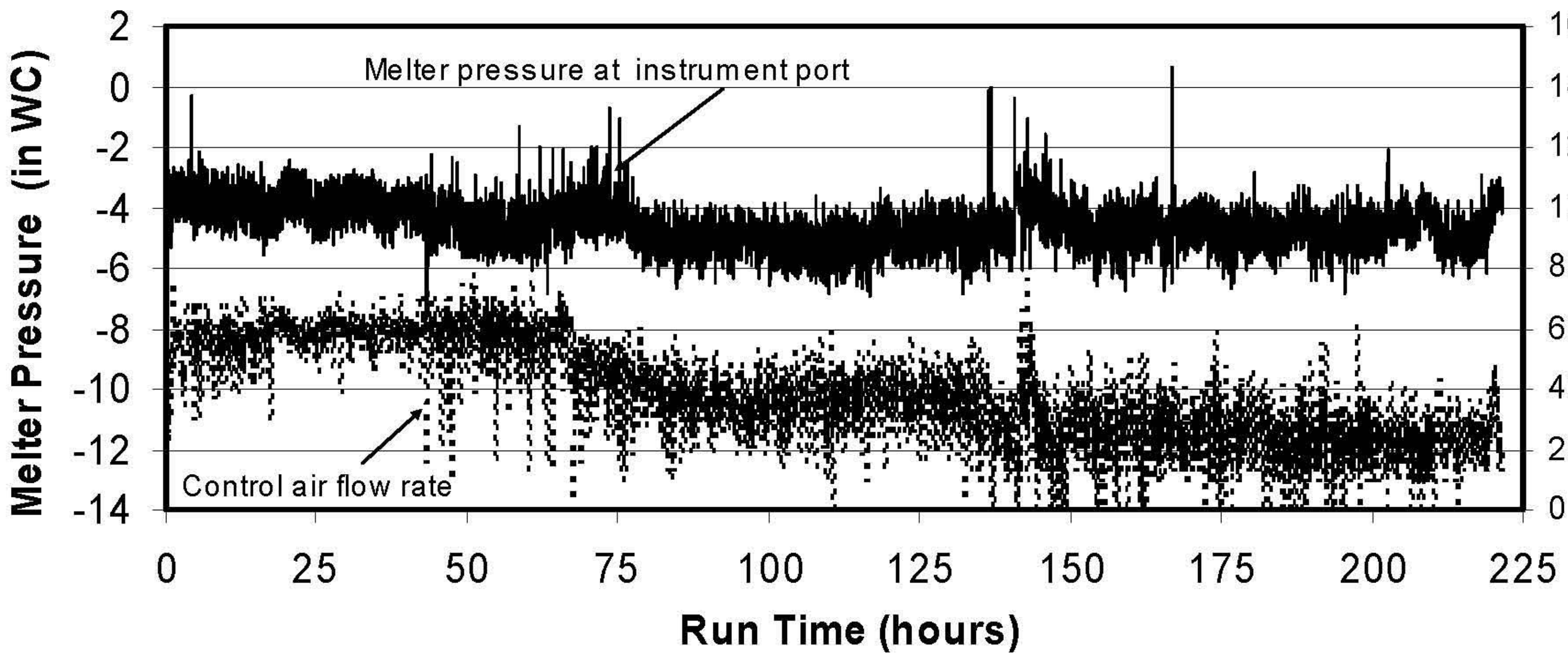

Figure 5.11. Melter pressure at instrument port and control air flow rate during Test 4.

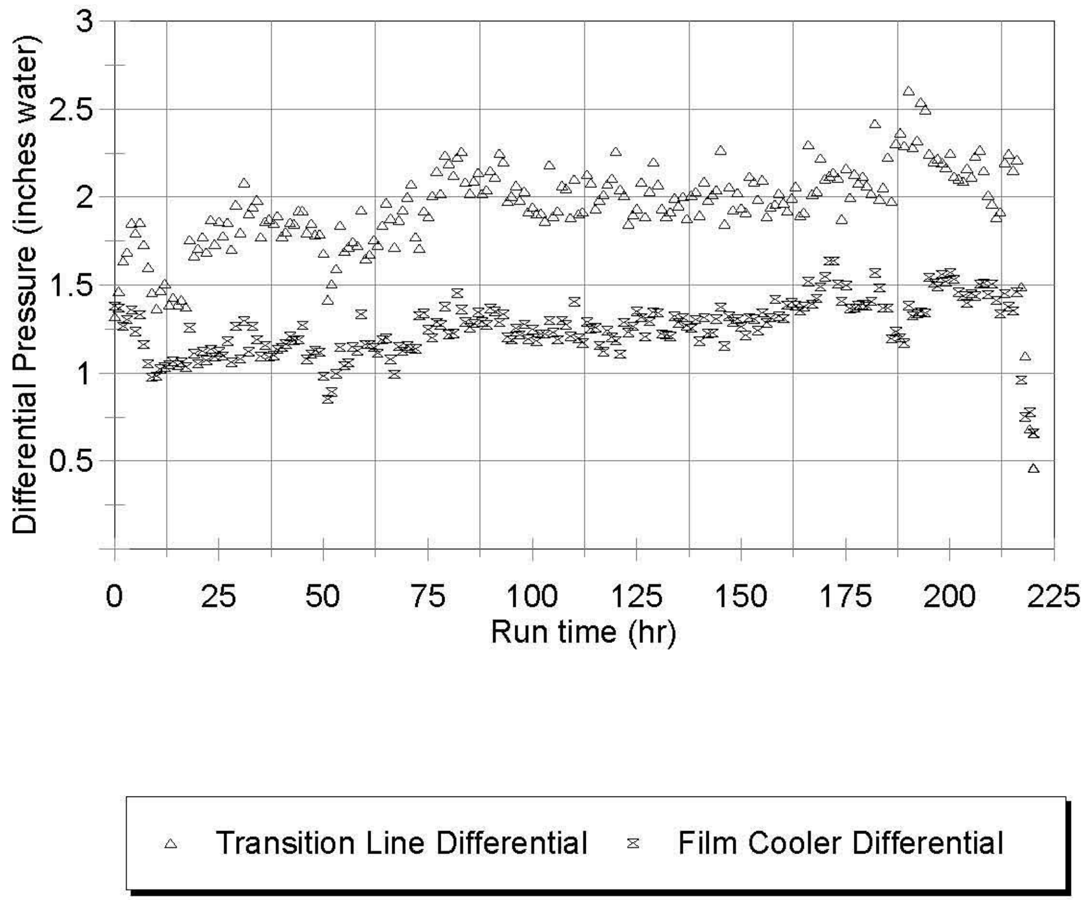

Figure 5.12. Transition line and film cooler differential pressures (hourly average values) during Test 5.

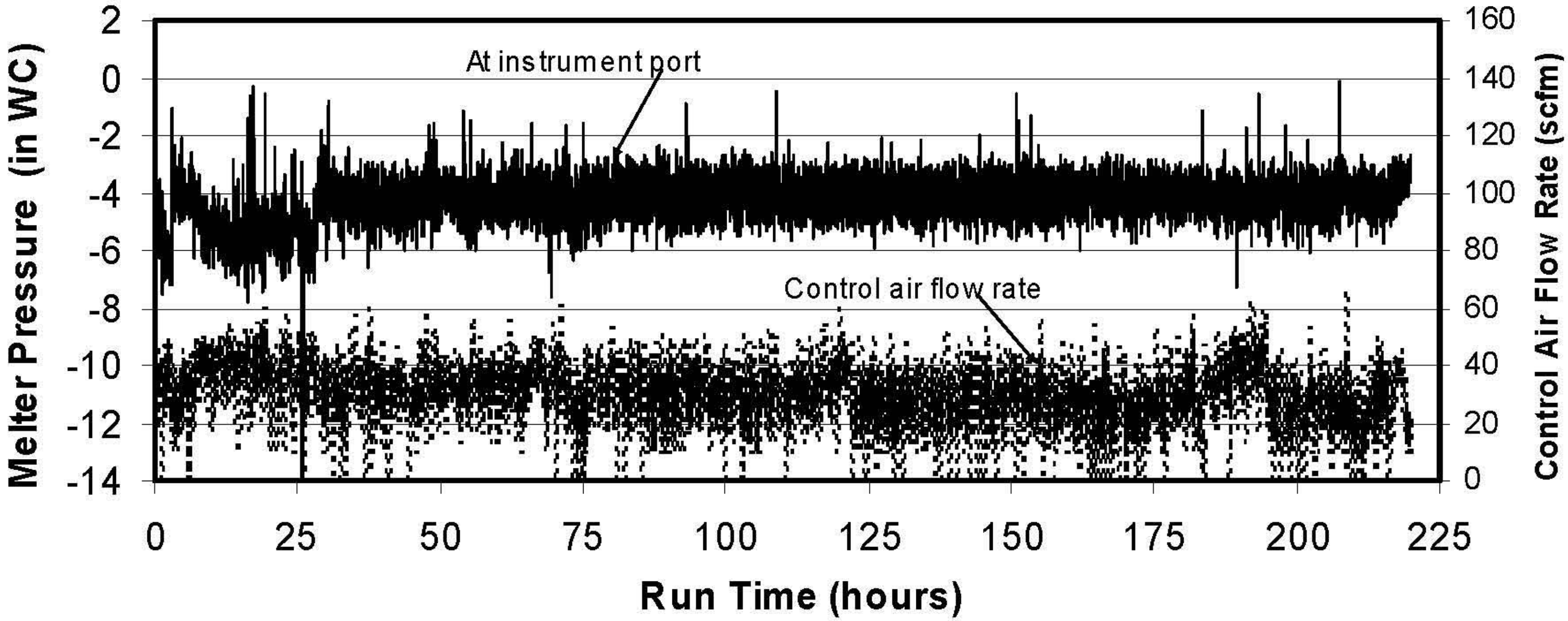

Figure 5.13a. Melter pressure at instrument port and control air flow rate during Test 5.

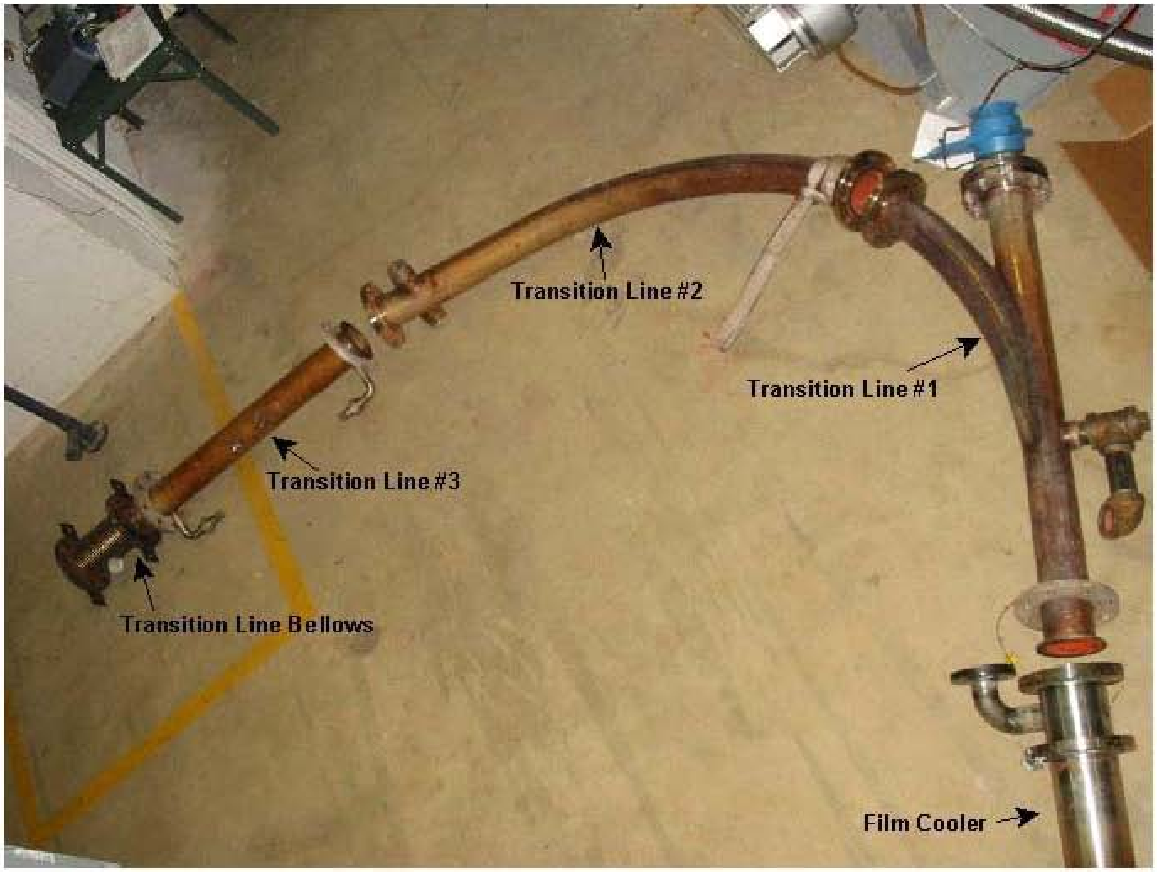

Figure 5.13b. Layout of film cooler and transition line sections.

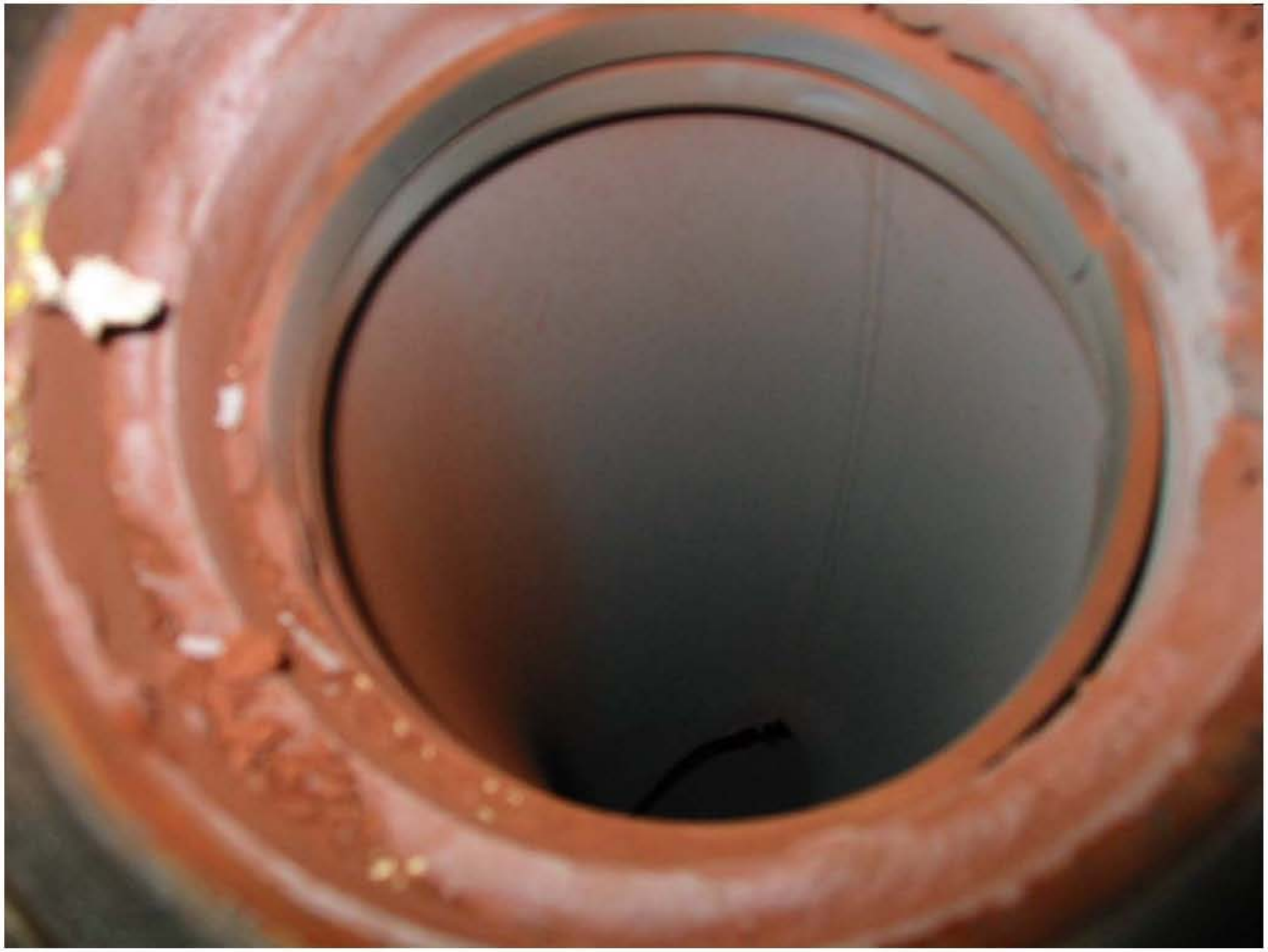

Figure 5.14. View of transition line section #1 inlet after Test 5.

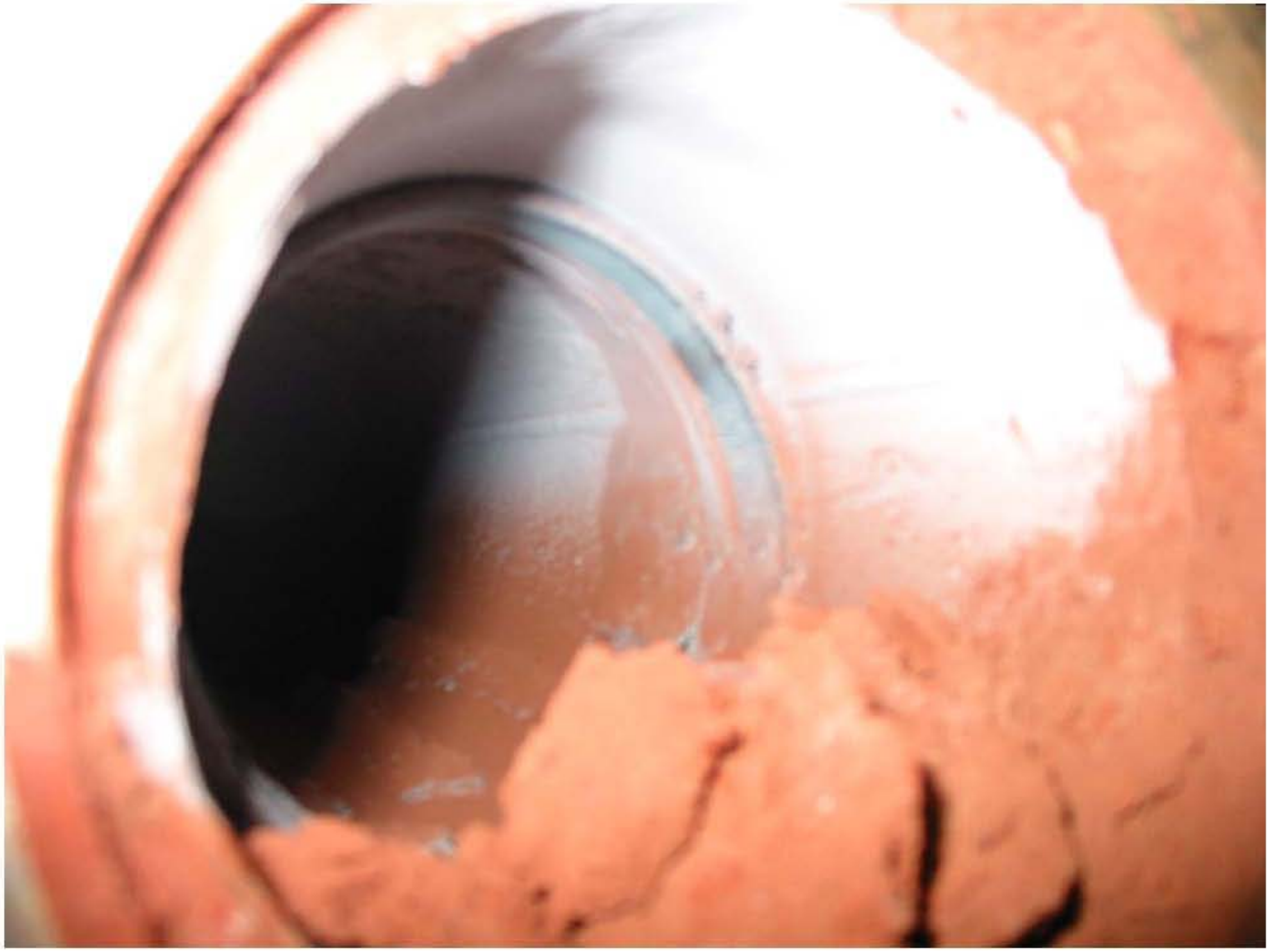

Figure 5.15. View of deposited solids in the transition line outlet on SBS side after Test 5.

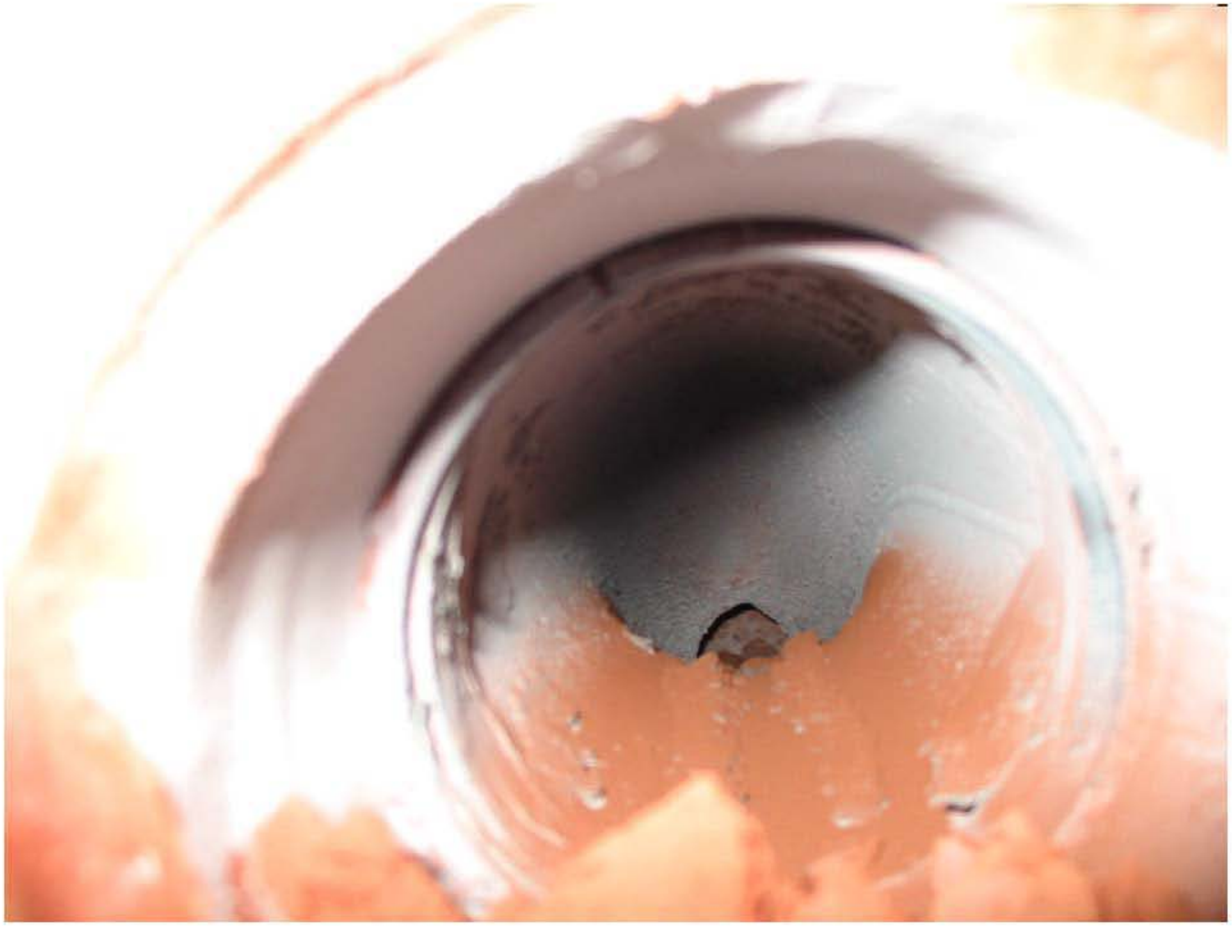

Figure 5.16. Another view of the deposited solids in the transition line outlet on SBS side after Test 5.

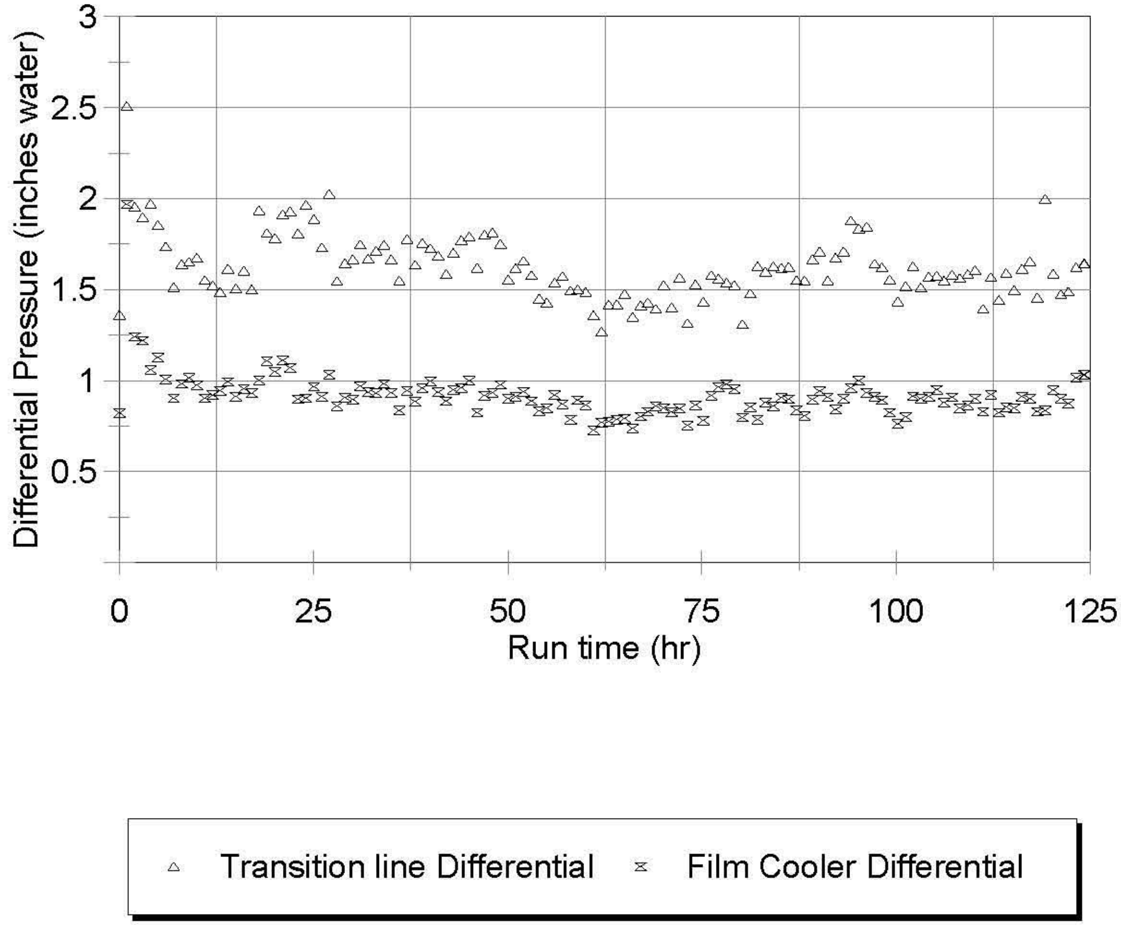

Figure 5.17. Transition line and film cooler differential pressures (hourly average values) during Test 6.

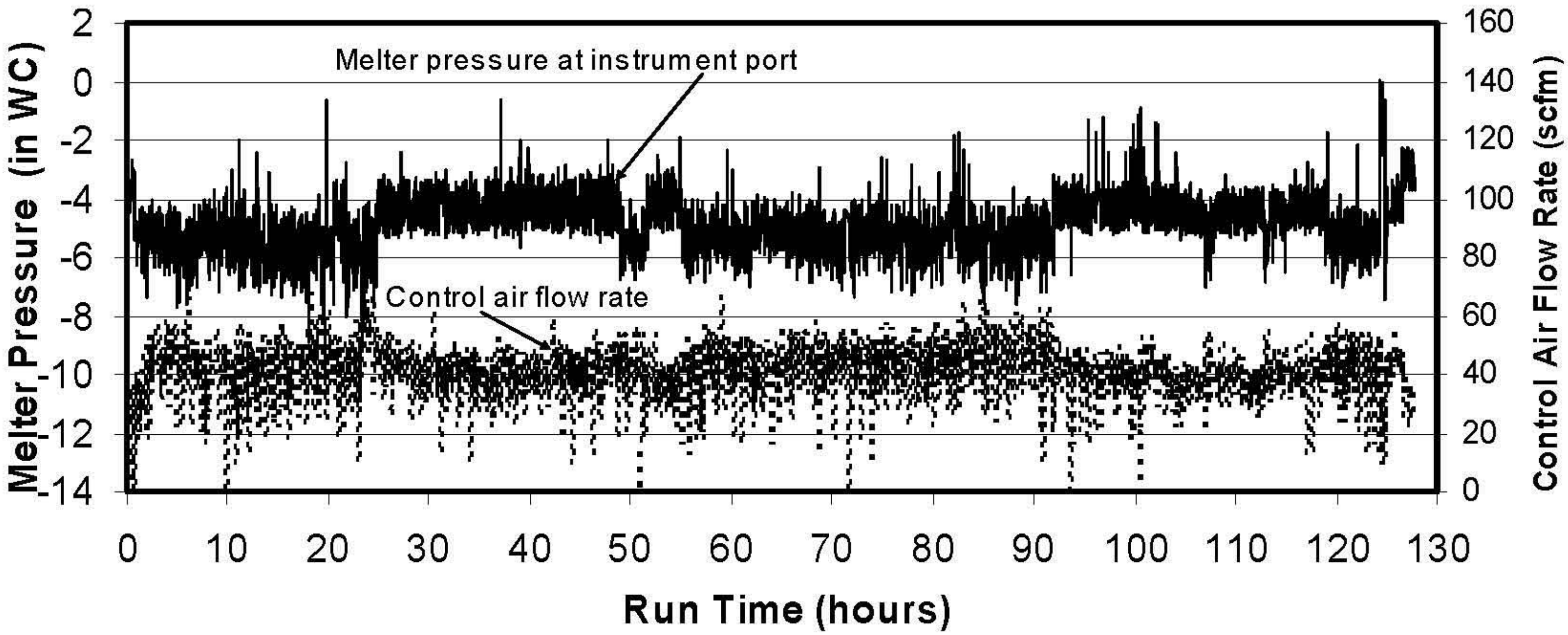

Figure 5.18. Melter pressure at instrument port and control air flow rate during Test 6.

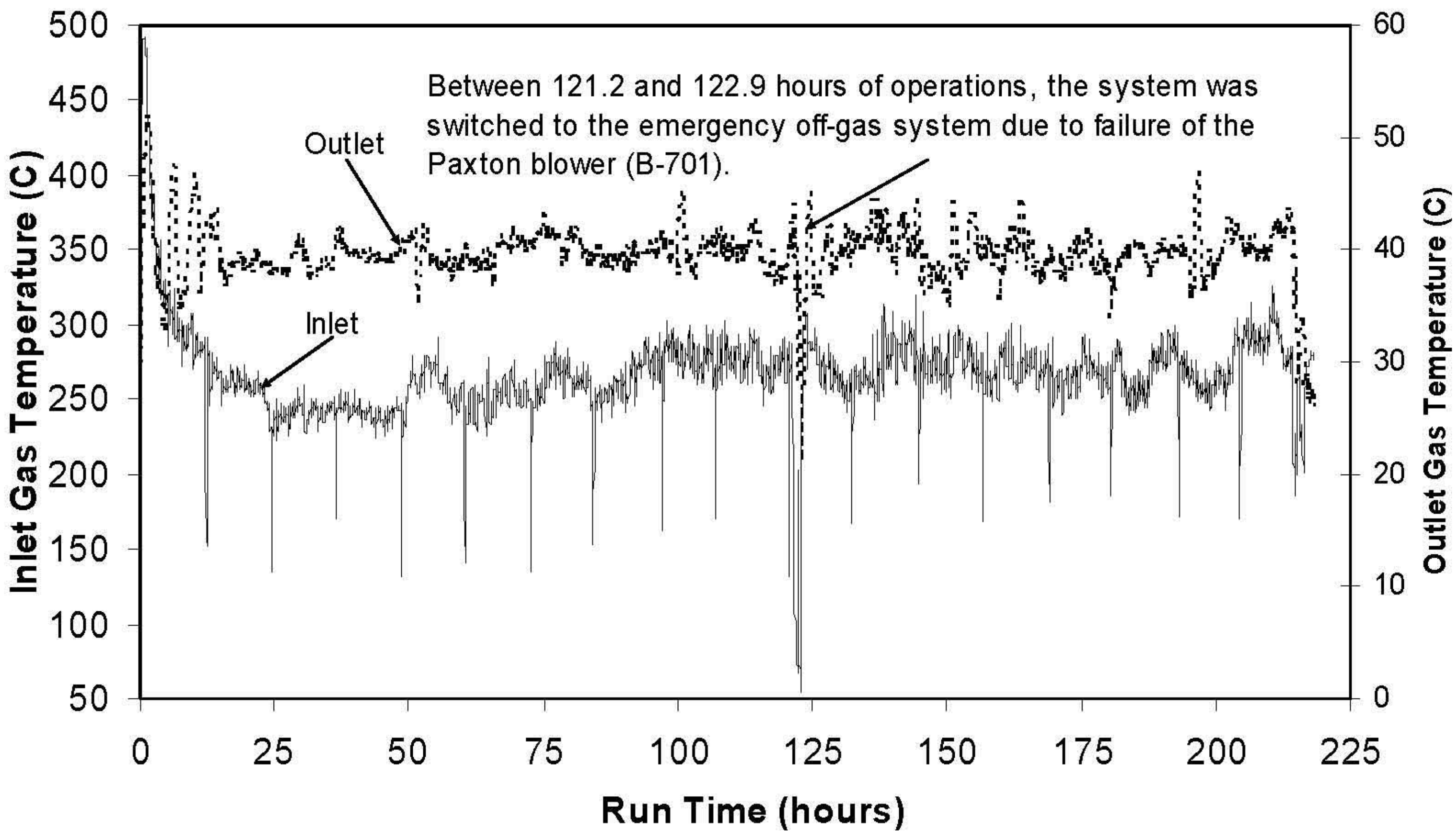

Figure 5.19. SBS inlet and outlet gas temperatures during Tests 1 and 2.

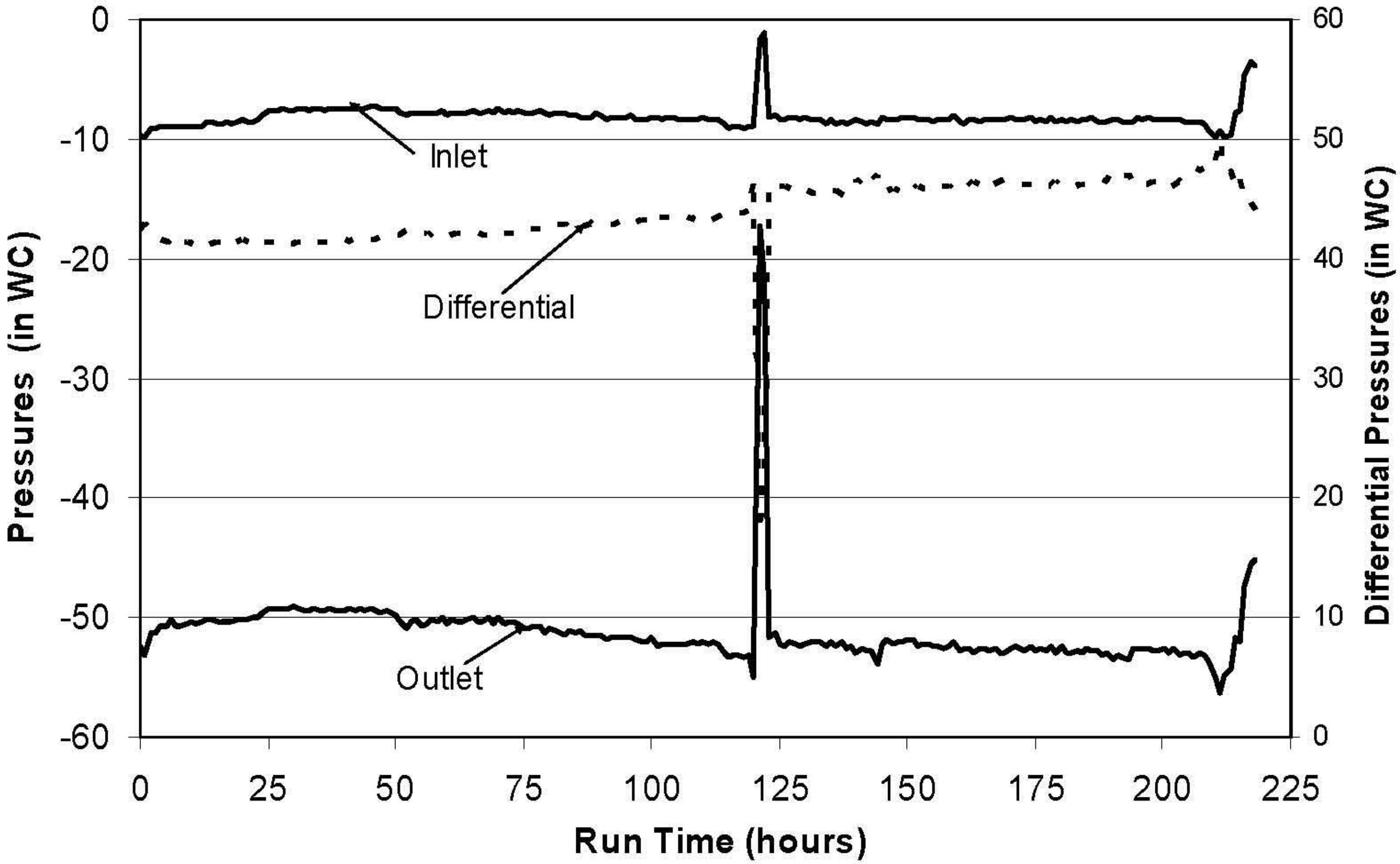

Figure 5.20. SBS inlet, outlet and differential pressures (hourly average values) during Tests 1 and 2.

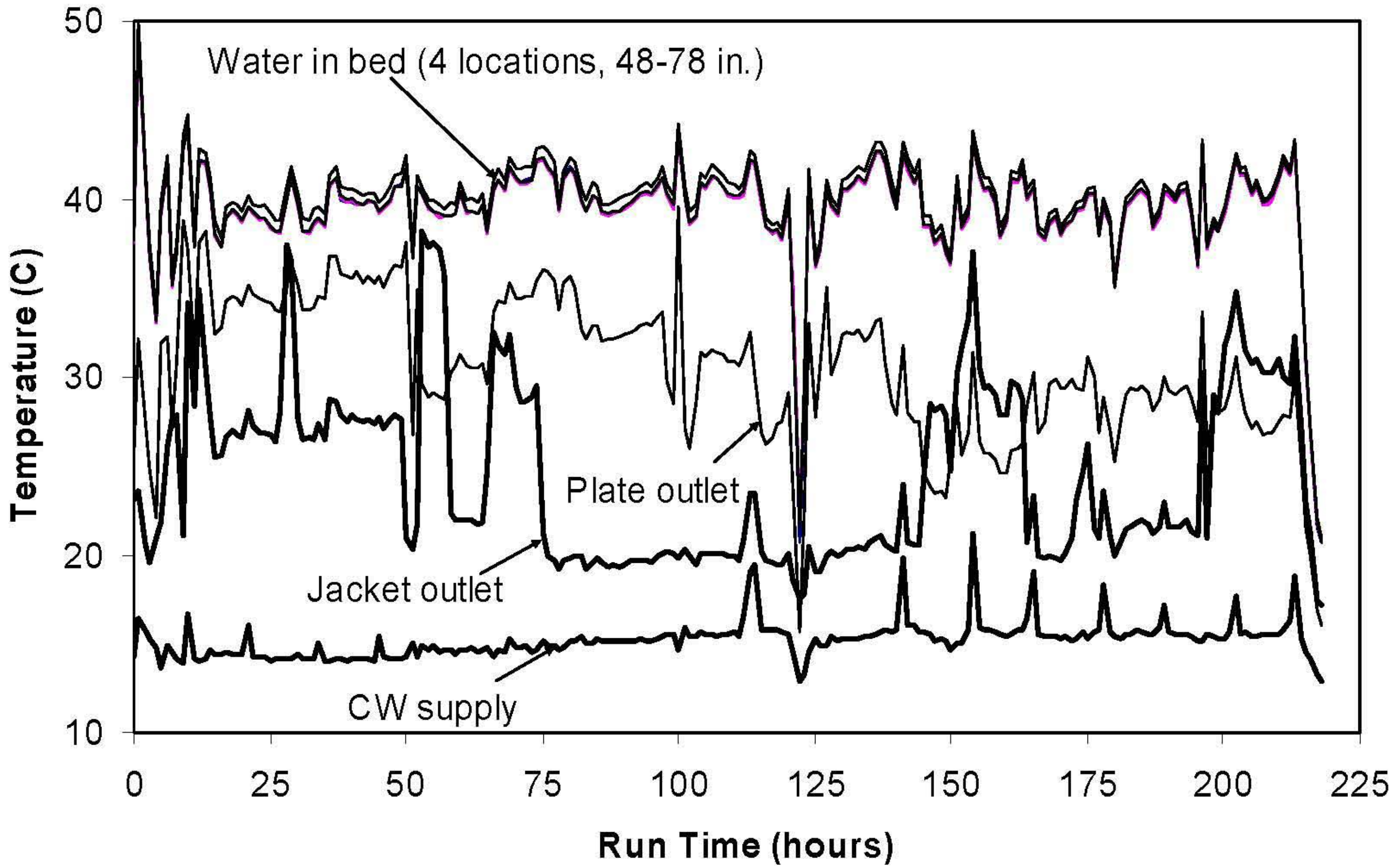

Figure 5.21. SBS cooling water and bed temperatures (hourly average values) during Tests 1 and 2.

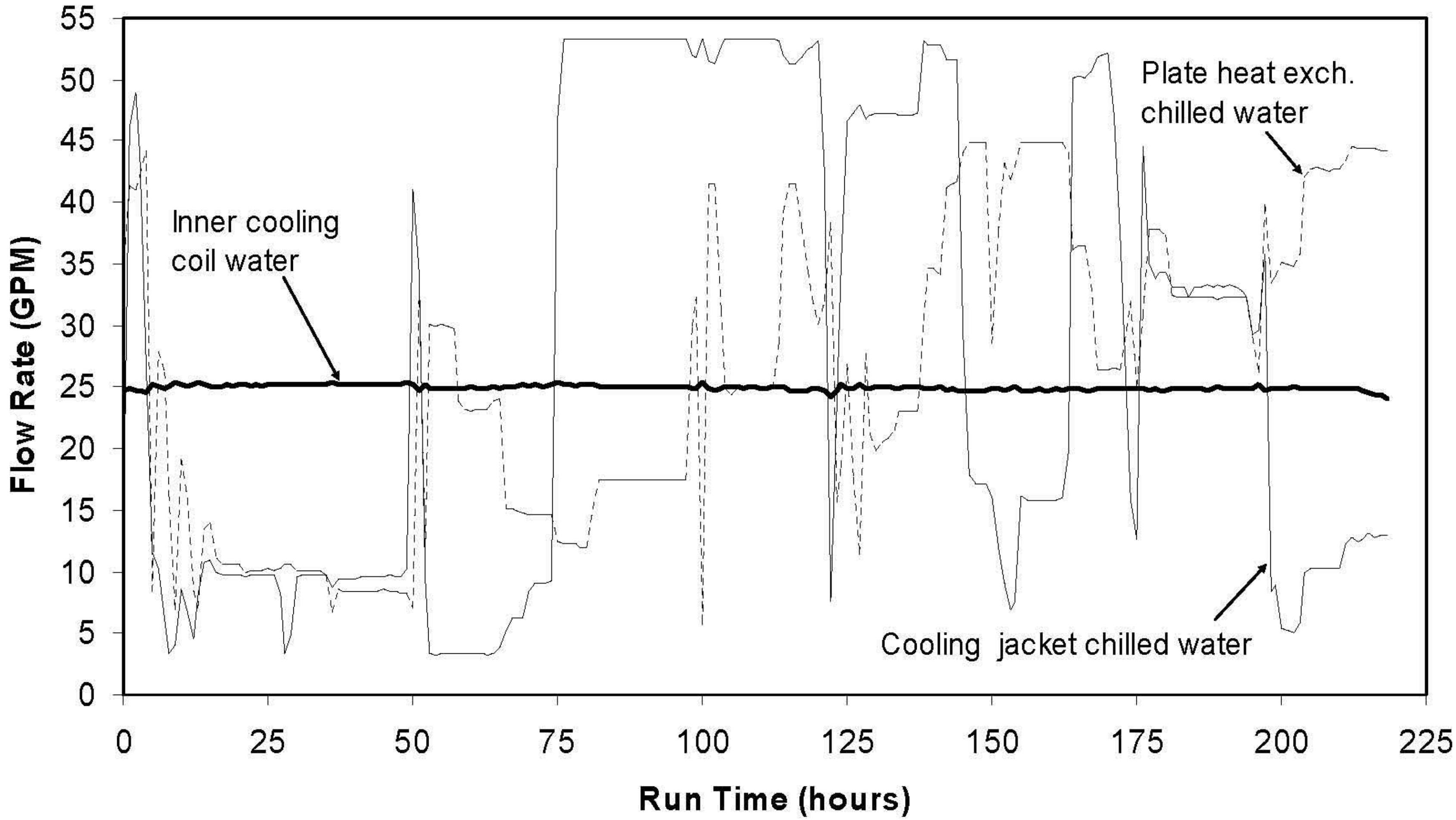

Figure 5.22. SBS jacket, inner coil, and heat exchanger water flow rates (hourly average values) during Tests 1 and 2.

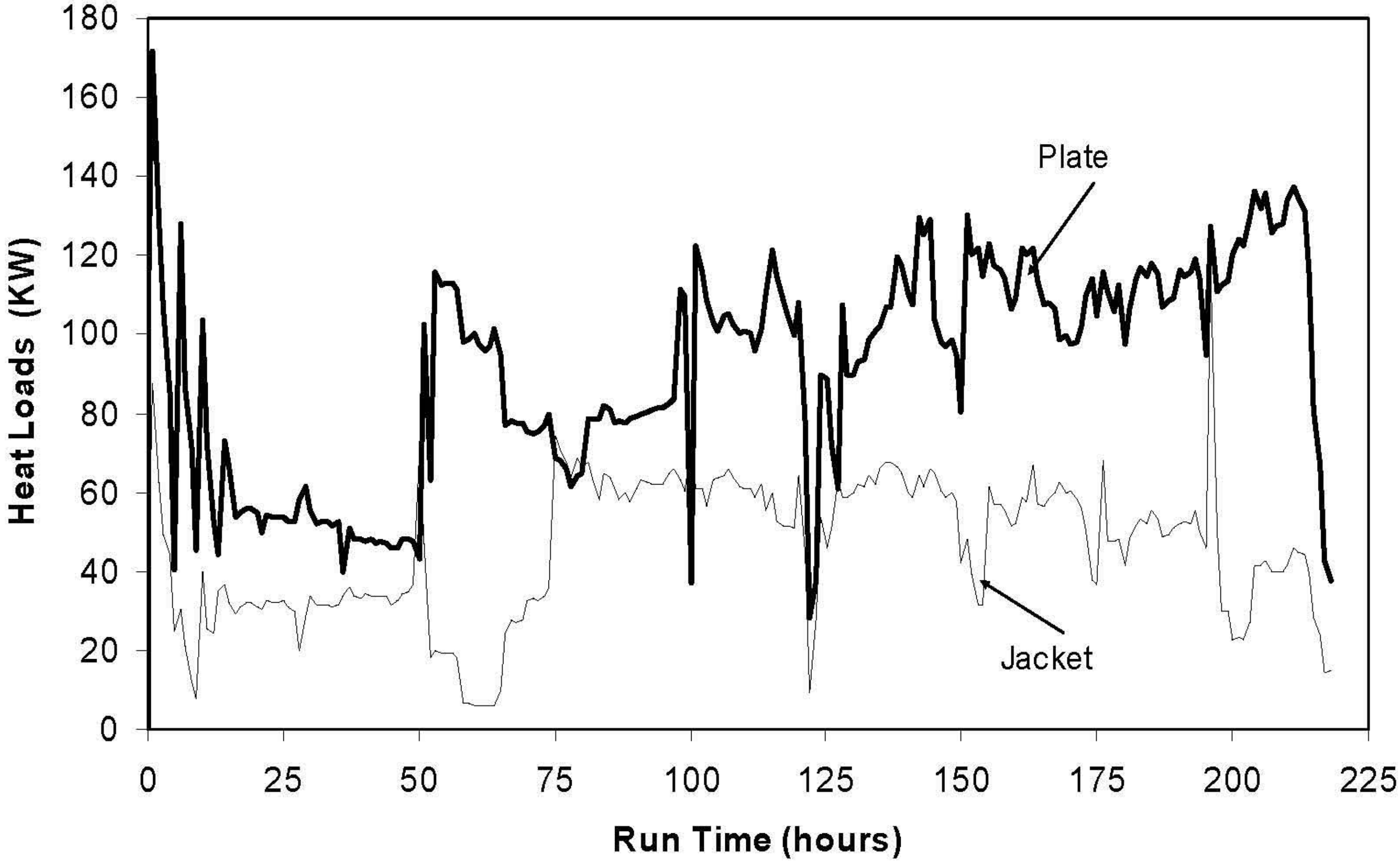

Figure 5.23. Calculated heat loads on the cooling jacket and plate heat exchanger (hourly average values) during Tests 1 and 2.

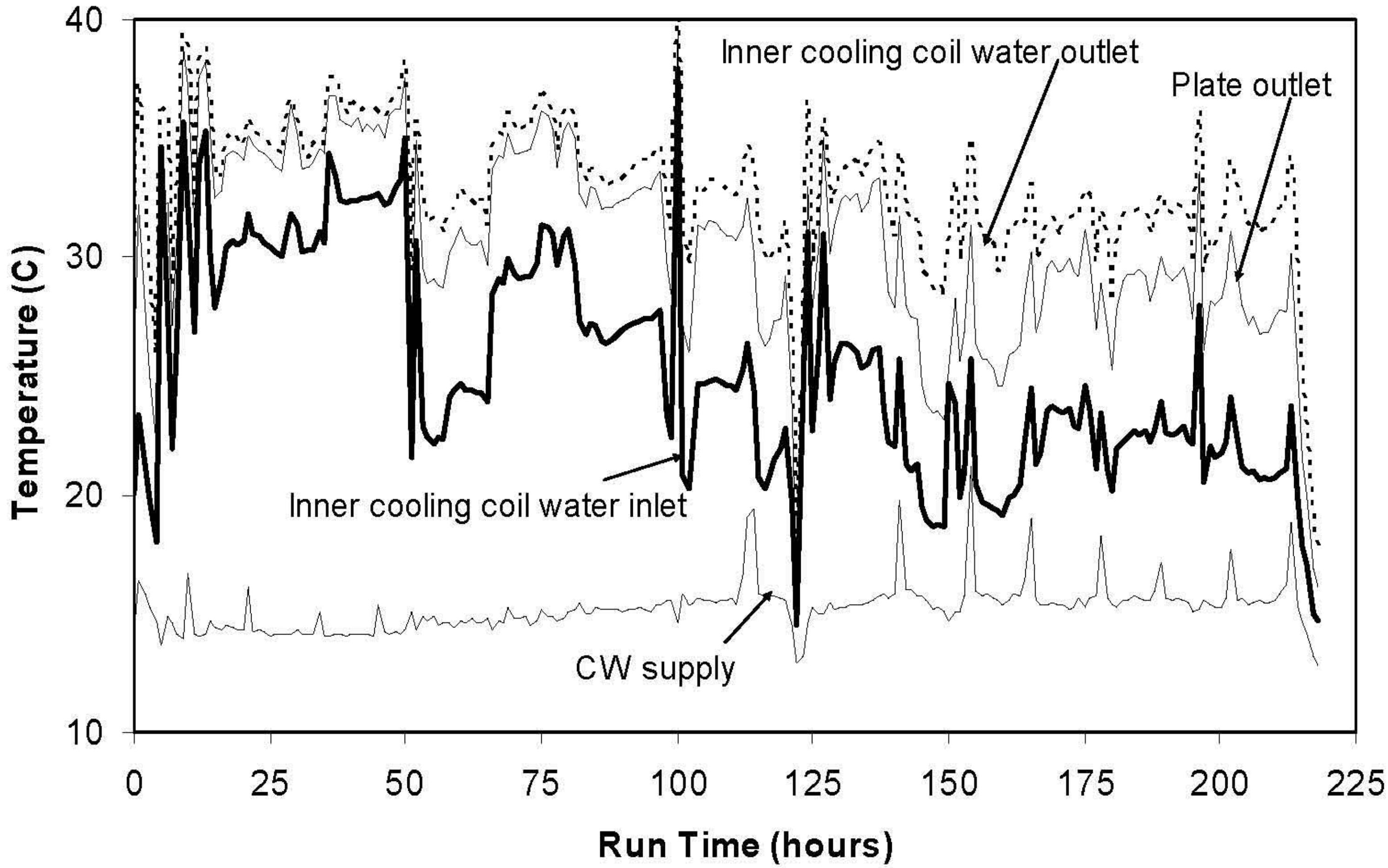

Figure 5.24. SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Tests 1 and 2.

Figure 5.25. SBS bowl before cleaning after Tests 1 and 2.

Figure 5.26. Another view of SBS bowl before cleaning after Tests 1 and 2.

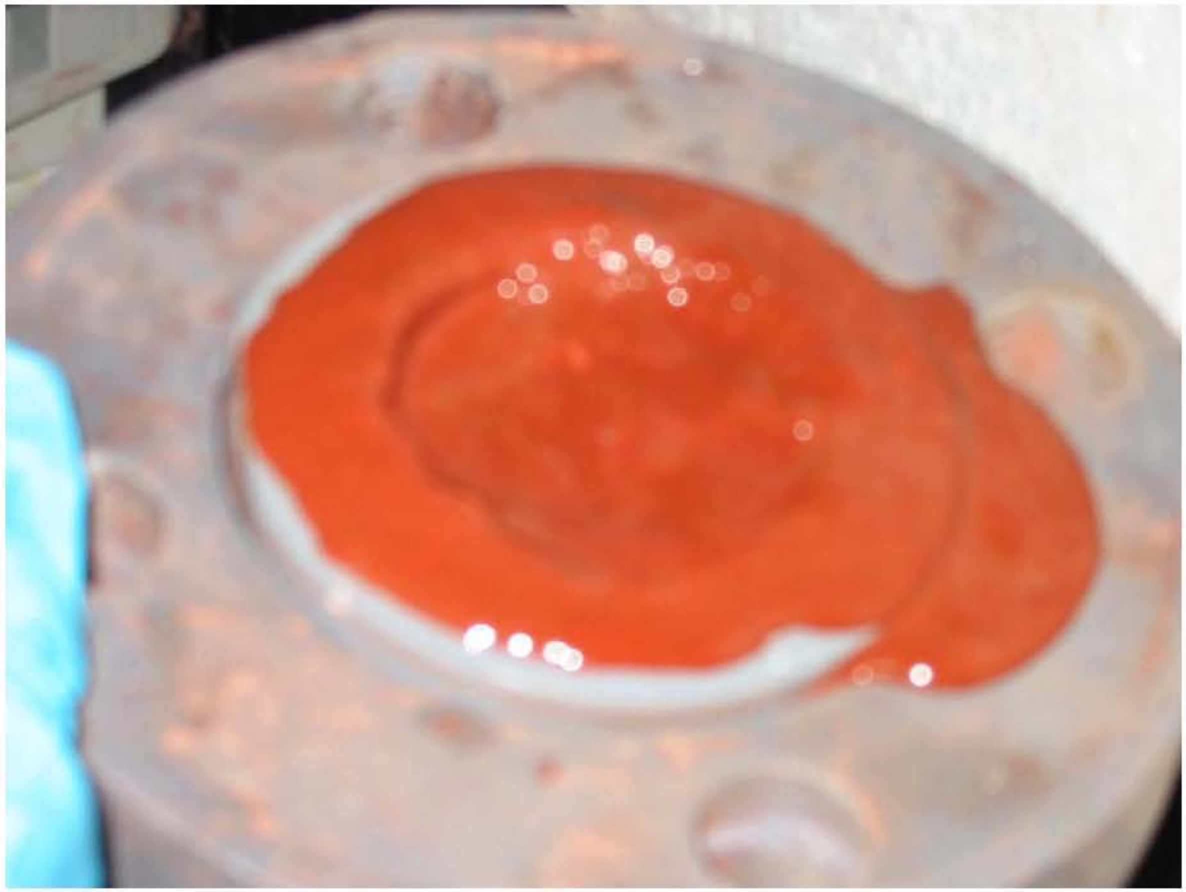

Figure 5.27. Solids deposits in SBS bottom drain pipe after Tests 1 and 2.

Figure 5.28. Bottom view of SBS weir tubes (with rubber plugs installed) before Test 1.

Figure 5.29. SBS weir tubes and cooling coil (with plugs) after Tests 1 and 2.

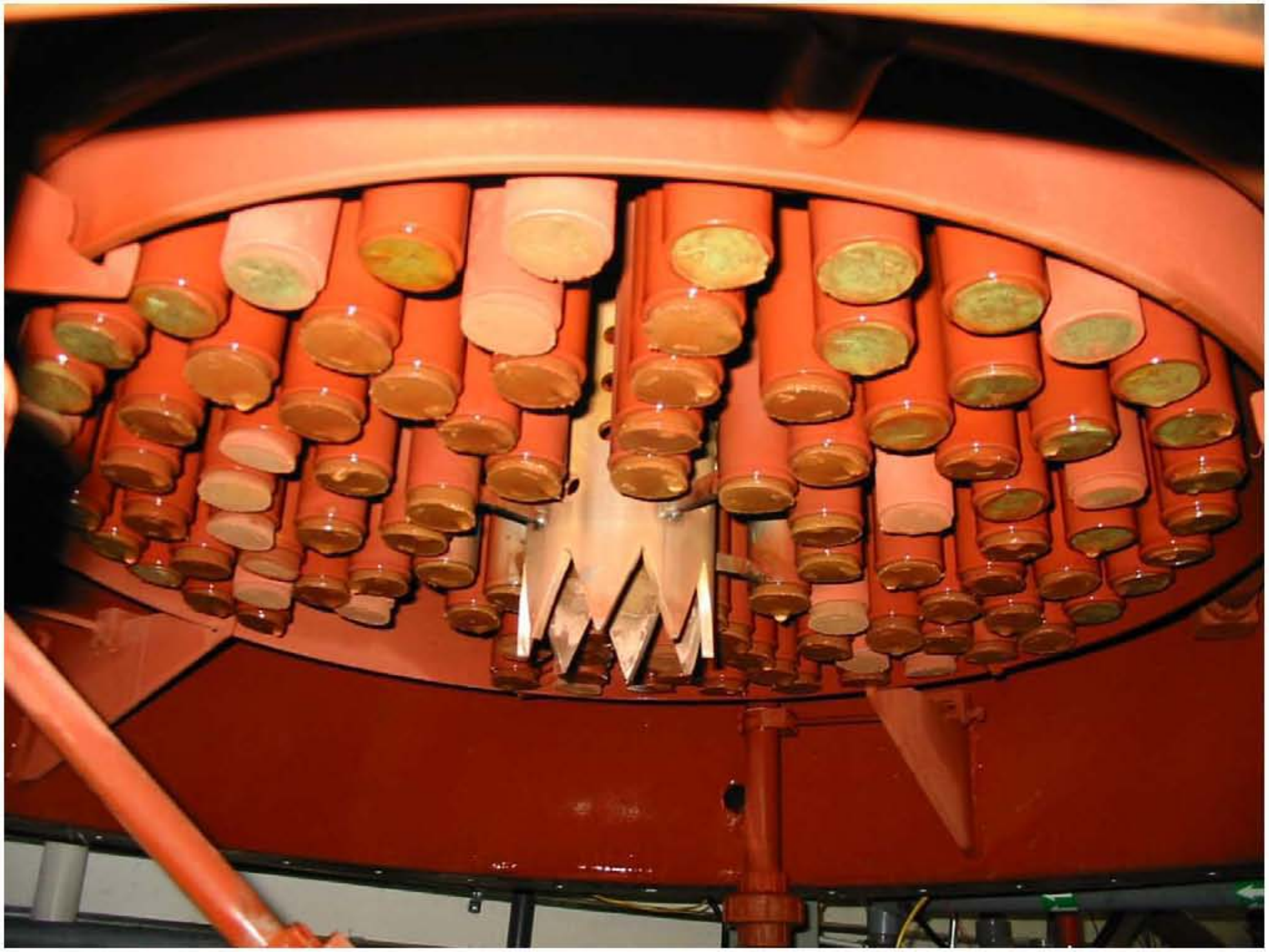

Figure 5.30. Another view of the SBS weir tubes (with plugs) after Tests 1 and 2.

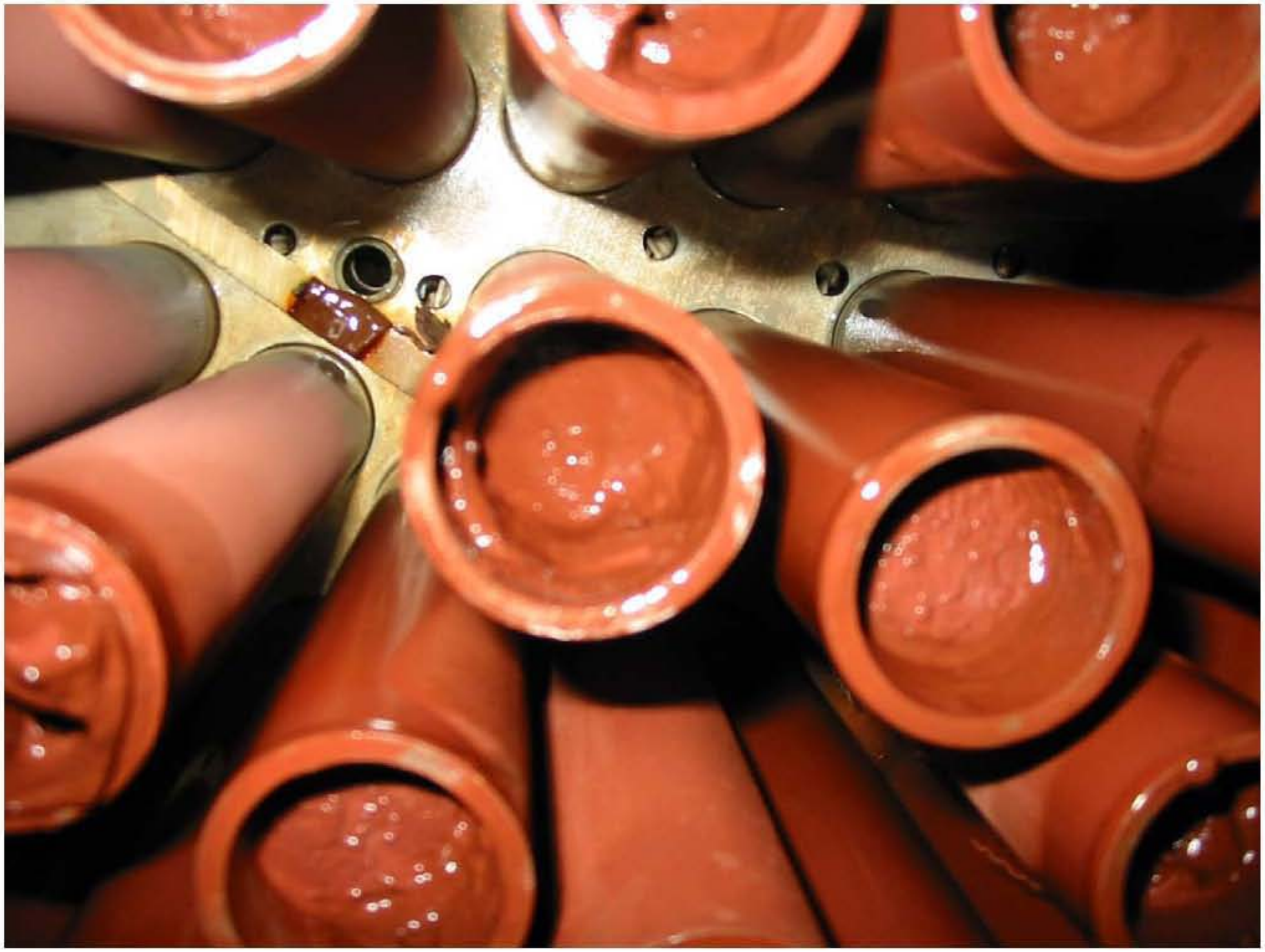

Figure 5.31. View of the SBS weir tubes (after removal of plugs) after Tests 1 and 2.

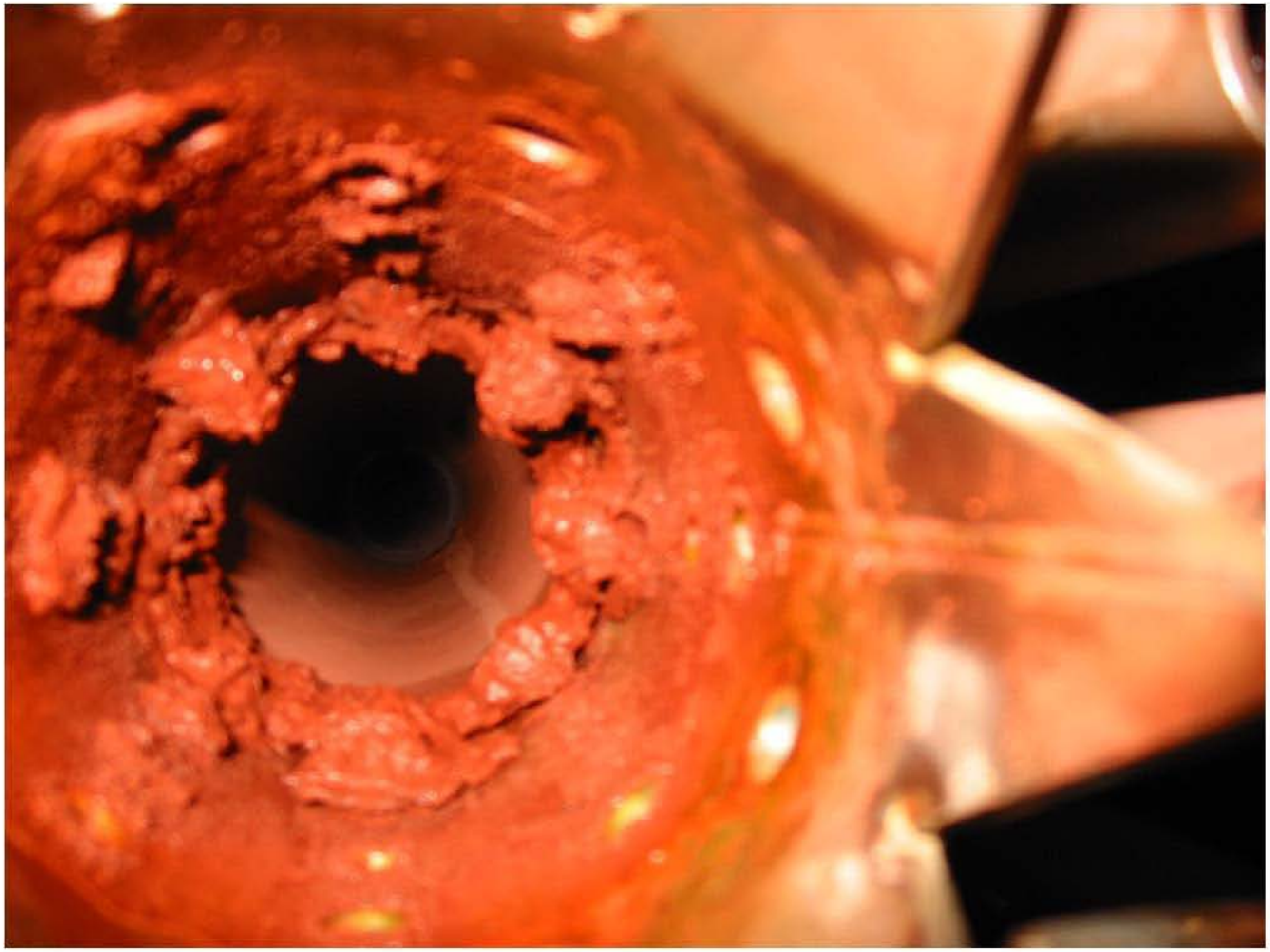

Figure 5.32. View of SBS down-comer before cleaning after Tests 1 and 2.

Figure 5.33. View of weir tubes at various locations following cleaning after Tests 1 and 2.

Figure 5.34. Additional view of weir tubes at various locations following cleaning after Tests 1 and 2.

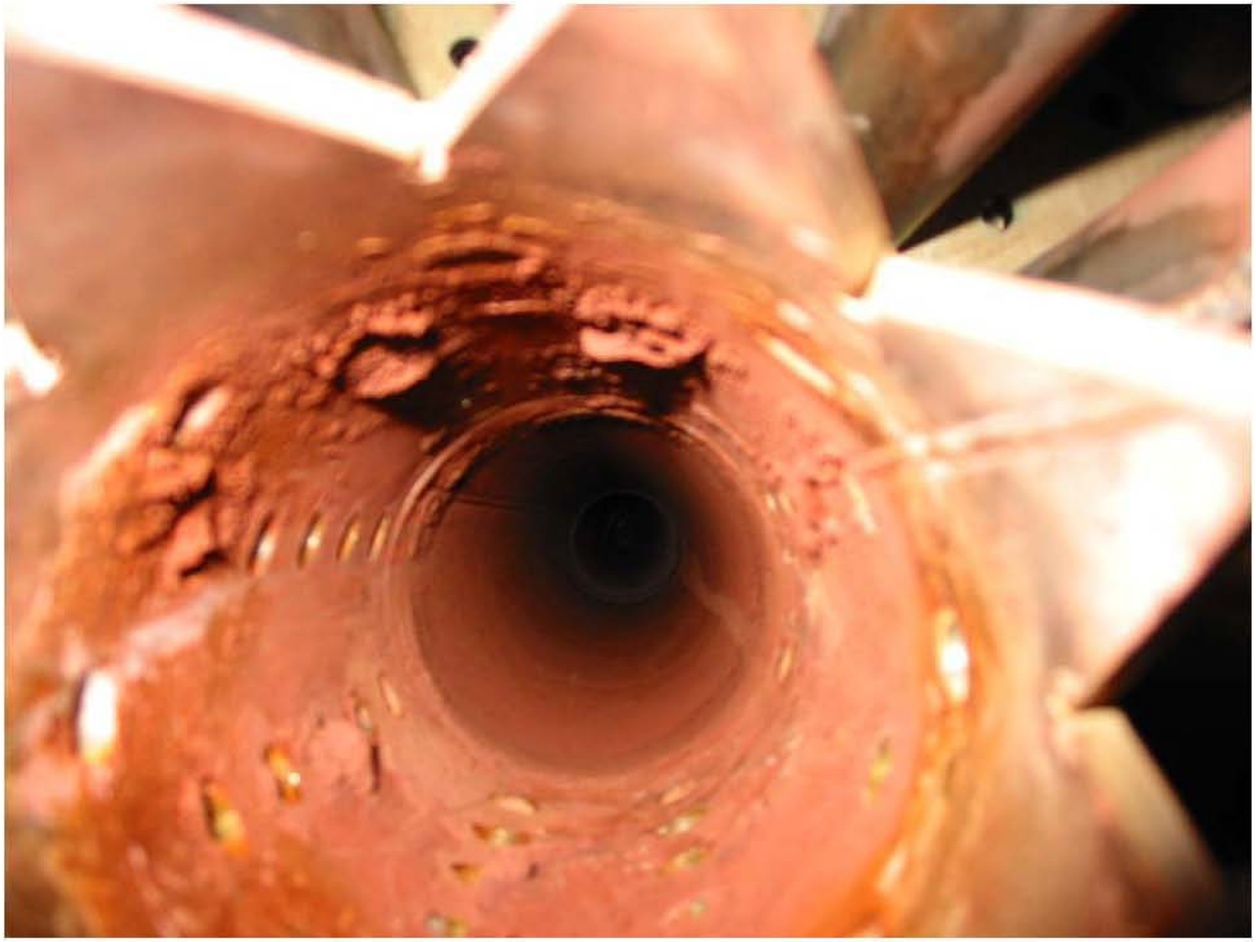

Figure 5.35. View of SBS down-comer after cleaning after Tests 1 and 2.

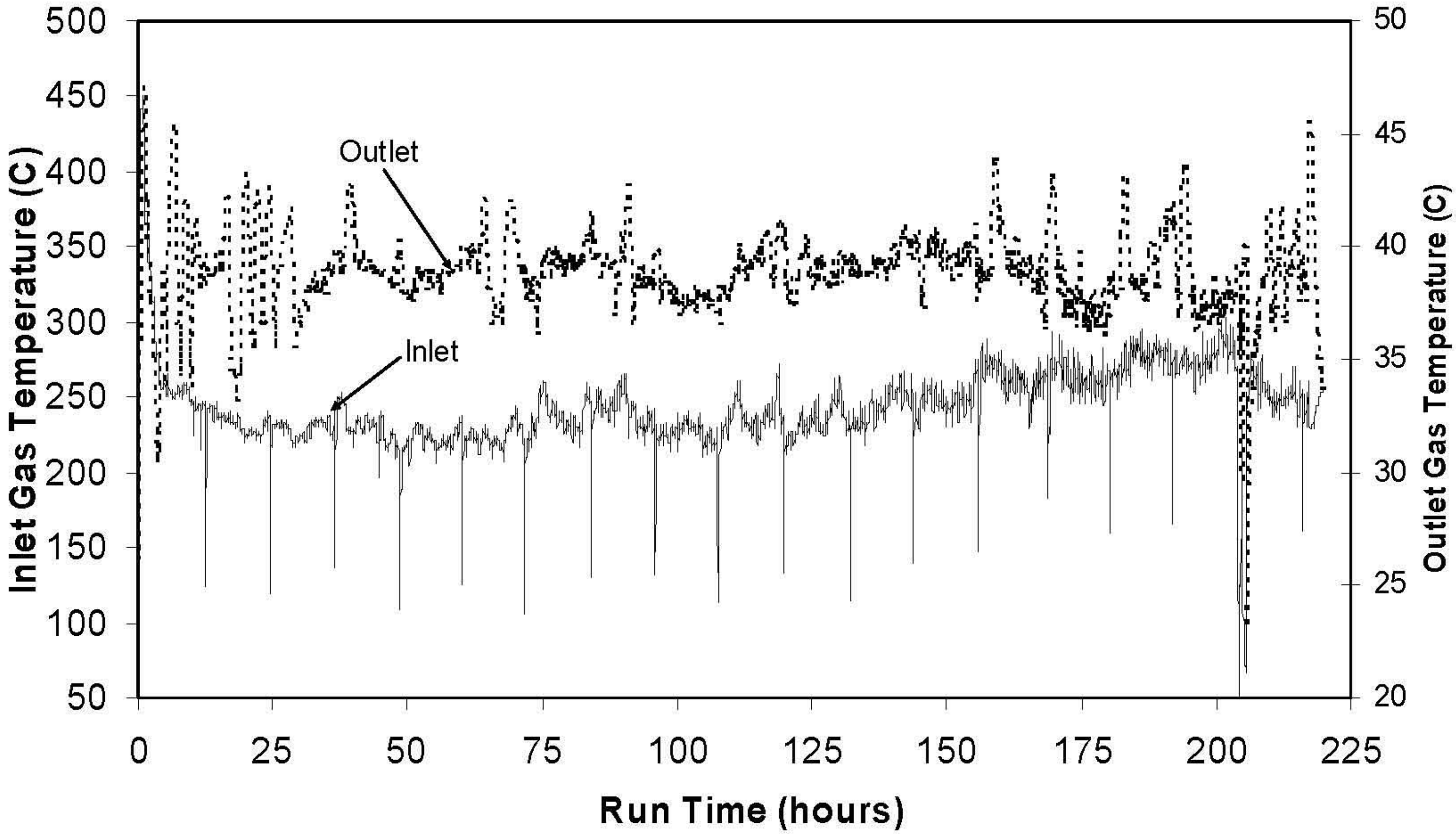

Figure 5.36. SBS inlet and outlet gas temperatures during Test 3.

