Second Generation Pressurized Fluidized-Bed Combustion (PFBC) Research and Development Phase 2 - Task 4 Carbonizer Testing

Volume I - Test Results

Topical Report

R. Froehlich
A. Robertson
J. Vanhook
A. Goyal
A. Rehmat
R. Newby

November 1994

Work Performed Under Contract No.: DE-AC21-86MC21023

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Foster Wheeler Development Corporation
Livingston, New Jersey

MASTER

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EXECUTIVE SUMMARY

A team of companies, led by Foster Wheeler Development Corporation (FWDC) and consisting of Gilbert/Commonwealth, Institute of Gas Technology, the Power Generation Business Unit of Westinghouse Electric Corporation, and the Science & Technology Center of Westinghouse Electric Corporation has been developing an advanced second-generation pressurized fluidized-bed combustion system. A carbonizer is an essential element of this system. The primary responsibility of IGT in this program was to develop a carbonizer model for scale-up which initially utilized data available in the literature and was subsequently updated with actual data generated in the carbonizer pilot plant during the component testing.

Prior to the carbonizer pilot plant testing at FWDC, an extensive literature search was conducted, and correlations were developed for predicting yields of various species as a function of coal properties and carbonizer operating parameters. Based on these correlations, a computer model for the carbonizer was developed. This model could simulate a bubbling or a circulating fluidized-bed reactor with or without fines recycle in which the coal and sorbent could be introduced into the fluidized-bed region and/or into the freeboard region of the carbonizer.

During the period beginning November 1991 and ending September 1992, a series of tests were conducted at FWDC in a fluidized-bed coal carbonizer to determine its performance characteristics. The carbonizer was operated for 533 hours in a jetting fluidized-bed configuration during which 36 set points (steady-state periods) were achieved. Testing was completed with four different fuels, namely, Pittsburgh No. 8 bituminous coal, Illinois No. 6 bituminous coal, Wyoming Eagle Butte subbituminous coal, and petroleum coke; a total of 83 tons of feedstock was consumed. In addition, an exploratory carbonizer test in a circulating fluidized-bed configuration entailing four set points and 9.9 tons of two different fuels (Pittsburgh No. 8 bituminous coal and petroleum coke) was completed. Sorbent (dolomite or limestone) was also fed to the carbonizer during each of the set points to capture sulfur.

Extensive data were collected on the feed and product stream compositions, heating values, temperatures, and flow rates. With this data, elemental and energy balances were computed to evaluate and confirm the accuracy of the data. The carbonizer data were not as self-consistent as could be desired (balance closure imperfection). A software package, called BALAID, has been developed by Science Ventures, Inc., of California, which reconciles the data by applying conservation laws and other equality and inequality constraints. Adjustments are made to all the species flows, temperatures, and variable-species compositions with the adjustments weighted according to the statistical variance of each variable. A maximum-likelihood set of reconciled values is computed in which all the elemental and energy balances close exactly. This approach takes advantage of all the available measurement information as well as information embodied in the conservation laws and in the estimated quality of the measurements. The program utilizes advanced principles in statistics, numerical techniques, and constrained nonlinear optimization theory. This program was successfully applied to reconcile the carbonizer data.

The reconciled data for the carbonizer, while operating in the jetting fluidized-bed configuration, were rigorously analyzed, correlations were developed, and the model was updated accordingly. The model was then used for simulating each of the 36 steady-state periods achieved in the pilot plant.

Many correlations were also developed that were not in the forms present in the existing model. Incorporation of these new correlations in the model would have required significant changes in the computer code, and would have required additional resources. These correlations, if incorporated into the model, could have improved its predictive capabilities.

This report has been divided into two volumes. Volume 1 provides details of the data analysis, data correlations, model update, and model predictions, while Volume 2 provides details of the carbonizer data reconciliation.

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1. INTRODUCTION

During the period beginning November 1991 and ending September 1992, a series of tests were conducted at Foster Wheeler Development Corporation in a fluidized-bed coal carbonizer to determine its performance characteristics. The carbonizer was operated for 533 hours in a jetting fluidized-bed configuration during which 36 set points (steady-state periods) were achieved.

Extensive data were collected on the feed and product stream compositions, heating values, temperatures, and flow rates. With these data, elemental and energy balances were computed to evaluate and confirm accuracy of the data. The carbonizer data were not as self-consistent as could be desired (balance closure imperfection). A software package developed by Science Ventures, Inc., of California, called BALAID, was used to reconcile the carbonizer data; the details of the reconciliation have been given in Volume 1 of this report.

The reconciled data for the carbonizer were rigorously analyzed, correlations were developed, and the model was updated accordingly. The model was then used in simulating each of the 36 steady-state periods achieved in the pilot plant. The details are given in this Volume of the report.

2. CARBONIZER PILOT PLANT DATA

The description of the carbonizer pilot plant, the data obtained from this pilot plant, and the reconciliation of these data are discussed in this section.

2.1. Carbonizer Pilot Plant Description

By November 1991, Foster Wheeler Development Corporation (FWDC) completed the construction of the second-generation Pressurized Fluidized-Bed (PFB) combustion pilot plant at its John Blizzard Research Center in Livingston, New Jersey, and completed two shakedown tests. The facility was designed to test a second-generation carbonizer and then follow it with a circulating pressurized fluidized-bed combustor/fluidized-bed heat exchanger.

Figure 2.1 is a simplified schematic of the carbonizer pilot plant. The coal and sorbent are pressurized in separate lock hoppers with screw feeders controlling their feed rate into a common, pneumatic transport line that injects these materials into the carbonizer.

The carbonizer is a 30-in.-OD X 34-ft, 6-in.-tall refractory-lined pressure vessel. It has a 19-ft-deep fluidized-bed region and a 9-ft, 5-3/4 in.-tall freeboard region (Figure 2.2). The carbonizer ID increases from the bottom to the top in three steps to enhance solids circulation and limit slugging and elutriation. The ID is 10 in. for the first 3 ft, 7 in. of the bed height, 12 in. in the middle section containing most of the bed, and 14 in. in the freeboard. Air, coal, and lime-based sorbent are injected into the unit at a 40 to 60 ft/s jet velocity through a central, vertical, 1-in. Schedule 80 stainless steel feed pipe at the bottom of the unit. Low-Btu fuel gas leaves through a 3-in.-ID radial nozzle at the top. Spent bed material and char drain through an annulus that surrounds the feed pipe, enter the packed-bed cooling section, and are cooled to about 300°F by counter flowing nitrogen before leaving through a 4-in. drain. A pressurized screw feeder in the drain line controls the material drain rate/bed height, and discharges to a lock hopper for depressuring and ultimate drum disposal.

Because a new facility and a new process (carbonization) were involved, the pilot plant was initially operated with a two-cyclone particulate-removing gas cleanup system. To minimize interactions, the stainless steel cyclones were placed in separate, refractory-lined pressure vessels, and provided with separate ash-cooling and depressuring systems. After sufficient operating experience was gained and the composition of the carbonizer-generated fuel gas was determined, the second-stage cyclone was removed, and a ceramic cross-flow filter was connected to the system (for Test Runs TR7 and TR8).

The gas leaving the second-stage cyclone (or the ceramic cross-flow filter) is lowered to atmospheric pressure as it passes through a choked-flow orifice. The high velocity orifice jet discharges into an Incoloy-shrouded refractory-lined chamber, where a nitrogen-atomized nozzle injects spray water to cool the gas to approximately 350°F. Although the cooling is accomplished by a dry quench, a wire mesh demister is provided at the base of the spray tower to remove any water droplets or oil condensation. The cooled gas then passes through a baghouse filter. The low-Btu fuel gas generated by the facility is burned in a natural-gas-fired incinerator before venting it to the atmosphere through an elevated stack.

The pilot plant was operated from November 1991 through June 1992 in the jetting fluidized-bed configuration. Then the pilot plant was modified to permit one exploratory test run in an 8-in.-ID circulating fluidized-bed carbonizer. Because only the data generated in the jetting fluidized-bed carbonizer

Figure 2.2. CARBONIZER TEST UNIT

were analyzed and correlated, the details of the circulating fluidized-bed carbonizer are not given here. However, these details are given in Volume 2 of this report.

The fuel gas generated by the carbonizer is sampled at two different locations in the plant, and analyzed within 24 hours by a gas chromatograph to determine the gas composition. The gas samples are collected from the freeboard of the carbonizer and at the demister outlet. The details of gas sampling are given in Volume 1 of this report. From the standpoint of the solids fed into and withdrawn from the plant during a test/set point, material samples are usually collected for analysis every time a feed system lock hopper is filled and a drain hopper is discharged.

2.2. Carbonizer Pilot Plant Operation

The carbonizer was operated in two modes: first (from November 1991 to June 1992) as a jetting fluidized bed (Figures 2.1 and 2.2), and then (from August 1992 to September 1992) as a circulating fluidized bed.

The jetting fluidized-bed carbonizer test program consisted of eight test runs (TR1 through TR8), comprising 36 set points and 533 hours of operation. Two test runs (TR3 and TR7) were aborted during start-up before establishing their first set points because of equipment problems unrelated to the process. Although Pittsburgh No. 8 bituminous coal and Ohio Plum Run dolomite (PR Dolo) were most frequently used, Illinois No. 6 bituminous coal, Wyoming Eagle Butte subbituminous coal, and Alabama Longview limestone (LV Lime) were also tested. As shown in Table 2.1, the Pittsburgh coal typically has a 3.5% sulfur content and a Free Swelling Index of 6.5; it is a highly caking coal that has caused agglomeration problems in other fluidized-bed gasification programs. Thus, it was purposely selected for use in this test program to demonstrate the capability of the carbonizer process. The Wyoming Eagle Butte subbituminous coal typically contains 0.7% sulfur and 27% moisture. To preclude the risk of forming and condensing hydrocarbon vapors at start-up, when the plant "back end" was cold, the carbonizer was started up with a low-volatile petroleum coke. The transition to coal was made after about 4 hours, when the choked-flow orifice temperature reached approximately 1200°F. Typical analyses for the sorbents used in this program are presented in Table 2.2. As shown in Table 2.3, a total of 83.4 tons of four different fuels have been successfully carbonized - 45.3 tons of Pittsburgh No. 8, 15.4 tons of Eagle Butte, 15.3 tons of Illinois No. 6, and 7.4 tons of coke.

The circulating fluidized-bed carbonizer test program entailed two test runs (TR9 and TR10) comprising four set points and 94 hours of operation. The first test run was aborted during start-up before establishing the first set point because of an equipment problem unrelated to the process (leaking bag in the baghouse filter). Pittsburgh No. 8 bituminous coal and Genstar limestone were the feedstocks used during the four set points completed in Test Run TR10. As shown in Table 2.3, 8.8 tons of Pittsburgh No. 8 bituminous coal and 1.1 tons of coke were processed during these tests.

The details of the pilot plant operation are given by Robertson *et al.* (1992).

2.3. Reconciled Carbonizer Data

The carbonizer operation was smooth and controlled throughout the entire test program. A total of 36 set points (steady-state periods) was achieved while operating in a jetting fluidized-bed carbonizer mode, and 4 set points were achieved while operating in a circulating fluidized-bed mode. A set point was typically held for 4 hours, and gas samples were collected at about 1-hour intervals during this period. Allowing time for transition from set point to set point, for establishing steady-state conditions, and for

Table 2.1. TYPICAL CARBONIZER COAL FEED ANALYSES

Feedstock	Petroleum <u>Coke</u>	<u>Coal</u>		
		<u>Pittsburgh No. 8 Bituminous</u>	<u>Illinois No. 6 Bituminous</u>	<u>Wyoming Eagle Butte Subbituminous</u>
Feed Size, in	-1/8	-1/8 to 3/16	-1/8	-1/8
Free Swelling Index	0	6.5	4	0
<u>Proximate Analysis, wt%</u>				
Fixed Carbon	83.96	51.06	45.05	36.16
Volatile Matter	14.97	34.23	33.49	31.39
Ash	0.94	12.61	10.59	5.58
Moisture	<u>0.13</u>	<u>2.10</u>	<u>10.87</u>	<u>26.87</u>
Total	100.00	100.00	100.00	100.00
<u>Ultimate Analysis, wt%</u>				
C	89.89	69.44	62.74	50.76
H	4.42	4.62	4.40	3.60
O	0.73	5.70	6.78	11.49
N	2.30	2.03	1.57	0.98
S	1.59	3.50	3.05	0.72
Ash	0.94	12.61	10.59	5.58
Moisture	<u>0.13</u>	<u>2.10</u>	<u>10.87</u>	<u>26.87</u>
Total	100.00	100.00	100.00	100.00
HHV, Btu/lb	15,743	12,724	11,172	8,729

Table 2.2. TYPICAL CARBONIZER SORBENT FEED ANALYSES

	<u>Plum Run Dolomite</u>	<u>Longview Limestone</u>
Supplier	Highland Stone Div. of Davon, Inc. Hillsboro, Ohio	Longview Lime Saginaw, Alabama
Feed Size, in	-1/8	-1/8
<u>Composition, wt%</u>		
CaCO ₃	55.96	96.89
MgCO ₃	42.82	1.91
S	0.19	0.15
Ash	<u>1.03</u>	<u>1.05</u>
Total	100.00	100.00

Table 2.3. CARBONIZER OPERATING SUMMARY

Feedstock	Petroleum <u>Coke</u>	Pittsburgh No. 8 <u>Bituminous</u>	Illinois No. 6 <u>Bituminous</u>	Wyoming Eagle Butte <u>Subbituminous</u>	Plum Run <u>Dolomite</u>	Longview <u>Limestone</u>	Genstar <u>Limestone</u>
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A. Jetting Fluidized-Bed Operating Mode• Operating Time, hours

Shakedown Runs 1-2	8	5	--	--	13	--	
Test Runs TR1-TR8	<u>59</u>	<u>289</u>	<u>76</u>	<u>96</u>	317	203	
Subtotal	67	294	76	96			
Total			533		330	203	

• Feedstock Consumption, tons*

Shakedown Runs 1-2	1.0	0.8	--	--	0.7	--	
Test Runs TR1-TR8	<u>6.4</u>	<u>44.5</u>	<u>15.3</u>	<u>15.4</u>	12.3	5.8	
Subtotal	7.4	45.3	15.3	15.4			
Total			83.4		13.0	5.8	

α.

B. Circulating Fluidized-Bed Operating Mode• Operating Time, hours

Test Run TR9	14	21			35	--	
Test Run TR10	<u>4</u>	<u>55</u>			6	53	
Subtotal	18	76					
Total		94			41	53	

• Feedstock Consumption, tons*

Test Run TR9	0.7	1.3			0.9	--	
Test Run TR10	<u>0.4</u>	<u>7.5</u>			0.2	1.5	
Subtotal	1.1	8.8					
Total		9.9			1.1	1.5	

*1 ton = 2000 lb.

tending to problems, a set point was typically completed every 12 hours. A test run typically involved starting preheat of the facility on Monday and shutting down the plant on Friday, with operation occurring around the clock during the interim.

Table 2.4 summarizes the coal and sorbent types used, date and duration, pressure, and bed and freeboard temperatures for each of these set points (steady-state periods). The bed temperatures were measured at the 2.5, 7.5, 12.5, and 17.5-ft levels (measured from the top of the feed pipe); these temperatures are reasonably uniform, and the average bed temperature has been calculated as the average value of these measurements.

With regard to the overall carbonizer test program, at no point were any tars or oil vapors found/condensed from the fuel gas. This is a very important finding because their presence might jeopardize barrier filter operation by causing filter blinding and blocking. The high carbonizer operating temperature, relatively long in-bed gas residence time (approximately 6 to 10 seconds for the jetting fluidized-bed configuration), high pressure, exposure to lime-based sorbents, and method of coal/air feed (coal and air injected at the same point) destroy all tars and oil vapors in the bed.

Carbonizer fuel gas samples extracted from the top of the carbonizer and from a point downstream of the dry-quench spray tower were analyzed by a gas chromatograph, and these analyses were found to be in excellent agreement. Thus, analyses of the samples taken from the point downstream of the dry-quench spray tower were used for preparing material and energy balances.

Based on the analyses of the gas and solid samples and the flow rate and temperature measurements of all the streams entering and leaving the pilot plant, material and energy balances for each of the steady-state periods were prepared. These balances showed that the carbonizer data were not as self-consistent as could be desired (balance closure imperfection); the details have been discussed in Volume 1 of this report.

A software package, called BALAID (for BALance AID), has been developed by Science Ventures, Inc., of California which reconciles the data by applying conservation laws and other equality and inequality constraints. Adjustments are made to all species flows, temperatures, and variable-species compositions, with the adjustments weighted according to the statistical variance of each variable. A maximum-likelihood set of reconciled values is computed in which all elemental and energy balances close exactly. This approach takes advantage of all the available measurement information, as well as information embodied in the conservation laws and in the estimated quality of the measurements. The BALAID program utilizes advanced principles in statistics, numerical techniques, and constrained nonlinear optimization theory. This program was successfully applied to reconcile the carbonizer data. The details of the data reconciliation have been given in Volume 1 of this report. The reconciled data are now self-consistent (that is, all energy, mass, and elemental balances close exactly). These reconciled data have been analyzed rigorously, and correlations have been developed; these correlations have been used to update the carbonizer model developed earlier (Rehmat and Goyal, 1987). All the information presented below is based on the reconciled data.

A summary of the reconciled data for each of these set points (steady-state periods) is provided in this section. The compositions of the coal and sorbent feed for each of the 24 set points achieved while feeding the Pittsburgh coal are given in Table 2.5. The minimum, maximum, average, and standard deviation values for each species measurement, showing variations among set points, are also given in this table. For example, the carbon content of the coal feed ranged from 66.15% to 74.86% with an average value of 70.49% and a standard deviation of 2.13%. The significance of standard deviation is shown in

**Table 2.4 SUMMARY OF STEADY-STATE PERIODS FROM
CARBONIZER PILOT PLANT OPERATION**

Set Point	Coal Feed	Sorbent Feed	Date	Duration, hours	Pressure, psig	Bed Temp., °F	Freeboard Temp., °F
TR1-1	Pittsburgh No 8	Dolomite	11/20/91	0300-0700	152.6	1584	1553
TR1-2	Pittsburgh No 8	Dolomite	11/21/91	0200-0600	132.9	1681	1651
TR1-3	Pittsburgh No 8	Dolomite	11/21/91	1000-1400	144.7	1608	1581
TR1-4	Pittsburgh No 8	Dolomite	11/21/91	2100-2330	125.4	1482	1440
TR2-1	Pittsburgh No 8	Dolomite	12/19/91	0100-0500	139.8	1698	1652
TR2-2	Pittsburgh No 8	Dolomite	12/19/91	1300-1700	128.3	1598	1567
TR2-3	Pittsburgh No 8	Dolomite	12/20/91	0100-0500	138.1	1797	1705
TR2-4	Pittsburgh No 8	Dolomite	12/20/91	1000-1400	191.8	1784	1738
TR2-5	Pittsburgh No 8	Dolomite	12/20/91	1600-1800	198.6	1679	1675
TR4-1	Pittsburgh No 8	Dolomite	3/10/92	2030-0030	153.3	1663	1626
TR4-2	Pittsburgh No 8	Dolomite	3/11/92	0430-0830	155.9	1608	1573
TR4-3	Pittsburgh No 8	Dolomite	3/12/92	0230-0630	125.2	1708	1643
TR4-4	Pittsburgh No 8	Dolomite	3/12/92	1600-2000	129.1	1607	1568
TR4-5	Pittsburgh No 8	Dolomite	3/13/92	0530-0930	193.2	1720	1691
TR4-6	Pittsburgh No 8	Dolomite	3/13/92	1300-1700	175.8	1713	1681
TR4-7	Pittsburgh No 8	Dolomite	3/13/92	2200-0200	177.9	1601	1582
TR4-8	Pittsburgh No 8	Dolomite	3/14/92	0200-0600	182.2	1618	1600
TR5-1	Pittsburgh No 8	Dolomite	3/24/92	1100-1500	134.3	1693	1653
TR5-2	Pittsburgh No 8	Dolomite	3/24/92	1900-2300	154.8	1701	1662
TR5-3	Pittsburgh No 8	Limestone	3/25/92	0500-0900	147.4	1706	1667
TR6-1	Wyoming	Limestone	4/21/92	2100-0100	145.9	1580	1567
TR6-2	Wyoming	Limestone	4/22/92	0430-0830	129.8	1509	1500
TR6-3	Wyoming	Limestone	4/22/92	1400-1800	157.5	1511	1515
TR6-4	Wyoming	Limestone	4/22/92	2100-0100	191.9	1609	1579
TR6-5	Wyoming	Limestone	4/23/92	0400-0800	189.6	1632	1593
TR6-6	Illinois No 6	Limestone	4/23/92	1800-2200	143.5	1600	1573
TR6-7	Illinois No 6	Limestone	4/23/92	2300-0330	122.4	1599	1573
TR8-1	Wyoming	Limestone	6/10/92	2000-0100	128.6	1476	1432
TR8-2	Wyoming	Limestone	6/11/92	0300-0800	132.7	1593	1541
TR8-3	Wyoming	Limestone	6/11/92	1330-1730	156.5	1613	1575
TR8-4	Illinois No 6	Limestone	6/12/92	2100-0200	113.2	1652	1623
TR8-5	Illinois No 6	Limestone	6/13/92	0700-1100	160.6	1715	1680
TR8-6/7	Pittsburgh No 8	Dolomite	6/14/92	2100-0100	156.0	1699	1675
TR8-8	Pittsburgh No 8	Dolomite	6/16/92	0200-0600	143.5	1707	1683
TR8-9	Pittsburgh No 8	Dolomite	6/16/92	0800-1230	135.0	1713	1683
TR8-10	Pittsburgh No 8	Dolomite	6/16/92	1430-1930	126.5	1729	1697
TR10-1*	Pittsburgh No 8	Limestone	9/1/92	0200-0600	113.7	1675	1652
TR10-2*	Pittsburgh No 8	Limestone	9/1/92	1630-2100	68.7	1675	1618
TR10-3*	Pittsburgh No 8	Limestone	9/2/92	0000-0400	72.7	1706	1677
TR10-4*	Pittsburgh No 8	Limestone	9/2/92	0610-1240	55.9	1601	1571

*The carbonizer was operated in a circulating fluidized-bed mode during Test TR10.

Table 2.5. RECONCILED COMPOSITION OF COAL AND SORBENT FEEDS FOR STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
Moisture in Coal Feed, wt %	2.16	2.18	2.32	2.32	2.29	2.24	2.30	2.29	2.38	2.33	2.37	2.19
Coal (MF) Feed Composition, wt %												
C	68.424	69.142	66.150	67.646	69.668	70.266	69.684	69.567	68.963	69.717	69.927	72.138
H	4.742	4.736	4.627	4.763	4.701	4.762	4.698	4.685	4.628	4.715	4.794	4.847
O	6.764	6.684	9.072	8.171	6.225	5.963	6.091	6.223	6.928	7.771	7.697	5.931
N	1.894	1.905	1.887	1.904	1.965	1.973	1.964	1.964	1.962	1.924	1.928	1.937
S	3.476	3.349	3.313	3.213	4.655	4.688	4.695	4.652	4.628	3.404	3.410	3.413
Ash	14.700	14.185	14.951	14.302	12.787	12.348	12.867	12.909	12.892	12.469	12.245	11.735
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
HHV, Btu/lb (MF)	12322	12452	11943	12530	12729	12969	12608	12774	12555	12709	12832	12926
Sorbent Feed Composition, wt %												
CaCO ₃	52.992	56.061	56.070	56.600	53.783	53.349	53.403	54.196	53.763	53.342	53.458	53.465
MgCO ₃	45.263	42.140	42.272	41.396	45.179	45.614	45.537	44.715	45.234	45.636	45.514	45.508
CaS ^A	0.525	0.493	0.492	0.477	0.359	0.371	0.366	0.357	0.370	0.380	0.379	0.379
Inerts	1.220	1.306	1.166	1.527	0.679	0.666	0.694	0.732	0.633	0.642	0.649	0.648
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

^A Sulfur in Sorbent is reported as CaS.

Table 2.5 (cont). RECONCILED COMPOSITION OF COAL AND SORBENT FEEDS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
Moisture in Coal Feed, wt %	2.43	2.37	2.56	2.33	2.13	1.63	1.52	1.55	2.88	2.99	2.96	2.96
Coal (MF) Feed Composition, wt %												
C	70.092	72.687	72.321	69.721	72.979	74.014	74.859	74.801	70.072	69.431	69.658	69.722
H	4.840	4.840	4.923	4.724	4.855	4.673	4.718	4.698	4.359	4.321	4.343	4.348
O	7.881	7.524	8.750	7.791	5.640	5.467	5.185	5.164	5.674	5.869	5.849	5.941
N	1.937	1.986	2.010	1.922	1.945	2.052	2.066	2.062	1.802	1.790	1.795	1.798
S	3.409	3.505	3.553	3.382	3.432	1.898	1.895	1.884	4.167	4.140	4.101	4.121
Ash	11.842	9.458	8.443	12.461	11.148	11.895	11.277	11.391	13.926	14.449	14.253	14.070
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
HHV, Btu/lb (MF)	12713	13108	13214	12850	13123	13116	13211	13193	12680	12565	12642	12660
Sorbent Feed Composition, wt %												
CaCO ₃	53.383	53.450	53.462	53.457	53.370	63.737	62.446	96.595	58.270	57.238	57.112	57.366
MgCO ₃	45.622	45.523	45.510	45.528	45.618	35.418	36.732	2.786	40.395	41.517	41.674	41.394
CaS ^A	0.380	0.378	0.378	0.379	0.379	0.466	0.501	0.298	0.182	0.500	0.519	0.500
Inerts	0.615	0.649	0.650	0.636	0.633	0.379	0.321	0.321	1.153	0.745	0.695	0.740
Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

^A Sulfur in Sorbent is reported as CaS.

Table 2.5 (cont). RECONCILED COMPOSITION OF COAL AND SORBENT FEEDS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----
Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
	(No. of Set Points = 24)			
Moisture in Coal Feed, wt %	1.52	2.99	2.32	0.38
Coal (MF) Feed Composition, wt %				

C	66.150	74.859	70.485	2.131
H	4.321	4.923	4.681	0.167
O	5.164	9.072	6.677	1.113
N	1.790	2.066	1.932	0.077
S	1.884	4.695	3.599	0.819
Ash	8.443	14.951	12.625	1.584
Total	100.000	100.000	100.000	
HHV, Btu/lb (MF)	11943	13214	12768	303
Sorbent Feed Composition**, wt %				

CaCO ₃	52.992	63.737	55.381	2.888
MgCO ₃	35.418	45.636	43.432	2.897
CaS*	0.182	0.525	0.413	0.078
Inerts	0.321	1.527	0.773	0.288
Total	100.000	100.000	100.000	

* Sulfur in Sorbent is reported as CaS.

** Minimum, Maximum, Average, and Standard Deviation do not include Set Point TR5-3,
in which Limestone was fed.

Figure 2.3. As shown in the figure, if the data are normally distributed, then the probability is about 68.3% that a given value would agree with the average value within plus or minus one standard deviation value. Thus, the larger the value of the standard deviation, the larger would be the spread of data from its average value. The reconciled data for each of the 24 steady-state periods obtained with the Pittsburgh coal feed are given in Table 2.6. The table also includes statistical information (minimum, maximum, average, and standard deviation values) for each of the parameters. As shown in Table 2.6, the average bed temperature ranged from 1482° to 1797°F, the pressure ranged from 125 to 199 psig, the coal feed rate ranged from 181 to 489 lb/h, and the sorbent feed rate ranged from 40 to 182 lb/h.

The compositions of the coal and sorbent feed for each of the 4 set points achieved while feeding the Illinois coal are given in Table 2.7; the reconciled data are given in Table 2.8. As shown in Table 2.8, the average bed temperature ranged from 1599° to 1715°F, the pressure ranged from 113 to 161 psig, the coal feed rate ranged from 236 to 388 lb/h, and the sorbent feed rate ranged from 36 to 101 lb/h.

The compositions of the coal and sorbent feed rate for each of the 8 set points achieved while feeding the Wyoming coal are given in Table 2.9; the reconciled data are given in Table 2.10. As illustrated in Table 2.10, the average bed temperature ranged from 1476° to 1632°F, the pressure ranged from 129 to 192 psig, the coal feed rate ranged from 284 to 444 lb/h, and the sorbent feed rate ranged from 21 to 68 lb/h.

The data contained in Tables 2.5 to 2.10 form the basis for the data analysis, data correlation, and model update presented in the next section.