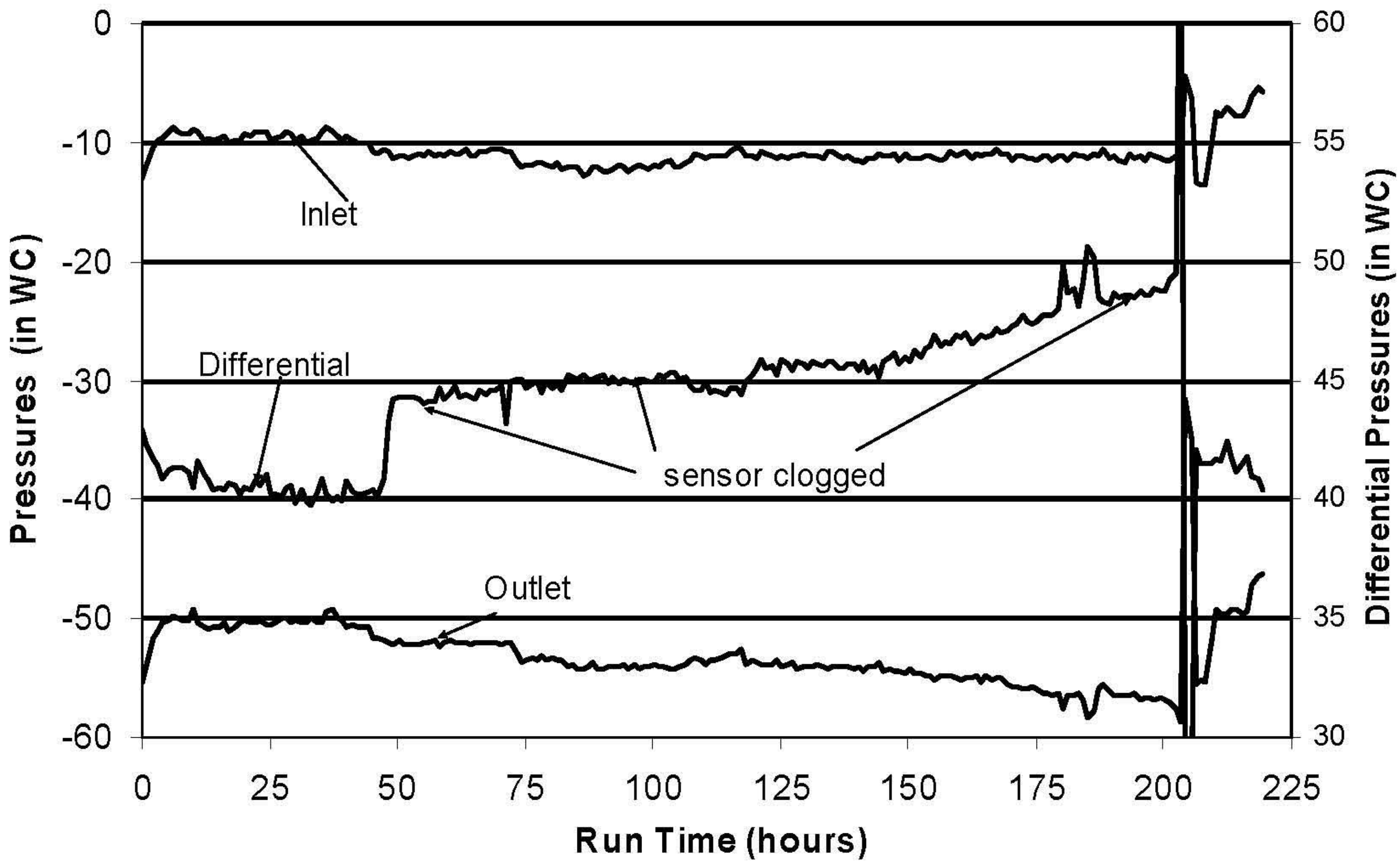

Figure 5.37. SBS inlet, outlet, and differential pressures (hourly average values) during Test 3.

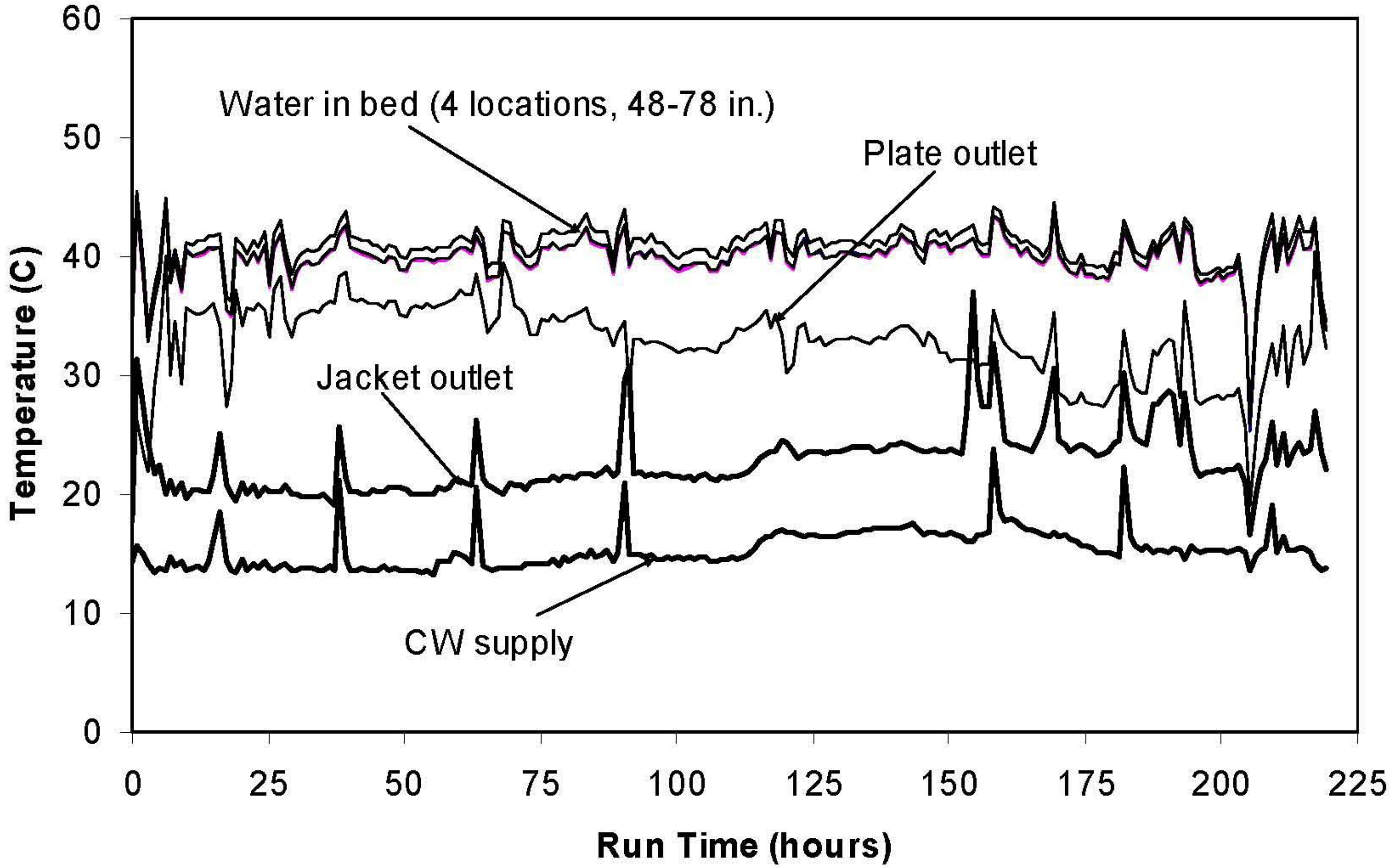

Figure 5.38. SBS cooling water and bed temperatures (hourly average values) during Test 3.

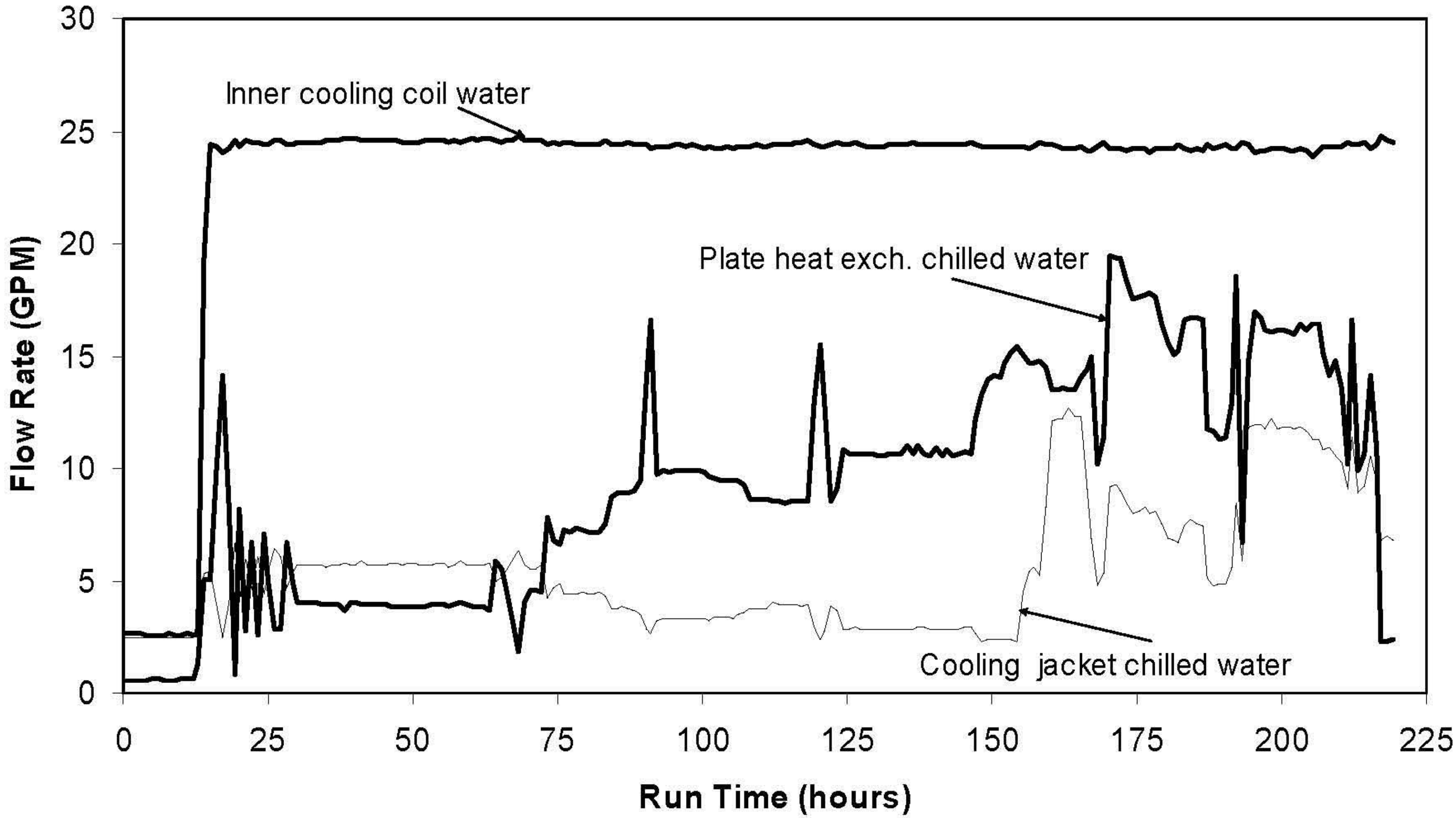

Figure 5.39. SBS jacket, inner coil and heat exchanger water flow rates (hourly average values) during Test 3.

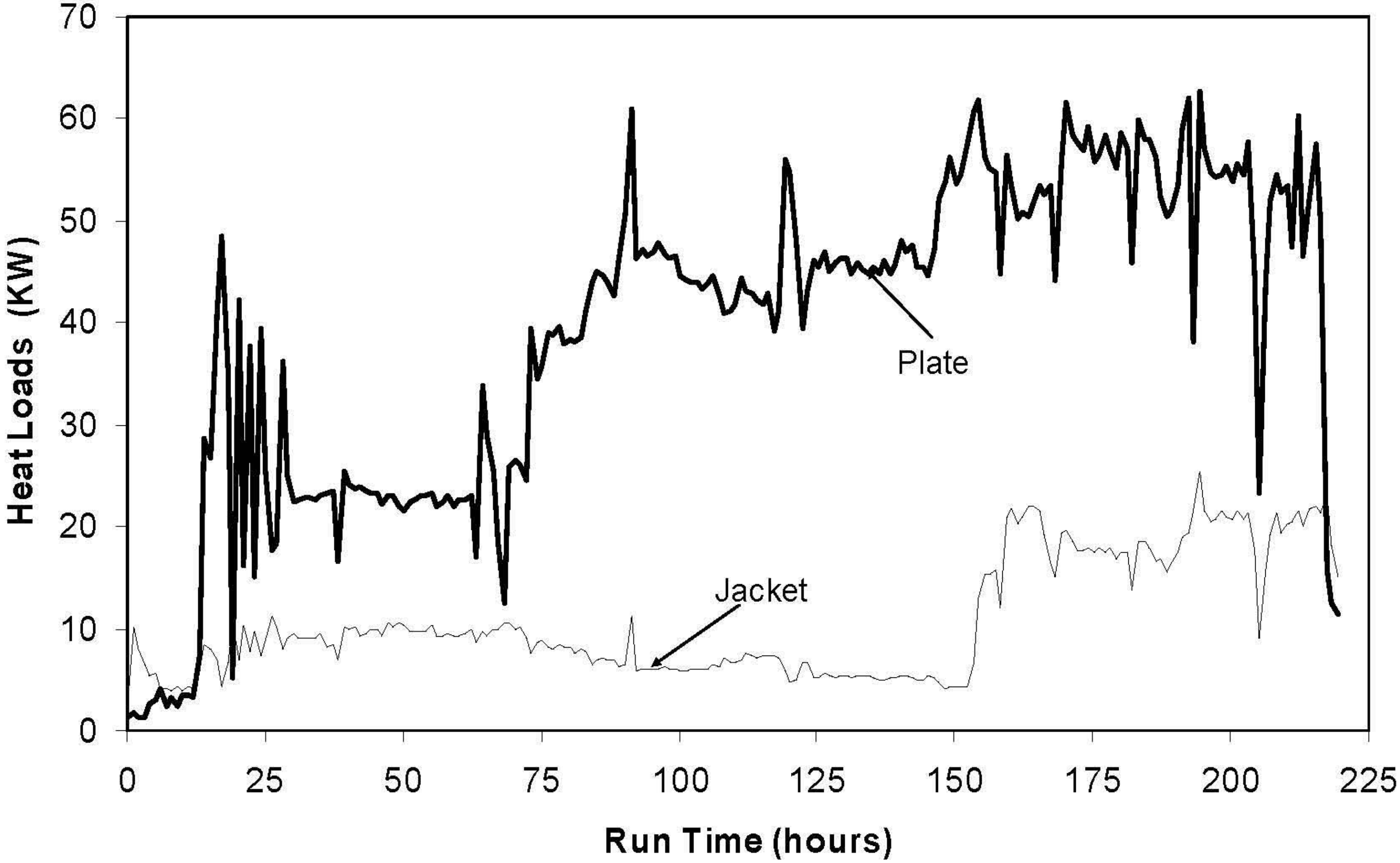

Figure 5.40. Calculated heat loads on the cooling jacket and plate heat exchanger (hourly average values) during Test 3.

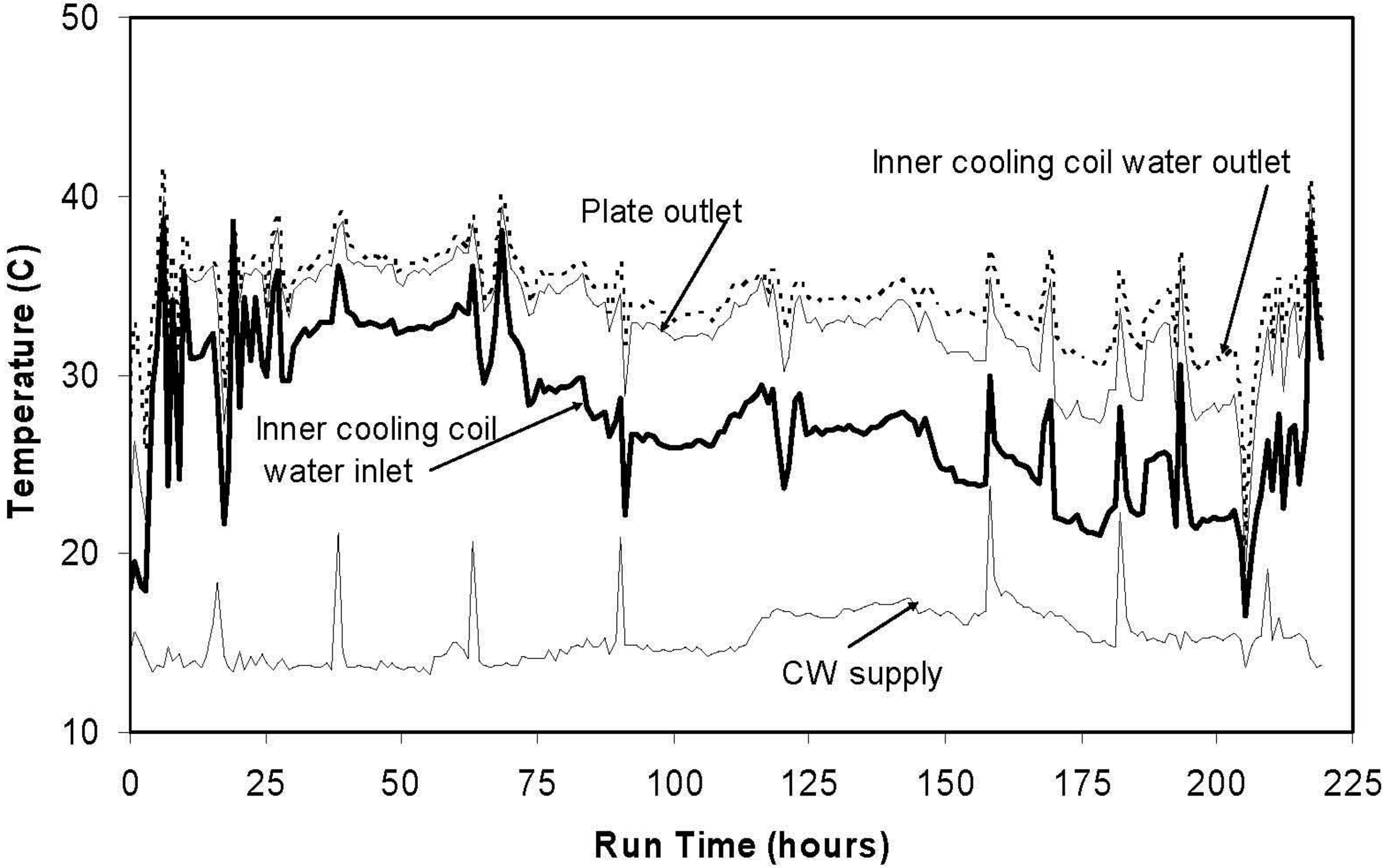

Figure 5.41. SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Test 3.

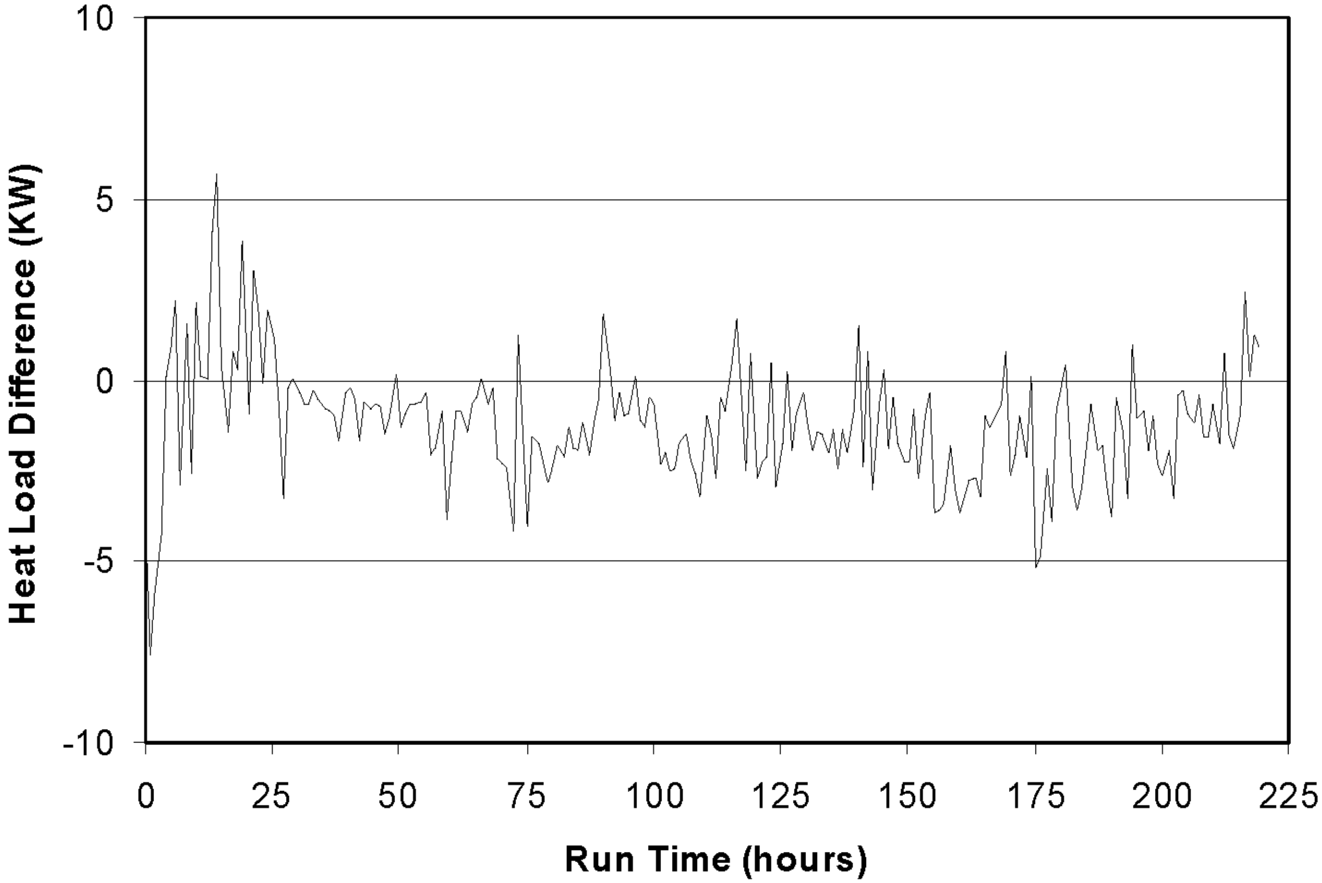

Figure 5.42. Calculated heat load difference between plate heat exchanger and SBS inner coil (hourly average values) during Test 3.

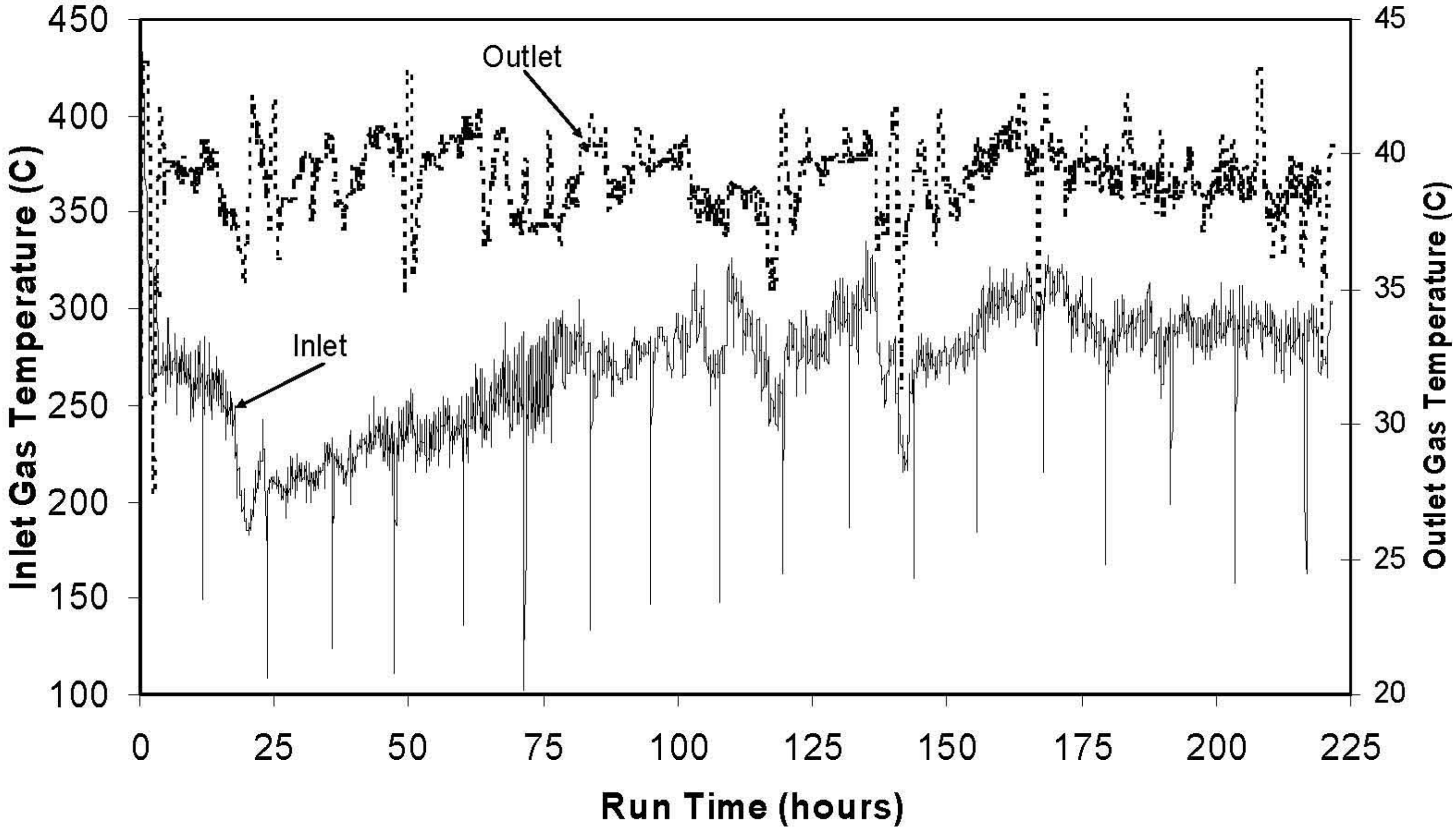

Figure 5.43. SBS inlet and outlet gas temperatures during Test 4.

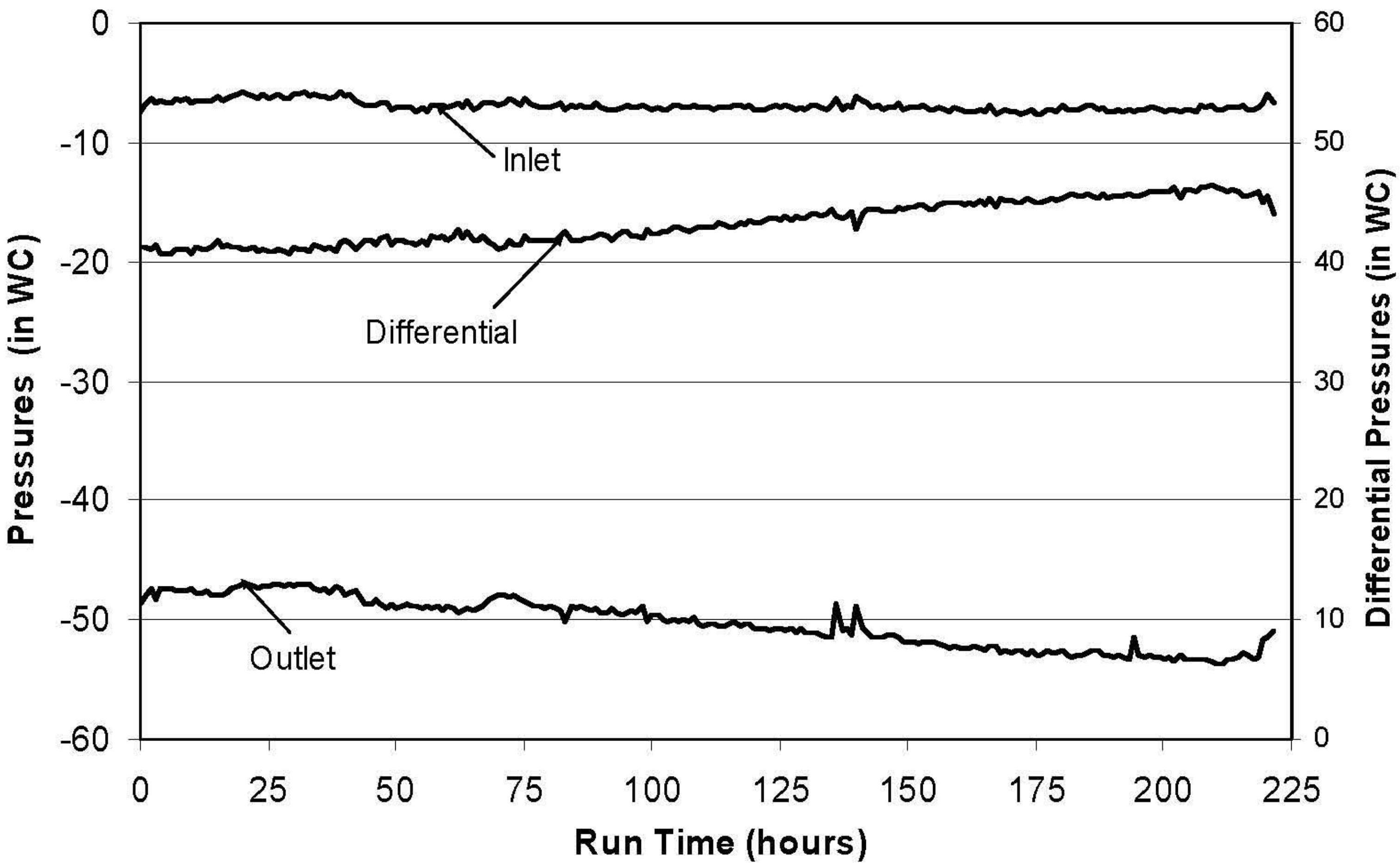

Figure 5.44. SBS inlet, outlet, and differential pressures (hourly average values) during Test 4.

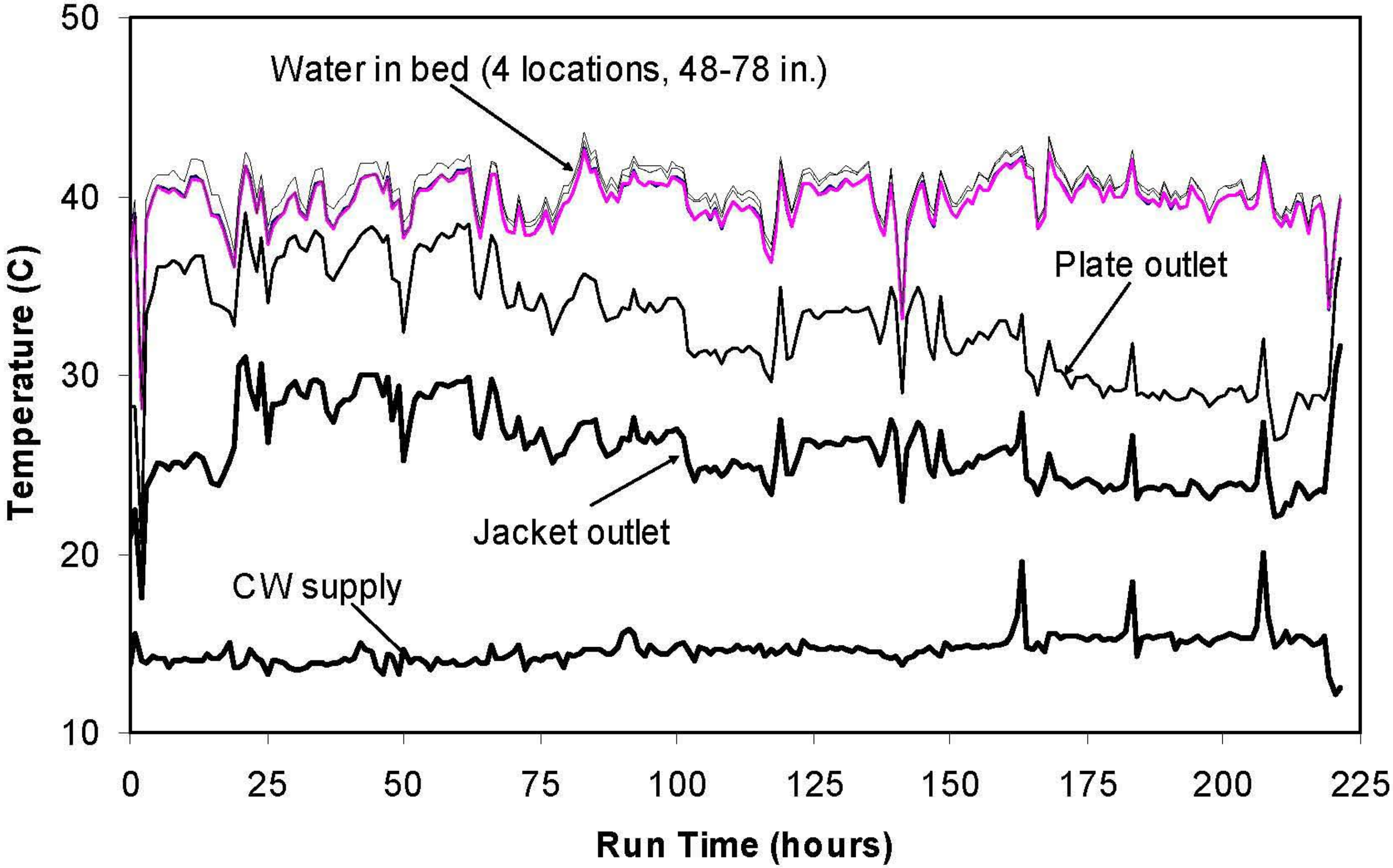

Figure 5.45. SBS cooling water and bed temperatures (hourly average values) during Test 4.

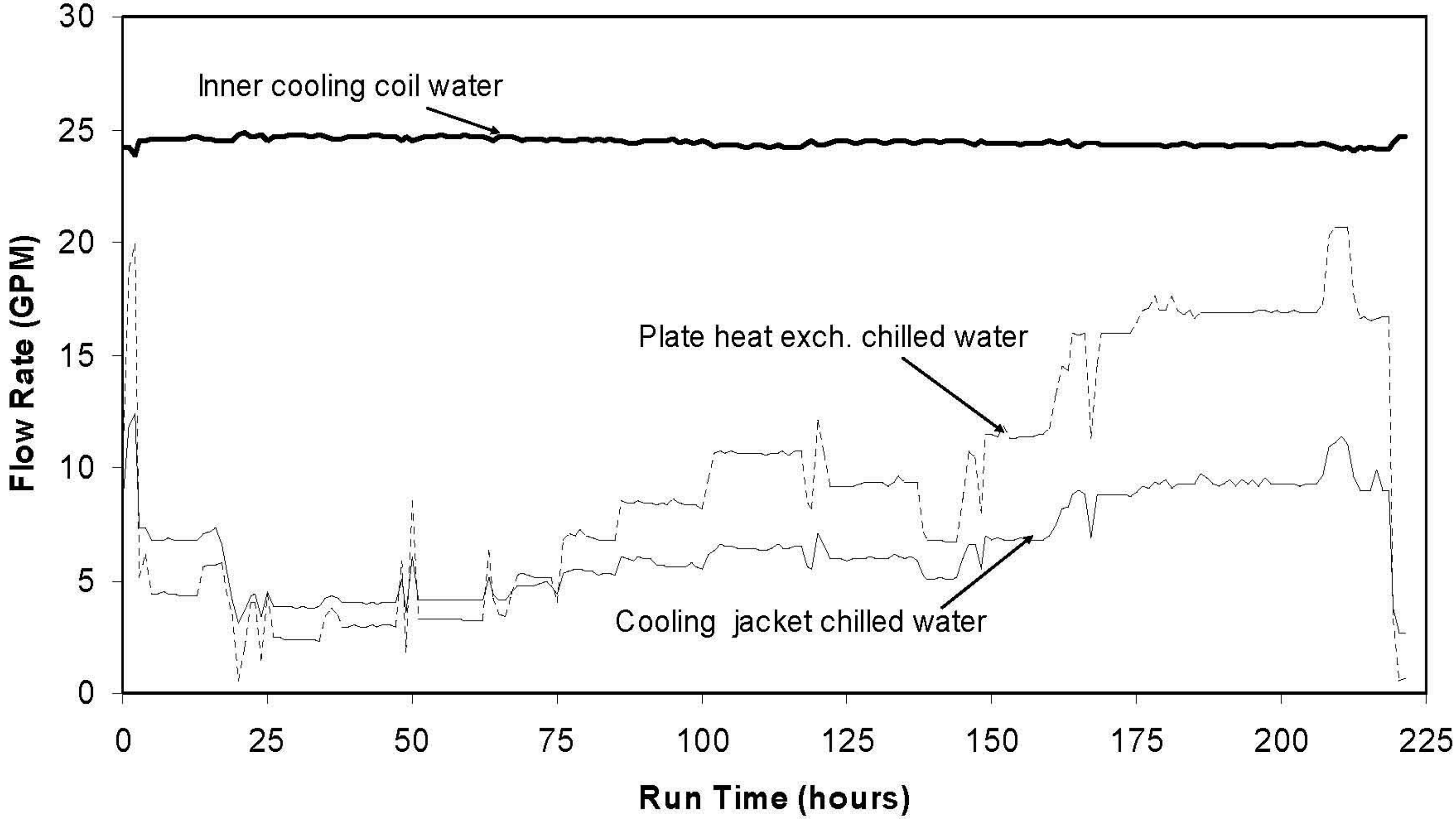

Figure 5.46. SBS jacket, inner coil and heat exchanger water flow rates (hourly average values) during Test 4.

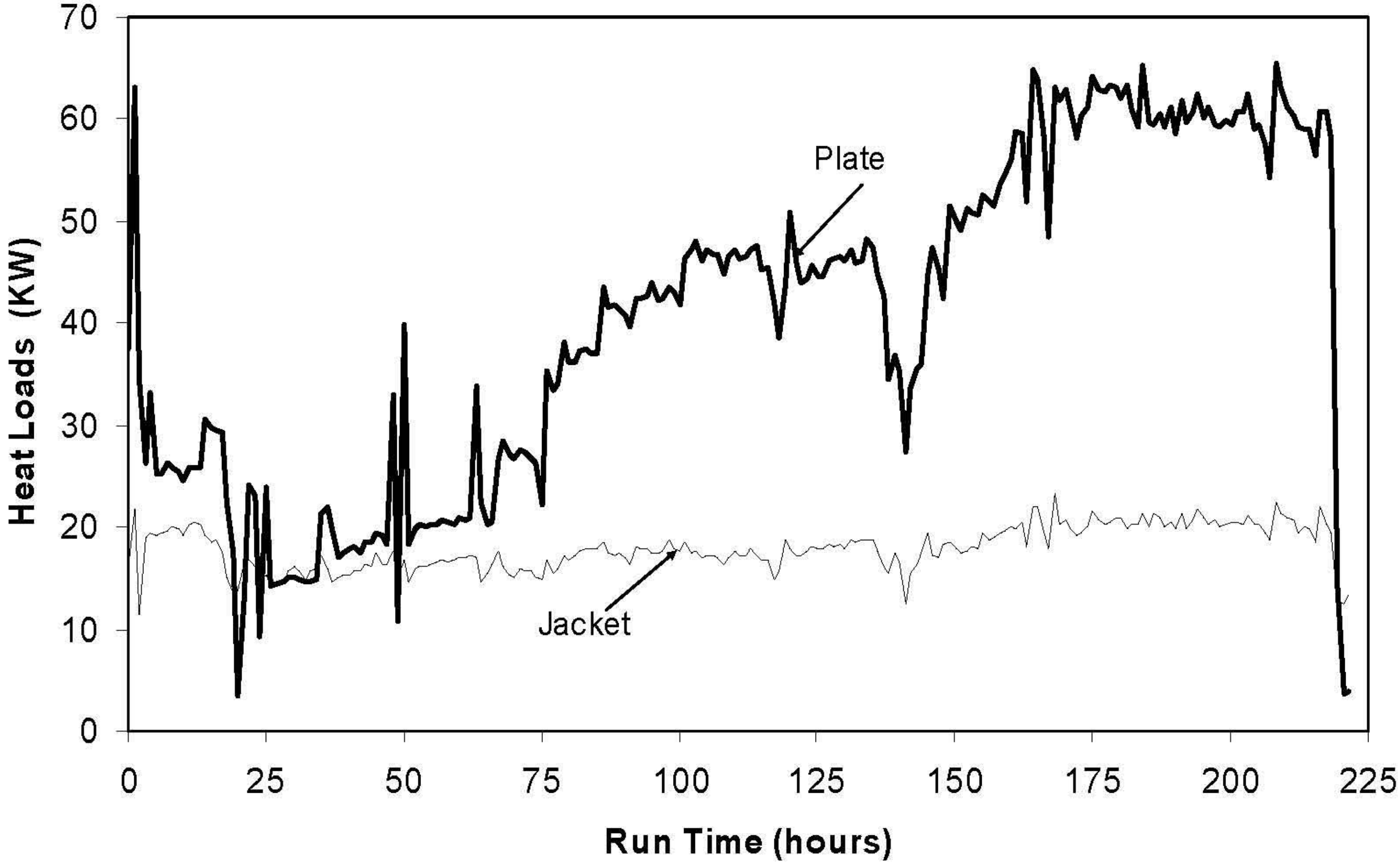

Figure 5.47. Calculated heat loads on the cooling jacket and plate heat exchanger (hourly average values) during Test 4.

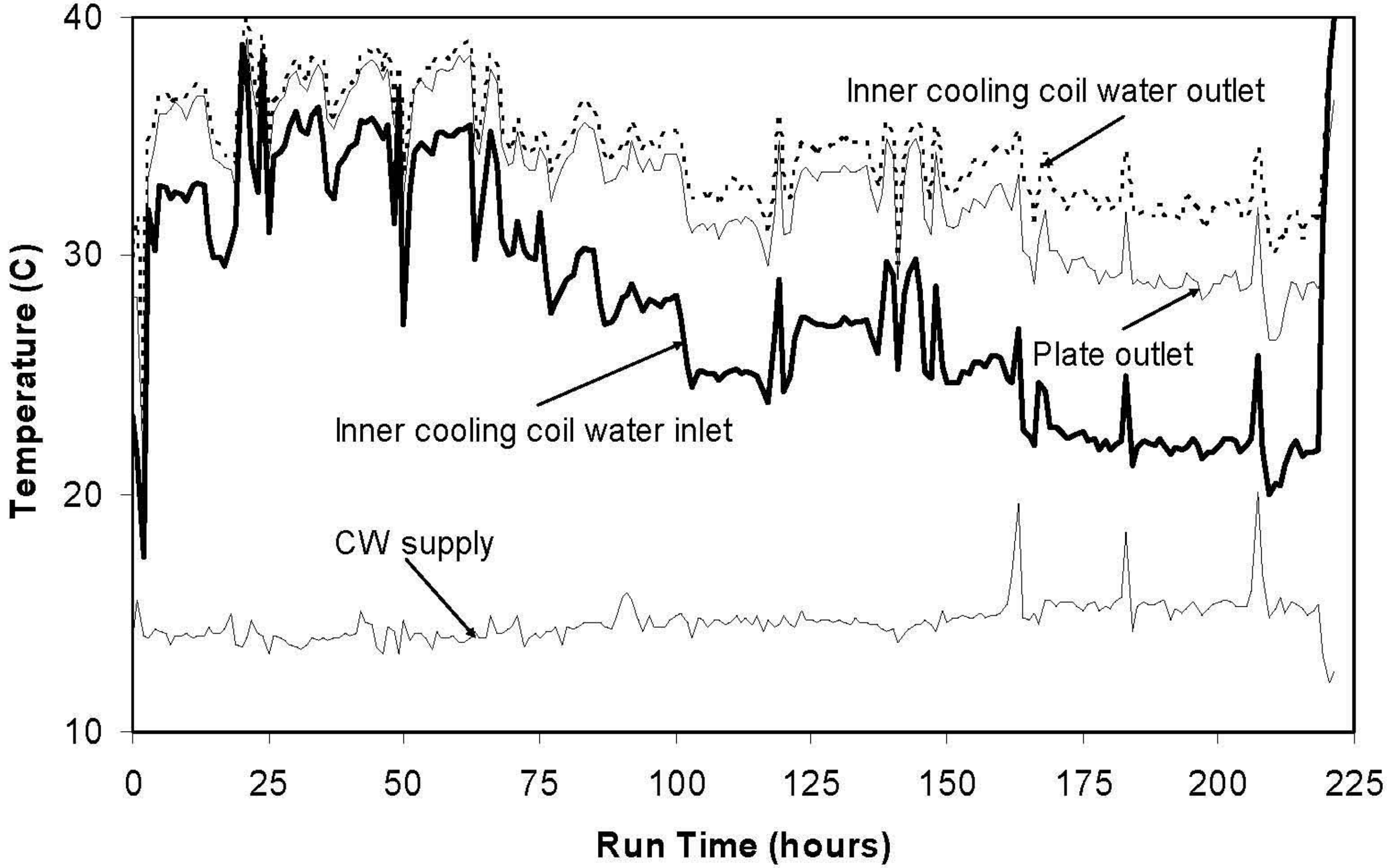

Figure 5.48. SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Test 4.

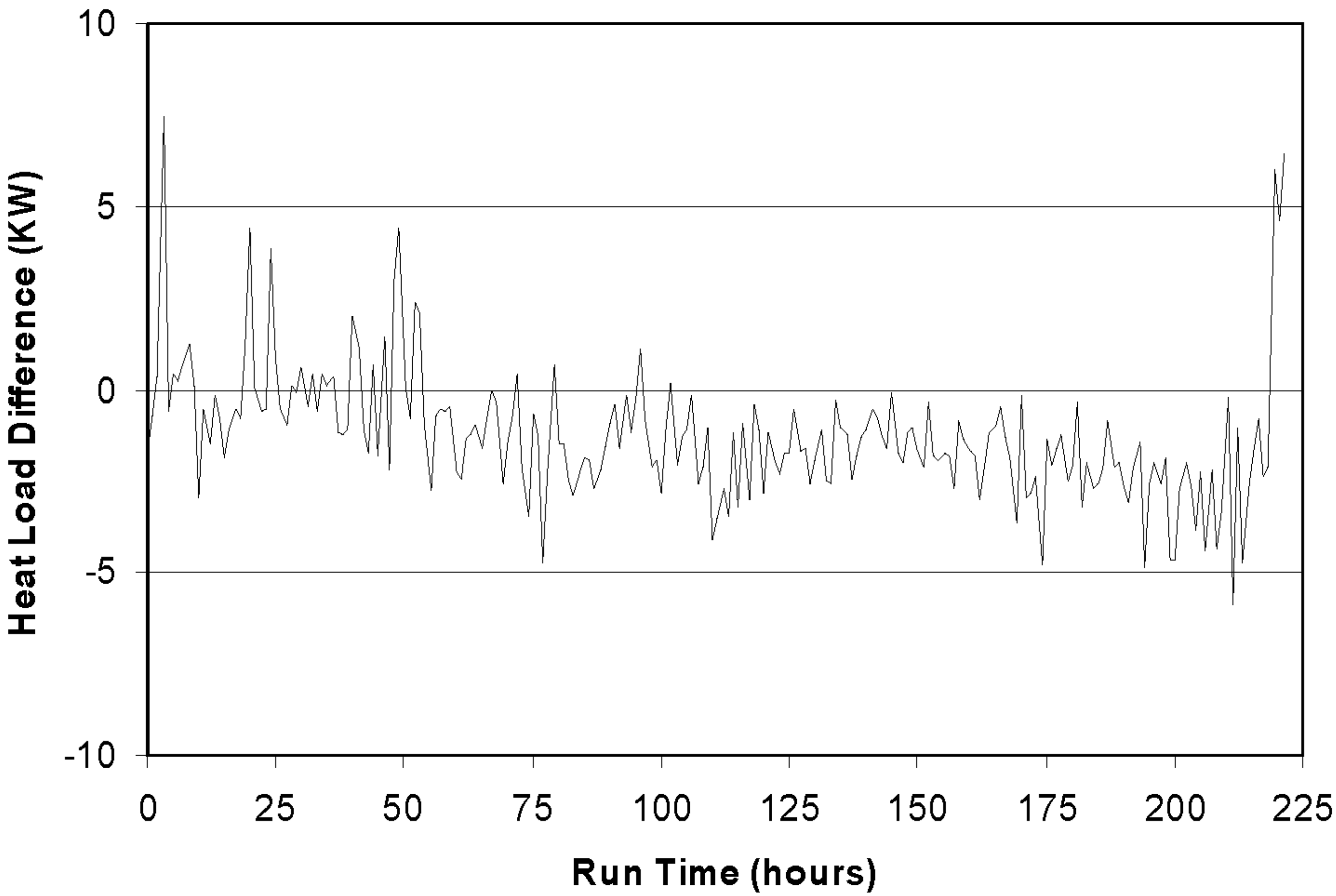

Figure 5.49. Calculated heat load difference between plate heat exchanger and SBS inner coil (hourly average values) during Test 4.

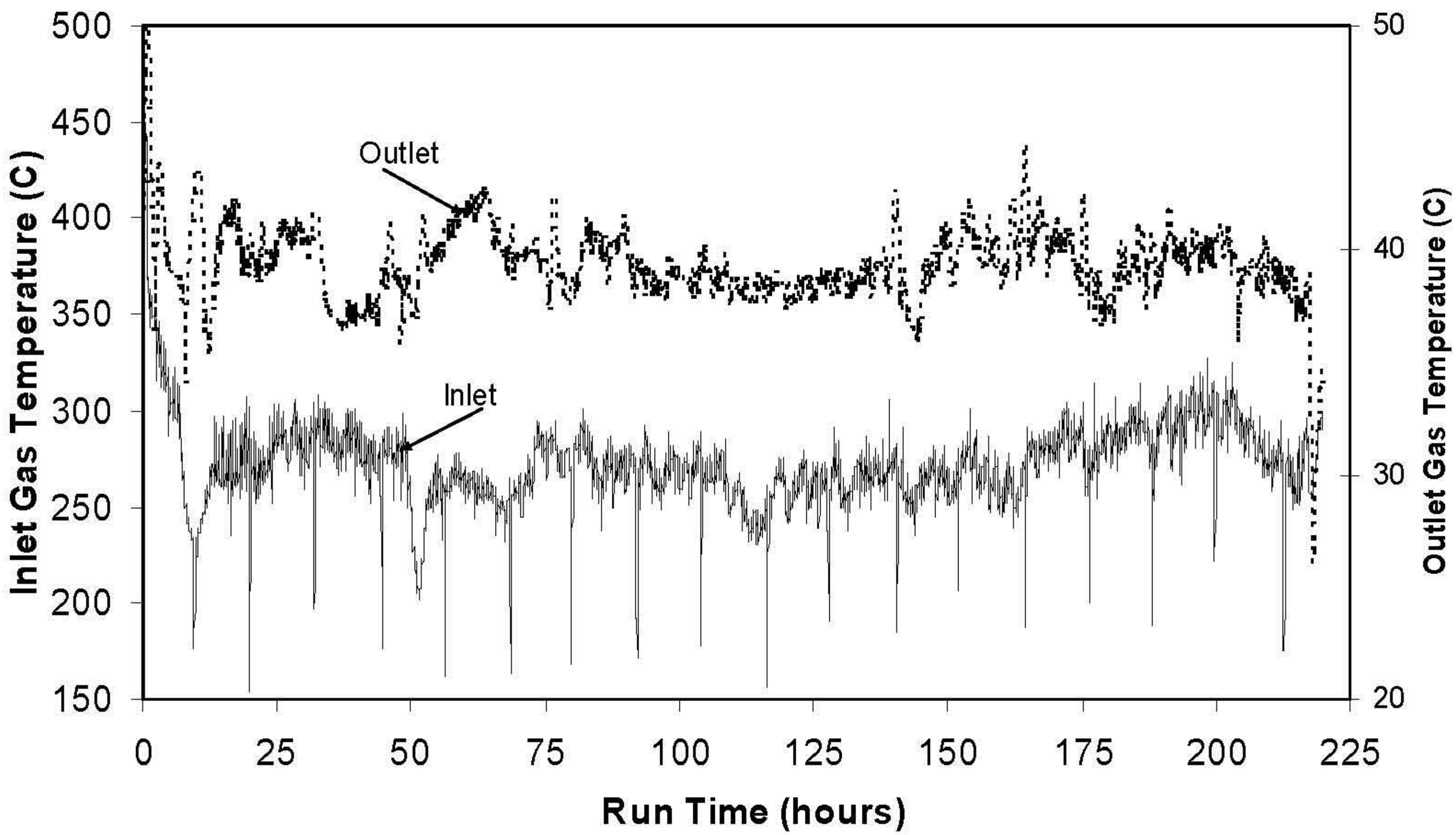

Figure 5.50. SBS inlet and outlet gas temperatures during Test 5.

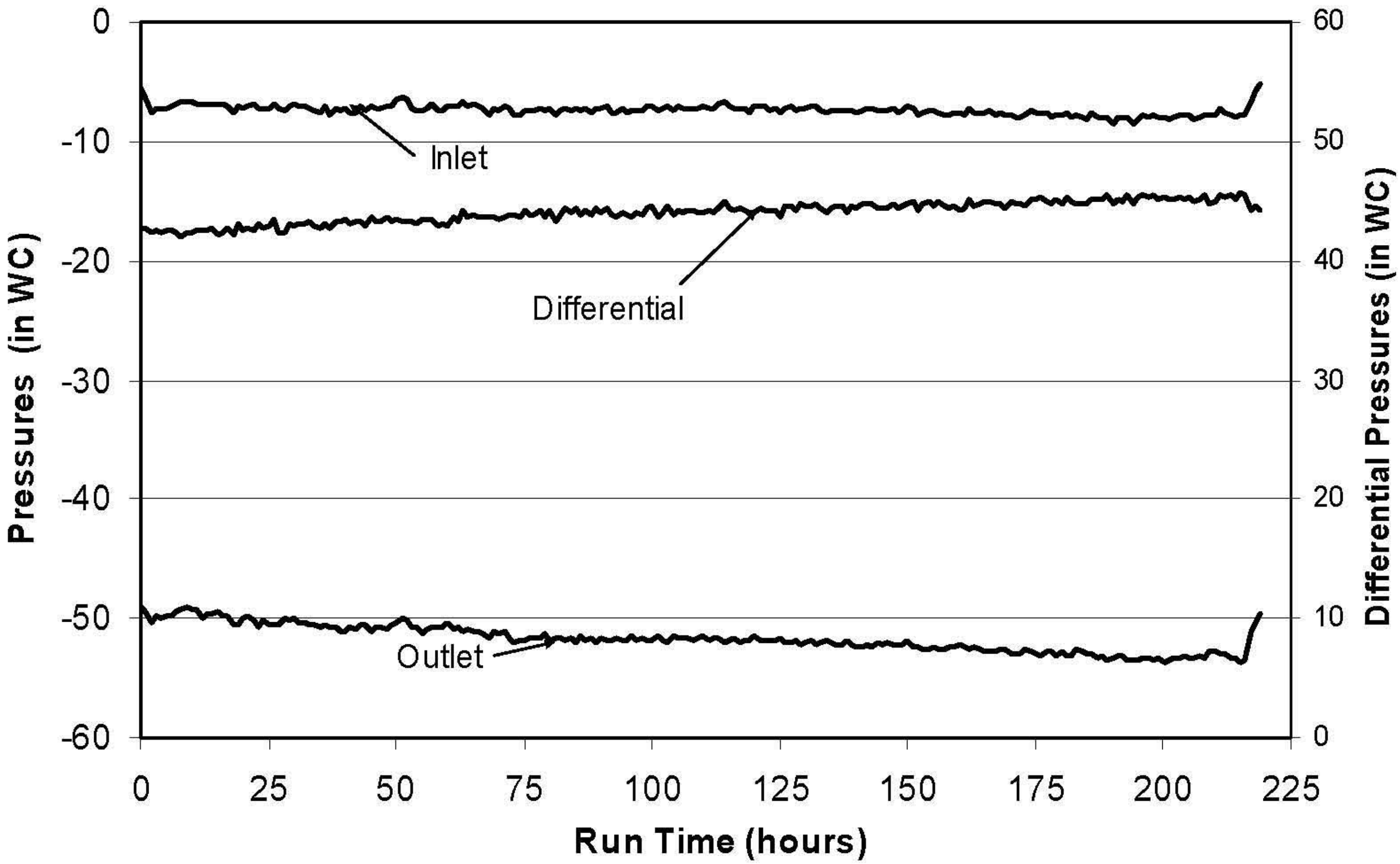

Figure 5.51. SBS inlet, outlet and differential pressures (hourly average values) during Test 5.

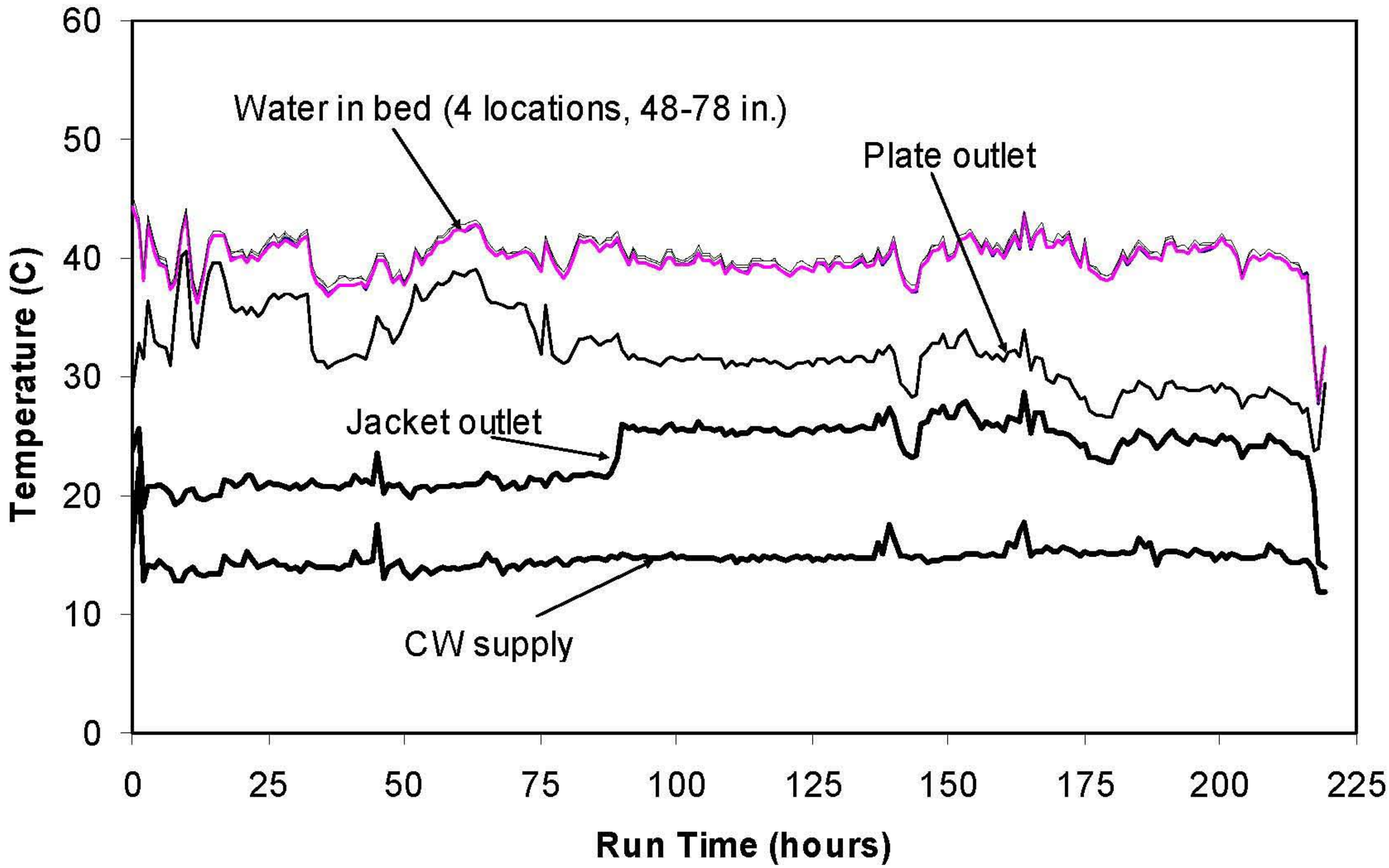

Figure 5.52. SBS cooling water and bed temperatures (hourly average values) during Test 5.

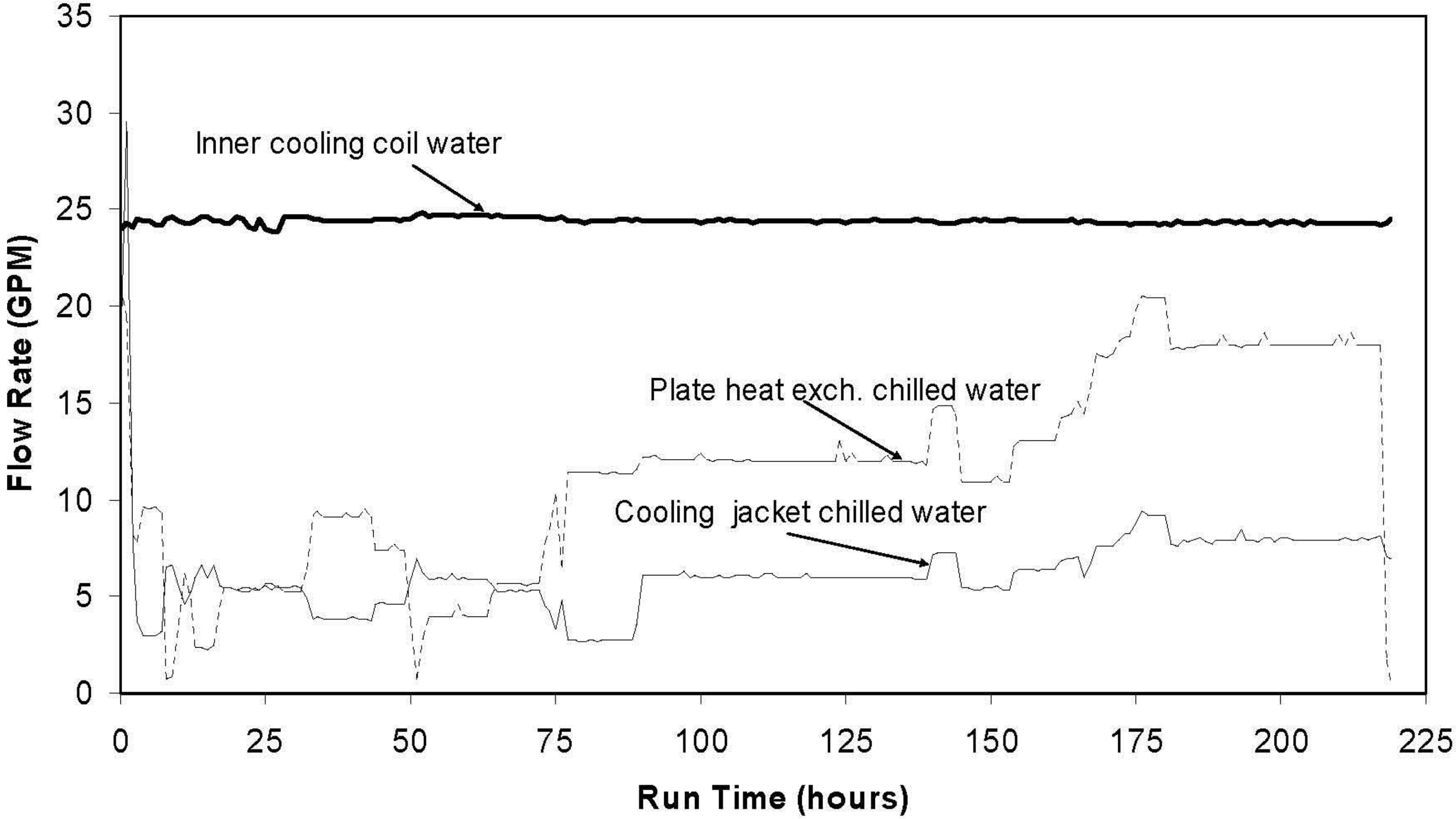

Figure 5.53. SBS jacket, inner coil and heat exchanger water flow rates (hourly average values) during Test 5.

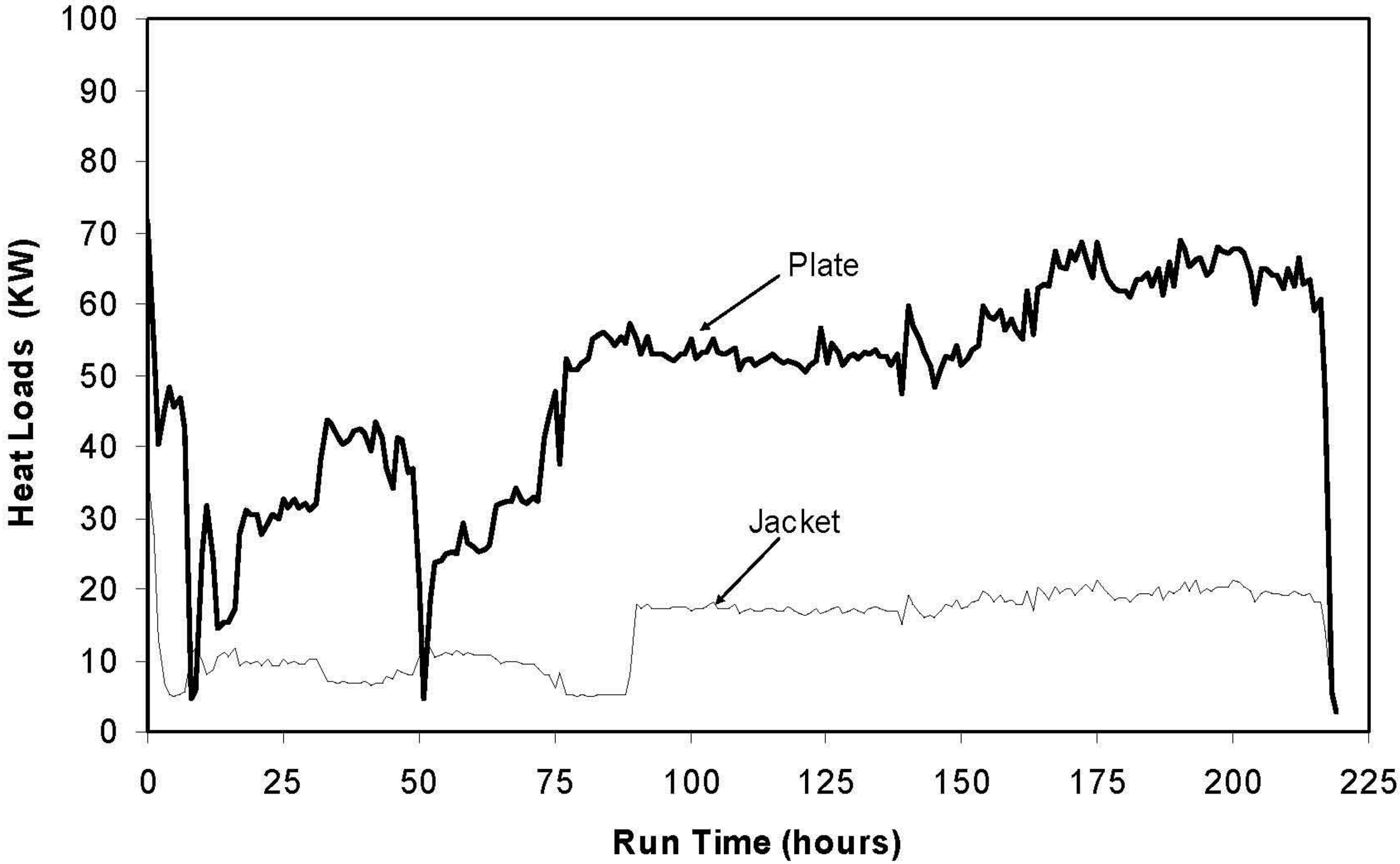

Figure 5.54. Calculated heat loads on the cooling jacket and the plate heat exchanger (hourly average values) during Test 5.

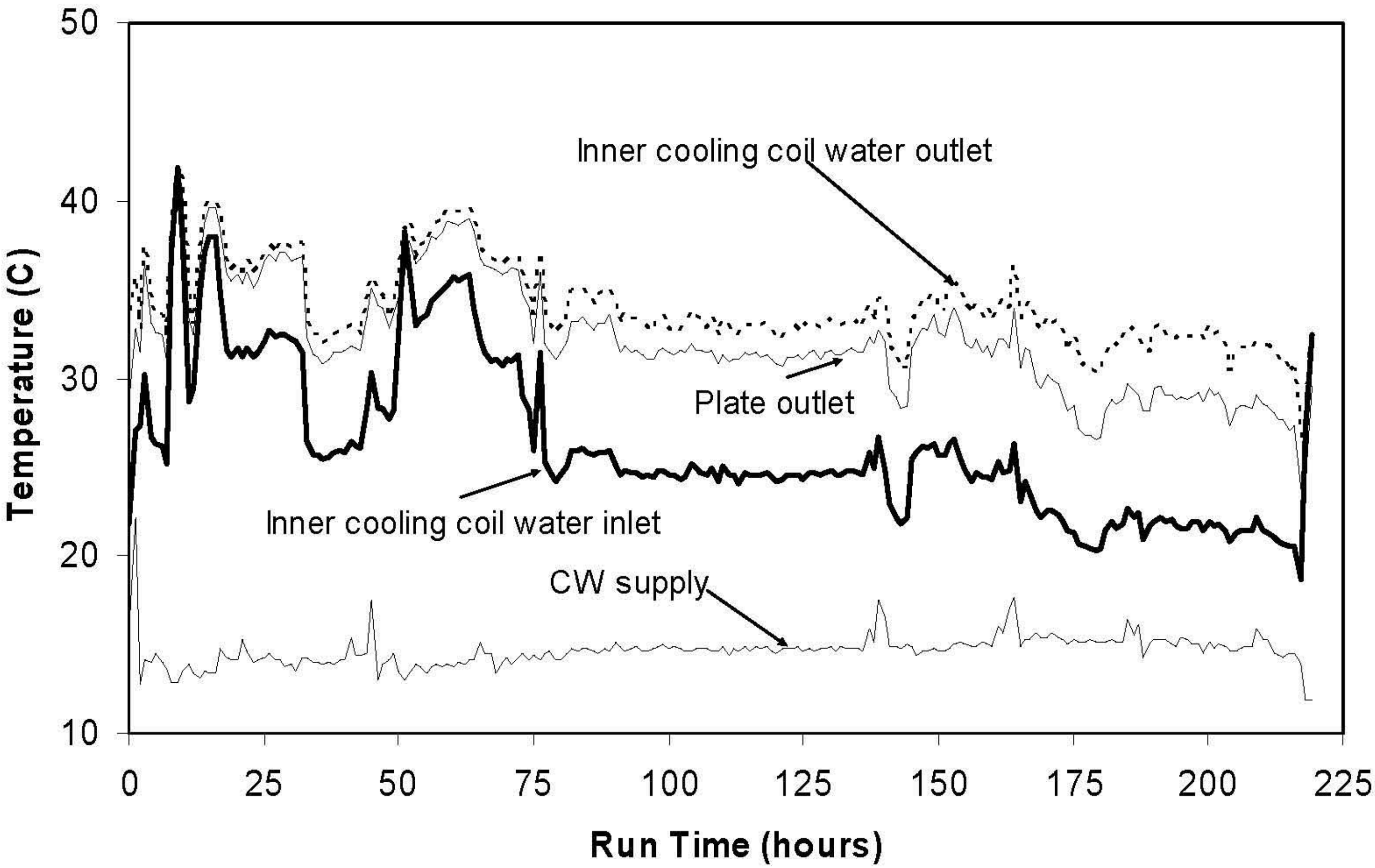

Figure 5.55. SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Test 5.

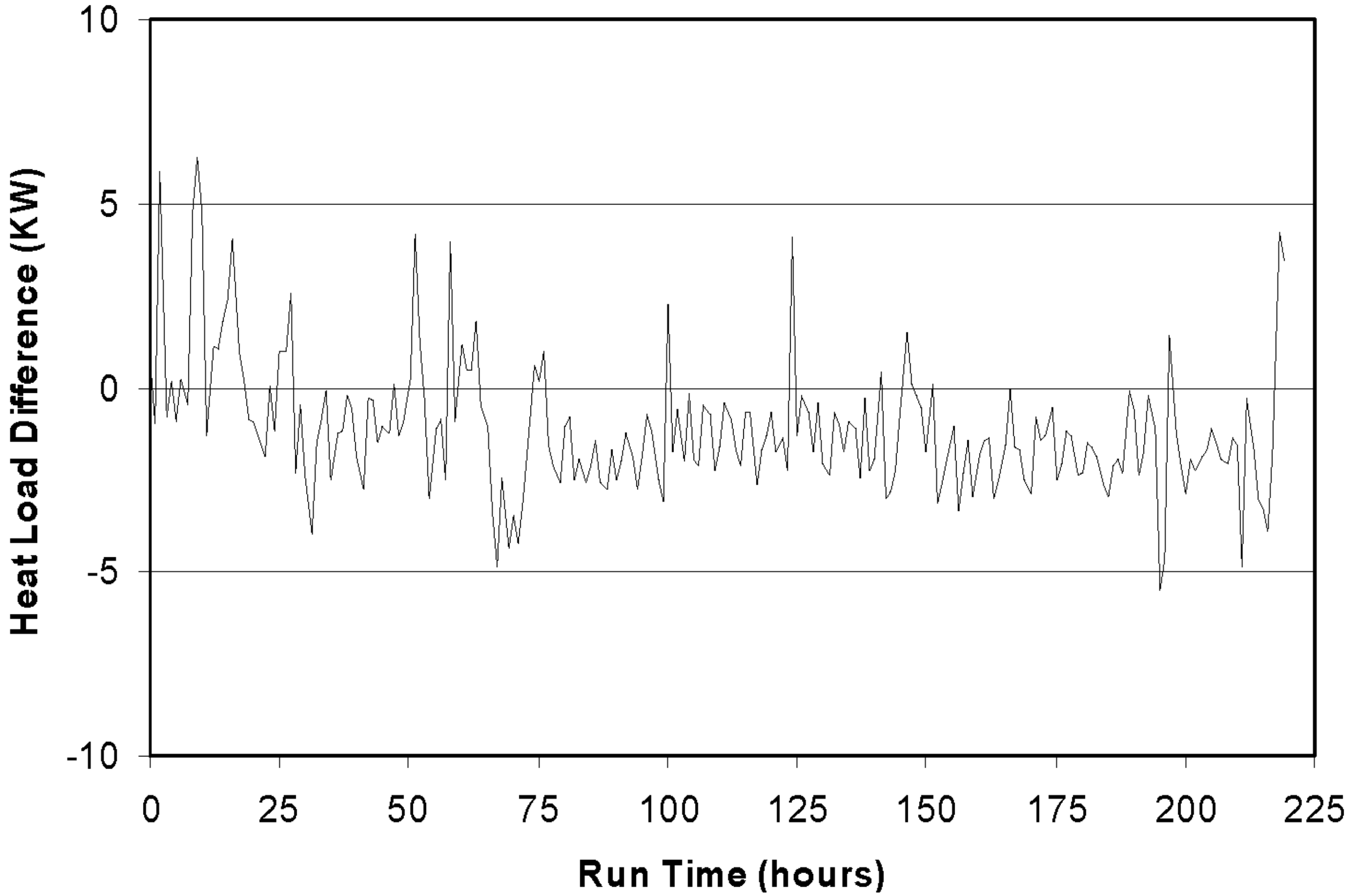

Figure 5.56. Calculated heat load difference between plate heat exchanger and SBS inner coil (hourly average values) during Test 5.