Figure 2.3. STANDARD DEVIATION AND A NORMAL CURVE

Table 2.6. RECONCILED CARBONIZER PILOT PLANT DATA FOR STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1 Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
2 Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo
3 Begin Date	11/20/91	11/21/91	11/21/91	11/21/91	12/19/91	12/19/91	12/20/91	12/20/91	12/20/91	3/10/92	3/11/92	3/12/92
4 Begin Clock Time, hours	0300	0200	1000	2100	0100	1300	0100	1000	1600	2030	0430	0230
5 End Clock Time, hours	0700	0600	1400	2330	0500	1700	0500	1400	1800	0030	0830	0630
6 Steady-State Period Duration, h	4	4	4	2.5	4	4	4	4	2	4	4	4
7 Reactor Pressure, psig	152.6	132.9	144.7	125.4	139.8	128.3	138.1	191.8	198.6	153.3	155.9	125.2
8 Orifice Pressure, psig	150.0	130.4	142.0	123.1	137.1	125.7	135.3	187.9	194.5	150.1	152.6	122.8
9 Average Bed Temp, F	1584	1681	1608	1482	1698	1598	1797	1784	1679	1663	1608	1708
10 Bed Temp (@7.5 ft), F	1611	1696	1636	1512	1700	1605	1794	1793	1692	1664	1605	1710
11 Freeboard Temp (@22.5 ft), F	1553	1651	1581	1440	1652	1567	1705	1738	1675	1626	1573	1643
12 Freeboard Temp (@27.5 ft), F	1505	1591	1533	1394	1605	1504	1629	1669	1589	1583	1531	1591
13 Orifice Temperature, F	1258	1267	1270	1164	1323	1255	1324	1437	1400	1326	1292	1311
14 Coal Feed Rate, lb/h	337.9	238.7	341.9	386.7	235.5	327.6	181.3	373.8	489.1	232.8	270.7	202.4
15 Sorbent Feed Rate, lb/h	82.3	66.1	96.5	98.7	115.1	88.5	79.6	97.2	151.1	97.2	89.9	85.9
16 Bed Drain Rate, lb/h	80.5	64.9	147.1	90.9	85.1	173.7	35.2	149.1	212.1	81.2	111.6	66.5
17 First Cyclone Rate, lb/h	72.5	74.8	106.8	116.5	104.3	72.8	83.4	82.7	155.8	73.9	88.2	78.8
18 Second Cyclone Rate, lb/h	128.7	44.9	23.8	116.3	4.0	7.0	3.2	2.8	5.7	3.8	4.1	6.6
19 Baghouse Fines Rate, lb/h	0.0	0.0	0.0	0.0	5.0	11.8	8.2	18.8	14.7	15.5	7.8	4.7
20 Total Drains Rate, lb/h	281.7	184.6	277.8	323.6	198.4	265.4	129.9	253.2	388.3	174.4	211.8	156.6
21 Steam Feed Rate, lb/h	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.6	118.3	96.3
22 Air Feed Rate, lb/h	623.0	570.8	611.0	537.7	677.0	555.8	664.4	959.5	955.8	666.4	644.2	600.5
23 N2 Purges to Carbonizer, lb/h	364.4	291.7	281.8	184.8	378.5	380.9	366.9	339.9	306.0	307.9	289.9	125.0
24 N2 Purges to Cyclones + O.M., lb/h	135.5	144.3	140.0	144.9	54.5	54.3	52.3	40.1	36.8	33.3	33.7	37.0
25 N2 Purge to Spray Tower, lb/h	194.5	210.4	208.4	212.0	203.1	204.4	209.9	196.6	193.8	173.7	172.6	164.0
26 Total N2 Purges to System, lb/h	694.3	646.4	630.2	541.7	636.0	639.6	629.1	576.6	536.6	515.0	496.3	326.0
27 Reactor Exit Gas, lb/h	1126.0	982.9	1053.5	884.4	1207.7	1087.6	1162.4	1517.4	1513.8	1185.5	1201.4	953.7
28 Orifice Gas, lb/h	1261.4	1127.2	1193.5	1029.3	1262.2	1141.9	1214.7	1557.5	1550.7	1218.8	1235.1	990.7
29 Demister Gas, lb/h	1455.9	1337.6	1401.9	1241.3	1465.3	1346.3	1424.6	1754.1	1744.4	1392.6	1407.8	1154.7
30 Reactor Exit Gas, lbmol/h	41.880	36.396	39.323	33.573	43.664	40.054	41.760	56.091	56.153	43.967	46.082	36.692
31 Orifice Gas, lbmol/h	46.715	41.545	44.319	38.743	45.609	41.991	43.627	57.521	57.467	45.157	47.285	38.013
32 Demister Gas, lbmol/h	53.656	49.054	51.756	46.311	52.856	49.286	51.118	64.539	64.383	51.357	53.446	43.865
33 Bed Density, lb/ft3	14.41	13.70	13.43	15.23	15.45	12.61	14.39	13.53	14.56	17.17	16.17	21.33
34 Bed Height, ft	25.7	17.7	25.8	26.5	15.6	16.9	16.5	17.0	22.9	15.1	16.0	14.9

Table 2.6 (cont). RECONCILED CARBONIZER PILOT PLANT DATA FOR STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1 Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
2 Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
3 Begin Date	3/12/92	3/13/92	3/13/92	3/13/92	3/14/92	3/24/92	3/24/92	3/25/92	6/14/92	6/16/92	6/16/92	6/16/92
4 Begin Clock Time, hours	1600	0530	1300	2200	0200	1100	1900	0500	2100	0200	0800	1430
5 End Clock Time, hours	2000	0930	1700	0200	0600	1500	2300	0900	0100	0600	1230	1930
6 Steady-State Period Duration, h	4	4	4	4	4	4	4	4	4	4	4.5	5
7 Reactor Pressure, psig	129.1	193.2	175.8	177.9	182.2	134.3	154.8	147.4	156.0	143.5	135.0	126.5
8 Orifice Pressure, psig	126.6	189.3	172.2	174.7	178.8	131.8	152.1	144.7	155.2	142.5	134.2	125.8
9 Average Bed Temp, F	1607	1720	1713	1601	1618	1693	1701	1706	1699	1707	1713	1729
10 Bed Temp (@7.5 ft), F	1607	1729	1722	1614	1623	1699	1706	1711	1698	1703	1707	1724
11 Freeboard Temp (@22.5 ft), F	1568	1691	1681	1582	1600	1653	1662	1667	1675	1683	1683	1697
12 Freeboard Temp (@27.5 ft), F	1524	1638	1602	1547	1558	1610	1618	1621	1634	1610	1602	1614
13 Orifice Temperature, F	1269	1429	1409	1347	1367	1324	1353	1364	1232	1226	1206	1199
14 Coal Feed Rate, lb/h	227.8	329.1	333.3	412.2	347.4	203.8	224.1	220.3	375.7	342.8	337.0	337.7
15 Sorbent Feed Rate, lb/h	94.6	106.1	106.1	181.6	149.9	59.4	108.1	70.1	120.0	79.5	79.9	39.8
16 Bed Drain Rate, lb/h	112.9	97.2	117.7	270.2	204.4	68.9	79.2	54.2	98.2	103.9	102.9	120.7
17 First Cyclone Rate, lb/h	56.6	97.0	85.3	68.5	90.4	45.0	68.1	51.3	120.6	100.0	74.7	94.5
18 Second Cyclone Rate, lb/h	5.5	3.3	4.4	26.2	3.3	3.8	16.5	35.2	32.6	11.1	32.4	1.6
19 Baghouse Fines Rate, lb/h	17.1	23.7	20.1	17.0	18.0	7.0	6.6	16.2	41.1	36.0	33.1	17.2
20 Total Drains Rate, lb/h	192.1	221.1	227.4	382.0	316.0	124.7	170.4	156.9	292.5	251.0	243.1	234.0
21 Steam Feed Rate, lb/h	78.1	142.8	85.1	51.7	53.5	90.7	90.2	100.1	99.8	90.5	55.5	55.7
22 Air Feed Rate, lb/h	544.3	895.5	819.2	769.6	751.6	636.1	707.5	676.0	879.7	823.0	782.7	661.7
23 N2 Purges to Carbonizer, lb/h	243.8	167.1	161.9	295.8	302.2	203.5	198.4	211.0	261.9	273.9	275.9	263.1
24 N2 Purges to Cyclones + O.M., lb/h	37.3	27.3	38.8	37.5	35.9	32.3	30.5	13.9	24.9	23.0	22.9	22.5
25 N2 Purge to Spray Tower, lb/h	165.0	149.3	148.5	147.7	135.4	187.5	175.3	180.4	23.9	54.5	59.0	20.8
26 Total N2 Purges to System, lb/h	446.1	343.8	349.2	481.0	473.5	423.2	404.2	405.4	310.6	351.4	357.8	306.4
27 Reactor Exit Gas, lb/h	996.6	1419.7	1278.5	1329.1	1288.7	1068.9	1158.0	1120.8	1444.6	1358.8	1288.2	1124.1
28 Orifice Gas, lb/h	1033.9	1447.0	1317.3	1366.6	1324.5	1101.1	1188.5	1134.7	1469.5	1381.9	1311.0	1146.6
29 Demister Gas, lb/h	1198.9	1596.4	1465.7	1514.3	1460.0	1288.6	1363.8	1315.1	1493.3	1436.3	1370.0	1167.4
30 Reactor Exit Gas, lbmol/h	37.938	55.333	49.039	50.307	48.537	41.131	43.325	42.761	54.833	51.690	48.560	43.091
31 Orifice Gas, lbmol/h	39.268	56.309	50.423	51.644	49.818	42.282	44.414	43.259	55.721	52.512	49.377	43.895
32 Demister Gas, lbmol/h	45.157	61.638	55.722	56.916	54.650	48.973	50.669	49.698	56.572	54.457	51.482	44.636
33 Bed Density, lb/ft3	17.31	13.58	14.44	14.04	16.49	11.72	11.88	12.71	16.06	16.68	18.81	16.48
34 Bed Height, ft	15.9	18.8	18.7	23.4	17.2	17.5	18.2	16.8	18.5	16.1	15.5	17.1

Table 2.6 (cont). RECONCILED CARBONIZER PILOT PLANT DATA FOR STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	Minimum	Maximum	Average	Std Dev
1 Coal	----Pittsburgh No. 8 Bituminous----			
2 Sorbent	Plum Run Dolomite/Longview Limestone			
3 Begin Date				
4 Begin Clock Time, hours	(No. of Set Points = 24)			
5 End Clock Time, hours				
6 Steady-State Period Duration, h	2.0	5.0	3.9	0.6
7 Reactor Pressure, psig	125.2	198.6	151.8	22.6
8 Orifice Pressure, psig	122.8	194.5	149.1	22.0
9 Average Bed Temp, F	1482	1797	1671	69
10 Bed Temp (@7.5 ft), F	1512	1794	1678	63
11 Freeboard Temp (@22.5 ft), F	1440	1738	1635	64
12 Freeboard Temp (@27.5 ft), F	1394	1669	1579	58
13 Orifice Temperature, F	1164	1437	1306	73
14 Coal Feed Rate, lb/h	181.3	489.1	304.6	77.1
15 Sorbent Feed Rate, lb/h	39.8	181.6	97.6	30.1
16 Bed Drain Rate, lb/h	35.2	270.2	113.7	54.1
17 First Cyclone Rate, lb/h	45.0	155.8	85.9	23.6
18 Second Cyclone Rate, lb/h	1.6	128.7	21.9	32.8
19 Baghouse Fines Rate, lb/h	0.0	41.1	14.2	11.0
20 Total Drains Rate, lb/h	124.7	388.3	235.7	70.2
21 Steam Feed Rate, lb/h	0.0	142.8	52.7	45.5
22 Air Feed Rate, lb/h	537.7	959.5	708.9	124.0
23 N2 Purges to Carbonizer, lb/h	125.0	380.9	269.8	69.9
24 N2 Purges to Cyclones + O.M., lb/h	13.9	144.9	52.2	40.9
25 N2 Purge to Spray Tower, lb/h	20.8	212.0	157.9	57.6
26 Total N2 Purges to System, lb/h	306.4	694.3	480.0	121.0
27 Reactor Exit Gas, lb/h	884.4	1517.4	1198.0	169.8
28 Orifice Gas, lb/h	990.7	1557.5	1250.2	153.0
29 Demister Gas, lb/h	1154.7	1754.1	1408.2	148.4
30 Reactor Exit Gas, lbmol/h	33.573	56.153	45.091	6.442
31 Orifice Gas, lbmol/h	38.013	57.521	46.955	5.775
32 Demister Gas, lbmol/h	43.865	64.539	52.592	5.424
33 Bed Density, lb/ft ³	11.72	21.33	15.09	2.20
34 Bed Height, ft	14.9	26.5	18.5	3.5

Table 2.7. RECONCILED COMPOSITION OF COAL AND SORBENT FEEDS FOR STEADY-STATE PERIODS WITH ILLINOIS NO. 6 BITUMINOUS COAL FEED

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Ill Bit	Ill Bit	Ill Bit	Ill Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
Moisture in Coal Feed, wt %	11.34	10.73	9.88	10.25	9.88	11.34	10.55	0.55
Coal (MF) Feed Composition, wt %								

C	69.760	70.656	69.262	68.420	68.420	70.656	69.524	0.810
H	4.898	4.970	4.183	4.135	4.135	4.970	4.547	0.389
O	7.841	7.452	8.778	9.134	7.452	9.134	8.301	0.681
N	1.752	1.765	1.585	1.574	1.574	1.765	1.669	0.090
S	3.318	3.464	3.294	3.283	3.283	3.464	3.340	0.073
Ash	12.431	11.693	12.897	13.454	11.693	13.454	12.619	0.646

Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	
HHV, Btu/lb (MF)	12457	12536	12514	12459	12457	12536	12492	34
Sorbent Feed Composition, wt %								

CaCO ₃	97.090	97.116	97.456	97.951	97.090	97.951	97.403	0.348
MgCO ₃	1.749	1.791	1.984	1.490	1.490	1.984	1.753	0.176
CaS*	0.333	0.336	0.389	0.397	0.333	0.397	0.364	0.029
Inerts	0.828	0.757	0.171	0.162	0.162	0.828	0.479	0.314

Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	

* Sulfur in Sorbent is reported as CaS.

Table 2.8. RECONCILED CARBONIZER PILOT PLANT DATA FOR STEADY-STATE PERIODS
WITH ILLINOIS NO. 6 BITUMINOUS COAL FEED

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----
1 Coal	111 Bit	111 Bit	111 Bit	111 Bit				
2 Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
3 Begin Date	4/23/92	4/23/92	6/12/92	6/13/92				
4 Begin Clock Time, hours	1800	2300	2100	0700				
5 End Clock Time, hours	2200	0330	0200	1100				
6 Steady-State Period Duration, h	4	4.5	5	4	4.0	5.0	4.4	0.4
7 Reactor Pressure, psig	143.5	122.4	113.2	160.6	113.2	160.6	134.9	18.4
8 Orifice Pressure, psig	140.7	120.2	112.7	159.9	112.7	159.9	133.4	18.4
9 Average Bed Temp, F	1600	1599	1652	1715	1599	1715	1642	48
10 Bed Temp (@7.5 ft), F	1605	1603	1645	1706	1603	1706	1640	42
11 Freeboard Temp (@22.5 ft), F	1573	1573	1623	1680	1573	1680	1612	44
12 Freeboard Temp (@27.5 ft), F	1536	1532	1588	1645	1532	1645	1575	46
13 Orifice Temperature, F	1297	1267	1071	1214	1071	1297	1212	87
14 Coal Feed Rate, lb/h	291.8	236.2	302.4	388.1	236.2	388.1	304.6	54.3
15 Sorbent Feed Rate, lb/h	35.9	38.7	75.6	101.2	35.9	101.2	62.9	27.1
16 Bed Drain Rate, lb/h	77.7	80.3	84.8	94.1	77.7	94.1	84.2	6.2
17 First Cyclone Rate, lb/h	61.8	42.2	60.8	66.0	42.2	66.0	57.7	9.2
18 Second Cyclone Rate, lb/h	5.4	13.0	35.5	38.8	5.4	38.8	23.2	14.3
19 Baghouse Fines Rate, lb/h	28.9	15.4	25.4	36.6	15.4	36.6	26.6	7.6
20 Total Drains Rate, lb/h	173.7	151.0	206.4	235.4	151.0	235.4	191.6	32.0
21 Steam Feed Rate, lb/h	112.7	58.6	96.7	144.7	58.6	144.7	103.2	31.0
22 Air Feed Rate, lb/h	634.1	512.7	668.5	935.5	512.7	935.5	687.7	154.3
23 N2 Purges to Carbonizer, lb/h	186.7	186.3	177.9	209.2	177.9	209.2	190.0	11.6
24 N2 Purges to Cyclones + O.M., lb/h	21.9	23.5	18.4	26.7	18.4	26.7	22.6	3.0
25 N2 Purge to Spray Tower, lb/h	120.2	115.6	88.7	94.7	88.7	120.2	104.8	13.3
26 Total N2 Purges to System, lb/h	328.7	325.3	285.1	330.6	285.1	330.6	317.4	18.8
27 Reactor Exit Gas, lb/h	1087.6	881.7	1114.9	1543.3	881.7	1543.3	1156.9	240.6
28 Orifice Gas, lb/h	1109.5	905.2	1133.3	1570.0	905.2	1570.0	1179.5	242.3
29 Demister Gas, lb/h	1229.7	1020.7	1222.1	1664.7	1020.7	1664.7	1284.3	235.1
30 Reactor Exit Gas, lbmol/h	43.074	34.197	43.018	59.162	34.197	59.162	44.863	9.012
31 Orifice Gas, lbmol/h	43.855	35.034	43.675	60.114	35.034	60.114	45.669	9.070
32 Demister Gas, lbmol/h	48.143	39.159	46.842	63.495	39.159	63.495	49.409	8.827
33 Bed Density, lb/ft ³	12.58	11.81	14.63	30.02	11.81	30.02	17.26	7.44
34 Bed Height, ft	16.6	18.3	17.8	15.4	15.4	18.3	17.0	1.1

Table 2.9. RECONCILED COMPOSITION OF COAL AND SORBENT FEEDS
FOR STEADY-STATE PERIODS WITH WYOMING EAGLE
BUTTE SUBBITUMINOUS COAL FEED

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
Moisture in Coal Feed, wt %	28.17	28.33	27.75	27.60	27.93	29.24	30.67	30.24	27.60	30.67	28.74	1.10
Coal (MF) Feed Composition, wt %												

C	68.362	67.471	67.406	67.922	67.856	67.691	66.888	66.852	66.852	68.362	67.556	0.483
H	4.971	4.868	4.838	4.825	4.888	4.610	4.565	4.569	4.565	4.971	4.767	0.150
O	16.356	17.125	17.251	16.726	16.809	18.198	18.566	18.752	16.356	18.752	17.473	0.850
N	1.334	1.331	1.331	1.330	1.332	1.188	1.181	1.182	1.181	1.334	1.276	0.071
S	0.908	0.964	0.969	0.961	0.937	0.941	0.904	0.873	0.873	0.969	0.932	0.032
Ash	8.070	8.241	8.205	8.236	8.179	7.372	7.896	7.771	7.372	8.241	7.996	0.285

Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	
HHV, Btu/lb (MF)	11831	11730	11750	11646	11744	11541	11403	11418	11403	11831	11633	151
Sorbent Feed Composition, wt %												

CaCO ₃	97.073	97.480	97.167	97.054	97.477	97.181	97.708	97.159	97.054	97.708	97.287	0.222
MgCO ₃	1.753	1.331	1.644	1.759	1.499	2.348	1.760	2.277	1.331	2.348	1.796	0.329
CaS*	0.324	0.333	0.333	0.332	0.274	0.428	0.390	0.386	0.274	0.428	0.350	0.045
Inerts	0.850	0.856	0.856	0.855	0.750	0.043	0.142	0.178	0.043	0.856	0.566	0.348

Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	

* Sulfur in Sorbent is reported as CaS.

Table 2.10. RECONCILED CARBONIZER PILOT PLANT DATA FOR STEADY-STATE PERIODS WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL FEED

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1 Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
2 Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
3 Begin Date	4/21/92	4/22/92	4/22/92	4/22/92	4/23/92	6/10/92	6/11/92	6/11/92				
4 Begin Clock Time, hours	2100	0430	1400	2100	0400	2000	0300	1330				
5 End Clock Time, hours	0100	0830	1800	0100	0800	0100	0800	1730				
6 Steady-State Period Duration, h	4	4	4	4	4	5	5	4	4.0	5.0	4.3	0.4
7 Reactor Pressure, psig	145.9	129.8	157.5	191.9	189.6	128.6	132.7	156.5	128.6	191.9	154.1	23.6
8 Orifice Pressure, psig	143.1	127.3	154.3	188.2	186.0	128.2	132.2	156.1	127.3	188.2	151.9	22.7
9 Average Bed Temp, F	1580	1509	1511	1609	1632	1476	1593	1613	1476	1632	1565	54
10 Bed Temp (@7.5 ft), F	1578	1507	1509	1607	1632	1478	1587	1602	1478	1632	1563	53
11 Freeboard Temp (@22.5 ft), F	1567	1500	1515	1579	1593	1432	1541	1575	1432	1593	1538	50
12 Freeboard Temp (@27.5 ft), F	1515	1453	1462	1549	1563	1396	1492	1533	1396	1563	1495	52
13 Orifice Temperature, F	788	763	1267	1354	1367	770	822	963	763	1367	1012	254
14 Coal Feed Rate, lb/h	330.4	310.6	397.8	443.5	429.6	288.4	283.7	362.8	283.7	443.5	355.8	58.5
15 Sorbent Feed Rate, lb/h	67.8	66.7	44.9	55.0	20.5	37.2	54.5	27.0	20.5	67.8	46.7	16.4
16 Bed Drain Rate, lb/h	64.2	70.9	44.5	60.4	19.4	30.0	46.1	21.3	19.4	70.9	44.6	18.4
17 First Cyclone Rate, lb/h	45.6	47.4	69.9	50.6	53.3	53.1	35.9	35.8	35.8	69.9	48.9	10.2
18 Second Cyclone Rate, lb/h	3.7	5.8	6.7	1.3	4.5	11.6	4.6	7.6	1.3	11.6	5.7	2.9
19 Baghouse Fines Rate, lb/h	8.1	12.5	8.1	25.6	26.4	2.1	1.4	7.8	1.4	26.4	11.5	9.0
20 Total Drains Rate, lb/h	121.6	136.6	129.2	137.8	103.7	96.9	88.1	72.6	72.6	137.8	110.8	22.6
21 Steam Feed Rate, lb/h	0.0	0.0	0.0	0.0	0.0	46.5	46.5	53.1	0.0	53.1	18.3	23.6
22 Air Feed Rate, lb/h	755.1	656.2	799.8	992.6	970.9	600.1	691.4	823.1	600.1	992.6	786.1	132.2
23 N2 Purges to Carbonizer, lb/h	208.3	231.9	176.7	152.0	159.6	224.7	214.7	192.5	152.0	231.9	195.1	28.0
24 N2 Purges to Cyclones + O.M., lb/h	26.6	23.8	25.7	18.0	16.0	164.6	174.7	152.8	16.0	174.7	75.3	69.1
25 N2 Purge to Spray Tower, lb/h	136.7	138.2	129.0	105.7	97.9	131.3	138.6	86.8	86.8	138.6	120.5	19.2
26 Total N2 Purges to System, lb/h	371.6	393.9	331.4	275.7	273.5	520.5	528.1	432.1	273.5	528.1	390.8	92.4
27 Reactor Exit Gas, lb/h	1240.2	1128.9	1290.2	1505.4	1477.0	1100.2	1202.8	1386.1	1100.2	1505.4	1291.4	142.6
28 Orifice Gas, lb/h	1266.7	1152.7	1315.8	1523.4	1493.1	1264.7	1377.6	1538.9	1152.7	1538.9	1366.6	131.8
29 Demister Gas, lb/h	1403.4	1290.9	1444.8	1629.1	1591.0	1396.0	1516.2	1625.7	1290.9	1629.1	1487.1	115.4
30 Reactor Exit Gas, lbmol/h	47.280	42.937	50.006	57.832	57.063	42.251	45.739	53.347	42.251	57.832	49.557	5.661
31 Orifice Gas, lbmol/h	48.227	43.786	50.921	58.474	57.635	48.124	51.976	58.799	43.786	58.799	52.243	5.212
32 Demister Gas, lbmol/h	53.105	48.717	55.526	62.245	61.129	52.809	56.921	61.897	48.717	62.245	56.543	4.615
33 Bed Density, lb/ft3	55.45	48.06	38.38	43.43	45.80	26.86	55.00	59.69	26.86	59.69	46.58	9.94
34 Bed Height, ft	20.2	20.7	23.7	15.6	14.5	19.7	17.1	18.1	14.5	23.7	18.7	2.8

3. CARBONIZER DATA ANALYSIS, DATA CORRELATIONS, AND MODEL UPDATE

The details of the data analysis, data correlations, and model update are given in this section.

3.1. Data Analysis and Data Correlations

The reconciled carbonizer data were analyzed rigorously. For each of the set points, hundreds of parameters of possible interest were computed, and attempts were made to correlate several of them. Tables 3.1, 3.2, and 3.3 provide data and the derived parameters for steady-state periods with Pittsburgh No. 8 bituminous coal, Illinois No. 6 bituminous coal, and Wyoming Eagle Butte subbituminous coal feeds, respectively. These tables also provide minimum value, maximum value, average value, and standard deviation for each of the measured data and derived parameters.

Some of the data are presented graphically to get an overview of the operating ranges (including temperature, pressure, feed rates, bed height), deviation from target values (such as velocities), and fluctuations in parameters (such as nitrogen purges, product-gas flow rate, sulfur in coal feed, Ca/S ratio, bed density, and gas residence time).

Figure 3.1 shows the carbonizer average bed temperature during different set points. The bed temperatures were measured at 2.5, 7.5, 12.5, and 17.5-ft levels (measured from the top of the feed pipe); these temperatures are reasonably uniform, and the average bed temperature has been calculated as the average value of these measurements. The average bed temperature ranged for Pittsburgh coal from 1482° to 1797°F, for Illinois coal from 1599° to 1715°F, and for Wyoming coal from 1476° to 1632°F. The data show (Tables 3.1, 3.2, and 3.3) that the average bed temperature is quite close to the mid-bed temperature measured at the 7.5-ft level.

Figure 3.2 shows the carbonizer pressure during different set points. The pressure ranged for Pittsburgh coal from 125 to 199 psig, for Illinois coal from 113 to 161 psig, and for Wyoming coal from 129 to 192 psig. Usually the pressure was between 120 to 160 psig.

Figure 3.3 shows the sulfur content in the coal feed during different set points. The sulfur content varied a lot during set points with Pittsburgh coal feed; it ranged from 1.88% to 4.70% (moisture-free basis) with an average value of 3.60% and a standard deviation of 0.82%. It ranged from 3.28% to 3.46% (average = 3.34%) and from 0.87% to 0.97% (average = 0.93%) for set points with Illinois coal and Wyoming coal feeds, respectively.

Figure 3.4 shows the coal feed rate during different set points. The coal feed rate ranged for Pittsburgh coal from 181 to 489 lb/h, for Illinois coal from 236 to 388 lb/h, and for Wyoming coal from 284 to 444 lb/h. In general, the feed rates for Wyoming subbituminous coal were higher relative to those for the bituminous coals, while the operating temperatures were lower relative to the bituminous coals; this trend is expected.