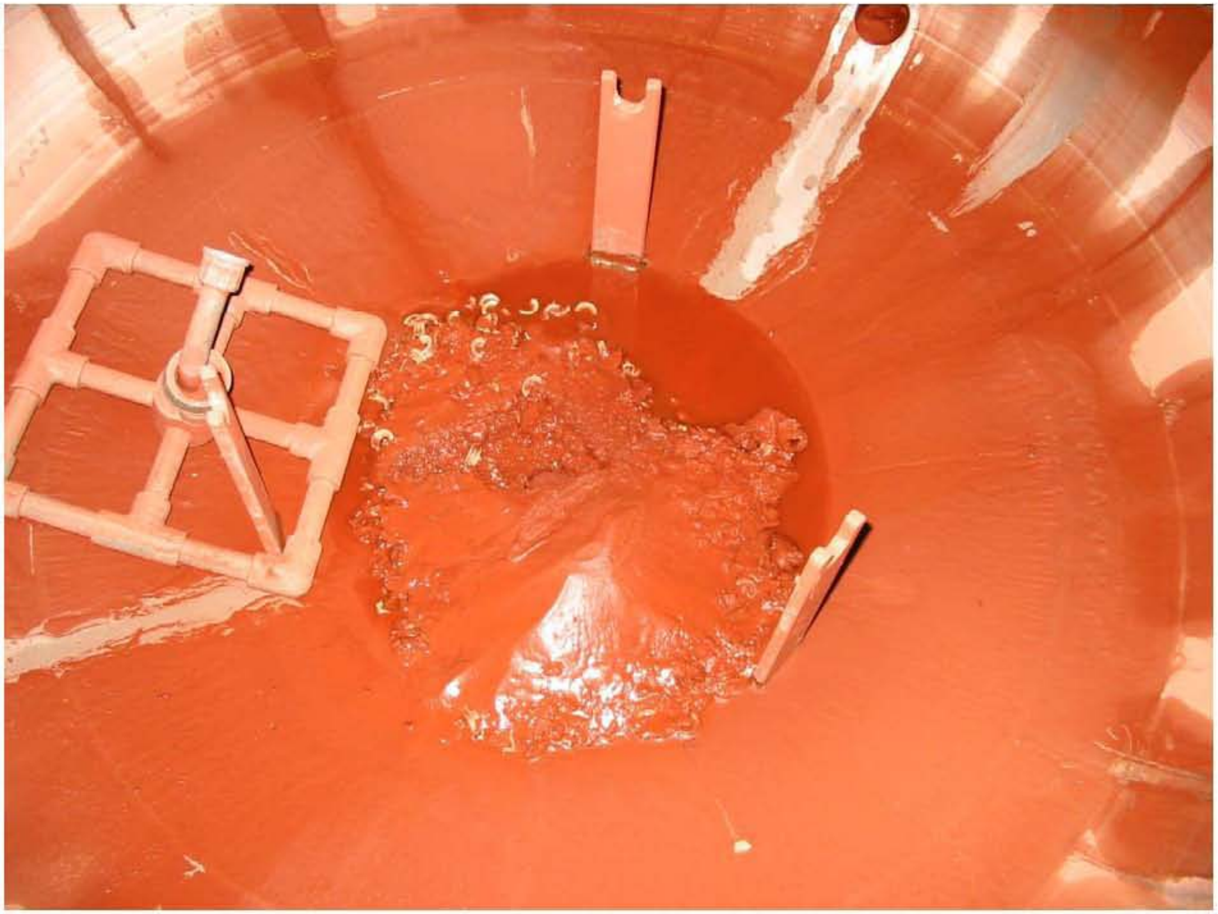

Figure 5.57. SBS bowl before cleaning after Test 5.

Figure 5.58. Close-up view of SBS bowl before cleaning after Test 5.

Figure 5.59. Another close-up view of SBS bowl before cleaning after Test 5.

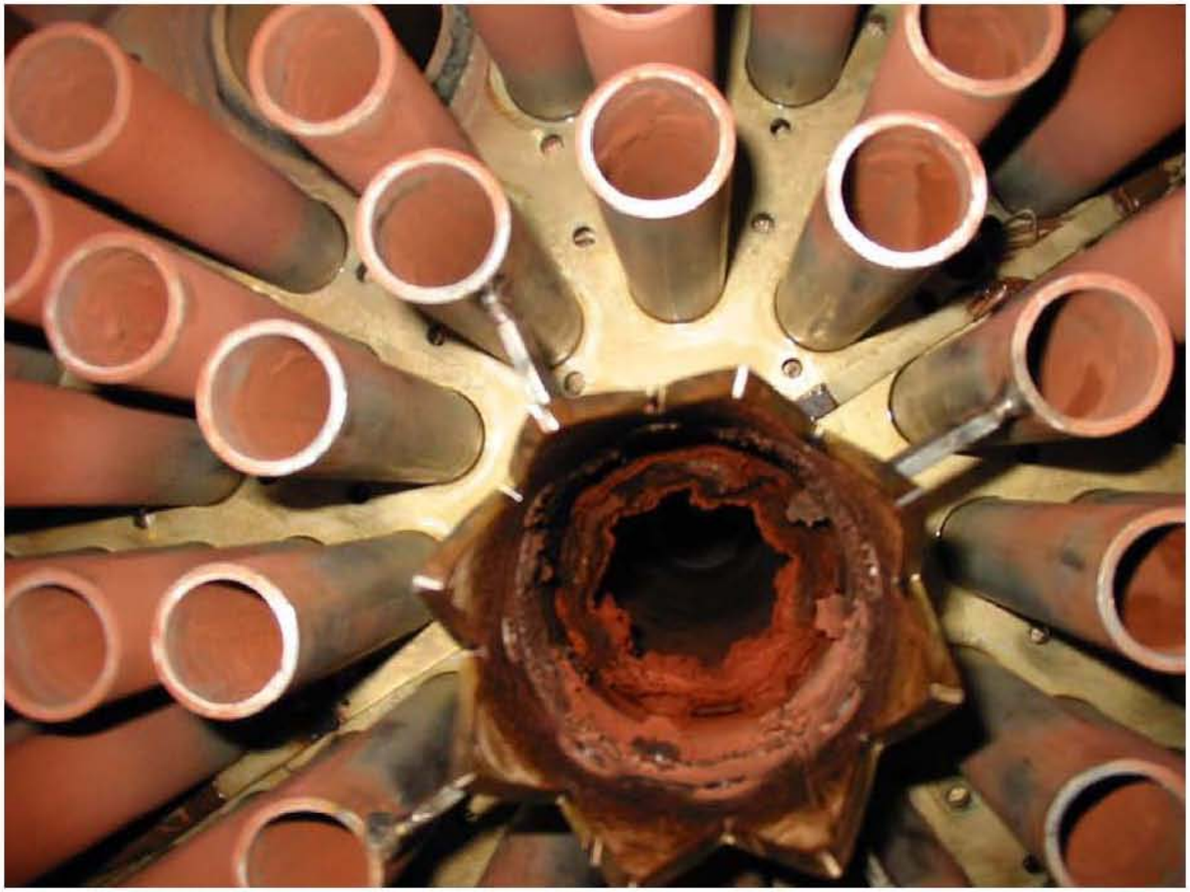

Figure 5.60. SBS weir tubes and down-comer before cleaning after Test 5.

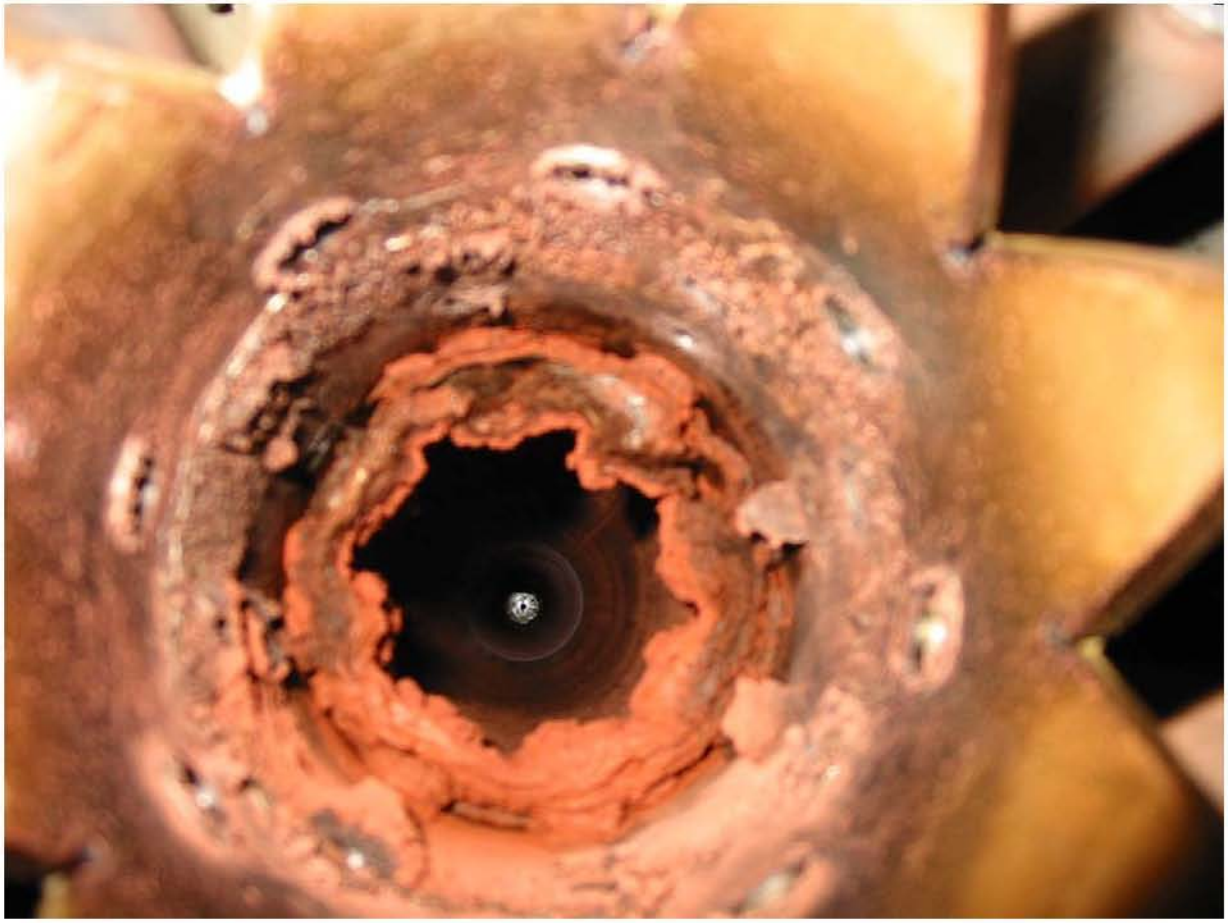

Figure 5.61. SBS down-comer end before cleaning after Test 5.

Figure 5.62. View of SBS of down-comer from inlet viewport before cleaning after Test 5.

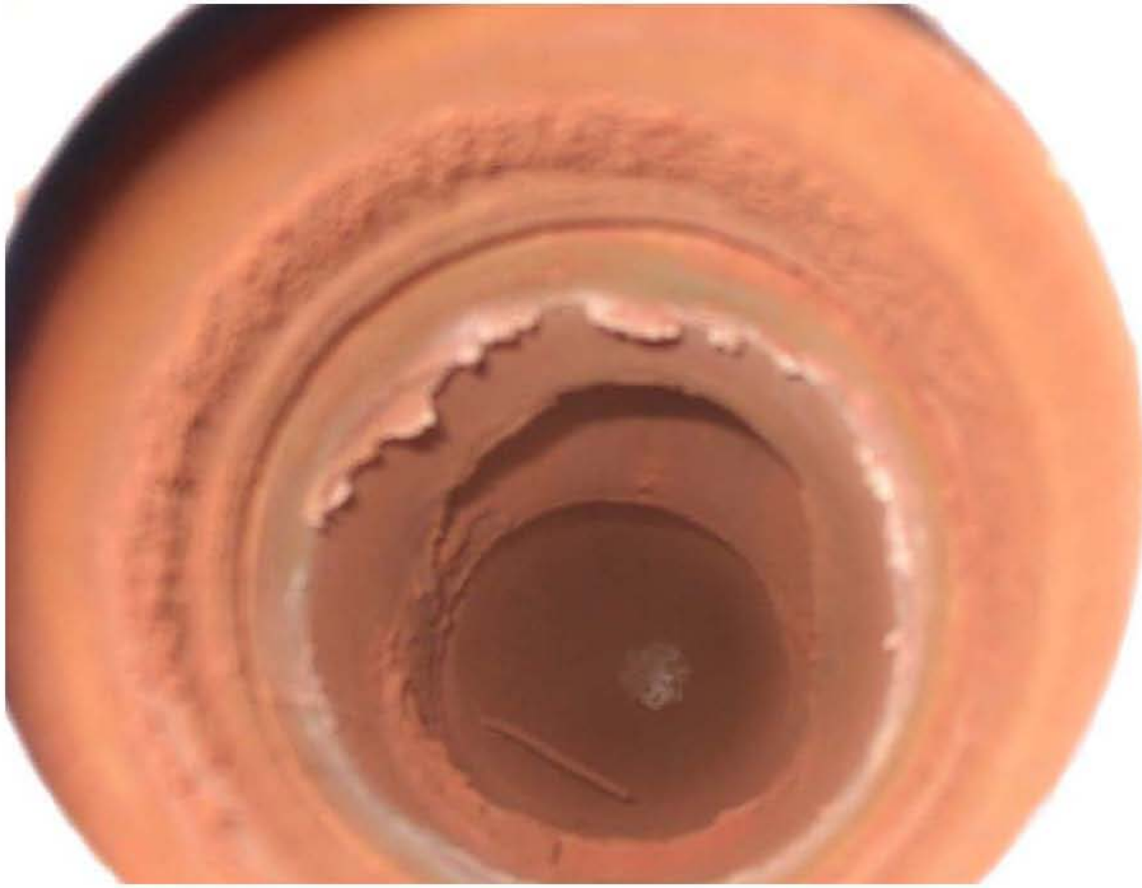

Figure 5.63. Close-up view of SBS down-comer from inlet viewport before cleaning after Test 5.

Figure 5.64. SBS bowl after cleaning after Test 5.

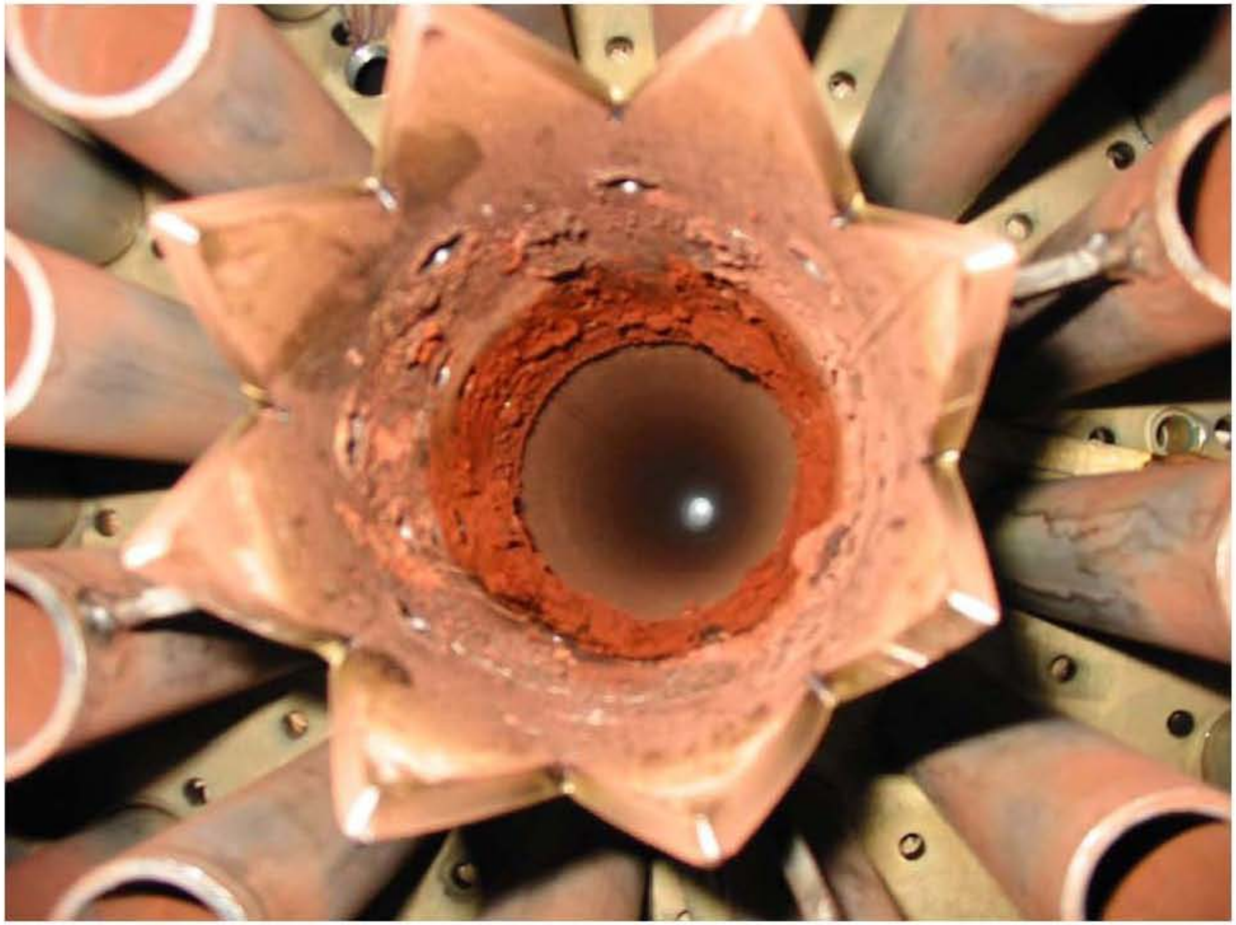

Figure 5.65. SBS down-comer after first attempt to clean after Test 5.

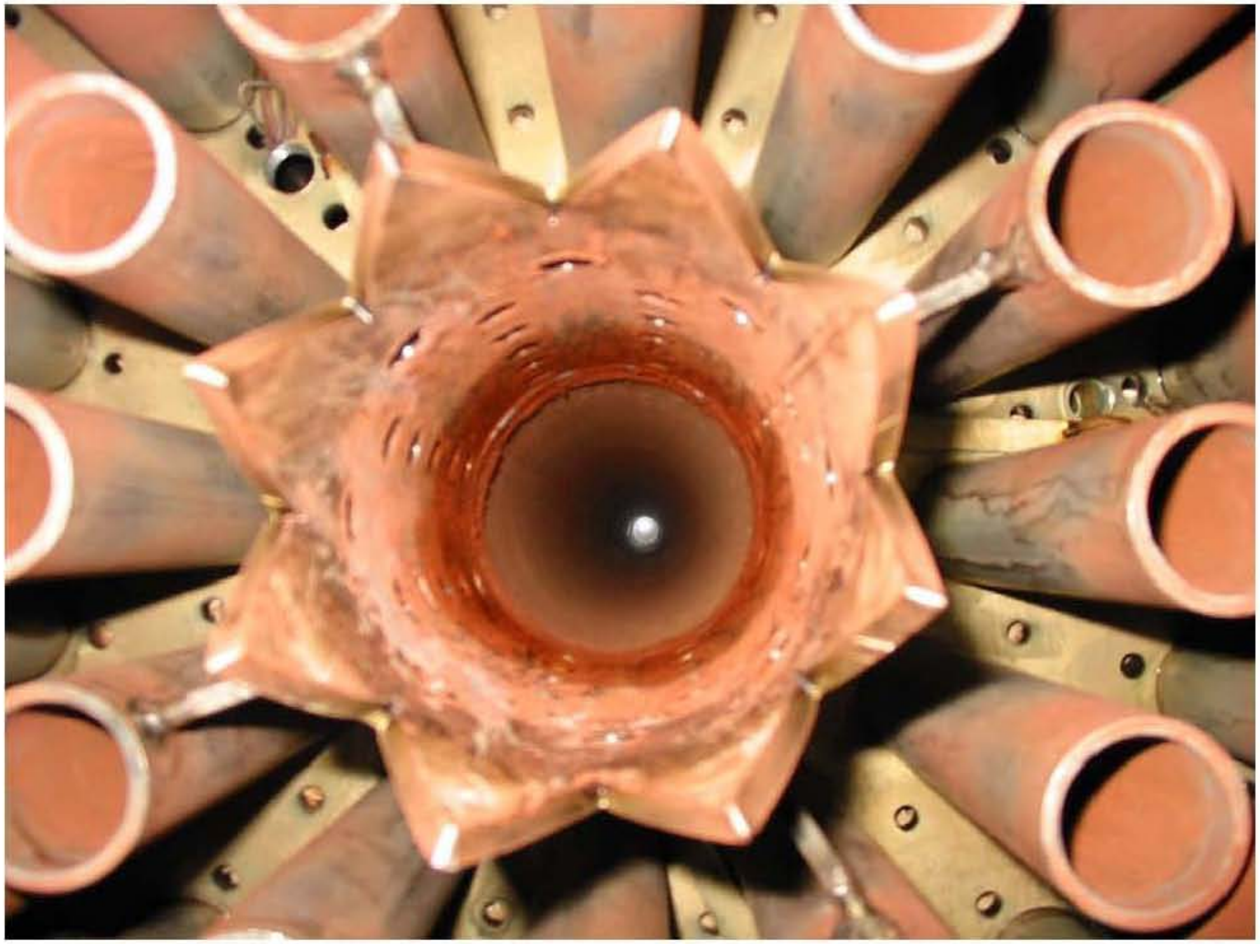

Figure 5.66. SBS down-comer after second cleaning after Test 5.

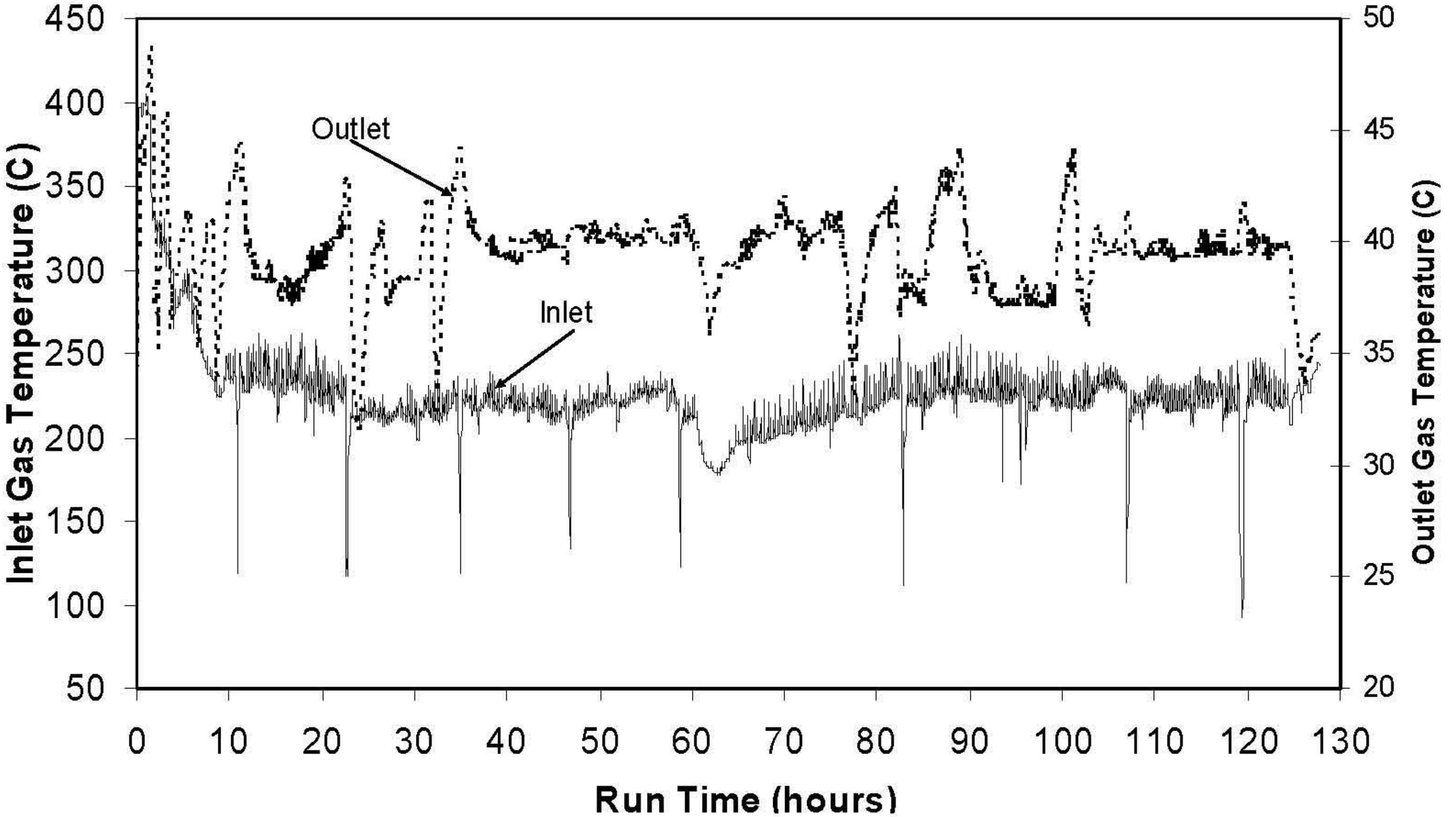

Figure 5.67. SBS inlet and outlet gas temperatures during Test 6.

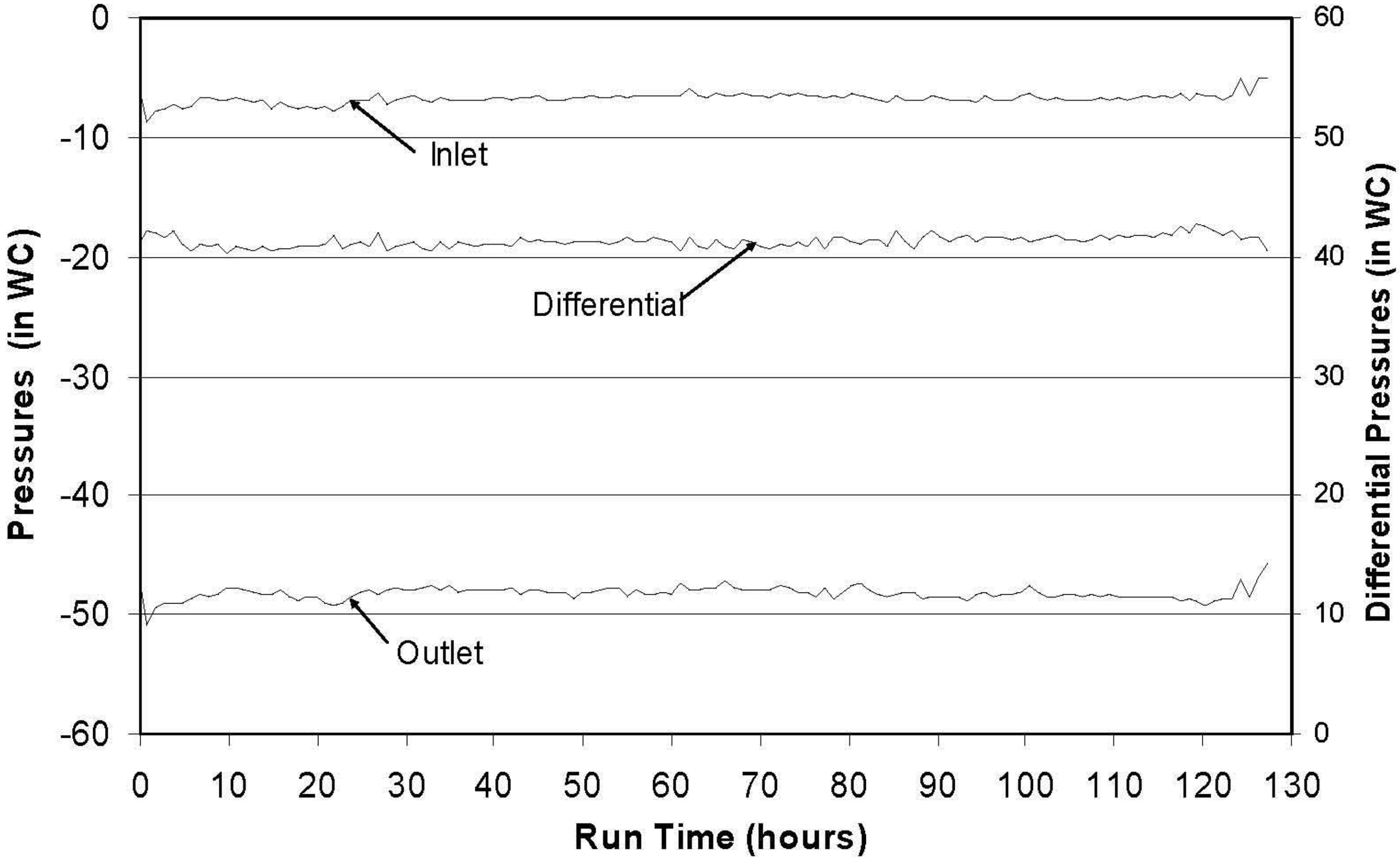

Figure 5.68. SBS inlet, outlet and differential pressures (hourly average values) during Test 6.

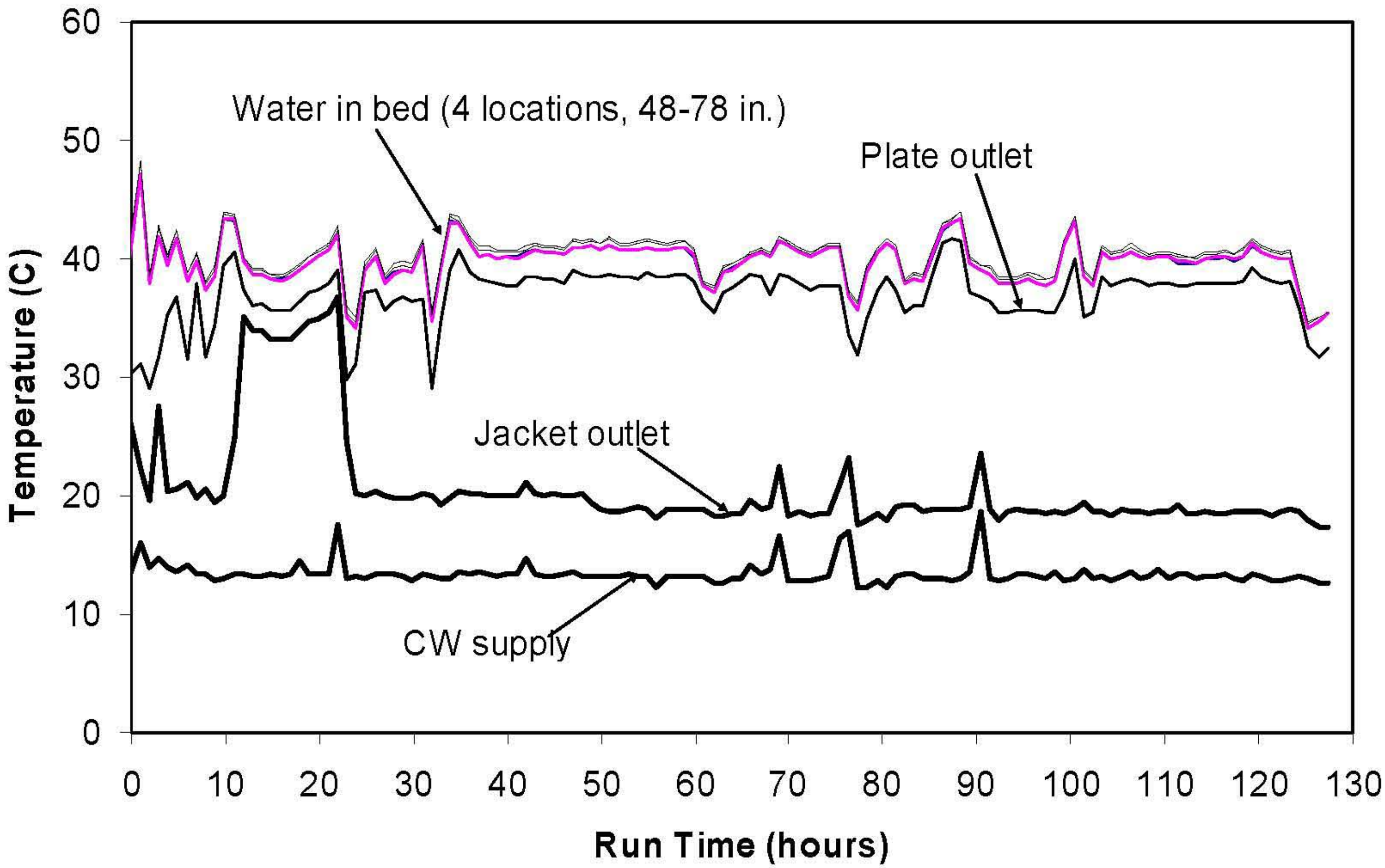

Figure 5.69. SBS cooling water and bed temperatures (hourly average values) during Test 6.

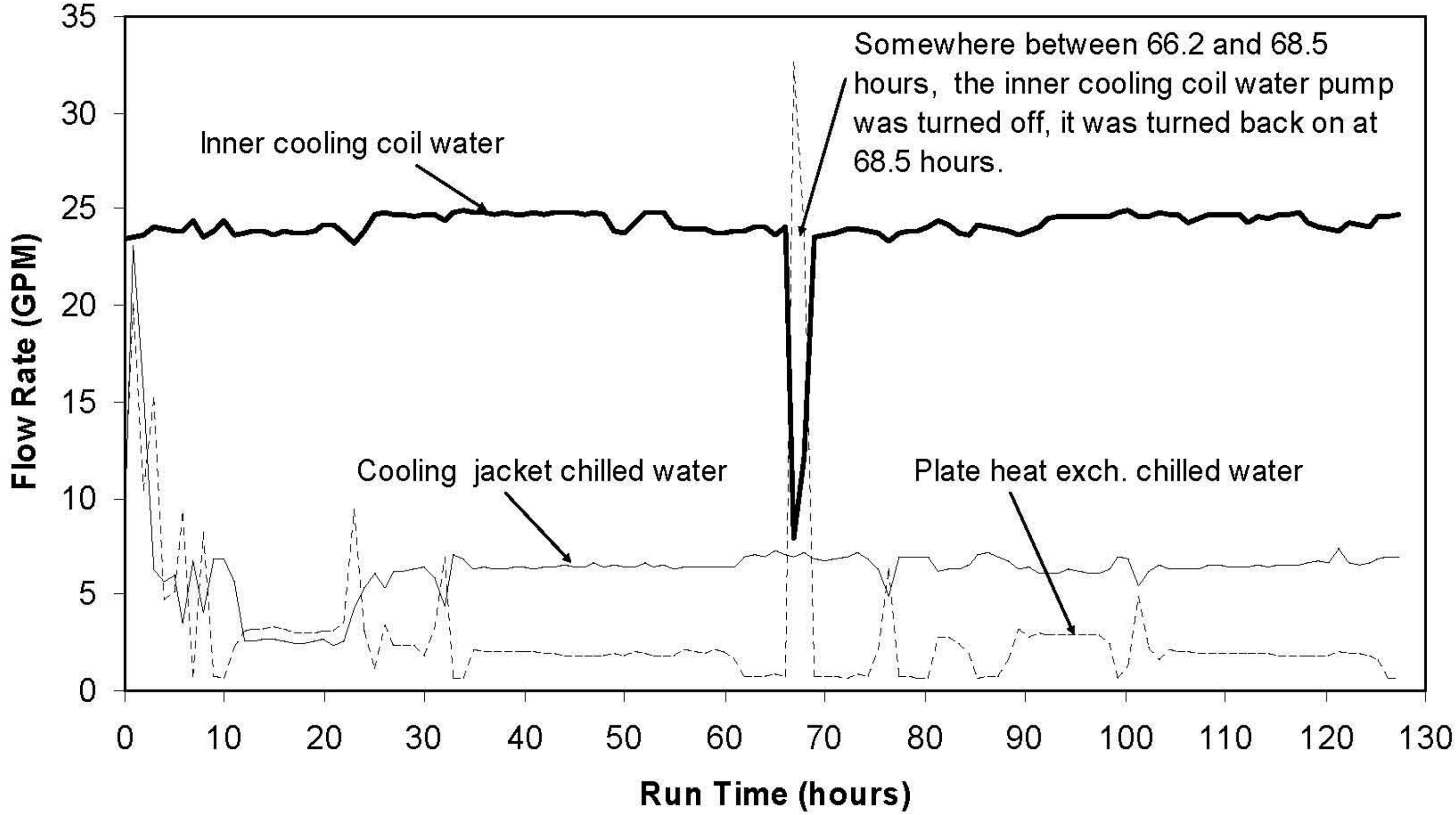

Figure 5.70. SBS jacket, inner coil and heat exchanger water flow rates (hourly average values) during Test 6.

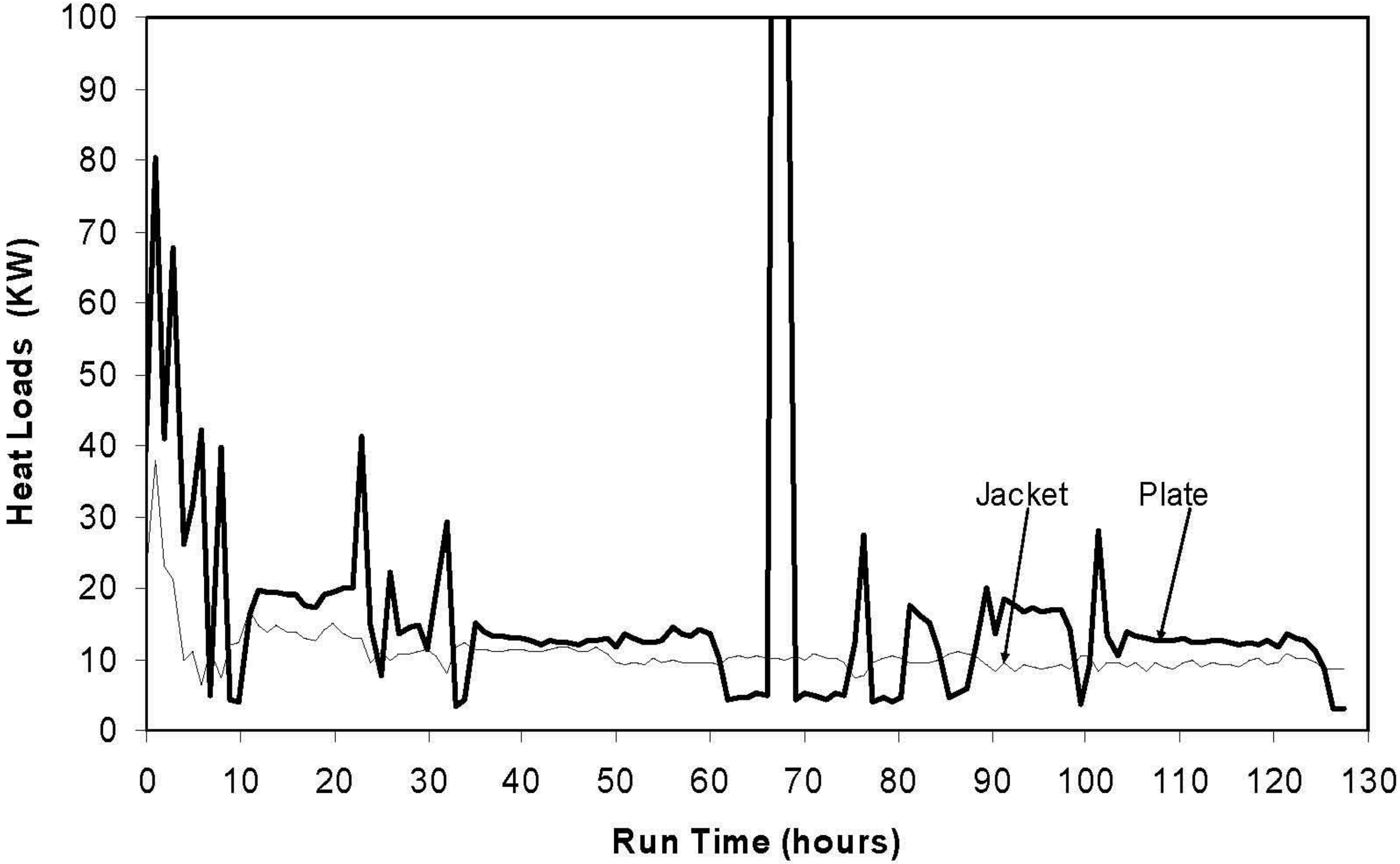

Figure 5.71. Calculated heat loads on the cooling jacket and plate exchanger (hourly average values) during Test 6.

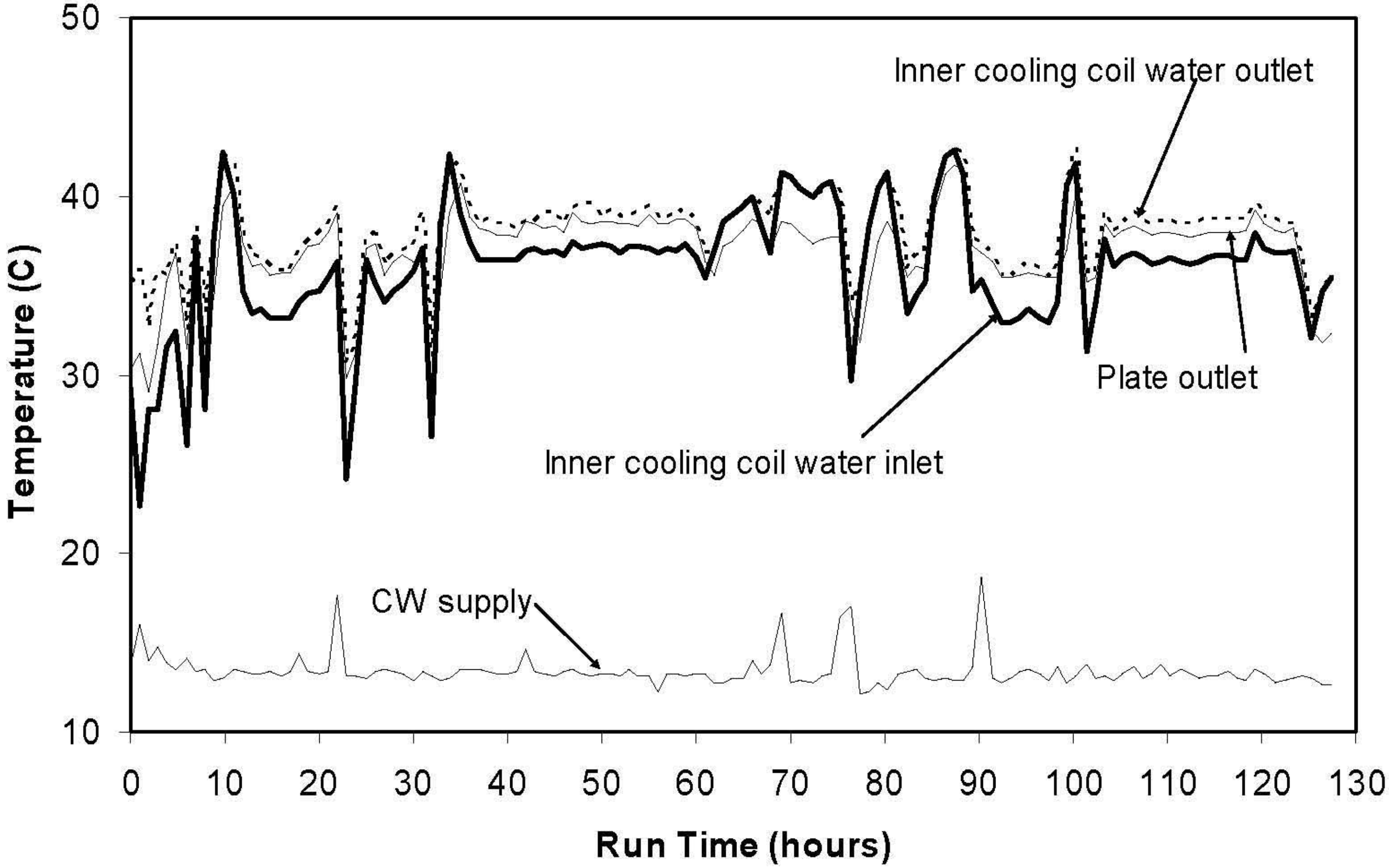

Figure 5.72. SBS inner coil and plate heat exchanger water temperatures (hourly average values) during Test 6.

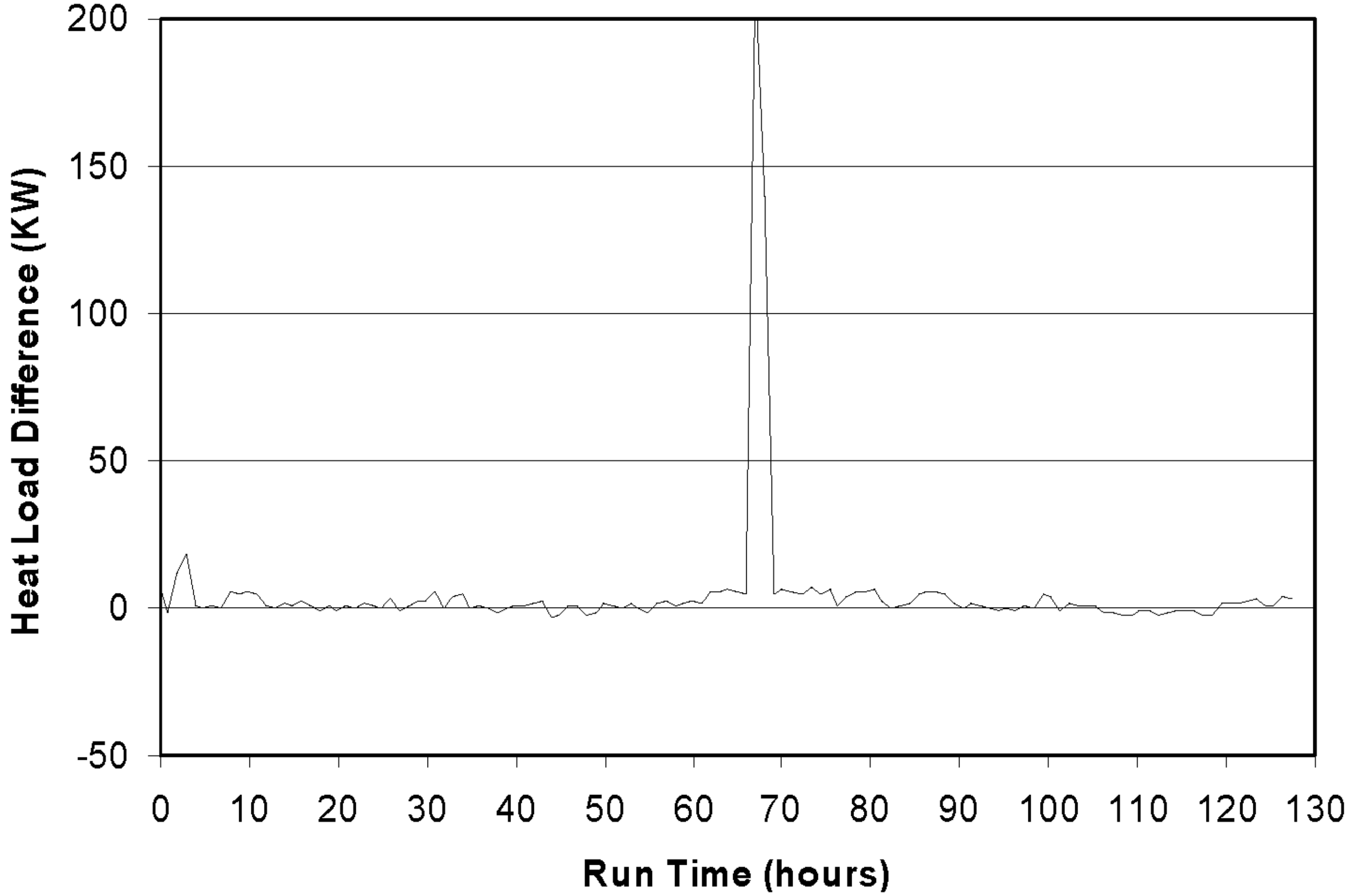

Figure 5.73. Calculated heat load difference between plate heat exchanger and SBS inner coil (hourly average values) during Test 6.

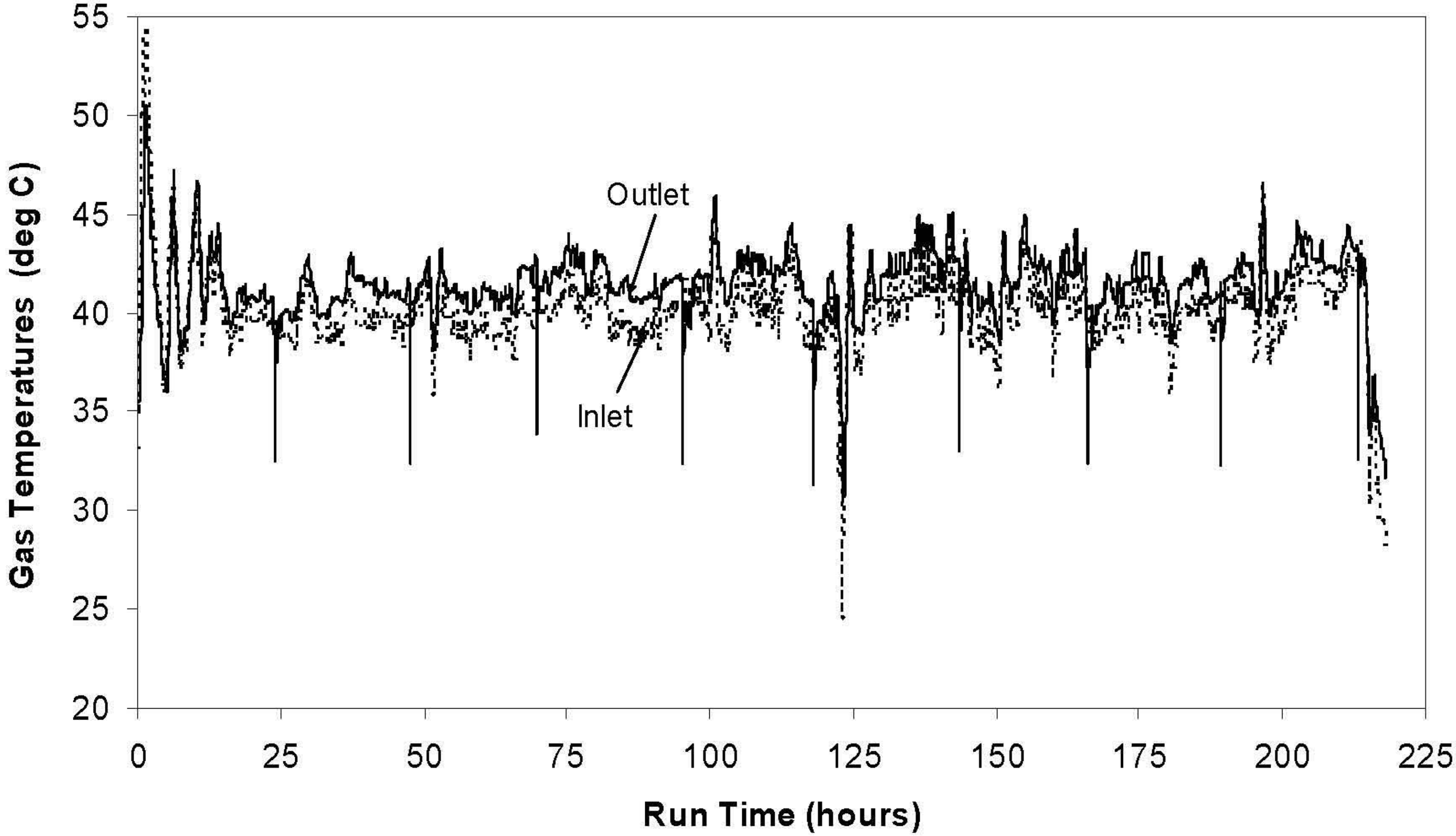

Figure 5.74. WESP inlet and outlet temperatures during Tests 1 and 2. (Note: Downward outlet temperature spikes are the result of WESP deluges.)

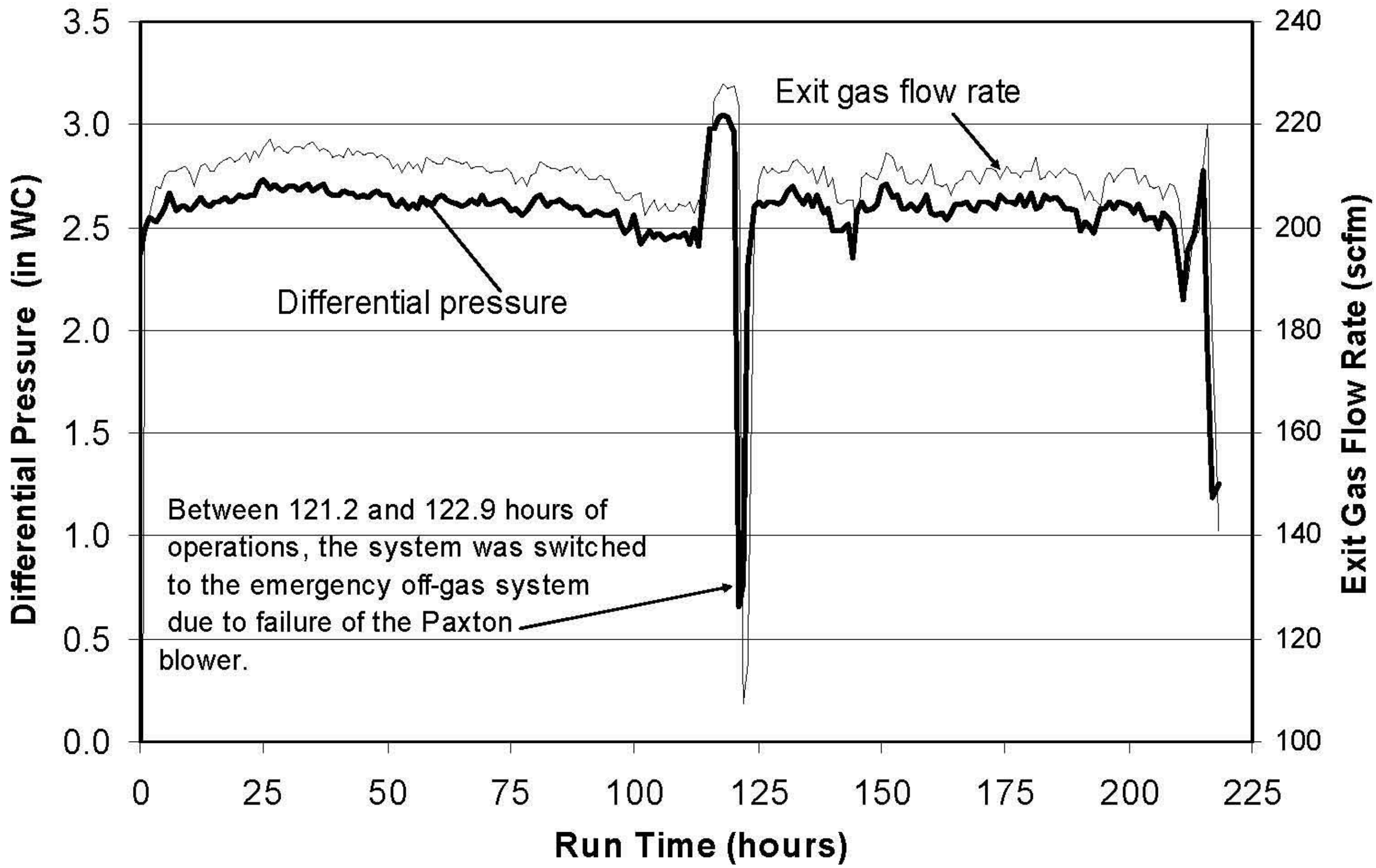

Figure 5.75. WESP differential pressure and outlet gas flow rate (hourly average values) during Tests 1 and 2.

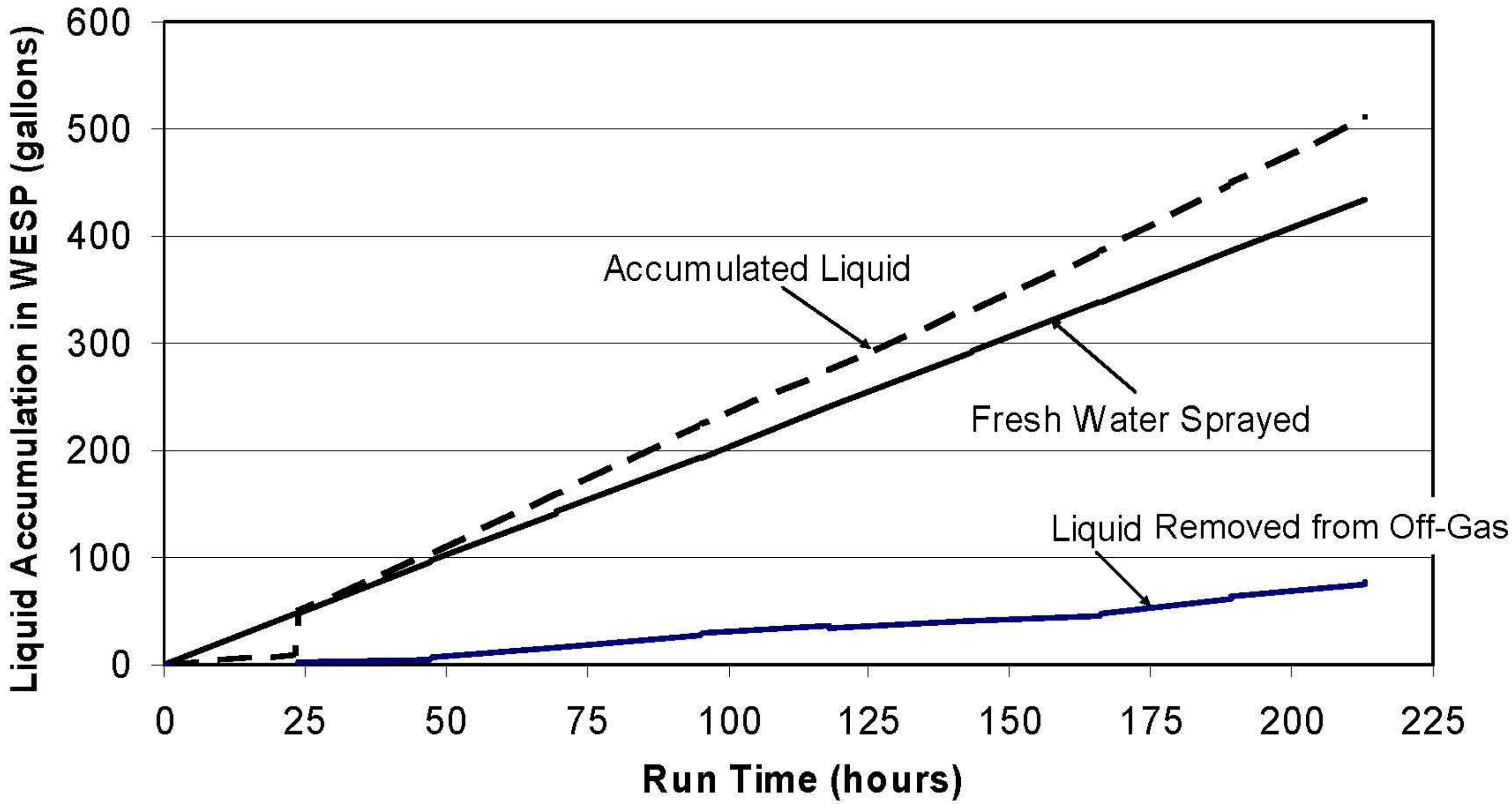

Figure 5.76. Accumulated WESP blow-down volume, accumulated fresh spray water and water removed from off-gas during Tests 1 and 2.

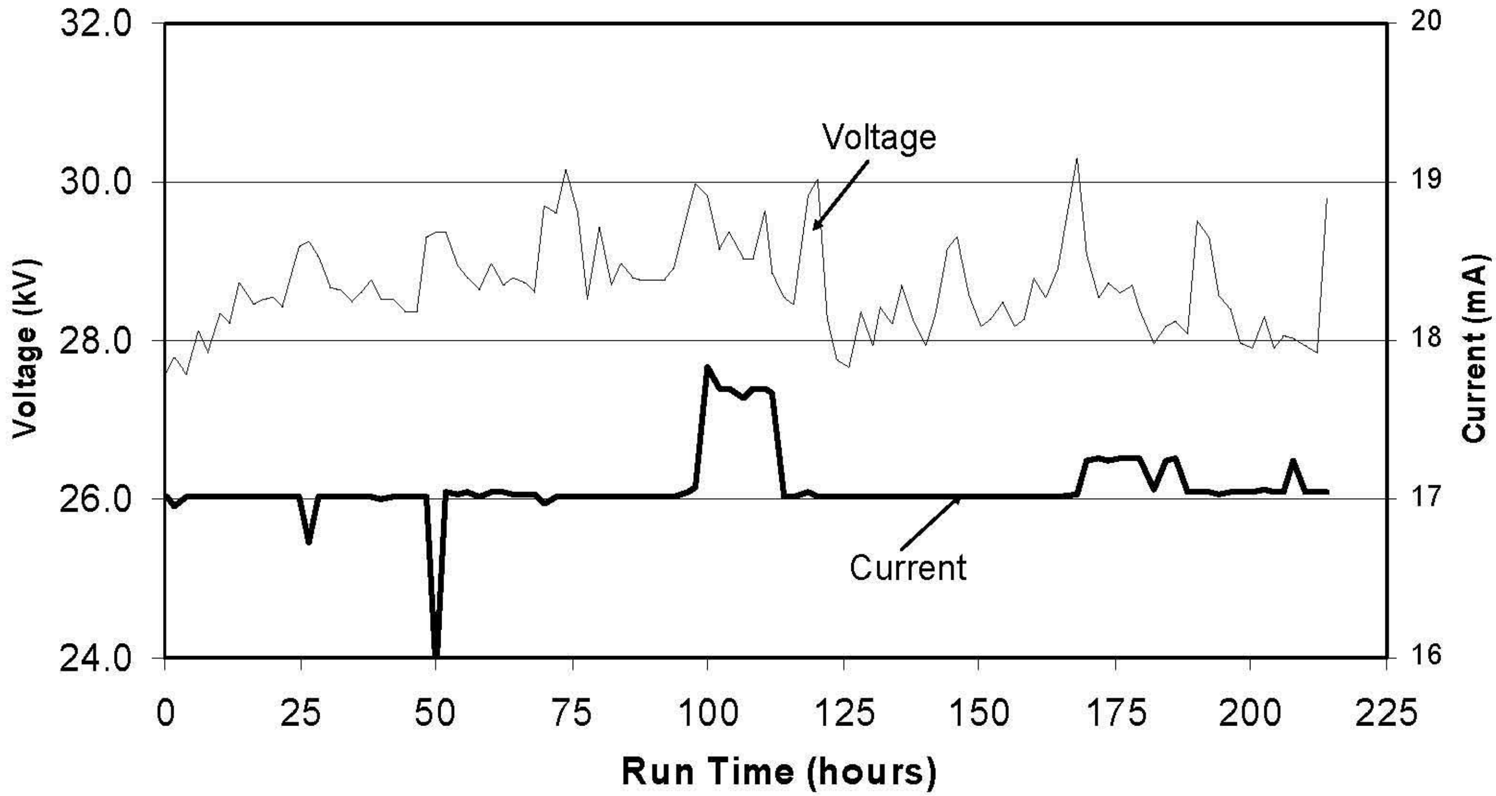

Figure 5.77. Voltage and current across the WESP during Tests 1 and 2. (Note: During the deluges, WESP was turned off.)

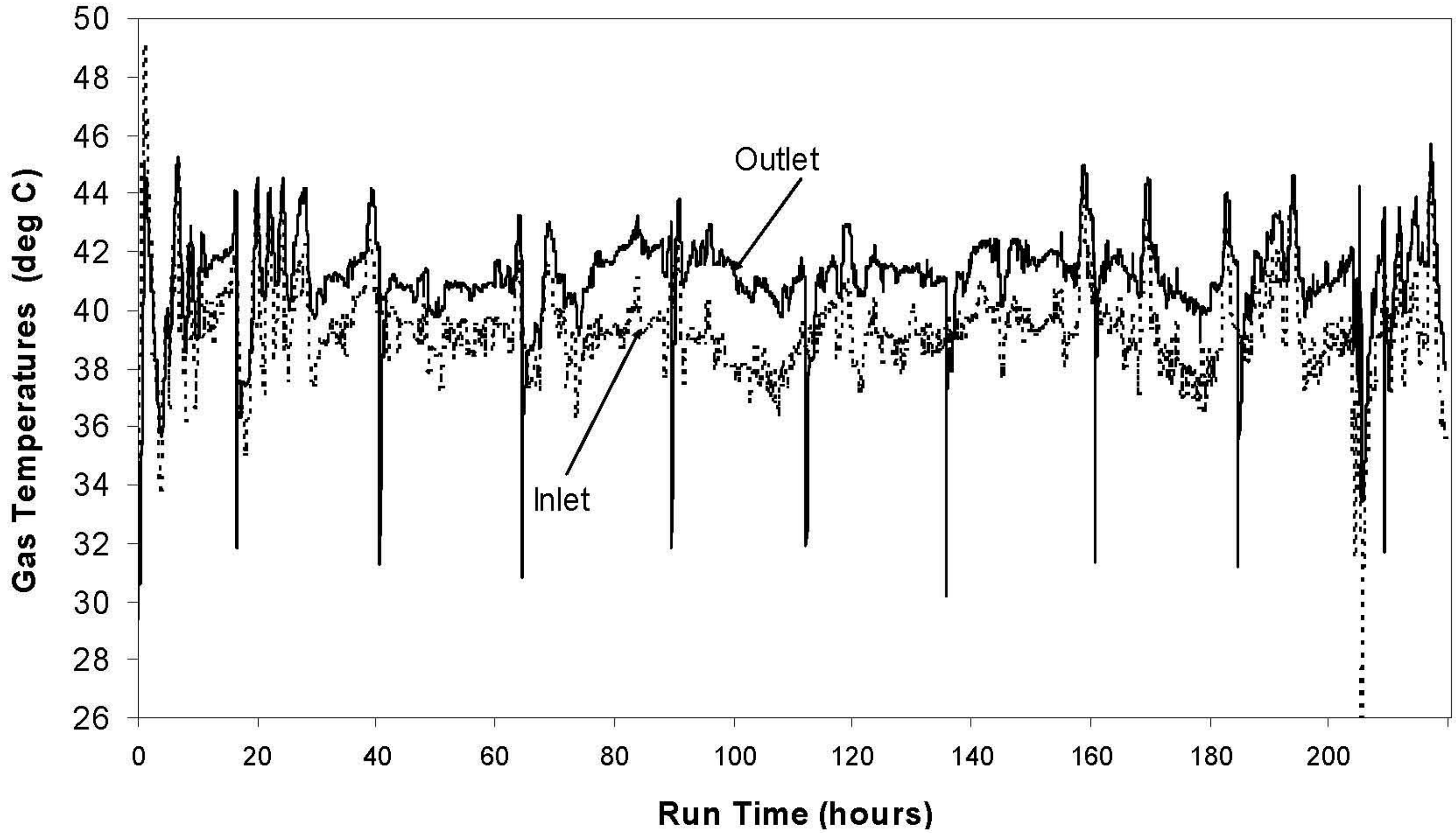

Figure 5.78. WESP inlet and outlet temperatures during Test 3. (Note: Downward outlet temperature spike are the result of WESP deluges.)

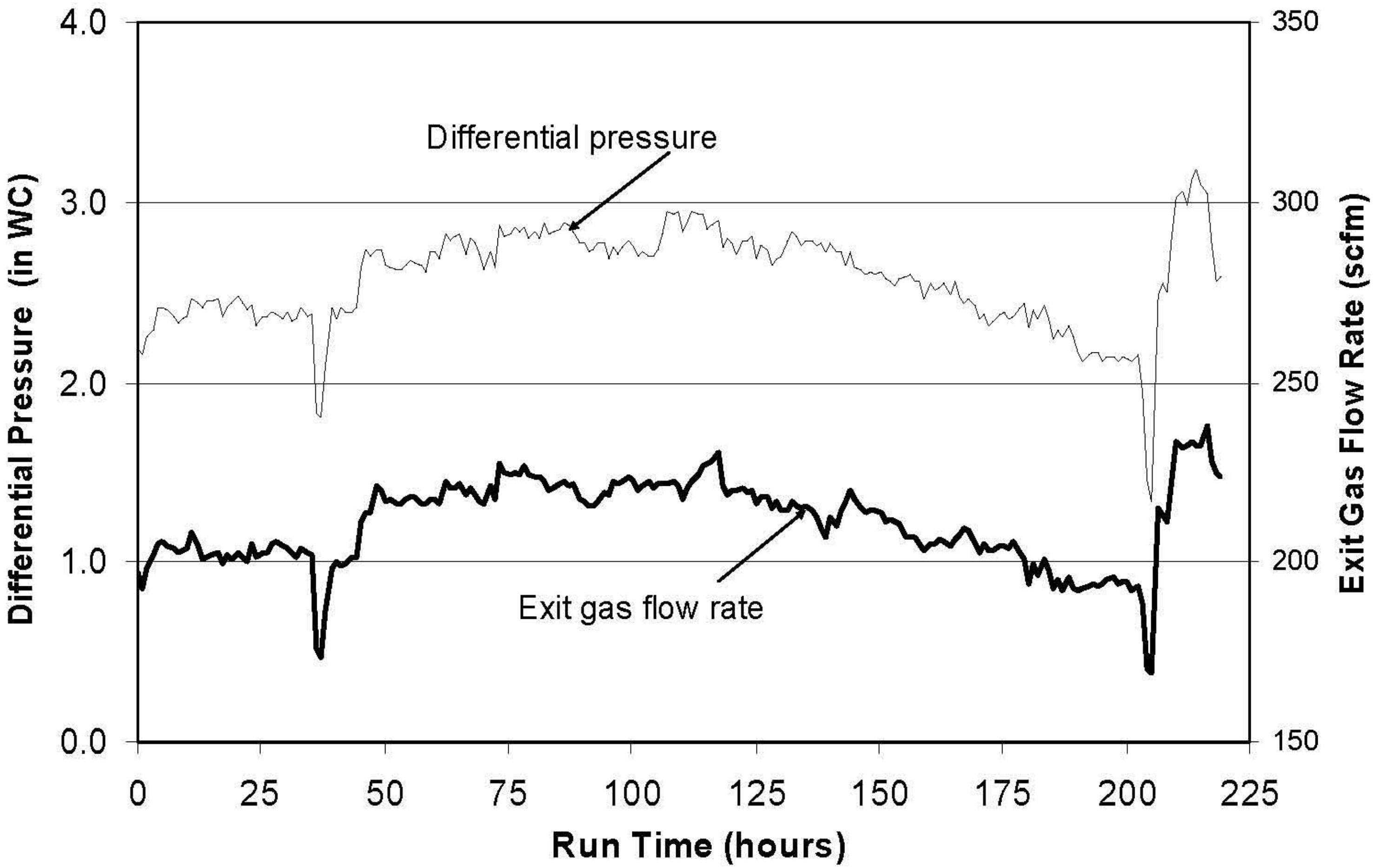

Figure 5.79. WESP differential pressure and gas flow rate (hourly average values) during Test 3.

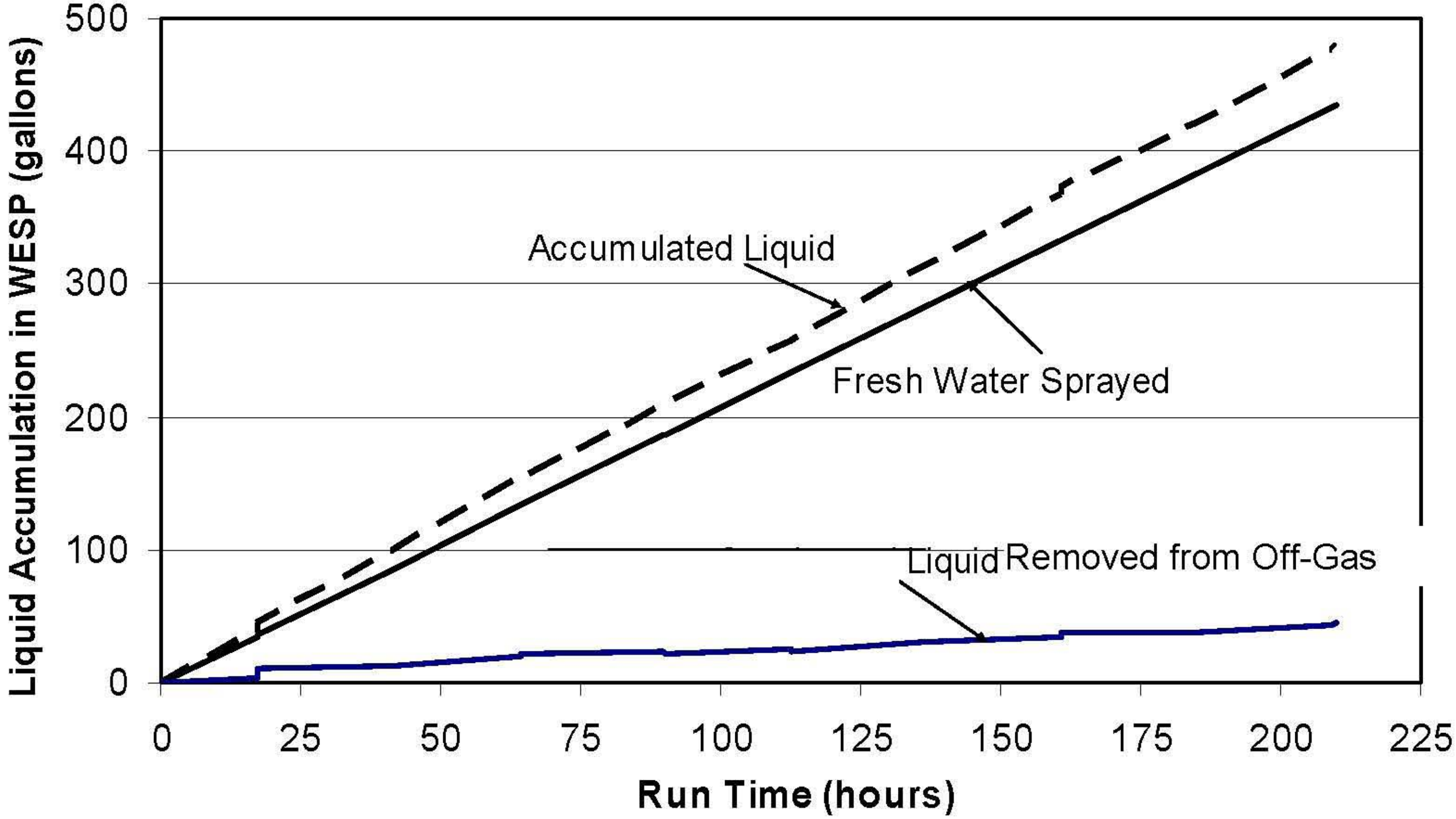

Figure 5.80. Accumulated WESP blow-down volume, accumulated fresh spray water, and water removed from off-gas during Test 3.

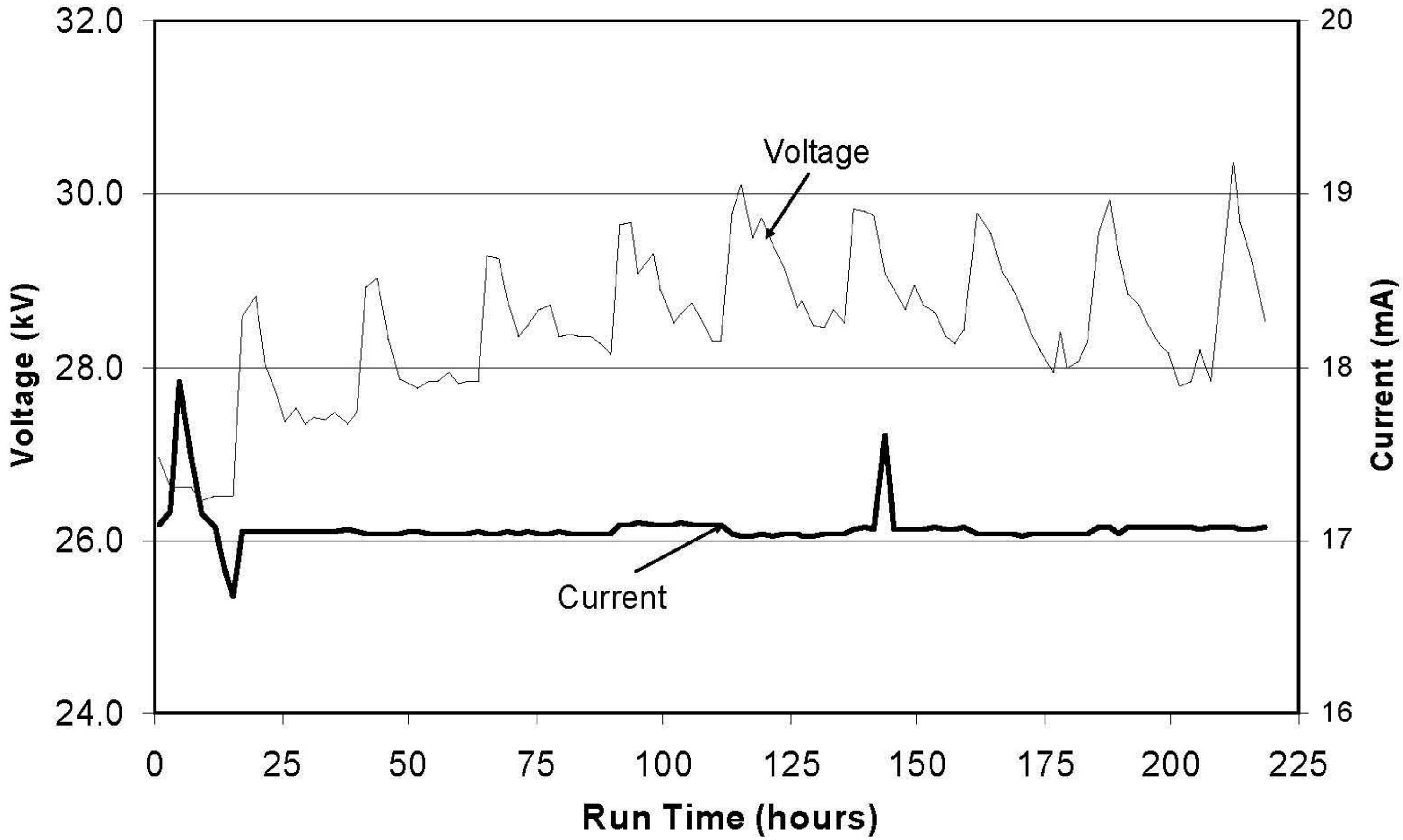

Figure 5.81. Voltage and current across the WESP during Test 3. (Note: During the deluges, WESP was turned off.)

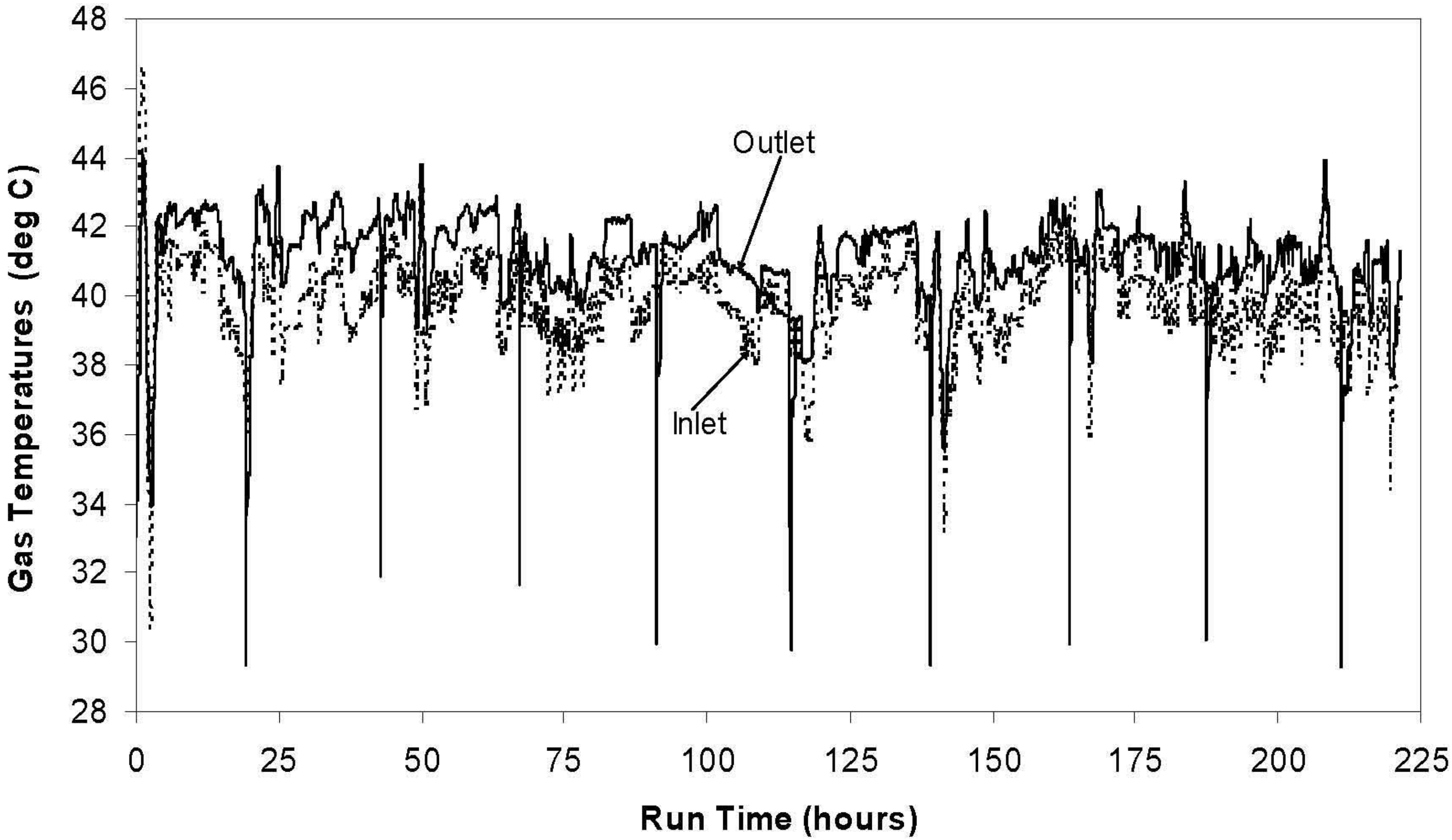

Figure 5.82. WESP inlet and outlet temperatures during Test 4. (Note: Downward outlet temperature spikes are the result of WESP deluges.)

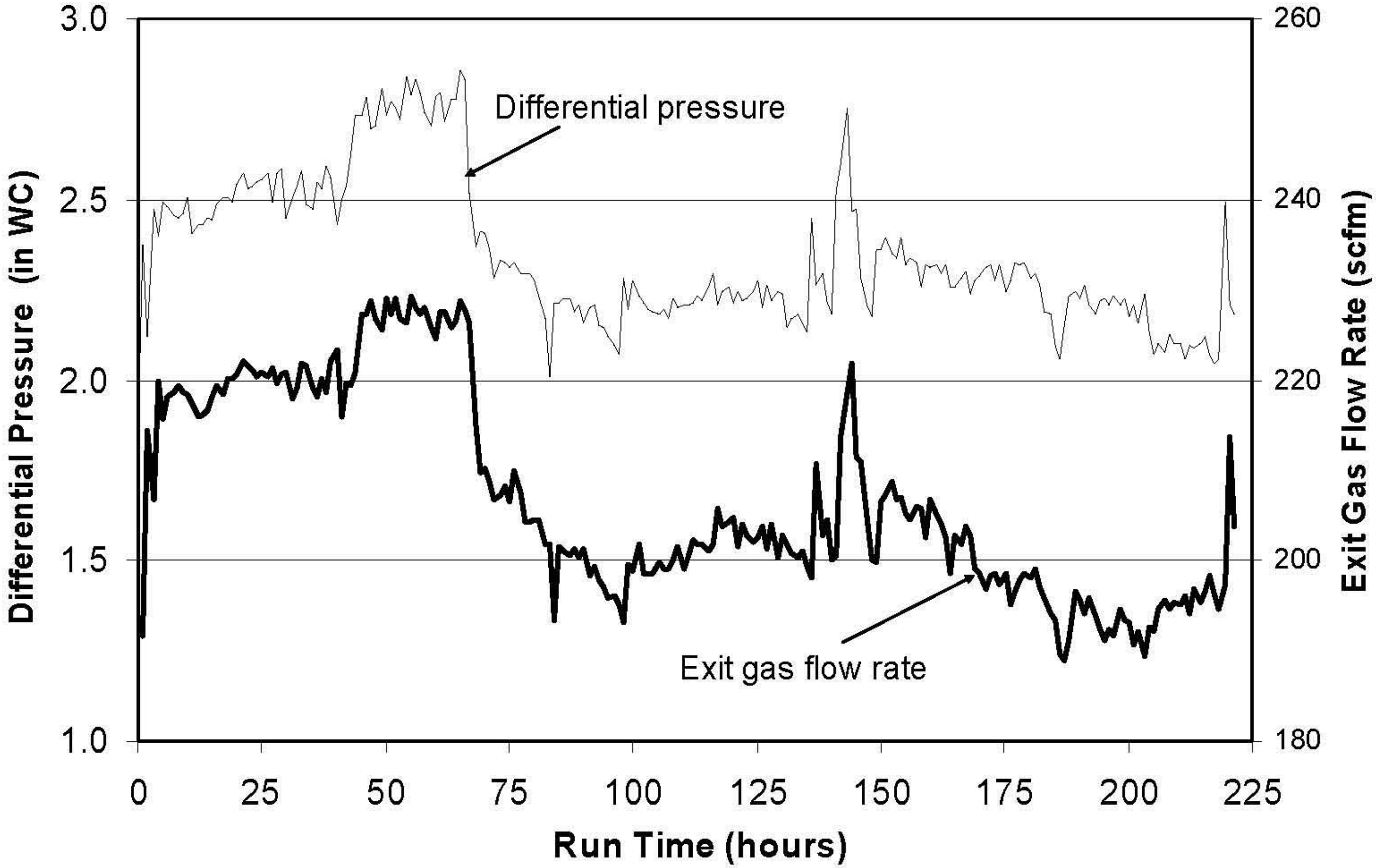

Figure 5.83. WESP differential pressure and gas flow rate (hourly average values) during Test 4.

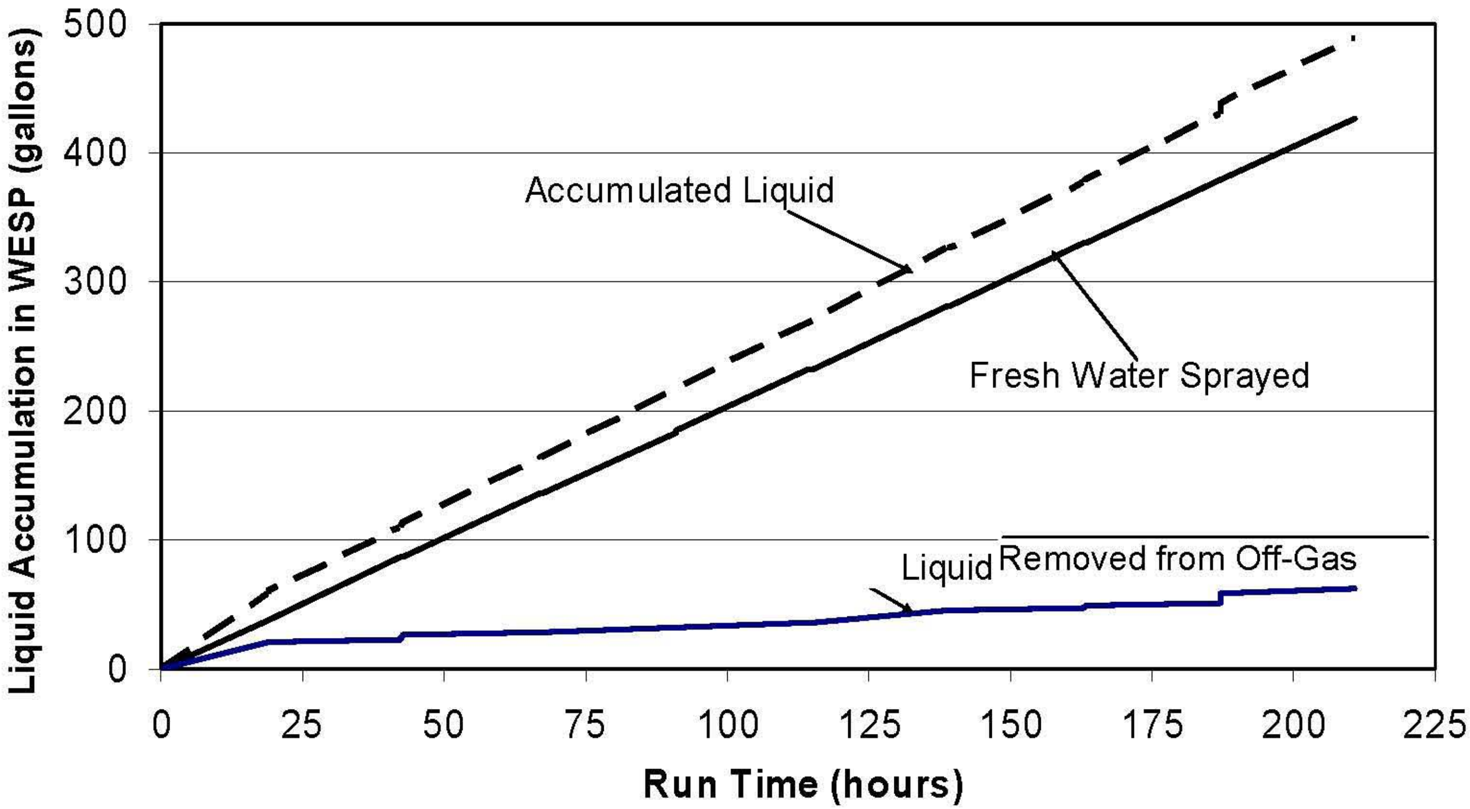

Figure 5.84. Accumulated WESP blow-down volume, accumulated fresh spray water, and water removed from off-gas during Test 4.

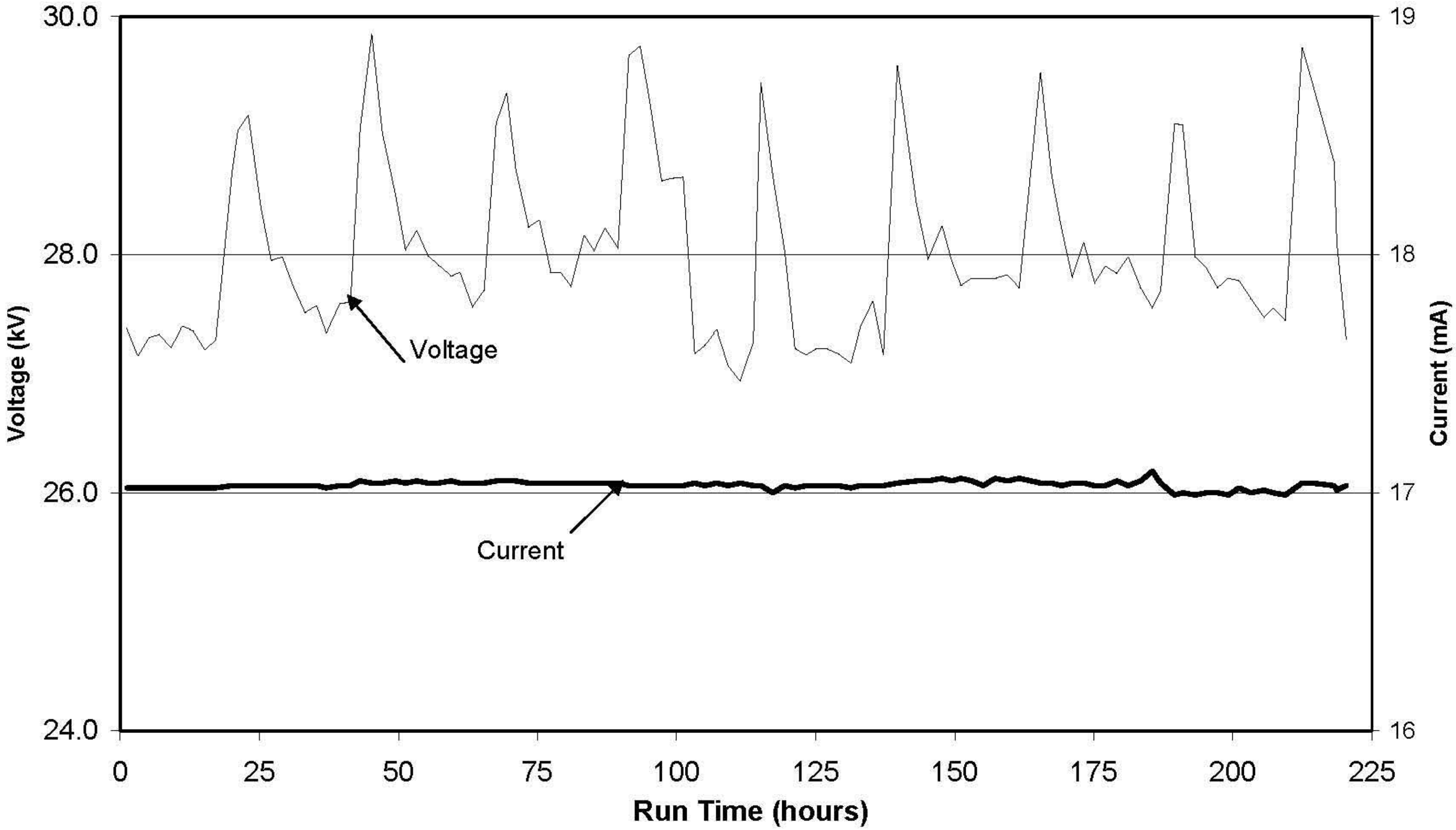

Figure 5.85. Voltage and current across the WESP during Test 4. (Note: During the deluges, WESP was turned off.)

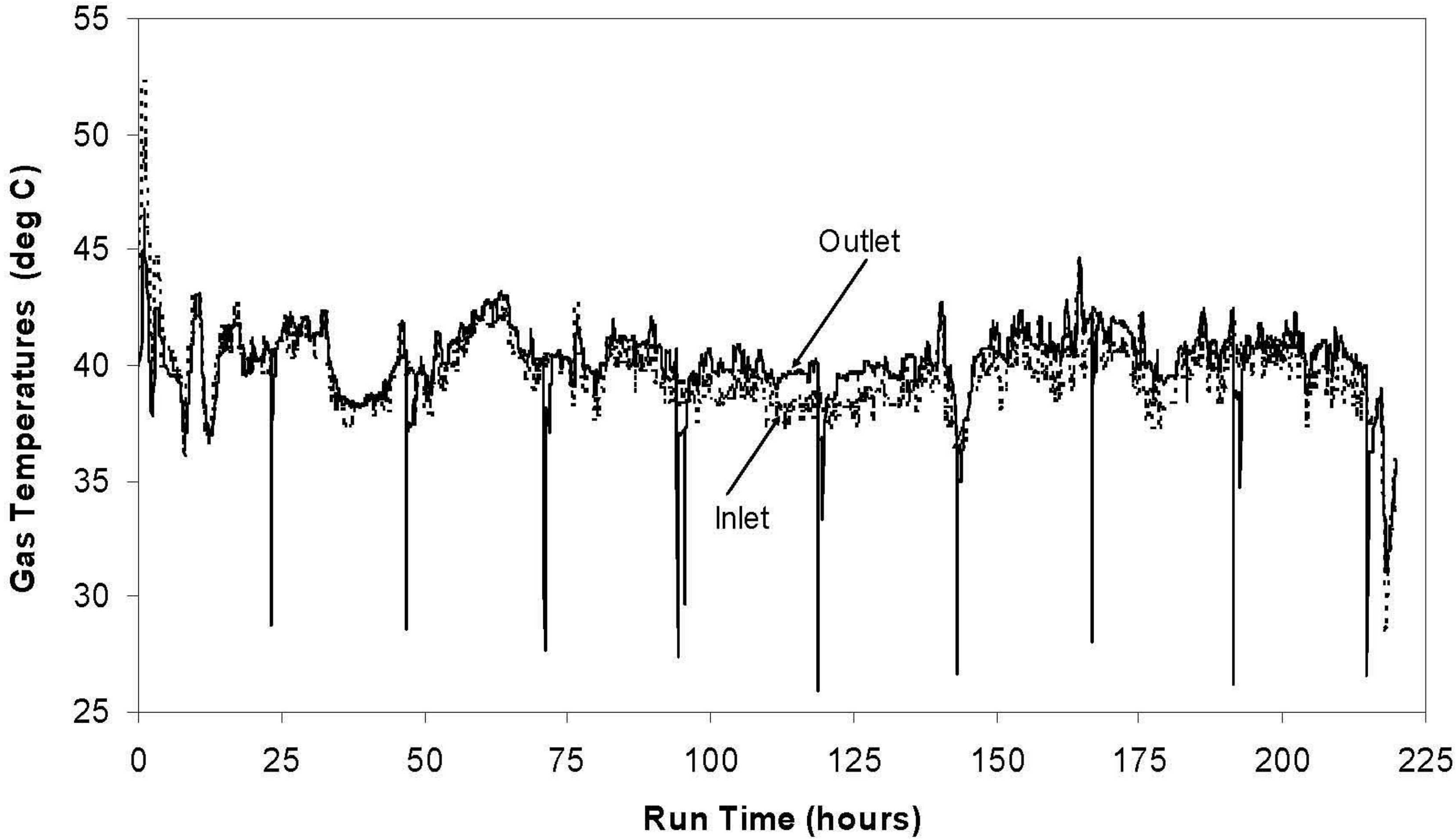

Figure 5.86. WESP inlet and outlet temperatures during Test 5. (Note: Downward outlet temperature spikes are the result of WESP deluges.)

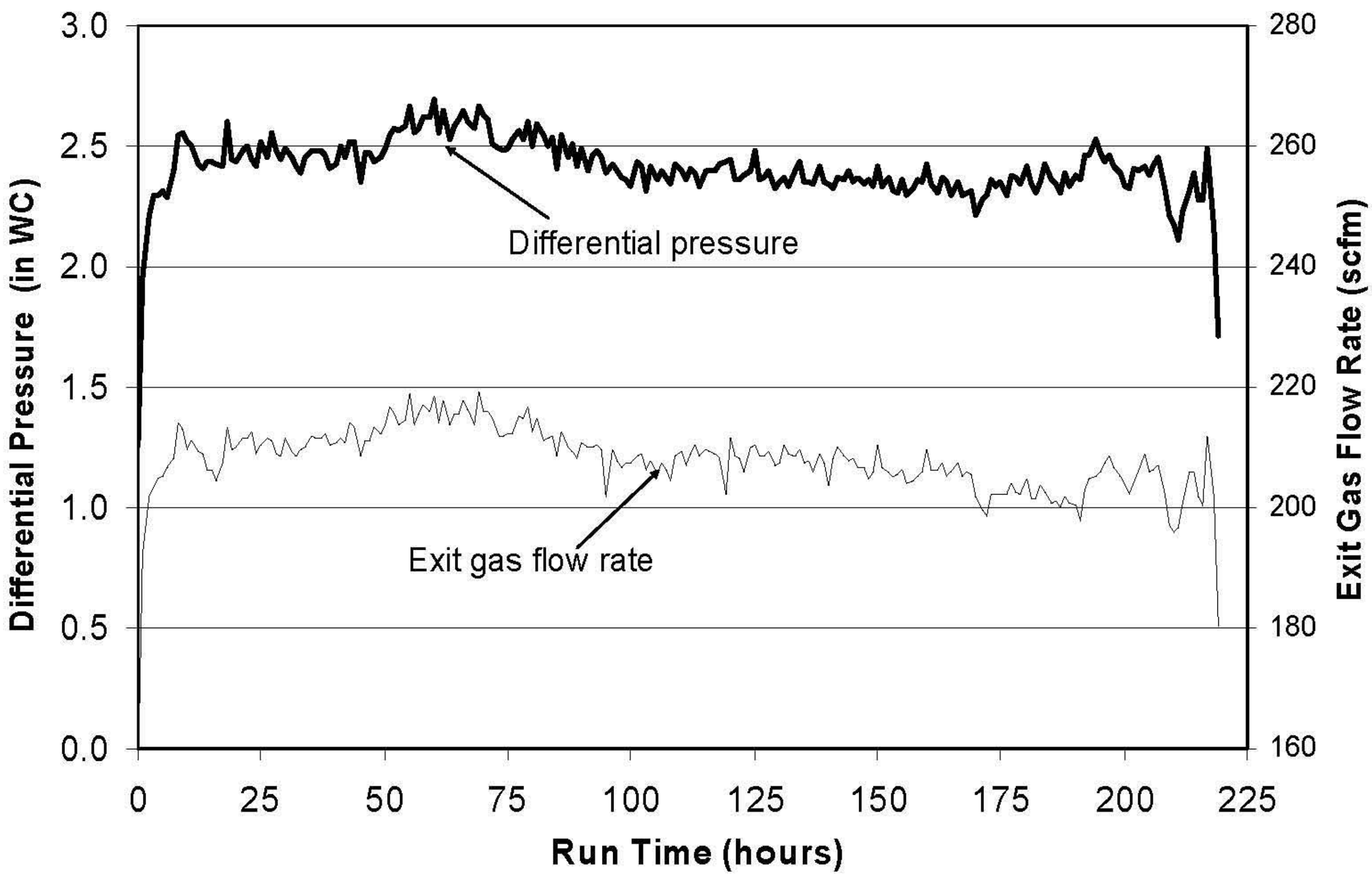

Figure 5.87. WESP differential pressure and gas flow rate (hourly average values) during Test 5.

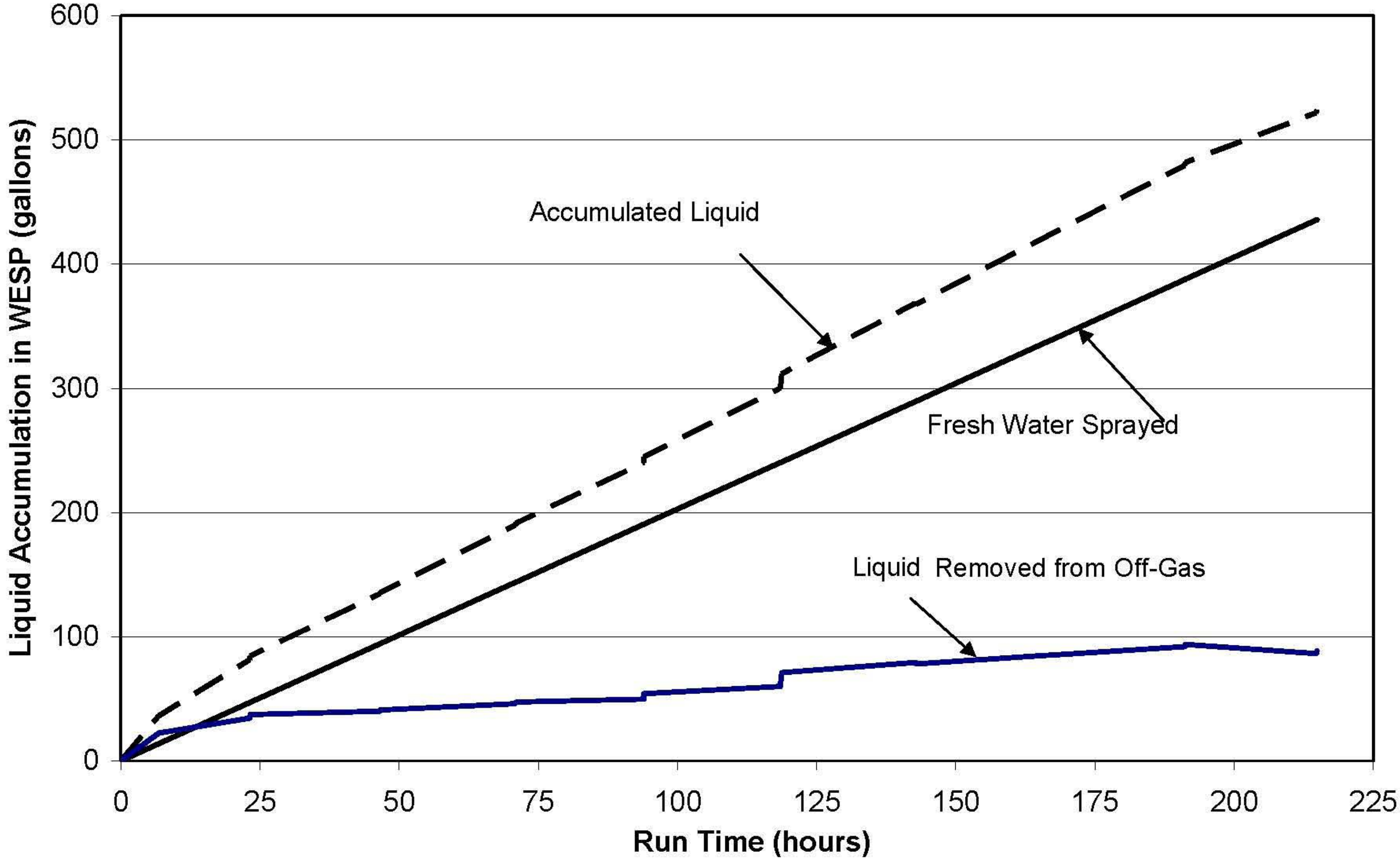

Figure 5.88. Accumulated WESP blow-down volume, accumulated fresh spray water, and water removed from off-gas during Test 5.

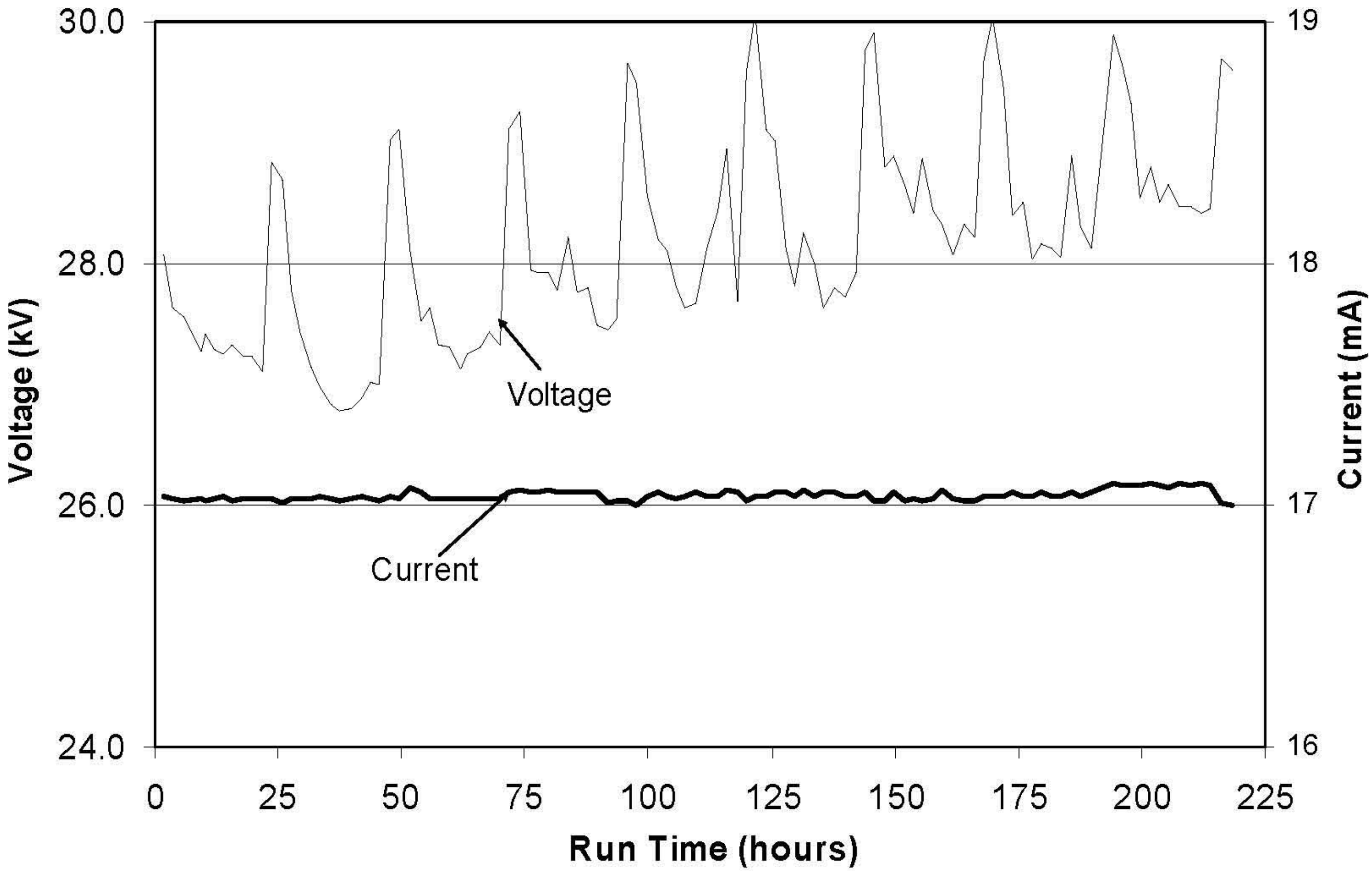

Figure 5.89. Voltage and current across the WESP during Test 5. (Note: During the deluges, WESP was turned off.

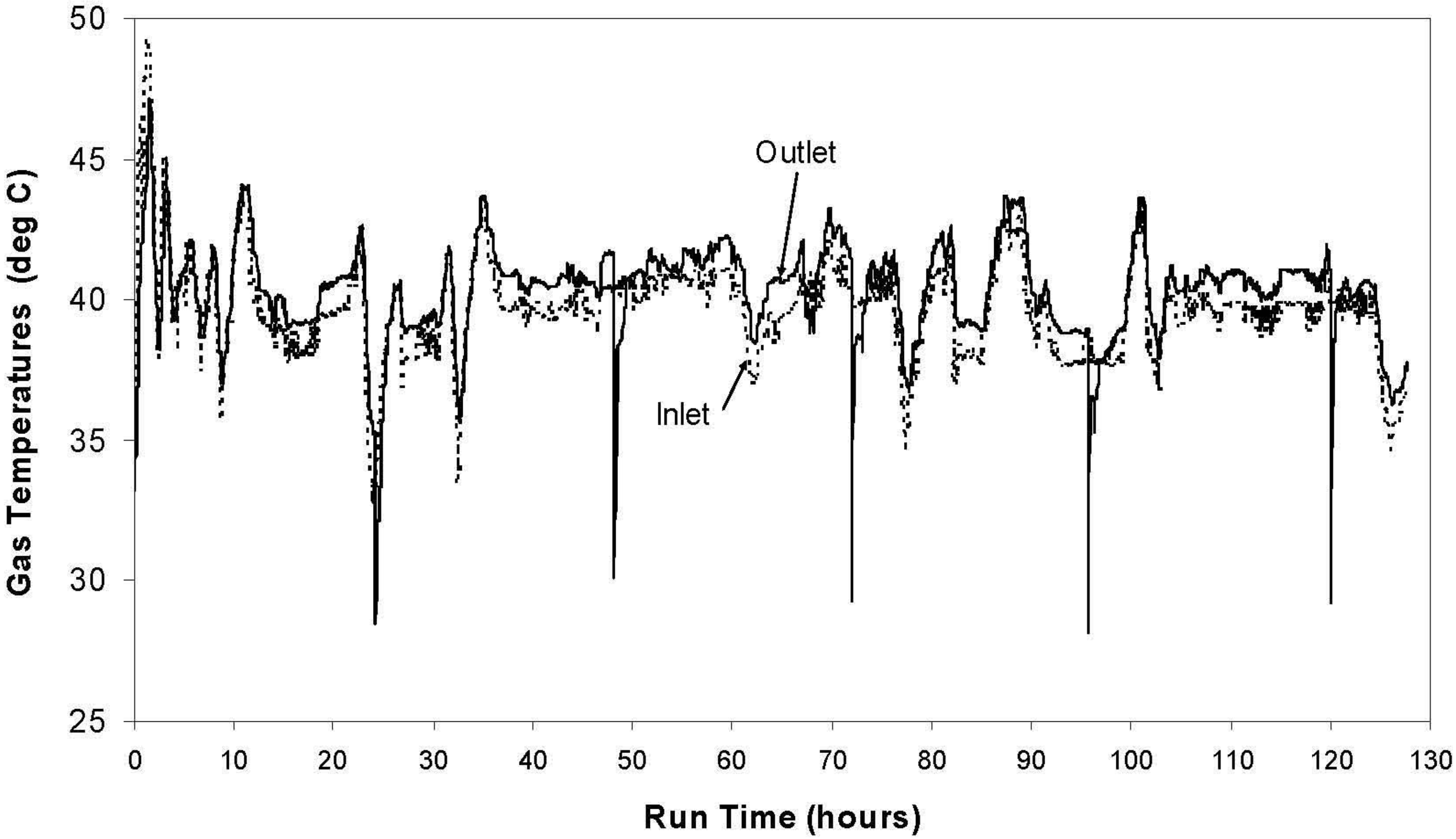

Figure 5.90. WESP inlet and outlet temperatures during Test 6. (Note: Downward outlet temperature spikes are the result of WESP deluges.)

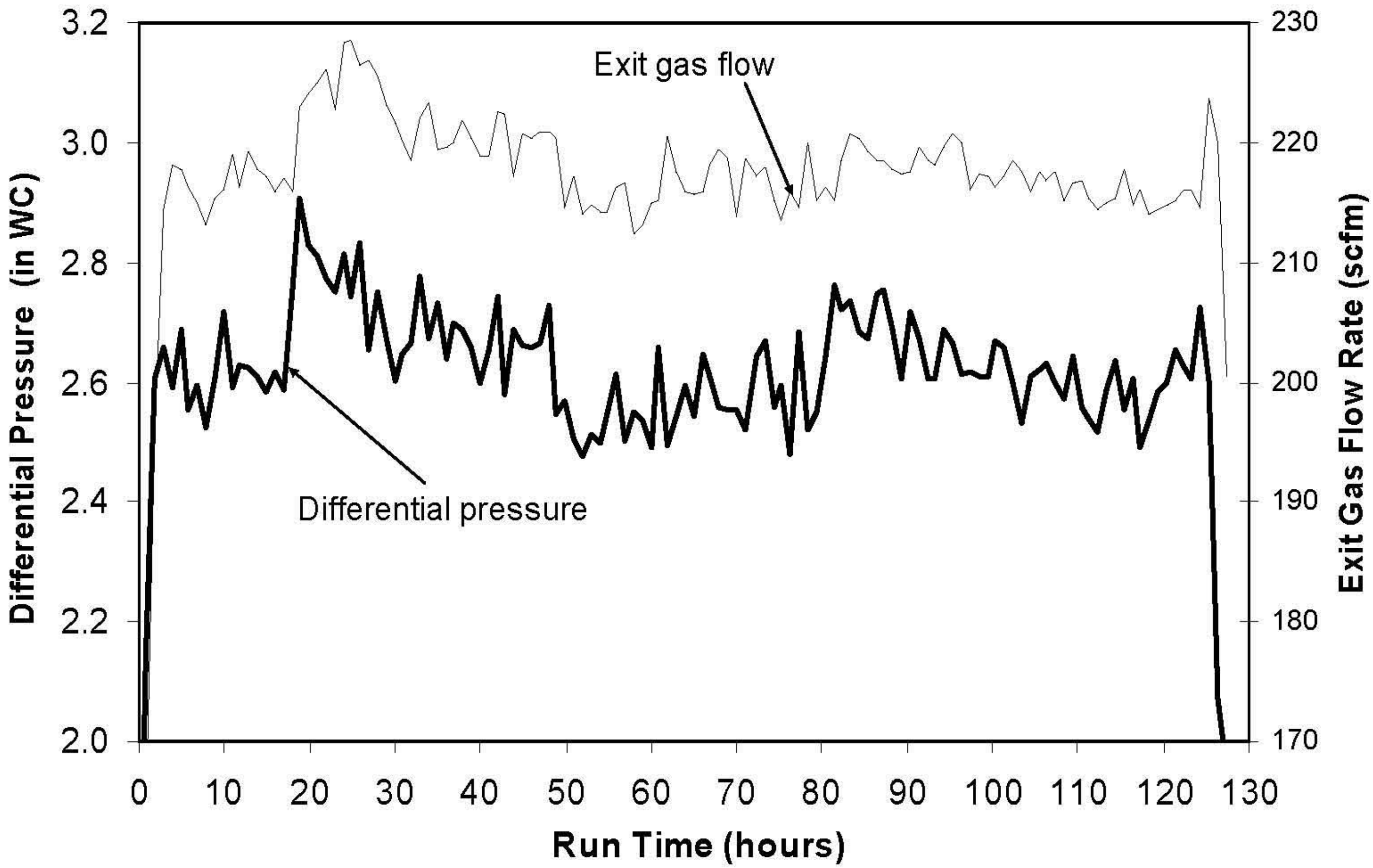

Figure 5.91. WESP differential pressure and gas flow rate (hourly average values) during Test 6.

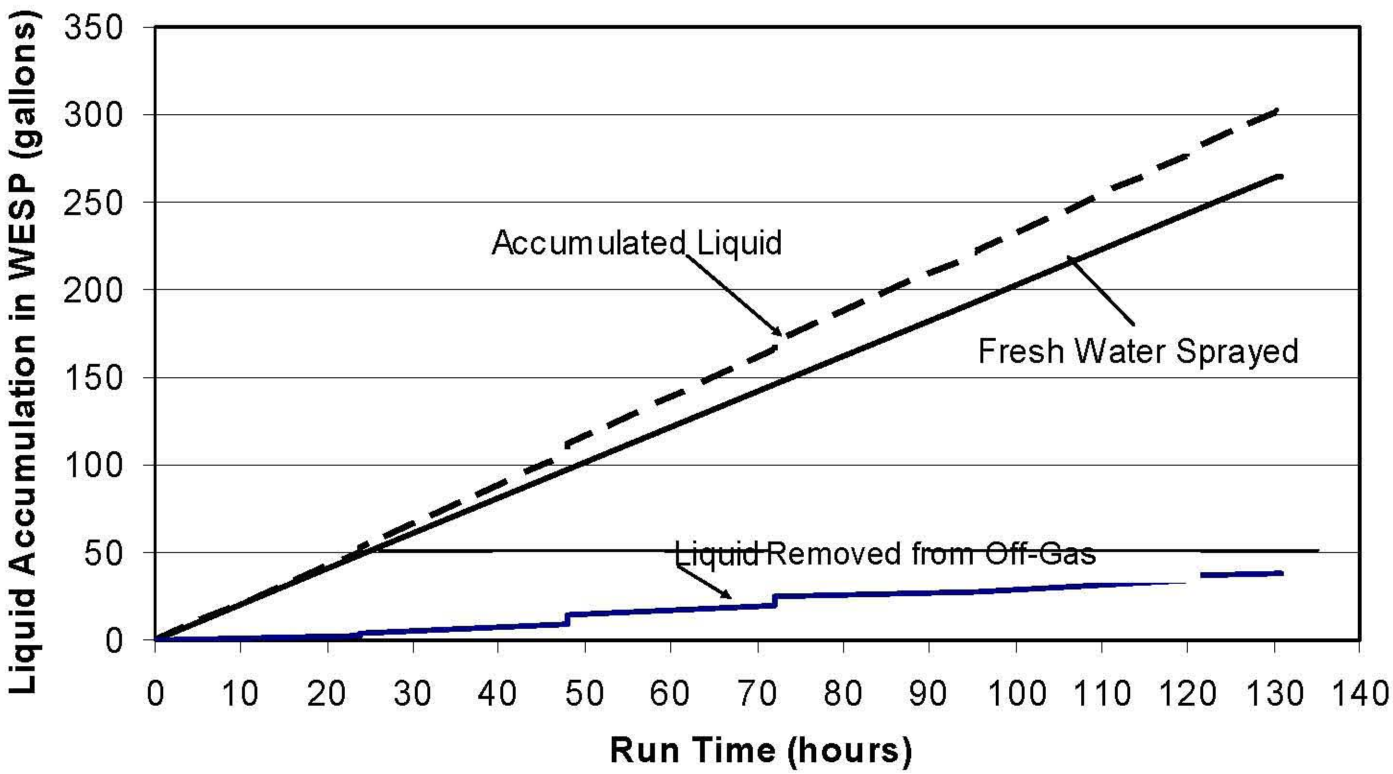

Figure 5.92. Accumulated WESP blow-down volume, accumulated fresh spray water, and water removed from off-gas during Test 6.

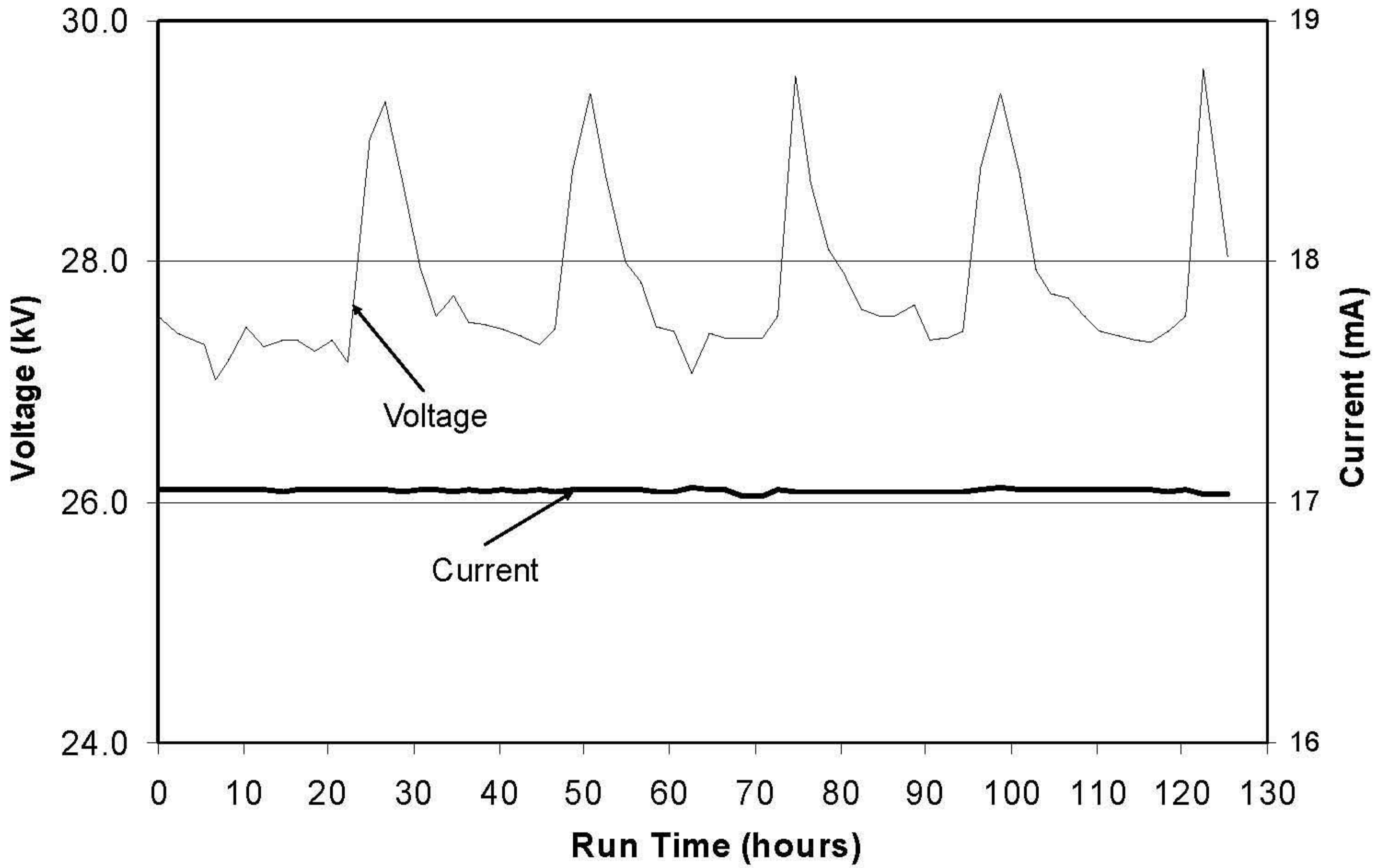

Figure 5.93. Voltage and current across the WESP during Test 6. (Note: During the deluges, WESP was turned off.)

Figure 5.94. WESP overall view of grid after Test 6.

Figure 5.95. WESP power supply wire connection after Test 6.

Figure 5.96. WESP south grid support after Test 6.

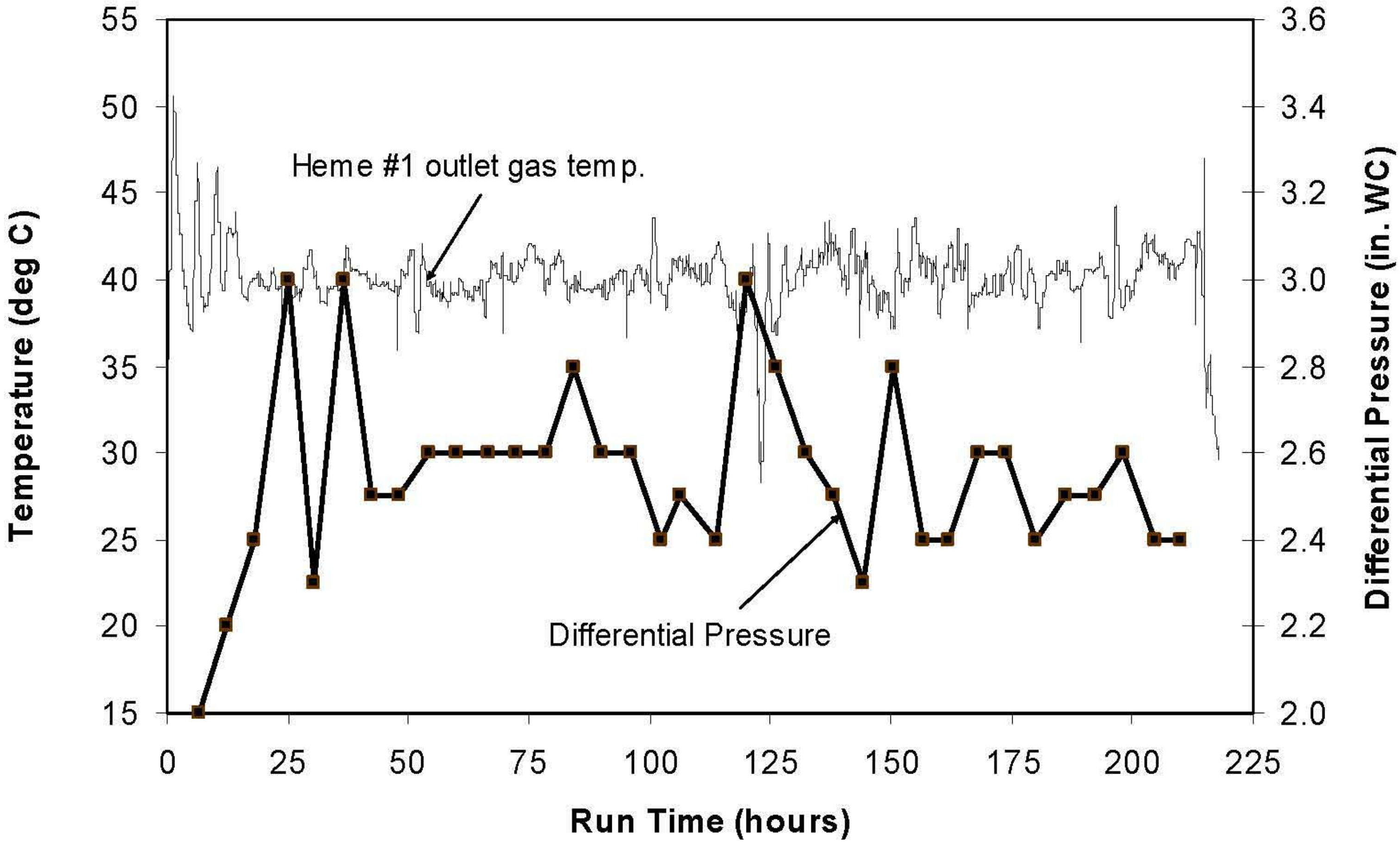

Figure 5.97. Outlet temperature and differential pressure for HEME #1 during Tests 1 and 2.

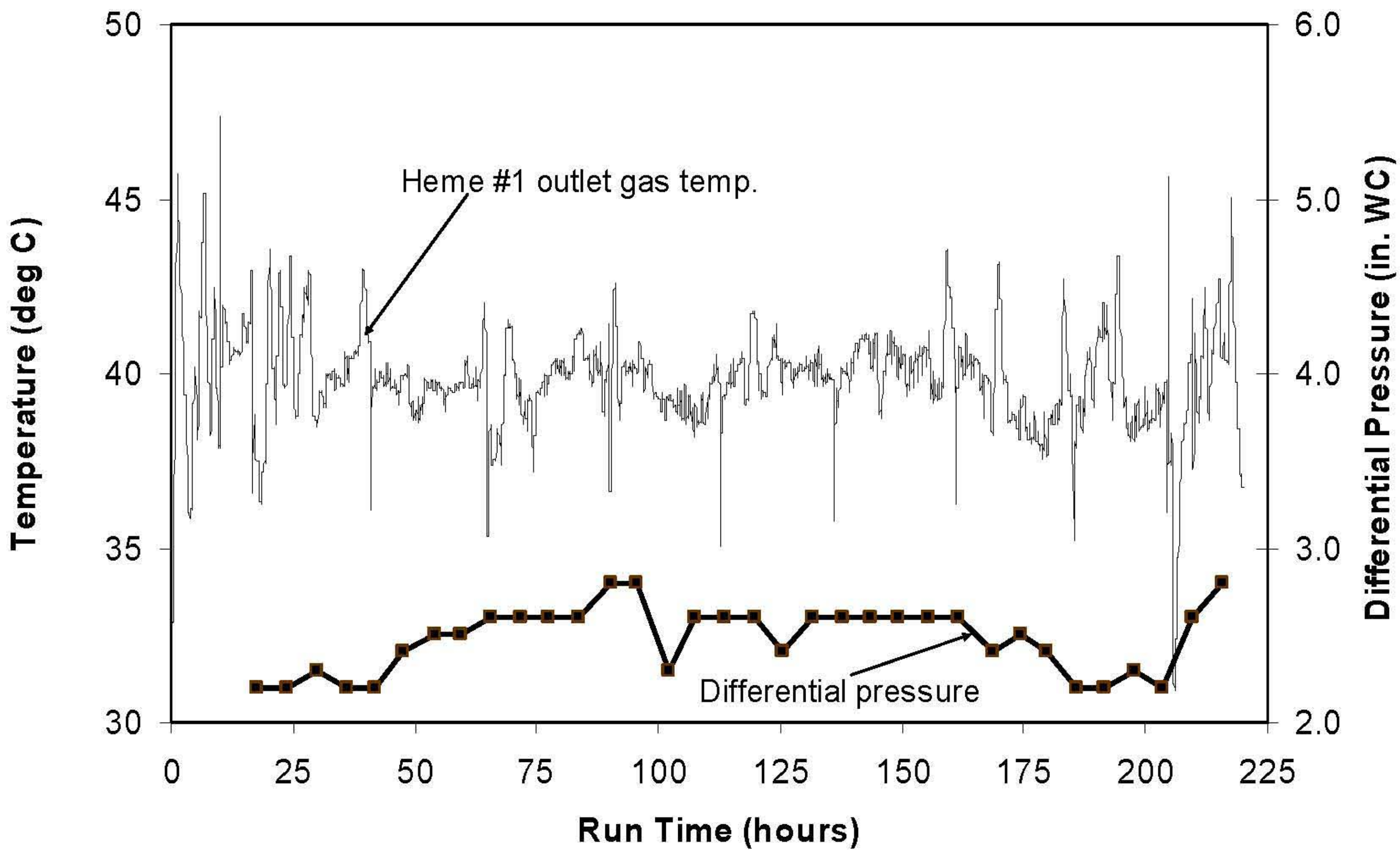

Figure 5.98. Outlet temperature and differential pressure for HEME #1 during Test 3.

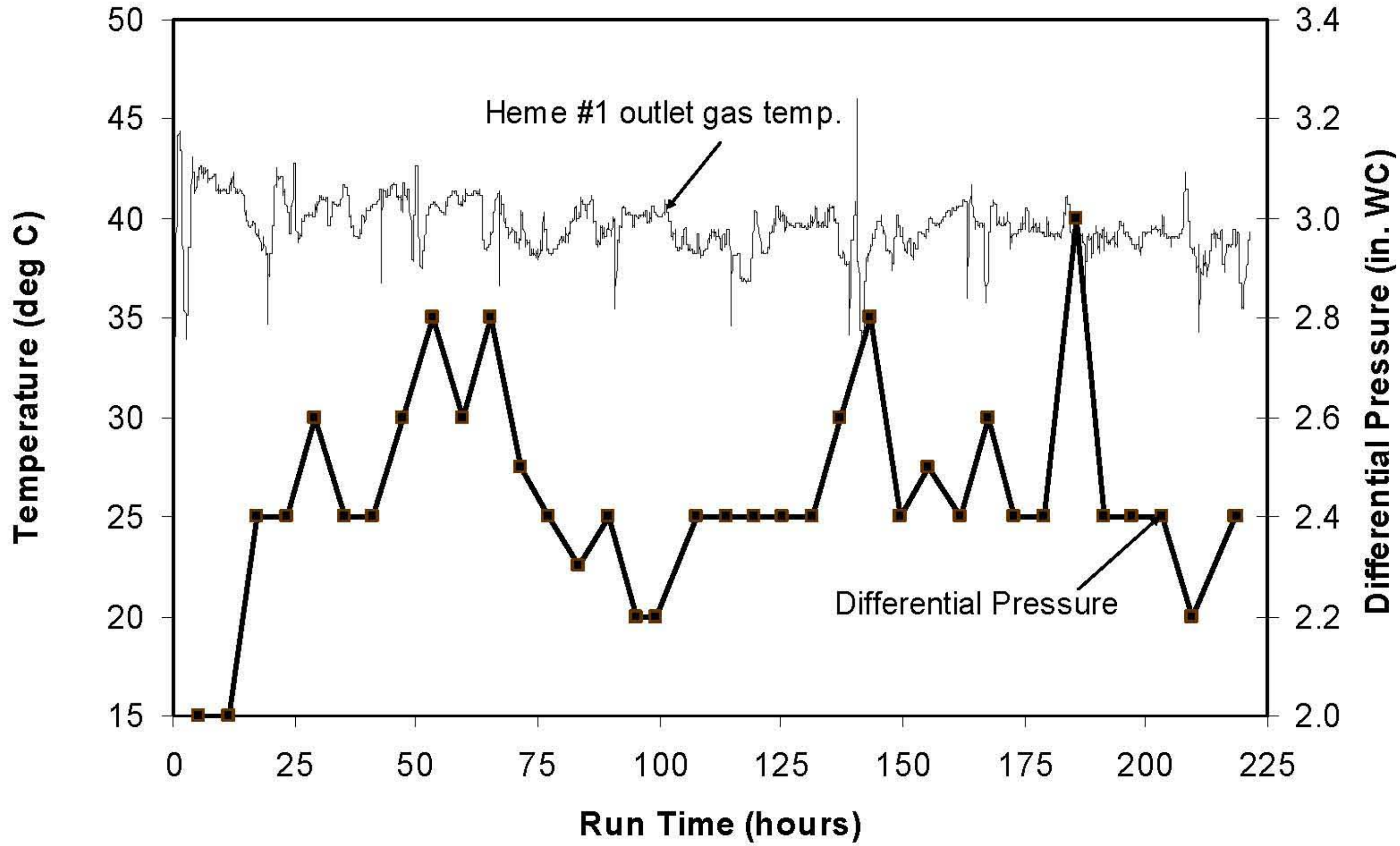

Figure 5.99. Outlet temperature and differential pressure for HEME #1 during Test 4.

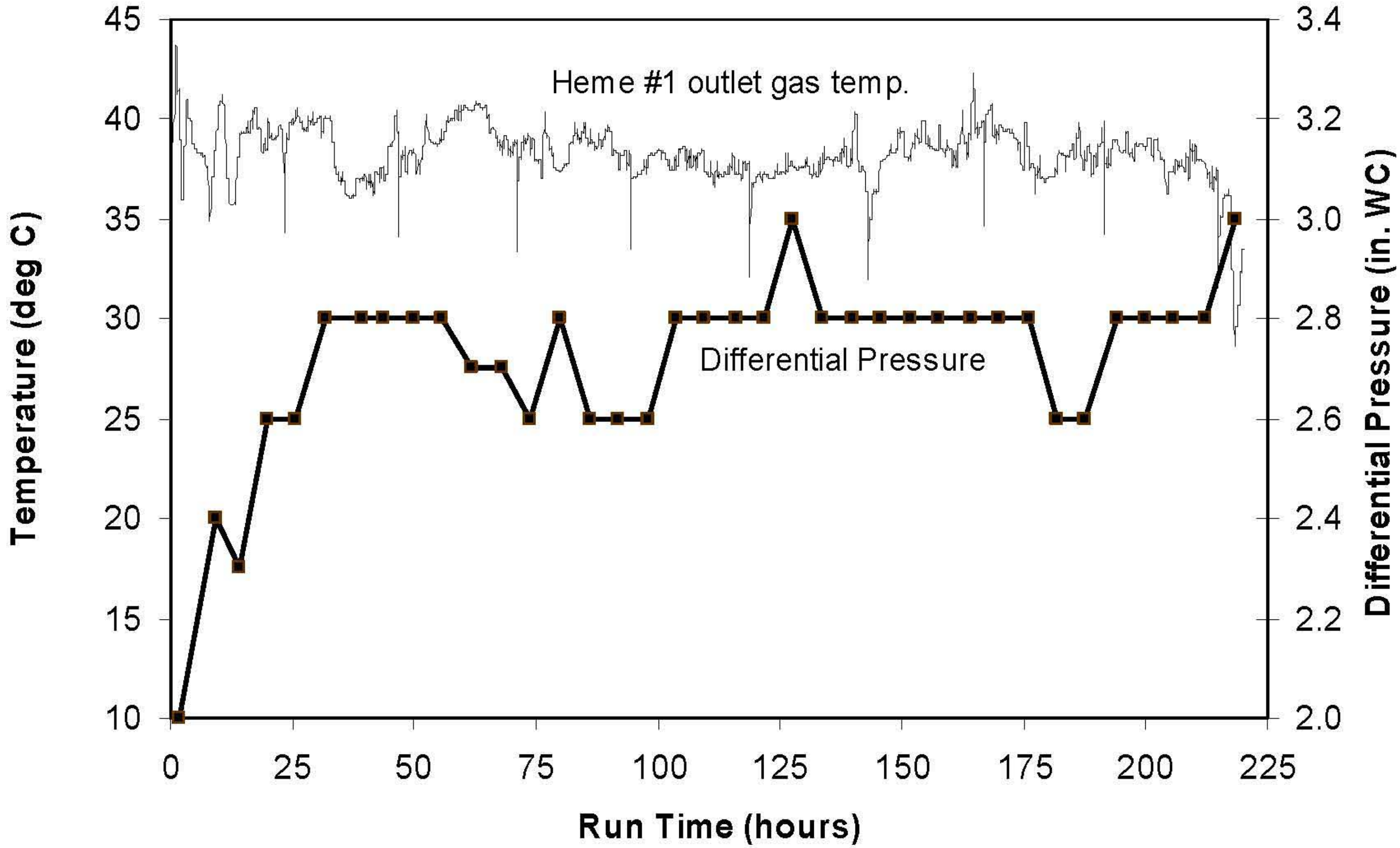

Figure 5.100. Outlet temperature and differential pressure for HEME #1 during Test 5.

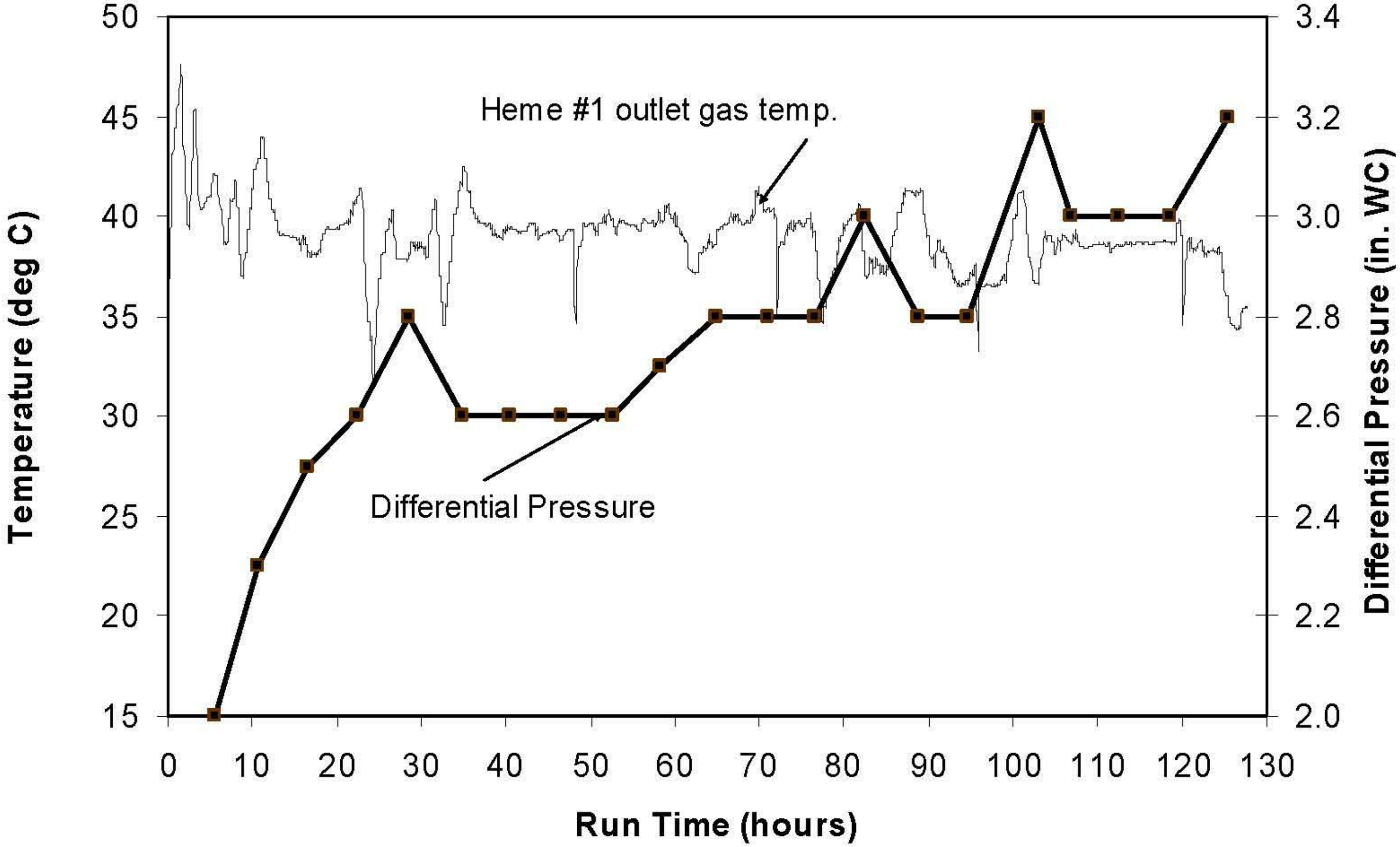

Figure 5.101. Outlet temperature and differential pressure for HEME #1 during Test 6.

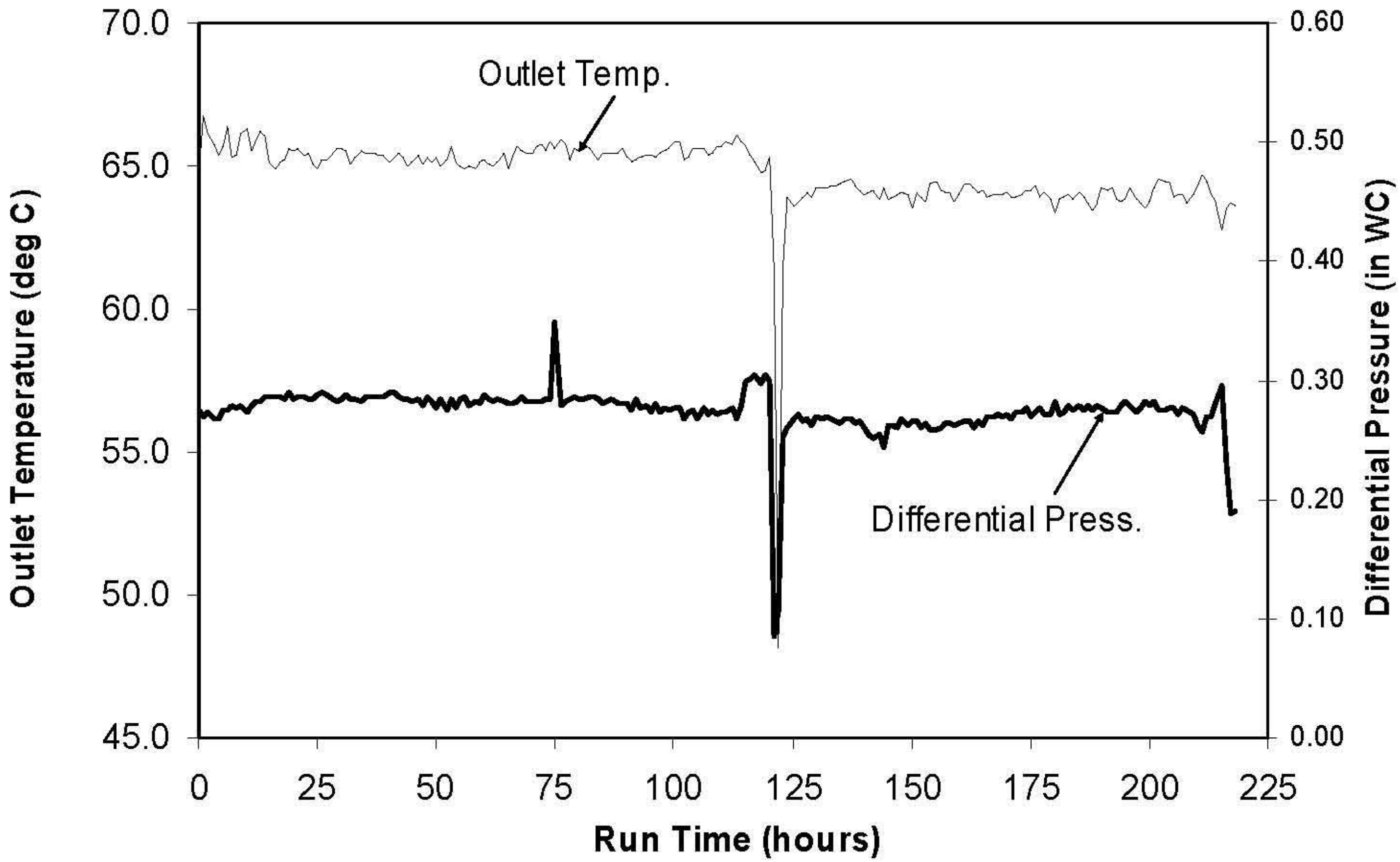

Figure 5.102. Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Tests 1 and 2.

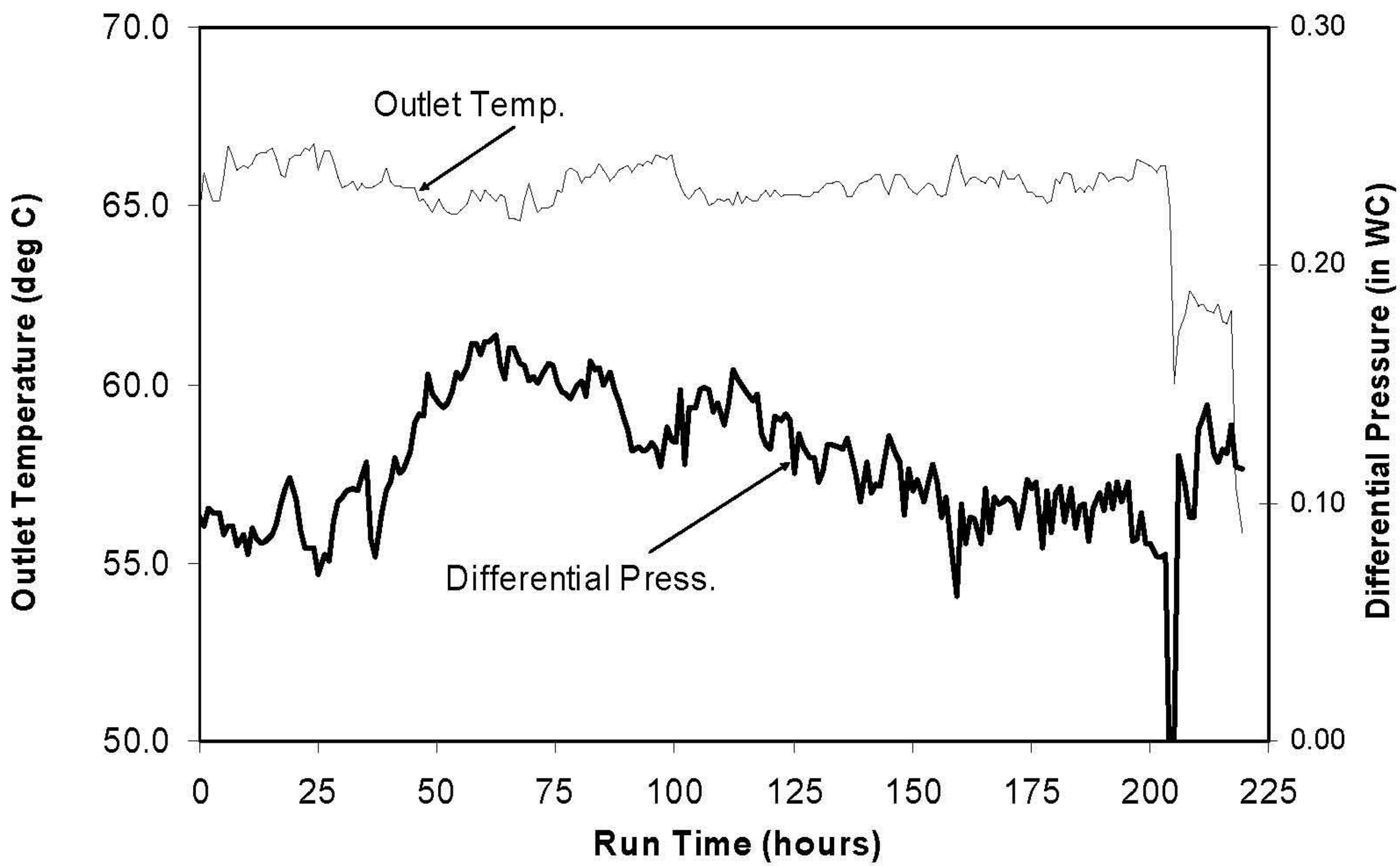

Figure 5.103. Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 3.