Figure 3.5 shows the sorbent feed rate during different set points. The sorbent feed rate ranged for Pittsburgh coal from 40 to 182 lb/h, for Illinois coal from 36 to 101 lb/h, and for Wyoming coal from 21 to 68 lb/h. The sorbent feed rate for set points with Wyoming coal feed was lower due to the lower sulfur content of this coal. Figures 3.6 and 3.7 show the ratio of calcium in sorbent-to-sulfur in coal feed for different set points with bituminous coals and subbituminous coal feed, respectively. This ratio ranged for Pittsburgh coal from 0.54 to 5.31 lb-mol/lb-mol (average = 1.92 lb-mol/lb-mol), for Illinois coal from

**Table 3.1. MEASURED AND DERIVED CARBONIZER DATA WITH
PITTSBURGH NO. 8 BITUMINOUS COAL**

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1 Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
2 Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo
3 Begin Date	11/20/91	11/21/91	11/21/91	11/21/91	12/19/91	12/19/91	12/20/91	12/20/91	12/20/91	3/10/92	3/11/92	3/12/92
4 Begin Clock Time, hours	0300	0200	1000	2100	0100	1300	0100	1000	1600	2030	0430	0230
5 End Clock Time, hours	0700	0600	1400	2330	0500	1700	0500	1400	1800	0030	0830	0630
6 Steady-State Period Duration, h	4	4	4	2.5	4	4	4	4	2	4	4	4
7 Carbonizer Pressure, psig	152.6	132.9	144.7	125.4	139.8	128.3	138.1	191.8	198.6	153.3	155.9	125.2
8 Carbonizer Pressure, psia	167.3	147.6	159.4	140.1	154.5	143.0	152.8	206.5	213.3	168.0	170.6	139.9
9 Carbonizer Pressure, atm	11.38	10.04	10.85	9.53	10.51	9.73	10.40	14.05	14.51	11.43	11.61	9.52
10 Average Bed Temp, F	1584	1681	1608	1482	1698	1598	1797	1784	1679	1663	1608	1708
11 Bed Temp (@7.5 ft), F	1611	1696	1636	1512	1700	1605	1794	1793	1692	1664	1605	1710
12 Freeboard Temp (@ 22.5 ft), F	1553	1651	1581	1440	1652	1567	1705	1738	1675	1626	1573	1643
13 Freeboard Temp (@ 27.5 ft), F	1505	1591	1533	1394	1605	1504	1629	1669	1589	1583	1531	1591
14 Avg Bed T - Freebd T(@22.5 ft), F	31	30	27	42	46	31	92	46	4	37	35	65
15 Avg Bed T - Freebd T(@27.5 ft), F	79	90	75	88	93	94	168	115	90	80	77	117
16 Freebd T(@22.5 Ft - @27.5 ft), F	48	60	48	46	47	63	76	69	86	43	42	52
17												
18 Coal Feed Rate, lb/h	337.88	238.72	341.93	386.68	235.47	327.62	181.25	373.85	489.06	232.76	270.66	202.43
19 Sorbent Feed Rate, lb/h	82.26	66.14	96.47	98.66	115.08	88.54	79.56	97.18	151.10	97.18	89.93	85.90
20 Air Feed Rate, lb/h	622.98	570.82	611.04	537.71	676.99	555.83	664.43	959.48	955.79	666.39	644.25	600.46
21 Steam Feed Rate, lb/h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	55.56	118.30	96.28
22 N2 Purges to Carbonizer, lb/h	364.39	291.71	281.81	184.84	378.49	380.92	366.88	339.94	306.02	307.89	289.90	125.01
23 N2 Purges to Cyclones + O.M., lb/h	135.46	144.30	140.01	144.88	54.50	54.30	52.32	40.07	36.82	33.35	33.72	37.02
24 N2 Purge to Spray Tower, lb/h	194.50	210.40	208.38	212.03	203.05	204.41	209.87	196.64	193.77	173.74	172.63	163.98
25 Total N2 Purges to System, lb/h	694.35	646.41	630.20	541.75	636.05	639.62	629.07	576.65	536.61	514.98	496.25	326.01
26 Air+Steam+N2 Feed to Carb., lb/h	987.37	862.52	892.85	722.55	1055.49	936.75	1031.31	1299.42	1261.82	1029.84	1052.45	821.75
27 Air+Steam+N2 Feed to System, lb/h	1317.33	1217.23	1241.24	1079.46	1313.04	1195.46	1293.50	1536.13	1492.41	1236.93	1258.80	1022.75
28 Air Feed to Carbonizer, lbmol/h	21.507	19.706	21.094	18.563	23.371	19.189	22.938	33.123	32.996	23.005	22.241	20.729
29 Steam Feed to Carbonizer, lbmol/h	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.084	6.567	5.345
30 N2 Purges to Carbonizer, lbmol/h	13.007	10.413	10.060	6.598	13.511	13.598	13.096	12.135	10.924	10.991	10.349	4.463
31 Carbonizer Drain Rate, lb/h	80.52	64.91	147.15	90.87	85.12	173.70	35.16	149.11	212.09	81.20	111.65	66.48
32 Primary-Cyclone Drain Rate, lb/h	72.48	74.81	106.83	116.46	104.25	72.83	83.38	82.74	155.79	73.89	88.16	78.84
33 Secondary-Cyclone Drain Rate, lb/h	128.70	44.86	23.85	116.31	4.03	7.05	3.16	2.56	5.75	3.76	4.14	6.56
34 Baghouse Drain Rate, lb/h	0.00	0.00	0.00	0.00	5.04	11.84	8.19	18.81	14.67	15.54	7.83	4.71
35 Total Drains Rate, lb/h	281.69	184.58	277.83	323.64	198.44	265.42	129.89	253.23	388.30	174.40	211.77	156.59

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
1 Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
2 Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
3 Begin Date	3/12/92	3/13/92	3/13/92	3/13/92	3/14/92	3/24/92	3/24/92	3/25/92	6/14/92	6/16/92	6/16/92	6/16/92
4 Begin Clock Time, hours	1600	0530	1300	2200	0200	1100	1900	0500	2100	0200	0800	1430
5 End Clock Time, hours	2000	0930	1700	0200	0600	1500	2300	0900	0100	0600	1230	1930
6 Steady-State Period Duration, h	4	4	4	4	4	4	4	4	4	4	4.5	5
7 Carbonizer Pressure, psig	129.1	193.2	175.8	177.9	182.2	134.3	154.8	147.4	156.0	143.5	135.0	128.5
8 Carbonizer Pressure, psia	143.8	207.9	190.5	192.6	196.9	149.0	169.5	162.1	170.7	158.2	149.7	141.2
9 Carbonizer Pressure, atm	9.78	14.15	12.96	13.11	13.40	10.14	11.53	11.03	11.62	10.76	10.19	9.61
10 Average Bed Temp, F	1607	1720	1713	1601	1618	1693	1701	1706	1699	1707	1713	1729
11 Bed Temp (@7.5 ft), F	1607	1729	1722	1614	1623	1699	1706	1711	1698	1703	1707	1724
12 Freeboard Temp (@ 22.5 ft), F	1568	1691	1681	1582	1600	1653	1662	1667	1675	1683	1683	1697
13 Freeboard Temp (@ 27.5 ft), F	1524	1638	1602	1547	1558	1610	1618	1621	1634	1610	1602	1614
14 Avg Bed T - Freebd T(@22.5 ft), F	39	29	32	19	18	40	39	39	24	24	30	32
15 Avg Bed T - Freebd T(@27.5 ft), F	83	82	111	54	60	83	83	85	65	97	111	115
16 Freebd T(@22.5 Ft - @27.5 ft), F	44	53	79	35	42	43	44	46	41	73	81	83
17												
18 Coal Feed Rate, lb/h	227.83	329.15	333.34	412.24	347.37	203.82	224.12	220.30	375.66	342.85	337.02	337.71
19 Sorbent Feed Rate, lb/h	94.64	106.13	106.09	181.55	149.89	59.40	108.12	70.09	119.98	79.47	79.93	39.76
20 Air Feed Rate, lb/h	544.25	895.50	819.21	769.56	751.59	636.08	707.45	676.01	879.66	823.02	782.67	661.67
21 Steam Feed Rate, lb/h	78.08	142.76	85.09	51.75	53.48	90.68	90.19	100.14	99.78	90.48	55.54	55.72
22 N2 Purges to Carbonizer, lb/h	243.84	167.09	161.94	295.83	302.20	203.46	198.38	211.03	261.87	273.86	275.95	263.09
23 N2 Purges to Cyclones + O.M., lb/h	37.28	27.34	38.79	37.47	35.88	32.25	30.52	13.93	24.88	23.05	22.88	22.53
24 N2 Purge to Spray Tower, lb/h	165.01	149.33	148.47	147.73	135.41	187.47	175.27	180.42	23.85	54.49	58.98	20.77
25 Total N2 Purges to System, lb/h	446.14	343.76	349.19	481.03	473.50	423.18	404.17	405.38	310.60	351.39	357.81	306.39
26 Air+Steam+N2 Feed to Carb., lb/h	866.17	1205.34	1066.25	1117.14	1107.27	930.22	996.02	987.17	1241.31	1187.36	1114.15	980.48
27 Air+Steam+N2 Feed to System, lb/h	1068.47	1382.01	1253.50	1302.34	1278.57	1149.94	1201.82	1181.53	1290.04	1264.89	1196.01	1023.77
28 Air Feed to Carbonizer, lbmol/h	18.789	30.914	28.281	26.567	25.946	21.959	24.423	23.337	30.368	28.412	27.019	22.842
29 Steam Feed to Carbonizer, lbmol/h	4.334	7.925	4.723	2.872	2.969	5.034	5.006	5.559	5.539	5.022	3.083	3.093
30 N2 Purges to Carbonizer, lbmol/h	8.704	5.964	5.781	10.560	10.787	7.263	7.082	7.533	9.348	9.776	9.850	9.392
31 Carbonizer Drain Rate, lb/h	112.94	97.16	117.66	270.24	204.40	68.95	79.24	54.20	98.21	103.88	102.86	120.75
32 Primary-Cyclone Drain Rate, lb/h	56.61	96.97	85.28	68.54	90.35	45.05	68.15	51.27	120.57	100.00	74.70	94.47
33 Secondary-Cyclone Drain Rate, lb/h	5.48	3.25	4.39	26.16	3.30	3.78	16.47	35.24	32.60	11.09	32.41	1.57
34 Baghouse Drain Rate, lb/h	17.09	23.70	20.05	17.04	17.95	6.96	6.57	16.17	41.15	36.04	33.14	17.22
35 Total Drains Rate, lb/h	192.12	221.07	227.39	381.99	316.00	124.74	170.43	156.89	292.53	251.00	243.10	234.00

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
1 Coal	----Pittsburgh No. 8 Bituminous----			
2 Sorbent	Plum Run Dolomite/Longview Limestone			
3 Begin Date				
4 Begin Clock Time, hours	(No. of Set Points = 24)			
5 End Clock Time, hours				
6 Steady-State Period Duration, h	2.0	5.0	3.9	0.6
7 Carbonizer Pressure, psig	125.2	198.6	151.8	22.6
8 Carbonizer Pressure, psia	139.9	213.3	166.5	22.6
9 Carbonizer Pressure, atm	9.52	14.51	11.33	1.54
10 Average Bed Temp, F	1482	1797	1671	69
11 Bed Temp (@7.5 ft), F	1512	1794	1678	63
12 Freeboard Temp (@ 22.5 ft), F	1440	1738	1635	64
13 Freeboard Temp (@ 27.5 ft), F	1394	1669	1579	58
14 Avg Bed T - Freebd T(@22.5 ft), F	4	92	35	16
15 Avg Bed T - Freebd T(@27.5 ft), F	54	168	91	23
16 Freebd T(@22.5 Ft - @27.5 ft), F	35	86	56	16
17				
18 Coal Feed Rate, lb/h	181.25	489.06	304.57	77.14
19 Sorbent Feed Rate, lb/h	39.76	181.55	97.63	30.10
20 Air Feed Rate, lb/h	537.71	959.48	708.87	124.01
21 Steam Feed Rate, lb/h	0.00	142.76	52.66	45.54
22 N2 Purges to Carbonizer, lb/h	125.01	380.92	269.85	69.86
23 N2 Purges to Cyclones + O.M., lb/h	13.93	144.88	52.23	40.93
24 N2 Purge to Spray Tower, lb/h	20.77	212.03	157.94	57.57
25 Total N2 Purges to System, lb/h	306.39	694.35	480.02	121.02
26 Air+Steam+N2 Feed to Carb., lb/h	722.55	1299.42	1031.38	142.46
27 Air+Steam+N2 Feed to System, lb/h	1022.75	1536.13	1241.55	122.70
28 Air Feed to Carbonizer, lbmol/h	18.563	33.123	24.472	4.281
29 Steam Feed to Carbonizer, lbmol/h	0.000	7.925	2.923	2.528
30 N2 Purges to Carbonizer, lbmol/h	4.463	13.598	9.633	2.494
31 Carbonizer Drain Rate, lb/h	35.16	270.24	113.69	54.08
32 Primary Cyclone Drain Rate, lb/h	45.05	155.79	85.93	23.60
33 Secondary-Cyclone Drain Rate, lb/h	1.57	128.70	21.94	32.81
34 Baghouse Drain Rate, lb/h	0.00	41.15	14.15	11.04
35 Total Drains Rate, lb/h	124.74	388.30	235.71	70.19

**Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL**

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
36 Carbonizer Exit Gas, lb/h	1126.0	982.9	1053.5	884.4	1207.7	1087.6	1162.4	1517.4	1513.8	1185.5	1201.4	953.7
37 Orifice Gas, lb/h	1261.4	1127.2	1193.5	1029.3	1262.2	1141.9	1214.7	1557.5	1550.7	1218.8	1235.1	990.7
38 Demister Gas, lb/h	1455.9	1337.6	1401.9	1241.3	1465.3	1346.3	1424.6	1754.1	1744.4	1392.6	1407.8	1154.7
39 Carbonizer Exit Gas, lbmol/h	41.880	36.396	39.323	33.573	43.664	40.054	41.760	56.091	56.153	43.967	46.082	36.692
40 Orifice Gas, lbmol/h	46.715	41.545	44.319	38.743	45.609	41.991	43.627	57.521	57.467	45.157	47.285	38.013
41 Demister Gas, lbmol/h	53.656	49.054	51.756	46.311	52.856	49.286	51.118	64.539	64.383	51.357	53.446	43.865
42												
43 Carbonizer Gas HHV, Btu/SCF(wet)	60.44	57.94	74.07	88.65	55.05	73.45	47.23	74.27	79.63	58.18	61.64	61.73
44 Carbonizer Gas LHV, Btu/SCF(wet)	51.30	50.35	64.34	75.61	48.80	64.19	42.16	66.49	69.80	48.48	47.65	47.94
45 Carbonizer Gas HHV, Btu/lb	851.2	812.2	1046.7	1274.0	753.5	1024.1	642.4	1039.4	1118.3	816.9	895.1	899.2
46 Carbonizer Gas LHV, Btu/lb	722.4	705.8	909.2	1086.6	668.0	895.0	573.5	930.5	980.3	680.8	692.0	698.3
47												
48 Bed Density, lb/ft ³	14.41	13.70	13.43	15.23	15.45	12.61	14.39	13.53	14.56	17.17	16.17	21.33
49 Bed Height, ft	25.7	17.7	25.8	26.5	15.6	16.9	16.5	17.0	22.9	15.1	16.0	14.9
50 Bed Weight, lb	305.62	178.99	286.69	336.30	176.50	156.88	174.43	168.89	265.90	188.35	188.94	231.19
51 Bed Weight/Coal Feed Rate, lb/(lb/h)	0.905	0.750	0.838	0.870	0.750	0.479	0.962	0.452	0.544	0.809	0.698	1.142
52 Solids Residence Time, min	227.7	165.4	116.9	222.1	124.4	54.2	297.6	68.0	75.2	139.2	101.5	208.7
53												
54 Inlet Superficial Vel (D=10 in), ft/s	2.30	2.39	2.21	1.90	2.81	2.58	2.91	2.69	2.41	2.56	2.59	2.58
55 Product Gas Super. Vel (D=10 in), ft/s	2.79	2.88	2.79	2.54	3.33	3.15	3.37	3.33	3.08	3.03	3.05	3.11
56 Product Gas Super. Vel (D=12 in), ft/s	1.94	2.00	1.94	1.77	2.31	2.19	2.34	2.31	2.14	2.11	2.12	2.16
57 Freebd Gas Super. Vel (D=14 in), ft/s	1.40	1.45	1.40	1.27	1.66	1.58	1.65	1.66	1.57	1.52	1.53	1.54
58 Gas Residence Time, s	14.0	8.3	14.1	16.1	6.3	7.2	6.6	6.9	10.9	6.6	7.0	6.4
59												
60 Carbonizer Wall Heat Losses, Btu/h	95324	100522	105252	98000	95009	97272	100777	92076	91902	100066	96268	98123
61 Overhead Heat Losses, Btu/h	137915	113424	107686	119469	139050	108057	132220	143562	156933	125831	130051	121297
62												
63 Moisture in Coal Feed, %	2.16	2.18	2.32	2.32	2.29	2.24	2.30	2.29	2.38	2.33	2.37	2.19
64 Coal Feed (MF), lb/h	330.59	233.51	334.01	377.72	230.08	320.26	177.08	365.27	477.44	227.33	264.25	198.00
65 Carbon in Coal Feed, lb/h	226.20	161.45	220.95	255.52	160.29	225.04	123.39	254.11	329.26	158.49	184.78	142.83
66												
67 H ₂ Content in Freeboard Gas, mol%	4.34	4.75	5.11	6.08	3.23	4.03	2.64	4.84	4.27	4.56	5.42	6.15
68 P(H ₂) in Carbonizer Gas, psia	7.3	7.0	8.1	8.5	5.0	5.8	4.0	10.0	9.1	7.7	9.3	8.6

**Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL**

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
36 Carbonizer Exit Gas, lb/h	996.6	1419.7	1278.5	1329.1	1288.7	1068.9	1158.0	1120.8	1444.6	1358.8	1288.2	1124.1
37 Orifice Gas, lb/h	1033.9	1447.0	1317.3	1366.6	1324.5	1101.1	1188.5	1134.7	1469.5	1381.9	1311.0	1146.6
38 Demister Gas, lb/h	1198.9	1596.4	1465.7	1514.3	1460.0	1288.6	1363.8	1315.1	1493.3	1436.3	1370.0	1167.4
39 Carbonizer Exit Gas, lbmol/h	37.938	55.333	49.039	50.307	48.537	41.131	43.325	42.761	54.833	51.690	48.560	43.091
40 Orifice Gas, lbmol/h	39.268	56.309	50.423	51.644	49.818	42.282	44.414	43.259	55.721	52.512	49.377	43.895
41 Demister Gas, lbmol/h	45.157	61.638	55.722	56.916	54.650	48.973	50.669	49.698	56.572	54.457	51.482	44.636
42												
43 Carbonizer Gas HHV, Btu/SCF(wet)	62.22	77.36	80.33	70.16	69.72	75.51	66.86	62.18	62.56	62.45	64.40	70.07
44 Carbonizer Gas LHV, Btu/SCF(wet)	49.41	63.12	67.26	57.97	58.27	63.72	55.10	49.81	50.22	50.50	53.79	58.01
45 Carbonizer Gas HHV, Btu/lb	896.7	1141.6	1166.6	1005.5	994.3	1100.2	947.0	898.2	899.0	899.4	919.2	1016.9
46 Carbonizer Gas LHV, Btu/lb	712.2	931.4	976.8	830.7	830.9	928.3	780.5	719.5	721.8	727.3	767.7	841.9
47												
48 Bed Density, lb/ft3	17.31	13.58	14.44	14.04	16.49	11.72	11.88	12.71	16.06	16.68	18.81	16.48
49 Bed Height, ft	15.9	18.8	18.7	23.4	17.2	17.5	18.2	16.8	18.5	16.1	15.5	17.1
50 Bed Weight, lb	201.39	189.09	199.37	263.62	208.81	151.04	159.23	156.99	219.04	197.22	212.55	207.02
51 Bed Weight/Coal Feed Rate, lb/(lb/h)	0.884	0.574	0.598	0.639	0.601	0.741	0.710	0.713	0.583	0.575	0.631	0.613
52 Solids Residence Time, min	107.0	116.8	101.7	58.5	61.3	131.4	120.6	173.8	133.8	113.9	124.0	102.9
53												
54 Inlet Superficial Vel (D=10 in), ft/s	2.50	2.57	2.42	2.34	2.29	2.70	2.54	2.66	3.13	3.23	3.17	2.99
55 Product Gas Super. Vel (D=10 in), ft/s	2.98	3.17	3.06	2.94	2.80	3.25	3.02	3.12	3.79	3.87	3.85	3.65
56 Product Gas Super. Vel (D=12 in), ft/s	2.07	2.20	2.12	2.04	1.94	2.25	2.10	2.17	2.63	2.69	2.67	2.53
57 Freebd Gas Super. Vel (D=14 in), ft/s	1.49	1.60	1.54	1.49	1.42	1.63	1.51	1.56	1.91	1.95	1.94	1.83
58 Gas Residence Time, s	7.2	8.1	8.3	11.7	8.3	7.3	8.1	7.3	6.6	5.6	5.4	6.3
59												
60 Carbonizer Wall Heat Losses, Btu/h	106952	95275	101866	96441	96061	94214	90209	90171	71864	84226	81625	85977
61 Overhead Heat losses, Btu/h	104180	145053	115442	121304	116339	117850	135625	136749	268538	228299	218005	200705
62												
63 Moisture in Coal Feed, %	2.43	2.37	2.56	2.33	2.13	1.63	1.52	1.55	2.88	2.99	2.96	2.96
64 Coal Feed (MF), lb/h	222.29	321.36	324.82	402.62	339.97	200.49	220.71	216.89	364.84	332.60	327.04	327.71
65 Carbon in Coal Feed, lb/h	155.81	233.59	234.91	280.71	248.11	148.39	165.22	162.23	255.65	230.93	227.81	228.49
66												
67 H2 Content in Freeboard Gas, mol%	5.78	8.13	7.28	5.68	6.31	8.14	5.14	5.54	5.78	5.73	5.82	6.29
68 P(H2) in Carbonizer Gas, psia	8.3	16.9	13.9	10.9	12.4	12.1	8.7	9.0	9.9	9.1	8.7	8.9

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----
Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
36 Carbonizer Exit Gas, lb/h	884.4	1517.4	1198.0	169.8
37 Orifice Gas, lb/h	990.7	1557.5	1250.2	153.0
38 Demister Gas, lb/h	1154.7	1754.1	1408.2	148.4
39 Carbonizer Exit Gas, lbmol/h	33.573	56.153	45.091	6.442
40 Orifice Gas, lbmol/h	38.013	57.521	46.955	5.775
41 Demister Gas, lbmol/h	43.865	64.539	52.592	5.424
42				
43 Carbonizer Gas HHV, Btu/SCF(wet)	47.23	88.65	67.34	9.22
44 Carbonizer Gas LHV, Btu/SCF(wet)	42.16	75.61	56.43	8.43
45 Carbonizer Gas HHV, Btu/lb	642.4	1274.0	960.7	139.3
46 Carbonizer Gas LHV, Btu/lb	573.5	1086.6	804.6	123.8
47				
48 Bed Density, lb/ft ³	11.72	21.33	15.09	2.20
49 Bed Height, ft	14.9	26.5	18.5	3.5
50 Bed Weight, lb	151.04	336.30	209.34	48.28
51 Bed Weight/Coal Feed Rate, lb/(lb/h)	0.452	1.142	0.711	0.161
52 Solids Residence Time, min	54.2	297.6	131.1	58.3
53				
54 Inlet Superficial Vel (D=10 in), ft/s	1.90	3.23	2.60	0.31
55 Product Gas Super. Vel (D=10 in), ft/s	2.54	3.87	3.16	0.34
56 Product Gas Super. Vel (D=12 in), ft/s	1.77	2.69	2.20	0.23
57 Freebd Gas Super. Vel (D=14 in), ft/s	1.27	1.95	1.59	0.17
58 Gas Residence Time, s	5.4	16.1	8.4	2.8
59				
60 Carbonizer Wall Heat Losses, Btu/h	71864	106952	94395	7587
61 Overhead Heat Losses, Btu/h	104180	268538	143483	41506
62				
63 Moisture in Coal Feed, %	1.52	2.99	2.32	0.38
64 Coal Feed (MF), lb/h	177.08	477.44	297.37	74.89
65 Carbon in Coal Feed, lb/h	123.39	329.26	208.92	50.32
66				
67 H ₂ Content in Freeboard Gas, mol%	2.64	8.14	5.46	1.29
68 P(H ₂) in Carbonizer Gas, psia	4.0	16.9	9.1	2.7

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
69 Available Hydrogen, lbatom/lbatom	0.770	0.762	0.756	0.771	0.754	0.760	0.754	0.752	0.743	0.743	0.755	0.754
70 CH ₄ Yield, % of Feed Carbon	4.627	3.153	5.312	5.235	4.451	5.192	2.647	4.780	5.617	4.437	5.141	2.755
71 C ₂ H ₄ Yield, % of Feed Carbon	0.387	0.131	0.399	0.657	0.063	0.642	0.000	0.012	0.094	0.078	0.195	0.015
72 C ₂ H ₆ Yield, % of Feed Carbon	0.142	0.000	0.158	0.988	0.032	2.136	0.090	0.000	0.113	0.039	0.139	0.000
73 Total HC Yield, % of Feed Carbon	5.156	3.284	5.869	6.881	4.546	7.970	2.736	4.792	5.824	4.553	5.475	2.770
74 CH ₄ in Freeboard Gas, mol%	2.081	1.165	2.485	3.318	1.361	2.429	0.651	1.803	2.743	1.332	1.717	0.893
75 C ₂ H ₄ in Freeboard Gas, mol%	0.087	0.024	0.093	0.208	0.010	0.150	0.000	0.002	0.023	0.012	0.032	0.002
76 C ₂ H ₆ in Freeboard Gas, mol%	0.032	0.000	0.037	0.313	0.005	0.500	0.011	0.000	0.028	0.006	0.023	0.000
77 Total HC in Freeboard Gas, mol%	2.200	1.189	2.615	3.839	1.375	3.079	0.662	1.805	2.793	1.349	1.772	0.895
78 CH ₄ in Demister Gas, mol%	1.624	0.864	1.888	2.405	1.124	1.974	0.532	1.567	2.392	1.140	1.480	0.747
79 C ₂ H ₄ in Demister Gas, mol%	0.068	0.018	0.071	0.151	0.008	0.122	0.000	0.002	0.020	0.010	0.028	0.002
80 C ₂ H ₆ in Demister Gas, mol%	0.025	0.000	0.028	0.227	0.004	0.406	0.009	0.000	0.024	0.005	0.020	0.000
81 Total HC in Demister Gas, mol%	1.717	0.882	1.987	2.783	1.136	2.502	0.541	1.569	2.436	1.155	1.528	0.749
82												
83 Water Content in Freeboard Gas, mol%	9.07	7.64	8.60	11.51	6.16	7.35	5.90	6.52	9.11	11.56	18.13	19.23
84 P(H ₂ O) in Carbonizer Gas, psia	15.2	11.3	13.7	16.1	9.5	10.5	9.0	13.5	19.4	19.4	30.9	26.9
85 Water-Gas Shift Temp, F	1777	1867	1795	1635	1935	1725	2193	1951	2129	1909	1771	1998
86 WGS Temp - Avg Bed Temp, F	193	186	187	153	237	127	396	167	450	246	163	290
87 WGS Temp - Freebd Temp(@22.5 ft), F	224	216	214	195	283	158	488	213	454	283	198	355
88 WGS Temp - Freebd Temp(@27.5 ft), F	272	276	262	241	330	221	564	282	540	326	240	407
89												
90 Oxygen in Air Feed, lbmol/h	4.515	4.137	4.428	3.897	4.906	4.028	4.815	6.953	6.927	4.829	4.669	4.351
91 Feed O ₂ /Carbon in Feed, mol/mol	0.240	0.308	0.241	0.183	0.368	0.215	0.469	0.329	0.253	0.366	0.303	0.366
92 Feed Air/Feed Coal, lb/lb	1.844	2.391	1.787	1.391	2.875	1.697	3.666	2.567	1.954	2.863	2.380	2.966
93 Feed Air/Feed Coal, lb/lb(MF)	1.884	2.445	1.829	1.424	2.942	1.736	3.752	2.627	2.002	2.931	2.438	3.033
94 Feed Air/Feed Coal, lb/lb(MAF)	2.209	2.849	2.151	1.661	3.374	1.980	4.306	3.016	2.298	3.349	2.778	3.436
95 Feed Steam/Carbon in Feed, mol/mol	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.234	0.427	0.449
96 Feed Steam/Feed Coal, lb/lb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.239	0.437	0.476
97 Feed Steam/Feed Coal, lb/lb(MF)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.244	0.448	0.486
98 Total (Steam+Moist)/Carbon, mol/mol	0.021	0.021	0.024	0.023	0.022	0.022	0.023	0.022	0.024	0.256	0.450	0.470
99 Total (Steam+Moist)/Coal, lb/lb	0.022	0.022	0.023	0.023	0.023	0.022	0.023	0.023	0.024	0.262	0.461	0.498
100 Total (Steam+Moist)/Coal, lb/lb(MF)	0.022	0.022	0.024	0.024	0.023	0.023	0.024	0.023	0.024	0.268	0.472	0.509
101 Bed Drain Char/Coal Feed, lb/lb(MF)	0.1238	0.1447	0.2521	0.1472	0.1610	0.3670	0.0798	0.2660	0.3070	0.1778	0.2295	0.1544

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	LV Lime	PR DoLo	PR DoLo	PR DoLo
69 Available Hydrogen, lbatom/lbatom	0.759	0.735	0.743	0.744	0.749	0.711	0.712	0.709	0.696	0.694	0.696	0.695
70 CH ₄ Yield, % of Feed Carbon	4.880	4.066	5.119	4.766	5.450	3.872	5.731	3.565	3.580	3.730	3.621	4.411
71 C ₂ H ₄ Yield, % of Feed Carbon	0.348	0.000	0.011	0.219	0.148	0.016	0.000	0.000	0.043	0.051	0.038	0.042
72 C ₂ H ₆ Yield, % of Feed Carbon	0.139	0.076	0.000	0.146	0.095	0.000	0.000	0.000	0.043	0.062	0.049	0.070
73 Total HC Yield, % of Feed Carbon	5.368	4.142	5.131	5.131	5.693	3.888	5.731	3.565	3.665	3.843	3.707	4.523
74 CH ₄ in Freeboard Gas, mol%	1.669	1.429	2.042	2.214	2.319	1.163	1.820	1.126	1.390	1.387	1.414	1.947
75 C ₂ H ₄ in Freeboard Gas, mol %	0.060	0.000	0.002	0.051	0.032	0.002	0.000	0.000	0.008	0.009	0.007	0.009
76 C ₂ H ₆ in Freeboard Gas, mol%	0.024	0.013	0.000	0.034	0.020	0.000	0.000	0.000	0.008	0.012	0.010	0.016
77 Total HC in Freeboard Gas, mol %	1.752	1.443	2.044	2.299	2.371	1.166	1.820	1.126	1.406	1.409	1.431	1.972
78 CH ₄ in Demister Gas, mol%	1.402	1.283	1.797	1.957	2.060	0.977	1.556	0.969	1.347	1.317	1.334	1.880
79 C ₂ H ₄ in Demister Gas, mol%	0.050	0.000	0.002	0.045	0.028	0.002	0.000	0.000	0.008	0.009	0.007	0.009
80 C ₂ H ₆ in Demister Gas, mol%	0.020	0.012	0.000	0.030	0.018	0.000	0.000	0.000	0.008	0.011	0.009	0.015
81 Total HC in Demister Gas, mol%	1.472	1.295	1.799	2.032	2.106	0.979	1.556	0.969	1.363	1.337	1.350	1.904
82												
83 Water Content in Freeboard Gas, mol%	15.74	16.97	14.39	13.61	11.33	12.39	14.18	16.39	15.70	14.99	12.17	13.34
84 P(H ₂ O) in Carbonizer Gas, psia	22.6	35.3	27.4	26.2	22.3	18.5	24.0	26.6	26.8	23.7	18.2	18.8
85 Water-Gas Shift Temp, F	1696	1823	1817	1770	1505	1728	1894	2096	1862	1917	1853	1851
86 WGS Temp - Avg Bed Temp, F	89	103	104	169	-113	35	193	390	163	210	140	122
87 WGS Temp - Freebd Temp(@22.5 ft), F	128	132	136	188	-95	75	232	429	187	234	170	154
88 WGS Temp - Freebd Temp(@27.5 ft), F	172	185	215	223	-53	118	276	475	228	307	251	237
89												
90 Oxygen in Air feed, lbmol/h	3.944	6.490	5.937	5.577	5.447	4.610	5.127	4.899	6.375	5.964	5.672	4.795
91 Feed O ₂ /Carbon in Feed, mol/mol	0.304	0.334	0.304	0.239	0.264	0.373	0.373	0.363	0.299	0.310	0.299	0.252
92 Feed Air/Feed Coal, lb/lb	2.389	2.721	2.458	1.867	2.164	3.121	3.157	3.069	2.342	2.401	2.322	1.959
93 Feed Air/Feed Coal, lb/lb(MF)	2.448	2.787	2.522	1.911	2.211	3.173	3.205	3.117	2.411	2.475	2.393	2.019
94 Feed Air/Feed Coal, lb/lb(MAF)	2.777	3.078	2.755	2.183	2.488	3.601	3.613	3.518	2.801	2.892	2.791	2.350
95 Feed Steam/Carbon in Feed, mol/mol	0.334	0.407	0.241	0.123	0.144	0.407	0.364	0.411	0.260	0.261	0.162	0.163
96 Feed Steam/Feed Coal, lb/lb	0.343	0.434	0.255	0.126	0.154	0.445	0.402	0.455	0.266	0.264	0.165	0.165
97 Feed Steam/Feed Coal, lb/lb(MF)	0.351	0.444	0.262	0.129	0.157	0.452	0.409	0.462	0.273	0.272	0.170	0.170
98 Total (Steam+Moist)/Carbon, mol/mol	0.358	0.430	0.266	0.146	0.164	0.422	0.378	0.425	0.288	0.291	0.192	0.192
99 Total (Steam+Moist)/Coal, lb/lb	0.367	0.457	0.281	0.149	0.175	0.461	0.418	0.470	0.294	0.294	0.194	0.195
100 Total (Steam+Moist)/Coal, lb/lb(MF)	0.376	0.468	0.288	0.152	0.179	0.469	0.424	0.477	0.303	0.303	0.200	0.201
101 Bed Drain Char/Coal Feed, lb/lb(MF)	0.2461	0.1201	0.1861	0.4167	0.3212	0.1744	0.1166	0.0925	0.1568	0.1655	0.2033	0.2979