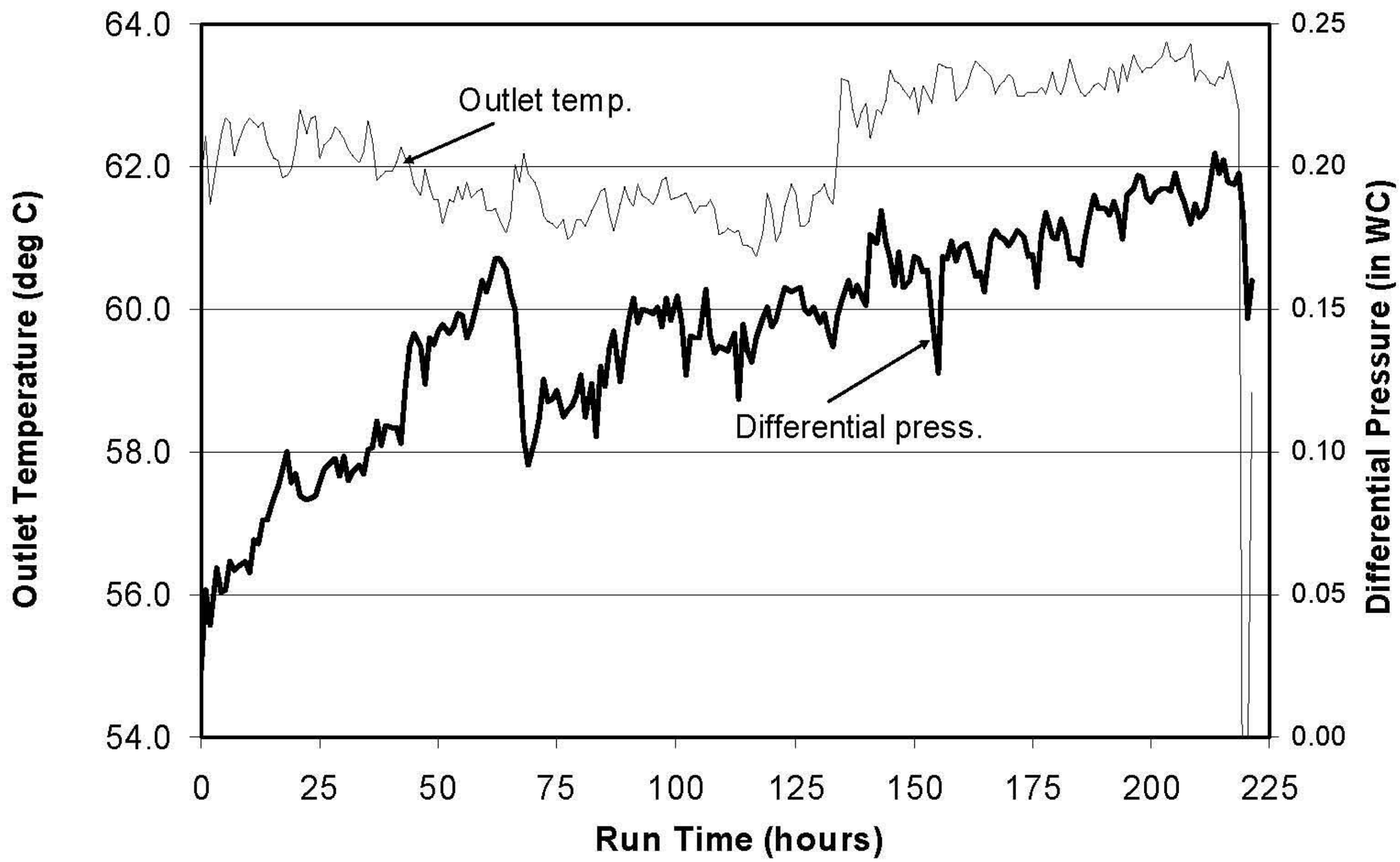

Figure 5.104. Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 4.

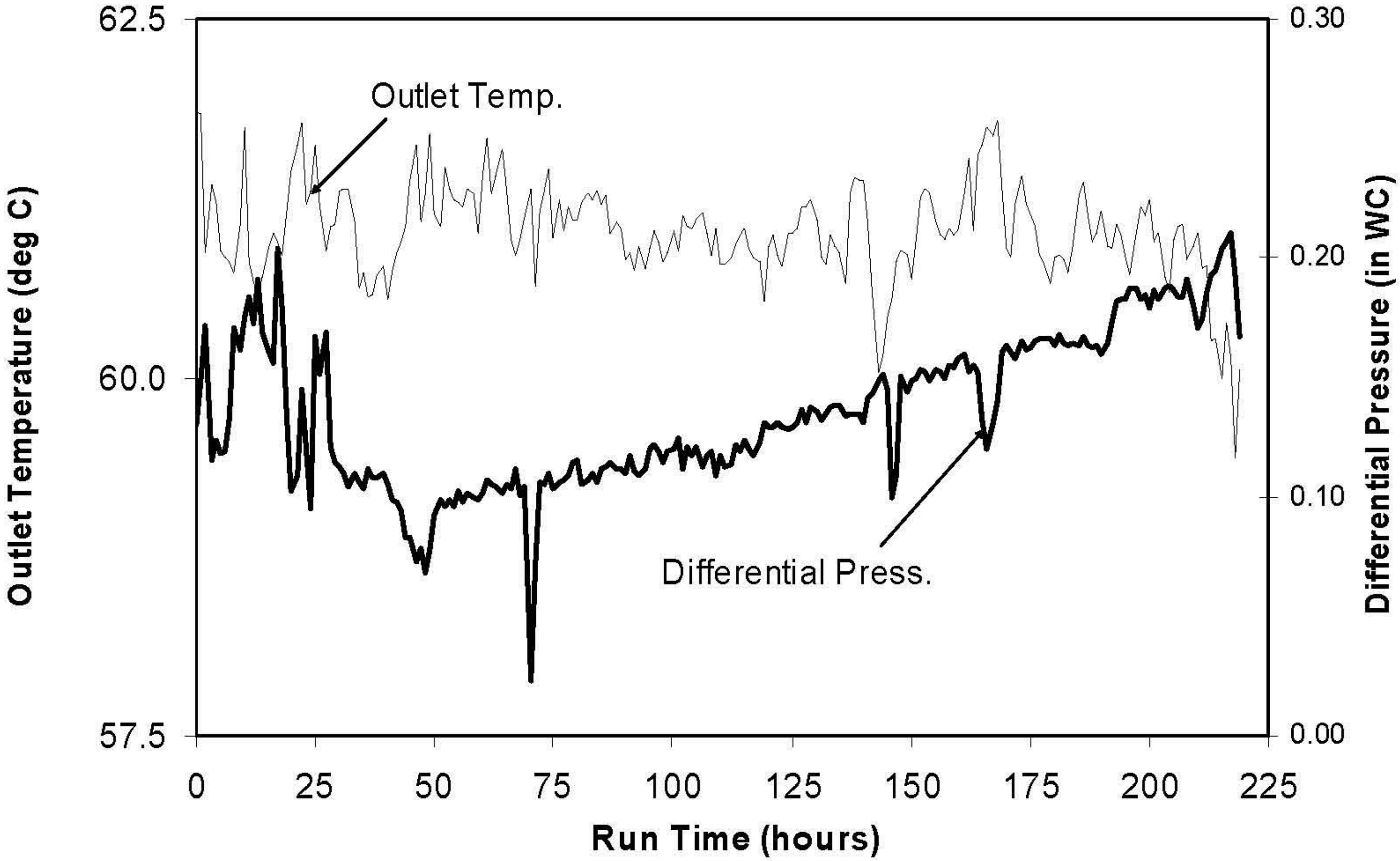

Figure 5.105. Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 5.

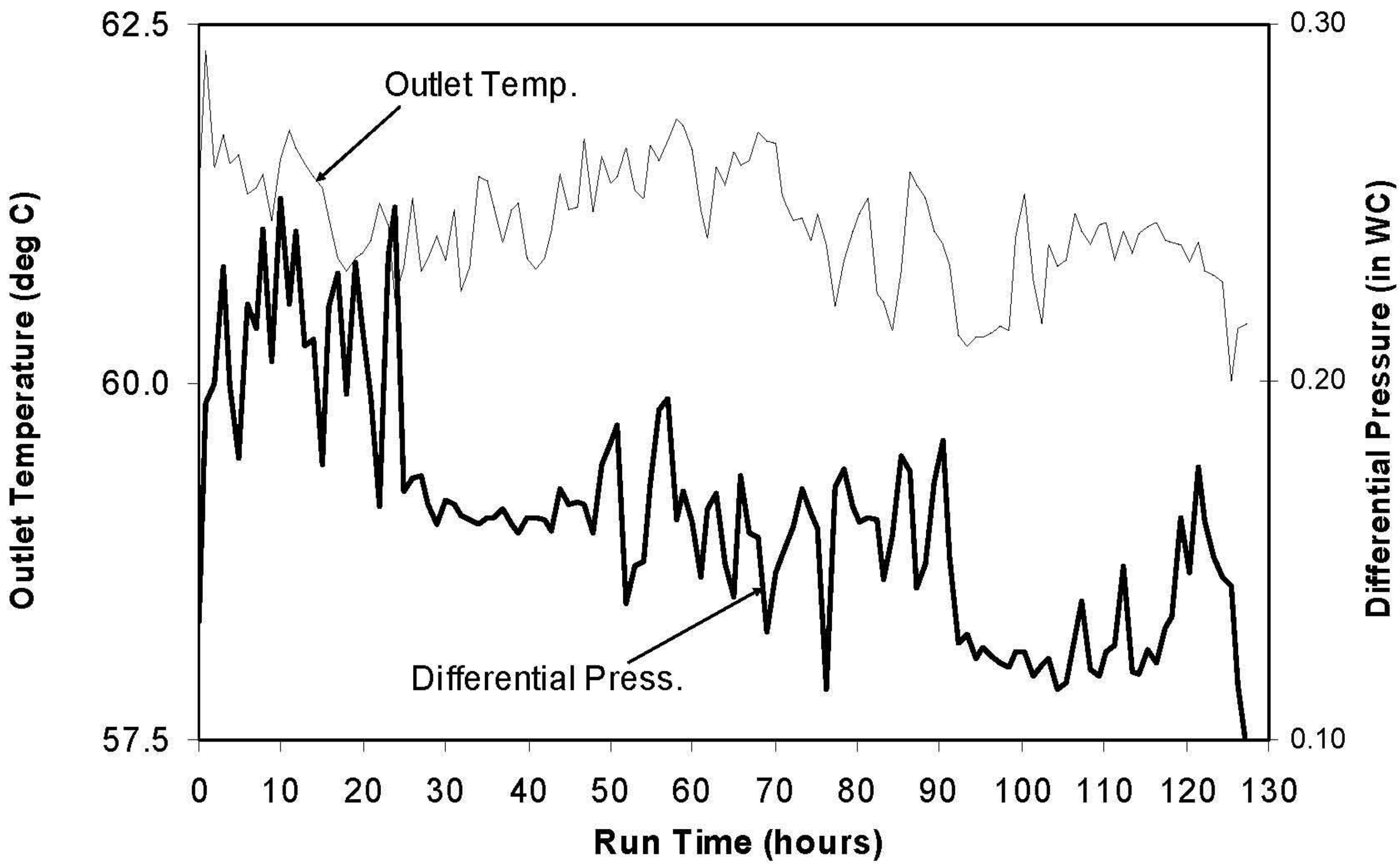

Figure 5.106. Outlet temperature and differential pressure for HEPA #1 (hourly average values) during Test 6.

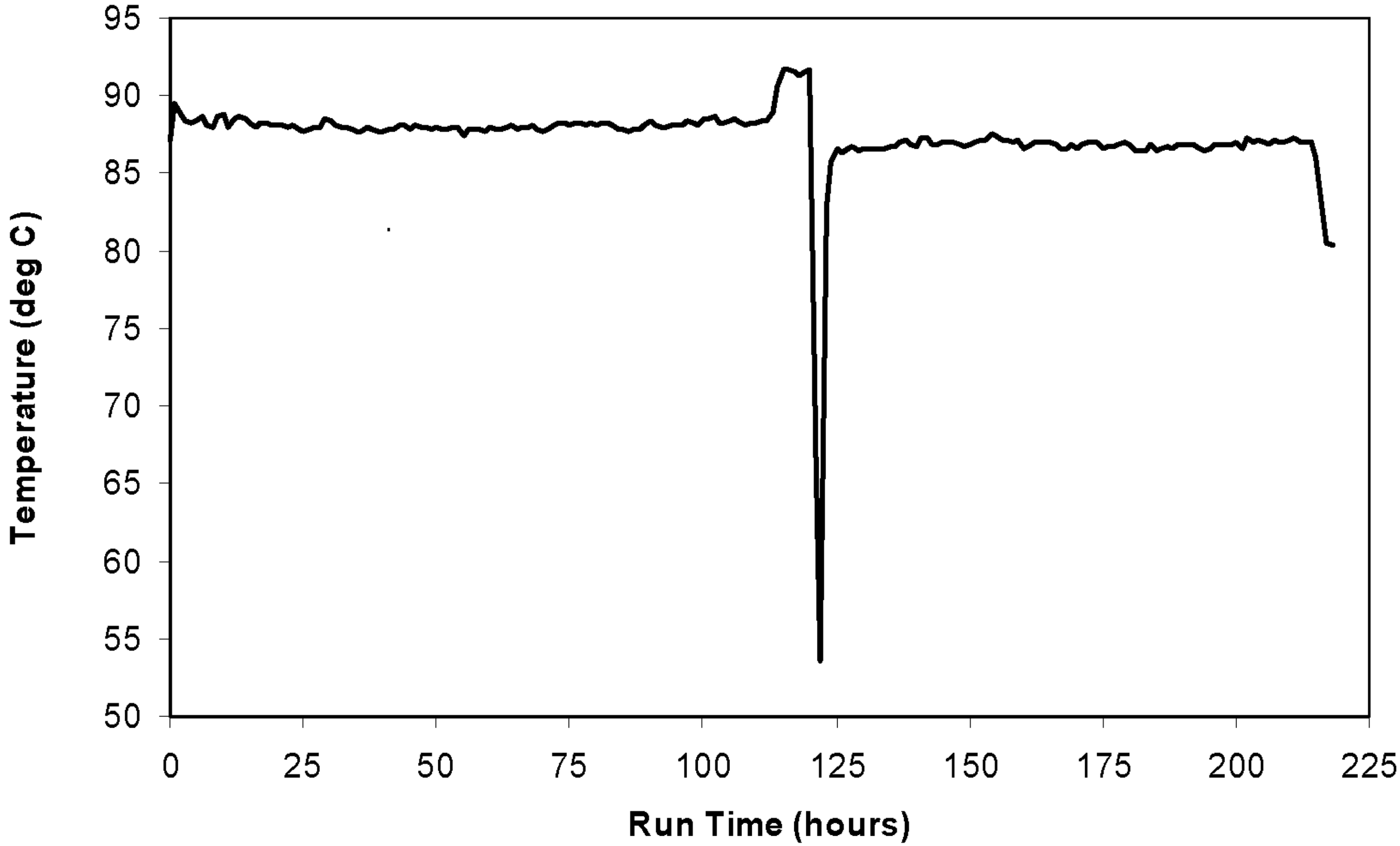

Figure 5.107. Paxton 1 outlet temperature (hourly average values) during Tests 1 and 2.

Figure 5.108. View of the blower 701 head inlet port before Test 1.

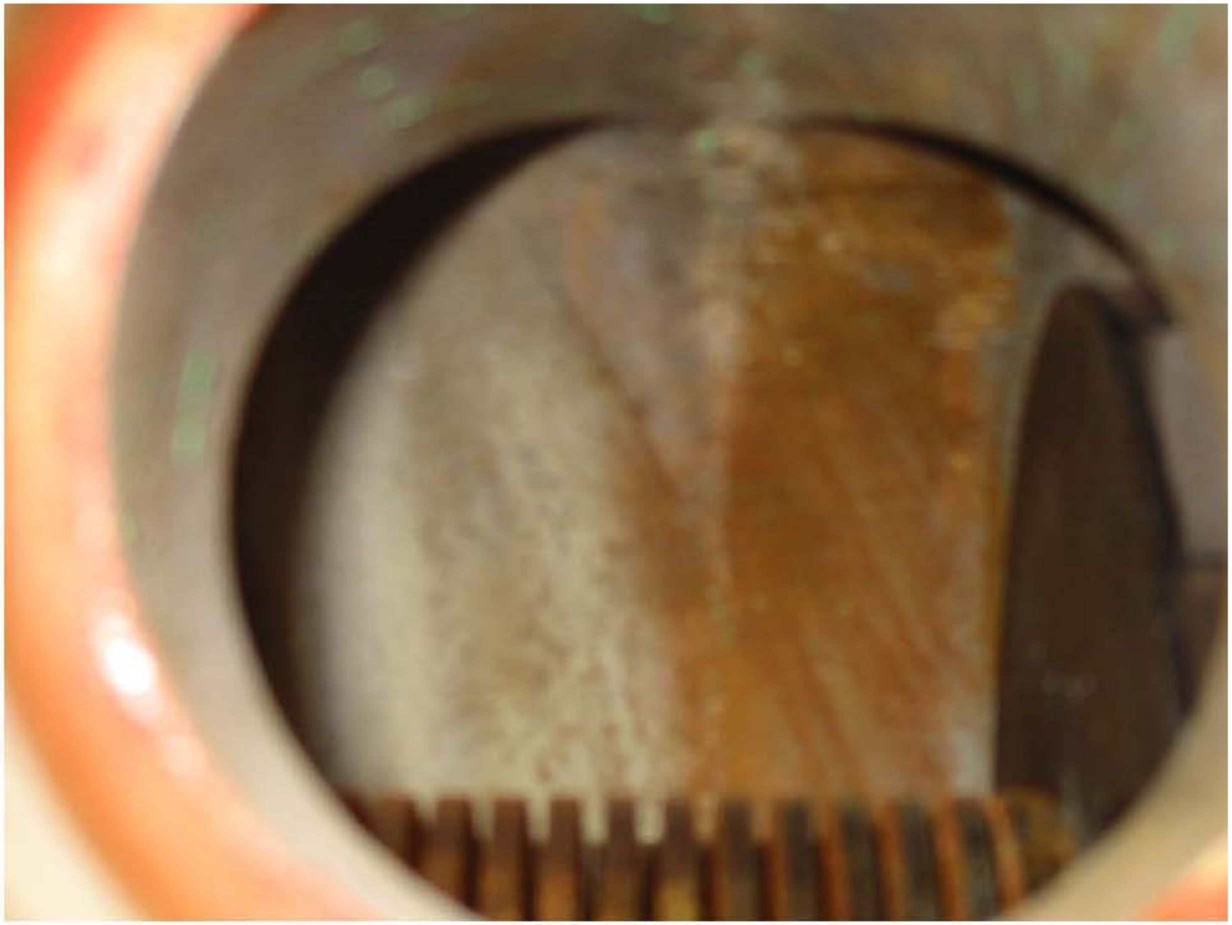

Figure 5.109. View of the blower 701 head outlet port before Test 1.

Figure 5.110. Post failure view of the blower 701 inlet port after 121.2 hours of operation during Test 1.

Figure 5.111. Post failure view of the blower 701 outlet port after 121.2 hours of operation during Test 1.

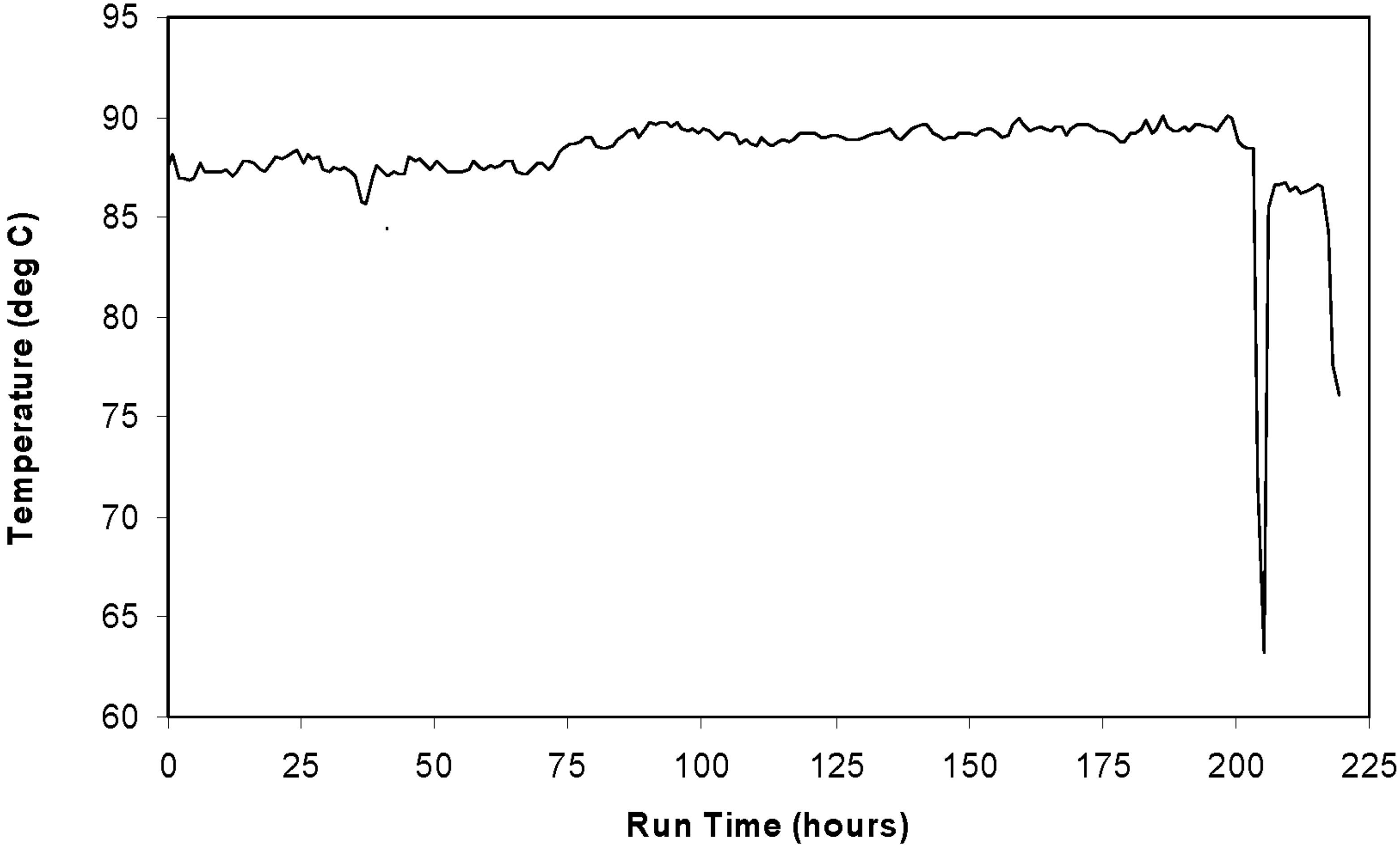

Figure 5.112. Paxton 1 outlet temperature (hourly average values) during Test 3.

Figure 5.113. View of the blower 701 intake impeller with mushroomed edges due to friction after Test 3.

Figure 5.114. Another view of the blower 701 intake impeller with mushroomed edges due to friction after Test 3.

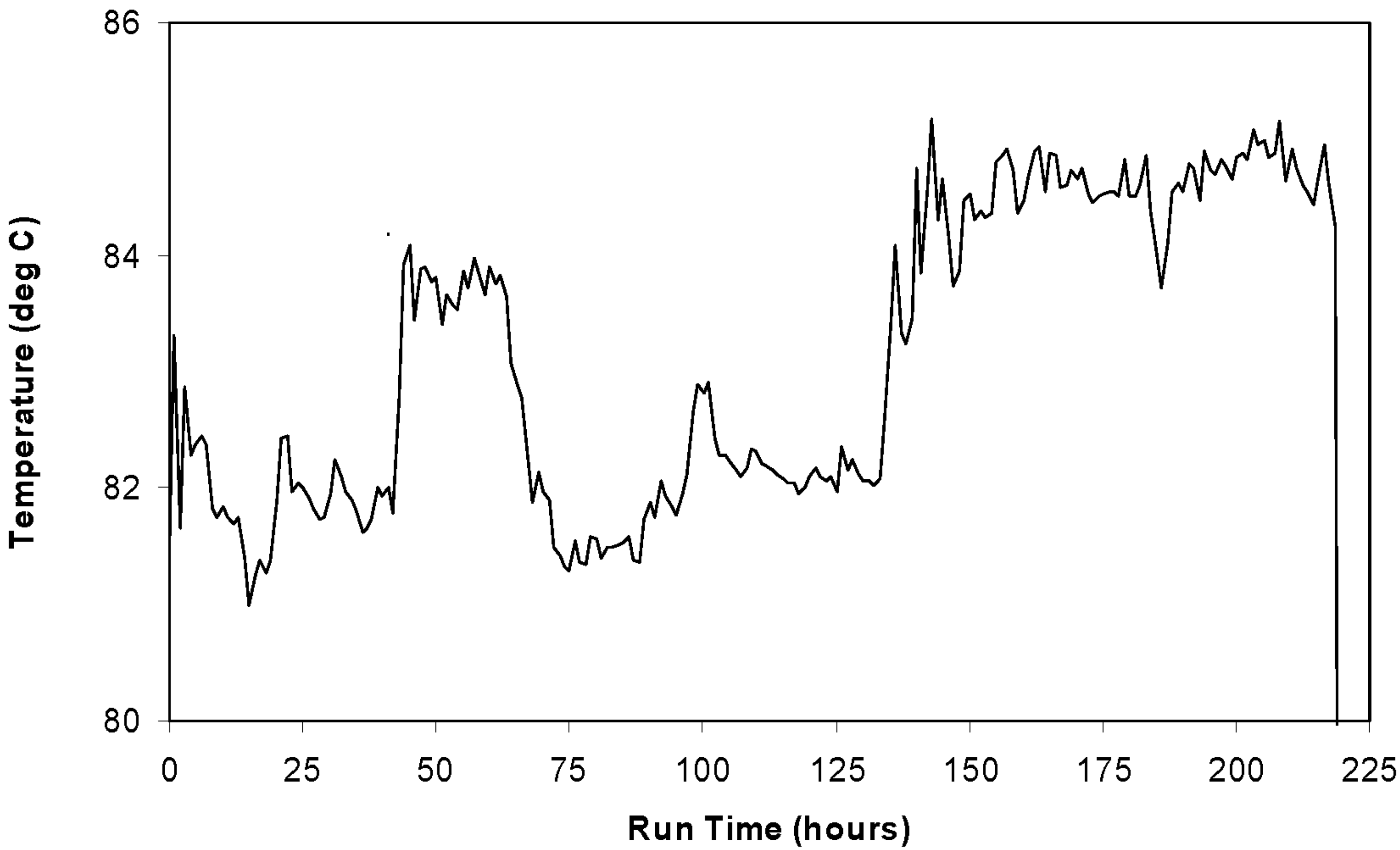

Figure 5.115. Paxton 1 outlet temperature (hourly average values) during Test 4.

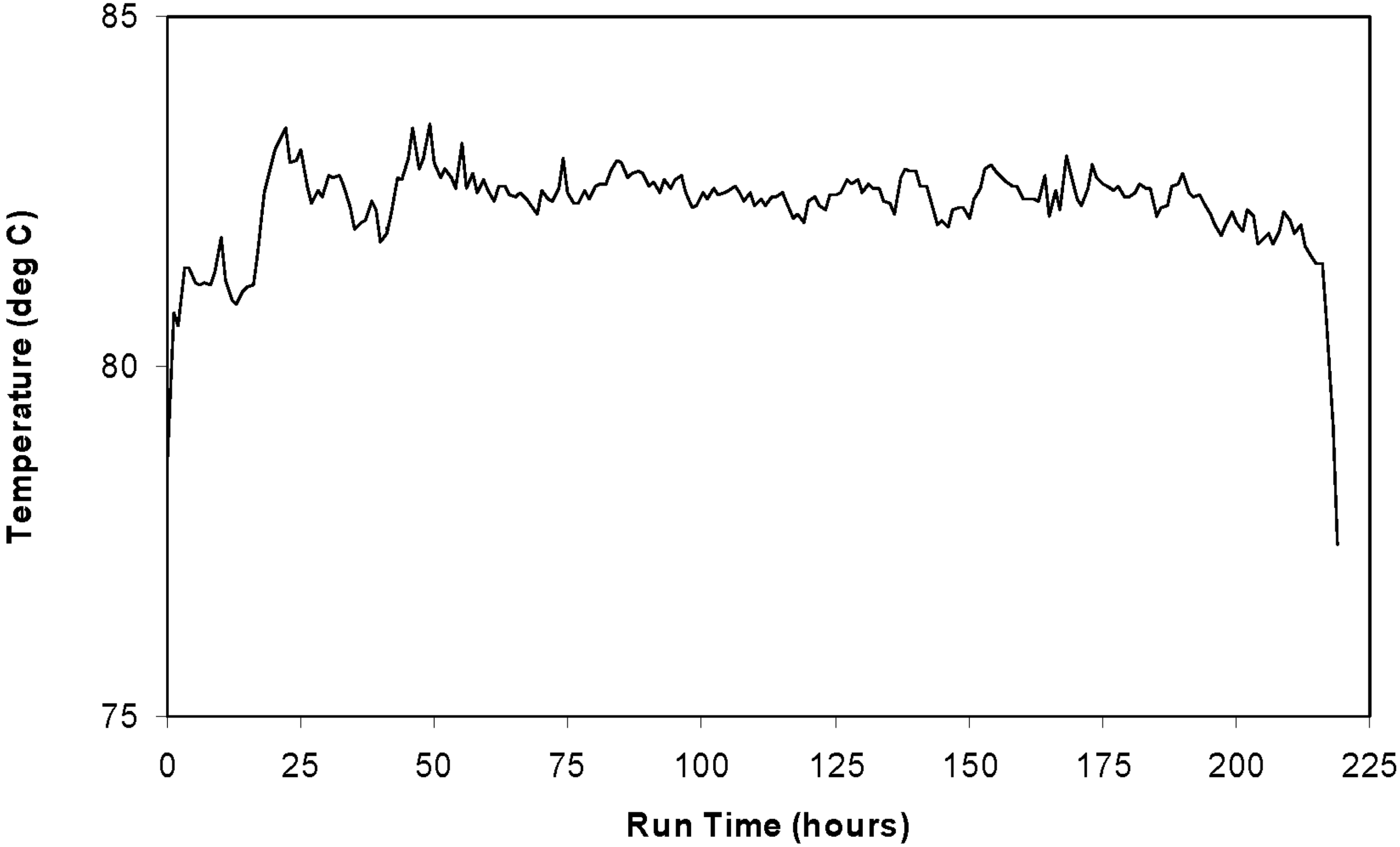

Figure 5.116. Paxton 1 outlet temperature (hourly average values) during Test 5.

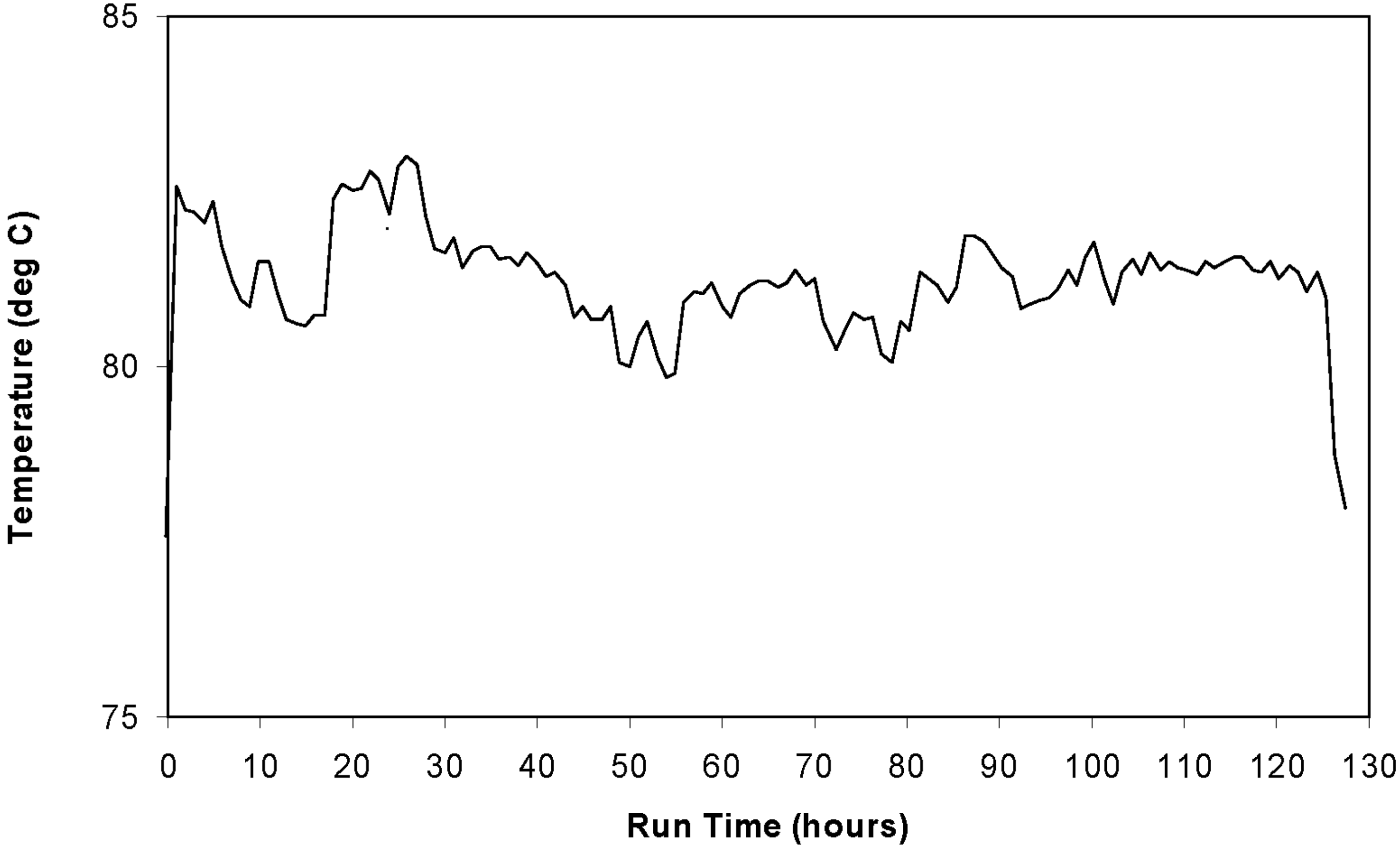

Figure 5.117. Paxton 1 outlet temperature (hourly average values) during Test 6.

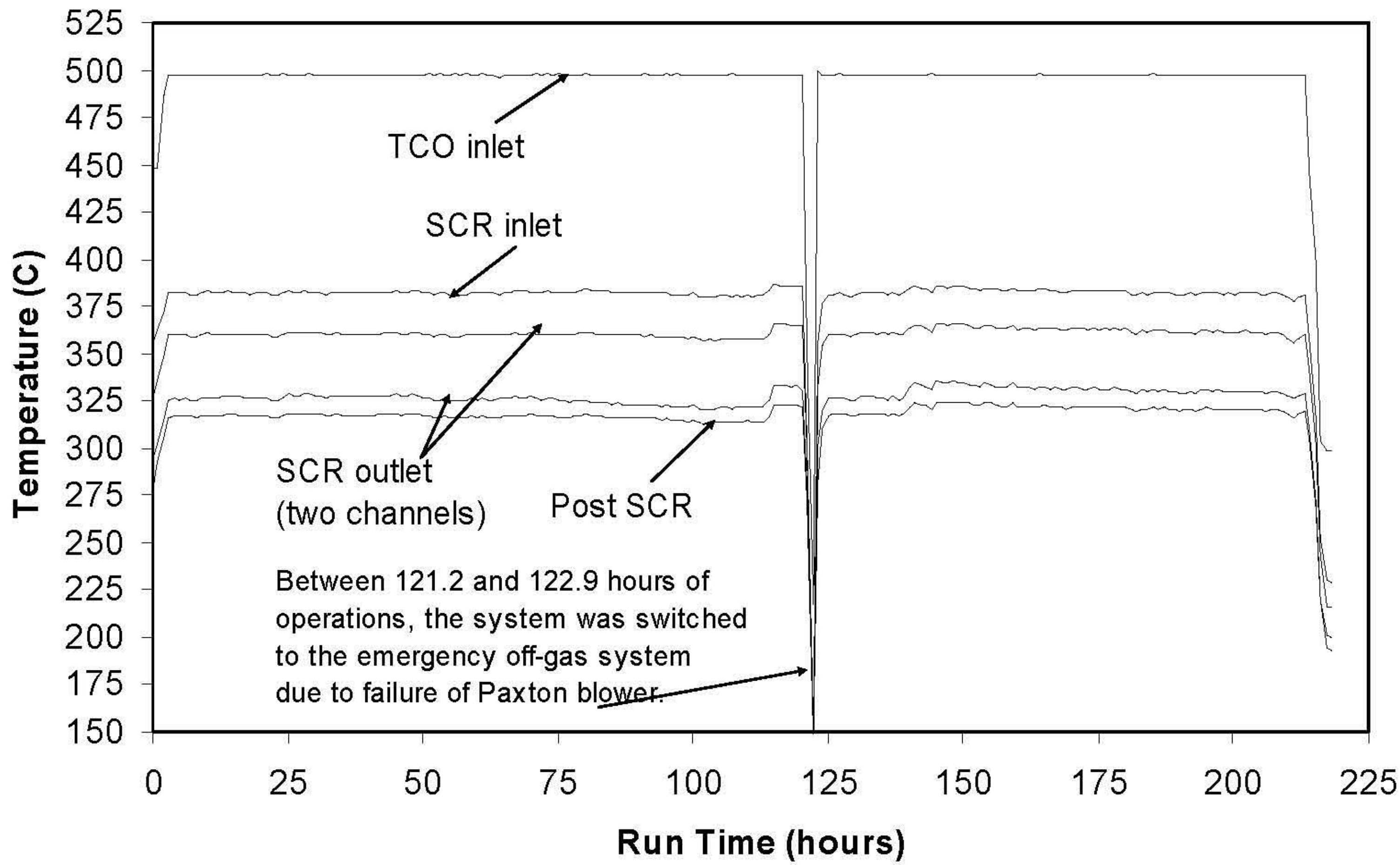

Figure 5.118. TCO/SCR temperatures (hourly average values) during Tests 1 and 2.

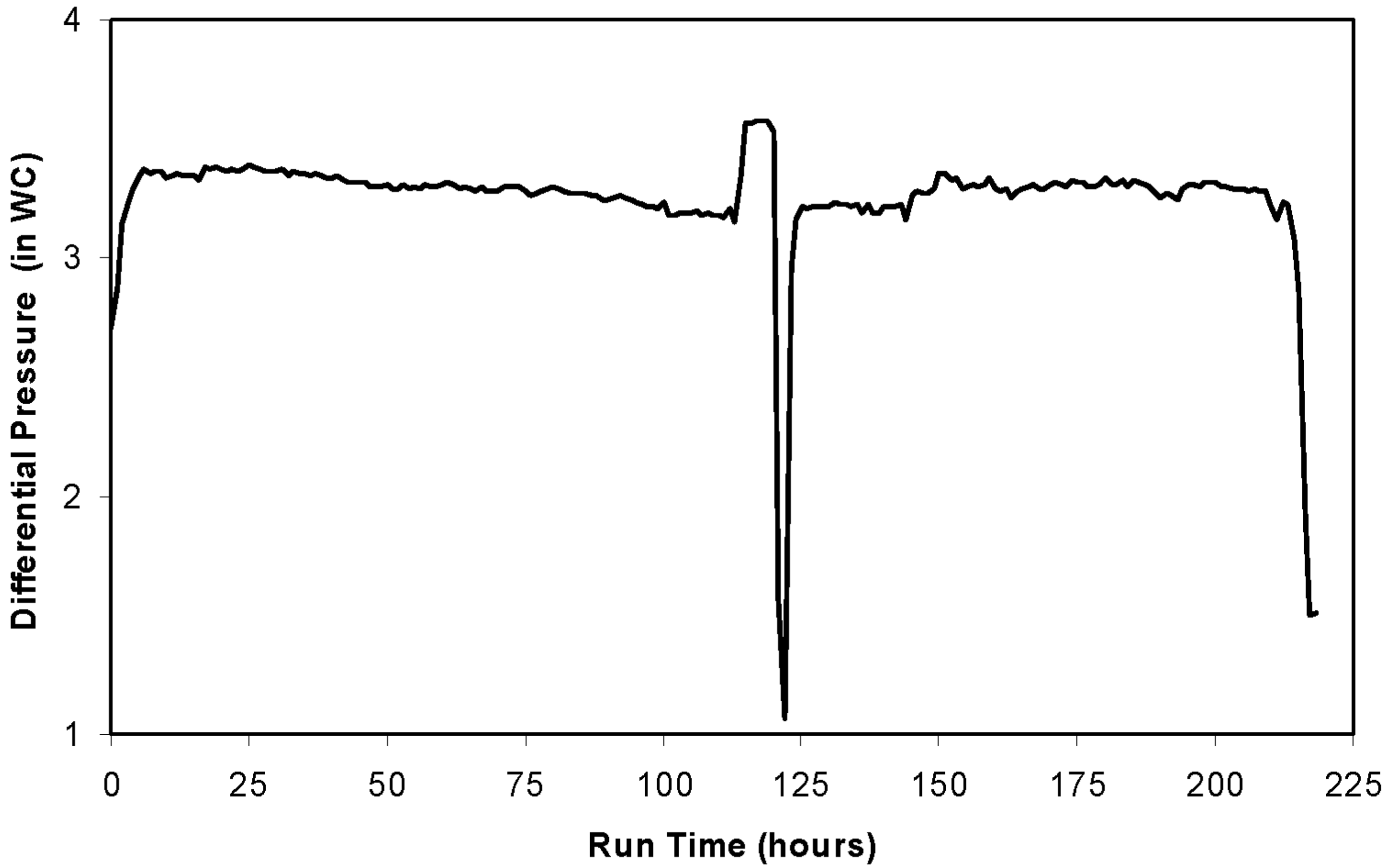

Figure 5.119. TCO differential pressure (hourly average values) during Tests 1 and 2.

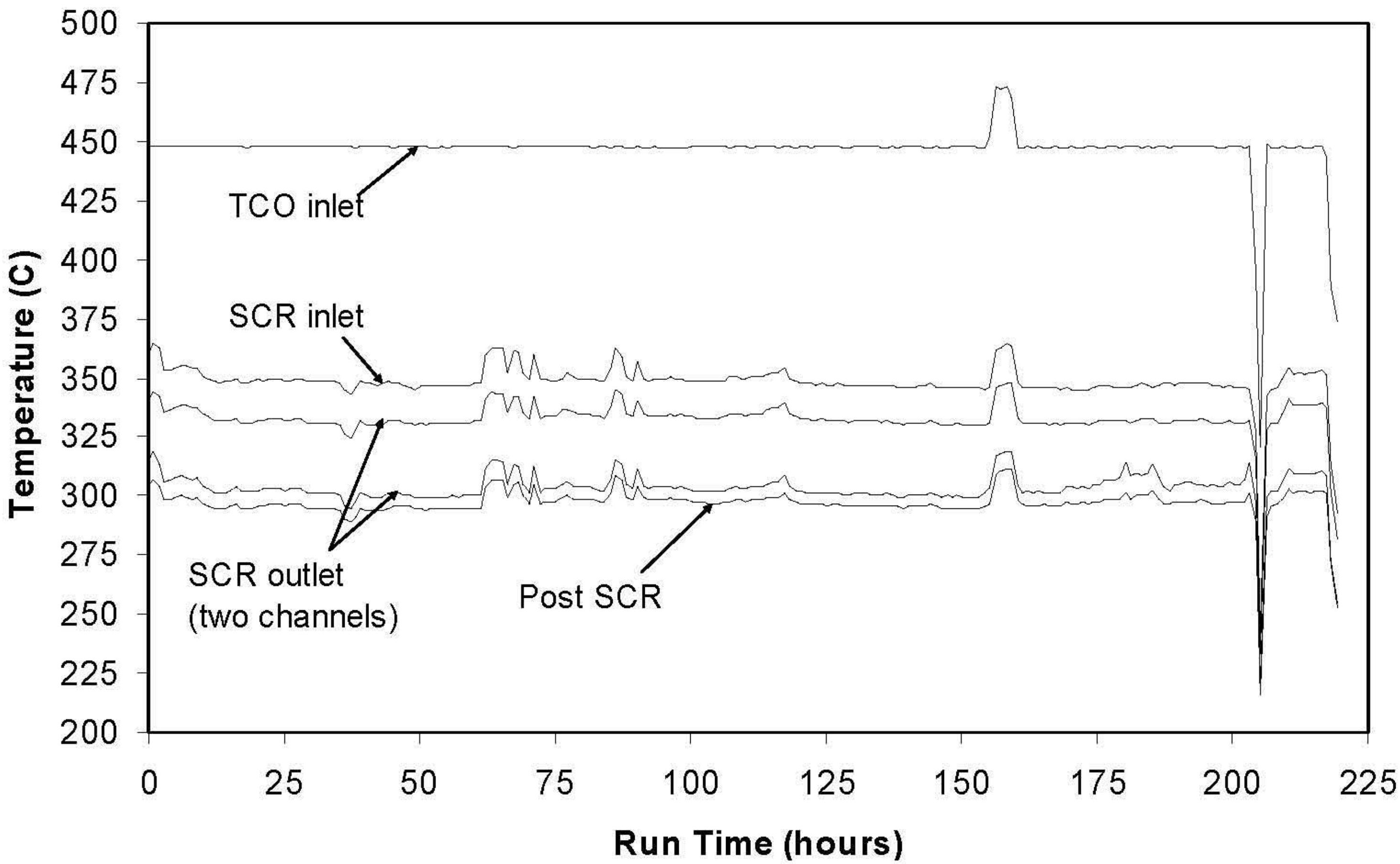

Figure 5.120. TCO/SCR temperatures (hourly average values) during Test 3.

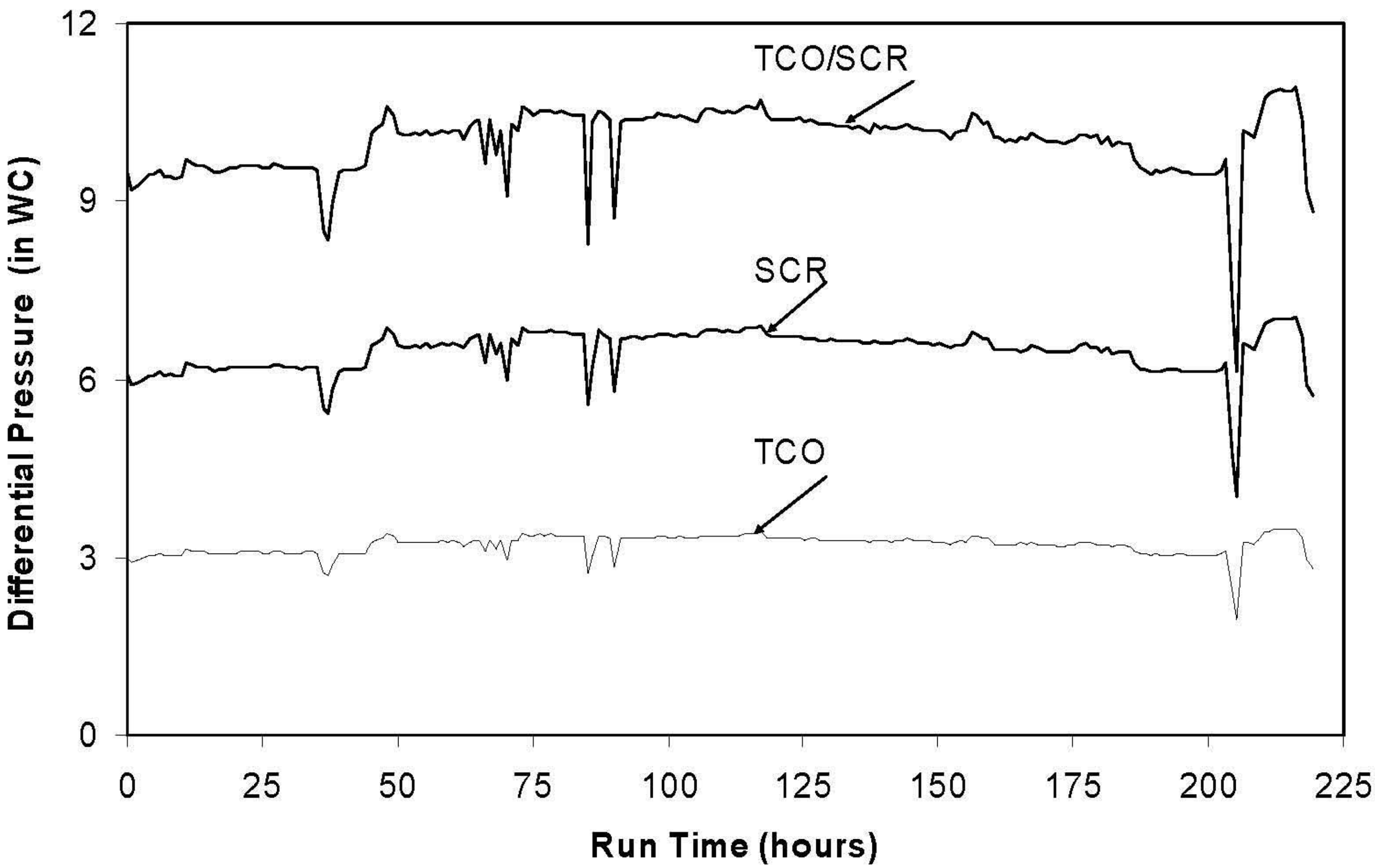

Figure 5.121. TCO/SCR differential pressures (hourly average values) during Test 3.

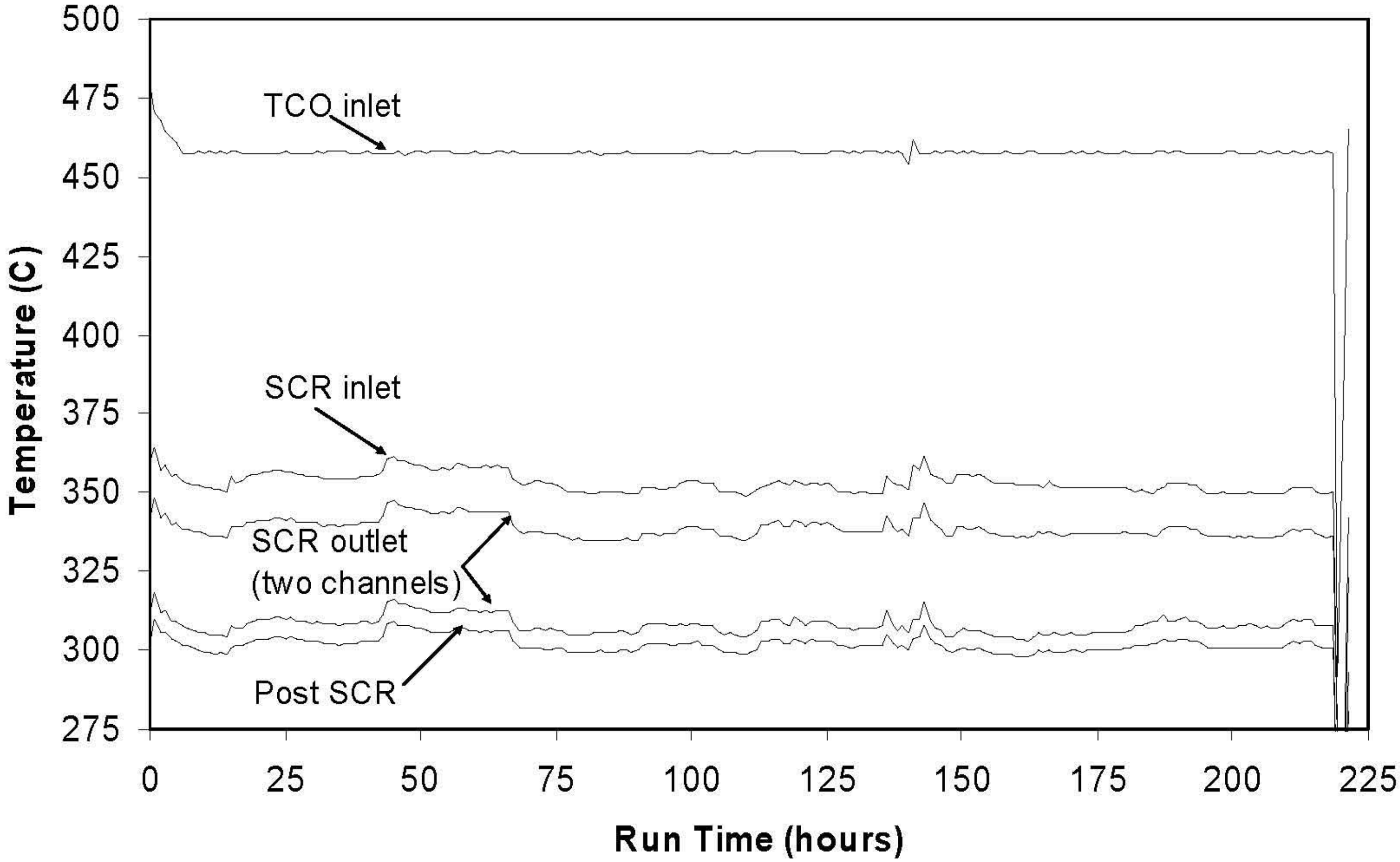

Figure 5.122. TCO/SCR temperatures (hourly average values) during Test 4.

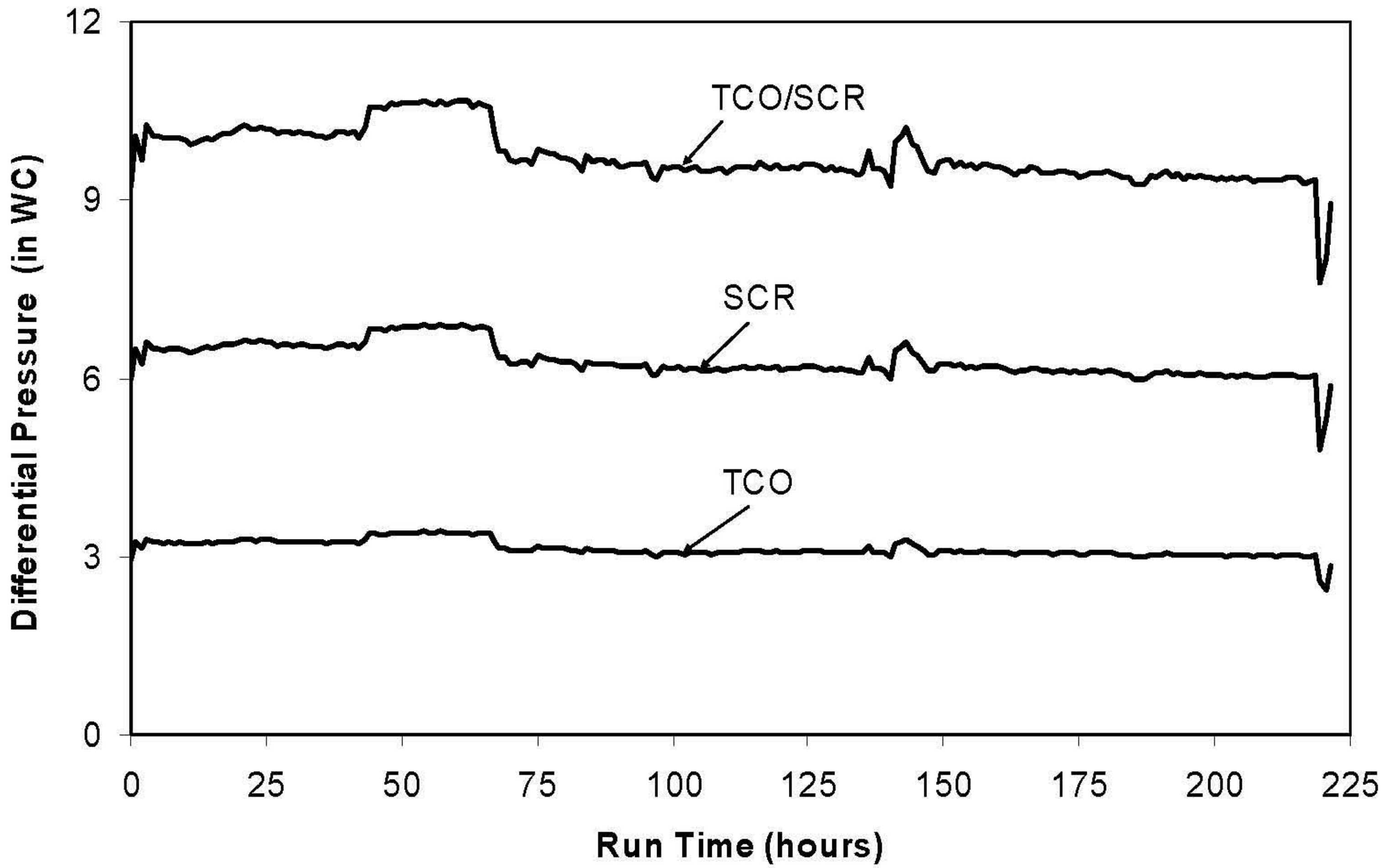

Figure 5.123. TCO/SCR differential pressures (hourly average values) during Test 4.

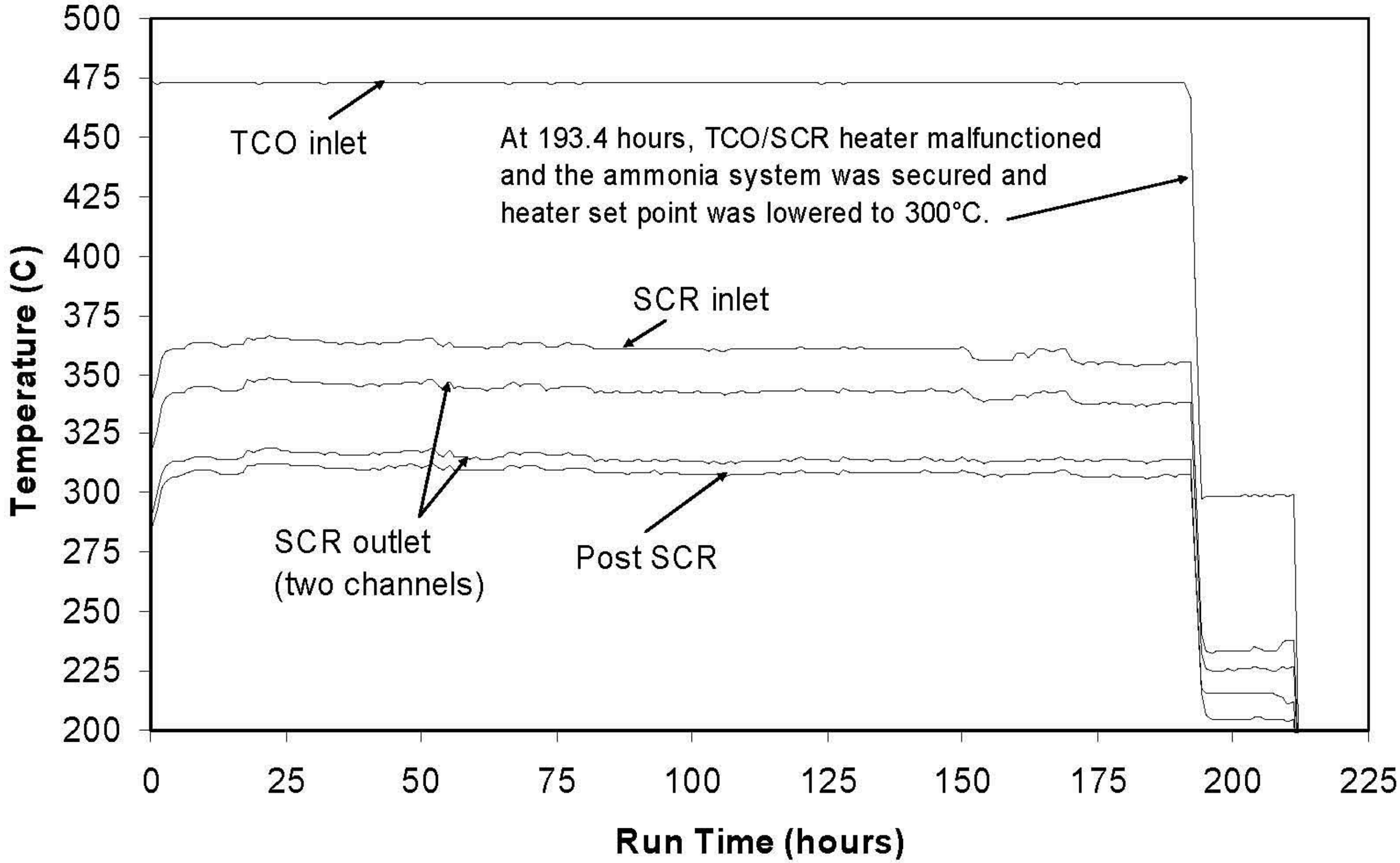

Figure 5.124. TCO/SCR temperatures (hourly average values) during Test 5.

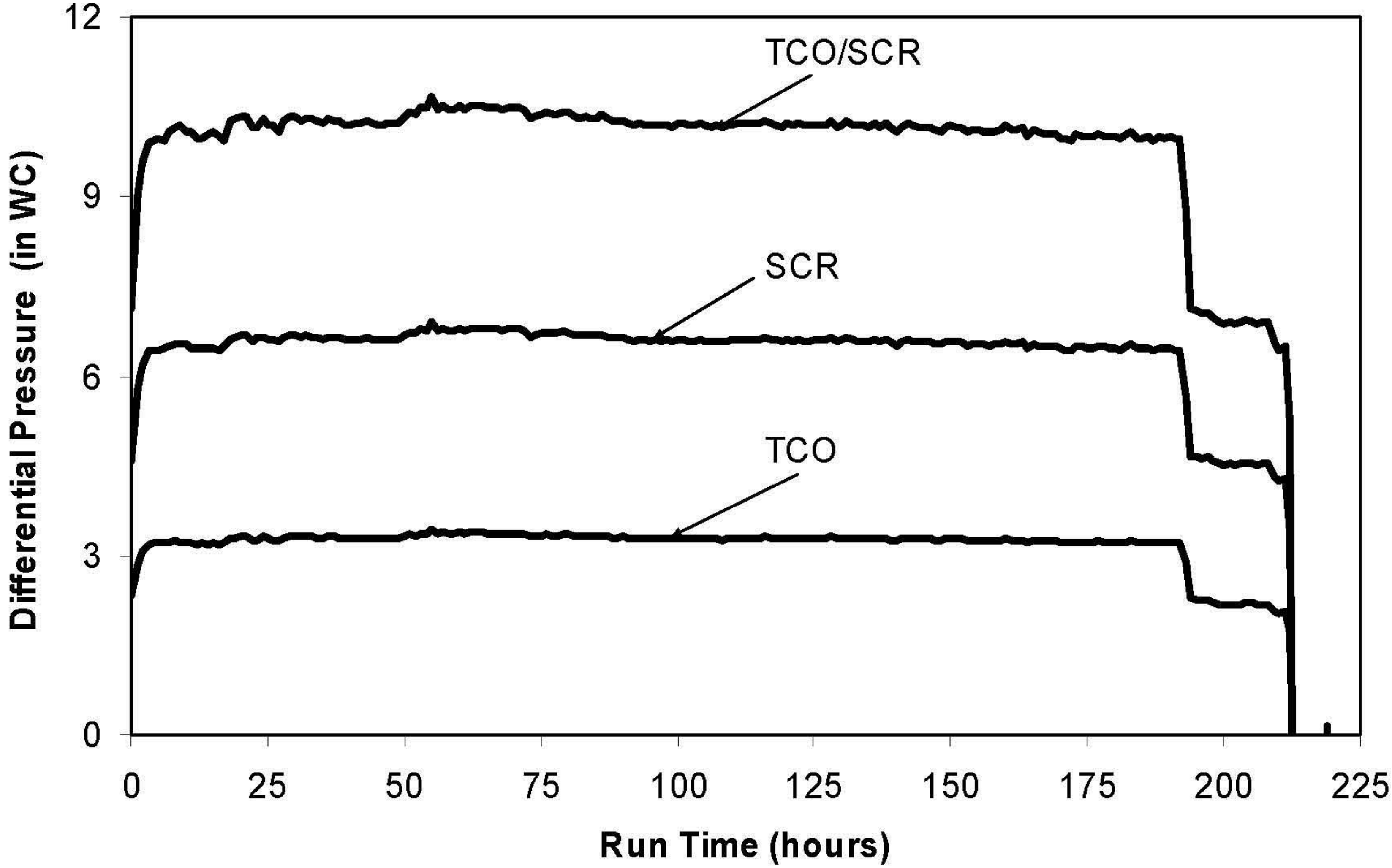

Figure 5.125. TCO/SCR differential pressures (hourly average values) during Test 5.

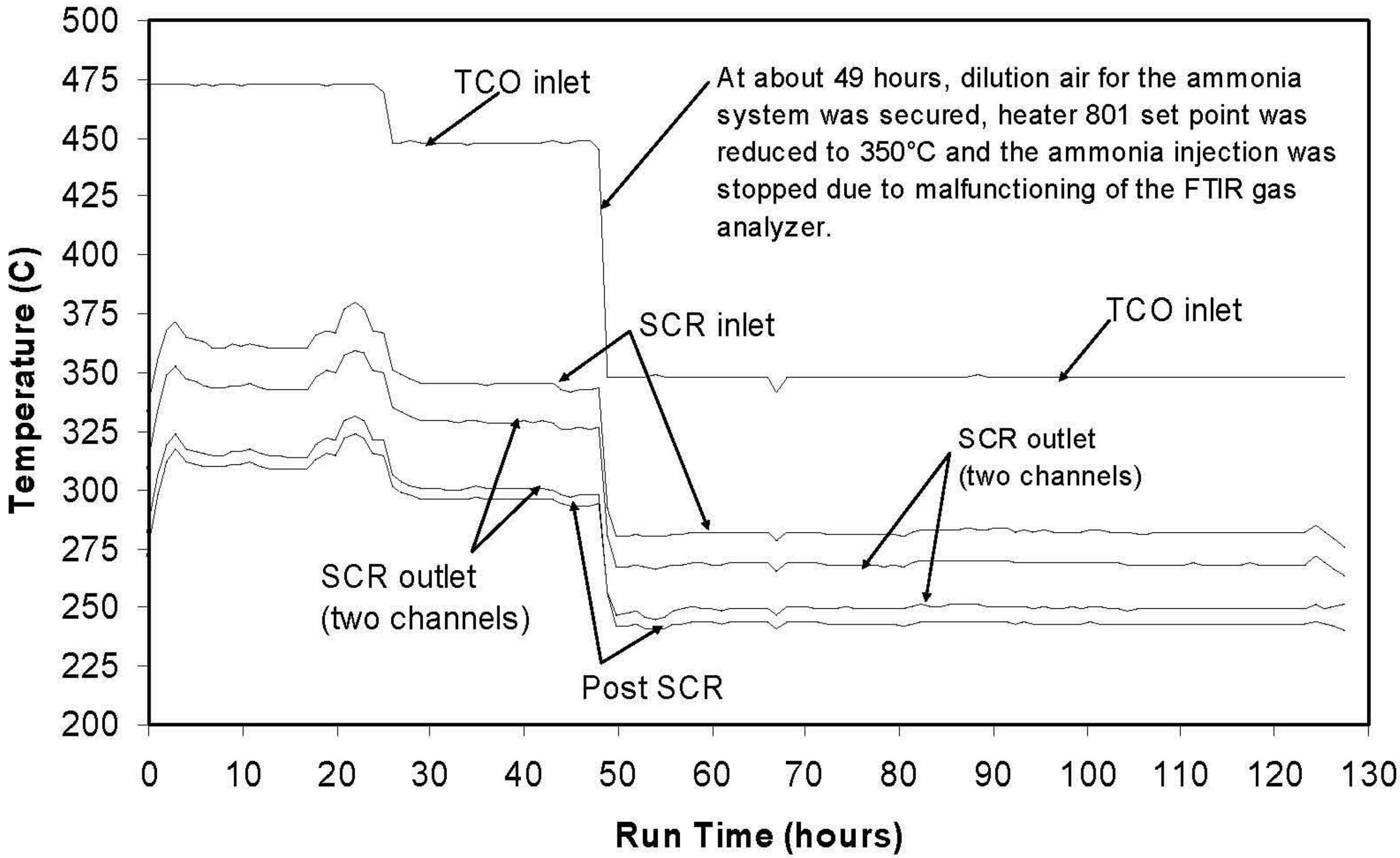

Figure 5.126. TCO/SCR temperatures (hourly average values) during Test 6.

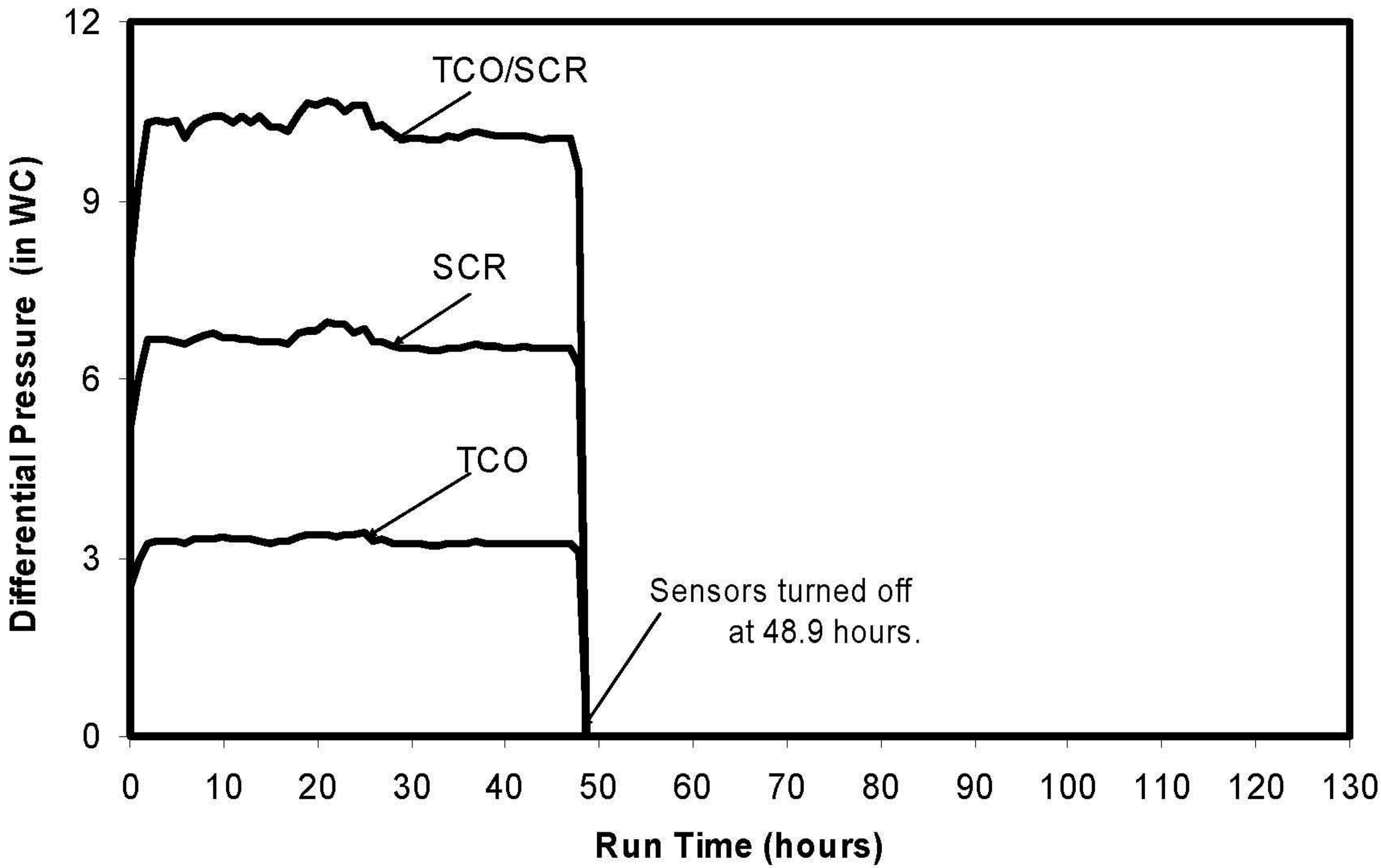

Figure 5.127. TCO/SCR differential pressures (hourly average values) during Test 6.

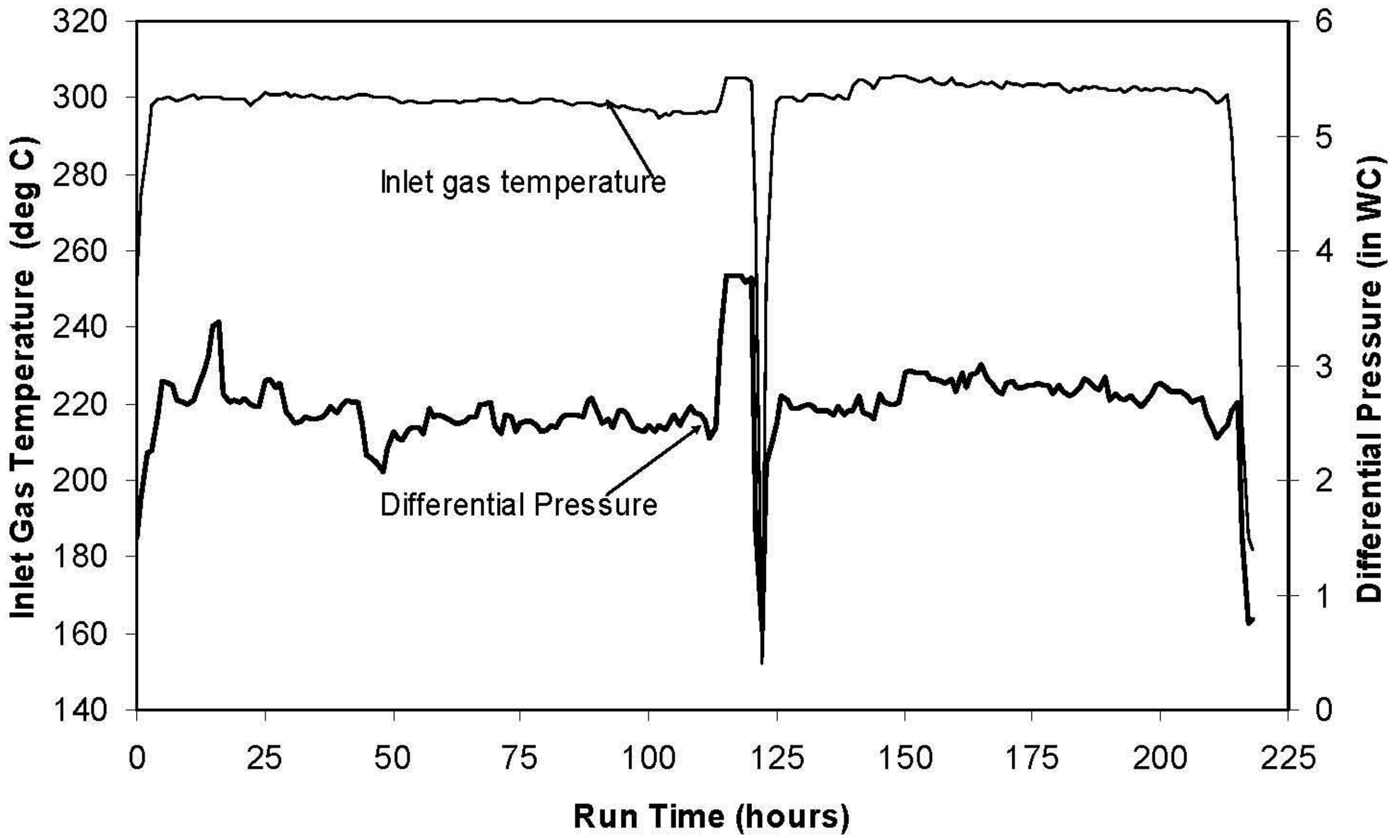

Figure 5.128. Inlet temperature and differential pressure for PBS (hourly average values) during Tests 1 and 2.