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
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Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
69 Available Hydrogen, lbatom/lbatom	0.694	0.771	0.738	0.025
70 CH ₄ Yield, % of Feed Carbon	2.647	5.731	4.422	0.873
71 C ₂ H ₄ Yield, % of Feed Carbon	0.000	0.657	0.150	0.193
72 C ₂ H ₆ Yield, % of Feed Carbon	0.000	2.136	0.188	0.449
73 Total HC Yield, % of Feed Carbon	2.736	7.970	4.760	1.231
74 CH ₄ in Freeboard Gas, mol%	0.651	3.318	1.746	0.614
75 C ₂ H ₄ in Freeboard Gas, mol %	0.000	0.208	0.034	0.052
76 C ₂ H ₆ in Freeboard Gas, mol%	0.000	0.500	0.045	0.113
77 Total HC in Freeboard Gas, mol %	0.662	3.839	1.826	0.723
78 CH ₄ in Demister Gas, mol%	0.532	2.405	1.484	0.485
79 C ₂ H ₄ in Demister Gas, mol%	0.000	0.151	0.028	0.039
80 C ₂ H ₆ in Demister Gas, mol%	0.000	0.406	0.036	0.089
81 Total HC in Demister Gas, mol%	0.541	2.783	1.548	0.557
82				
83 Water Content in Freeboard Gas, mol%	5.90	19.23	12.17	3.85
84 P(H ₂ O) in Carbonizer Gas, psia	9.0	35.3	20.2	6.9
85 Water-Gas Shift Temp, F	1505	2193	1854	151
86 WGS Temp - Avg Bed Temp, F	-113	450	183	116
87 WGS Temp - Freebd Temp(@22.5 ft), F	-95	488	219	121
88 WGS Temp - Freebd Temp(@27.5 ft), F	-53	564	275	127
89				
90 Oxygen in Air Feed, lbmol/h	3.897	6.953	5.137	0.899
91 Feed O ₂ /Carbon in Feed, mol/mol	0.183	0.469	0.306	0.063
92 Feed Air/Feed Coal, lb/lb	1.391	3.666	2.431	0.538
93 Feed Air/Feed Coal, lb/lb(MF)	1.424	3.752	2.488	0.547
94 Feed Air/Feed Coal, lb/lb(MAF)	1.661	4.306	2.844	0.608
95 Feed Steam/Carbon in Feed, mol/mol	0.000	0.449	0.183	0.166
96 Feed Steam/Feed Coal, lb/lb	0.000	0.476	0.193	0.177
97 Feed Steam/Feed Coal, lb/lb(MF)	0.000	0.486	0.197	0.181
98 Total (Steam+Moist)/Carbon, mol/mol	0.021	0.470	0.205	0.165
99 Total (Steam+Moist)/Coal, lb/lb	0.022	0.498	0.216	0.176
100 Total (Steam+Moist)/Coal, lb/lb(MF)	0.022	0.509	0.221	0.180
101 Bed Drain Char/Coal Feed, lb/lb(MF)	0.0798	0.4167	0.2045	0.0864

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
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Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo
102 Total Char/Coal Feed, lb/lb(MF)	0.6448	0.5797	0.5958	0.6736	0.4957	0.6172	0.4136	0.4986	0.5808	0.4813	0.5411	0.5152
103 (Char+Spent Sorb)/(Coal+Sorbent), lb/lb	0.670	0.605	0.634	0.667	0.566	0.638	0.498	0.538	0.607	0.529	0.587	0.543
104 HHV of (Char+Spent Sorb), Btu/lb(MF)	8722	8156	8070	9320	6589	9228	6351	8913	8878	7391	8250	7621
105												
106 Carbon Conversion in CD, %	74.54	73.81	62.42	-567.39	72.90	41.28	86.60	60.35	42.77	76.02	62.14	84.98
107 Carbon Conversion in PD, %	33.75	11.49	-2.89	40.87	27.36	20.88	50.08	30.65	32.40	22.50	17.73	-37.33
108 Carbon Conversion in SD, %	-21.99	15.16	-27.50	48.32	64.00	24.82	51.55	39.05	30.71	27.30	30.58	44.78
109 Carbon Conversion in BD, %	100.00	100.00	100.00	100.00	-43.38	-9.59	17.90	24.27	15.86	-35.49	-32.25	10.32
110 Carbon Conversion in Mixture, %	30.74	39.77	36.03	27.01	49.85	33.38	60.96	49.27	37.64	51.31	42.68	47.70
111 Hydrogen Conversion in Mixture, %	92.49	94.59	93.22	91.73	95.27	91.82	96.01	96.34	94.02	95.40	93.25	93.46
112 Oxygen Conversion in Mixture, %	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
113 Nitrogen Conversion in Mixture, %	29.00	47.56	41.06	26.49	49.85	36.41	63.00	55.80	40.96	52.70	49.21	48.52
114 Sulfur Conversion in Mixture, %	80.07	73.65	73.16	41.21	86.37	80.49	92.07	86.75	83.99	82.50	85.74	78.38
115												
116 Coal Hydrogen Released, %	92.49	94.59	93.22	91.73	95.27	91.82	96.01	96.34	94.02	95.40	93.25	93.46
117 Coal Nitrogen Released, %	29.00	47.56	41.06	26.49	49.86	36.41	63.00	55.80	40.96	52.70	49.21	48.52
118 Released Nitrogen Going to NH ₃ , %	60.45	40.61	42.60	41.89	13.14	41.71	21.24	58.28	66.78	70.24	89.61	30.38
119 Coal Nitrogen Going to NH ₃ , %	17.53	19.32	17.49	11.10	6.55	15.19	13.38	32.52	27.35	37.02	44.10	14.74
120 NH ₃ Concentration in Freeboard, ppm	1871	1685	2001	1697	484	1710	796	2969	3256	2628	3479	1100
121												
122 Coal Sulfur Released, %	80.07	73.65	73.16	41.21	86.37	80.49	92.07	86.75	83.99	82.50	85.74	78.38
123 Sulfur Remaining in Chars frac., %	19.93	26.35	26.84	58.79	13.63	19.51	7.93	13.25	16.01	17.50	14.26	21.62
124 Organic Sulfur in Chars Fraction, %	20.09	27.13	26.87	59.10	16.93	20.33	8.45	13.27	16.09	17.59	16.50	21.78
125 Sulfur in Freeboard Gas, % Coal S	2.54	4.83	1.95	2.20	21.20	5.05	7.69	1.10	1.59	2.55	15.21	2.91
126 Sulfur in Solids Discharges, % Coal S	97.46	95.17	98.05	97.80	78.80	94.95	92.31	98.90	98.41	97.45	84.79	97.09
127 Sulfur in Freeboard Gas, % Rel S	3.18	6.55	2.66	5.34	24.55	6.28	8.35	1.26	1.89	3.09	17.74	3.72
128 Sulfur Capture by Sorbent, % Rel S	96.82	93.45	97.34	94.66	75.45	93.72	91.65	98.74	98.11	96.91	82.26	96.28
129 Feed Ca/Feed S Ratio, mol/mol	1.215	1.519	1.566	1.474	1.851	1.008	1.637	0.993	1.178	2.146	1.709	2.177
130 Feed Ca/Released S Ratio, mol/mol	1.517	2.062	2.140	3.576	2.143	1.252	1.778	1.145	1.402	2.601	1.993	2.777
131 H ₂ S Concentration in Freeboard, ppm	218	323	171	248	1622	591	477	104	195	140	928	167
132 Sorbent Ca Conversion/Utilization, %	65.23	46.60	46.65	27.61	36.11	75.87	52.51	87.24	70.91	38.23	42.25	35.67
133 CaS in Solids Discharges as CaSO ₄ , %	0.00	1.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
134												

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	LV Lime	PR DoLo	PR DoLo	PR DoLo	PR DoLo
102 Total Char/Coal Feed, lb/lb(MF)	0.5402	0.4663	0.4845	0.6181	0.6019	0.4278	0.4727	0.5069	0.5877	0.5730	0.5831	0.6233
103 (Char+Spent Sorb)/(Coal+Sorbent), lb/lb	0.596	0.508	0.517	0.643	0.635	0.474	0.513	0.540	0.590	0.594	0.583	0.620
104 HHV of (Char+Spent Sorb), Btu/lb(MF)	7326	8524	9338	8029	7703	7233	6979	8056	8750	9042	9318	10262
105												
106 Carbon Conversion in CD, %	56.42	-401.17	-2151.51	47.26	45.20	77.28	79.87	77.65	74.94	75.99	67.90	55.60
107 Carbon Conversion in PD, %	28.96	68.74	74.50	-43.70	30.27	40.68	39.68	42.90	5.75	9.31	22.00	1.50
108 Carbon Conversion in SD, %	31.23	67.84	61.10	-40.92	-17.12	20.35	18.11	38.19	13.54	-3.00	-6.33	-9.91
109 Carbon Conversion in BD, %	11.87	45.55	52.23	11.60	-15.37	-52.72	8.76	-2.56	13.91	6.54	3.01	6.58
110 Carbon Conversion in Mixture, %	42.86	51.41	47.06	33.14	36.77	59.74	54.01	49.69	39.94	42.08	41.01	35.35
111 Hydrogen Conversion in Mixture, %	93.57	94.29	94.79	92.89	93.44	94.77	94.99	93.83	92.21	93.45	93.46	94.23
112 Oxygen Conversion in Mixture, %	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
113 Nitrogen Conversion in Mixture, %	44.27	50.79	52.86	34.46	41.14	68.65	62.95	58.09	58.62	55.61	56.12	53.37
114 Sulfur Conversion in Mixture, %	78.31	83.02	85.64	66.24	58.10	89.63	70.10	73.00	59.67	62.41	53.74	49.15
115												
116 Coal Hydrogen Released, %	93.57	94.29	94.79	92.89	93.44	94.77	94.99	93.83	92.21	93.45	93.46	94.23
117 Coal Nitrogen Released, %	44.27	50.79	52.86	34.46	41.14	68.65	62.96	58.09	58.62	55.61	56.12	53.37
118 Released Nitrogen Going to NH ₃ , %	56.75	38.63	21.71	42.46	36.58	54.64	48.21	53.61	20.57	22.81	26.27	26.05
119 Coal Nitrogen Going to NH ₃ , %	25.12	19.62	11.48	14.63	15.05	37.51	30.35	31.14	12.06	12.68	14.74	13.90
120 NH ₃ Concentration in Freeboard, ppm	2035	1615	1091	1607	1464	2679	2281	2324	1032	1043	1272	1357
121												
122 Coal Sulfur Released, %	78.31	83.02	85.64	66.24	58.10	89.63	70.10	73.00	59.67	62.41	53.74	49.15
123 Sulfur Remaining in Chars Frac., %	21.69	16.98	14.36	33.76	41.90	10.37	29.90	27.00	40.33	37.59	46.26	50.85
124 Organic Sulfur in Chars Fraction, %	22.58	16.88	14.30	34.17	47.13	17.17	28.95	26.45	40.45	37.20	45.65	57.84
125 Sulfur in Freeboard Gas, % Coal S	6.11	1.05	1.24	3.48	13.21	42.91	2.33	0.00	0.95	0.25	0.00	12.72
126 Sulfur in Solids Discharges, % Coal S	93.89	98.95	98.76	96.52	86.79	57.09	97.67	100.00	99.05	99.75	100.00	87.28
127 Sulfur in Freeboard Gas, % Rel S	7.81	1.27	1.45	5.26	22.75	47.87	3.32	0.00	1.60	0.41	0.00	25.87
128 Sulfur Capture by Sorbent, % Rel S	92.19	98.73	98.55	94.74	77.25	52.13	96.68	100.00	98.40	99.59	100.00	74.13
129 Feed Ca/Feed S Ratio, mol/mol	2.136	1.613	1.574	2.283	2.196	3.187	5.171	5.307	1.473	1.058	1.090	0.541
130 Feed Ca/Released S Ratio, mol/mol	2.727	1.943	1.838	3.447	3.780	3.555	7.377	7.270	2.469	1.696	2.028	1.101
131 H ₂ S Concentration in Freeboard, ppm	381	67	91	294	991	1238	70	0	83	21	0	1243
132 Sorbent Ca Conversion/Utilization, %	34.82	51.84	54.64	28.49	21.40	15.69	14.19	14.15	40.31	59.97	50.52	68.52
133 CaS in Solids Discharges as CaSO ₄ , %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
134												

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
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Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
102 Total Char/Coal Feed, lb/lb(MF)	0.4136	0.6736	0.5468	0.0685
103 (Char+Spent Sorb)/(Coal+Sorbent), lb/lb	0.474	0.670	0.579	0.055
104 HHV of (Char+Spent Sorb), Btu/lb(MF)	6351	10262	8252	955
105				
106 Carbon Conversion in CD, %	-2151.51	86.60	-71.84	460.28
107 Carbon Conversion in PD, %	-43.70	74.50	23.67	26.63
108 Carbon Conversion in SD, %	-40.92	67.84	20.83	29.39
109 Carbon Conversion in BD, %	-52.72	100.00	18.21	43.80
110 Carbon Conversion in Mixture, %	27.01	60.96	43.31	8.72
111 Hydrogen Conversion in Mixture, %	91.73	96.34	93.90	1.20
112 Oxygen Conversion in Mixture, %	100.00	100.00	100.00	0.00
113 Nitrogen Conversion in Mixture, %	26.49	68.65	49.06	10.48
114 Sulfur Conversion in Mixture, %	41.21	92.07	73.89	13.39
115				
116 Coal Hydrogen Released, %	91.73	96.34	93.90	1.20
117 Coal Nitrogen Released, %	26.49	68.65	49.06	10.48
118 Released Nitrogen Going to NH ₃ , %	13.14	89.61	42.72	18.26
119 Coal Nitrogen Going to NH ₃ , %	6.55	44.10	20.61	9.81
120 NH ₃ Concentration in Freeboard, ppm	484	3479	1811	763
121				
122 Coal Sulfur Released, %	41.21	92.07	73.89	13.39
123 Sulfur Remaining in Chars Frac., %	7.93	58.79	26.11	13.39
124 Organic Sulfur in Chars Fraction, %	8.45	59.10	27.20	13.73
125 Sulfur in Freeboard Gas, % Coal S	0.00	42.91	6.38	9.31
126 Sulfur in Solids Discharges, % Coal S	57.09	100.00	93.62	9.31
127 Sulfur in Freeboard Gas, % Rel S	0.00	47.87	8.43	11.23
128 Sulfur Capture by Sorbent, % Rel S	52.13	100.00	91.57	11.23
129 Feed Ca/Feed S Ratio, mol/mol	0.541	5.307	1.921	1.139
130 Feed Ca/Released S Ratio, mol/mol	1.101	7.377	2.651	1.598
131 H ₂ S Concentration in Freeboard, ppm	0	1622	403	449
132 Sorbent Ca Conversion/Utilization, %	14.15	87.24	44.98	19.43
133 CaS in Solids Discharges as CaSO ₄ , %	0.00	1.92	0.08	0.38
134				

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo
135 O/C in Coal Feed, lbatom/lbatom	0.0742	0.0726	0.1030	0.0907	0.0671	0.0637	0.0656	0.0672	0.0754	0.0837	0.0826	0.0617
136 H/C in Coal feed, lbatom/lbatom	0.826	0.816	0.833	0.839	0.804	0.808	0.803	0.803	0.800	0.806	0.817	0.801
137 H/C in Combined Disch, lbatom/lbatom	0.090	0.073	0.088	0.095	0.076	0.099	0.082	0.058	0.077	0.076	0.096	0.100
138 N/C in Coal Feed, lbatom/lbatom	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.023
139 N/C in Combined Disch, lbatom/lbatom	0.024	0.021	0.023	0.024	0.024	0.023	0.023	0.021	0.023	0.023	0.021	0.023
140 S/C in Coal Feed, lbatom/lbatom	0.019	0.018	0.019	0.018	0.025	0.025	0.025	0.025	0.025	0.018	0.018	0.018
141 S/C in Combined Disch, lbatom/lbatom	0.005	0.008	0.008	0.014	0.007	0.007	0.005	0.007	0.006	0.007	0.005	0.007
142 Char(N/C)/Coal(N/C) - molar basis	1.025	0.871	0.921	1.007	1.000	0.954	0.948	0.871	0.947	0.971	0.886	0.984
143 Char(S/C)/Coal(S/C) molar basis	0.288	0.437	0.420	0.805	0.272	0.293	0.203	0.261	0.257	0.359	0.249	0.413
144												
145 Mg/Ca in Sorbent, lbmol/lbmol	1.000	0.882	0.884	0.858	0.988	1.005	1.003	0.971	0.989	1.006	1.001	1.001
146 Ca/Mg in Sorbent, lbmol/lbmol	1.000	1.134	1.131	1.165	1.012	0.995	0.997	1.030	1.011	0.994	0.999	0.999
147 Mg/Ca in Sorbent, lb/lb	0.607	0.535	0.536	0.520	0.599	0.610	0.608	0.589	0.600	0.610	0.607	0.607
148 Ca/Mg in Sorbent, lb/lb	1.649	1.871	1.865	1.922	1.669	1.640	1.645	1.699	1.667	1.640	1.648	1.648
149 MgCO ₃ /CaCO ₃ in Sorbent Feed, mol/mol	1.0140	0.8923	0.8950	0.8682	0.9972	1.0150	1.0122	0.9794	0.9988	1.0156	1.0107	1.0104
150 CaS/CaCO ₃ in Sorbent Feed, mol/mol	0.01375	0.01220	0.01217	0.01169	0.00926	0.00965	0.00951	0.00914	0.00955	0.00988	0.00984	0.00984
151												
152 Coal Feed HHV, Btu/lb (MF)	12322	12452	11943	12530	12729	12969	12608	12774	12555	12709	12832	12926
153												
154 HHV of Gas/HHV of Coal, %	23.53	27.46	27.64	23.81	31.07	26.82	33.45	33.80	28.24	33.52	31.71	33.51
155 HHV of Gas/(HHV of Coal-HCALC), %	23.86	27.89	28.11	24.15	31.93	27.22	34.28	34.29	28.74	34.31	32.30	34.30
156 LHV of Gas/LHV of Coal, %	20.75	24.78	24.96	21.09	28.58	24.31	30.99	31.39	25.69	28.99	25.45	27.01
157 LHV of Gas/(LHV of Coal-HCALC), %	21.05	25.19	25.40	21.41	29.40	24.69	31.80	31.86	26.16	29.70	25.94	27.67
158												
159 HHV of Coal Char/HHV of Coal, %	57.96	50.21	53.46	59.87	41.20	54.65	32.42	41.21	51.43	40.09	47.15	44.20
160 HHV of Drains/(HHV of Coal-HCALC), %	61.15	52.60	57.15	64.65	45.89	59.84	37.88	49.08	58.52	45.67	52.48	47.73
161 LHV of Coal Char/LHV of Coal, %	59.94	51.95	55.33	61.88	42.58	56.40	33.51	42.62	53.15	41.44	48.70	45.65
162 LHV of Drains/(LHV of Coal-HCALC), %	63.29	54.46	59.20	66.89	47.49	61.82	39.20	50.80	60.55	47.27	54.27	49.34
163												
164 Feed - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
165 CD - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	81.8	100.0	100.0	100.0	100.0	100.0	77.6	100.0	52.1
166 PD - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	79.5	100.0	100.0	100.0	100.0	100.0	76.6	94.1	50.7
167 SD - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	66.2	100.0	100.0	100.0	91.3	100.0	59.0	60.0	44.5

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
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Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
135 O/C in Coal Feed, lbatom/lbatom	0.0844	0.0777	0.0908	0.0839	0.0580	0.0555	0.0520	0.0518	0.0608	0.0635	0.0630	0.0640
136 H/C in Coal Feed, lbatom/lbatom	0.823	0.794	0.811	0.807	0.793	0.752	0.751	0.748	0.741	0.742	0.743	0.743
137 H/C in Combined Disch, lbatom/lbatom	0.093	0.093	0.080	0.086	0.082	0.098	0.082	0.092	0.096	0.084	0.082	0.066
138 N/C in Coal Feed, lbatom/lbatom	0.024	0.023	0.024	0.024	0.023	0.024	0.024	0.024	0.022	0.022	0.022	0.022
139 N/C in Combined Disch, lbatom/lbatom	0.023	0.024	0.021	0.023	0.021	0.019	0.019	0.020	0.015	0.017	0.016	0.016
140 S/C in Coal Feed, lbatom/lbatom	0.018	0.018	0.018	0.018	0.018	0.010	0.009	0.009	0.022	0.022	0.022	0.022
141 S/C in Combined Disch, lbatom/lbatom	0.007	0.006	0.005	0.009	0.012	0.002	0.006	0.005	0.015	0.014	0.017	0.017
142 Char(N/C)/Coal(N/C) - molar basis	0.975	1.013	0.890	0.980	0.931	0.779	0.806	0.833	0.689	0.766	0.744	0.721
143 Char(S/C)/Coal(S/C) - molar basis	0.379	0.349	0.271	0.505	0.663	0.257	0.650	0.537	0.672	0.649	0.784	0.787
144												
145 Mg/Ca in Sorbent, lbmol/lbmol	1.005	1.001	1.001	1.001	1.005	0.653	0.691	0.034	0.819	0.851	0.855	0.846
146 Ca/Mg in Sorbent, lbmol/lbmol	0.995	0.999	0.999	0.999	0.995	1.531	1.448	29.332	1.220	1.175	1.169	1.182
147 Mg/Ca in Sorbent, lb/lb	0.609	0.607	0.607	0.607	0.609	0.396	0.419	0.021	0.497	0.516	0.519	0.513
148 Ca/Mg in Sorbent, lb/lb	1.642	1.647	1.648	1.647	1.641	2.525	2.388	48.369	2.012	1.938	1.928	1.948
149 MgCO ₃ /CaCO ₃ in Sorbent Feed, mol/mol	1.0145	1.0110	1.0105	1.0110	1.0147	0.6597	0.6983	0.0342	0.8230	0.8611	0.8662	0.8566
150 CaS/CaCO ₃ in Sorbent Feed, mol/mol	0.00988	0.00981	0.00981	0.00984	0.00985	0.01014	0.01113	0.00428	0.00433	0.01212	0.01261	0.01209
151												
152 Coal Feed HHV, Btu/lb (MI)	12713	13108	13214	12850	13123	13116	13211	13193	12680	12565	12642	12660
153												
154 HHV of Gas/HHV of Coal, %	31.62	38.47	34.75	25.83	28.72	44.72	37.61	35.18	28.07	29.24	28.64	27.55
155 HHV of Gas/(HHV of Coal-HCALC), %	32.37	39.15	35.35	26.47	29.40	45.44	38.62	35.85	28.58	29.63	29.03	27.74
156 LHV of Gas/LHV of Coal, %	26.09	32.57	30.20	22.14	24.90	39.08	32.10	29.18	23.34	24.49	24.77	23.62
157 LHV of Gas/(LHV of Coal-HCALC), %	26.73	33.16	30.74	22.70	25.51	39.73	32.99	29.76	23.78	24.83	25.12	23.79
158												
159 HHV of Coal Char/HHV of Coal, %	47.57	40.68	43.51	54.74	53.09	34.26	39.18	43.01	50.47	48.45	49.27	53.68
160 HHV of Drains/(HHV of Coal-HCALC), %	50.97	45.52	50.32	60.74	55.85	34.86	41.88	45.01	56.34	55.03	55.53	58.27
161 LHV of Coal Char/LHV of Coal, %	49.19	42.01	44.97	56.54	54.84	35.30	40.41	44.32	52.00	49.96	50.81	55.41
162 LHV of Drains/(LHV of Coal-HCALC), %	52.76	47.06	52.08	62.81	57.75	35.95	43.24	46.43	58.12	56.80	57.32	60.16
163												
164 Feed - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
165 CD - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	78.9	75.5	100.0	100.0	40.7	18.4	17.2	52.6	100.0	38.1	100.0
166 PD - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	82.5	100.0	84.0	100.0	50.6	49.0	76.3	100.0	100.0
167 SD - CaCO ₃ /(CaCO ₃ +CaO), mole %	49.4	72.1	21.7	100.0	100.0	81.8	36.3	35.9	63.2	100.0	78.9	100.0

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----
1 Coal	----Pittsburgh No. 8 Bituminous----			
2 Sorbent	Plum Run Dolomite/Longview Limestone			
135 O/C in Coal Feed, lbatom/lbatom	0.0518	0.1030	0.0714	0.0131
136 H/C in Coal Feed, lbatom/lbatom	0.741	0.839	0.792	0.032
137 H/C in Combined Disch, lbatom/lbatom	0.058	0.100	0.085	0.011
138 N/C in Coal Feed, lbatom/lbatom	0.022	0.024	0.024	0.001
139 N/C in Combined Disch, lbatom/lbatom	0.015	0.024	0.021	0.003
140 S/C in Coal Feed, lbatom/lbatom	0.009	0.025	0.019	0.005
141 S/C in Combined Disch, lbatom/lbatom	0.002	0.017	0.008	0.004
142 Char(N/C)/Coal(N/C) - molar basis	0.689	1.025	0.896	0.098
143 Char(S/C)/Coal(S/C) - molar basis	0.203	0.805	0.448	0.192
144				
145 Mg/Ca in Sorbent, lbmol/lbmol	0.034	1.006	0.890	0.205
146 Ca/Mg in Sorbent, lbmol/lbmol	0.994	29.332	2.271	5.644
147 Mg/Ca in Sorbent, lb/lb	0.021	0.610	0.539	0.124
148 Ca/Mg in Sorbent, lb/lb	1.640	48.369	3.746	9.308
149 MgCO ₃ /CaCO ₃ in Sorbent Feed, mol/mol	0.0342	1.0156	0.8987	0.2066
150 CaS/CaCO ₃ in Sorbent Feed, mol/mol	0.00428	0.01375	0.01010	0.00214
151				
152 Coal Feed HHV, Btu/lb (MF)	11943	13214	12768	303
153				
154 HHV of Gas/HHV of Coal, %	23.53	44.72	31.04	4.85
155 HHV of Gas/(HHV of Coal-HCALC), %	23.86	45.44	31.62	4.98
156 LHV of Gas/LHV of Coal, %	20.75	39.08	26.94	4.18
157 LHV of Gas/(LHV of Coal-HCALC), %	21.05	39.73	27.46	4.29
158				
159 HHV of Coal Char/HHV of Coal, %	32.42	59.87	47.16	7.08
160 HHV of Drains/(HHV of Coal-HCALC), %	34.86	64.65	51.79	7.47
161 LHV of Coal Char/LHV of Coal, %	33.51	61.88	48.70	7.33
162 LHV of Drains/(LHV of Coal-HCALC), %	35.95	66.89	53.54	7.73
163				
164 Feed - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	0.0
165 CD - CaCO ₃ /(CaCO ₃ +CaO), mole %	17.2	100.0	80.5	27.5
166 PD - CaCO ₃ /(CaCO ₃ +CaO), mole %	49.0	100.0	89.3	16.9
167 SD - CaCO ₃ /(CaCO ₃ +CaO), mole %	21.7	100.0	77.5	25.2

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Do/o	PR Do/o	PR Do/o	PR Do/o	PR Do/o	PR Do/o	PR Do/o	PR Do/o	PR Do/o	PR Do/o	PR Do/o	PR Do/o
168 BD - CaCO ₃ /(CaCO ₃ +CaO), mole %	0.0	0.0	0.0	0.0	100.0	100.0	77.4	100.0	100.0	32.9	28.3	44.1
169 Mixt - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	77.8	100.0	100.0	99.3	99.8	100.0	74.4	95.3	51.1
170												
171 Feed - MgCO ₃ /(MgCO ₃ +MgO), mole %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
172 CD - MgCO ₃ /(MgCO ₃ +MgO), mole %	65.0	13.6	50.3	0.0	1.6	49.5	22.3	40.2	28.9	0.0	41.5	0.0
173 PD - MgCO ₃ /(MgCO ₃ +MgO), mole %	91.1	23.9	43.4	0.0	20.1	46.0	5.1	47.6	37.7	0.0	0.0	0.0
174 SD - MgCO ₃ /(MgCO ₃ +MgO), mole %	62.3	4.5	62.2	0.0	14.4	21.5	3.3	0.0	19.5	0.0	0.0	0.0
175 BD - MgCO ₃ /(MgCO ₃ +MgO), mole %	0.0	0.0	0.0	0.0	23.7	22.5	0.0	27.9	30.2	0.0	0.0	0.0
176 Mixt - MgCO ₃ /(MgCO ₃ +MgO), mole %	69.3	14.5	49.3	0.0	9.4	48.2	11.6	41.0	32.1	0.0	29.6	0.0
177												
178 Feed - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	1.4	1.2	1.2	1.2	0.9	1.0	0.9	0.9	0.9	1.0	1.0	1.0
179 CD - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	64.4	51.6	46.6	33.2	31.8	79.4	84.8	92.9	74.3	42.2	45.0	46.0
180 PD - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	99.9	39.8	42.9	23.2	42.3	56.6	32.1	70.7	64.3	32.2	35.4	14.8
181 SD - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	34.9	24.0	52.6	17.7	35.4	46.4	25.6	28.1	45.9	25.8	30.1	15.8
182 BD - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	0.0	0.0	0.0	0.0	12.4	37.3	19.3	58.7	69.8	20.0	20.0	8.2
183 Mixt - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	64.3	45.1	46.1	27.3	35.8	75.1	52.0	86.4	70.2	37.9	41.8	35.3
184												
185 Feed - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
186 CD - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
187 PD - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
188 SD - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
189 BD - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190 Mixt - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
191												
192 Actual PCO ₂ , psia	11.63	9.98	12.15	12.29	11.55	10.39	10.66	14.55	16.77	14.87	15.56	13.56
193 Equilibrium PCO ₂ (Squires), psia	8.67	19.45	10.66	3.39	22.25	9.78	46.70	42.53	19.15	16.84	10.66	24.05
194 Equilibrium PCO ₂ (IGT/B&K), psia	18.49	42.47	22.88	7.05	48.75	20.95	104.49	94.90	41.78	36.60	22.88	52.82
195 Equilibrium PCO ₂ (H&W), psia	8.49	18.22	10.32	3.50	20.68	9.52	41.64	38.12	17.94	15.89	10.32	22.26
196												
197 Actual PCO ₂ -Equil PCO ₂ (Squires), psia	2.97	-9.48	1.49	8.89	-10.69	0.60	-36.05	-27.98	-2.37	-1.97	4.90	-10.49
198 Actual PCO ₂ -Equil PCO ₂ (IGT/B&K), psia	-6.86	-32.49	-10.73	5.23	-37.19	-10.56	-93.83	-80.35	-25.00	-21.74	-7.32	-39.26
199 Actual PCO ₂ -Equil PCO ₂ (H&W), psia	3.14	-8.24	1.83	8.78	-9.12	0.87	-30.98	-23.57	-1.17	-1.02	5.24	-8.70