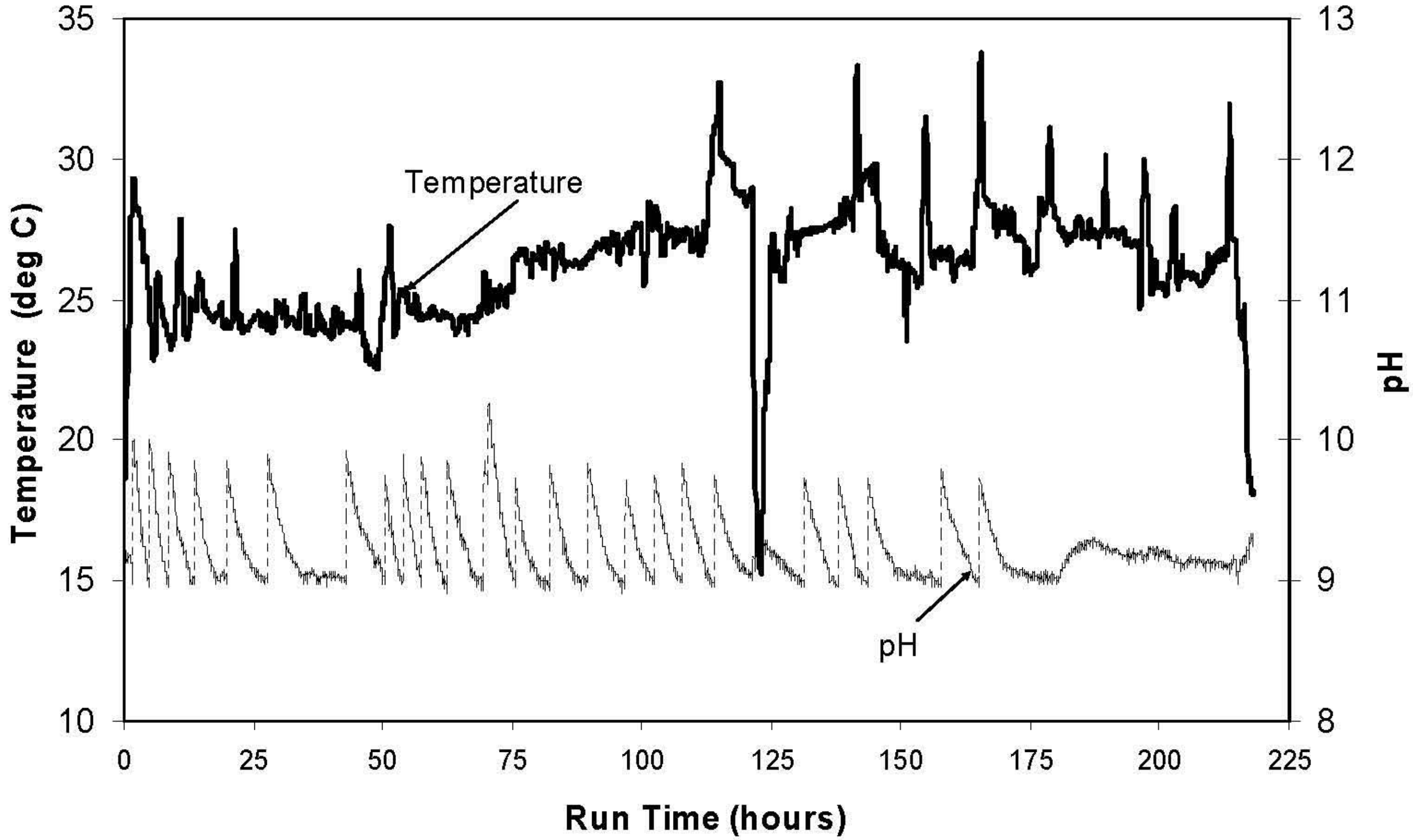

Figure 5.129. Sump temperature and pH for PBS during Tests 1 and 2.

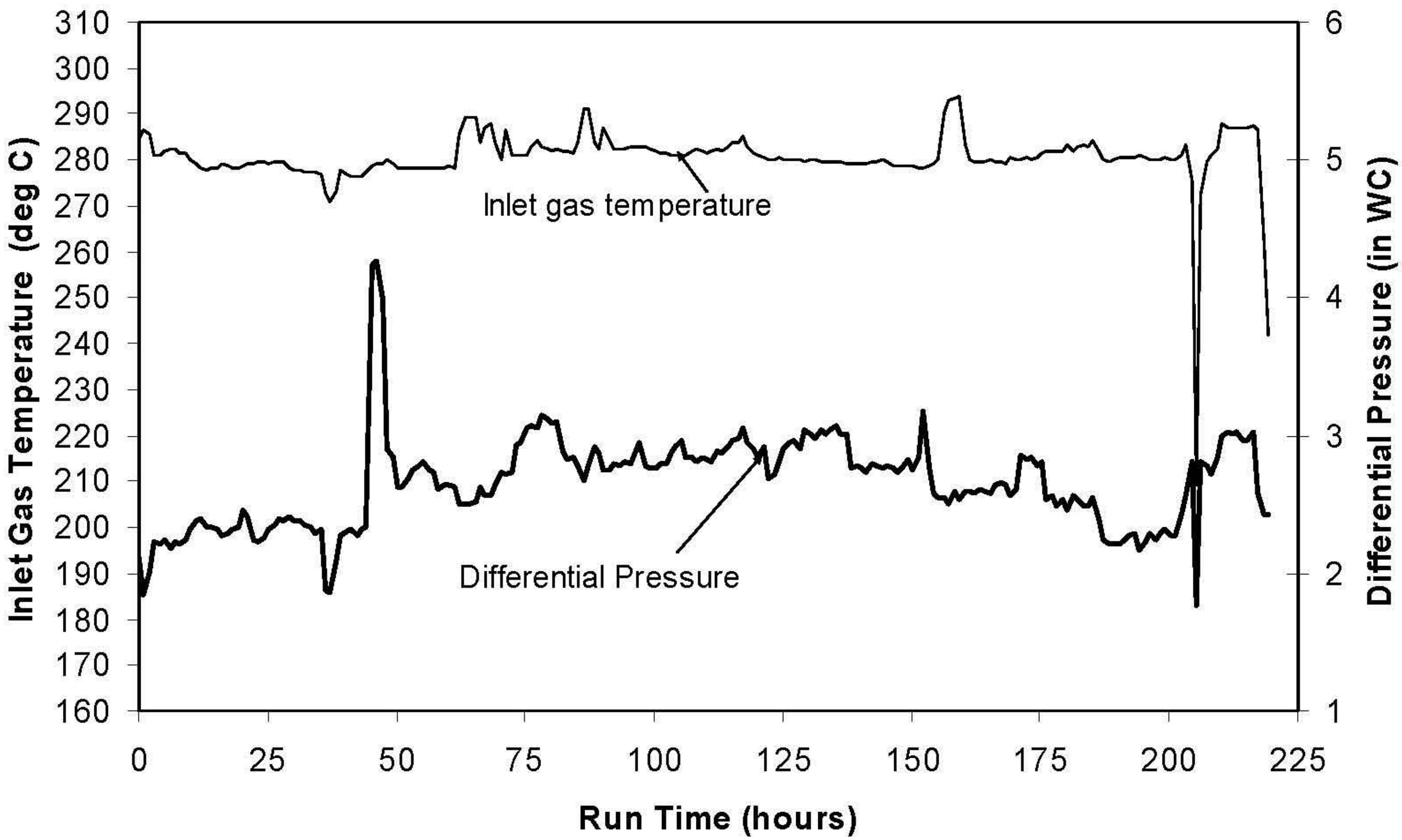

Figure 5.130. Inlet temperature and differential pressure for PBS (hourly average values) during Test 3.

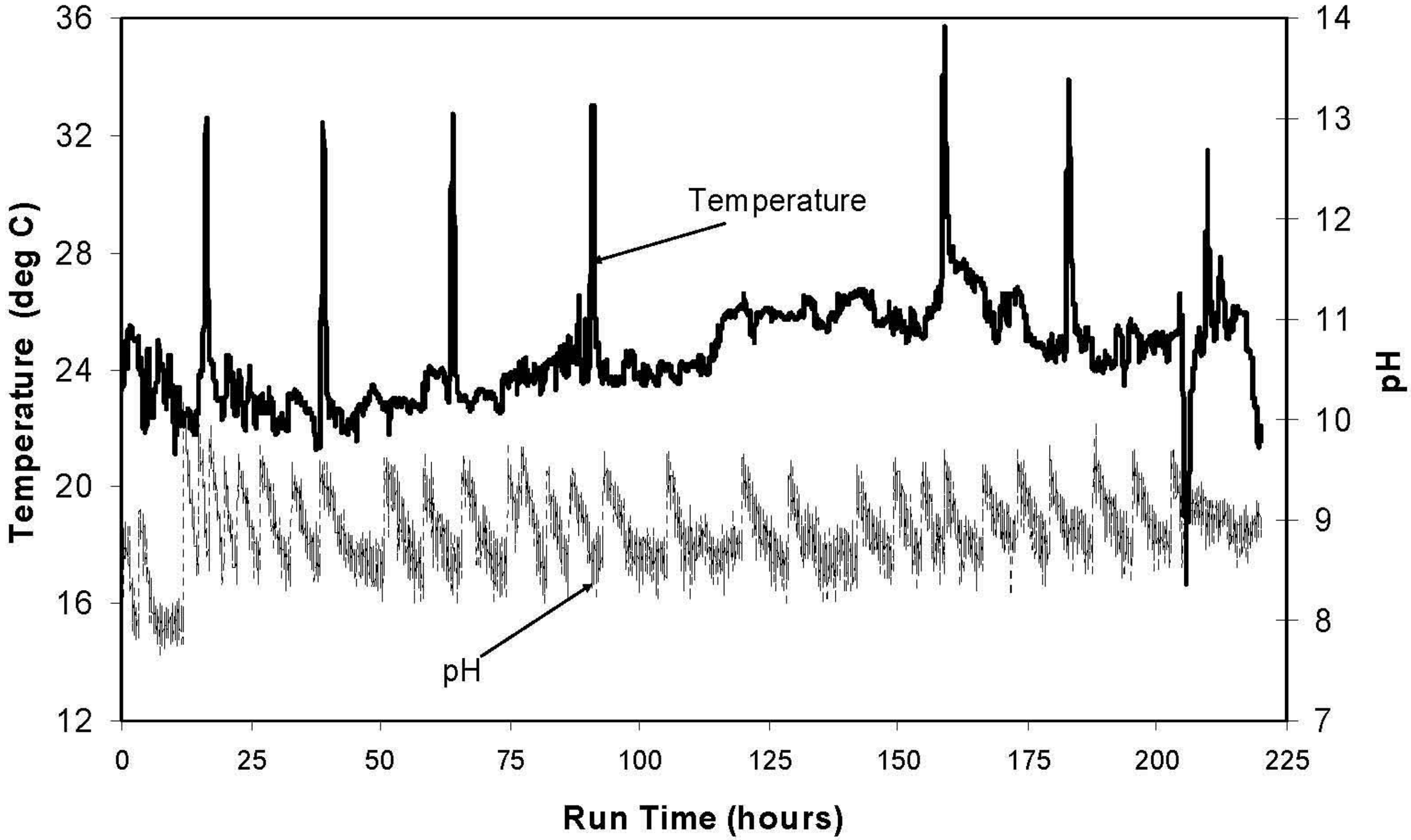

Figure 5.131. Sump temperature and pH for PBS during Test 3.

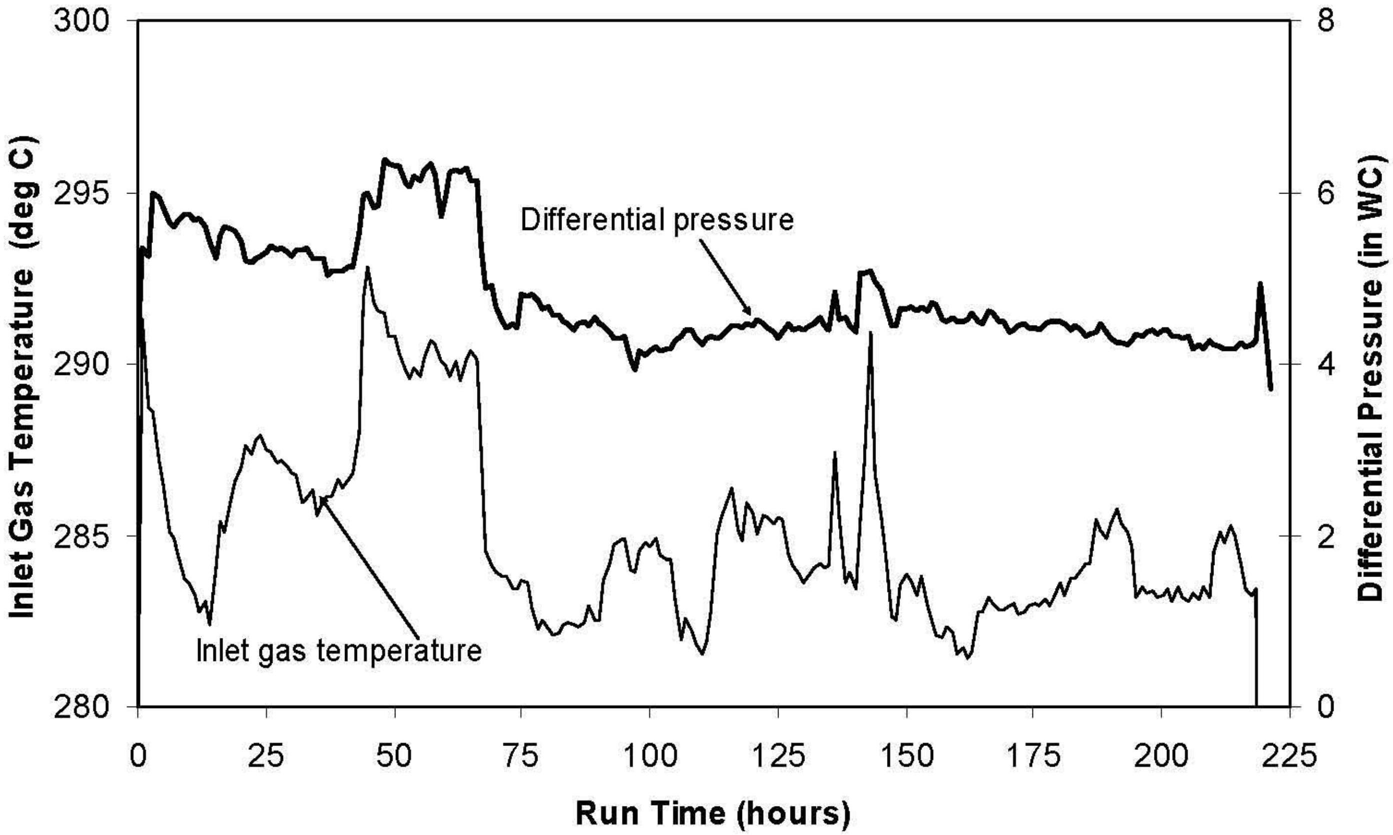

Figure 5.132. Inlet temperature and differential pressure for PBS (hourly average values) during Test 4.

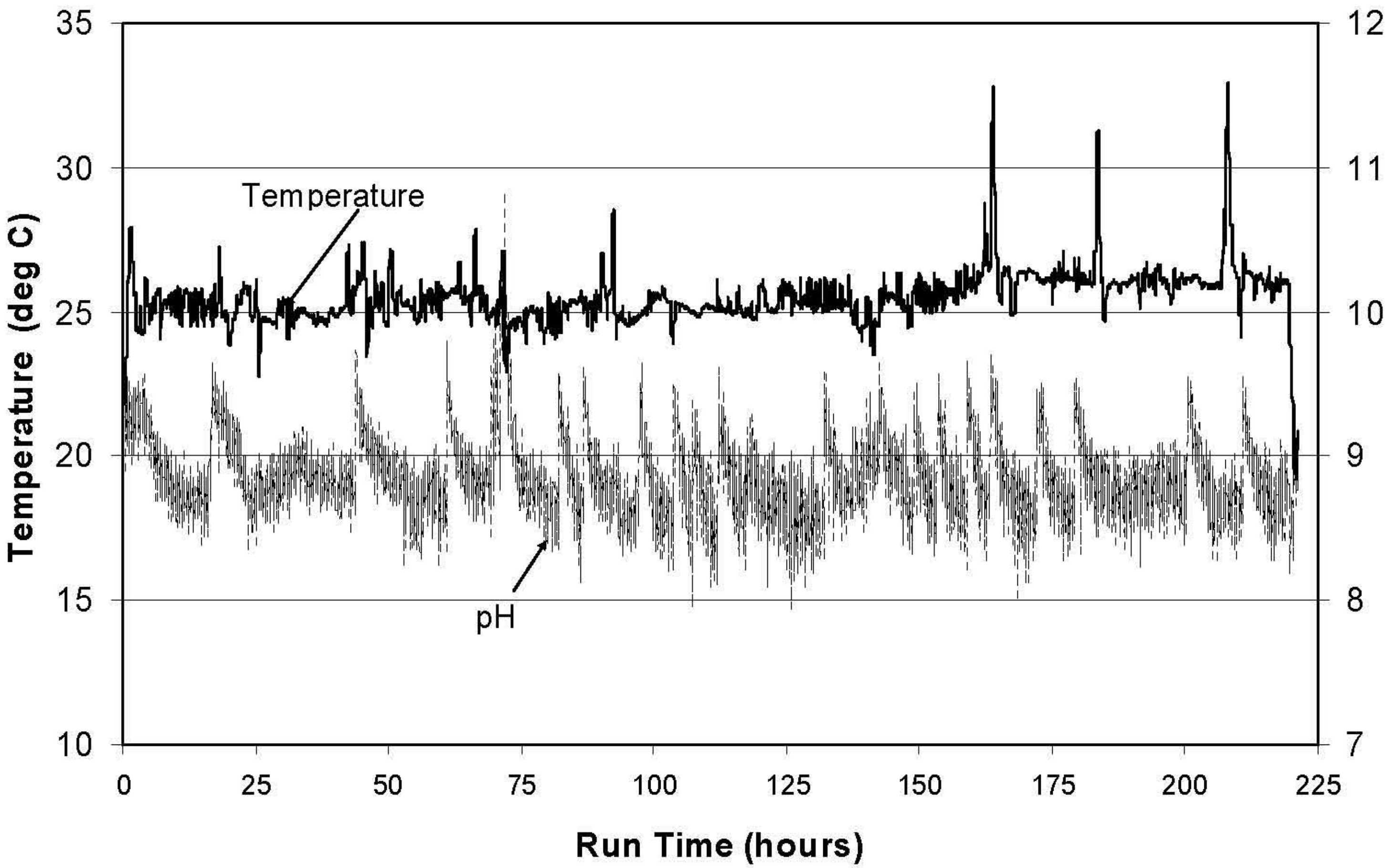

Figure 5.133. Sump temperature and pH for PBS during Test 4.

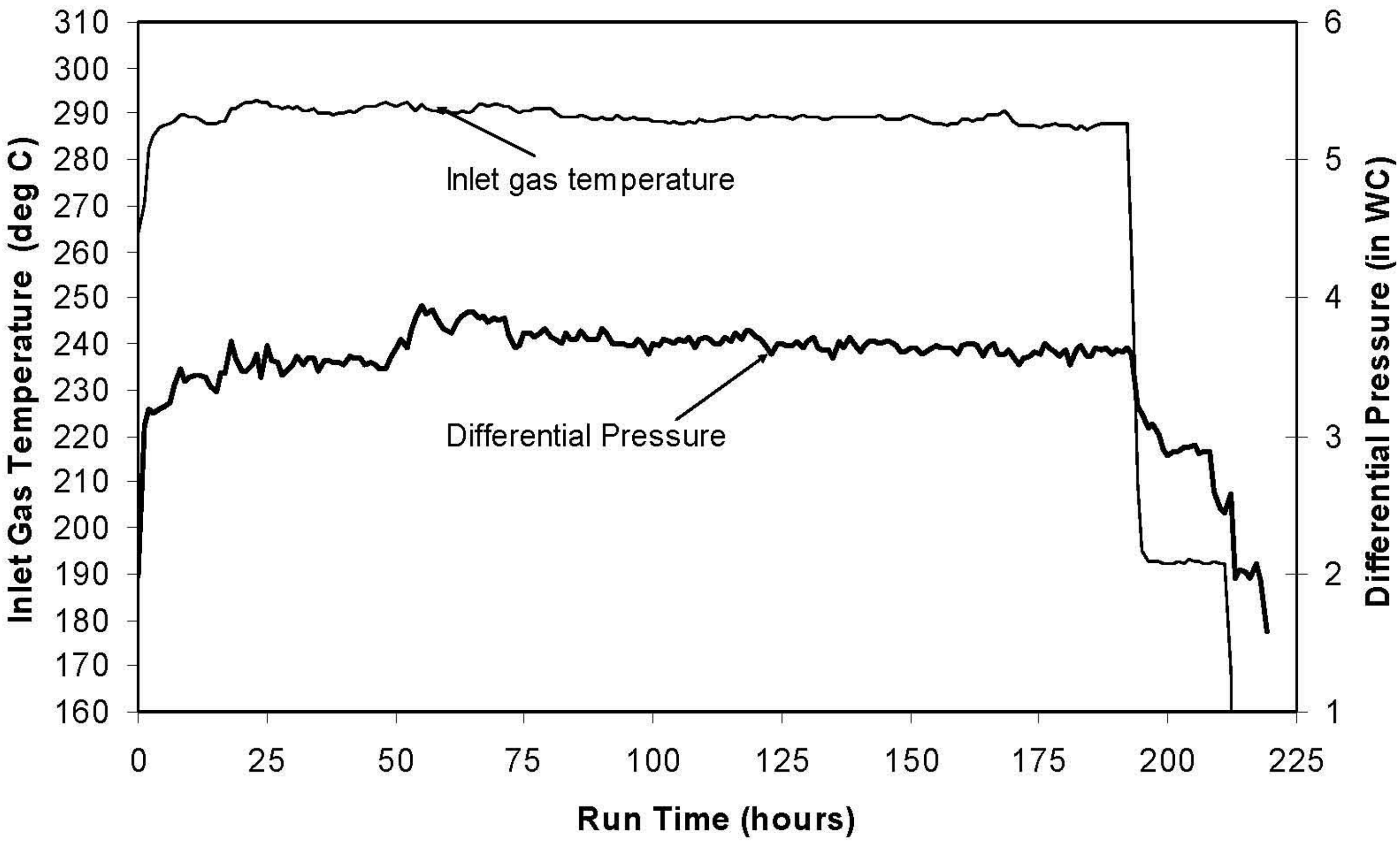

Figure 5.134. Inlet temperature and differential pressure for PBS (hourly average values) during Test 5.

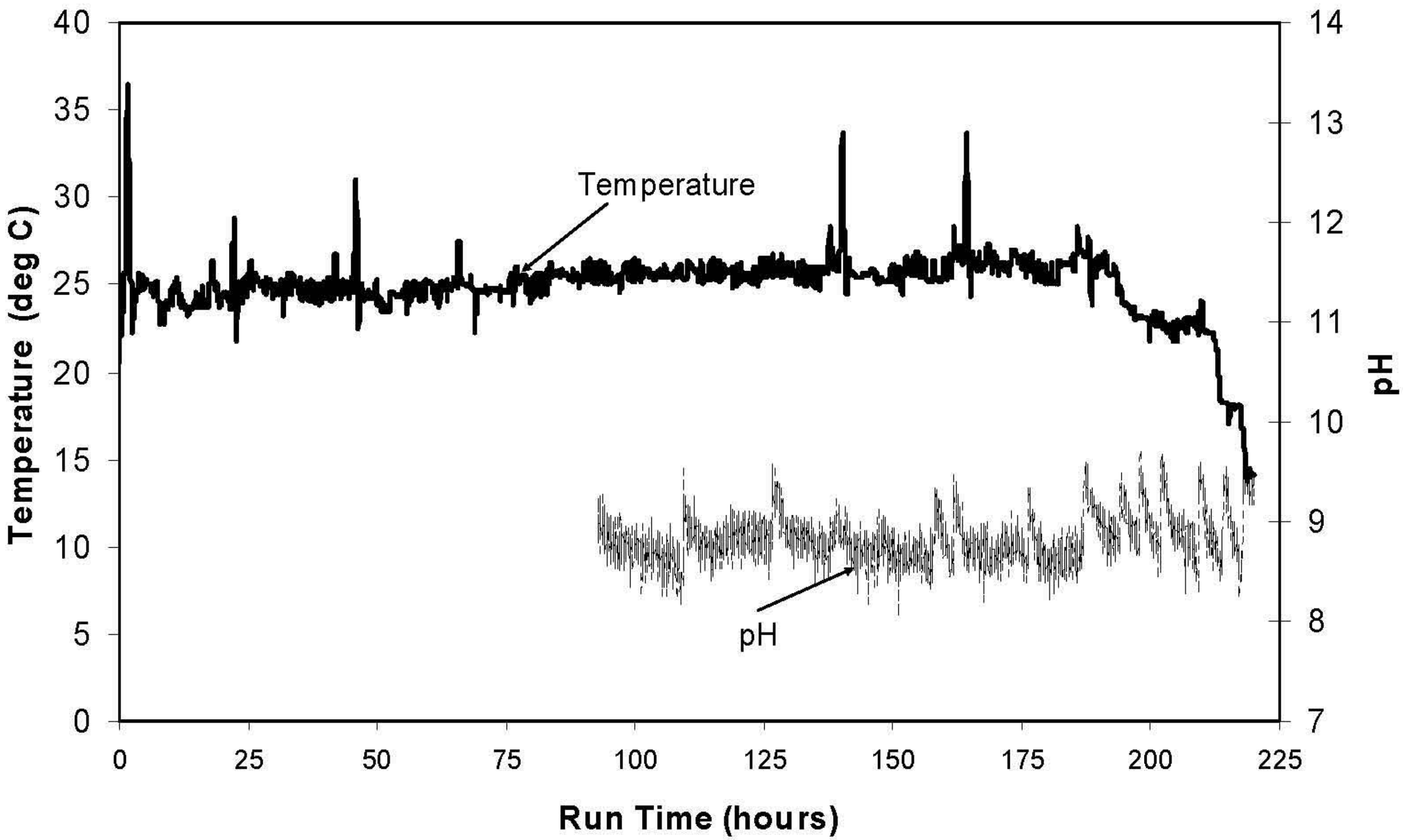

Figure 5.135. Sump temperature and pH for PBS during Test 5.

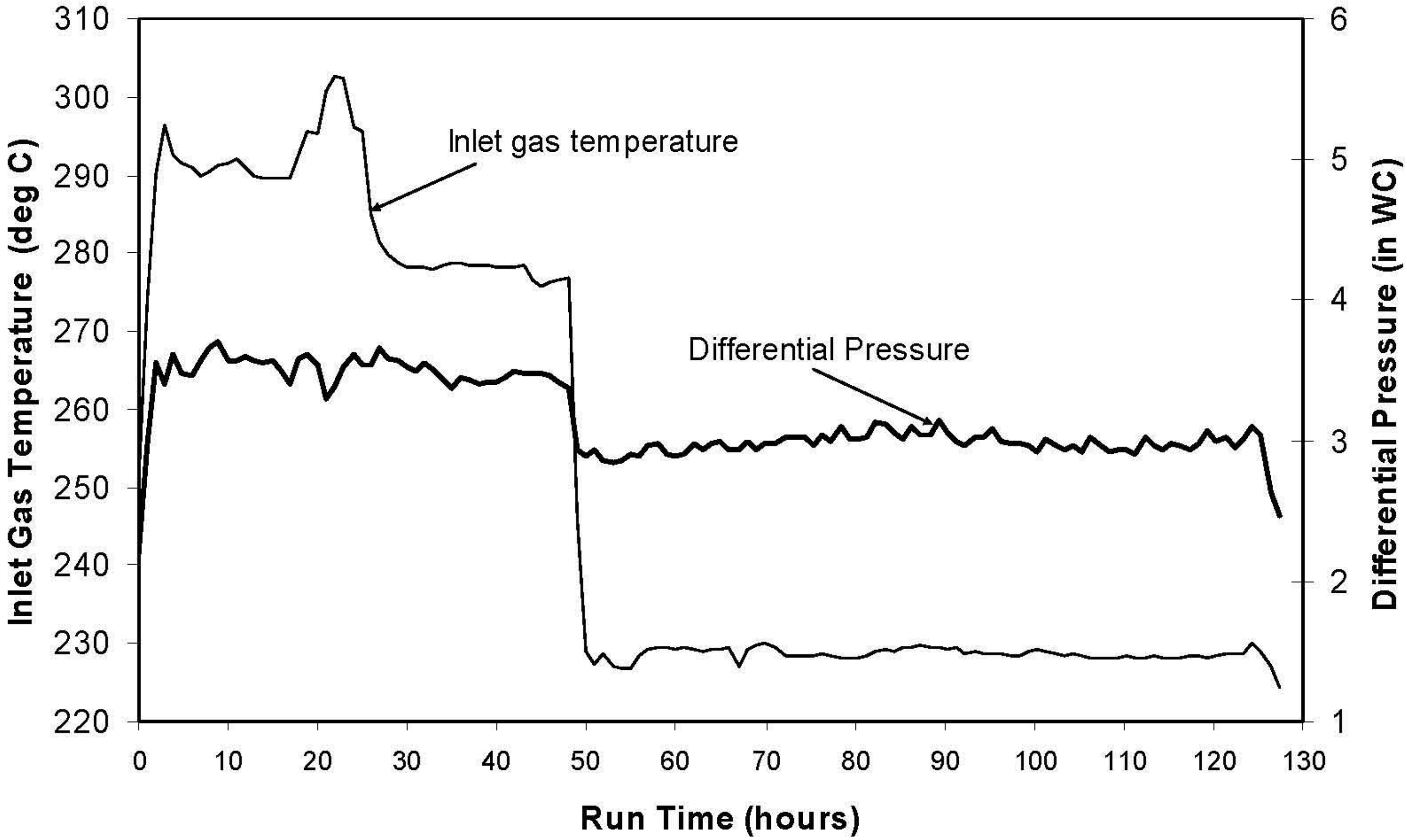

Figure 5.136. Inlet temperature and differential pressure for PBS (hourly average values) during Test 6.

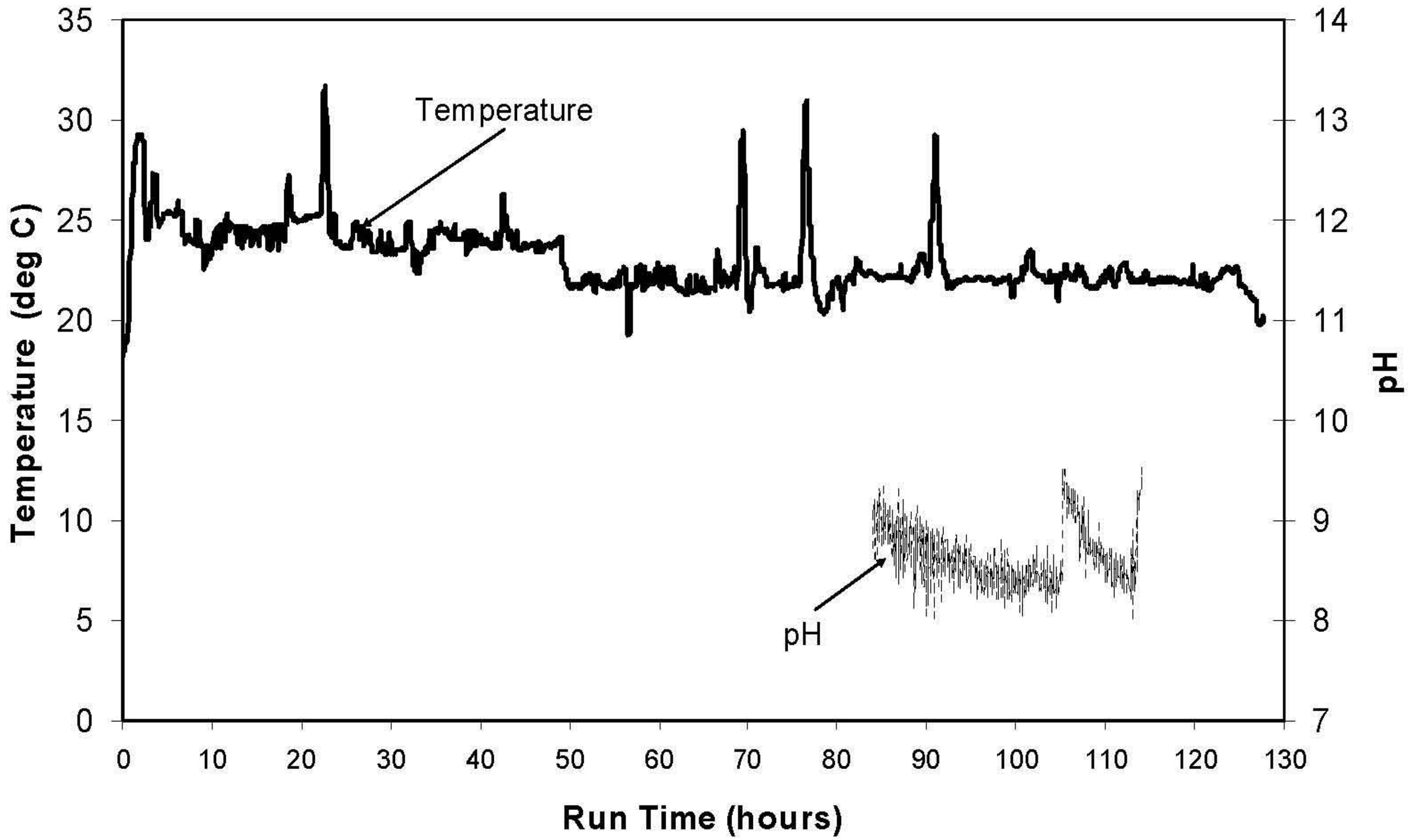

Figure 5.137. Sump temperature and pH for PBS during Test 6.

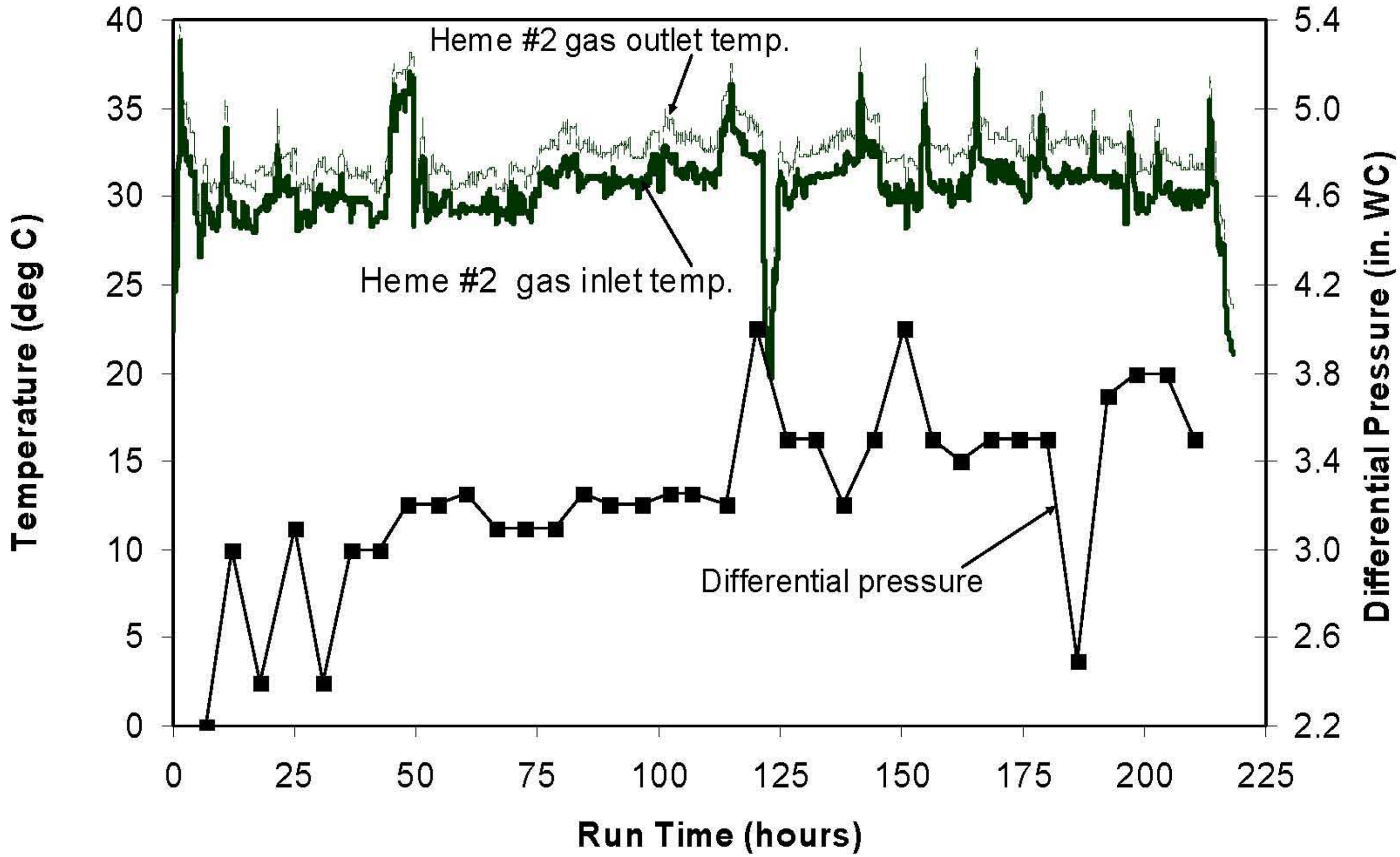

Figure 5.138. Inlet and outlet temperatures and differential pressure for HEME #2 during Tests 1 and 2.

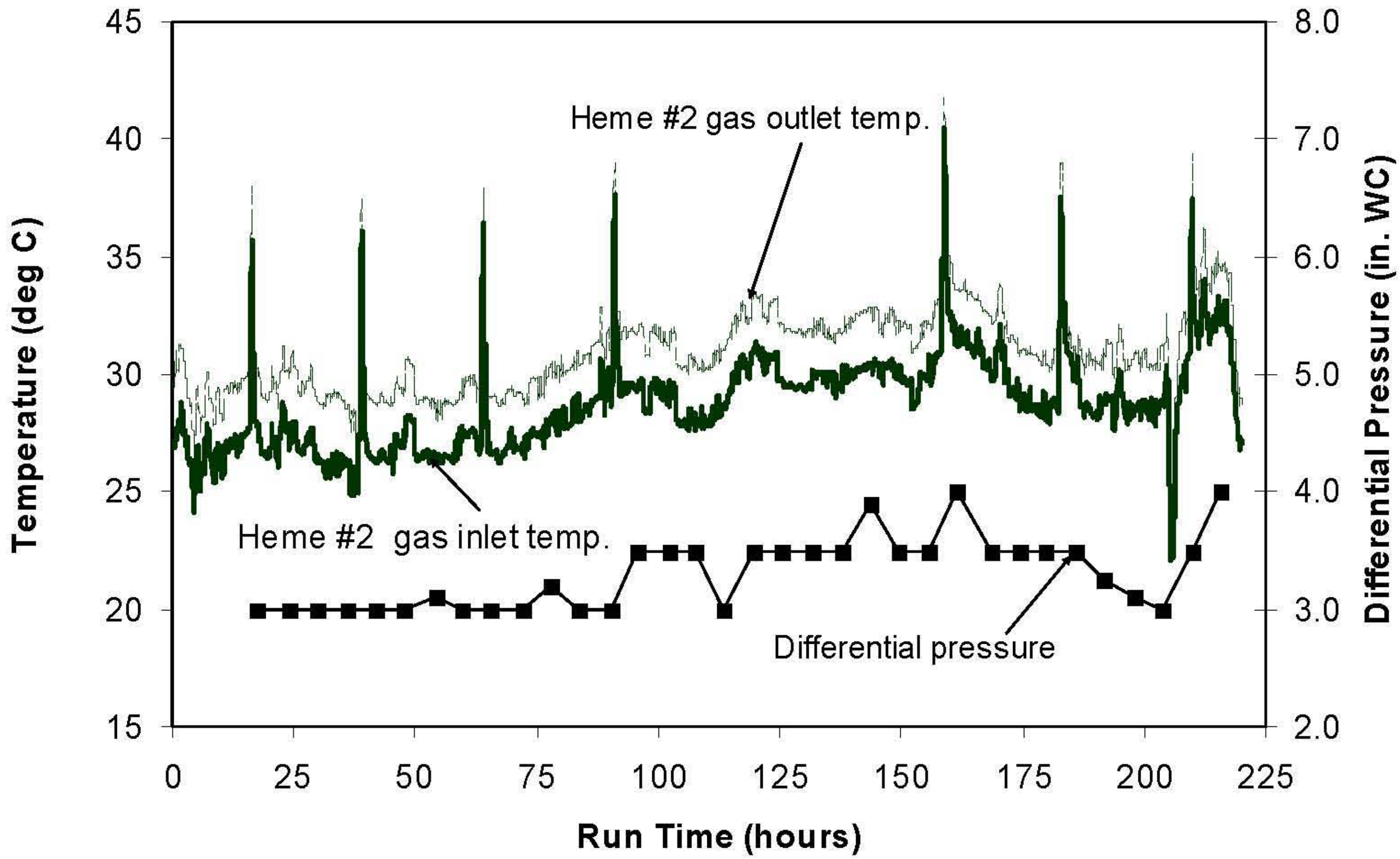

Figure 5.139. Inlet and outlet temperatures and differential pressure for HEME #2 during Test 3.

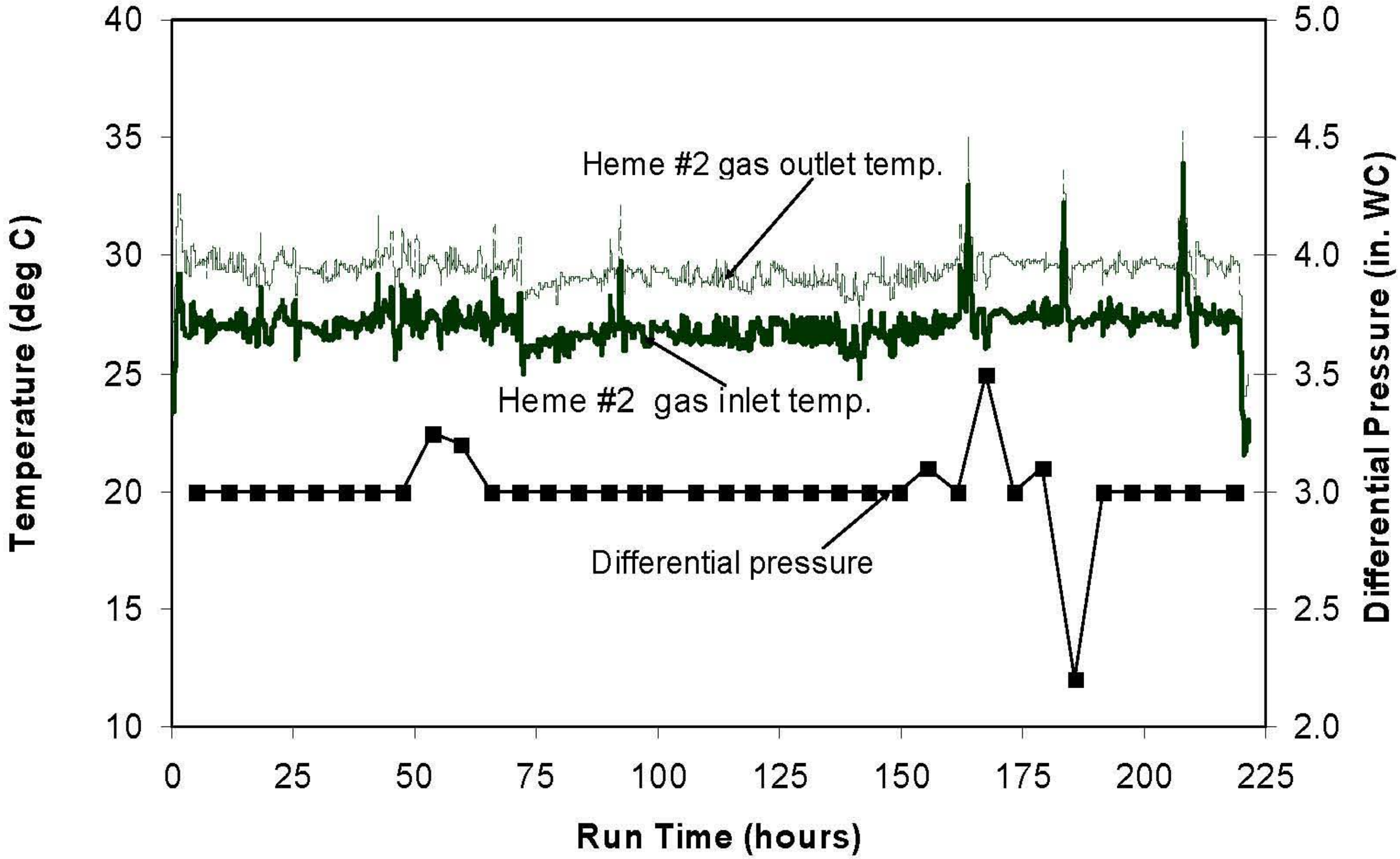

Figure 5.140. Inlet and outlet temperatures and differential pressure for HEME #2 during Test 4.

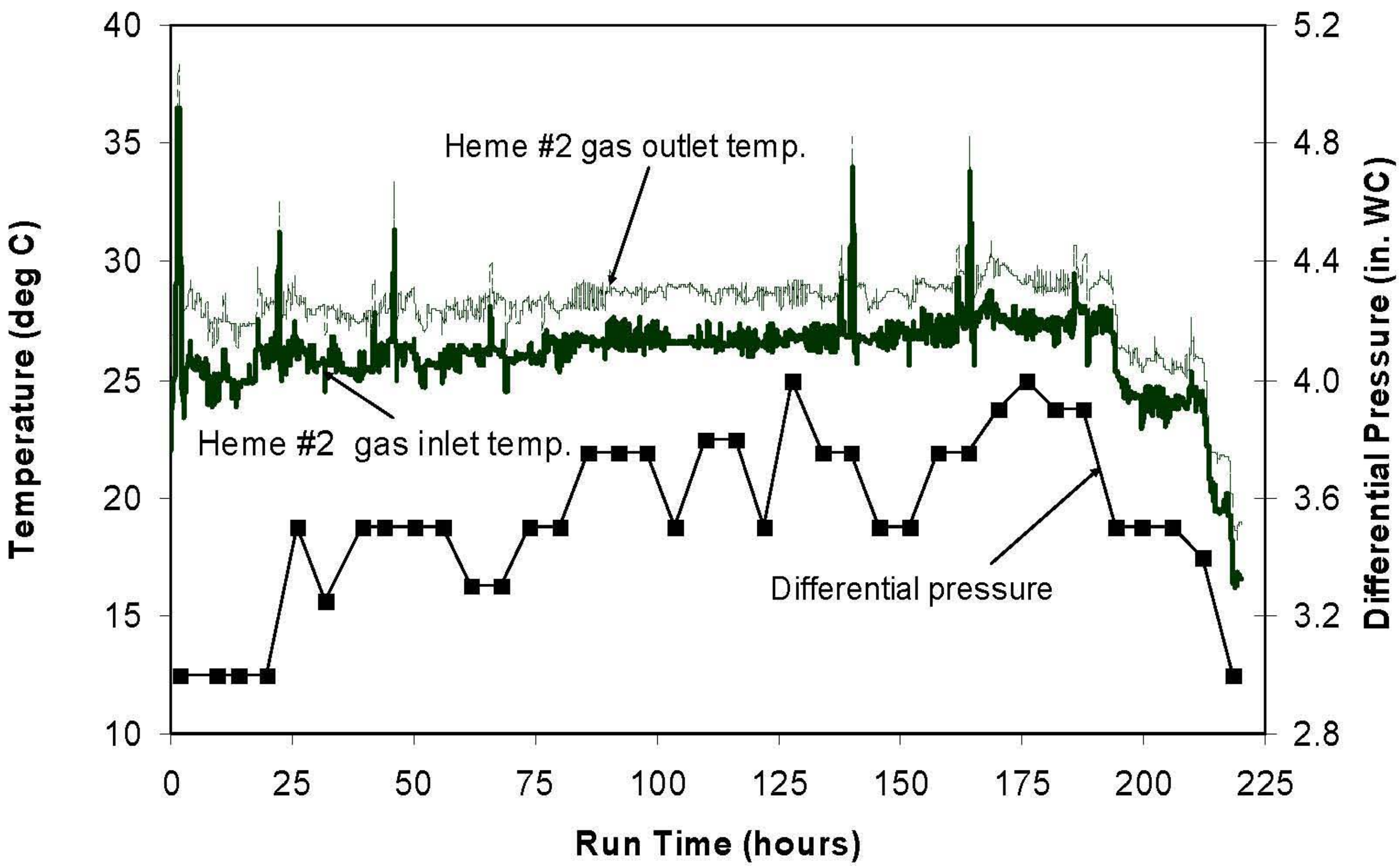

Figure 5.141. Inlet and outlet temperatures and differential pressure for HEME #2 during Test 5.

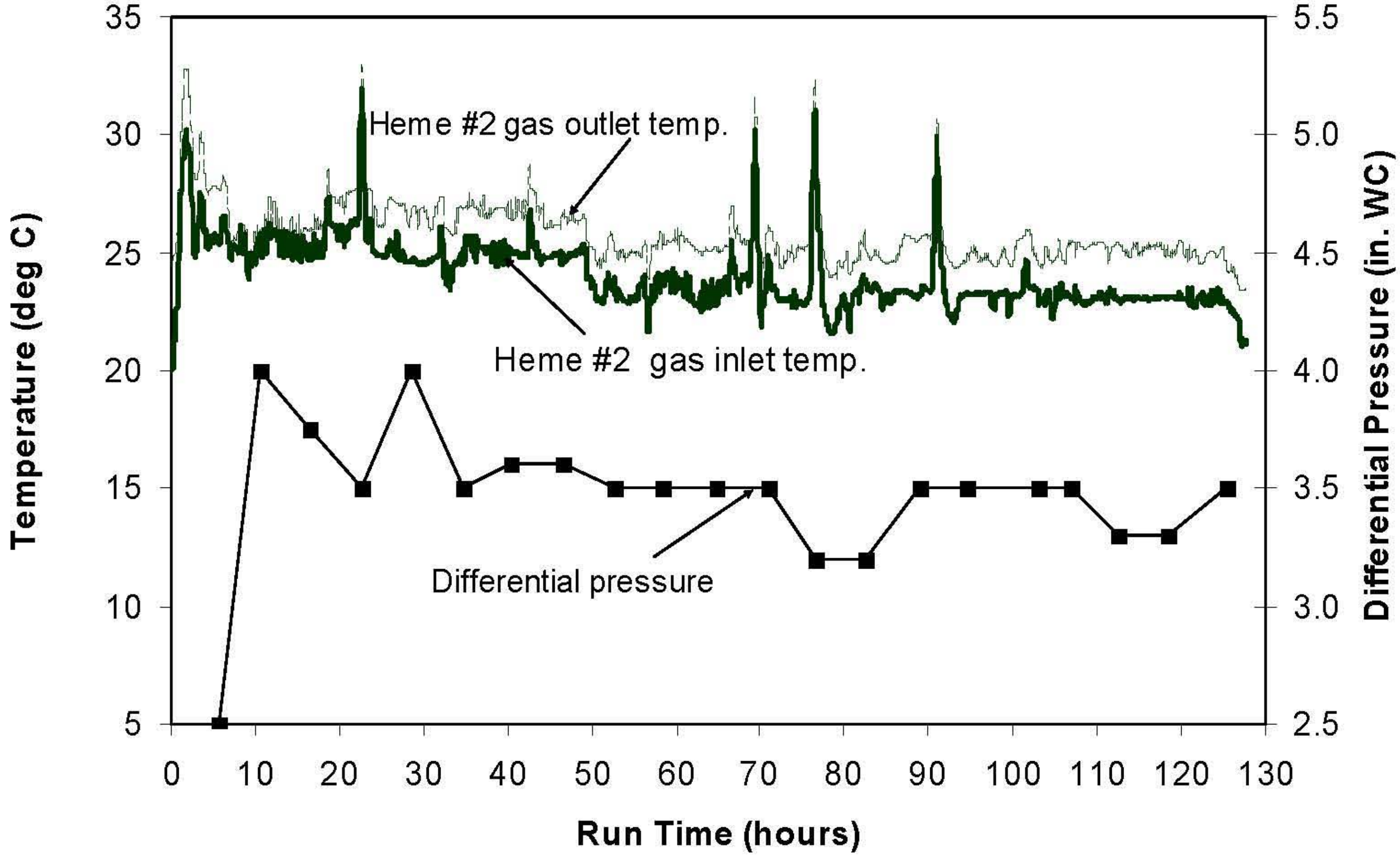

Figure 5.142. Inlet and outlet temperatures and differential pressure for HEME #2 during Test 6.

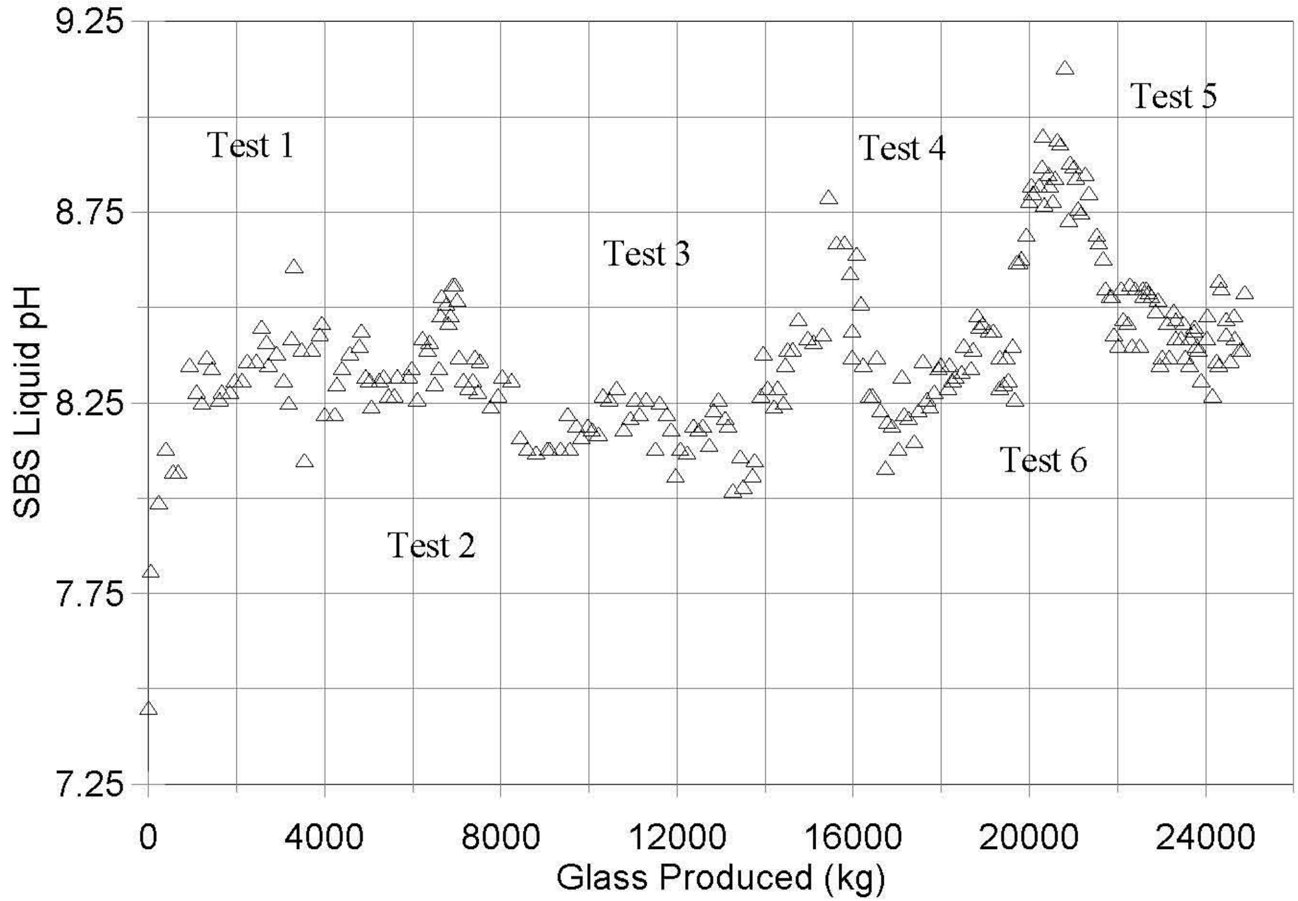

Figure 5.143. pH of SBS blow-down solutions.

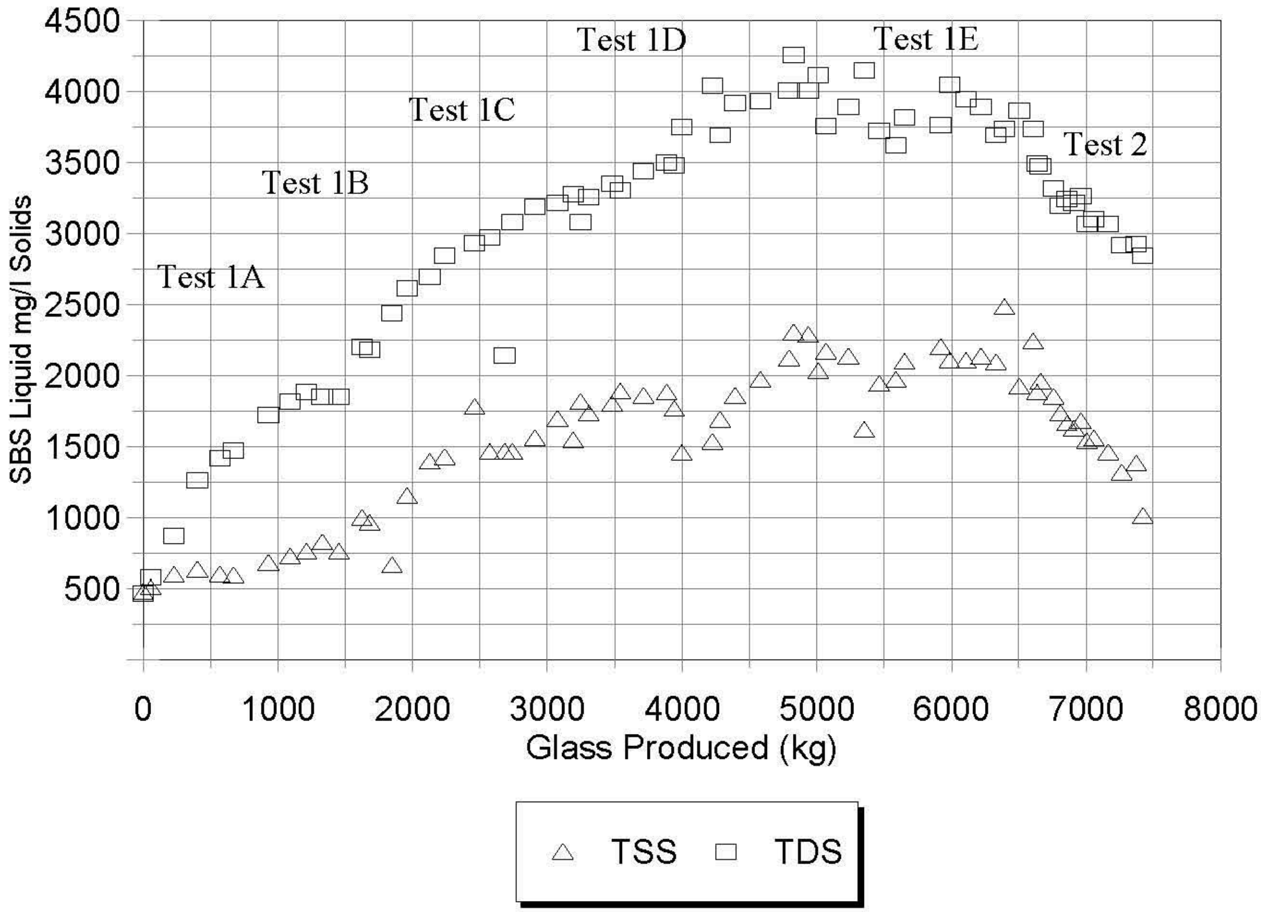

Figure 5.144. Total suspended and dissolved solids in SBS blow-down solutions in Tests 1 and 2.

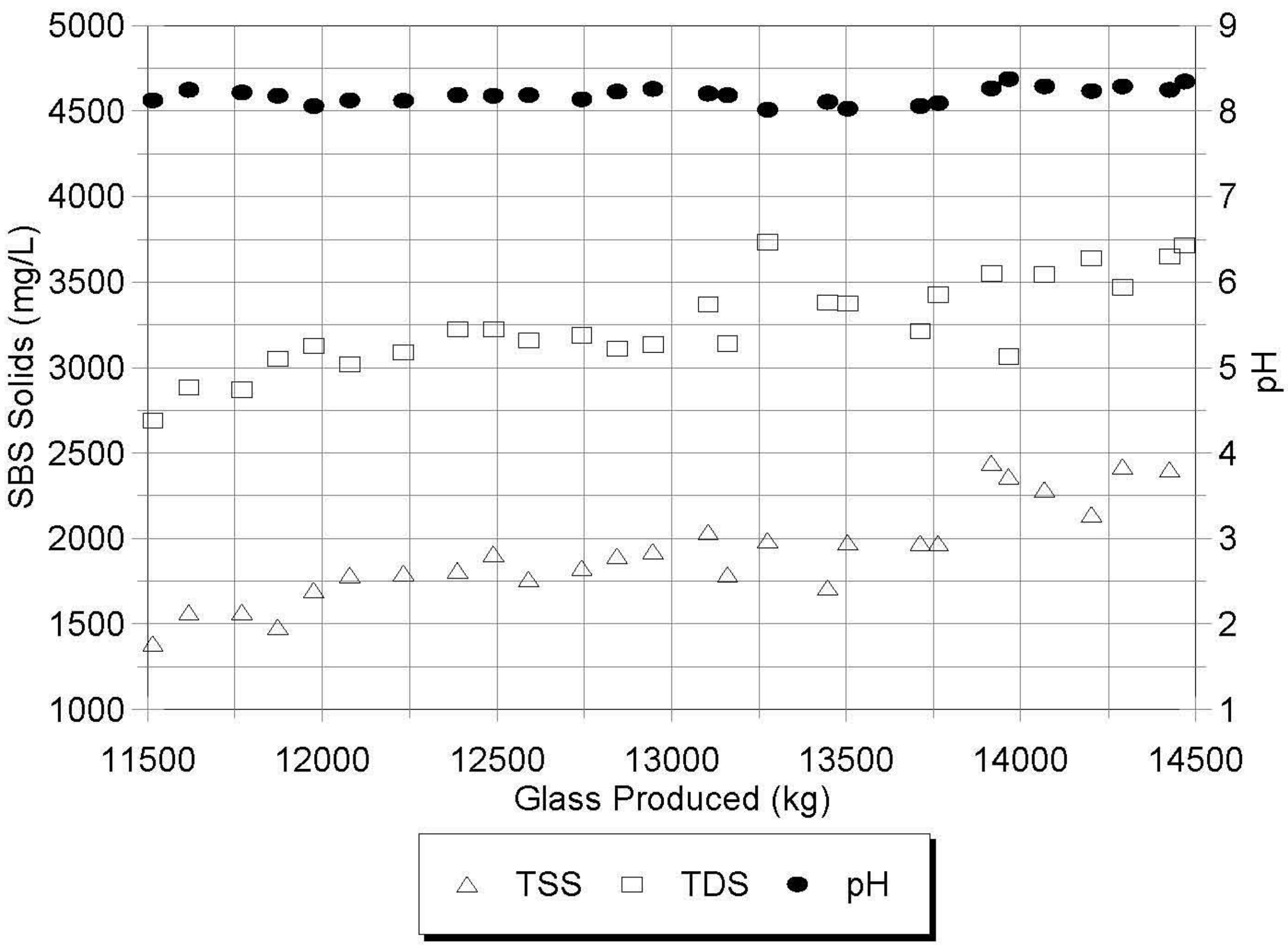

Figure 5.145. pH plus suspended and dissolved solids in SBS blow-down solutions in Test 3c.

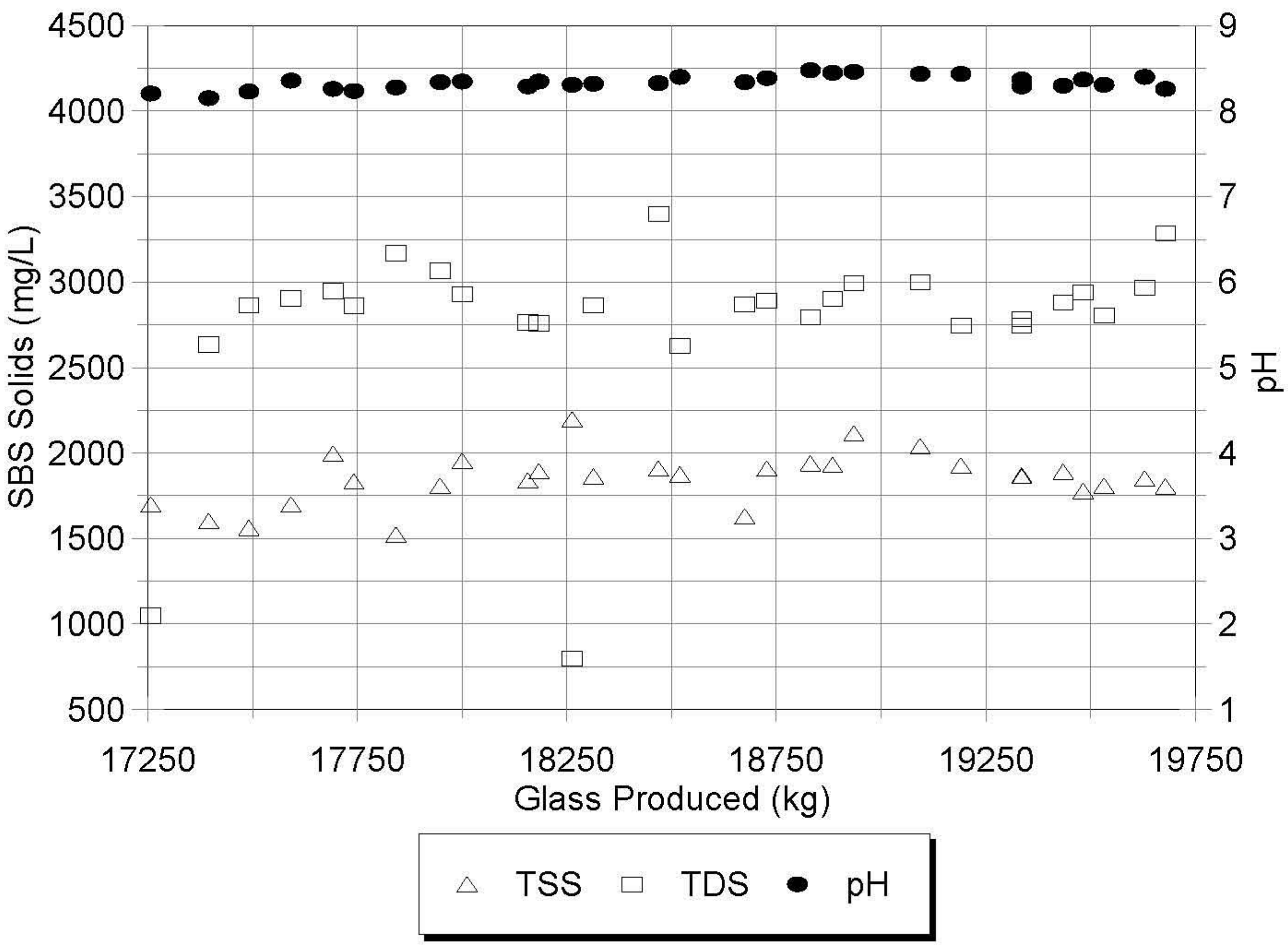

Figure 5.146. pH plus suspended and dissolved solids in SBS blow-down solutions in Test 4c.

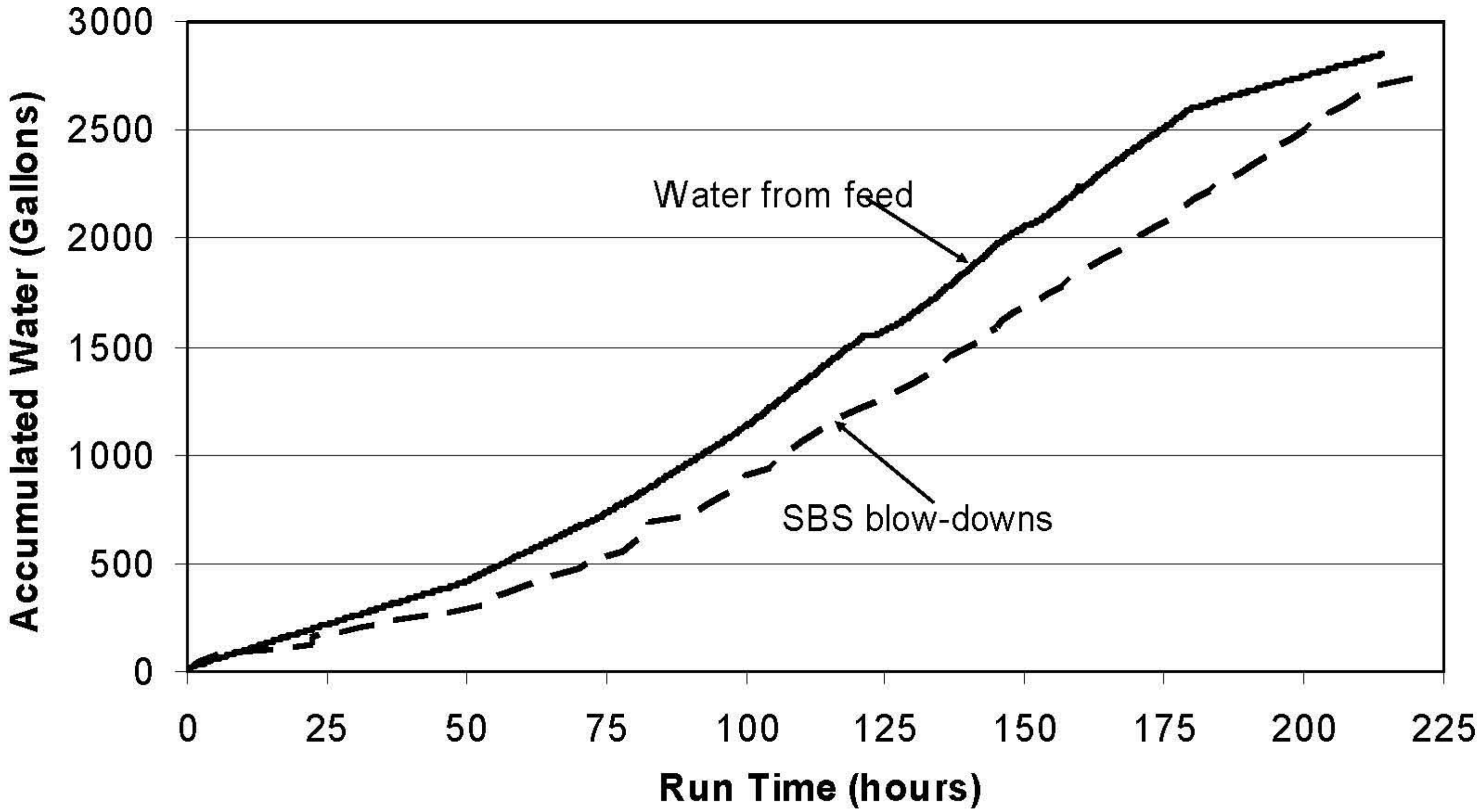

Figure 5.147. Accumulated SBS blow-down volumes and accumulated feed water during Tests 1 and 2.

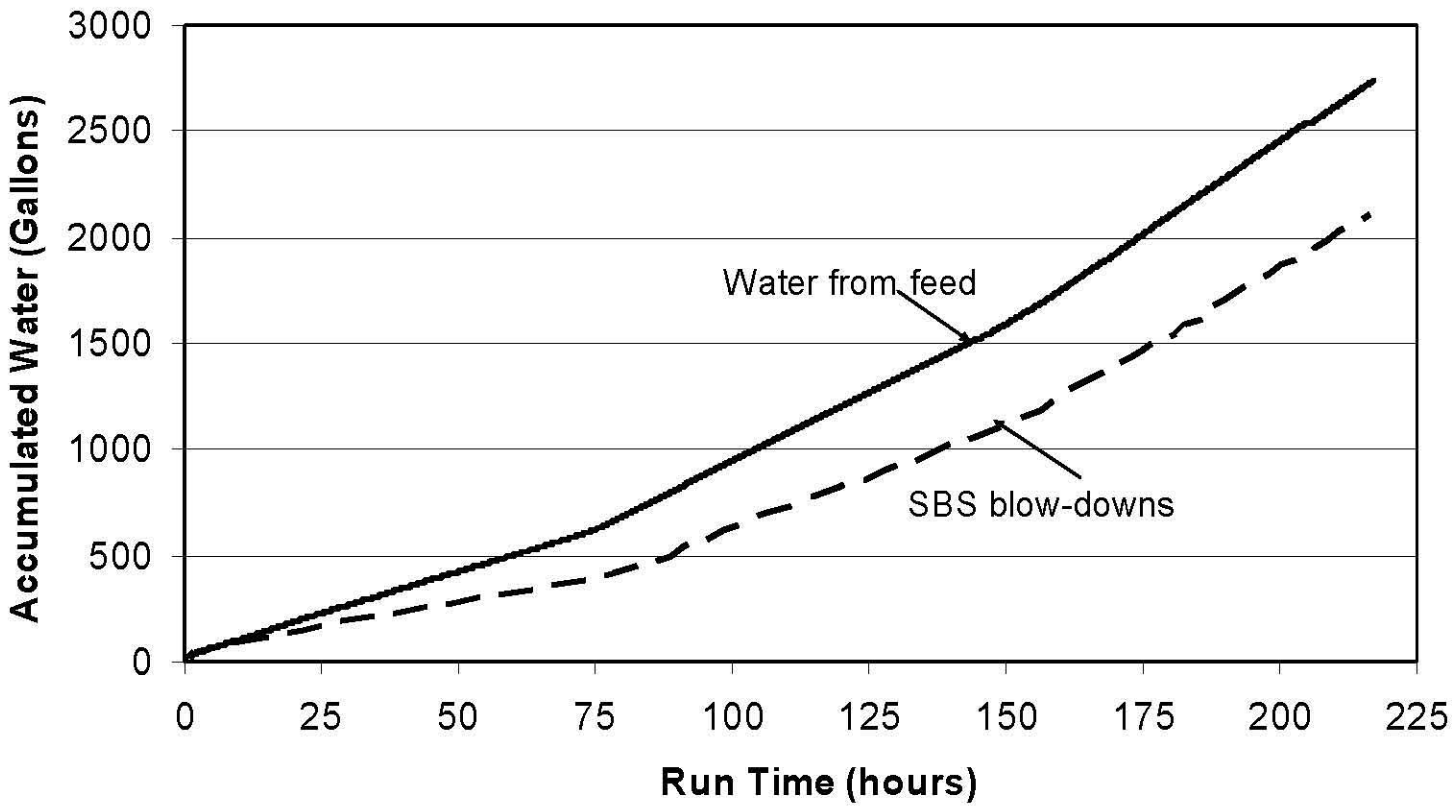

Figure 5.148. Accumulated SBS blow-down volumes and accumulated feed water during Test 3.

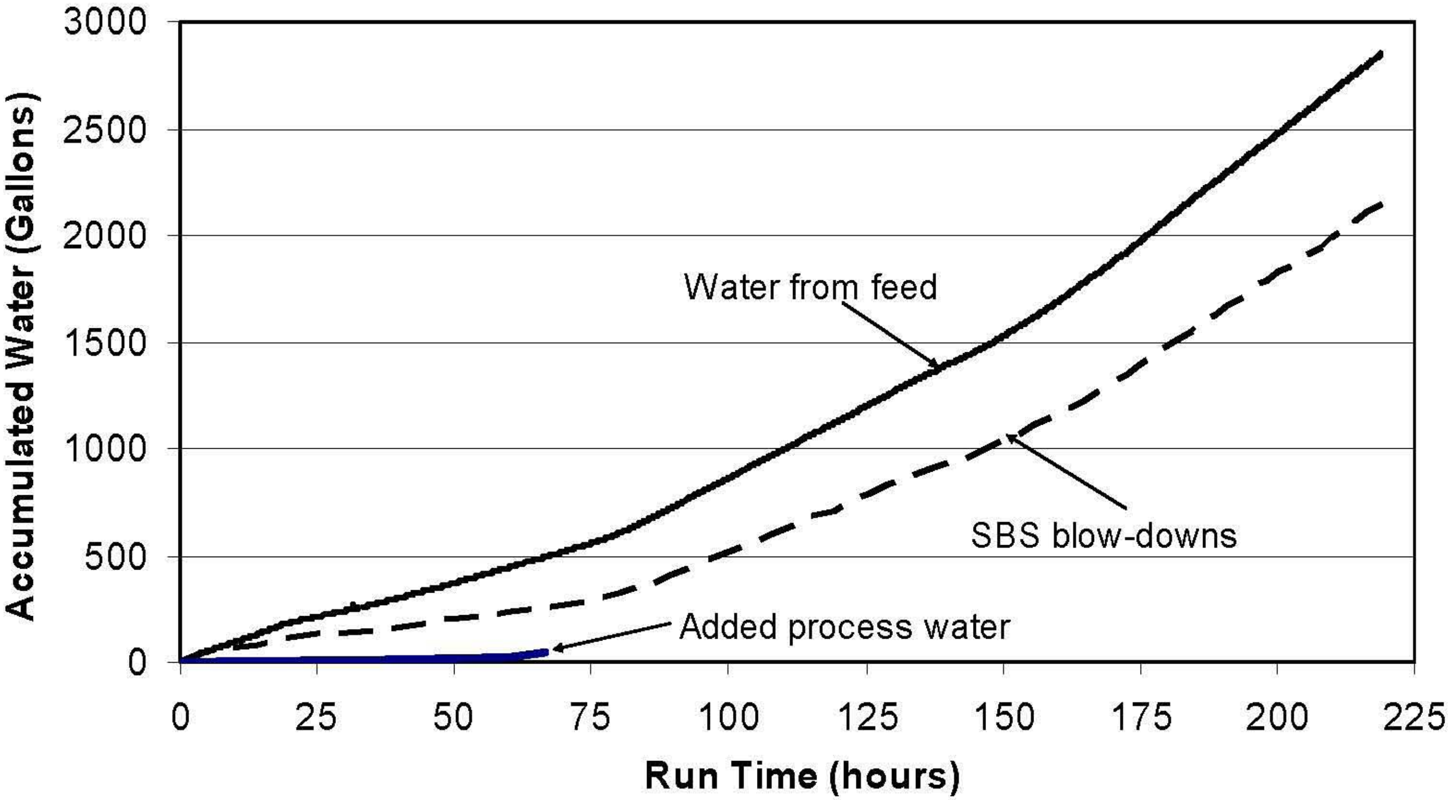

Figure 5.149. Accumulated SBS blow-down volumes, accumulated feed water and added process water volume during Test 4.

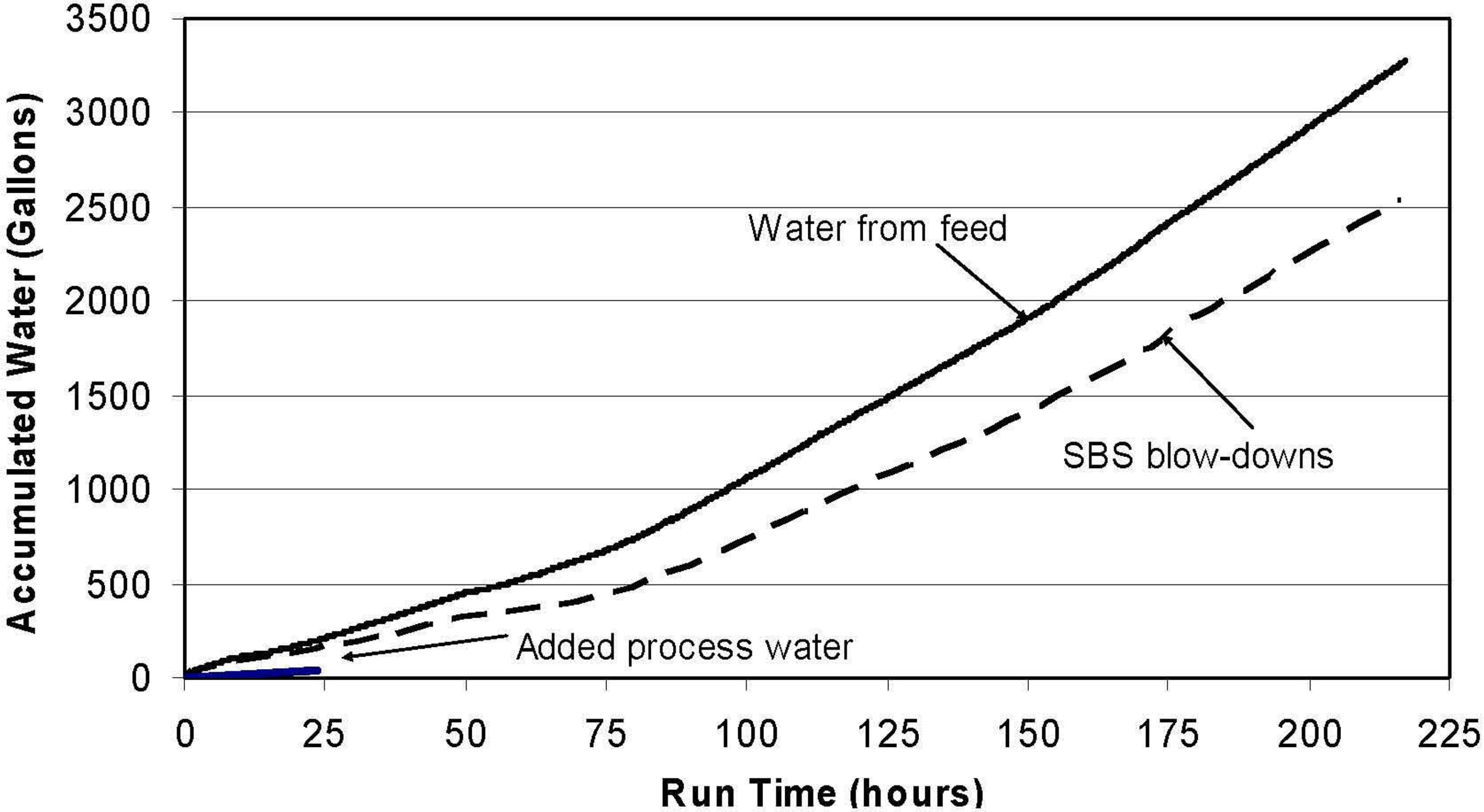

Figure 5.150. Accumulated SBS blow-down volumes, accumulated feed water and added process water volume during Test 5.

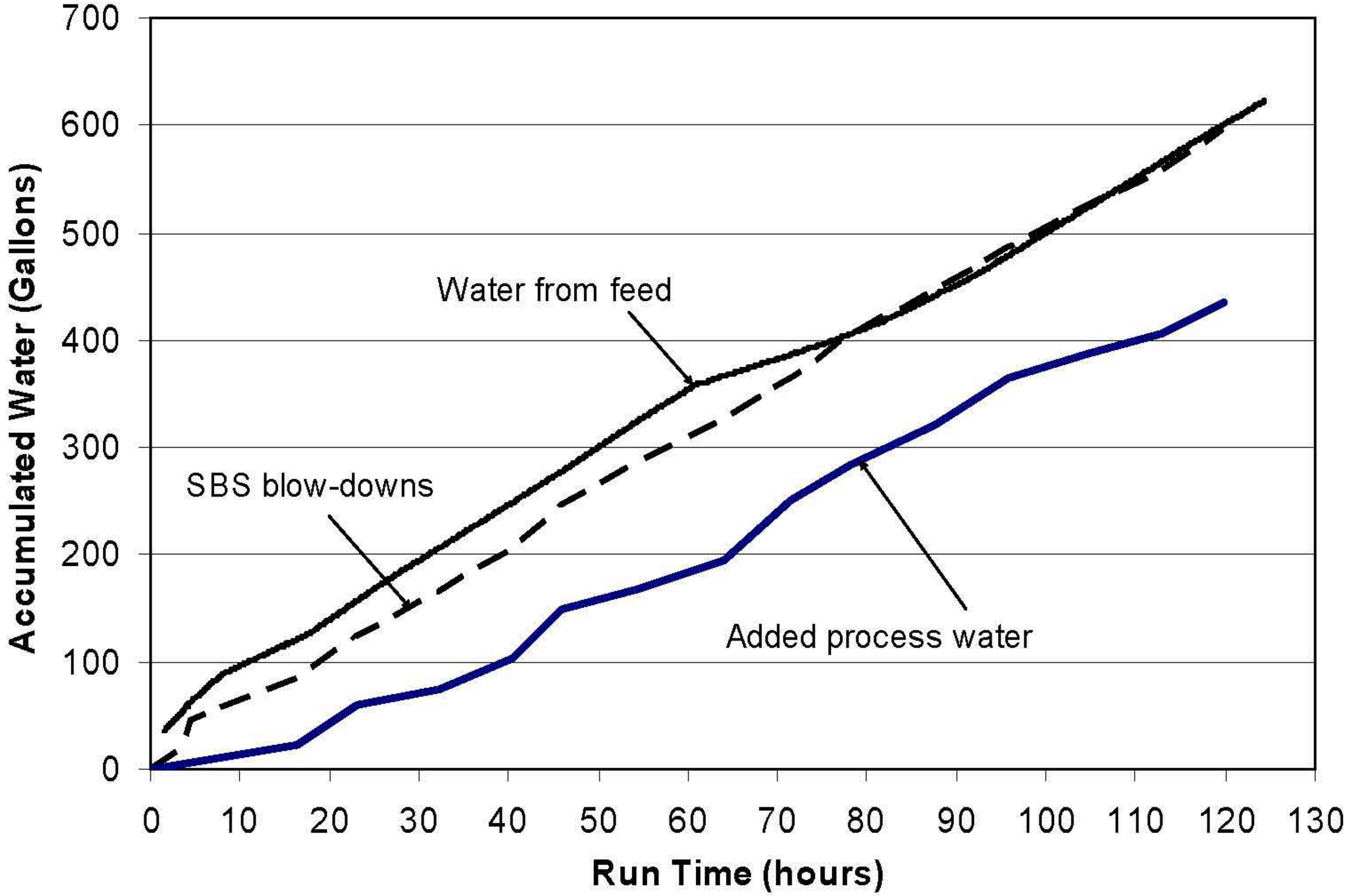

Figure 5.151. Accumulated SBS blow-down volumes, accumulated feed water and added process water volume during Test 6.

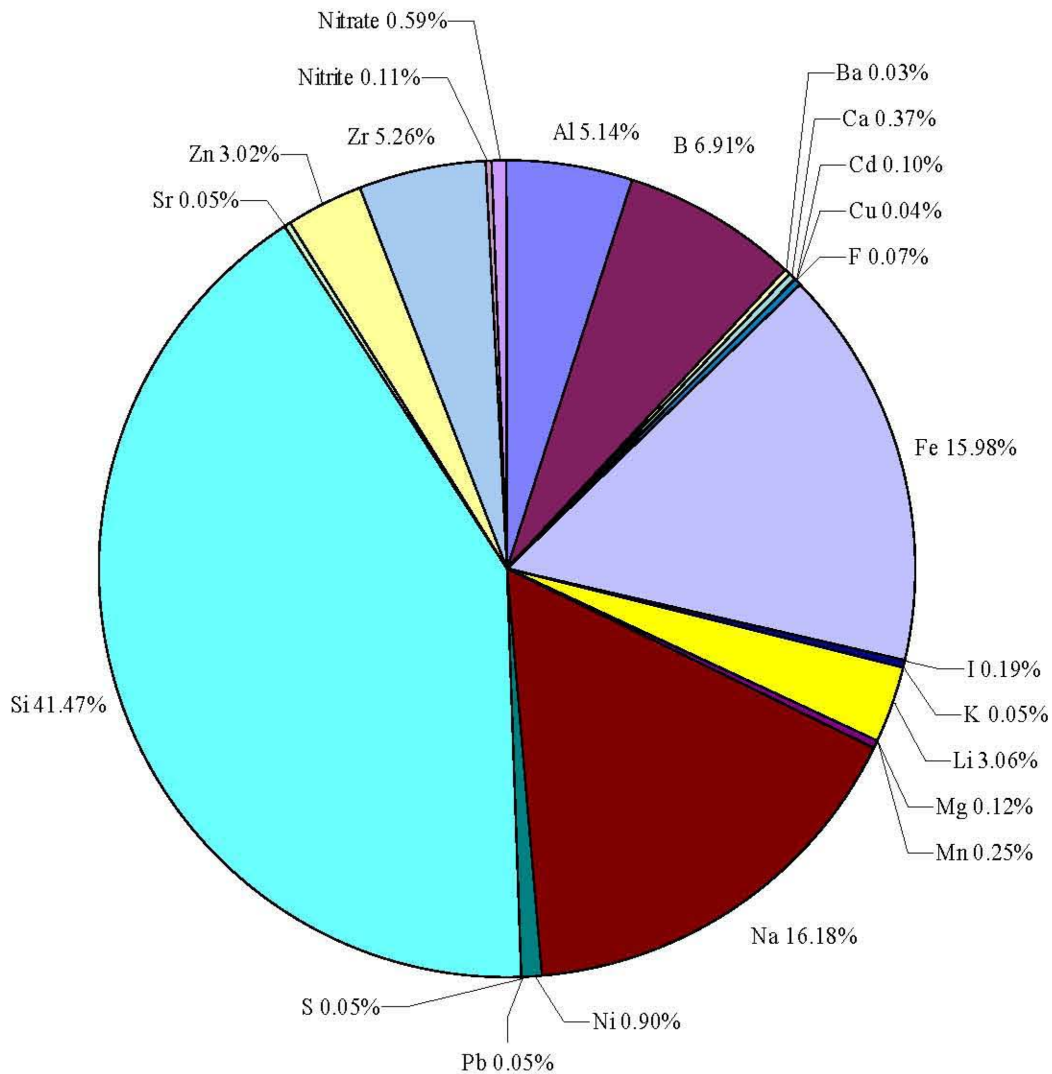

Figure 5.152. Feed composition (excludes oxygen and carbon).

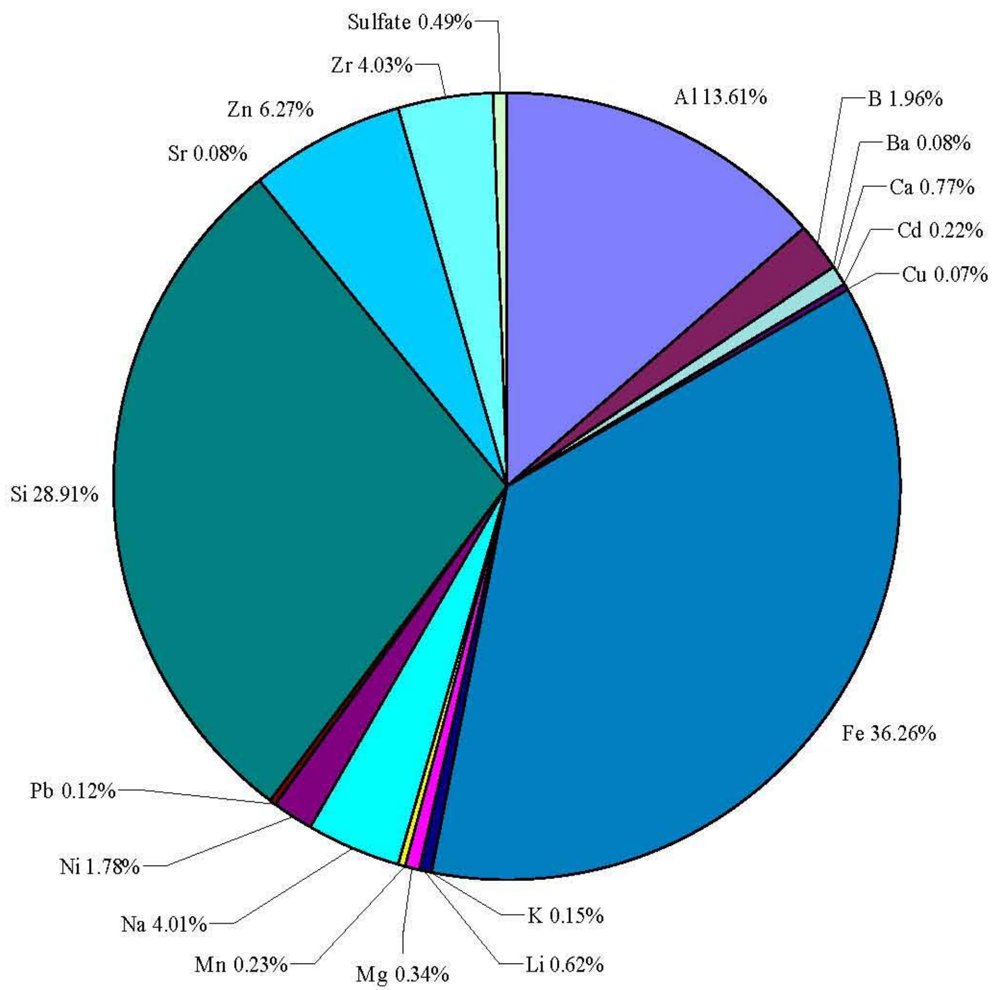

Figure 5.153. Suspended solids composition from SBS sample (G12-S-140A).

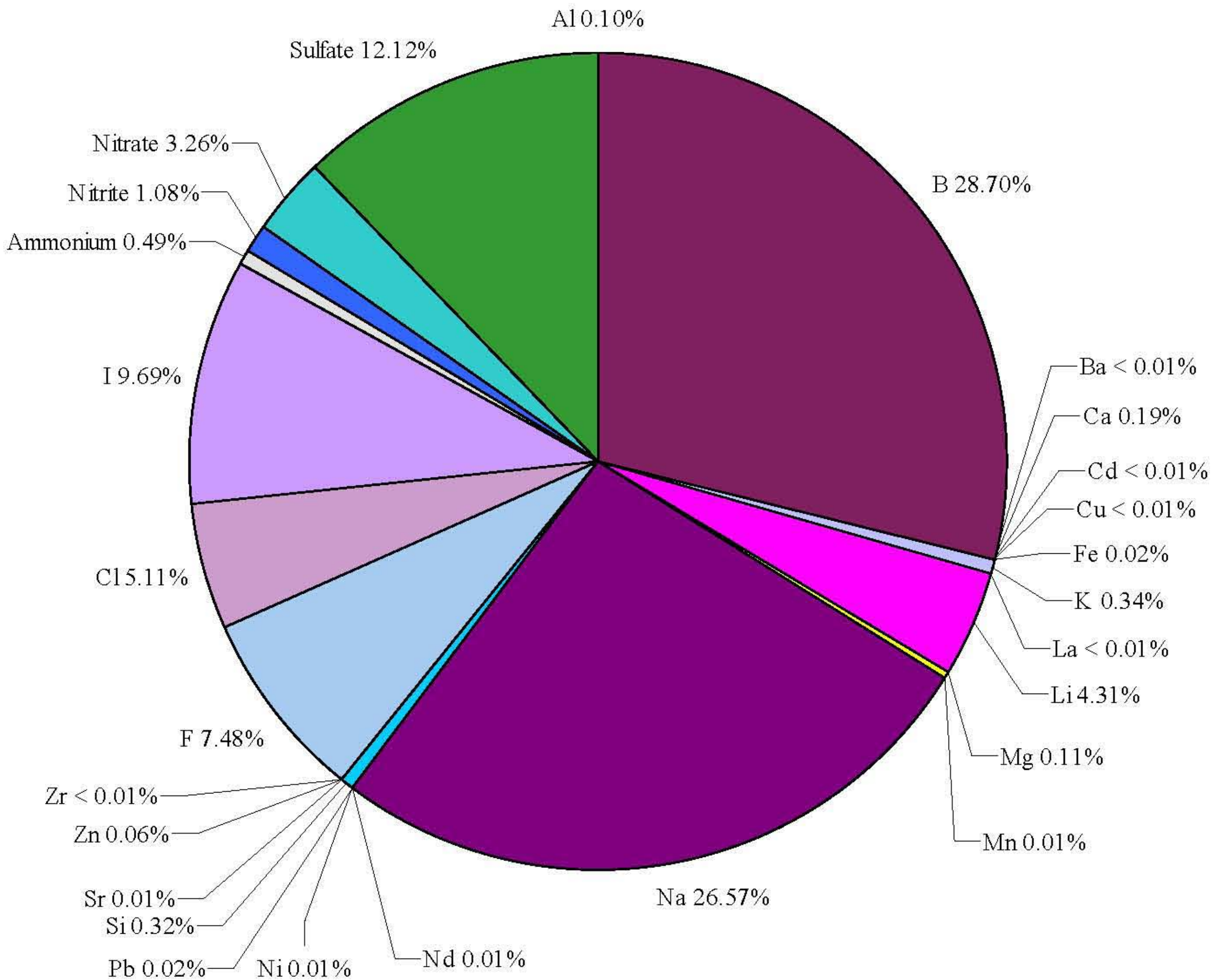

Figure 5.154. Dissolved solids composition from SBS sample (G12-S-140A).

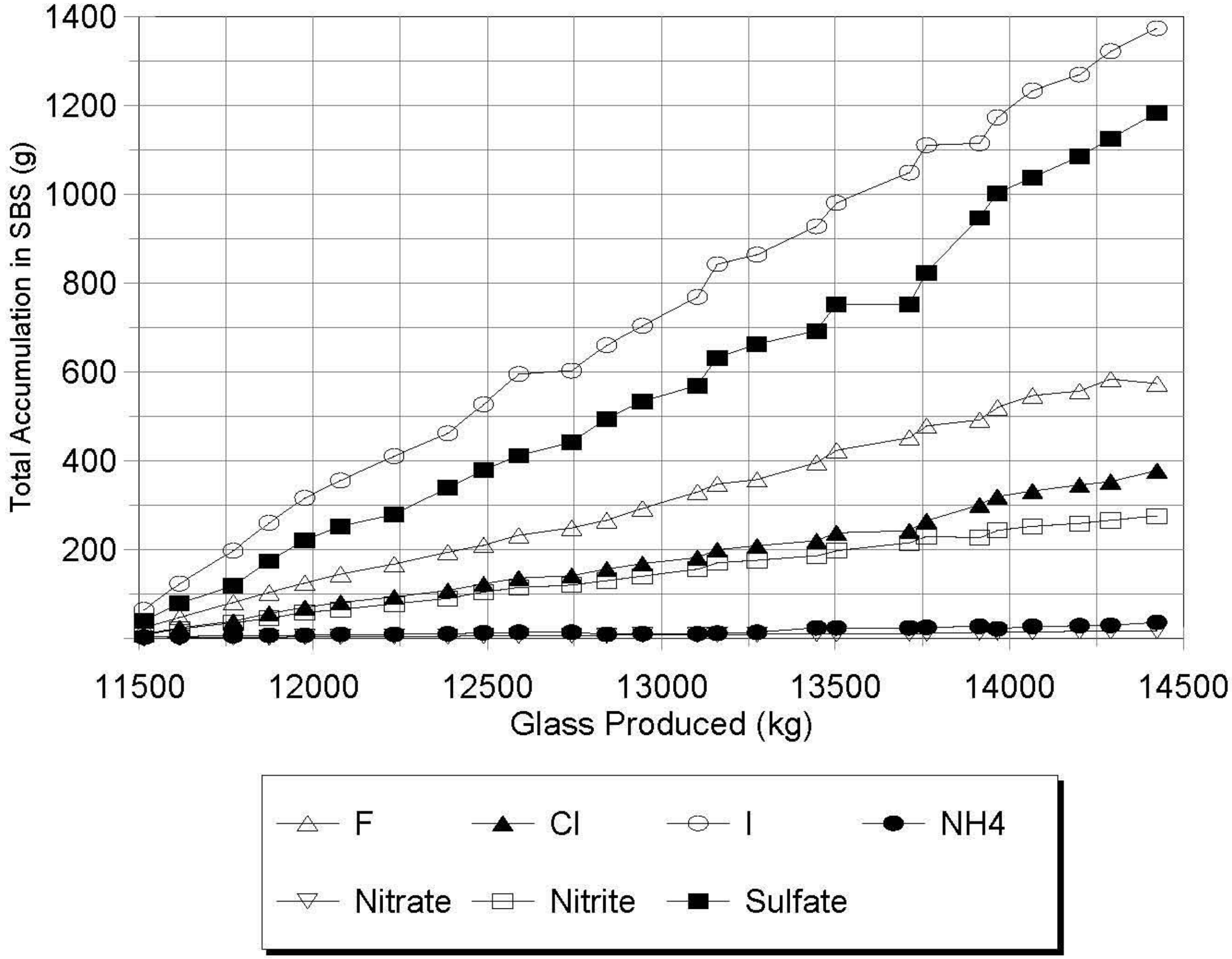

Figure 5.155. Accumulation of anions in SBS blow-down solution during Test 3c.

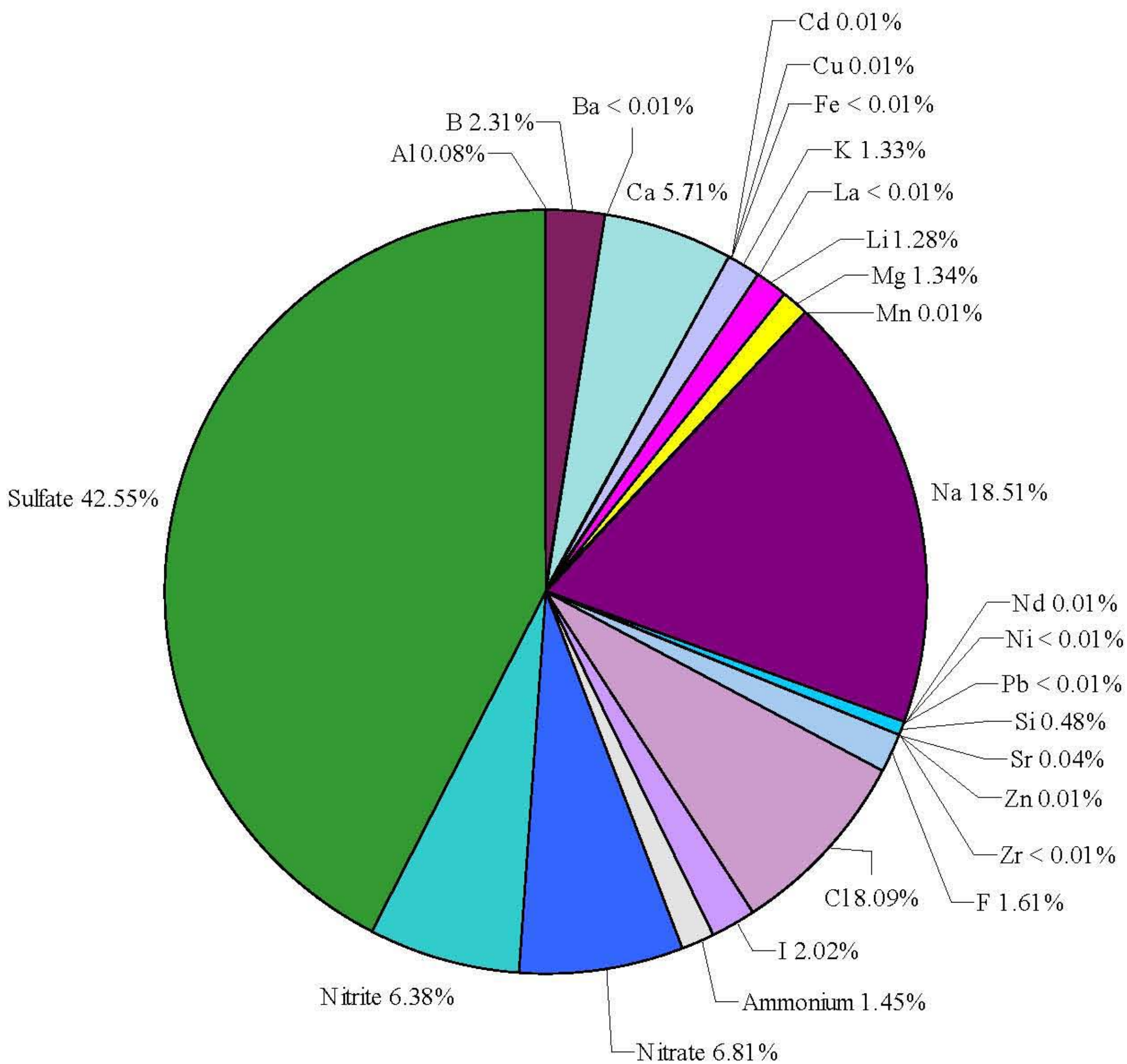

Figure 5.156. Dissolved solids composition from WESP sample (G12-W-140A).

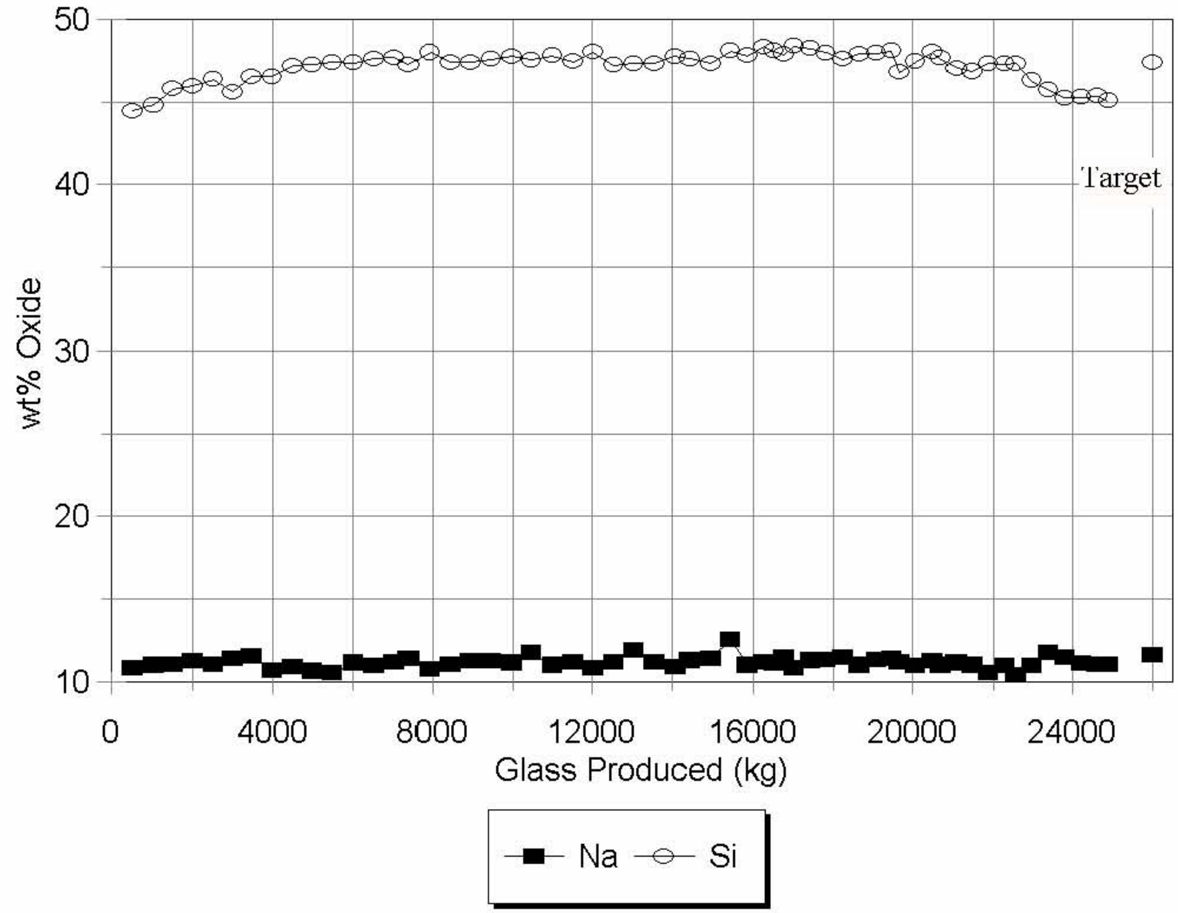

Figure 6.1. XRF analysis of sodium and silicon oxides in glasses from DM1200 testing.

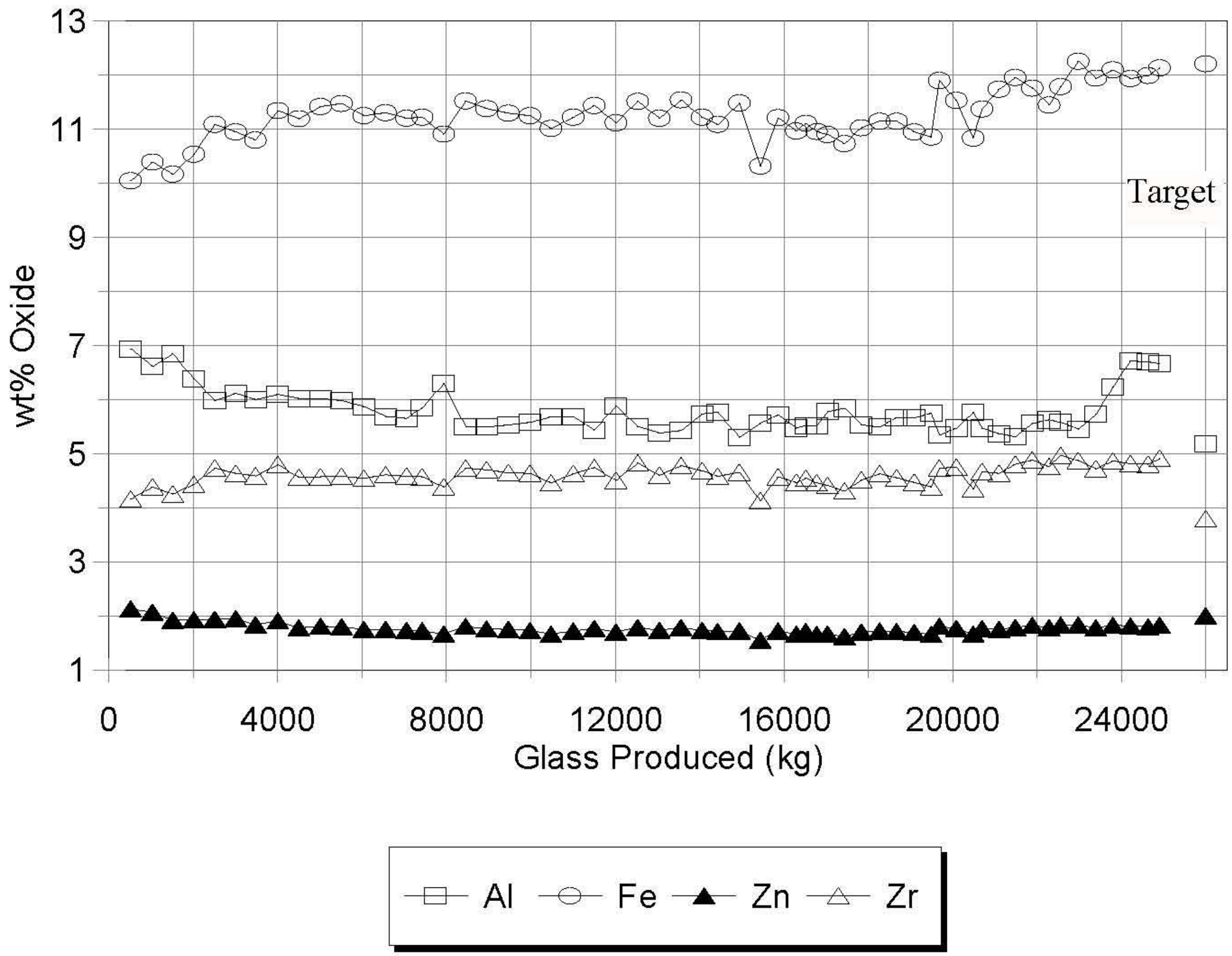

Figure 6.2. XRF analysis of selected oxides in glasses from DM1200 testing.

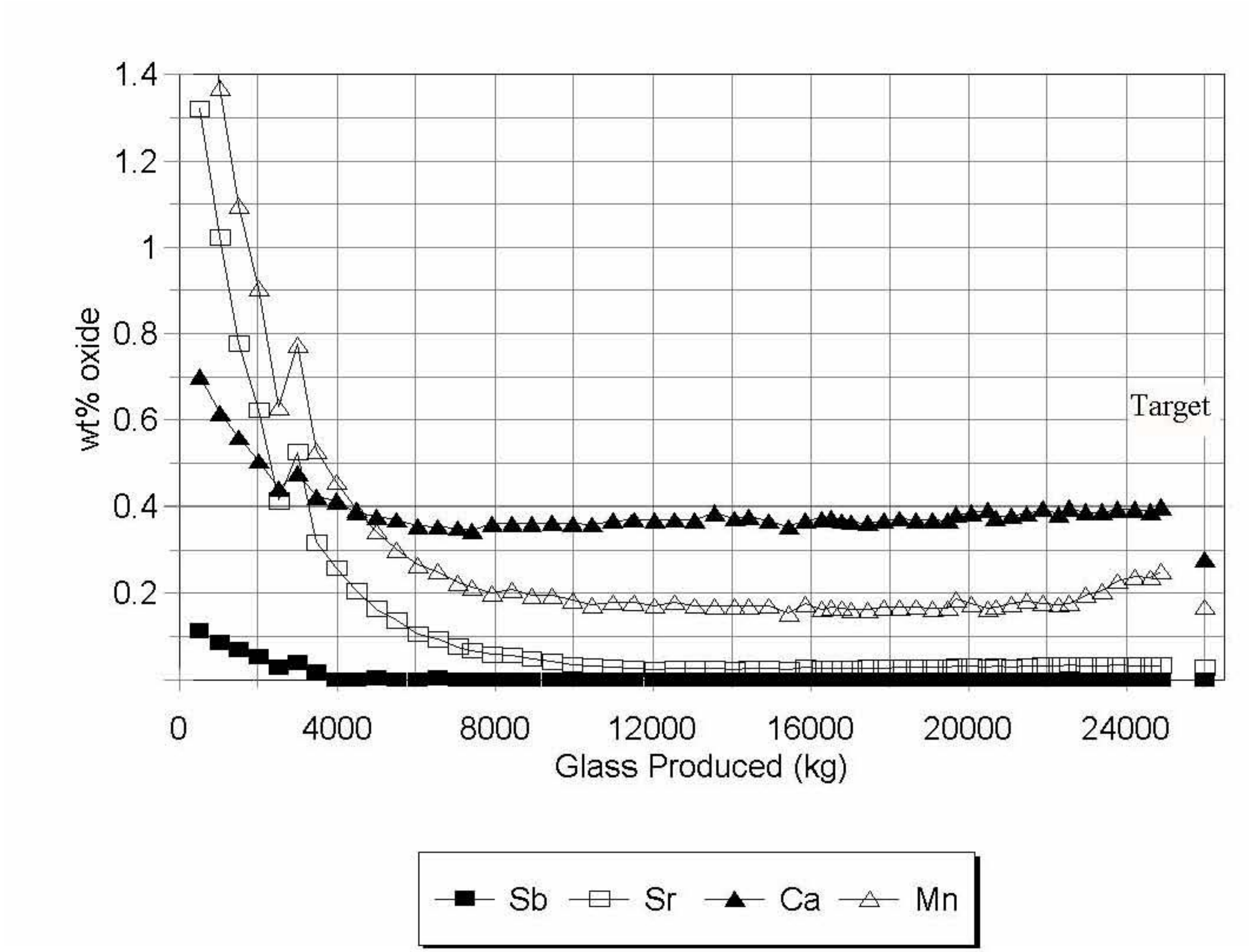

Figure 6.3. XRF analysis of oxides decreasing in concentration in glasses from DM1200 testing.

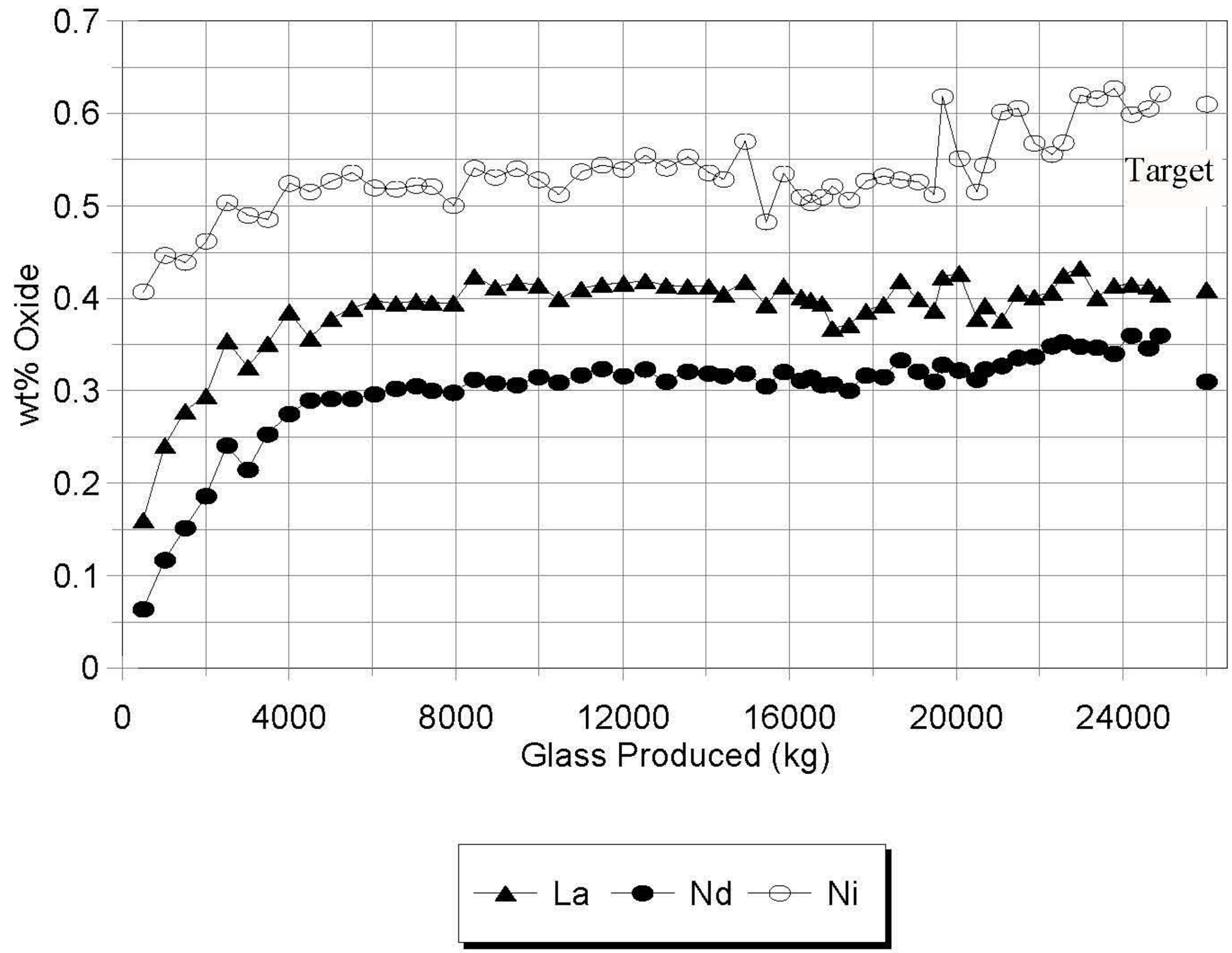

Figure 6.4. XRF analysis of oxides increasing in concentration in glasses from DM1200 testing.

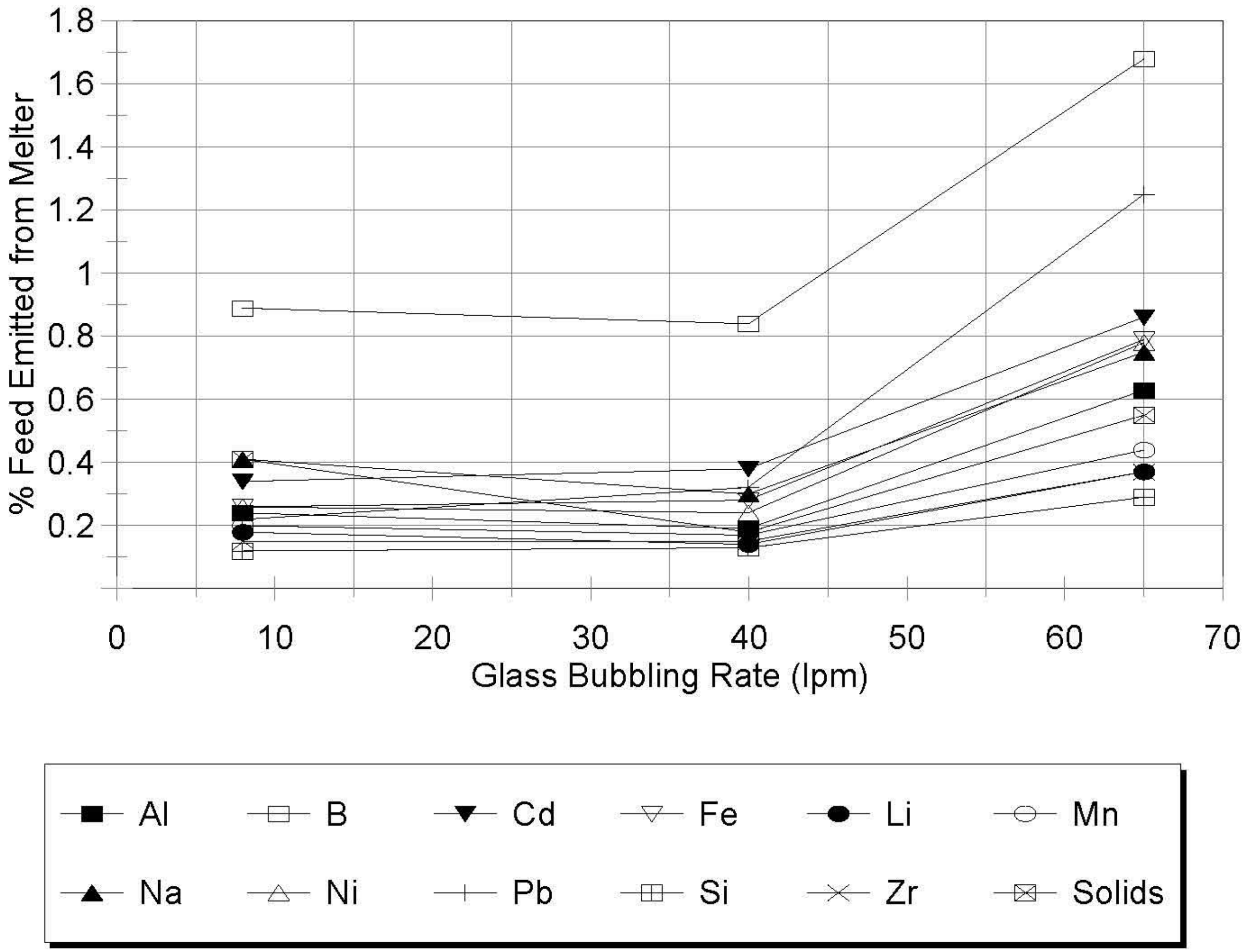

Figure 7.1. Melter emission as a function of glass bubbling rate during Test 3 (530 g glass/liter).

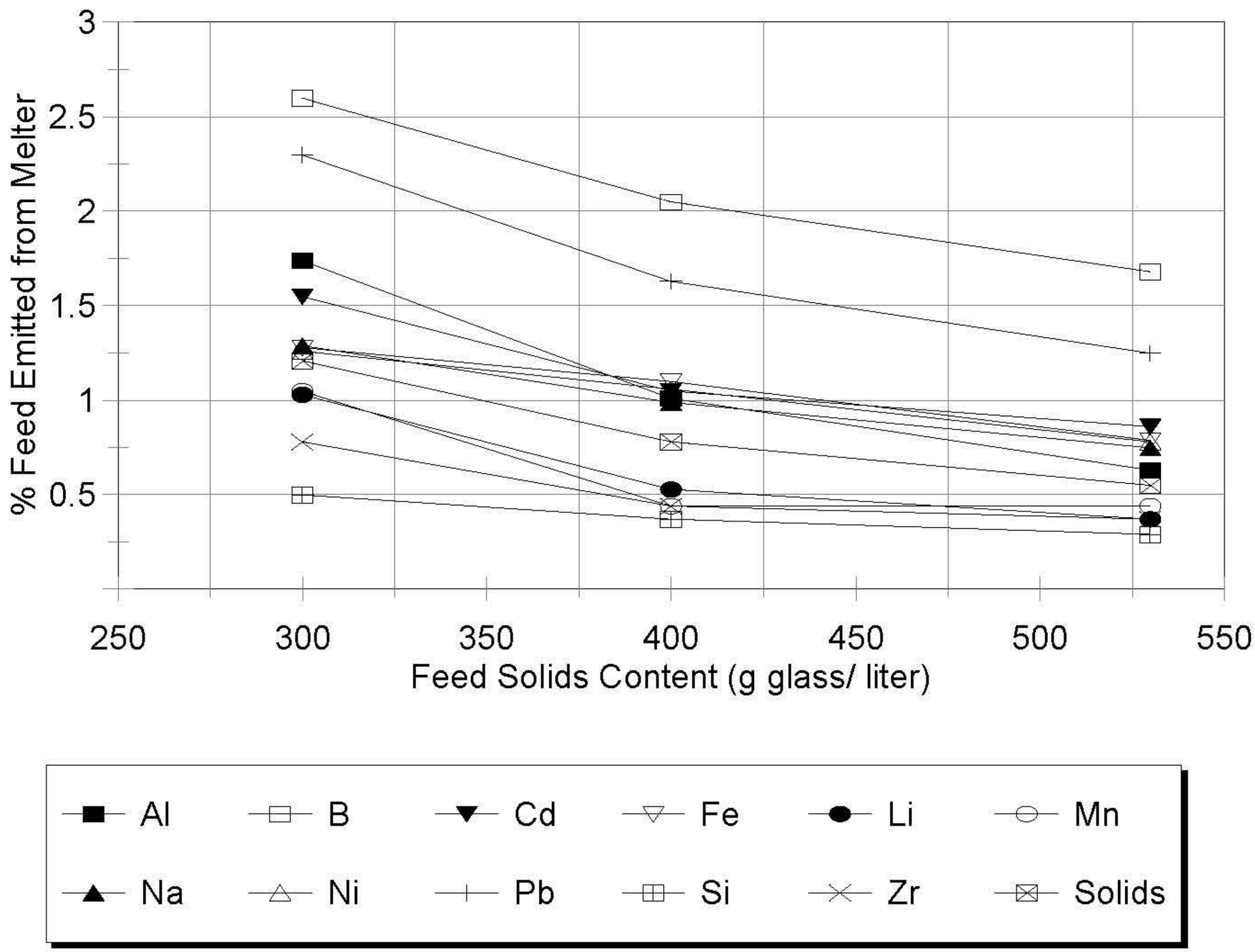

Figure 7.2. Melter emissions as a function of feed solids content at a glass pool bubbling rate of 65 lpm (Tests 3c 4c, and 5c).

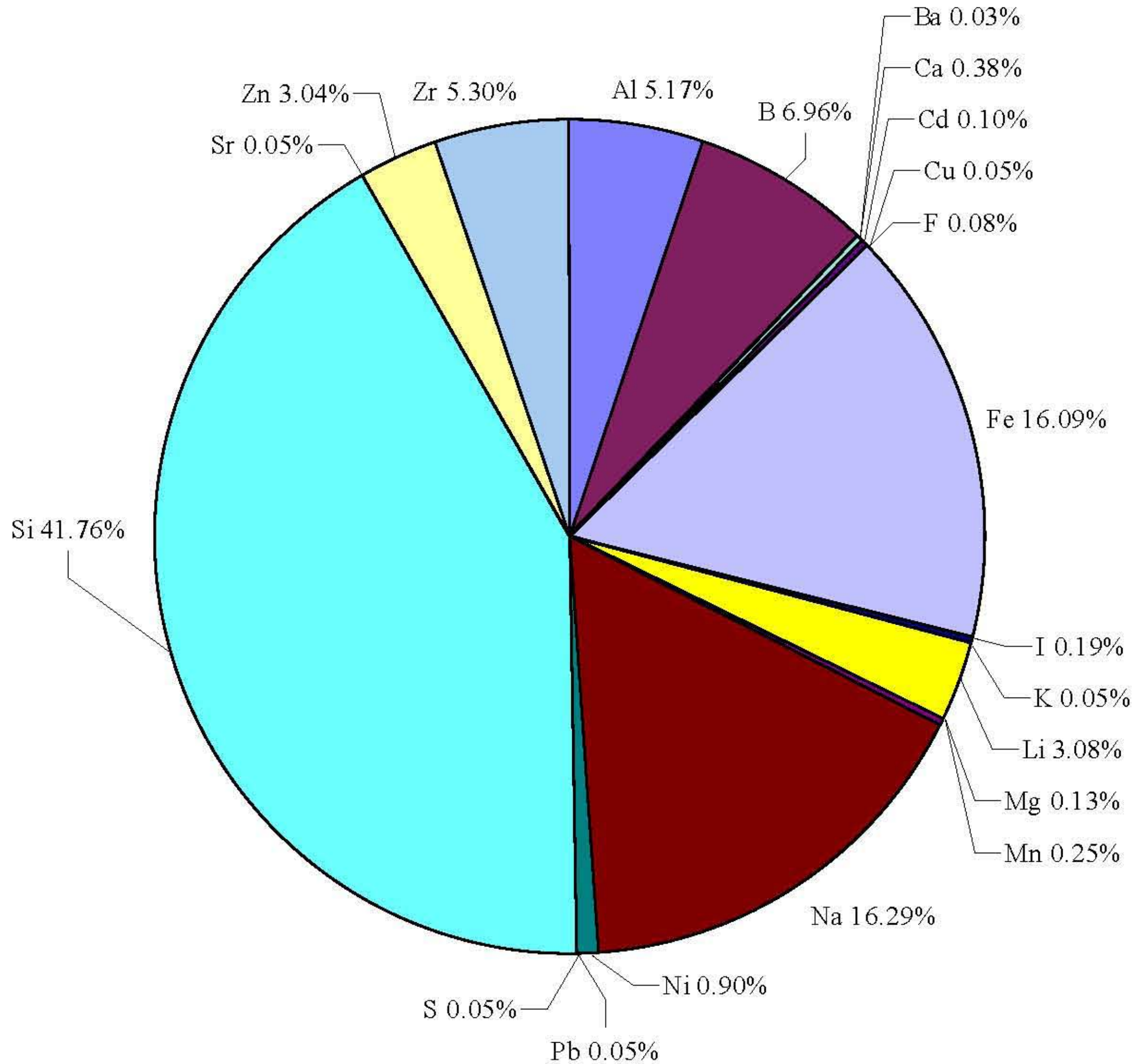

Figure 7.3. Feed composition (excludes oxygen, nitrogen and carbon compounds).

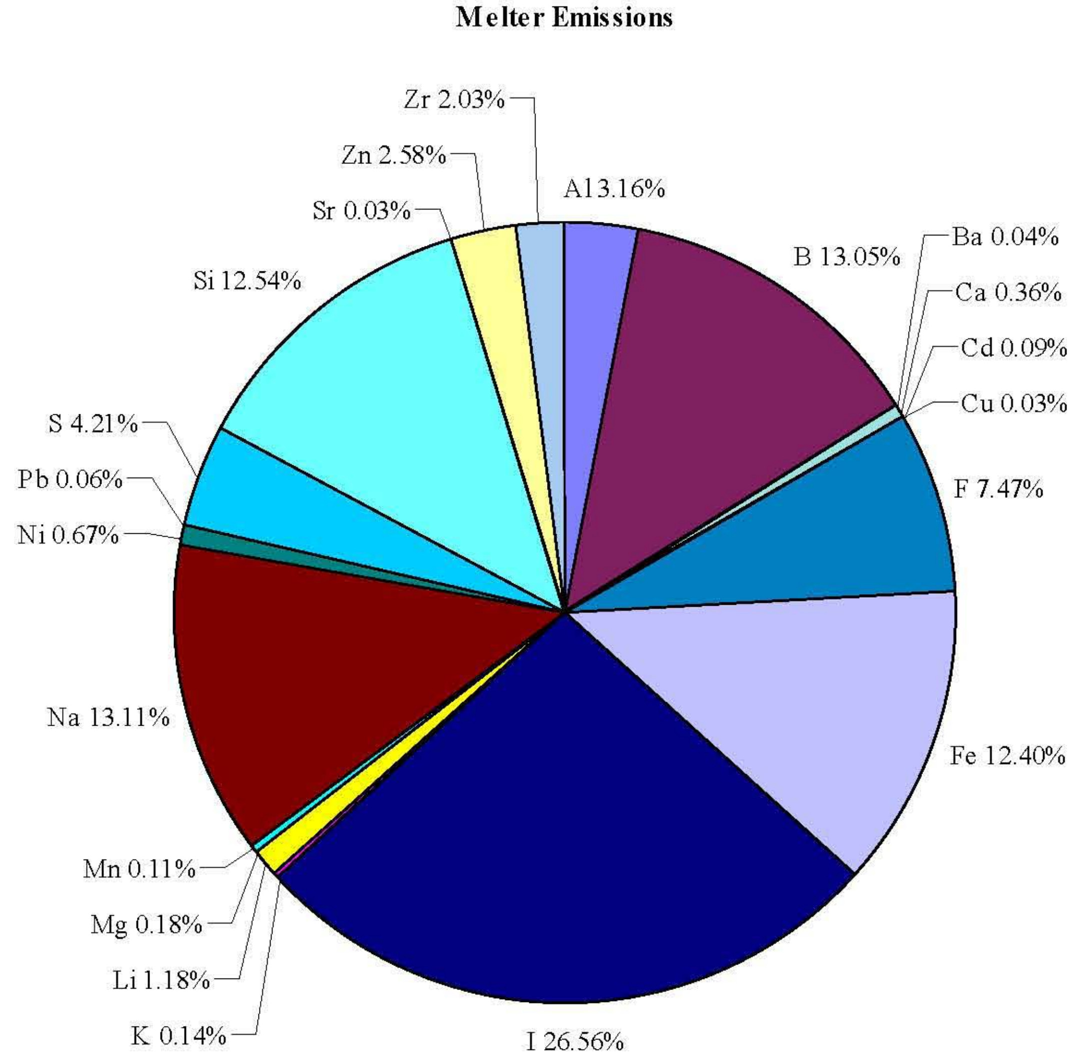

Figure 7.4. Average melter exhaust composition (excludes oxygen, nitrogen and carbon compounds) from Test 3.

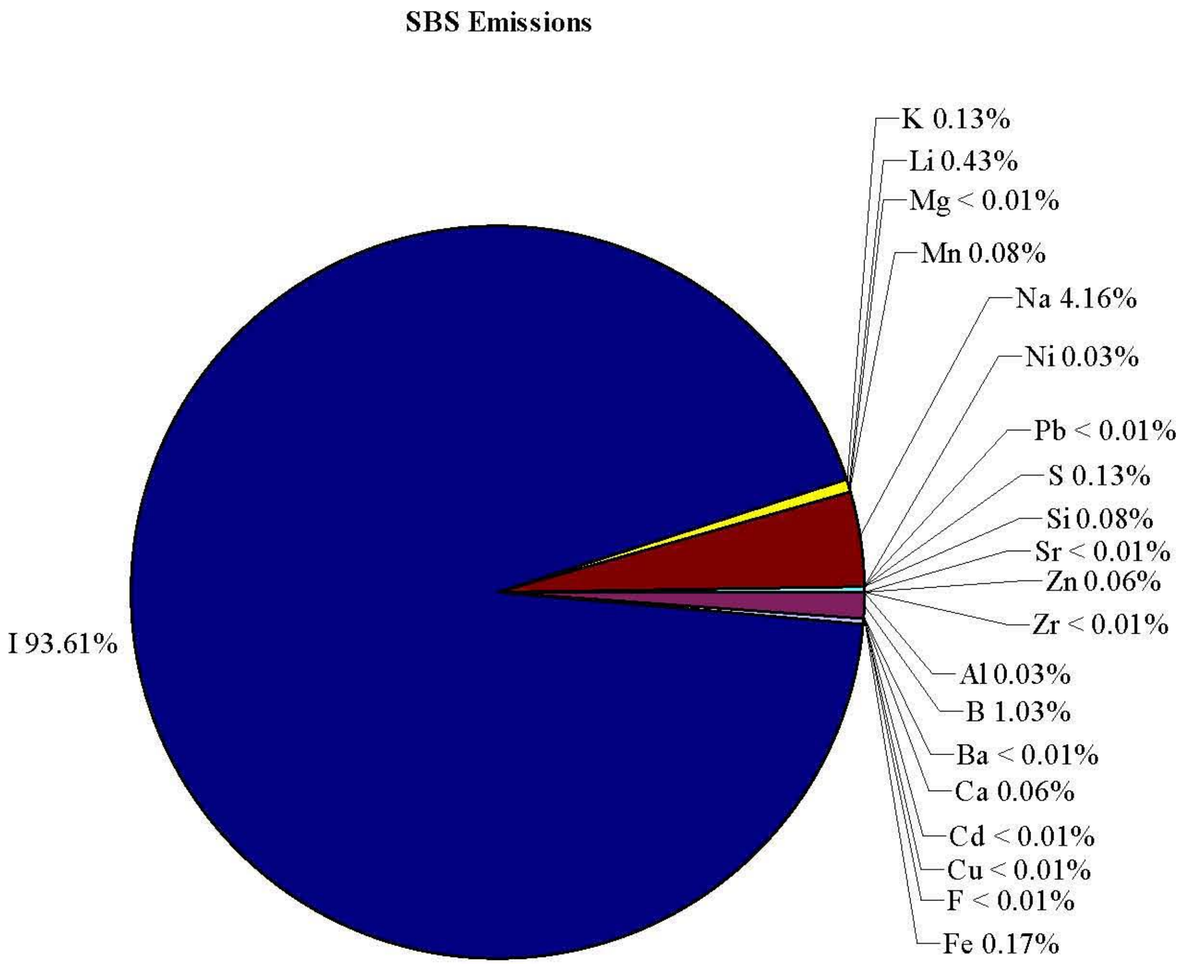

Figure 7.5. Average SBS exhaust composition (excludes oxygen, nitrogen and carbon compounds) from Test 3.

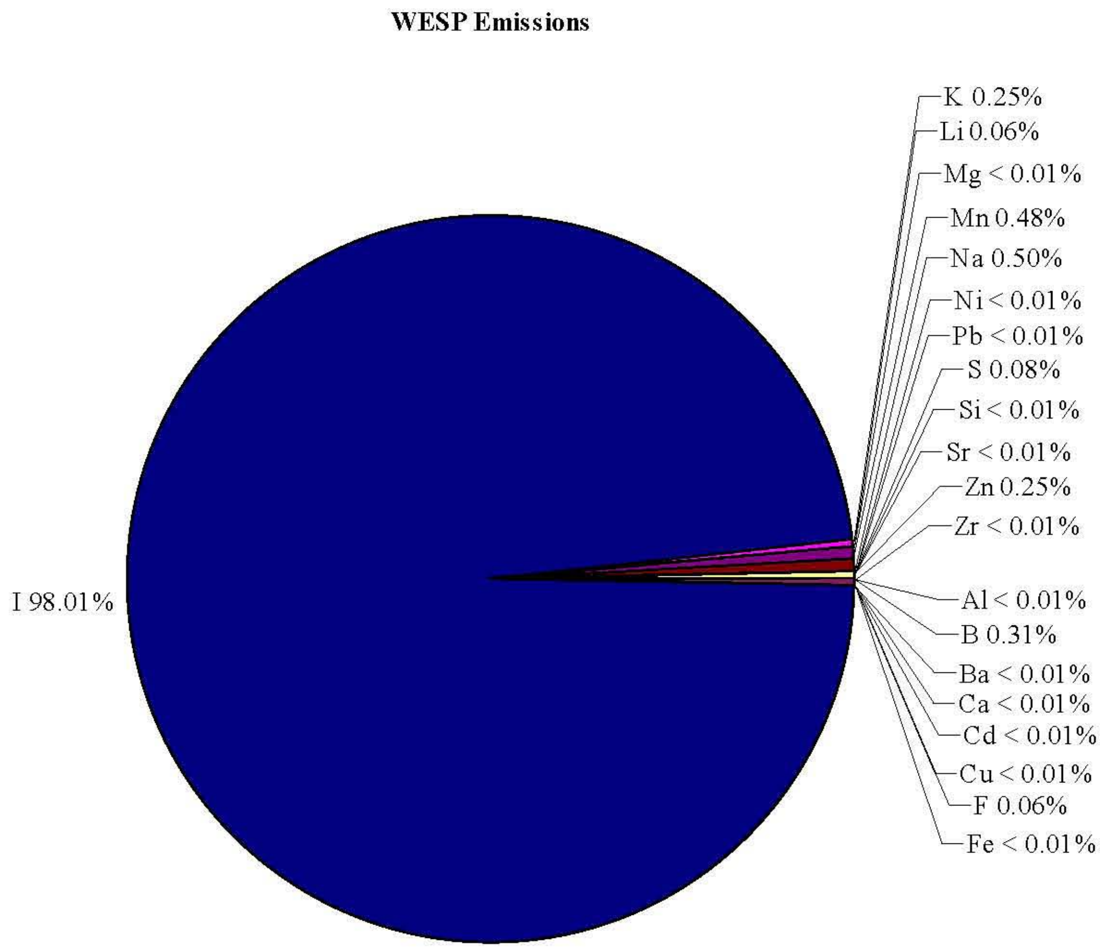

Figure 7.6. Average WESP exhaust composition (excludes oxygen, nitrogen, and carbon compounds) for Test 3.

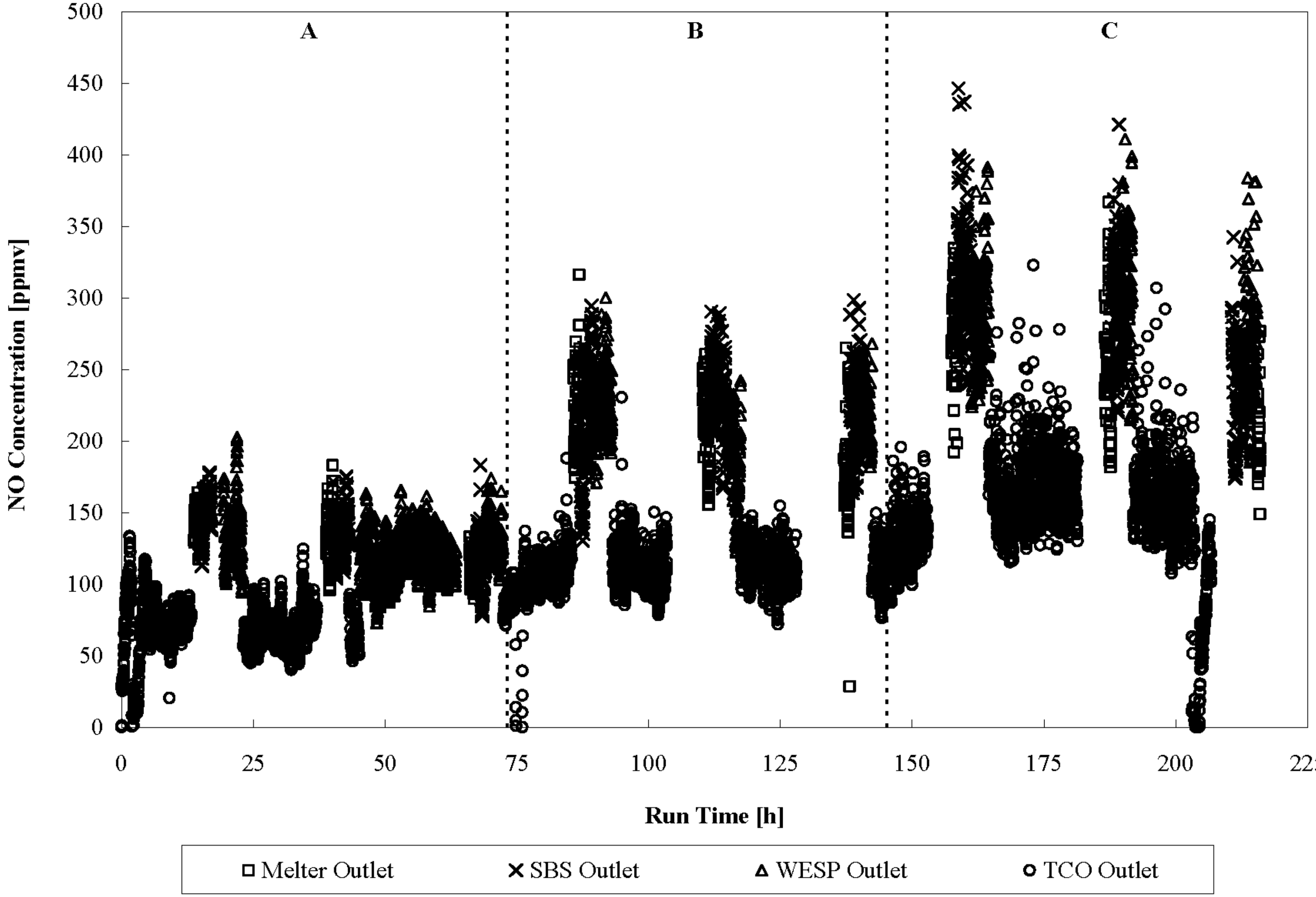

Figure 7.7.a. Concentration of NO at various points in the off-gas stream during Test 3.

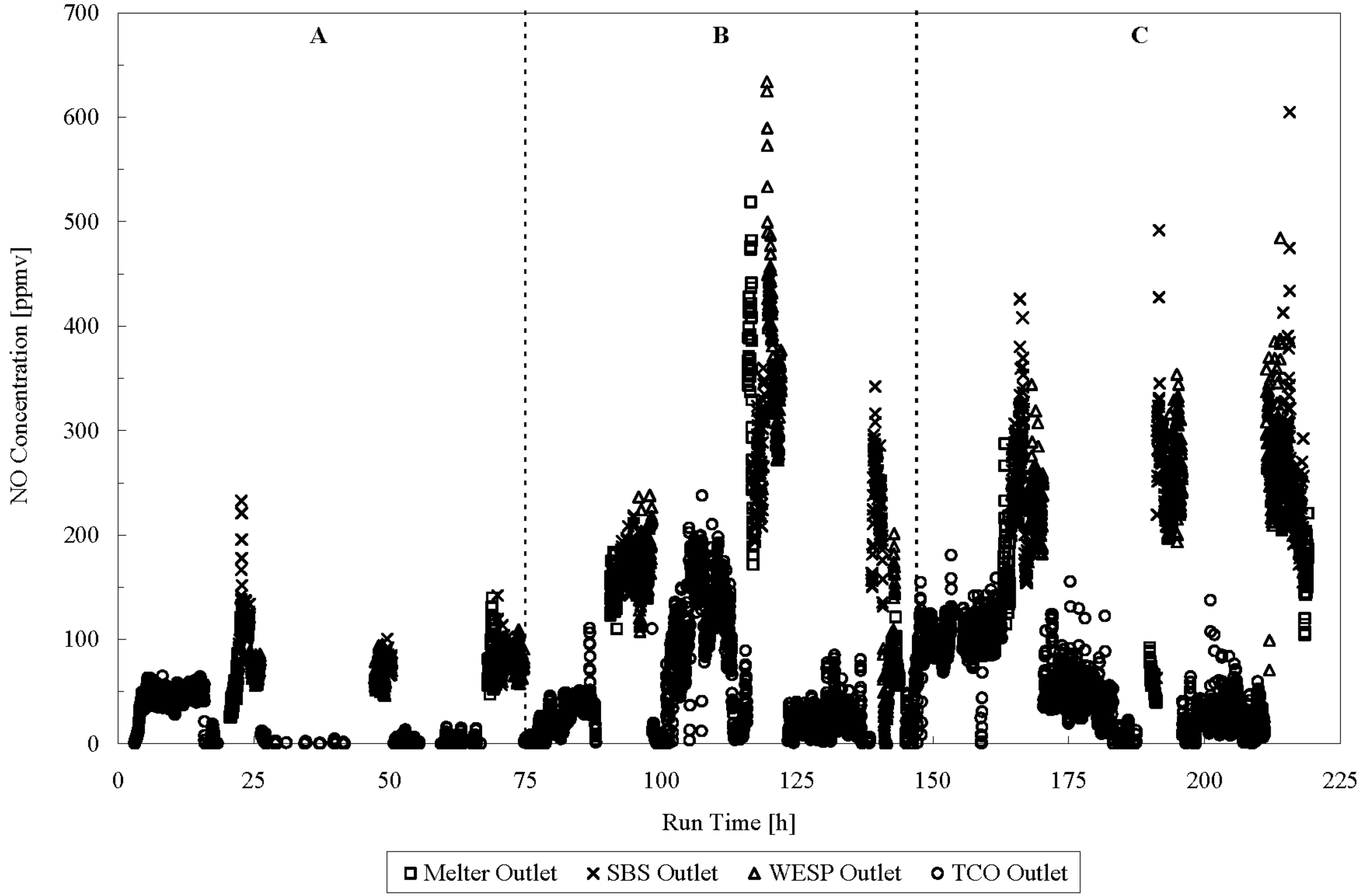

Figure 7.7.b. Concentration of NO at various points in the off-gas stream during Test 4.