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	LV Lime	PR DoLo	PR DoLo	PR DoLo
168 BD - $\text{CaCO}_3/(\text{CaCO}_3+\text{CaO})$, mole %	100.0	100.0	44.9	100.0	63.3	62.0	54.7	54.6	57.9	30.2	73.6	19.8
169 Mixt - $\text{CaCO}_3/(\text{CaCO}_3+\text{CaO})$, mole %	98.9	82.7	75.7	96.9	99.1	44.4	26.0	24.0	52.4	87.7	53.3	88.7
170												
171 Feed - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
172 CD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	22.2	0.0	0.0	8.3	2.6	0.0	0.0	0.0	0.0	49.2	0.0	49.6
173 PD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	23.3	5.3	14.3	0.0	30.1	0.0	11.4	0.0	0.0	0.0	29.0	1.8
174 SD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	0.0	0.0	0.0	20.1	11.1	0.0	0.0	0.0	0.0	21.9	0.0	17.5
175 BD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	10.6	52.2	0.0	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
176 Mixt - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	21.6	2.0	1.8	7.3	5.6	0.0	1.3	0.0	0.0	38.7	5.1	37.6
177												
178 Feed - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	1.0	1.0	1.0	1.0	1.0	1.0	1.1	0.4	0.4	1.2	1.2	1.2
179 CD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	34.9	52.8	56.2	27.1	18.0	13.5	10.7	13.2	50.7	64.4	51.8	72.5
180 PD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	34.4	44.1	51.8	31.0	43.9	36.9	37.7	21.4	31.6	49.3	54.1	62.8
181 SD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	26.5	23.2	13.3	30.4	26.5	11.2	17.2	14.5	19.0	39.5	35.7	48.1
182 BD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	26.6	46.2	28.9	44.3	29.7	14.6	21.3	8.2	16.5	19.1	20.7	22.7
183 Mixt - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	34.5	51.3	54.1	28.2	21.2	15.5	14.0	14.1	40.1	59.2	49.9	67.7
184												
185 Feed - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
186 CD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
187 PD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
188 SD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
189 BD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190 Mixt - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
191												
192 Actual PCO_2 , psia	13.40	20.47	18.75	17.58	18.86	13.29	17.43	13.88	16.15	13.59	12.71	10.75
193 Equilibrium PCO_2 (Squires), psia	10.57	26.39	24.43	10.04	11.60	21.39	22.78	23.68	22.42	23.87	25.00	28.27
194 Equilibrium PCO_2 (IGT/B&K), psia	22.68	58.10	53.67	21.51	24.97	46.82	49.94	51.98	49.14	52.40	54.96	62.35
195 Equilibrium PCO_2 (H&W), psia	10.24	24.29	22.59	9.76	11.19	19.93	21.14	21.93	20.83	22.09	23.09	25.92
196												
197 Actual PCO_2 -Equil PCO_2 (Squires), psia	2.83	-5.92	-5.68	7.54	7.26	-8.11	-5.35	-9.80	-6.28	-10.28	-12.29	-17.52
198 Actual PCO_2 -Equil PCO_2 (IGT/B&K), psia	-9.28	-37.63	-34.92	-3.93	-6.10	-33.54	-32.51	-38.10	-33.00	-38.81	-42.25	-51.60
199 Actual PCO_2 -Equil PCO_2 (H&W), psia	3.16	-3.82	-3.84	7.83	7.68	-6.64	-3.71	-8.05	-4.68	-8.51	-10.37	-15.17

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----Pittsburgh No. 8 Bituminous-----			
Sorbent	Plum Run Dolomite/Longview Limestone			
168 BD - $\text{CaCO}_3/(\text{CaCO}_3+\text{CaO})$, mole %	0.0	100.0	56.0	35.7
169 Mixt - $\text{CaCO}_3/(\text{CaCO}_3+\text{CaO})$, mole %	24.0	100.0	80.3	24.3
170				
171 Feed - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	100.0	100.0	100.0	0.0
172 CD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	0.0	65.0	18.5	21.7
173 PD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	0.0	91.1	17.9	22.3
174 SD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	0.0	62.3	10.8	17.5
175 BD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	0.0	52.2	7.6	13.6
176 Mixt - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	0.0	69.3	17.7	19.9
177				
178 Feed - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	0.4	1.4	1.0	0.2
179 CD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	10.7	92.9	48.3	22.5
180 PD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	14.8	99.9	43.9	17.8
181 SD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	11.2	52.6	28.6	11.5
182 BD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	0.0	69.8	22.7	17.8
183 Mixt - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	14.0	86.4	44.5	19.2
184				
185 Feed - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0
186 CD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	2.6	0.1	0.5
187 PD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0
188 SD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0
189 BD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0
190 Mixt - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	1.9	0.1	0.4
191				
192 Actual PCO_2 , psia	9.98	20.47	14.20	2.88
193 Equilibrium PCO_2 (Squires), psia	3.39	46.70	20.19	9.98
194 Equilibrium PCO_2 (IGT/B&K), psia	7.05	104.49	44.27	22.48
195 Equilibrium PCO_2 (H&W), psia	3.50	41.64	18.75	8.78
196				
197 Actual PCO_2 -Equil PCO_2 (Squires), psia	-36.05	8.89	-5.99	10.48
198 Actual PCO_2 -Equil PCO_2 (IGT/B&K), psia	-93.83	5.23	-30.07	22.76
199 Actual PCO_2 -Equil PCO_2 (H&W), psia	-30.98	8.78	-4.54	9.31
200				

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
201 Actual PCO ₂ /Equil PCO ₂ (Squires), psia	1.34	0.51	1.14	3.62	0.52	1.06	0.23	0.34	0.88	0.88	1.46	0.58
202 Actual PCO ₂ /Equil PCO ₂ (IGT/B&K), psia	0.63	0.23	0.53	1.74	0.24	0.50	0.10	0.15	0.40	0.41	0.68	0.26
203 Actual PCO ₂ /Equil PCO ₂ (H&W), psia	1.37	0.55	1.18	3.51	0.56	1.09	0.26	0.38	0.93	0.94	1.51	0.61
204												
205 Sulfur in Coal Feed, lb/h	11.492	7.820	11.065	12.138	10.709	15.015	8.314	16.991	22.096	7.739	9.010	6.757
206 Sulfur in Combined Char Discharge, lb/h	2.290	2.061	2.969	7.135	1.459	2.930	0.659	2.252	3.538	1.355	1.285	1.461
207 H ₂ S Without Sorbent Feed, lbmol/h	0.2870	0.1797	0.2525	0.1560	0.2885	0.3769	0.2388	0.4597	0.5788	0.1991	0.2410	0.1652
208 Carbonizer Exit Gas, lbmol/h	41.8803	36.3955	39.3226	33.5728	43.6638	40.0535	41.7603	56.0908	56.153	43.9667	46.0817	36.6918
209 H ₂ S Without Sorbent Feed, ppm	6853	4936	6421	4648	6608	9411	5717	8196	10308	4529	5229	4502
210												
211 * For Reaction: CaO+H ₂ S=CaS+H ₂ O												
212 Equilibrium Constant (= H ₂ O/H ₂ S)	678.508	491.029	624.565	987.139	465.364	646.348	345.940	359.141	494.167	520.235	624.565	451.076
213 Equilibrium H ₂ S Concentration, ppm	133.6	155.6	137.7	116.6	132.5	113.8	170.5	181.6	184.4	222.2	290.3	426.4
214 Approach to Equilibrium Conc.(1), %	61.35	48.10	80.49	46.97	8.17	19.26	35.72	175.33	94.61	158.49	31.28	254.76
215 Approach to Equilibrium Capture(1), %	98.75	96.49	99.47	97.09	76.99	94.87	94.47	100.97	99.90	101.90	87.09	106.35
216												
217 * For Reaction: CaCO ₃ +H ₂ S=CaS+H ₂ O+CO ₂												
218 Equilibrium Const (=CO ₂ *H ₂ O*P/H ₂ S)	400.102	649.995	453.057	227.959	704.519	430.342	1099.365	1039.294	643.811	596.018	453.057	738.268
219 Equilibrium H ₂ S Concentration, ppm	179.3	79.8	157.0	422.2	68.8	120.8	38.9	62.1	161.6	196.2	423.8	240.4
220 Approach to Equilibrium Conc.(2), %	82.34	24.67	91.73	170.04	4.24	20.45	8.15	59.98	82.89	139.96	45.67	143.63
221 Approach to Equilibrium Capture(2), %	99.42	94.98	99.77	104.12	76.24	94.94	92.28	99.49	99.67	101.29	89.51	101.71
222												
223 Diff. in Apprch to Equil Conc (2-1), %	21.00	-23.43	11.24	123.07	-3.93	1.19	-27.57	-115.35	-11.72	-18.52	14.39	-111.13
224 Diff. in Apprch to Equil Capt (2-1), %	0.68	-1.51	0.31	7.02	-0.75	0.07	-2.19	-1.48	-0.22	-0.61	2.42	-4.64
225												
226 Coal Feed Temp, F	59.9	59.9	59.8	59.9	59.9	60.0	59.9	60.0	59.8	59.9	59.9	59.9
227 Sorbent Feed Temp, F	59.9	59.9	59.8	59.9	59.9	60.0	59.9	60.0	59.8	59.9	59.9	59.9
228 Air Feed Temp, F	89.3	84.9	81.6	79.2	75.1	81.8	80.2	82.4	83.8	78.4	78.9	81.2
229 Steam Feed Temp, F	387.6	387.6	387.6	387.6	387.6	387.6	387.6	387.6	387.6	387.8	394.4	393.9
230 Purge N ₂ Temp, F	86.4	79.2	82.2	82.7	91.8	98.4	102.1	106.7	113.9	146.7	115.6	93.1
231												
232 Orifice Temp, F	1258	1267	1270	1164	1323	1255	1324	1437	1400	1326	1292	1311
233 Orifice Pressure, psig	150.0	130.4	142.0	123.1	137.1	125.7	135.3	187.9	194.5	150.1	152.6	122.8

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
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Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	LV Lime	PR DoLo	PR DoLo	PR DoLo
201 Actual PCO ₂ /Liquil PCO ₂ (Squires), psia	1.27	0.78	0.77	1.75	1.63	0.62	0.77	0.59	0.72	0.57	0.51	0.38
202 Actual PCO ₂ /Equil PCO ₂ (IGT/B&K), psia	0.59	0.35	0.35	0.82	0.76	0.28	0.35	0.27	0.33	0.26	0.23	0.17
203 Actual PCO ₂ /Equil PCO ₂ (H&W), psia	1.31	0.84	0.83	1.80	1.69	0.67	0.82	0.63	0.78	0.62	0.55	0.41
204												
205 Sulfur in Coal Feed, lb/h	7.578	11.263	11.540	13.616	11.668	3.805	4.182	4.086	15.203	13.768	13.413	13.505
206 Sulfur in Combined Char Discharge, lb/h	1.643	1.913	1.657	4.597	4.889	0.394	1.251	1.103	6.132	5.175	6.204	6.867
207 H ₂ S Without Sorbent Feed, lbmol/h	0.1851	0.2917	0.3083	0.2813	0.2114	0.1064	0.0914	0.0930	0.2829	0.2680	0.2249	0.2070
208 Carbonizer Exit Gas, lbmol/h	37.9377	55.3333	49.0388	50.3069	48.5369	41.131	43.325	42.7613	54.8334	51.6899	48.5601	43.0908
209 H ₂ S Without Sorbent Feed, ppm	4879	5271	6286	5592	4356	2587	2111	2176	5160	5185	4630	4805
210												
211 * For Reaction: CaO+H ₂ S-CaS+H ₂ O												
212 Equilibrium Constant (= H ₂ O/H ₂ S)	626.701	434.672	448.287	639.712	603.716	472.728	461.017	453.887	463.909	452.479	444.145	422.874
213 Equilibrium H ₂ S Concentration, ppm	251.2	390.5	321.0	212.8	187.7	262.1	307.6	361.0	338.3	331.2	274.0	315.4
214 Approach to Equilibrium Conc.(1), %	65.95	584.27	353.09	72.33	18.95	21.17	438.34		409.91	1571.79		25.37
215 Approach to Equilibrium Capture(1), %	97.20	106.63	103.86	98.49	80.73	58.00	113.17	119.89	105.31	106.39	106.29	79.34
216												
217 * For Reaction: CaCO ₃ +H ₂ S=CaS+H ₂ O+CO ₂												
218 Equilibrium Const (=CO ₂ *H ₂ O*P/H ₂ S)	450.743	780.466	745.171	437.057	476.736	688.115	714.511	731.417	707.837	734.836	755.623	813.364
219 Equilibrium H ₂ S Concentration, ppm	318.6	302.9	246.3	372.6	305.1	162.8	235.4	211.6	243.6	188.5	139.3	119.9
220 Approach to Equilibrium Conc.(2), %	83.63	453.25	270.98	126.65	30.80	13.15	335.45		295.16	894.86		9.65
221 Approach to Equilibrium Capture(2), %	98.63	104.75	102.57	101.50	83.07	55.63	108.81	110.77	103.28	103.35	103.10	76.03
222												
223 Diff. in Apprch to Equil Conc (2-1), %	17.68	-131.02	-82.12	54.32	11.85	-8.02	-102.89	0.00	-114.75	-676.93	0.00	-15.72
224 Diff. in Apprch to Equil Capt (2-1), %	1.44	-1.88	-1.28	3.07	2.34	-2.38	-4.36	-9.12	-2.03	-3.04	-3.19	-3.31
225												
226 Coal Feed Temp, F	59.8	59.9	59.8	60.0	60.0	60.0	60.1	60.1	76.0	76.0	70.0	76.0
227 Sorbent Feed Temp, F	59.8	59.9	59.8	60.0	60.0	60.0	60.1	60.1	76.0	76.0	70.0	76.0
228 Air Feed Temp, F	77.4	78.1	81.6	82.3	82.2	82.8	84.4	79.3	85.2	78.1	80.0	88.6
229 Steam Feed Temp, F	394.6	394.1	394.7	394.6	395.0	387.6	386.9	387.0	386.8	387.2	387.1	386.9
230 Purge N ₂ Temp, F	101.7	99.4	102.5	115.5	125.0	107.4	126.2	119.7	126.3	115.9	122.6	128.4
231												
232 Orifice Temp, F	1269	1429	1409	1347	1367	1324	1353	1364	1232	1226	1206	1199
233 Orifice Pressure, psig	126.6	189.3	172.2	174.7	178.8	131.8	152.1	144.7	155.2	142.5	134.2	125.8

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----	-----	-----	-----
Sorbent	-----Pittsburgh No. 8 Bituminous-----			
	Plum Run Dolomite/Longview Limestone			
201 Actual PCO ₂ /Equil PCO ₂ (Squires), psia	0.23	3.62	0.95	0.69
202 Actual PCO ₂ /Equil PCO ₂ (IGT/B&K), psia	0.10	1.74	0.44	0.33
203 Actual PCO ₂ /Equil PCO ₂ (H&W), psia	0.26	3.51	0.99	0.66
204				
205 Sulfur in Coal Feed, lb/h	3.805	22.096	10.949	4.230
206 Sulfur in Combined Char Discharge, lb/h	0.394	7.135	2.968	2.035
207 H ₂ S Without Sorbent Feed, lbmol/h	0.0914	0.5788	0.2490	0.1082
208 Carbonizer Exit Gas, lbmol/h	33.5728	56.1530	45.0907	6.4420
209 H ₂ S Without Sorbent Feed, ppm	2111	10308	5433	1909
210				
211 * For Reaction: CaO+H ₂ S=CaS+H ₂ O				
212 Equilibrium Constant (= H ₂ O/H ₂ S)	345.940	987.139	525.508	132.914
213 Equilibrium H ₂ S Concentration, ppm	113.8	426.4	242.4	90.8
214 Approach to Equilibrium Conc.(1), %	8.17	1571.79	207.99	337.32
215 Approach to Equilibrium Capture(1), %	58.00	119.89	97.07	12.78
216				
217 * For Reaction: CaCO ₃ +H ₂ S=CaS+H ₂ O+CO ₂				
218 Equilibrium Const (=CO ₂ *H ₂ O*P/H ₂ S)	227.959	1099.365	644.653	197.344
219 Equilibrium H ₂ S Concentration, ppm	38.9	423.8	208.2	105.8
220 Approach to Equilibrium Conc.(2), %	4.24	894.86	153.97	200.00
221 Approach to Equilibrium Capture(2), %	55.63	110.77	96.04	12.11
222				
223 Diff. in Apprch to Equil Conc (2-1), %	-676.93	123.07	-49.52	143.49
224 Diff. in Apprch to Equil Capt (2-1), %	-9.12	7.02	-1.03	3.07
225				
226 Coal Feed Temp, F	59.8	76.0	62.4	5.5
227 Sorbent Feed Temp, F	59.8	76.0	62.4	5.5
228 Air Feed Temp, F	75.1	89.3	81.5	3.3
229 Steam Feed Temp, F	386.8	395.0	389.5	3.2
230 Purge N ₂ Temp, F	79.2	146.7	107.9	16.8
231				
232 Orifice Temp, F	1164	1437	1306	73
233 Orifice Pressure, psig	122.8	194.5	149.1	22.0

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo
234 Orifice Diameter, in	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
235 Bed Density DP (DH = 3.0 ft), in H2O	8.307	7.901	7.742	8.780	8.908	7.272	8.301	7.803	8.395	9.900	9.325	12.301
236 Bed Level DP (PDI-3057), in H2O	65.646	41.470	61.514	71.769	40.565	36.245	40.238	39.027	58.619	43.173	43.487	52.950
237												
238 Carbonizer Drain, % of Total Drains	28.58	35.17	52.96	28.08	42.89	65.44	27.07	58.89	54.62	46.56	52.72	42.45
239 Primary-Cyclone Drain, %	25.73	40.53	38.45	35.98	52.54	27.44	64.19	32.67	40.12	42.37	41.63	50.35
240 Secondary-Cyclone Drain, %	45.69	24.30	8.58	35.94	2.03	2.65	2.43	1.01	1.48	2.16	1.95	4.19
241 Baghouse Drain, %	0.00	0.00	0.00	0.00	2.54	4.46	6.30	7.43	3.78	8.91	3.70	3.01
242												
243 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
244												
245 CD Char, lb/h	40.93	33.78	84.21	55.61	37.04	117.55	14.13	97.16	146.56	40.43	60.64	30.58
246 CD Sorbent, lb/h	39.59	31.13	62.94	35.26	48.08	56.15	21.04	51.96	65.53	40.77	51.01	35.90
247 PD Char, lb/h	59.65	63.78	92.79	94.90	70.12	63.11	49.41	67.04	113.41	53.32	72.51	62.74
248 PD Sorbent, lb/h	12.83	11.04	14.04	21.56	34.14	9.72	33.97	15.70	42.38	20.57	15.64	16.10
249 SD Char, lb/h	112.60	37.81	22.01	103.92	2.87	6.19	2.56	2.21	4.75	2.76	3.31	4.85
250 SD Sorbent, lb/h	16.10	7.05	1.84	12.39	1.16	0.85	0.60	0.34	1.00	1.00	0.83	1.71
251 BD Char, lb/h	0.00	0.00	0.00	0.00	4.01	10.82	7.14	15.71	12.56	12.91	6.54	3.83
252 BD Sorbent, lb/h	0.00	0.00	0.00	0.00	1.03	1.03	1.05	3.11	2.11	2.63	1.29	0.88
253 Mixt Char, lb/h	213.17	135.36	199.01	254.43	114.04	197.67	73.24	182.12	277.28	109.43	143.00	102.00
254 Mixt Sorbent, lb/h	68.51	49.22	78.81	69.22	84.40	67.74	56.66	71.10	111.02	64.97	68.78	54.59
255												
256 Char in Carbonizer Drain, %	50.84	52.04	57.23	61.19	43.51	67.68	40.17	65.16	69.10	49.79	54.31	46.00
257 Char in Primary-Cyclone Drain, %	82.30	85.25	86.86	81.49	67.26	86.66	59.26	81.03	72.80	72.16	82.26	79.58
258 Char in Secondary-Cyclone Drain, %	87.49	84.28	92.30	89.34	71.33	87.91	81.13	86.58	82.66	73.32	79.95	73.91
259 Char in Baghouse Drain, %	0.00	0.00	0.00	0.00	79.56	91.34	87.16	83.49	85.59	83.10	83.53	81.29
260 Char in Total Drains, %	75.68	73.34	71.63	78.61	57.47	74.48	56.38	71.92	71.41	62.74	67.52	65.14
261												
262 Sorbent in Carbonizer Drain, %	49.16	47.96	42.77	38.81	56.49	32.32	59.83	34.84	30.90	50.21	45.69	54.00
263 Sorbent in Primary-Cyclone Drain, %	17.70	14.75	13.14	18.51	32.74	13.34	40.74	18.97	27.20	27.84	17.74	20.42
264 Sorbent in Secondary-Cyclone Drain, %	12.51	15.72	7.70	10.66	28.67	12.09	18.87	13.42	17.34	26.68	20.05	26.09
265 Sorbent in Baghouse Drain, %	100.00	100.00	100.00	100.00	20.44	8.66	12.84	16.51	14.41	16.90	16.47	18.71
266 Sorbent in Total Drains, %	24.32	26.66	28.37	21.39	42.53	25.52	43.62	28.08	28.59	37.26	32.48	34.86

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
234 Orifice Diameter, in	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.54	0.54	0.54	0.54
235 Bed Density DP (DH = 3.0 ft), in H2O	9.980	7.829	8.330	8.095	9.511	6.761	6.851	7.332	9.260	9.621	10.849	9.503
236 Bed level DP (PDI-3057), in H2O	46.341	43.963	46.330	57.822	48.292	34.967	36.943	36.255	50.870	45.425	48.816	47.857
237												
238 Carbonizer Drain, % of Total Drains	58.79	43.95	51.74	70.75	64.68	55.28	46.50	34.55	33.57	41.39	42.31	51.60
239 Primary-Cyclone Drain, %	29.46	43.86	37.50	17.94	28.59	36.11	39.99	32.68	41.22	39.84	30.73	40.37
240 Secondary-Cyclone Drain, %	2.85	1.47	1.93	6.85	1.04	3.03	9.66	22.46	11.15	4.42	13.33	0.67
241 Baghouse Drain, %	8.90	10.72	8.82	4.46	5.68	5.58	3.85	10.31	14.07	14.36	13.63	7.36
242												
243 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
244												
245 CD Char, lb/h	54.70	38.58	60.44	167.77	109.20	34.96	25.73	20.07	57.22	55.05	66.50	97.61
246 CD Sorbent, lb/h	58.24	58.57	57.22	102.47	95.20	33.99	53.51	34.13	40.99	48.83	36.36	23.14
247 PD Char, lb/h	45.95	86.66	75.73	45.23	77.71	41.33	58.89	44.94	92.65	92.05	64.03	89.30
248 PD Sorbent, lb/h	10.66	10.31	9.55	23.31	12.64	3.72	9.26	6.34	27.92	7.95	10.87	5.18
249 SD Char, lb/h	4.33	2.96	3.64	20.54	2.61	3.18	13.72	31.06	27.59	10.21	29.87	1.50
250 SD Sorbent, lb/h	1.16	0.30	0.75	5.62	0.69	0.60	2.75	4.18	5.02	0.88	2.54	0.06
251 BD Char, lb/h	15.11	21.65	17.56	15.32	15.12	6.30	5.98	13.86	36.97	33.26	30.31	15.84
252 BD Sorbent, lb/h	1.98	2.05	2.50	1.72	2.83	0.66	0.59	2.31	4.17	2.78	2.83	1.38
253 Mixt Char, lb/h	120.09	149.85	157.36	248.87	204.64	85.77	104.33	109.93	214.43	190.57	190.71	204.26
254 Mixt Sorbent, lb/h	72.03	71.22	70.03	133.12	111.36	38.97	66.10	46.96	78.10	60.43	52.40	29.74
255												
256 Char in Carbonizer Drain, %	48.43	39.71	51.37	62.08	53.42	50.70	32.47	37.03	58.26	53.00	64.65	80.84
257 Char in Primary-Cyclone Drain, %	81.17	89.37	88.80	65.99	86.01	91.74	86.42	87.64	76.84	92.05	85.72	94.54
258 Char in Secondary-Cyclone Drain, %	78.93	90.84	82.89	78.52	79.11	84.16	83.33	88.14	84.61	92.10	92.15	95.91
259 Char in Baghouse Drain, %	88.42	91.37	87.55	89.88	84.23	90.57	91.09	85.70	89.86	92.28	91.47	91.99
260 Char in Total Drains, %	62.51	67.78	69.20	65.15	64.76	68.76	61.22	70.07	73.30	75.92	78.45	87.29
261												
262 Sorbent in Carbonizer Drain, %	51.57	60.29	48.63	37.92	46.58	49.30	67.53	62.97	41.74	47.00	35.35	19.16
263 Sorbent in Primary-Cyclone Drain, %	18.83	10.63	11.20	34.01	13.99	8.26	13.58	12.36	23.16	7.95	14.28	5.46
264 Sorbent in Secondary-Cyclone Drain, %	21.07	9.16	17.11	21.48	20.89	15.84	16.67	11.86	15.39	7.90	7.85	4.09
265 Sorbent in Baghouse Drain, %	11.58	8.63	12.45	10.12	15.77	9.43	8.91	14.30	10.14	7.72	8.53	8.01
266 Sorbent in Total Drains, %	37.49	32.22	30.80	34.85	35.24	31.24	38.78	29.93	26.70	24.08	21.55	12.71

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----
Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
234 Orifice Diameter, in	0.49	0.54	0.50	0.02
235 Bed Density DP (DH = 3.0 ft), in H ₂ O	6.761	12.301	8.702	1.270
236 Bed Level DP (PDI-3057), in H ₂ O	34.967	71.769	47.441	9.516
237				
238 Carbonizer Drain, % of Total Drains	27.07	70.75	47.11	11.91
239 Primary-Cyclone Drain, %	17.94	64.19	37.93	9.34
240 Secondary-Cyclone Drain, %	0.67	45.69	8.80	11.58
241 Baghouse Drain, %	0.00	14.36	6.16	4.32
242				
243 Total	100.00	100.00	100.00	0.00
244				
245 CD Char, lb/h	14.13	167.77	64.44	39.08
246 CD Sorbent, lb/h	21.04	102.47	49.25	19.09
247 PD Char, lb/h	41.33	113.41	69.89	18.85
248 PD Sorbent, lb/h	3.72	42.38	16.05	9.76
249 SD Char, lb/h	1.50	112.60	19.04	29.01
250 SD Sorbent, lb/h	0.06	16.10	2.89	3.90
251 BD Char, lb/h	0.00	36.97	12.53	10.04
252 BD Sorbent, lb/h	0.00	4.17	1.62	1.12
253 Mixt Char, lb/h	73.24	277.28	165.90	55.55
254 Mixt Sorbent, lb/h	29.74	133.12	69.81	22.50
255				
256 Char in Carbonizer Drain, %	32.47	80.84	53.71	11.03
257 Char in Primary-Cyclone Drain, %	59.26	94.54	81.80	8.65
258 Char in Secondary-Cyclone Drain, %	71.33	95.91	84.20	6.30
259 Char in Baghouse Drain, %	0.00	92.28	72.89	32.79
260 Char in Total Drains, %	56.38	87.29	69.61	7.00
261				
262 Sorbent in Carbonizer Drain, %	19.16	67.53	46.29	11.03
263 Sorbent in Primary-Cyclone Drain, %	5.46	40.74	18.20	8.65
264 Sorbent in Secondary-Cyclone Drain, %	4.09	28.67	15.80	6.30
265 Sorbent in Baghouse Drain, %	7.72	100.00	27.11	32.79
266 Sorbent in Total Drains, %	12.71	43.62	30.39	7.00