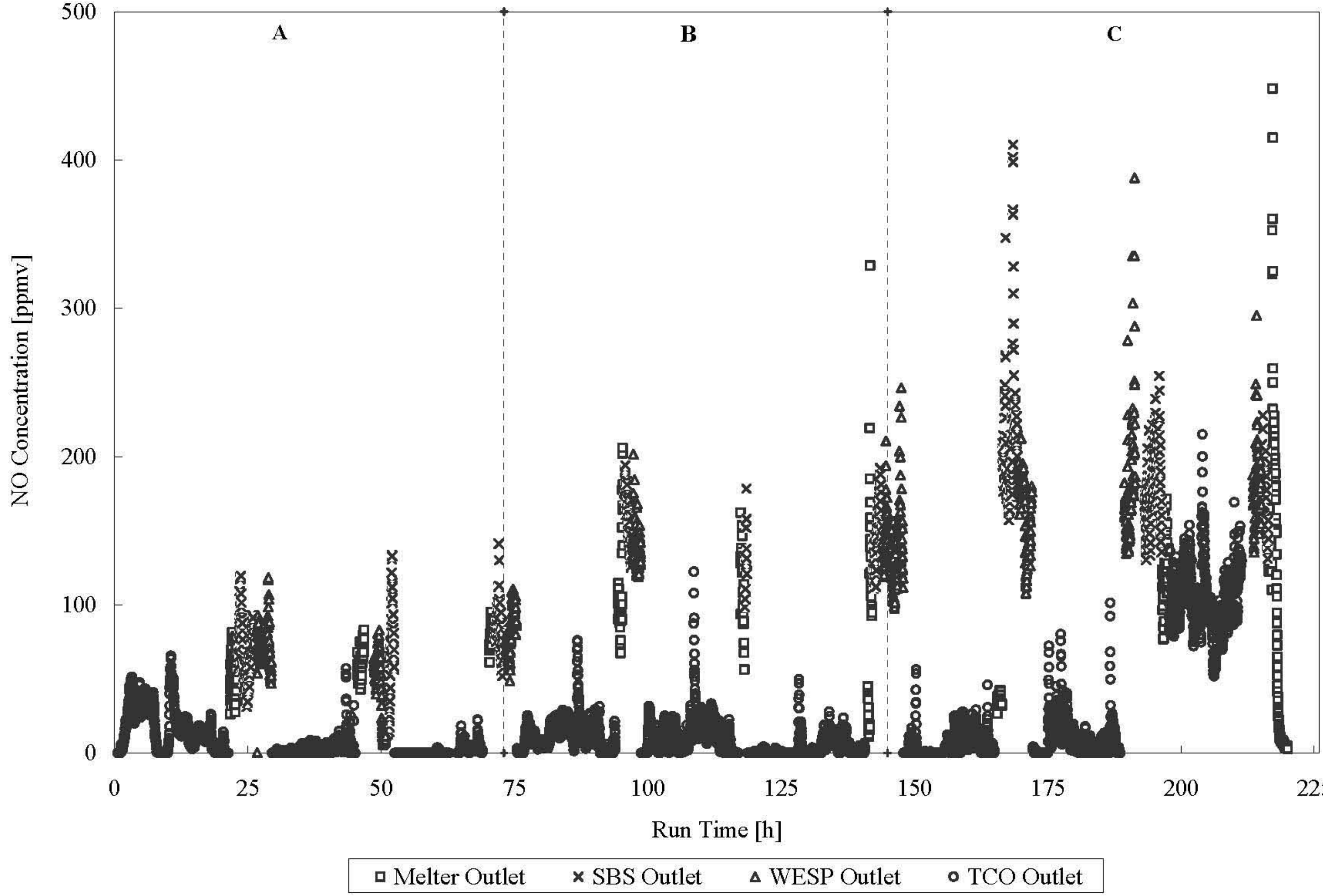

Figure 7.7.c. Concentration of NO at various points in the off-gas stream during Test 5.

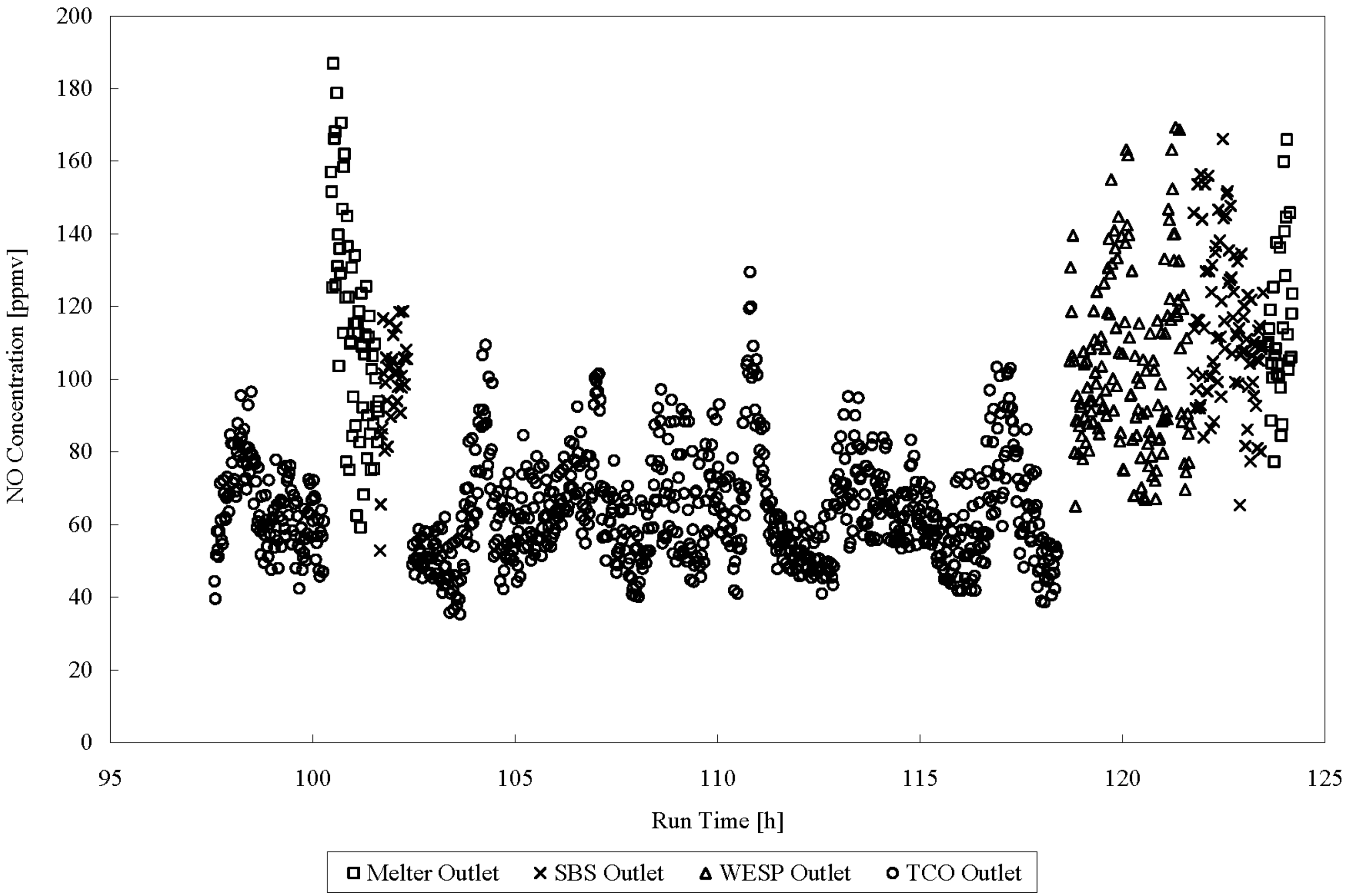

Figure 7.7.d. Concentration of NO at various points in the off-gas stream during Test 6.

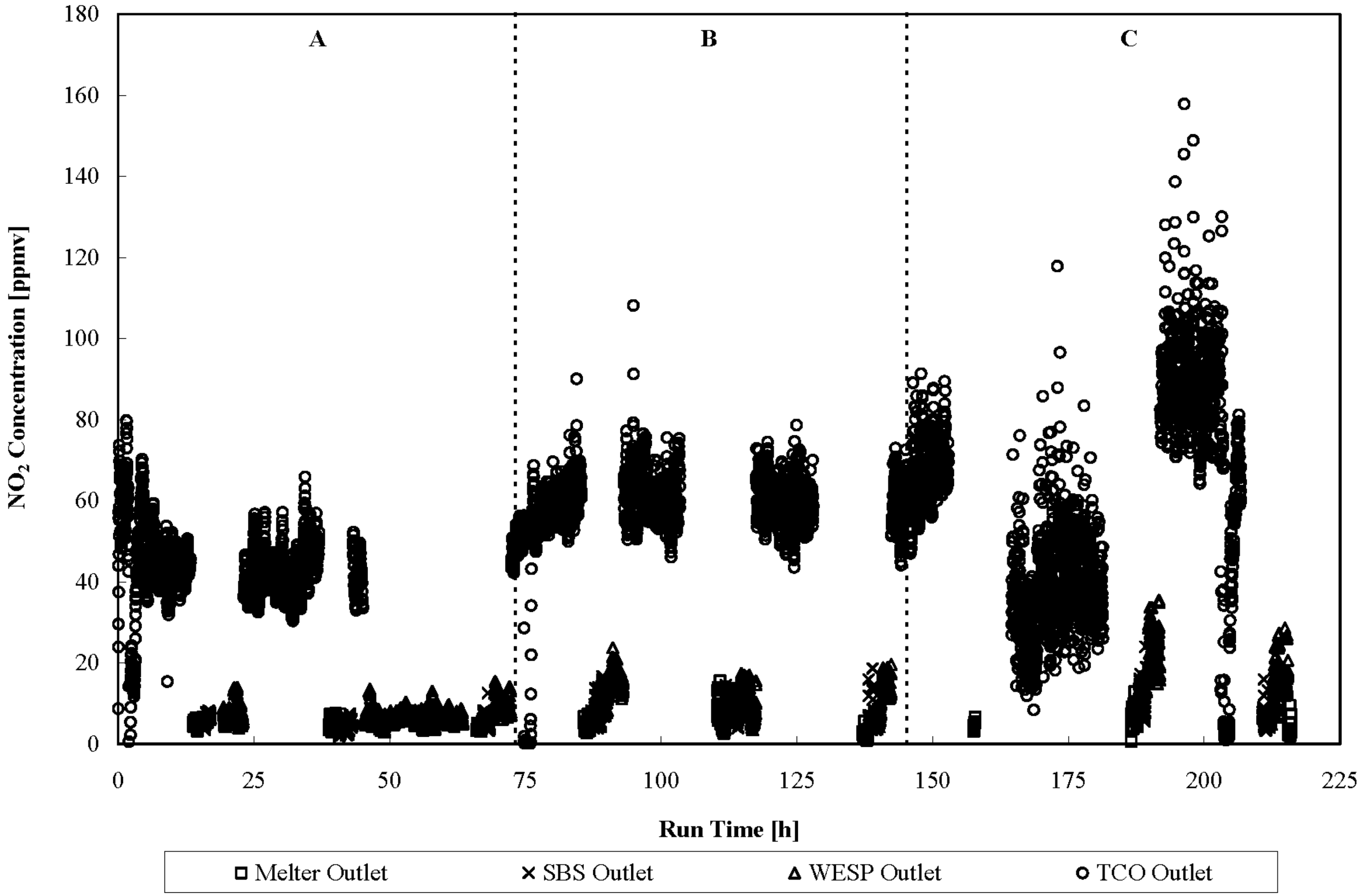

Figure 7.8.a. Concentration of NO_2 at various points in the off-gas stream during Test 3.

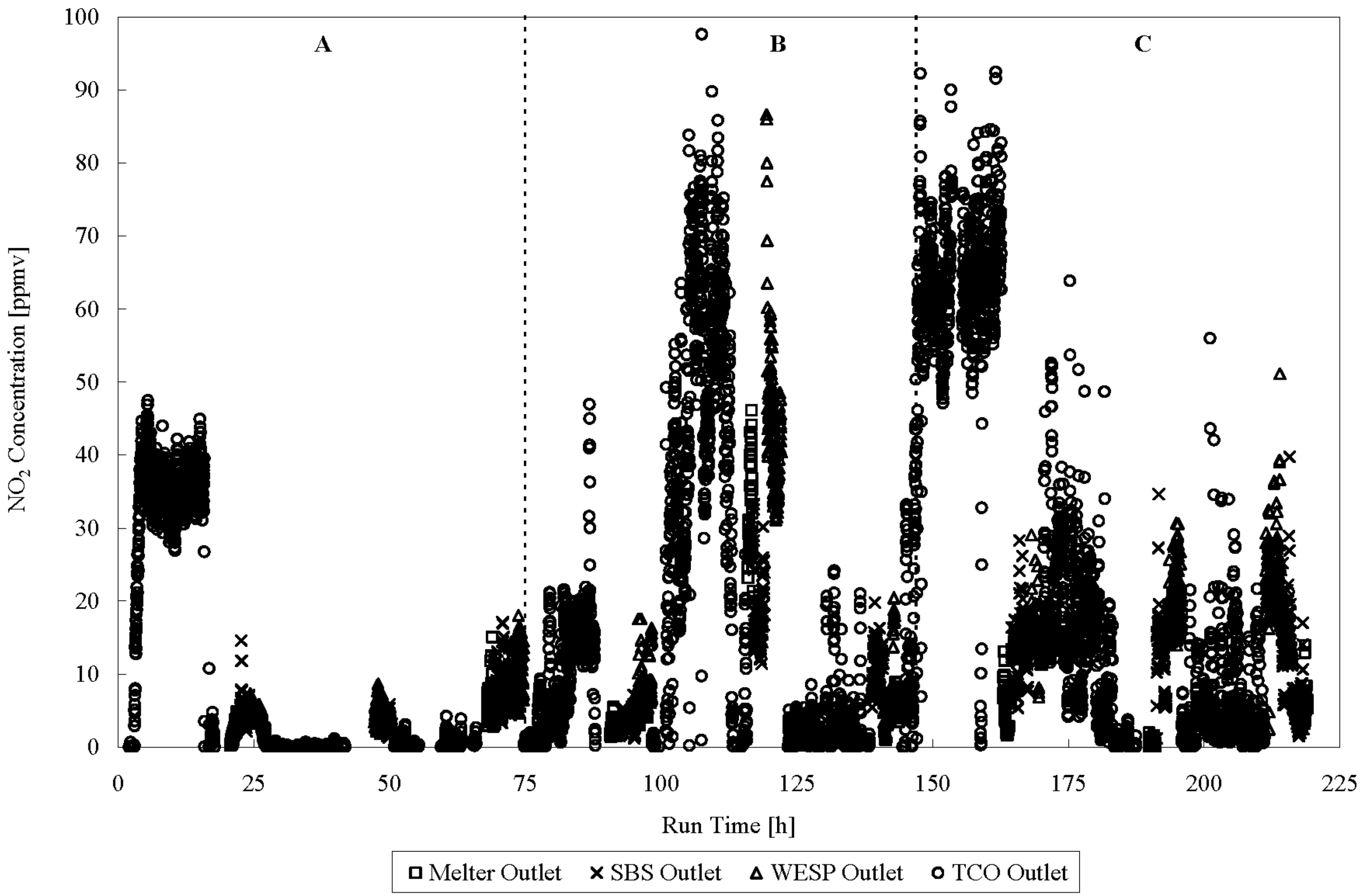

Figure 7.8.b. Concentration of NO_2 at various points in the off-gas stream during Test 4.

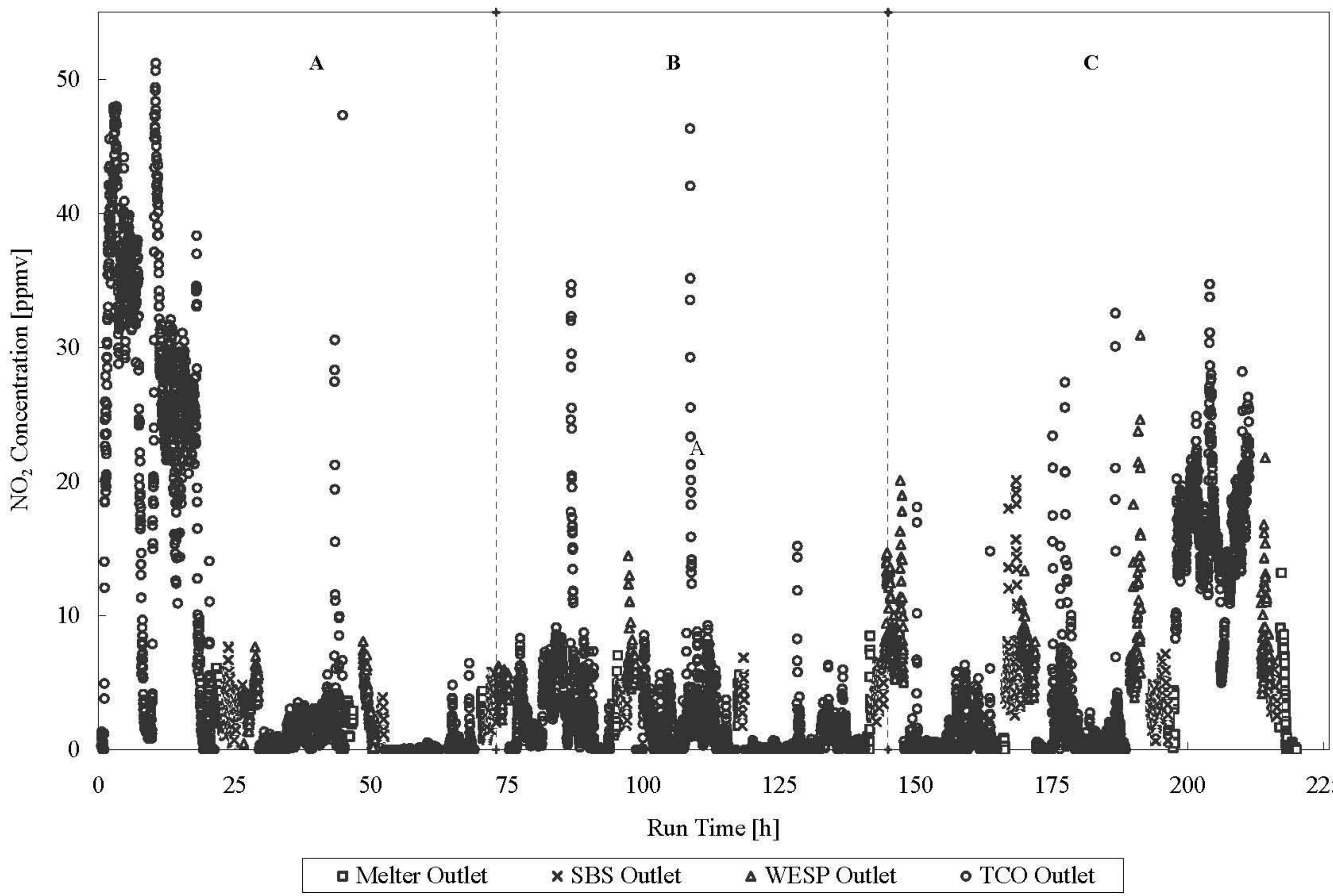

Figure 7.8.c. Concentration of NO_2 at various points in the off-gas stream during Test 5.

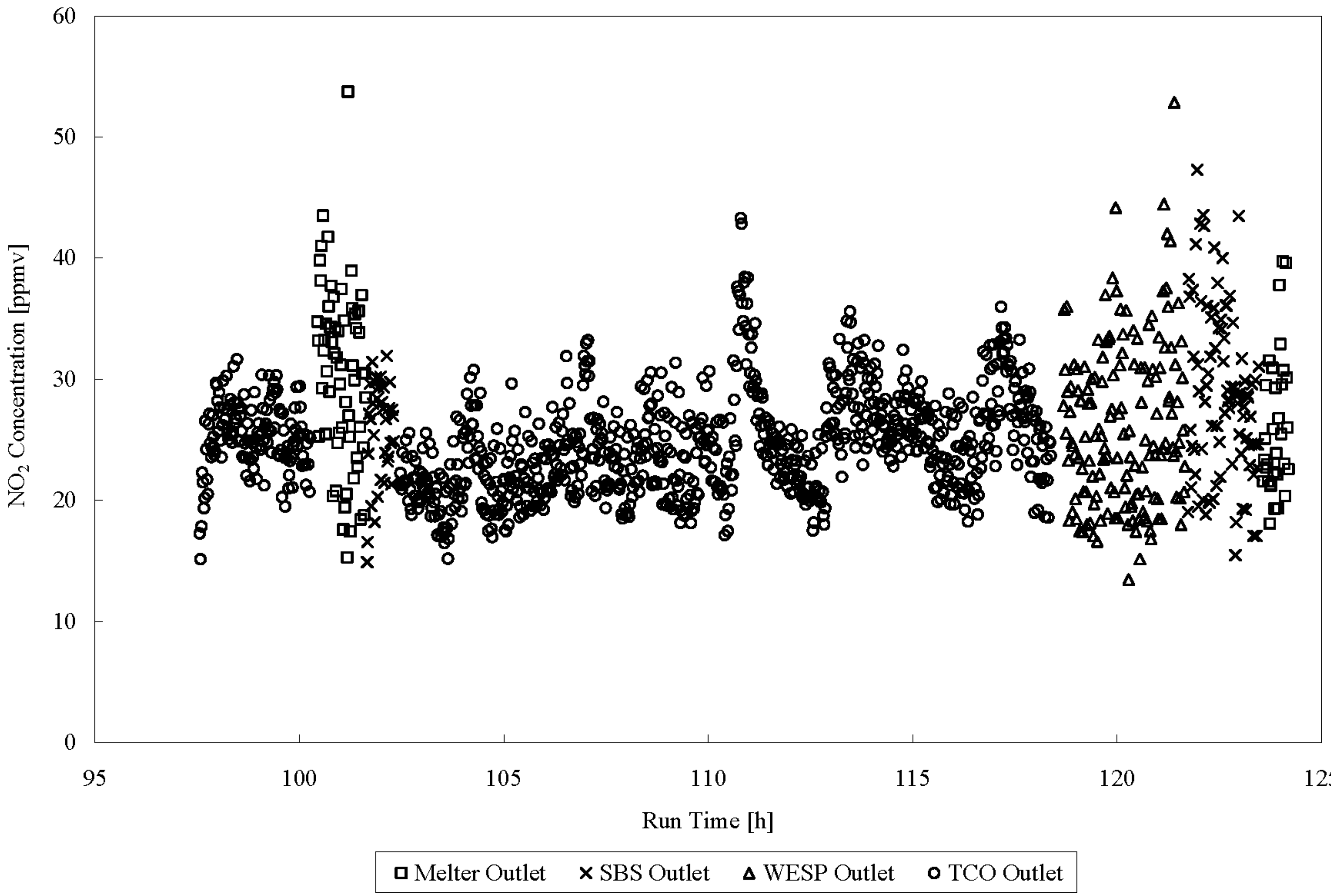

Figure 7.8.d. Concentration of NO_2 at various points in the off-gas stream during Test 6.

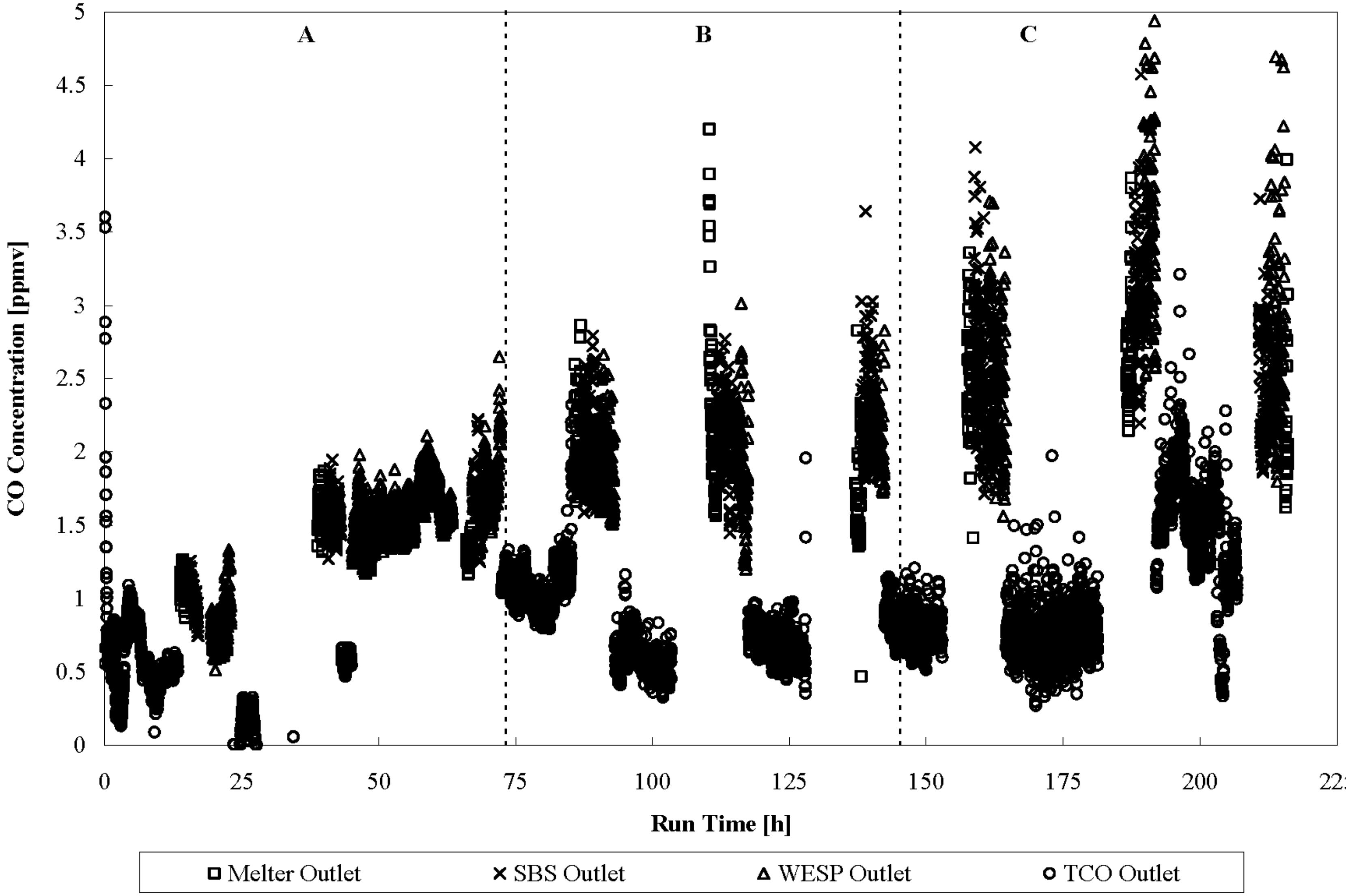

Figure 7.9.a. Concentration of CO at various points in the off-gas stream during Test 3.

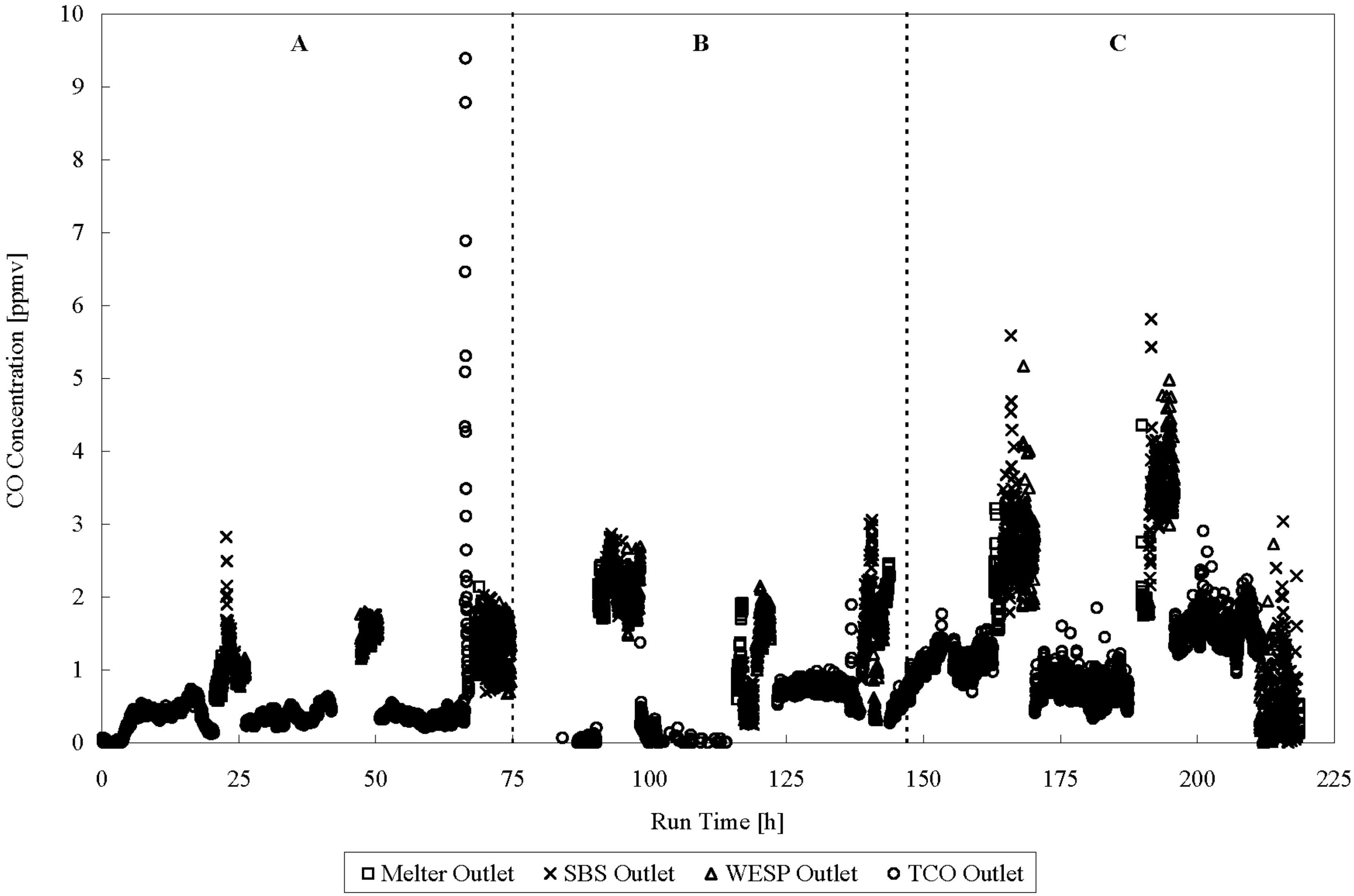

Figure 7.9.b. Concentration of CO at various points in the off-gas stream during Test 4.

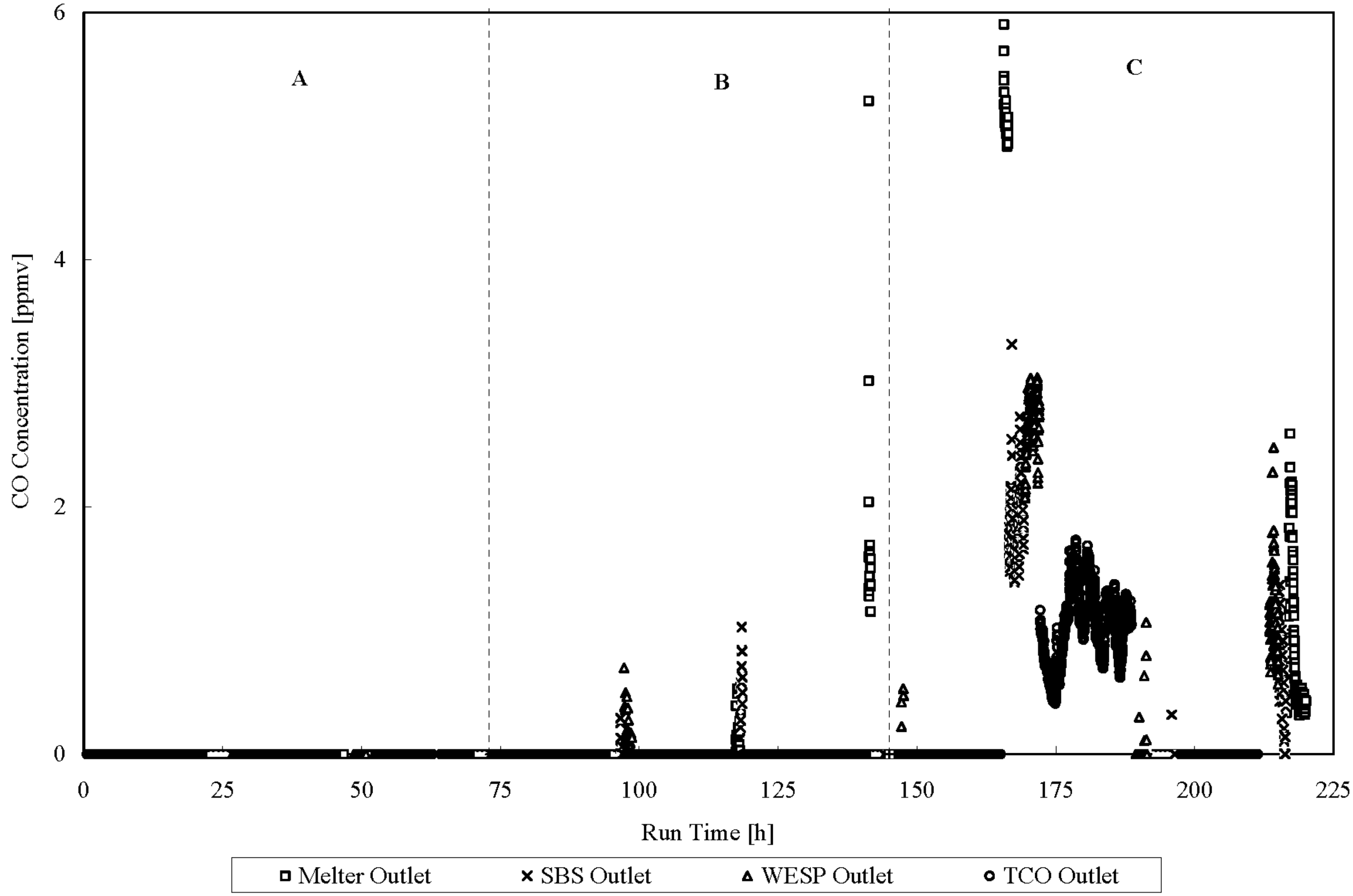

Figure 7.9.c. Concentration of CO at various points in the off-gas stream during Test 5.

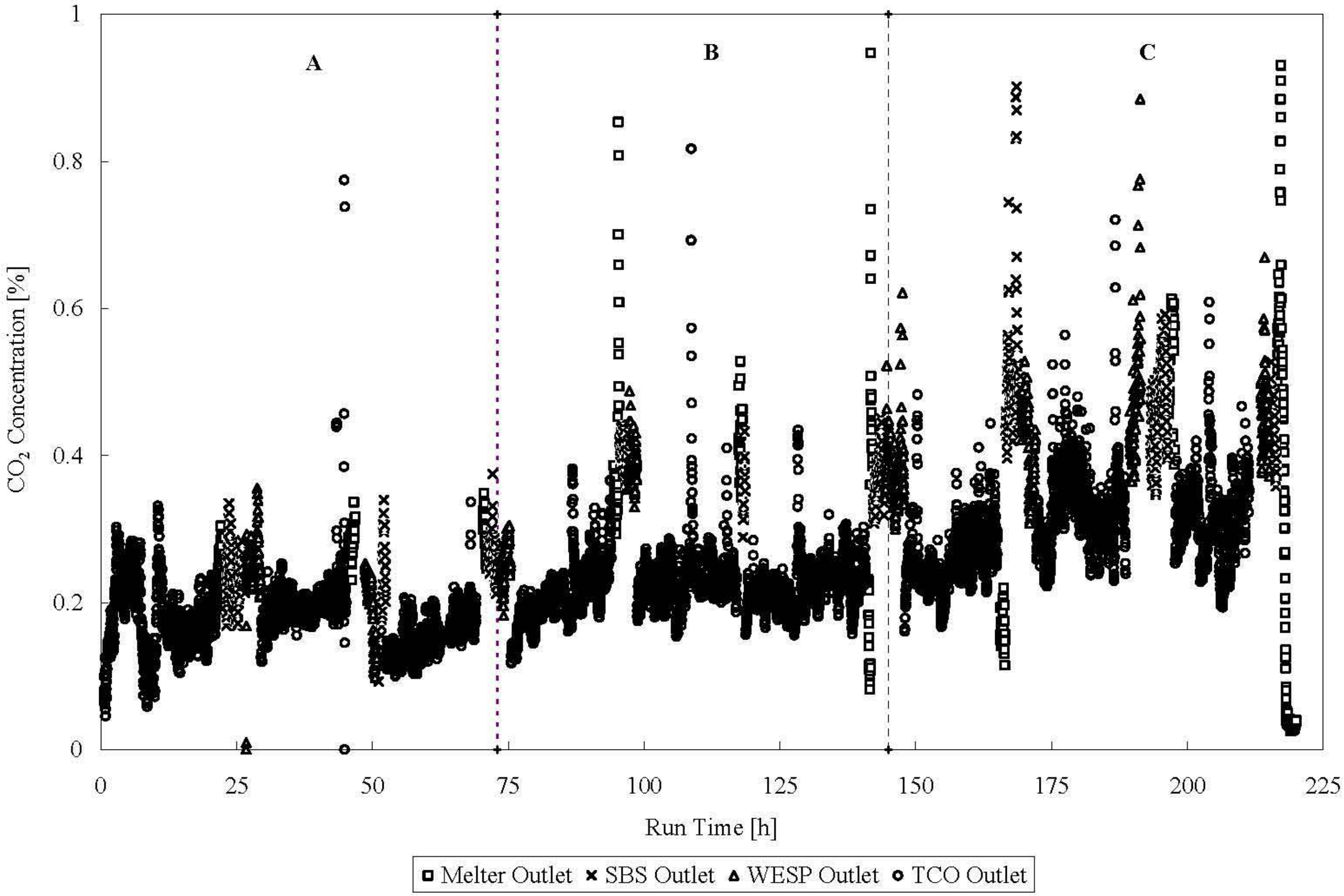

Figure 7.10.a. Concentration of CO_2 at various points in the off-gas stream during Test 3.

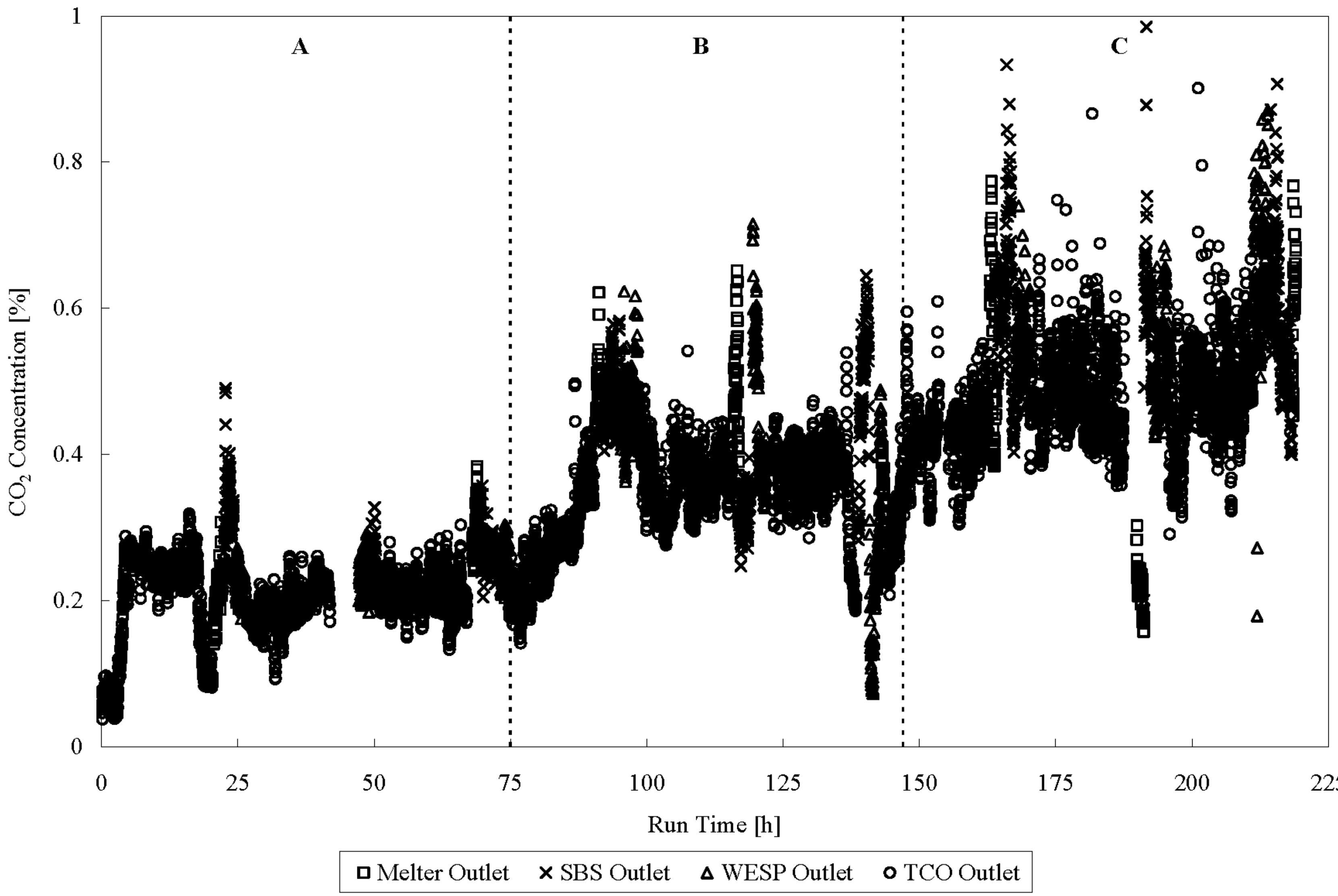

Figure 7.10.b. Concentration of CO_2 at various points in the off-gas stream during Test 4.

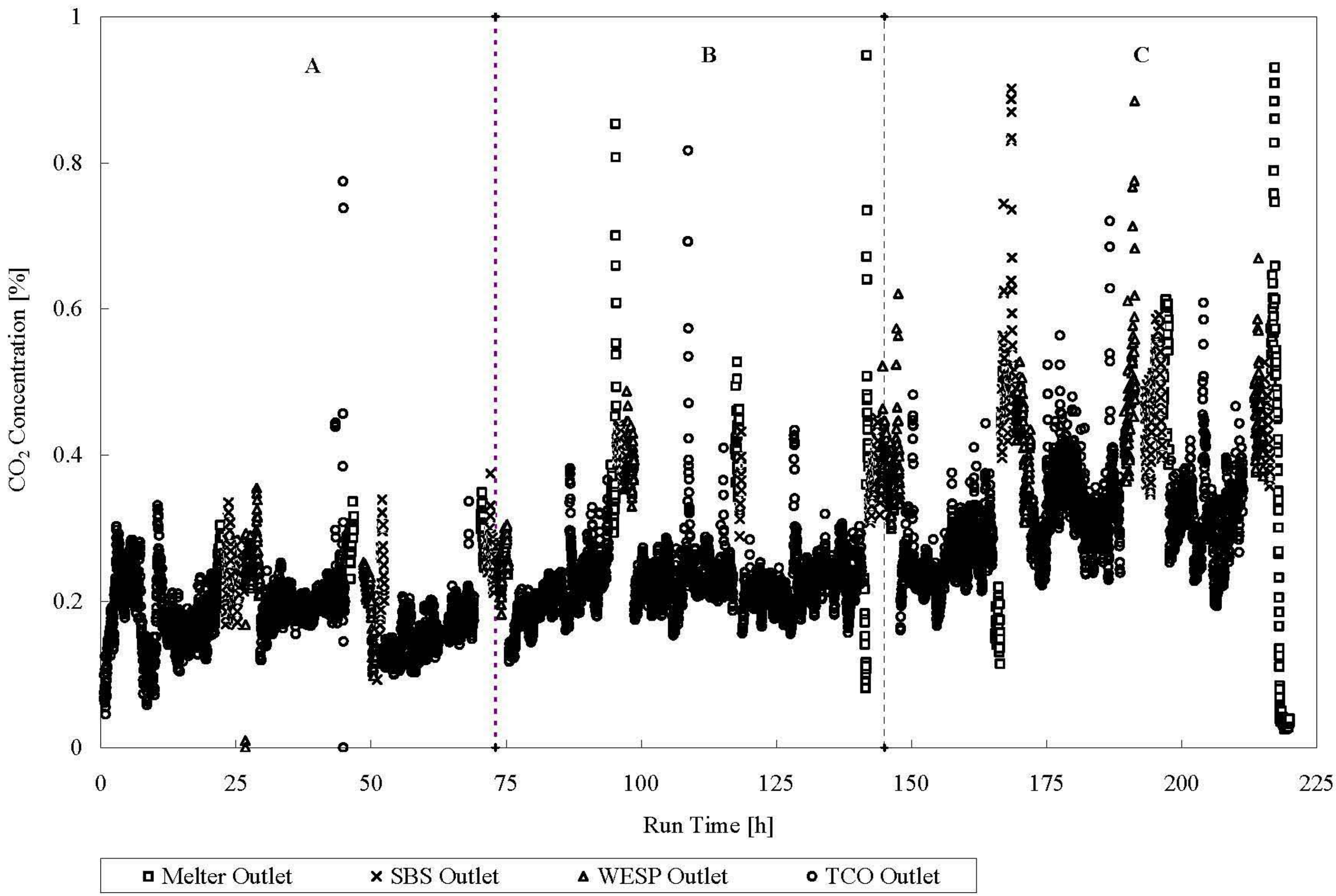

Figure 7.10.c. Concentration of CO_2 at various points in the off-gas stream during Test 5.

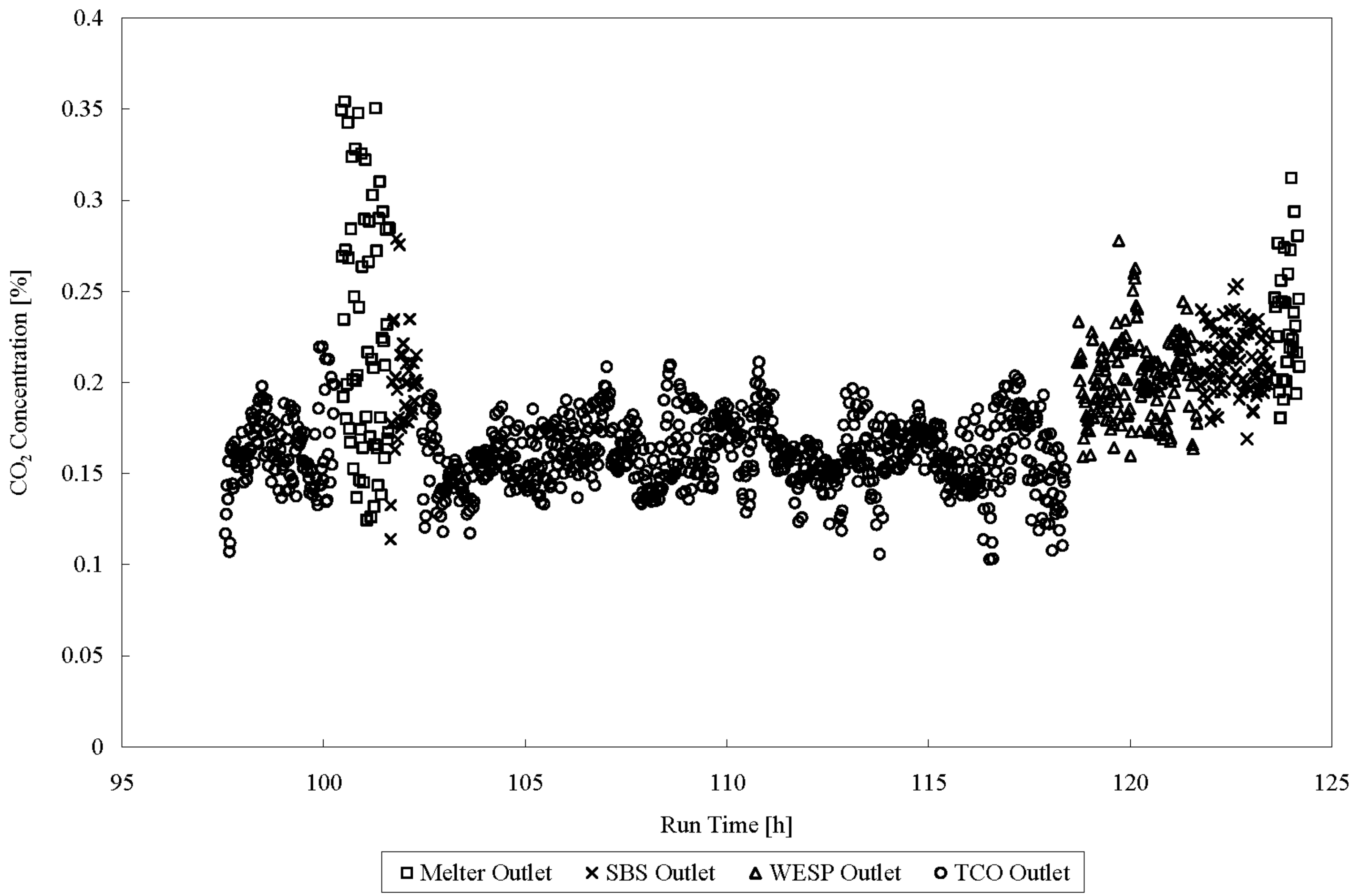

Figure 7.10.d. Concentration of CO_2 at various points in the off-gas stream during Test 6.

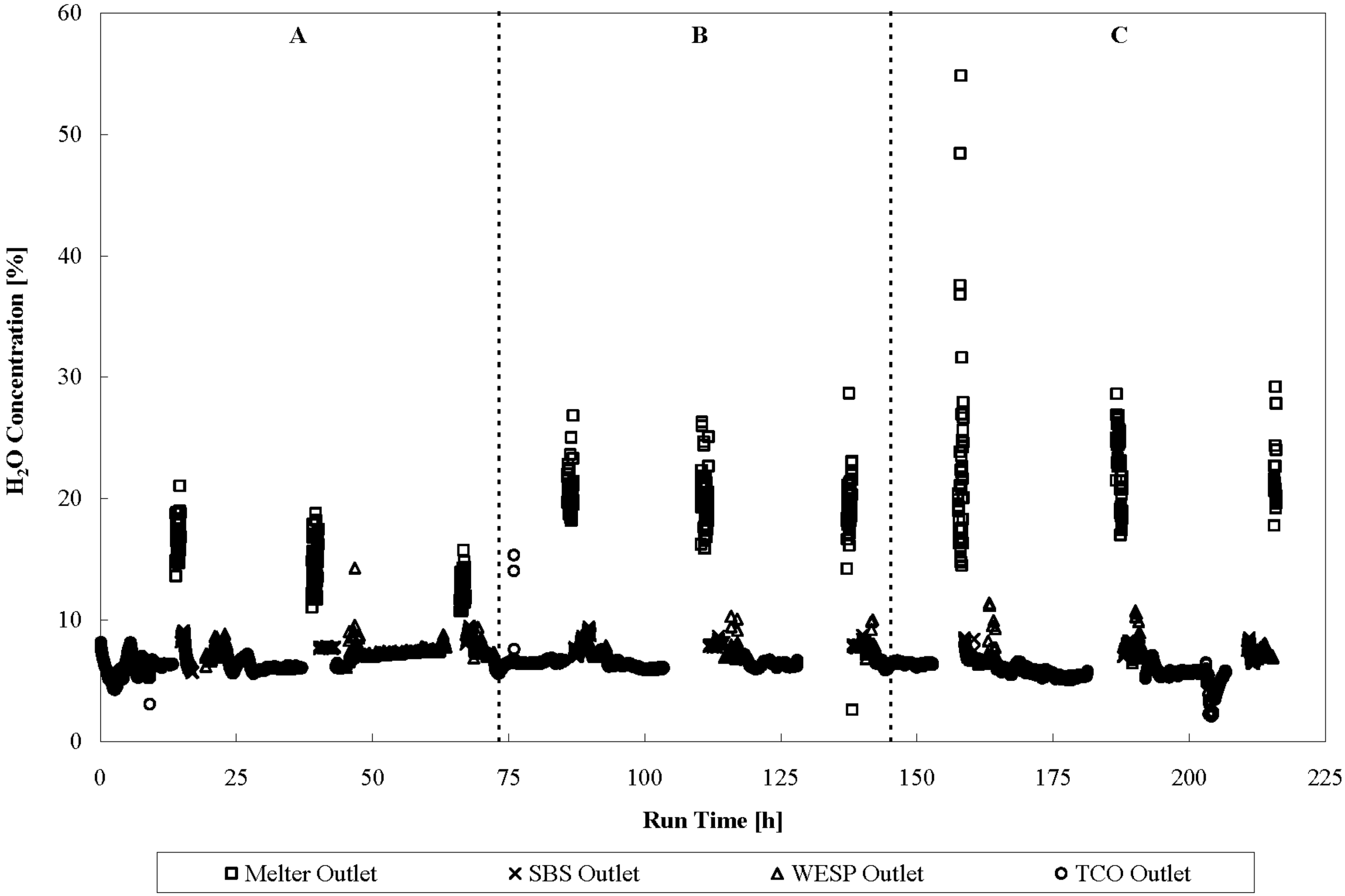

Figure 7.11.a. Concentration of water at various points in the off-gas stream during Test 3.

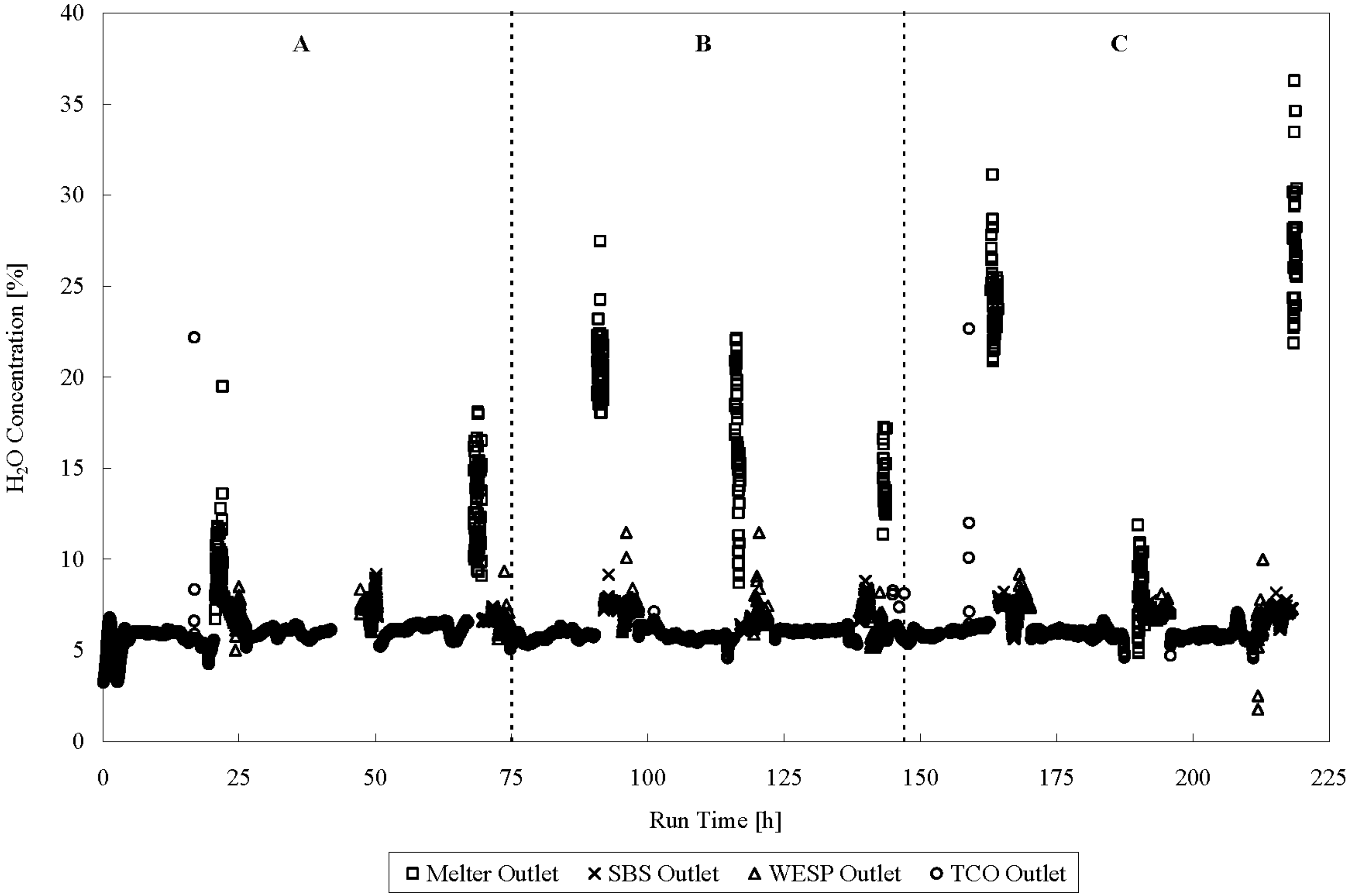

Figure 7.11.b. Concentration of water at various points in the off-gas stream during Test 4.

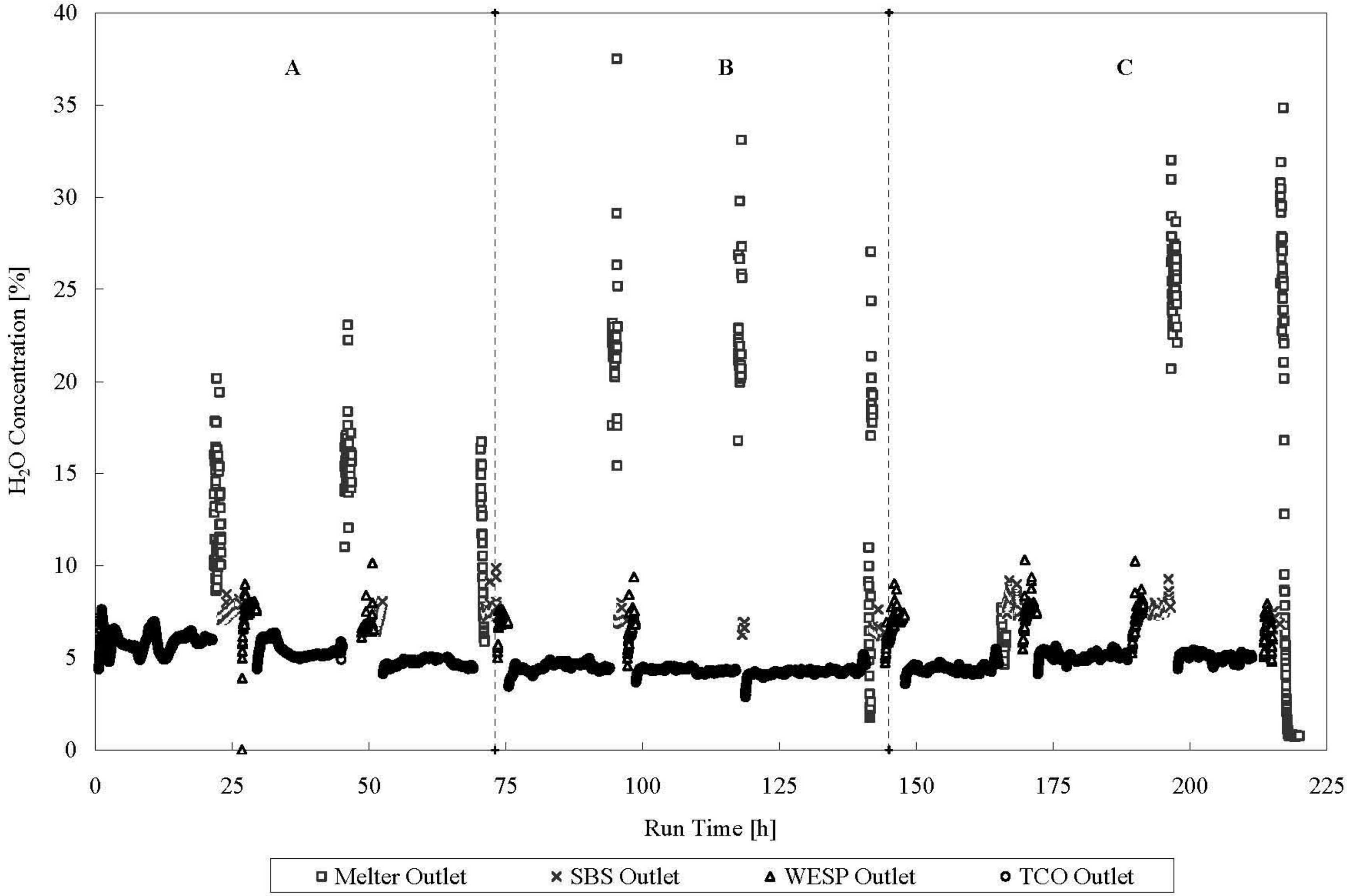

Figure 7.11.c. Concentration of water at various points in the off-gas stream during Test 5.

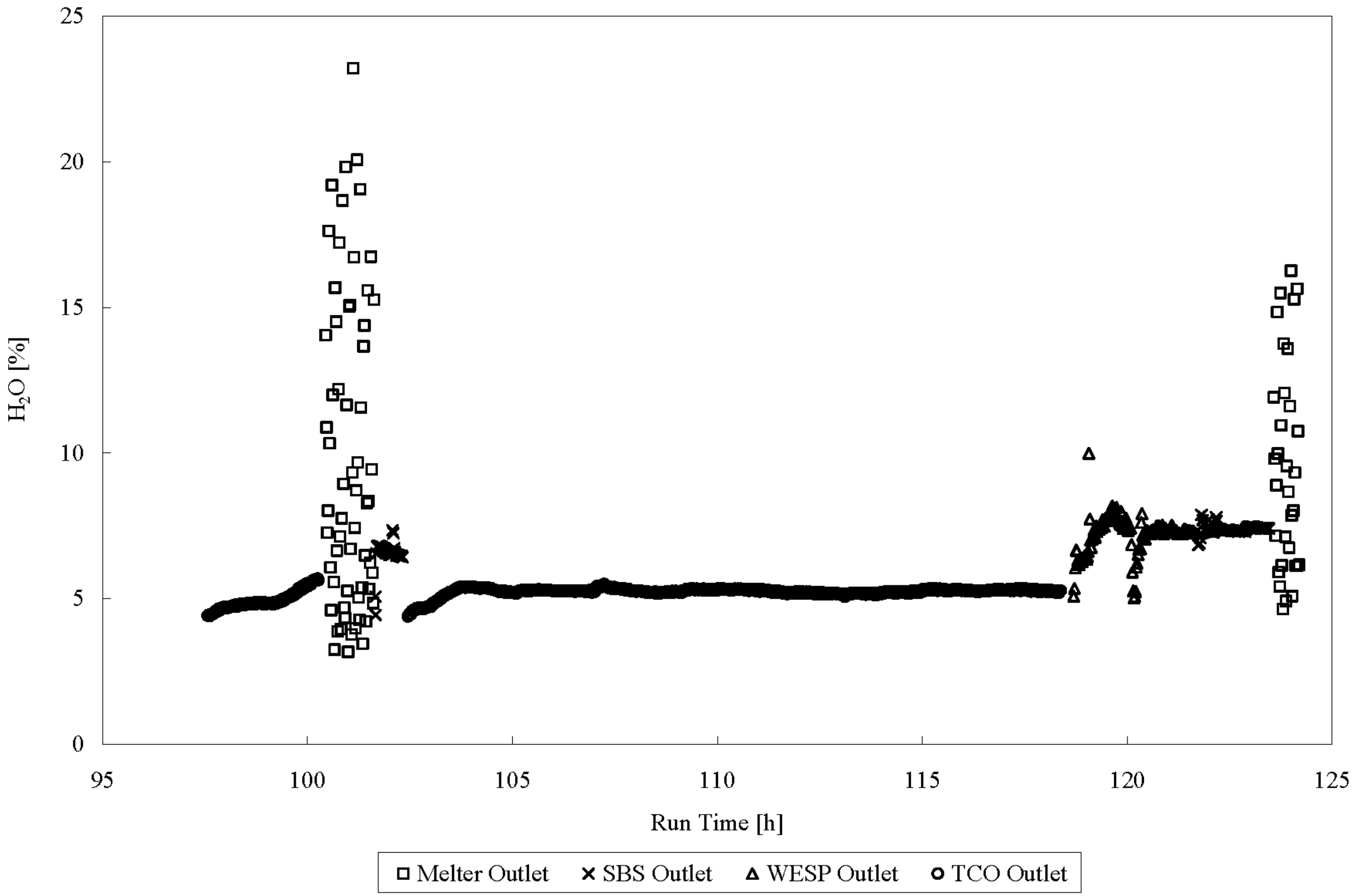

Figure 7.11.d. Concentration of water at various points in the off-gas stream during Test 6.

R&T Subcontractor Document Review Record

1) To Be Completed by Cognizant R&T Personnel			
Document Number	Revision	Document Title	
VSL-03R3800-4	A	DM1200 Tests with AZ-101 HLW Simulants	
Test Spec: 24590-HLW-TSP-RT-02-005		Scoping Statement(s): VH-4, VHO-3, VHO-2, VH-5	

R&T Contact:	Lawrence Petkus	MS1-B	371-8436	December 9, 2003
	Name (Print)	MSIN	Telephone Number	Date

Review Distribution

Organization	Contact	MSIN	Required?
Process Operations	L Hagie	MS-1C	Yes ☒ No ☐
Quality Assurance	S Sunday	MS14-4B	Yes ☐ No ☒
Environmental and Nuclear Safety	E Sauceda	MS4-C1	Yes ☐ No ☒
Commissioning and Training	K Vermillion	MS12-2B	Yes ☐ No ☒
Engineering	M Ongpin	MS4-A2	Yes ☒ No ☐
R&T Functional Manager	Joe Perez	MS1-B	Yes ☒ No ☐
HLW APM	Phil Schuetz	MS5-1	Yes ☐ No ☒
			Yes ☐ No ☐
			Yes ☐ No ☐
			Yes ☐ No ☐

Comments Due By: December 26, 2003

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: Reynolds, Jacob
Sent: Monday, February 09, 2004 9:41 AM
To: Petkus, Lawrence
Subject: RE: Comment Resolution "DM1200 Tests with AZ101 HLW Simulants"

I accept the document in its present form.

Jacob reynolds

-----Original Message-----
From: Petkus, Lawrence
Sent: Monday, February 09, 2004 9:13 AM
To: Reynolds, Jacob
Subject: FW: Comment Resolution "DM1200 Tests with AZ101 HLW Simulants"

Jake,
Per our hallway conversation, please return comment acceptance E-mail

Larry

-----Original Message-----
From: Petkus, Lawrence
Sent: Tuesday, February 03, 2004 8:01 AM
To: Carl, Daniel; Reynolds, Jacob; Valenti, Thomas
Cc: Tevis, Christine; Amistad, Stephanie; Doyle, Jeanette; Knighton, David; Suarez, Linda
Subject: Comment Resolution "DM1200 Tests with AZ101 HLW Simulants"

All,
Attached are the responces to comments made on test report VSL-03-3800-4, "DM1200 Tests with AZ101 HLW Simulants." Please review the comment responces and let me know if they are adequate. In order to maintain the report review schedule, please respond by noon tomorrow, Wednesday 2/4/04.

Larry Petkus
R&T, Sigma IV
Ph. 371-8436
<< File: AZ101 CRF_Eng_dc-d.doc >> << File: AZ101CRF_PrOps_dc-b.doc >>

Petkus, Lawrence

From: Hyman, Marve
Sent: Tuesday, February 17, 2004 10:01 AM
To: Petkus, Lawrence
Cc: Amistad, Stephanie; Ongpin, Maria; Grazzini, Janice; Valenti, Thomas
Subject: FW: Comment Resolution "DM1200 Tests with AZ101 HLW Simulants" VSL-03R3800-4

Importance: High

Attachment information.   AZ101 CRF :omResp Revised.do

Larry: On behalf of Engineering I concur with Document VSL-03R3800-4 Rev A.

(I just now found Tom's concurrance.)
Marve

-----Original Message-----
From: Petkus, Lawrence
Sent: Thursday, February 12, 2004 3:38 PM
To: Hyman, Marve; Amistad, Stephanie
Subject: FW: Comment Resolution "DM1200 Tests with AZ101 HLW Simulants"

Marve,
I have been told by Tom Valenti and Dan Carl that comment responses are acceptable for this test report. Do you need something else to provide concurrance for Engineering? I think this is complete, please let me know.

Larry

-----Original Message-----
From: Carl, Daniel
Sent: Tuesday, February 10, 2004 12:42 PM
To: Amistad, Stephanie; Petkus, Lawrence; Hyman, Marve
Cc: Eaton, William; Peters, Richard D (WTP); Pullen, Jeff; Rouse, James; 'rmeigs@duratekinc.com'
Subject: FW: Comment Resolution "DM1200 Tests with AZ101 HLW Simulants"

Marve,

Responses are acceptable.

Dan

-----Original Message-----
From: Petkus, Lawrence
Sent: Tuesday, February 10, 2004 12:31 PM
To: Carl, Daniel
Subject: FW: Comment Resolution "DM1200 Tests with AZ101 HLW Simulants"

Dan,
Round two.

Larry

-----Original Message-----
From: ianp@vsl.cua.edu [mailto:ianp@vsl.cua.edu]

Sent: Tuesday, February 10, 2004 12:22 PM
To: Petkus, Lawrence
Cc: Perez, Joseph; dcallow@duratekinc.com; ijoseph@duratekinc.com
Subject: RE: Comment Resolution "DM1200 Tests with AZ101 HLW Simulants"

Larry:

Per our discussion this morning, please find our revised responses to Dan comments (the changes are highligted). Please let us know whether these resolve Dan's concerns.

Regards,

Ian.

On 9 Feb 2004 at 9:08, Petkus, Lawrence wrote:

From: "Petkus, Lawrence" <llpetkus@bechtel.com>
To: "'Ian Pegg (E-mail)'" <ianp@vsl.cua.edu>, "'Keith Scanlan Matlack (E-mail)'" <keithm@vsl.cua.edu>
Copies to: "Knighton, David" <dknighto@bechtel.com>, "Perez, Joseph" <jmperez2@bechtel.com>, "Doyle, Jeanette" <jfdoyle1@bechtel.com>
Subject: RE: Comment Resolution "DM1200 Tests with AZ101 HLW Simulants"
Date sent: Mon, 9 Feb 2004 09:08:46 -0800

> Ian, Keith,
> All other comments have been found to be acceptable.
> Larry
>
> > -----Original Message-----
> > From: Petkus, Lawrence
> > Sent: Tuesday, February 03, 2004 11:49 AM
> > To: Ian Pegg (E-mail); Keith Scanlan Matlack (E-mail)
> > Subject: FW: Comment Resolution "DM1200 Tests with AZ101 HLW
> > Simulants"
> >
> > Ian, Keith,
> > Your response to my comments was acceptable. Dan Carl had the following
> > rebuttal. There are two more reviewers that have not yet replied, but I
> > thought that I would give you the benefit of a quick response.
> >
> > Larry
> >
> > -----Original Message-----
> > From: Carl, Daniel
> > Sent: Tuesday, February 03, 2004 11:08 AM
> > To: Hyman, Marve
> > Cc: Petkus, Lawrence; Eaton, William
> > Subject: RE: Comment Resolution "DM1200 Tests with AZ101 HLW
> > Simulants"
> >
> > Marve,
> >
> > Response quality was high. All were acceptable except for the following:
> >
> > DC-5 Describe changes, if any, that will be made in the text to
> > document the response.
> >
> > DC-11 I'm bothered by the response, but won't insist the text be
> > changed, since the text is obviously inconsistent with normal engineering
> > terminology. That is, most engineers would not describe the WESP as
> > having a condensing function when the mole fraction of water vapor in the
> > off-gas increases across the unit.
> >
> > DC-18 The first part of the response was acceptable. Unless the
> > tables were changed, the second part is confusing. The comment referred

> > to test 3C (see table 7.4 in the review document, which reported iodine
> > effluent measurements [relative to feed] for the melter, SBS and WESP as
> > 102%, 58%, and 29%, respectively). The response states it is reporting
> > test 3C data, but the table references seem to be for test 5C in the
> > review document. Both the review document and the response reported
> > (except for the test identifier) 58% for the melter effluent in table 7.9
> > and 45% for the WESP effluent in table 7.11. However, table 7.10 reported
> > 119% for the SBS effluent for test 5C. I'd recommend the response end
> > with the explanation of the limitation of the mass balance, and
> > incorporate this explanation into the text since the text now gives an
> > incorrect impression of better mass balance than is justified.
> >
> > Dan
> >
> >
> > -----Original Message-----
> > From: Hyman, Marve
> > Sent: Tuesday, February 03, 2004 9:11 AM
> > To: Carl, Daniel
> > Subject: FW: Comment Resolution "DM1200 Tests with AZ101 HLW
> > Simulants"
> >
> > Dan: Please send me your replies and I will coordinate them with
> > Tom Valenti's replies.
> > Thanks, Marve
> >
> > -----Original Message-----
> > From: Amistad, Stephanie
> > Sent: Tuesday, February 03, 2004 8:01 AM
> > To: Hyman, Marve
> > Subject: FW: Comment Resolution "DM1200 Tests with AZ101 HLW
> > Simulants"
> >
> >
> >
> > Stephanie Amistad
> > Discipline Specialist
> > Central Process Engineering / Mechanical Systems
> > 371-3648 / MPF B-265 / MS4- B2
> >
> >
> > -----Original Message-----
> > From: Petkus, Lawrence
> > Sent: Tuesday, February 03, 2004 8:01 AM
> > To: Carl, Daniel; Reynolds, Jacob; Valenti, Thomas
> > Cc: Tevis, Christine; Amistad, Stephanie; Doyle, Jeanette;
> > Knighton, David; Suarez, Linda
> > Subject: Comment Resolution "DM1200 Tests with AZ101 HLW
> > Simulants"
> >
> > All,
> > Attached are the responces to comments made on test report
> > VSL-03-3800-4, "DM1200 Tests with AZ101 HLW Simulants." Please review the
> > comment responces and let me know if they are adequate. In order to
> > maintain the report review schedule, please respond by noon tomorrow,
> > Wednesday 2/4/04.
> >
> > Larry Petkus
> > R&T, Sigma IV
> > Ph. 371-8436
> > << File: AZ101 CRF_Eng_dc-d.doc >> << File:
> > AZ101CRF_PrOps_dc-b.doc >>
>

COMMENT RESOLUTION FORM

Return to: Lawrence Petkus

Comments Due: December 26, 2003

Document Title: DM1200 Tests with AZ-101 HLW Simulants		Document No. VSL-03R3800-4		Revision: A	Date: December 9, 2003
Reviewer: Lawrence Petkus	Date: 12/29/03	Response by:	Date:	Comments Resolved: Lawrence Petkus	Date: 2/17/04

Item No.	Section/ Paragraph	Comment	Significance[a]	"M" Comment Justification[B]	Response	Resolution
1	5.1.1/ General	Discussion of melter pressure behavior using hourly averaged data seems inadequate. Pressure surges and melter stability need "real time" data not hourly averages. Pressure surges are mentioned, but it is not explained whether there is a more sensitive measurement of the pressure. Add representative data/ figures to discuss melter stability. See Objectives #3, #7, and #14.			We will remove the hourly averaged data (e.g., remove pressure traces from Fig 5.6), and use just the information shown on Fig 5.7 (and others),which is the information being asked for. The text will be reorganized slightly to clarify the discussion based on the two minute data.	
2	7.1 / 1	No discussion of Cs off gas emissions or Df is provided, although Cs is present.			Table 2.2 indicates the Cs2O is included as 0.01% in the stimulant, which itself is 25 wt% of the glass. This corresponds to Cs2O of 0.0025% in the target glass which is rounded to 0.00% in Table 2.2. This amount is too small for reasonable quantification of emissions.	
3	Summary	Expand discussion of each objective in the summary.	M	Modification needed to support deletion of completion form	Information in Table 8.1 will be included in the summary to conform to latest format requirements.	
4	Summary	Add discussion of success criteria and how they were met.	M	Modification needed to support deletion of completion form	Summary section to be revised to conform to latest format requirements.	

ORP-51440, Rev. 0

COMMENT RESOLUTION FORM

Item No.	Section/ Paragraph	Comment	Significance[a]	"M" Comment Justification[B]	Response	Resolution
5	Summary	Add list of any Test Exceptions or "none"	M	Modification needed to support deletion of completion form	Summary section to be revised to conform to latest format requirements.	
6	Summary	Add short discussion of simulant selection in summary	M	Modification needed to support deletion of completion form	Summary section to be revised to conform to latest format requirements.	

ORP-51440, Rev.0

[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: DM1200 Tests with AZ-101 HLW Simulant

Test Report Number: VSL-03R3800-4

Prepared By: Lawrence Petkus **Date:** February 25, 2004

Signature: Lawrence Petkus

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.

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

Additional comments (include researcher recommendations):

Operating conditions for the HEME specified ~1 gph or per manufacture's recommendations. Manufactured recommended no spray unless DP increase indicates solids build up. Operation subsequent to this test used spray at 0.2 gph.