100

Set Point		TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
267													
268	Coal Feed Composition, wt %												
269	-----												
270	C	66.947	67.633	64.618	66.080	68.072	68.689	68.078	67.972	67.325	68.092	68.271	70.560
271	H	4.640	4.633	4.520	4.653	4.593	4.655	4.590	4.578	4.518	4.605	4.680	4.741
272	O	6.618	6.538	8.862	7.982	6.082	5.829	5.951	6.080	6.763	7.590	7.515	5.801
273	N	1.853	1.863	1.843	1.860	1.920	1.929	1.919	1.919	1.915	1.879	1.882	1.895
274	S	3.401	3.276	3.236	3.139	4.548	4.583	4.587	4.545	4.518	3.325	3.329	3.338
275	Ash	14.382	13.875	14.605	13.971	12.494	12.071	12.571	12.613	12.586	12.179	11.955	11.478
276	Moisture	2.159	2.181	2.317	2.315	2.291	2.244	2.304	2.293	2.376	2.331	2.368	2.187
277		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
278	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
279	MF Coal Feed Composition, wt %												
280	-----												
281	C	68.424	69.142	66.150	67.646	69.668	70.266	69.684	69.567	68.963	69.717	69.927	72.138
282	H	4.742	4.736	4.627	4.763	4.701	4.762	4.698	4.685	4.828	4.715	4.794	4.847
283	O	6.764	6.684	9.072	8.171	6.225	5.963	6.091	6.223	6.928	7.771	7.697	5.931
284	N	1.894	1.905	1.887	1.904	1.965	1.973	1.964	1.964	1.962	1.924	1.928	1.937
285	S	3.476	3.349	3.313	3.213	4.655	4.688	4.695	4.652	4.628	3.404	3.410	3.413
286	Ash	14.700	14.185	14.951	14.302	12.787	12.348	12.867	12.909	12.892	12.469	12.245	11.735
287		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
288	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
289													
290	Sorbent Feed Composition, wt %												
291	-----												
292	CaCO3	52.992	56.061	56.070	56.600	53.783	53.349	53.403	54.196	53.763	53.342	53.458	53.465
293	MgCO3	45.263	42.140	42.272	41.396	45.179	45.614	45.537	44.715	45.234	45.636	45.514	45.508
294	CaO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
295	MgO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
296	CaS	0.525	0.493	0.492	0.477	0.359	0.371	0.366	0.357	0.370	0.380	0.379	0.379
297	CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
298	Inerts	1.220	1.306	1.166	1.527	0.679	0.666	0.694	0.732	0.633	0.642	0.649	0.648
299		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
267												
268 Coal Feed Composition, wt %												
269 -----												
270 C	68.386	70.968	70.472	68.094	71.425	72.806	73.719	73.643	68.055	67.356	67.597	67.657
271 H	4.722	4.726	4.797	4.614	4.752	4.597	4.646	4.625	4.234	4.192	4.215	4.219
272 O	7.689	7.346	8.526	7.609	5.520	5.378	5.106	5.084	5.511	5.694	5.676	5.765
273 N	1.890	1.939	1.959	1.877	1.904	2.019	2.035	2.030	1.750	1.737	1.742	1.745
274 S	3.326	3.422	3.462	3.303	3.359	1.867	1.866	1.855	4.047	4.016	3.980	3.999
275 Ash	11.554	9.234	8.227	12.170	10.911	11.701	11.105	11.215	13.525	14.017	13.831	13.653
276 Moisture	2.433	2.365	2.558	2.333	2.130	1.632	1.523	1.548	2.879	2.989	2.959	2.962
277 -----												
278 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
279 MF Coal Feed Composition, wt %												
280 -----												
281 C	70.092	72.687	72.321	69.721	72.979	74.014	74.859	74.801	70.072	69.431	69.658	69.722
282 H	4.840	4.840	4.923	4.724	4.855	4.673	4.718	4.698	4.359	4.321	4.343	4.348
283 O	7.881	7.524	8.750	7.791	5.640	5.467	5.185	5.164	5.674	5.869	5.849	5.941
284 N	1.937	1.986	2.010	1.922	1.945	2.052	2.066	2.062	1.802	1.790	1.795	1.798
285 S	3.409	3.505	3.553	3.382	3.432	1.898	1.895	1.884	4.167	4.140	4.101	4.121
286 Ash	11.842	9.458	8.443	12.461	11.148	11.895	11.277	11.391	13.926	14.449	14.253	14.070
287 -----												
288 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
289 -----												
290 Sorbent Feed Composition, wt %												
291 -----												
292 CaCO3	53.383	53.450	53.462	53.457	53.370	63.737	62.446	96.595	58.270	57.238	57.112	57.366
293 MgCO3	45.622	45.523	45.510	45.528	45.618	35.418	36.732	2.786	40.395	41.517	41.674	41.394
294 CaO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
295 MgO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
296 CaS	0.380	0.378	0.378	0.379	0.379	0.466	0.501	0.298	0.182	0.500	0.519	0.500
297 CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
298 Inerts	0.615	0.649	0.650	0.636	0.633	0.379	0.321	0.321	1.153	0.745	0.695	0.740
299 -----												

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
267				
268 Coal Feed Composition, wt %				
269 -----				
270 C	64.618	73.719	68.855	2.251
271 H	4.192	4.797	4.573	0.173
272 O	5.084	8.862	6.521	1.083
273 N	1.737	2.035	1.888	0.082
274 S	1.855	4.587	3.514	0.793
275 Ash	8.227	14.605	12.330	1.529
276 Moisture	1.523	2.989	2.320	0.380
277				
278 Total	100.000	100.000	100.000	0.000
279 MF Coal Feed Composition, wt %				
280 -----				
281 C	66.150	74.859	70.485	2.131
282 H	4.321	4.923	4.681	0.167
283 O	5.164	9.072	6.677	1.113
284 N	1.790	2.066	1.932	0.077
285 S	1.884	4.695	3.599	0.819
286 Ash	8.443	14.951	12.625	1.584
287				
288 Total	100.000	100.000	100.000	0.000
289				
290 Sorbent Feed Composition, wt %				
291 -----				
292 CaCO ₃	52.992	96.595	57.099	8.707
293 MgCO ₃	2.786	45.636	41.739	8.603
294 CaO	0.000	0.000	0.000	0.000
295 MgO	0.000	0.000	0.000	0.000
296 CaS	0.182	0.525	0.409	0.080
297 CaSO ₄	0.000	0.000	0.000	0.000
298 Inerts	0.321	1.527	0.754	0.296
299				

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
300 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
301												
302 CD Composition, wt %												
303 -----												
304 C	27.103	28.746	34.962	54.989	25.075	50.250	16.236	43.063	50.133	27.669	36.423	21.136
305 H	0.130	0.116	0.204	0.321	0.118	0.329	0.163	0.142	0.273	0.128	0.238	0.334
306 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
307 N	0.735	0.592	0.907	1.612	0.659	1.275	0.549	1.054	1.342	0.760	0.800	0.561
308 S	0.000	0.072	0.126	2.529	0.676	0.782	0.852	0.744	0.976	0.593	0.000	1.076
309 Ash	22.868	22.516	21.030	1.742	16.984	15.039	22.375	20.154	16.377	20.637	16.848	22.889
310 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
311 CaCO3	11.433	17.459	15.832	17.289	29.005	4.714	7.123	1.881	5.987	18.129	17.066	12.950
312 MgCO3	17.577	3.739	11.107	0.000	0.578	9.573	8.806	8.704	5.611	0.000	10.862	0.000
313 CaO	0.000	0.000	0.000	2.154	0.000	0.000	0.000	0.000	0.000	2.928	0.000	6.672
314 MgO	4.528	11.395	5.253	10.938	16.637	4.677	14.691	6.183	6.583	16.371	7.318	18.555
315 CaS	14.898	13.815	9.970	7.582	9.735	13.078	28.604	17.721	12.447	12.303	10.073	15.274
316 CaSO4	0.000	0.696	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
317 Inerts	0.729	0.854	0.610	0.844	0.532	0.283	0.602	0.354	0.271	0.482	0.373	0.553
318												
319 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
320												
321 PD Composition, wt %												
322 -----												
323 C	59.944	66.188	67.487	56.858	51.635	67.312	42.099	61.563	54.887	56.555	64.968	68.391
324 H	0.413	0.448	0.541	0.469	0.349	0.655	0.201	0.389	0.407	0.376	0.574	0.448
325 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
326 N	1.503	1.649	1.771	1.616	1.487	1.967	1.109	1.522	1.507	1.393	1.637	1.819
327 S	1.002	1.623	2.233	2.216	0.739	1.770	0.276	1.078	0.818	0.787	1.249	0.824
328 Ash	19.437	15.341	14.825	20.330	13.046	14.951	15.572	16.473	15.180	13.052	13.828	8.101
329 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
330 CaCO3	0.008	6.533	5.268	9.128	13.694	3.957	20.494	3.946	6.958	11.494	8.295	7.422
331 MgCO3	8.781	1.924	2.980	0.000	3.965	3.558	1.306	5.236	6.133	0.000	0.000	0.000
332 CaO	0.000	0.000	0.000	1.322	0.000	0.000	0.000	0.000	0.000	1.967	0.292	4.043

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
300 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
301												
302 CD Composition, wt %												
303 -----												
304 C	33.563	36.553	49.180	44.565	39.626	29.092	17.893	21.330	30.501	26.834	36.992	52.189
305 H	0.210	0.369	0.324	0.289	0.218	0.278	0.121	0.160	0.209	0.115	0.203	0.184
306 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
307 N	0.905	1.041	1.015	1.125	0.994	0.602	0.397	0.537	0.580	0.585	0.671	0.987
308 S	0.745	0.801	0.592	1.003	1.541	0.152	0.670	0.467	2.783	2.200	3.206	3.757
309 Ash	13.012	0.949	0.255	15.102	11.046	20.575	13.393	14.536	24.191	23.261	23.580	23.722
310 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
311 CaCO3	23.685	18.329	13.273	20.088	27.738	17.242	11.922	14.120	9.791	12.293	6.009	3.942
312 MgCO3	6.826	0.000	0.000	1.918	0.732	0.000	0.000	0.000	0.000	12.181	0.000	5.072
313 CaO	0.000	2.753	2.419	0.000	0.000	14.099	29.544	38.195	4.945	0.000	5.463	0.000
314 MgO	11.466	19.861	16.186	10.196	13.331	12.895	20.126	1.302	12.459	6.023	11.267	2.465
315 CaS	9.172	18.752	16.273	5.390	4.378	4.778	5.565	9.039	13.797	16.063	12.216	7.499
316 CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
317 Inerts	0.415	0.592	0.484	0.325	0.397	0.288	0.368	0.314	0.744	0.445	0.393	0.183
318												
319 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
320												
321 PD Composition, wt %												
322 -----												
323 C	62.987	61.042	58.877	55.139	67.437	70.184	66.917	66.987	60.462	71.542	64.640	75.047
324 H	0.556	0.400	0.385	0.453	0.550	0.539	0.458	0.509	0.469	0.482	0.460	0.517
325 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
326 N	1.675	1.657	1.700	1.619	1.626	1.538	1.512	1.485	1.110	1.461	1.245	1.359
327 S	0.975	0.861	0.877	1.922	1.621	0.469	0.817	0.794	2.052	2.153	2.419	2.238
328 Ash	14.980	25.409	26.959	6.858	14.773	19.015	16.712	17.865	12.749	16.416	16.957	15.375
329 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
330 CaCO3	8.678	4.521	4.049	15.169	5.505	3.900	6.981	6.251	7.009	2.637	4.988	1.717
331 MgCO3	2.605	0.362	1.011	0.000	2.502	0.000	0.740	0.000	0.000	0.000	2.271	0.059
332 CaO	0.000	0.000	0.000	1.806	0.000	0.417	0.000	3.416	4.080	0.460	0.000	0.000

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----Pittsburgh No. 8 Bituminous-----			
Sorbent	Plum Run Dolomite/Longview Limestone			
300 Total	100.000	100.000	100.000	0.000
301				
302 CD Composition, wt %				
303 -----				
304 C	16.236	54.989	34.754	11.075
305 H	0.115	0.369	0.216	0.080
306 O	0.000	0.000	0.000	0.000
307 N	0.397	1.612	0.845	0.294
308 S	0.000	3.757	1.098	1.019
309 Ash	0.255	24.191	16.795	7.095
310 Moisture	0.000	0.000	0.000	0.000
311 CaCO ₃	1.881	29.005	14.054	6.980
312 MgCO ₃	0.000	17.577	4.304	5.089
313 CaO	0.000	38.195	4.549	9.485
314 MgO	1.302	20.126	10.863	5.380
315 CaS	4.378	28.604	12.018	5.326
316 CaSO ₄	0.000	0.696	0.029	0.139
317 Inerts	0.183	0.854	0.476	0.180
318				
319 Total	100.000	100.000	100.000	0.000
320				
321 PD Composition, wt %				
322 -----				
323 C	42.099	75.047	62.465	7.100
324 H	0.201	0.655	0.460	0.090
325 O	0.000	0.000	0.000	0.000
326 N	1.109	1.967	1.540	0.198
327 S	0.276	2.419	1.326	0.640
328 Ash	6.858	26.959	16.009	4.277
329 Moisture	0.000	0.000	0.000	0.000
330 CaCO ₃	0.008	20.494	7.025	4.435
331 MgCO ₃	0.000	8.781	1.810	2.292
332 CaO	0.000	4.080	0.742	1.304

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point		TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
333	MgO	0.411	2.932	1.858	5.167	7.549	1.993	11.566	2.757	4.839	8.967	5.504	6.919
334	CaS	8.241	3.112	2.848	2.495	7.239	3.724	6.988	6.856	9.043	5.145	3.489	1.827
335	CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
336	inerts	0.260	0.250	0.189	0.399	0.297	0.113	0.388	0.180	0.228	0.264	0.164	0.206
337													
338	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
339													
340	SD Composition, wt %												
341													
342	C	71.019	64.810	74.641	60.448	45.116	68.112	56.384	63.998	62.494	56.164	60.774	55.354
343	H	0.601	0.420	0.712	0.559	0.352	0.698	0.445	0.495	0.542	0.382	0.515	0.359
344	O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
345	N	2.148	1.592	2.045	1.668	1.593	1.735	1.483	1.367	1.445	1.777	1.778	1.227
346	S	1.215	1.783	1.671	1.940	1.261	1.446	1.333	1.230	1.314	1.182	1.549	0.667
347	Ash	12.507	15.672	13.232	24.729	23.004	15.921	21.489	19.485	16.860	13.818	15.331	16.306
348	Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
349	CaCO3	5.085	8.995	2.480	4.839	13.472	4.684	10.328	6.787	6.871	9.638	6.965	8.392
350	MgCO3	4.100	0.398	2.424	0.000	2.503	1.595	0.382	0.000	2.062	0.000	0.000	0.000
351	CaO	0.000	0.000	0.000	1.382	0.000	0.000	0.000	0.361	0.000	3.755	2.597	5.864
352	MgO	1.185	4.011	0.704	3.067	7.106	2.777	5.420	4.042	4.070	8.921	6.689	9.020
353	CaS	1.963	2.047	1.983	1.131	5.331	2.924	2.557	2.097	4.194	4.100	3.602	2.542
354	CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
355	Inerts	0.177	0.272	0.108	0.237	0.261	0.108	0.179	0.138	0.148	0.263	0.200	0.269
356													
357	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
358													
359	BD Composition, wt %												
360													
361	C	0.000	0.000	0.000	0.000	67.233	74.493	68.142	64.479	67.537	69.436	69.714	65.791
362	H	0.000	0.000	0.000	0.000	0.660	1.264	1.131	0.423	0.524	0.622	0.791	0.610
363	O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
364	N	0.000	0.000	0.000	0.000	1.819	2.106	1.495	1.623	1.719	2.285	2.262	1.850
365	S	0.000	0.000	0.000	0.000	1.245	1.527	1.069	1.166	0.808	1.589	1.533	1.105

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point		TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	LV Lime	PR DoLo	PR DoLo	PR DoLo	PR DoLo
333	MgO	4.109	3.085	2.903	10.753	2.771	1.936	2.762	0.216	6.895	2.337	2.656	1.543
334	CaS	3.284	2.566	3.138	5.967	3.100	1.959	3.044	2.425	4.762	2.424	4.233	2.086
335	CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
336	Inerts	0.151	0.097	0.101	0.314	0.115	0.043	0.057	0.052	0.412	0.088	0.131	0.059
337													
338	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
339													
340	SD Composition, wt %												
341	-----												
342	C	61.266	62.824	61.578	65.849	66.965	67.636	68.249	68.527	66.237	73.650	74.089	78.215
343	H	0.459	0.429	0.355	0.583	0.536	0.419	0.481	0.470	0.561	0.695	0.527	0.480
344	O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
345	N	1.292	1.522	1.757	2.359	1.637	1.695	1.392	1.519	1.228	1.160	1.398	1.350
346	S	0.861	0.642	0.725	1.379	1.241	0.765	0.654	0.743	1.364	1.715	1.879	1.502
347	Ash	15.051	25.421	18.479	8.351	8.734	13.648	12.555	16.885	15.225	14.880	14.256	14.361
348	Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
349	CaCO3	6.496	4.042	2.977	10.535	11.032	9.854	4.999	4.946	6.762	3.603	3.327	1.654
350	MgO	0.000	0.000	0.000	2.567	1.407	0.000	0.000	0.000	0.000	0.933	0.000	0.397
351	CaO	3.725	0.875	6.029	0.000	0.000	1.231	4.906	4.955	2.203	0.000	0.500	0.000
352	MgO	7.233	2.940	6.387	4.878	5.402	3.571	4.620	0.221	4.355	1.593	2.259	0.896
353	CaS	3.413	1.217	1.522	3.321	2.870	1.101	2.059	1.681	1.805	1.694	1.686	1.104
354	CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
355	Inerts	0.204	0.088	0.191	0.178	0.176	0.080	0.085	0.053	0.260	0.077	0.079	0.041
356													
357	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
358													
359	BD Composition, wt %												
360	-----												
361	C	70.880	70.747	67.769	71.738	70.960	79.253	75.500	71.483	70.678	72.624	72.543	73.024
362	H	0.669	0.543	0.539	0.631	0.683	0.569	0.531	0.712	0.695	0.729	0.620	0.608
363	O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
364	N	2.097	1.996	1.781	1.785	1.883	1.694	1.756	1.771	1.002	1.238	1.518	1.458
365	S	1.186	1.177	0.901	1.221	1.303	0.710	0.840	1.121	1.166	1.518	1.481	1.121

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----	-----	-----	-----
Sorbent	----Pittsburgh No. 8 Bituminous----			
	Plum Run	Dolomite	Longview	Limestone
333 MgO	0.216	11.566	4.268	3.014
334 CaS	1.827	9.043	4.166	2.076
335 CaSO ₄	0.000	0.000	0.000	0.000
336 Inerts	0.043	0.412	0.190	0.111
337				
338 Total	100.000	100.000	100.000	0.000
339				
340 SD Composition, wt %				
341 -----				
342 C	45.116	78.215	64.767	7.138
343 H	0.352	0.712	0.503	0.102
344 O	0.000	0.000	0.000	0.000
345 N	1.160	2.359	1.590	0.289
346 S	0.642	1.940	1.253	0.396
347 Ash	8.351	25.421	16.092	4.214
348 Moisture	0.000	0.000	0.000	0.000
349 CaCO ₃	1.654	13.472	6.615	3.031
350 MgCO ₃	0.000	4.100	0.782	1.136
351 CaO	0.000	6.029	1.599	2.063
352 MgO	0.221	9.020	4.224	2.430
353 CaS	1.101	5.331	2.414	1.085
354 CaSO ₄	0.000	0.000	0.000	0.000
355 Inerts	0.041	0.272	0.161	0.073
356				
357 Total	100.000	100.000	100.000	0.000
358				
359 BD Composition, wt %				
360 -----				
361 C	0.000	79.253	58.918	26.528
362 H	0.000	1.264	0.565	0.308
363 O	0.000	0.000	0.000	0.000
364 N	0.000	2.285	1.464	0.714
365 S	0.000	1.589	0.991	0.497

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point		TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
366	Ash	100.000	100.000	100.000	100.000	8.606	11.945	15.326	15.800	15.005	9.166	9.231	11.933
367	Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
368	CaCO ₃	0.000	0.000	0.000	0.000	12.099	3.848	6.251	5.016	3.231	3.955	3.372	6.493
369	MgCO ₃	0.000	0.000	0.000	0.000	2.732	1.171	0.000	2.770	2.690	0.000	0.000	0.000
370	CaO	0.000	0.000	0.000	0.000	0.000	0.000	1.021	0.000	0.000	4.517	4.778	4.614
371	MgO	0.000	0.000	0.000	0.000	4.193	1.923	4.041	3.422	2.977	6.084	5.995	6.464
372	CaS	0.000	0.000	0.000	0.000	1.240	1.647	1.395	5.138	5.384	2.167	2.145	0.947
373	CaSO ₄	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
374	Inerts	0.000	0.000	0.000	0.000	0.173	0.076	0.129	0.163	0.125	0.179	0.179	0.193
375													
376	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
377													
378	Combined Discharges Comp., wt %												
379													
380	C	55.617	52.686	50.874	57.623	40.506	56.488	37.087	50.911	52.881	44.245	50.012	47.706
381	H	0.418	0.324	0.377	0.460	0.258	0.470	0.255	0.247	0.340	0.283	0.404	0.401
382	O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
383	N	1.578	1.263	1.337	1.634	1.142	1.514	0.991	1.252	1.424	1.186	1.222	1.261
384	S	0.813	1.116	1.069	2.205	0.735	1.104	0.508	0.889	0.911	0.777	0.607	0.933
385	Ash	17.251	17.945	17.975	16.692	14.825	14.900	17.542	18.621	15.852	16.254	15.280	14.838
386	Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
387	CaCO ₃	5.593	10.974	10.624	9.878	20.217	4.467	15.729	2.838	6.285	13.871	12.711	9.781
388	MgCO ₃	9.157	2.191	7.237	0.000	2.451	7.336	3.232	7.042	5.657	0.000	5.727	0.000
389	CaO	0.000	0.000	0.000	1.577	0.000	0.000	0.064	0.004	0.000	2.680	0.349	5.253
390	MgO	1.941	6.170	3.557	6.033	11.353	3.767	11.788	4.837	5.710	12.156	6.502	11.933
391	CaS	7.276	6.617	6.546	3.433	8.119	9.732	12.380	13.078	10.692	8.190	6.913	7.539
392	CaSO ₄	0.000	0.245	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
393	Inerts	0.356	0.468	0.405	0.466	0.394	0.222	0.425	0.281	0.246	0.358	0.275	0.356
394													
395	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
396													
397	CD-Char Fraction Composition, wt %												
398													

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
366 Ash	13.588	16.907	16.561	14.504	9.396	8.340	12.465	10.614	16.315	16.170	15.304	15.774
367 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
368 CaCO ₃	6.121	3.062	3.423	4.147	5.756	4.598	3.596	8.837	4.269	1.788	4.130	1.205
369 MgCO ₃	0.747	2.507	0.000	0.956	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
370 CaO	0.000	0.000	2.352	0.000	1.867	1.582	1.667	4.114	1.738	2.319	0.830	2.738
371 MgO	3.017	1.097	4.317	2.548	5.231	2.286	2.322	0.242	2.913	2.510	2.436	2.685
372 CaS	1.600	1.896	2.228	2.382	2.769	0.917	1.281	1.048	1.050	1.010	1.053	1.287
373 CaSO ₄	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
374 Inerts	0.095	0.068	0.129	0.088	0.152	0.051	0.042	0.058	0.174	0.094	0.085	0.100
375 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
376 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
377												
378 Combined Discharges Comp., wt %												
379												
380 C	46.342	51.346	54.695	49.132	49.643	47.899	44.581	52.023	52.484	53.288	55.279	63.124
381 H	0.360	0.402	0.366	0.354	0.343	0.393	0.306	0.401	0.424	0.375	0.382	0.352
382 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
383 N	1.249	1.421	1.354	1.328	1.232	1.034	0.991	1.195	0.930	1.053	1.060	1.174
384 S	0.855	0.865	0.729	1.203	1.547	0.316	0.734	0.703	2.096	2.062	2.552	2.935
385 Ash	13.701	13.748	12.060	13.134	11.994	19.119	14.604	15.747	17.368	19.146	19.174	19.705
386 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
387 CaCO ₃	17.211	10.426	8.746	17.840	19.958	11.494	8.957	8.943	7.530	6.554	5.082	2.827
388 MgCO ₃	4.847	0.428	0.379	1.575	1.204	0.000	0.296	0.000	0.000	5.082	0.698	2.644
389 CaO	0.106	1.223	1.576	0.324	0.106	8.069	14.276	15.849	3.832	0.516	2.491	0.201
390 MgO	8.426	10.242	9.968	9.590	9.769	8.063	10.999	0.595	7.920	3.854	6.216	2.098
391 CaS	6.599	9.588	9.823	5.218	3.905	3.433	4.053	4.401	6.944	7.833	6.838	4.814
392 CaSO ₄	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
393 Inerts	0.303	0.311	0.303	0.302	0.300	0.180	0.204	0.143	0.473	0.236	0.229	0.126
394 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
395 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
396												
397 CD-Char Fraction Composition, wt %												
398												

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----	-----	-----	-----
Sorbent	-----Pittsburgh No. 8 Bituminous-----			
	Plum Run Dolomite/Longview Limestone			
366 Ash	8.340	100.000	27.623	32.479
367 Moisture	0.000	0.000	0.000	0.000
368 CaCO ₃	0.000	12.099	3.967	2.802
369 MgCO ₃	0.000	2.770	0.566	0.996
370 CaO	0.000	4.778	1.422	1.643
371 MgO	0.000	6.464	2.779	1.925
372 CaS	0.000	5.384	1.608	1.333
373 CaSO ₄	0.000	0.000	0.000	0.000
374 Inerts	0.000	0.193	0.098	0.061
375				
376 Total	100.000	100.000	100.000	0.000
377				
378 Combined Discharges Comp., wt %				
379				
380 C	37.087	63.124	50.686	5.500
381 H	0.247	0.470	0.362	0.059
382 O	0.000	0.000	0.000	0.000
383 N	0.930	1.634	1.243	0.182
384 S	0.316	2.935	1.178	0.673
385 Ash	11.994	19.705	16.145	2.240
386 Moisture	0.000	0.000	0.000	0.000
387 CaCO ₃	2.827	20.217	10.356	4.939
388 MgCO ₃	0.000	9.157	2.799	2.878
389 CaO	0.000	15.849	2.437	4.283
390 MgO	0.595	12.156	7.229	3.397
391 CaS	3.433	13.078	7.248	2.605
392 CaSO ₄	0.000	0.245	0.010	0.049
393 Inerts	0.126	0.473	0.307	0.097
394				
395 Total	100.000	100.000	100.000	0.000
396				
397 CD-Char Fraction Composition, wt %				
398				

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point		TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
399	C	53.31	55.24	61.09	89.86	57.63	74.25	40.41	66.09	72.55	55.57	67.07	45.95
400	H	0.26	0.22	0.36	0.52	0.27	0.49	0.41	0.22	0.40	0.26	0.44	0.73
401	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
402	N	1.45	1.14	1.58	2.63	1.51	1.88	1.37	1.62	1.94	1.53	1.47	1.22
403	S	0.00	0.14	0.22	4.13	1.55	1.16	2.12	1.14	1.41	1.19	0.00	2.34
404	Ash	44.98	43.27	36.75	2.85	39.03	22.22	55.69	30.93	23.70	41.45	31.02	49.76
405													
406	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
407	PD-Char Fraction Composition, wt %												
408													
409	C	72.84	77.64	77.70	69.77	76.77	77.68	71.04	75.98	75.40	78.37	78.98	85.94
410	H	0.50	0.53	0.62	0.58	0.52	0.76	0.34	0.48	0.56	0.52	0.70	0.56
411	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
412	N	1.83	1.93	2.04	1.98	2.21	2.27	1.87	1.88	2.07	1.93	1.99	2.29
413	S	1.22	1.90	2.57	2.72	1.10	2.04	0.47	1.33	1.12	1.09	1.52	1.04
414	Ash	23.62	18.00	17.07	24.95	19.40	17.25	26.28	20.33	20.85	18.09	16.81	10.18
415													
416	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
417	SD-Char Fraction Composition, wt %												
418													
419	C	81.17	76.90	80.87	67.66	63.25	77.48	69.49	73.92	75.61	76.60	76.02	74.89
420	H	0.69	0.50	0.77	0.63	0.49	0.79	0.55	0.57	0.66	0.52	0.64	0.49
421	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
422	N	2.46	1.89	2.22	1.87	2.23	1.97	1.83	1.58	1.75	2.42	2.22	1.66
423	S	1.39	2.12	1.81	2.17	1.77	1.64	1.64	1.42	1.59	1.61	1.94	0.90
424	Ash	14.30	18.60	14.34	27.68	32.25	18.11	26.49	22.51	20.40	18.85	19.18	22.06
425													
426	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
427	BD Char Fraction Composition, wt %												
428													
429	C	0.00	0.00	0.00	0.00	84.50	81.56	78.18	77.23	78.90	83.56	83.46	80.93
430	H	0.00	0.00	0.00	0.00	0.83	1.38	1.30	0.51	0.61	0.75	0.95	0.75
431	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point		TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
399	C	69.29	92.04	95.74	71.78	74.17	57.38	55.10	57.60	52.35	50.63	57.22	64.56
400	H	0.43	0.93	0.63	0.47	0.41	0.55	0.37	0.43	0.36	0.22	0.31	0.23
401	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
402	N	1.87	2.62	1.98	1.81	1.86	1.19	1.22	1.45	1.00	1.10	1.04	1.22
403	S	1.54	2.02	1.15	1.62	2.88	0.30	2.06	1.26	4.78	4.15	4.96	4.65
404	Ash	26.87	2.39	0.50	24.33	20.68	40.58	41.24	39.25	41.52	43.89	36.47	29.34
405													
406	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
407	PD-Char Fraction Composition, wt %												
408													
409	C	77.60	68.30	66.30	83.56	78.41	76.50	77.44	76.43	78.68	77.72	75.41	79.38
410	H	0.68	0.45	0.43	0.69	0.64	0.59	0.53	0.58	0.61	0.52	0.54	0.55
411	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
412	N	2.06	1.85	1.91	2.45	1.89	1.68	1.75	1.69	1.44	1.59	1.45	1.44
413	S	1.20	0.96	0.99	2.91	1.88	0.51	0.95	0.91	2.67	2.34	2.82	2.37
414	Ash	18.45	28.43	30.36	10.39	17.18	20.73	19.34	20.38	16.59	17.83	19.78	16.26
415													
416	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
417	SD Char fraction Composition, wt %												
418													
419	C	77.62	69.16	74.29	83.86	84.64	80.36	81.90	77.74	78.28	79.97	80.40	81.55
420	H	0.58	0.47	0.43	0.74	0.68	0.50	0.58	0.53	0.66	0.75	0.57	0.50
421	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
422	N	1.64	1.68	2.12	3.00	2.07	2.01	1.67	1.72	1.45	1.26	1.52	1.41
423	S	1.09	0.71	0.87	1.76	1.57	0.91	0.78	0.84	1.61	1.86	2.04	1.57
424	Ash	19.07	27.99	22.29	10.64	11.04	16.22	15.07	19.16	17.99	16.16	15.47	14.97
425													
426	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
427	BD-Char Fraction Composition, wt %												
428													
429	C	80.16	77.43	77.40	79.82	84.25	87.51	82.88	83.41	78.66	78.70	79.31	79.39
430	H	0.76	0.59	0.62	0.70	0.81	0.63	0.58	0.83	0.77	0.79	0.68	0.66
431	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL.

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----	-----	-----	-----
Sorbent	-----Pittsburgh No. 8 Bituminous-----			
	Plum Run Dolomite/Longview Limestone			
399 C	40.41	95.74	64.04	13.79
400 H	0.22	0.93	0.41	0.17
401 O	0.00	0.00	0.00	0.00
402 N	1.00	2.63	1.57	0.43
403 S	0.00	4.96	1.95	1.52
404 Ash	0.50	55.69	32.03	14.29
405				
406 Total	100.00	100.00	100.00	0.00
407 PD Char Fraction Composition, wt %				
408 -----				
409 C	66.30	85.94	76.41	4.26
410 H	0.34	0.76	0.56	0.09
411 O	0.00	0.00	0.00	0.00
412 N	1.44	2.45	1.90	0.26
413 S	0.47	2.91	1.61	0.75
414 Ash	10.18	30.36	19.52	4.64
415				
416 Total	100.00	100.00	100.00	0.00
417 SD-Char Fraction Composition, wt %				
418 -----				
419 C	63.25	84.64	76.82	5.14
420 H	0.43	0.79	0.60	0.10
421 O	0.00	0.00	0.00	0.00
422 N	1.26	3.00	1.90	0.39
423 S	0.71	2.17	1.48	0.44
424 Ash	10.64	32.25	19.20	5.25
425				
426 Total	100.00	100.00	100.00	0.00
427 BD-Char Fraction Composition, wt %				
428 -----				
429 C	0.00	87.51	67.39	30.24
430 H	0.00	1.38	0.65	0.35
431 O	0.00	0.00	0.00	0.00

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point		TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
432	N	0.00	0.00	0.00	0.00	2.29	2.31	1.72	1.94	2.01	2.75	2.71	2.28
433	S	0.00	0.00	0.00	0.00	1.56	1.67	1.23	1.40	0.94	1.91	1.84	1.36
434	Ash	100.00	100.00	100.00	100.00	10.82	13.08	17.58	18.92	17.53	11.03	11.05	14.68
435													
436	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
437	Combined Disch-Char Frac Comp, wt %												
438													
439	C	73.49	71.84	71.02	73.30	70.49	75.85	65.78	70.79	74.05	70.52	74.07	73.24
440	H	0.55	0.44	0.53	0.58	0.45	0.63	0.45	0.34	0.48	0.45	0.60	0.62
441	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
442	N	2.09	1.72	1.87	2.08	1.99	2.03	1.76	1.74	1.99	1.89	1.81	1.94
443	S	1.07	1.52	1.49	2.80	1.28	1.48	0.90	1.24	1.28	1.24	0.90	1.43
444	Ash	22.80	24.47	25.09	21.23	25.80	20.01	31.11	25.89	22.20	25.90	22.63	22.78
445													
446	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
447													
448	CD-Sorbent Fraction Composition, wt %												
449													
450	CaCO3	23.25	36.40	37.01	44.55	51.35	14.58	11.91	5.40	19.38	36.10	37.35	23.98
451	MgCO3	35.75	7.80	25.97	0.00	1.02	29.61	14.72	24.98	18.16	0.00	23.77	0.00
452	CaO	0.00	0.00	0.00	5.55	0.00	0.00	0.00	0.00	0.00	5.83	0.00	12.35
453	MgO	9.21	23.76	12.28	28.19	29.45	14.47	24.56	17.75	21.30	32.60	16.02	34.36
454	CaS	30.30	28.81	23.31	19.54	17.23	40.46	47.81	50.86	40.28	24.50	22.05	28.28
455	CaSO4	0.00	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
456	Inerts	1.48	1.78	1.43	2.17	0.94	0.88	1.01	1.02	0.88	0.96	0.82	1.02
457													
458	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
459	PD Sorbent Fraction Composition, wt %												
460													
461	CaCO3	0.05	44.29	40.08	49.31	41.82	29.65	50.30	20.80	25.58	41.29	46.75	36.35
462	MgCO3	49.61	13.04	22.67	0.00	12.11	26.66	3.21	27.59	22.55	0.00	0.00	0.00
463	CaO	0.00	0.00	0.00	7.14	0.00	0.00	0.00	0.00	0.00	7.07	1.65	19.80
464	MgO	2.32	19.88	14.14	27.91	23.05	14.93	28.39	14.53	17.79	32.21	31.02	33.89

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL.

Set Point		TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
432	N	2.37	2.18	2.03	1.99	2.24	1.87	1.93	2.07	1.12	1.34	1.66	1.59
433	S	1.34	1.29	1.03	1.36	1.55	0.78	0.92	1.31	1.30	1.65	1.62	1.22
434	Ash	15.37	18.50	18.92	16.14	11.16	9.21	13.68	12.38	18.16	17.52	16.73	17.15
435													
436	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
437	Combined Bisch-Char Frac Comp, wt %												
438													
439	C	74.14	75.75	79.03	75.41	76.66	69.66	72.83	74.25	71.60	70.19	70.47	72.32
440	H	0.58	0.59	0.53	0.54	0.53	0.57	0.50	0.57	0.58	0.49	0.49	0.40
441	O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
442	N	2.00	2.10	1.96	2.04	1.90	1.50	1.62	1.70	1.27	1.39	1.35	1.35
443	S	1.37	1.28	1.05	1.85	2.39	0.46	1.20	1.00	2.86	2.72	3.25	3.36
444	Ash	21.92	20.28	17.43	20.16	18.52	27.81	23.86	22.47	23.69	25.22	24.44	22.57
445													
446	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
447													
448	CD-Sorbent Fraction Composition, wt %												
449													
450	CaCO ₃	45.93	30.40	27.29	52.98	59.55	34.97	17.66	22.42	23.46	26.15	17.00	20.57
451	MgCO ₃	13.24	0.00	0.00	5.06	1.57	0.00	0.00	0.00	0.00	25.91	0.00	26.47
452	CaO	0.00	4.57	4.97	0.00	0.00	28.60	43.75	60.66	11.85	0.00	15.45	0.00
453	MgO	22.24	32.94	33.28	26.89	28.62	26.16	29.81	2.07	29.85	12.81	31.87	12.86
454	CaS	17.79	31.10	33.46	14.22	9.40	9.69	8.24	14.35	33.06	34.17	34.56	39.14
455	CaSO ₄	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
456	Inerts	0.80	0.98	1.00	0.86	0.85	0.58	0.54	0.50	1.78	0.95	1.11	0.96
457													
458	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
459	PD-Sorbent Fraction Composition, wt %												
460													
461	CaCO ₃	46.09	42.53	36.15	44.60	39.34	47.24	51.39	50.57	30.27	33.19	34.93	31.42
462	MgCO ₃	13.84	3.41	9.03	0.00	17.88	0.00	5.45	0.00	0.00	0.00	15.90	1.08
463	CaO	0.00	0.00	0.00	5.31	0.00	5.05	0.00	27.64	17.62	5.79	0.00	0.00
464	MgO	21.83	29.02	25.92	31.62	19.80	23.45	20.33	1.75	29.77	29.41	18.60	28.24

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----	-----	-----	-----
Sorbent	-----Pittsburgh No. 8 Bituminous-----			
	Plum Run	Dolomite/Longview	Limestone	
432 N	0.00	2.75	1.68	0.84
433 S	0.00	1.91	1.14	0.57
434 Ash	9.21	100.00	29.15	31.81
435				
436 Total	100.00	100.00	100.00	0.00
437 Combined Disch Char Frac Comp, wt %				
438 -----				
439 C	65.78	79.03	72.78	2.73
440 H	0.34	0.63	0.52	0.07
441 O	0.00	0.00	0.00	0.00
442 N	1.27	2.10	1.79	0.25
443 S	0.46	3.36	1.64	0.79
444 Ash	17.43	31.11	23.26	2.94
445				
446 Total	100.00	100.00	100.00	0.00
447				
448 CD-Sorbent Fraction Composition, wt %				
449 -----				
450 CaCO ₃	5.40	59.55	29.99	13.58
451 MgCO ₃	0.00	35.75	10.58	12.10
452 CaO	0.00	60.66	8.07	15.13
453 MgO	2.07	34.36	23.06	8.73
454 CaS	8.24	50.86	27.19	11.71
455 CaSO ₄	0.00	1.45	0.06	0.29
456 Inerts	0.50	2.17	1.05	0.40
457				
458 Total	100.00	100.00	100.00	0.00
459 PD-Sorbent Fraction Composition, wt %				
460 -----				
461 CaCO ₃	0.05	51.39	38.08	11.33
462 MgCO ₃	0.00	49.61	10.17	12.40
463 CaO	0.00	27.64	4.04	7.26
464 MgO	1.75	33.89	22.49	8.46

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL.

Set Point		TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
465	CaS	46.56	21.10	21.67	13.48	22.11	27.91	17.15	36.13	33.25	18.48	19.66	8.95
466	CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
467	Inerts	1.47	1.69	1.44	2.16	0.91	0.85	0.95	0.95	0.84	0.95	0.92	1.01
468													
469	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
470	SD-Sorbent Fraction Composition, wt %												
471	-----												
472	CaCO3	40.65	57.21	32.21	45.41	46.98	38.75	54.74	50.55	39.61	36.13	34.73	32.17
473	MgCO3	32.77	2.53	31.48	0.00	8.73	13.19	2.02	0.00	11.89	0.00	0.00	0.00
474	CaO	0.00	0.00	0.00	12.97	0.00	0.00	0.00	2.69	0.00	14.08	12.95	22.48
475	MgO	9.47	25.51	9.14	28.78	24.78	22.97	28.73	30.11	23.46	33.44	33.36	34.58
476	CaS	15.69	13.02	25.76	10.61	18.59	24.19	13.55	15.62	24.18	15.37	17.96	9.74
477	CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
478	Inerts	1.41	1.73	1.40	2.22	0.91	0.89	0.95	1.03	0.85	0.99	1.00	1.03
479													
480	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
481	BD-Sorbent Fraction Composition, wt %												
482	-----												
483	CaCO3	0.00	0.00	0.00	0.00	59.20	44.41	48.70	30.38	22.43	23.40	20.47	34.70
484	MgCO3	0.00	0.00	0.00	0.00	13.37	13.51	0.00	16.78	18.67	0.00	0.00	0.00
485	CaO	0.00	0.00	0.00	0.00	0.00	0.00	7.95	0.00	0.00	26.72	29.01	24.66
486	MgO	0.00	0.00	0.00	0.00	20.52	22.19	31.48	20.73	20.66	36.00	36.40	34.55
487	CaS	0.00	0.00	0.00	0.00	6.07	19.01	10.87	31.12	37.37	12.82	13.02	5.06
488	CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
489	Inerts	0.00	0.00	0.00	0.00	0.85	0.88	1.00	0.99	0.87	1.06	1.09	1.03
490													
491	Total	0.00	0.00	0.00	0.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
492	Combined Disch-Sorbent Frac Comp, wt %												
493	-----												
494	CaCO3	23.00	41.15	37.45	46.19	47.53	17.50	36.06	10.11	21.98	37.23	39.14	28.06
495	MgCO3	37.65	8.22	25.51	0.00	5.76	28.74	7.41	25.08	19.79	0.00	17.63	0.00
496	CaO	0.00	0.00	0.00	7.37	0.00	0.00	0.15	0.01	0.00	7.19	1.07	15.07
497	MgO	7.98	23.14	12.54	28.21	26.69	14.76	27.03	17.23	19.97	32.63	20.02	34.23

**Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL**

Set Point		TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
465	CaS	17.44	24.14	28.01	17.55	22.15	23.73	22.41	19.62	20.56	30.51	29.64	38.18
466	CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
467	Inerts	0.80	0.91	0.90	0.92	0.82	0.52	0.42	0.42	1.78	1.11	0.92	1.08
468		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
469	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
470	SD-Sorbent Fraction Composition, wt %												
471	-----												
472	CaCO3	30.83	44.12	17.40	49.05	52.82	62.22	29.99	41.72	43.95	45.61	42.38	40.42
473	MgCO3	0.00	0.00	0.00	11.95	6.74	0.00	0.00	0.00	0.00	11.81	0.00	9.70
474	CaO	17.68	9.55	35.24	0.00	0.00	7.77	29.43	41.79	14.32	0.00	6.37	0.00
475	MgO	34.33	32.09	37.34	22.71	25.86	22.55	27.72	1.86	28.31	20.16	28.77	21.90
476	CaS	16.20	13.28	8.90	15.46	13.74	6.95	12.35	14.18	11.73	21.44	21.47	26.98
477	CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
478	Inerts	0.97	0.96	1.12	0.83	0.84	0.51	0.51	0.45	1.69	0.97	1.01	1.00
479		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
480	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
481	BD-Sorbent Fraction Composition, wt %												
482	-----												
483	CaCO3	52.86	35.48	27.50	40.97	36.49	48.74	40.37	61.80	42.08	23.16	48.39	15.03
484	MgCO3	6.45	29.05	0.00	9.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
485	CaO	0.00	0.00	18.89	0.00	11.84	16.77	18.71	28.77	17.13	30.03	9.73	34.16
486	MgO	26.05	12.71	34.68	25.18	33.16	24.23	26.07	1.69	28.72	32.51	28.54	33.50
487	CaS	13.82	21.97	17.90	23.54	17.55	9.72	14.38	7.33	10.35	13.08	12.34	16.06
488	CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
489	Inerts	0.82	0.79	1.04	0.87	0.96	0.54	0.47	0.41	1.72	1.22	1.00	1.25
490		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
491	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
492	Combined Disch-Sorbent Frac Comp, wt %												
493	-----												
494	CaCO3	45.90	32.36	28.40	51.19	56.63	36.79	23.09	29.88	28.20	27.22	23.58	22.24
495	MgCO3	12.93	1.33	1.23	4.52	3.42	0.00	0.76	0.00	0.00	21.11	3.24	20.80
496	CaO	0.28	3.80	5.12	0.93	0.30	25.83	36.81	52.95	14.35	2.14	11.56	1.58
497	MgO	22.47	31.79	32.37	27.52	27.72	25.81	28.36	1.99	29.66	16.01	28.84	16.51

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
465 CaS	8.95	46.56	24.18	8.22
466 CaSO4	0.00	0.00	0.00	0.00
467 Inerts	0.42	2.16	1.03	0.40
468				
469 Total	100.00	100.00	100.00	0.00
470 SD-Sorbent Fraction Composition, wt %				
471 -----				
472 CaCO3	17.40	62.22	42.07	9.74
473 MgCO3	0.00	32.77	5.95	9.22
474 CaO	0.00	41.79	9.47	12.00
475 MgO	1.86	37.34	25.33	8.38
476 CaS	6.95	26.98	16.12	5.34
477 CaSO4	0.00	0.00	0.00	0.00
478 Inerts	0.45	2.22	1.05	0.39
479				
480 Total	100.00	100.00	100.00	0.00
481 BD-Sorbent Fraction Composition, wt %				
482 -----				
483 CaCO3	0.00	61.80	31.52	18.39
484 MgCO3	0.00	29.05	4.47	7.87
485 CaO	0.00	34.16	11.43	12.08
486 MgO	0.00	36.40	22.07	12.51
487 CaS	0.00	37.37	13.06	9.24
488 CaSO4	0.00	0.00	0.00	0.00
489 Inerts	0.00	1.72	0.78	0.43
490				
491 Total	0.00	100.00	83.33	37.27
492 Combined Disch-Sorbent Frac Comp, wt %				
493 -----				
494 CaCO3	10.11	56.63	32.95	11.19
495 MgCO3	0.00	37.65	10.21	11.12
496 CaO	0.00	52.95	7.77	13.07
497 MgO	1.99	34.23	23.06	8.13

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point		TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
498	CaS	29.91	24.82	23.07	16.05	19.09	38.13	28.38	46.58	37.40	21.98	21.29	21.63
499	CaSO4	0.00	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
500	Inerts	1.46	1.75	1.43	2.18	0.93	0.87	0.97	1.00	0.86	0.96	0.85	1.02
501		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
502	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
503													
504	Carbonizer Exit Gas Comp., mol %												
505	-----												
506	CO	5.537	7.951	7.735	6.140	8.146	6.121	8.788	11.082	9.656	7.009	4.500	6.966
507	CO2	6.953	6.761	7.622	8.770	7.479	7.265	6.975	7.045	7.864	8.851	9.123	9.693
508	H2	4.342	4.747	5.108	6.080	3.234	4.035	2.642	4.842	4.266	4.565	5.424	6.152
509	H2O	9.066	7.641	8.601	11.511	6.164	7.354	5.899	6.521	9.113	11.557	18.129	19.233
510	CH4	2.081	1.165	2.485	3.318	1.361	2.429	0.651	1.803	2.743	1.332	1.717	0.893
511	C2H4	0.087	0.024	0.093	0.208	0.010	0.150	0.000	0.002	0.023	0.012	0.032	0.002
512	C2H6	0.032	0.000	0.037	0.313	0.005	0.500	0.011	0.000	0.028	0.006	0.023	0.000
513	N2	71.213	71.004	67.599	62.947	72.891	71.469	74.394	67.846	65.413	65.903	60.160	56.404
514	H2S	0.022	0.032	0.017	0.025	0.162	0.059	0.048	0.010	0.019	0.014	0.093	0.017
515	COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
516	NH3	0.187	0.168	0.200	0.170	0.048	0.171	0.080	0.297	0.326	0.263	0.348	0.110
517	Ar	0.480	0.507	0.501	0.517	0.501	0.448	0.514	0.552	0.549	0.489	0.451	0.528
518		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
519	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
520													
521	Orifice Gas Composition, mol %												
522	-----												
523	CO	4.964	6.965	6.863	5.320	7.798	5.838	8.411	10.806	9.435	6.824	4.385	6.724
524	CO2	6.233	5.923	6.763	7.600	7.160	6.930	6.676	6.870	7.684	8.617	8.891	9.356
525	H2	3.893	4.159	4.532	5.269	3.097	3.849	2.528	4.721	4.169	4.445	5.286	5.938
526	H2O	8.127	6.694	7.632	9.975	5.901	7.014	5.646	6.358	8.904	11.253	17.667	18.565
527	CH4	1.865	1.020	2.205	2.875	1.303	2.317	0.623	1.758	2.680	1.297	1.673	0.862
528	C2H4	0.078	0.021	0.083	0.180	0.009	0.143	0.000	0.002	0.022	0.011	0.032	0.002
529	C2H6	0.029	0.000	0.033	0.271	0.005	0.477	0.011	0.000	0.027	0.006	0.023	0.000
530	N2	74.192	74.599	71.252	67.892	74.047	72.786	75.490	68.645	66.204	66.802	61.174	57.919

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point		TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	LV Lime	PR DoLo	PR DoLo	PR DoLo	PR DoLo
498	CaS	17.60	29.76	31.90	14.97	11.08	10.99	10.45	14.70	26.01	32.54	31.72	37.87
499	CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
500	Inerts	0.81	0.97	0.99	0.87	0.85	0.58	0.53	0.48	1.77	0.98	1.06	0.99
501													
502	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
503													
504	Carbonizer Exit Gas Comp., mol %												
505	-----												
506	CO	5.015	8.389	8.777	6.268	5.572	9.037	7.326	7.315	6.543	6.660	7.536	6.654
507	CO2	9.321	9.846	9.841	9.128	9.581	8.917	10.284	8.562	9.459	8.589	8.493	7.615
508	H2	5.778	8.126	7.277	5.678	6.309	8.144	5.145	5.540	5.778	5.733	5.817	6.293
509	H2O	15.743	16.974	14.389	13.612	11.333	12.390	14.180	16.385	15.696	14.985	12.169	13.335
510	CH4	1.669	1.429	2.042	2.214	2.319	1.163	1.820	1.126	1.390	1.387	1.414	1.947
511	C2H4	0.060	0.000	0.002	0.051	0.032	0.002	0.000	0.000	0.008	0.009	0.007	0.009
512	C2H6	0.024	0.013	0.000	0.034	0.020	0.000	0.000	0.000	0.008	0.012	0.010	0.016
513	N2	61.686	54.531	57.015	62.331	64.089	59.456	60.483	60.328	60.489	62.003	63.907	63.375
514	H2S	0.038	0.007	0.009	0.029	0.099	0.124	0.007	0.000	0.008	0.002	0.000	0.124
515	COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
516	NH3	0.204	0.162	0.109	0.161	0.146	0.268	0.228	0.232	0.103	0.104	0.127	0.136
517	Ar	0.463	0.522	0.540	0.494	0.500	0.499	0.527	0.510	0.518	0.514	0.521	0.496
518													
519	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
520													
521	Orifice Gas Composition, mol %												
522	-----												
523	CO	4.845	8.244	8.536	6.106	5.429	8.791	7.146	7.231	6.439	6.556	7.411	6.532
524	CO2	9.005	9.676	9.571	8.892	9.334	8.674	10.031	8.464	9.308	8.455	8.353	7.475
525	H2	5.582	7.985	7.077	5.531	6.147	7.922	5.019	5.477	5.686	5.643	5.721	6.178
526	H2O	15.209	16.680	13.994	13.259	11.041	12.053	13.833	16.197	15.446	14.750	11.967	13.091
527	CH4	1.612	1.404	1.986	2.157	2.260	1.132	1.775	1.113	1.368	1.366	1.391	1.912
528	C2H4	0.057	0.000	0.002	0.050	0.031	0.002	0.000	0.000	0.008	0.009	0.007	0.009
529	C2H6	0.023	0.013	0.000	0.033	0.020	0.000	0.000	0.000	0.008	0.011	0.009	0.015
530	N2	62.985	55.319	58.195	63.306	65.012	60.559	61.452	60.784	61.118	62.598	64.504	64.045

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----	-----	-----	-----
Sorbent	-----Pittsburgh No. 8 Bituminous-----			
	Plum Run	Dolomite/Longview	Limestone	
498 CaS	10.45	46.58	24.91	9.53
499 CaSO4	0.00	0.92	0.04	0.18
500 Inerts	0.48	2.18	1.05	0.39
501				
502 Total	100.00	100.00	100.00	0.00
503				
504 Carbonizer Exit Gas Comp., mol %				
505 -----				
506 CO	4.500	11.082	7.280	1.505
507 CO2	6.761	10.284	8.502	1.051
508 H2	2.642	8.144	5.461	1.289
509 H2O	5.899	19.233	12.166	3.852
510 CH4	0.651	3.318	1.746	0.614
511 C2H4	0.000	0.208	0.034	0.052
512 C2H6	0.000	0.500	0.045	0.113
513 N2	54.531	74.394	64.039	5.247
514 H2S	0.000	0.162	0.040	0.045
515 COS	0.000	0.000	0.000	0.000
516 NH3	0.048	0.348	0.181	0.076
517 Ar	0.448	0.552	0.506	0.026
518				
519 Total	100.000	100.000	100.000	0.000
520				
521 Orifice Gas Composition, mol %				
522 -----				
523 CO	4.385	10.806	6.983	1.504
524 CO2	5.923	10.031	8.164	1.163
525 H2	2.528	7.985	5.244	1.301
526 H2O	5.646	18.565	11.719	3.896
527 CH4	0.623	2.875	1.665	0.554
528 C2H4	0.000	0.180	0.032	0.046
529 C2H6	0.000	0.477	0.042	0.105
530 N2	55.319	75.490	65.453	5.677

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point		TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo
531	H2S	0.020	0.028	0.015	0.022	0.155	0.056	0.046	0.010	0.019	0.014	0.090	0.016
532	COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
533	NH3	0.168	0.148	0.178	0.147	0.046	0.163	0.076	0.289	0.318	0.256	0.339	0.106
534	Ar	0.431	0.444	0.445	0.448	0.480	0.427	0.492	0.539	0.537	0.477	0.440	0.510
535		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
536	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
537													
538	Demister Gas Composition, mol %												
539	-----												
540	CO	4.322	5.899	5.877	4.451	6.729	4.974	7.179	9.631	8.422	6.000	3.880	5.827
541	CO2	5.427	5.016	5.791	6.358	6.178	5.904	5.698	6.123	6.859	7.577	7.866	8.108
542	H2	3.389	3.522	3.881	4.408	2.672	3.279	2.158	4.208	3.721	3.908	4.677	5.146
543	H2O	7.076	5.669	6.535	8.345	5.092	5.976	4.819	5.667	7.948	9.894	15.631	16.088
544	CH4	1.624	0.864	1.888	2.405	1.124	1.974	0.532	1.567	2.392	1.140	1.480	0.747
545	C2H4	0.068	0.018	0.071	0.151	0.008	0.122	0.000	0.002	0.020	0.010	0.028	0.002
546	C2H6	0.025	0.000	0.028	0.227	0.004	0.406	0.009	0.000	0.024	0.005	0.020	0.000
547	N2	77.531	78.487	75.383	73.139	77.605	76.814	79.081	72.055	69.834	70.810	65.649	63.534
548	H2S	0.017	0.024	0.013	0.018	0.134	0.048	0.039	0.009	0.017	0.012	0.080	0.014
549	COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
550	NH3	0.146	0.125	0.152	0.123	0.040	0.139	0.065	0.258	0.284	0.225	0.300	0.092
551	Ar	0.375	0.376	0.381	0.375	0.414	0.364	0.420	0.480	0.479	0.419	0.389	0.442
552		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
553	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL.

Set Point		TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
Coal		Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent		PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	LV Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
531	H2S	0.037	0.007	0.009	0.029	0.097	0.120	0.007	0.000	0.008	0.002	0.000	0.122
532	COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
533	NH3	0.197	0.159	0.106	0.156	0.143	0.261	0.222	0.230	0.102	0.103	0.125	0.133
534	Ar	0.447	0.513	0.525	0.482	0.487	0.485	0.515	0.504	0.510	0.506	0.512	0.487
535													
536	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000
537													
538	Demister Gas Composition, mol %												
539	-----												
540	CO	4.213	7.531	7.724	5.540	4.949	7.590	6.264	6.294	6.342	6.322	7.108	6.424
541	CO2	7.831	8.839	8.661	8.068	8.509	7.489	8.793	7.367	9.168	8.153	8.011	7.351
542	H2	4.854	7.295	6.404	5.019	5.603	6.840	4.399	4.767	5.600	5.442	5.487	6.075
543	H2O	13.226	15.238	12.663	12.031	10.065	10.406	12.125	14.098	15.213	14.224	11.478	12.874
544	CH4	1.402	1.283	1.797	1.957	2.060	0.977	1.556	0.969	1.347	1.317	1.334	1.880
545	C2H4	0.050	0.000	0.002	0.045	0.028	0.002	0.000	0.000	0.008	0.009	0.007	0.009
546	C2H6	0.020	0.012	0.000	0.030	0.018	0.000	0.000	0.000	0.008	0.011	0.009	0.015
547	N2	67.812	59.182	62.170	66.705	68.106	65.948	66.211	65.865	61.703	63.934	65.955	64.642
548	H2S	0.032	0.006	0.008	0.026	0.088	0.104	0.006	0.000	0.008	0.002	0.000	0.120
549	COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
550	NH3	0.171	0.145	0.096	0.142	0.130	0.225	0.195	0.200	0.100	0.099	0.120	0.131
551	Ar	0.389	0.469	0.475	0.437	0.444	0.419	0.451	0.439	0.502	0.488	0.491	0.479
552													
553	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000

Table 3.1 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH PITTSBURGH NO. 8 BITUMINOUS COAL

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----Pittsburgh No. 8 Bituminous-----			
Sorbent	Plum Run Dolomite/Longview Limestone			
531 H2S	0.000	0.155	0.039	0.044
532 COS	0.000	0.000	0.000	0.000
533 NH3	0.046	0.339	0.174	0.075
534 Ar	0.427	0.539	0.485	0.033
535				
536 Total	100.000	100.000	100.000	0.000
537				
538 Demister Gas Composition, mol %				
539 -----				
540 CO	3.880	9.631	6.229	1.364
541 CO2	5.016	9.168	7.298	1.187
542 H2	2.158	7.295	4.698	1.252
543 H2O	4.819	16.088	10.516	3.655
544 CH4	0.532	2.405	1.484	0.485
545 C2H4	0.000	0.151	0.028	0.039
546 C2H6	0.000	0.406	0.036	0.089
547 N2	59.182	79.081	69.090	5.760
548 H2S	0.000	0.134	0.034	0.039
549 COS	0.000	0.000	0.000	0.000
550 NH3	0.040	0.300	0.154	0.065
551 Ar	0.364	0.502	0.433	0.043
552				
553 Total	100.000	100.000	100.000	0.000

**Table 3.2. MEASURED AND DERIVED CARBONIZER DATA WITH
ILLINOIS NO. 6 BITUMINOUS COAL**

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----
1 Coal	111 Bit	111 Bit	111 Bit	111 Bit				
2 Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
3 Begin Date	4/23/92	4/23/92	6/12/92	6/13/92				
4 Begin Clock Time, hours	1800	2300	2100	0700				
5 End Clock Time, hours	2200	0330	0200	1100				
6 Steady-State Period Duration, h	4	4.5	5	4	4.0	5.0	4.4	0.4
7 Carbonizer Pressure, psig	143.5	122.4	113.2	160.6	113.2	160.6	134.9	18.4
8 Carbonizer Pressure, psia	158.2	137.1	127.9	175.3	127.9	175.3	149.6	18.4
9 Carbonizer Pressure, atm	10.76	9.33	8.70	11.93	8.70	11.93	10.18	1.26
10 Average Bed Temp, F	1600	1599	1652	1715	1599	1715	1642	48
11 Bed Temp (@ 1.5 ft), F	1605	1603	1645	1706	1603	1706	1640	42
12 Freeboard Temp (@ 22.5 ft), F	1573	1573	1623	1680	1573	1680	1612	44
13 Freeboard Temp (@ 27.5 ft), F	1536	1532	1588	1645	1532	1645	1575	46
14 Avg Bed T - Freebd T (@22.5 ft), F	27	26	29	35	26	35	29	3
15 Avg Bed T - Freebd T (@27.5 ft), F	64	67	64	70	64	70	66	2
16 Freebd T (@22.5 Ft - @27.5 ft), F	37	41	35	35	35	41	37	2
17								
18 Coal Feed Rate, lb/h	291.83	236.17	302.41	388.05	236.17	388.05	304.62	54.35
19 Sorbent Feed Rate, lb/h	35.94	38.73	75.62	101.16	35.94	101.16	62.86	27.10
20 Air Feed Rate, lb/h	634.07	512.72	668.53	935.47	512.72	935.47	687.70	154.31
21 Steam Feed Rate, lb/h	112.70	58.64	96.68	144.66	58.64	144.66	103.17	30.97
22 N2 Purges to Carbonizer, lb/h	186.67	186.32	177.90	209.21	177.90	209.21	190.02	11.62
23 N2 Purges to Cyclones + O.M., lb/h	21.88	23.46	18.42	26.67	18.42	26.67	22.61	2.97
24 N2 Purge to Spray Tower, lb/h	120.15	115.58	88.75	94.72	88.75	120.15	104.80	13.33
25 Total N2 Purges to System, lb/h	328.70	325.35	285.07	330.59	285.07	330.59	317.43	18.78
26 Air+Steam+N2 Feed to Carb., lb/h	933.44	757.68	943.11	1289.34	757.68	1289.34	980.89	192.77
27 Air+Steam+N2 Feed to System, lb/h	1075.47	896.71	1050.28	1410.72	896.71	1410.72	1108.30	187.53
28 Air Feed to Carbonizer, lbmol/h	21.889	17.700	23.079	32.294	17.700	32.294	23.741	5.327
29 Steam Feed to Carbonizer, lbmol/h	6.256	3.255	5.367	8.030	3.255	8.030	5.727	1.719
30 N2 Purges to Carbonizer, lbmol/h	6.663	6.651	6.350	7.468	6.350	7.468	6.783	0.415
31 Carbonizer Drain Rate, lb/h	77.66	80.33	84.76	94.05	77.66	94.05	84.20	6.23
32 Primary-Cyclone Drain Rate, lb/h	61.82	42.24	60.76	66.04	42.24	66.04	57.72	9.15
33 Secondary-Cyclone Drain Rate, lb/h	5.38	13.02	35.47	38.75	5.38	38.75	23.15	14.26
34 Baghouse Drain Rate, lb/h	28.86	15.39	25.44	36.56	15.39	36.56	26.56	7.60
35 Total Drains Rate, lb/h	173.72	150.98	206.42	235.41	150.98	235.41	191.63	32.05

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
36 Carbonizer Exit Gas, lb/h	1087.6	881.7	1114.9	1543.3	881.7	1543.3	1156.9	240.6
37 Orifice Gas, lb/h	1109.5	905.2	1133.3	1570.0	905.2	1570.0	1179.5	242.3
38 Demister Gas, lb/h	1229.7	1020.7	1222.1	1664.7	1020.7	1664.7	1284.3	235.1
39 Carbonizer Exit Gas, lbmol/h	43.074	34.197	43.018	59.162	34.197	59.162	44.863	9.012
40 Orifice Gas, lbmol/h	43.855	35.034	43.675	60.114	35.034	60.114	45.669	9.070
41 Demister Gas, lbmol/h	48.143	39.159	46.842	63.495	39.159	63.495	49.409	8.827
42								
43 Carbonizer Gas HHV, Btu/SCF(wet)	67.46	68.31	67.09	67.50	67.09	68.31	67.59	0.45
44 Carbonizer Gas LHV, Btu/SCF(wet)	51.13	54.28	52.76	53.21	51.13	54.28	52.84	1.13
45 Carbonizer Gas HHV, Btu/lb	1011.4	1003.1	980.1	979.6	979.6	1011.4	993.5	14.0
46 Carbonizer Gas LHV, Btu/lb	766.6	797.0	770.7	772.2	766.6	797.0	776.6	12.0
47								
48 Bed Density, lb/ft ³	12.58	11.81	14.63	30.02	11.81	30.02	17.26	7.44
49 Bed Height, ft	16.6	18.3	17.8	15.4	15.4	18.3	17.0	1.1
50 Bed Weight, lb	153.39	159.20	192.47	337.90	153.39	337.90	210.74	74.92
51 Bed Weight/Coal Feed Rate, lb/(lb/h)	0.526	0.674	0.636	0.871	0.526	0.871	0.677	0.125
52 Solids Residence Time, min	118.5	118.9	136.2	215.6	118.5	215.6	147.3	40.1
53								
54 Inlet Superficial Vel (D=10 in), ft/s	2.48	2.26	3.14	3.24	2.26	3.24	2.78	0.42
55 Product Gas Super. Vel (D=10 in), ft/s	3.06	2.81	3.88	4.01	2.81	4.01	3.44	0.52
56 Product Gas Super. Vel (D=12 in), ft/s	2.13	1.95	2.69	2.78	1.95	2.78	2.39	0.36
57 Freebd Gas Super. Vel (D=14 in), ft/s	1.54	1.41	1.95	2.01	1.41	2.01	1.73	0.26
58 Gas Residence Time, s	7.3	8.8	6.2	5.1	5.1	8.8	6.9	1.4
59								
60 Carbonizer Wall Heat Losses, Btu/h	95328	106322	83999	68784	68784	106322	88608	13903
61 Overhead Heat Losses, Btu/h	119524	100720	243227	280170	100720	280170	185910	77192
62								
63 Moisture in Coal Feed, %	11.34	10.73	9.88	10.25	9.88	11.34	10.55	0.55
64 Coal Feed (MF), lb/h	258.73	210.82	272.53	348.29	210.82	348.29	272.59	49.34
65 Carbon in Coal Feed, lb/h	180.49	148.95	188.76	238.30	148.95	238.30	189.12	32.04
66								
67 H ₂ Content in Freeboard Gas, mol%	7.04	6.55	7.08	7.23	6.55	7.23	6.98	0.26
68 P(H ₂) in Carbonizer Gas, psia	11.1	9.0	9.1	12.7	9.0	12.7	10.5	1.5

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
69 Available Hydrogen, lbatom/lbatom	0.773	0.779	0.648	0.645	0.645	0.779	0.711	0.065
70 CH ₄ Yield, % of Feed Carbon	4.267	4.395	4.030	4.599	4.030	4.599	4.323	0.206
71 C ₂ H ₄ Yield, % of Feed Carbon	0.282	0.246	0.203	0.000	0.000	0.282	0.183	0.109
72 C ₂ H ₆ Yield, % of Feed Carbon	0.090	0.101	0.155	0.115	0.090	0.155	0.115	0.025
73 Total HC Yield, % of Feed Carbon	4.639	4.742	4.387	4.714	4.387	4.742	4.621	0.140
74 CH ₄ in Freeboard Gas, mol%	1.489	1.594	1.472	1.542	1.472	1.594	1.524	0.048
75 C ₂ H ₄ in Freeboard Gas, mol%	0.049	0.045	0.037	0.000	0.000	0.049	0.033	0.019
76 C ₂ H ₆ in Freeboard Gas, mol%	0.016	0.018	0.028	0.019	0.016	0.028	0.020	0.005
77 Total HC in Freeboard Gas, mol%	1.554	1.657	1.538	1.562	1.538	1.657	1.577	0.047
78 CH ₄ in Demister Gas, mol%	1.332	1.392	1.352	1.437	1.332	1.437	1.378	0.040
79 C ₂ H ₄ in Demister Gas, mol%	0.044	0.039	0.034	0.000	0.000	0.044	0.029	0.017
80 C ₂ H ₆ in Demister Gas, mol%	0.014	0.016	0.026	0.018	0.014	0.026	0.019	0.005
81 Total HC in Demister Gas, mol%	1.390	1.447	1.412	1.455	1.390	1.455	1.426	0.026
82								
83 Water Content in Freeboard Gas, mol%	21.75	17.05	17.86	17.76	17.05	21.75	18.60	1.84
84 P(H ₂ O) in Carbonizer Gas, psia	34.4	23.4	22.8	31.1	22.8	34.4	27.9	5.0
85 Water-Gas Shift Temp, F	1821	1792	1646	1585	1585	1821	1711	98
86 WGS Temp - Avg Bed Temp, F	221	193	-6	-130	-130	221	70	145
87 WGS Temp - Freebd Temp(@22.5 ft), F	248	219	23	-95	-95	248	99	141
88 WGS Temp - Freebd Temp(@27.5 ft), F	285	260	58	-60	-60	285	136	143
89								
90 Oxygen in Air Feed, lbmol/h	4.595	3.716	4.845	6.779	3.716	6.779	4.984	1.118
91 Feed O ₂ /Carbon in feed, mol/mol	0.306	0.300	0.308	0.342	0.300	0.342	0.314	0.016
92 Feed Air/Feed Coal, lb/lb	2.173	2.171	2.211	2.411	2.171	2.411	2.241	0.099
93 Feed Air/Feed Coal, lb/lb(MF)	2.451	2.432	2.453	2.686	2.432	2.686	2.505	0.105
94 Feed Air/Feed Coal, lb/lb(MAF)	2.799	2.754	2.816	3.103	2.754	3.103	2.868	0.138
95 Feed Steam/Carbon in Feed, mol/mol	0.416	0.262	0.341	0.405	0.262	0.416	0.356	0.061
96 Feed Steam/Feed Coal, lb/lb	0.386	0.248	0.320	0.373	0.248	0.386	0.332	0.054
97 Feed Steam/Feed Coal, lb/lb(MF)	0.436	0.278	0.355	0.415	0.278	0.436	0.371	0.061
98 Total (Steam+Moist)/Carbon, mol/mol	0.538	0.376	0.447	0.516	0.376	0.538	0.469	0.064
99 Total (Steam+Moist)/Coal, lb/lb	0.500	0.356	0.419	0.475	0.356	0.500	0.437	0.056
100 Total (Steam+Moist)/Coal, lb/lb(MF)	0.564	0.398	0.464	0.530	0.398	0.564	0.489	0.063
101 Bed Drain Char/Coal Feed, lb/lb(MF)	0.2036	0.2391	0.1152	0.1072	0.1072	0.2391	0.1663	0.0565

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
102 Total Char/Coal Feed, lb/lb(MF)	0.5529	0.5481	0.5192	0.4692	0.4692	0.5529	0.5223	0.0333
103 (Char+Spent Sorb)/(Coal+Sorbent), lb/lb	0.530	0.549	0.546	0.481	0.481	0.549	0.527	0.027
104 HHV of (Char+Spent Sorb), Btu/lb(MF)	9227	8416	8446	8857	8416	9227	8736	333
105								
106 Carbon Conversion in CD, %	65.63	59.59	74.03	81.66	59.59	81.66	70.23	8.36
107 Carbon Conversion in PD, %	16.42	8.46	30.95	33.74	8.46	33.74	22.39	10.39
108 Carbon Conversion in SD, %	54.52	29.82	34.56	36.28	29.82	54.52	38.79	9.38
109 Carbon Conversion in BD, %	8.59	22.15	24.56	26.50	8.59	26.50	20.45	7.02
110 Carbon Conversion in Mixture, %	42.71	41.61	46.18	52.62	41.61	52.62	45.78	4.29
111 Hydrogen Conversion in Mixture, %	93.15	93.40	92.00	91.46	91.46	93.40	92.50	0.80
112 Oxygen Conversion in Mixture, %	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
113 Nitrogen Conversion in Mixture, %	52.33	51.00	61.35	72.40	51.00	72.40	59.27	8.56
114 Sulfur Conversion in Mixture, %	48.25	80.82	75.68	92.06	48.25	92.06	74.20	16.11
115								
116 Coal Hydrogen Released, %	93.15	93.40	92.00	91.46	91.46	93.40	92.50	0.80
117 Coal Nitrogen Released, %	52.33	51.00	61.35	72.40	51.00	72.40	59.27	8.56
118 Released Nitrogen Going to NH ₃ , %	72.53	86.42	55.24	28.91	28.91	86.42	60.77	21.46
119 Coal Nitrogen Going to NH ₃ , %	37.95	44.07	33.89	20.93	20.93	44.07	34.21	8.48
120 NH ₃ Concentration in Freeboard, ppm	2850	3424	2428	1384	1384	3424	2522	746
121								
122 Coal Sulfur Released, %	48.25	80.82	75.68	92.06	48.25	92.06	74.20	16.11
123 Sulfur Remaining in Chars Frac., %	51.75	19.18	24.32	7.94	7.94	51.75	25.80	16.11
124 Organic Sulfur in Chars Fraction, %	54.68	43.91	24.51	7.84	7.84	54.68	32.74	17.99
125 Sulfur in Freeboard Gas, % Coal S	5.93	57.08	2.17	0.36	0.36	57.08	16.39	23.58
126 Sulfur in Solids Discharges, % Coal S	94.07	42.92	97.83	99.64	42.92	99.64	83.61	23.58
127 Sulfur in Freeboard Gas, % Rel S	12.30	70.63	2.87	0.39	0.39	70.63	21.55	28.68
128 Sulfur Capture by Sorbent, % Rel S	87.70	29.37	97.13	99.61	29.37	99.61	78.45	28.68
129 Feed Ca/Feed S Ratio, mol/mol	1.302	1.650	2.629	2.775	1.302	2.775	2.089	0.628
130 Feed Ca/Released S Ratio, mol/mol	2.699	2.041	3.474	3.015	2.041	3.474	2.807	0.521
131 H ₂ S Concentration in Freeboard, ppm	369	3802	142	21	21	3802	1083	1574
132 Sorbent Ca Conversion/Utilization, %	32.94	14.85	28.48	33.62	14.85	33.62	27.47	7.55
133 CaS in Solids Discharges as CaSO ₄ , %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
134								

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
135 O/C in Coal Feed, lbatom/lbatom	0.0844	0.0792	0.0951	0.1002	0.0792	0.1002	0.0897	0.0084
136 H/C in Coal Feed, lbatom/lbatom	0.837	0.838	0.720	0.720	0.720	0.838	0.779	0.059
137 H/C in Combined Disch, lbatom/lbatom	0.100	0.095	0.107	0.130	0.095	0.130	0.108	0.013
138 N/C in Coal Feed, lbatom/lbatom	0.022	0.021	0.020	0.020	0.020	0.022	0.021	0.001
139 N/C in Combined Disch, lbatom/lbatom	0.018	0.018	0.014	0.011	0.011	0.018	0.015	0.003
140 S/C in Coal Feed, lbatom/lbatom	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.000
141 S/C in Combined Disch, lbatom/lbatom	0.016	0.006	0.008	0.003	0.003	0.016	0.008	0.005
142 Char(N/C)/Coal(N/C) - molar basis	0.832	0.839	0.718	0.583	0.583	0.839	0.743	0.104
143 Char(S/C)/Coal(S/C) - molar basis	0.903	0.329	0.452	0.168	0.168	0.903	0.463	0.274
144								
145 Mg/Ca in Sorbent, lbmol/lbmol	0.021	0.022	0.024	0.018	0.018	0.024	0.021	0.002
146 Ca/Mg in Sorbent, lbmol/lbmol	46.985	45.897	41.609	55.689	41.609	55.689	47.545	5.114
147 Mg/Ca in Sorbent, lb/lb	0.013	0.013	0.015	0.011	0.011	0.015	0.013	0.001
148 Ca/Mg in Sorbent, lb/lb	77.480	75.687	68.614	91.834	68.614	91.834	78.404	8.433
149 MgCO ₃ /CaCO ₃ in Sorbent Feed, mol/mol	0.0214	0.0219	0.0242	0.0181	0.0181	0.0242	0.0214	0.0022
150 CaS/CaCO ₃ in Sorbent Feed, mol/mol	0.00476	0.00480	0.00554	0.00562	0.00476	0.00562	0.00518	0.00040
151								
152 Coal Feed HHV, Btu/lb (MF)	12457	12536	12514	12459	12457	12536	12492	34
153								
154 HHV of Gas/HHV of Coal, %	34.13	33.47	32.04	34.84	32.04	34.84	33.62	1.03
155 HHV of Gas/(HHV of Coal-HCALC), %	34.42	33.84	32.59	35.47	32.59	35.47	34.08	1.04
156 LHV of Gas/LHV of Coal, %	27.16	27.90	26.26	28.62	26.26	28.62	27.48	0.88
157 LHV of Gas/(LHV of Coal-HCALC), %	27.40	28.23	26.72	29.16	26.72	29.16	27.88	0.91
158								
159 HHV of Coal Char/HHV of Coal, %	48.89	49.70	45.25	39.69	39.69	49.70	45.88	3.95
160 HHV of Drains/(HHV of Coal-HCALC), %	50.16	48.62	52.00	48.92	48.62	52.00	49.92	1.33
161 LHV of Coal Char/LHV of Coal, %	51.06	51.90	46.89	41.09	41.09	51.90	47.73	4.28
162 LHV of Drains/(LHV of Coal-HCALC), %	52.41	50.78	53.96	50.74	50.74	53.96	51.97	1.33
163								
164 Feed CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
165 CD CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	90.8	33.7	33.7	100.0	81.1	27.6
166 PD - CaCO ₃ /(CaCO ₃ +CaO), mole %	25.1	35.9	56.6	36.4	25.1	56.6	38.5	11.4
167 SD - CaCO ₃ /(CaCO ₃ +CaO), mole %	12.5	39.2	46.4	38.2	12.5	46.4	34.1	12.9

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
168 BD - $\text{CaCO}_3/(\text{CaCO}_3+\text{CaO})$, mole %	53.6	44.4	41.6	23.9	23.9	53.6	40.9	10.8
169 Mixt - $\text{CaCO}_3/(\text{CaCO}_3+\text{CaO})$, mole %	80.4	87.9	82.1	34.1	34.1	87.9	71.1	21.6
170								
171 Feed - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
172 CD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	100.0	100.0	0.0	0.0	0.0	100.0	50.0	50.0
173 PD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
174 SD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
175 BD - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
176 Mixt - $\text{MgCO}_3/(\text{MgCO}_3+\text{MgO})$, mole %	77.1	80.4	0.0	0.0	0.0	80.4	39.4	39.4
177								
178 Feed - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	0.5	0.5	0.6	0.6	0.5	0.6	0.5	0.0
179 CD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	36.8	14.4	30.0	38.6	14.4	38.6	29.9	9.5
180 PD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	18.8	17.9	26.1	14.8	14.8	26.1	19.4	4.1
181 SD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	10.9	21.5	13.0	13.4	10.9	21.5	14.7	4.0
182 BD - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	24.5	0.0	18.9	14.7	0.0	24.5	14.5	9.1
183 Mixt - $\text{CaS}/(\text{CaCO}_3+\text{CaO}+\text{CaS}+\text{CaSO}_4)$, mole %	32.8	14.8	28.3	33.4	14.8	33.4	27.3	7.5
184								
185 Feed - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
186 CD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
187 PD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
188 SD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
189 BD - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190 Mixt - $\text{CaSO}_4/(\text{CaS}+\text{CaSO}_4)$, mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
191								
192 Actual PCO_2 , psia	13.72	11.31	13.34	20.40	11.31	20.40	14.69	3.42
193 Equilibrium PCO_2 (Squires), psia	9.95	9.87	15.40	25.39	9.87	25.39	15.15	6.32
194 Equilibrium PCO_2 (IGT/B&K), psia	21.32	21.14	33.39	55.84	21.14	55.84	32.92	14.13
195 Equilibrium PCO_2 (H&W), psia	9.68	9.60	14.61	23.42	9.60	23.42	14.33	5.63
196								
197 Actual PCO_2 -Equil PCO_2 (Squires), psia	3.77	1.44	-2.06	-5.00	-5.00	3.77	-0.46	3.34
198 Actual PCO_2 -Equil PCO_2 (IGT/B&K), psia	-7.60	-9.82	-20.05	-35.45	-35.45	-7.60	-18.23	10.99
199 Actual PCO_2 -Equil PCO_2 (H&W), psia	4.05	1.71	-1.27	-3.03	-3.03	4.05	0.37	2.72
200								

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	IR6-6	IR6-7	IR6-4	IR6-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
201 Actual PCO ₂ /Equil PCO ₂ (Squires), psia	1.38	1.15	0.87	0.80	0.80	1.38	1.05	0.23
202 Actual PCO ₂ /Equil PCO ₂ (IGT/B&K), psia	0.64	0.54	0.40	0.37	0.37	0.64	0.49	0.11
203 Actual PCO ₂ /Equil PCO ₂ (H&W), psia	1.42	1.18	0.91	0.87	0.87	1.42	1.10	0.22
204								
205 Sulfur in Coal Feed, lb/h	8.585	7.302	8.978	11.435	7.302	11.435	9.075	1.497
206 Sulfur in Combined Char Discharge, lb/h	4.443	1.401	2.183	0.908	0.908	4.443	2.234	1.354
207 H ₂ S Without Sorbent Feed, lbmol/h	0.1292	0.1841	0.2120	0.3284	0.1292	0.3284	0.2134	0.0727
208 Carbonizer Exit Gas, lbmol/h	43.0737	34.1965	43.0175	59.1624	34.1965	59.1624	44.8625	9.0119
209 H ₂ S Without Sorbent Feed, ppm	2999	5383	4927	5550	2999	5550	4715	1016
210								
211 * For Reaction: CaO+H ₂ S=CaS+H ₂ O								
212 Equilibrium Constant (= H ₂ O/H ₂ S)	641.914	644.126	539.193	441.411	441.411	644.126	566.661	83.824
213 Equilibrium H ₂ S Concentration, ppm	338.8	264.7	331.2	402.3	264.7	402.3	334.2	48.7
214 Approach to Equilibrium Conc.(1), %	91.87	6.96	233.95	1874.10	6.96	1874.10	551.72	767.77
215 Approach to Equilibrium Capture(1), %	98.87	30.89	104.13	107.40	30.89	107.40	85.32	31.57
216								
217 * For Reaction: CaCO ₃ +H ₂ S=CaS+H ₂ O+CO ₂								
218 Equilibrium Const (=CO ₂ *H ₂ O*P/H ₂ S)	434.809	432.571	564.852	762.655	432.571	762.655	548.722	134.624
219 Equilibrium H ₂ S Concentration, ppm	467.1	303.4	286.9	323.1	286.9	467.1	345.1	71.6
220 Approach to Equilibrium Conc.(2), %	126.64	7.98	202.68	1505.36	7.98	1505.36	460.67	607.13
221 Approach to Equilibrium Capture(2), %	103.88	31.13	103.13	105.77	31.13	105.77	85.98	31.68
222								
223 Diff. in Apprch to Equil Conc (2-1), %	34.77	1.02	-31.27	-368.74	-368.74	34.77	-91.05	162.01
224 Diff. in Apprch to Equil Capt (2-1), %	5.01	0.24	-0.99	-1.63	-1.63	5.01	0.66	2.60
225								
226 Coal Feed Temp, F	76.0	76.0	76.0	76.0	76.0	76.0	76.0	0.0
227 Sorbent Feed Temp, F	76.0	76.0	76.0	76.0	76.0	76.0	76.0	0.0
228 Air Feed Temp, F	87.6	89.1	83.7	80.7	80.7	89.1	85.3	3.3
229 Steam Feed Temp, F	387.3	387.7	386.8	387.0	386.8	387.7	387.2	0.3
230 Purge N ₂ Temp, F	164.6	160.6	117.2	116.6	116.6	164.6	139.8	22.9
231								
232 Orifice Temp, F	1297	1267	1071	1214	1071	1297	1212	87
233 Orifice Pressure, psig	140.7	120.2	112.7	159.9	112.7	159.9	133.4	18.4

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL.

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	III Bit	III Bit	III Bit	III Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
234 Orifice Diameter, in	0.49	0.49	0.54	0.54	0.49	0.54	0.52	0.03
235 Bed Density DP (DH = 3.0 ft), in H2O	7.257	6.811	8.439	17.312	6.811	17.312	9.955	4.289
236 Bed Level DP (PDI-3057), in H2O	35.395	36.949	44.609	77.584	35.395	77.584	48.634	17.074
237								
238 Carbonizer Drain, % of Total Drains	44.70	53.21	41.06	39.95	39.95	53.21	44.73	5.20
239 Primary-Cyclone Drain, %	35.59	27.98	29.44	28.06	27.98	35.59	30.26	3.13
240 Secondary-Cyclone Drain, %	3.09	8.62	17.18	16.46	3.09	17.18	11.34	5.83
241 Baghouse Drain, %	16.61	10.19	12.32	15.53	10.19	16.61	13.66	2.55
242								
243 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
244								
245 CD Char, lb/h	52.67	50.41	31.40	37.35	31.40	52.67	42.96	8.87
246 CD Sorbent, lb/h	24.99	29.92	53.36	56.70	24.99	56.70	41.24	13.95
247 PD Char, lb/h	57.70	38.30	53.90	58.74	38.30	58.74	52.16	8.20
248 PD Sorbent, lb/h	4.13	3.94	6.86	7.30	3.94	7.30	5.56	1.53
249 SD Char, lb/h	4.96	12.14	32.78	33.31	4.96	33.31	20.80	12.51
250 SD Sorbent, lb/h	0.41	0.88	2.69	5.44	0.41	5.44	2.36	1.97
251 BD Char, lb/h	27.71	14.70	23.43	34.02	14.70	34.02	24.96	7.02
252 BD Sorbent, lb/h	1.15	0.69	2.01	2.54	0.69	2.54	1.60	0.72
253 Mixt Char, lb/h	143.04	115.54	141.50	163.41	115.54	163.41	140.88	16.99
254 Mixt Sorbent, lb/h	30.68	35.44	64.92	71.99	30.68	71.99	50.76	17.95
255								
256 Char in Carbonizer Drain, %	67.83	62.75	37.04	39.71	37.04	67.83	51.83	13.61
257 Char in Primary-Cyclone Drain, %	93.33	90.67	88.71	88.94	88.71	93.33	90.41	1.85
258 Char in Secondary-Cyclone Drain, %	92.28	93.22	92.42	85.95	85.95	93.22	90.97	2.92
259 Char in Baghouse Drain, %	96.01	95.52	92.11	93.05	92.11	96.01	94.17	1.64
260 Char in Total Drains, %	82.34	76.53	68.55	69.42	68.55	82.34	74.21	5.62
261								
262 Sorbent in Carbonizer Drain, %	32.17	37.25	62.96	60.29	32.17	62.96	48.17	13.61
263 Sorbent in Primary-Cyclone Drain, %	6.67	9.33	11.29	11.06	6.67	11.29	9.59	1.85
264 Sorbent in Secondary-Cyclone Drain, %	7.72	6.78	7.58	14.05	6.78	14.05	9.03	2.92
265 Sorbent in Baghouse Drain, %	3.99	4.48	7.89	6.95	3.99	7.89	5.83	1.64
266 Sorbent in Total Drains, %	17.66	23.47	31.45	30.58	17.66	31.45	25.79	5.62

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	Ill Bit	Ill Bit	Ill Bit	Ill Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
267								
268 Coal Feed Composition, wt %								
269 -----								
270 C	61.846	63.071	62.418	61.409	61.409	63.071	62.186	0.624
271 H	4.343	4.437	3.770	3.711	3.711	4.437	4.065	0.327
272 O	6.952	6.652	7.911	8.198	6.652	8.198	7.428	0.643
273 N	1.553	1.576	1.428	1.413	1.413	1.576	1.492	0.073
274 S	2.942	3.092	2.969	2.947	2.942	3.092	2.987	0.061
275 Ash	11.021	10.438	11.623	12.076	10.438	12.076	11.289	0.618
276 Moisture	11.344	10.734	9.882	10.247	9.882	11.344	10.552	0.548
277								
278 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
279 MF Coal Feed Composition, wt %								
280 -----								
281 C	69.760	70.656	69.262	68.420	68.420	70.656	69.524	0.810
282 H	4.898	4.970	4.183	4.135	4.135	4.970	4.547	0.389
283 O	7.841	7.452	8.778	9.134	7.452	9.134	8.301	0.681
284 N	1.752	1.765	1.585	1.574	1.574	1.765	1.669	0.090
285 S	3.318	3.464	3.294	3.283	3.283	3.464	3.340	0.073
286 Ash	12.431	11.693	12.897	13.454	11.693	13.454	12.619	0.646
287								
288 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
289								
290 Sorbent Feed Composition, wt %								
291 -----								
292 CaCO3	97.090	97.116	97.456	97.951	97.090	97.951	97.403	0.348
293 MgCO3	1.749	1.791	1.984	1.490	1.490	1.984	1.753	0.176
294 CaO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
295 MgO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
296 CaS	0.333	0.336	0.389	0.397	0.333	0.397	0.364	0.029
297 CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
298 Inerts	0.828	0.757	0.171	0.162	0.162	0.828	0.479	0.314
299								

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
300 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
301								
302 CD Composition, wt %								
303 -----								
304 C	41.803	43.791	20.563	18.942	18.942	43.791	31.275	11.558
305 H	0.241	0.268	0.146	0.427	0.146	0.427	0.270	0.101
306 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
307 N	0.732	0.757	0.374	0.030	0.030	0.757	0.473	0.297
308 S	3.378	0.000	1.212	0.000	0.000	3.378	1.148	1.380
309 Ash	21.672	17.932	14.745	20.315	14.745	21.672	18.666	2.630
310 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
311 CaCO ₃	22.011	32.341	44.494	17.303	17.303	44.494	29.037	10.451
312 MgCO ₃	0.624	0.694	0.000	0.000	0.000	0.694	0.330	0.330
313 CaO	0.000	0.000	2.539	19.031	0.000	19.031	5.392	7.942
314 MgO	0.000	0.000	0.677	0.603	0.000	0.677	0.320	0.321
315 CaS	9.242	3.924	15.127	23.212	3.924	23.212	12.876	7.163
316 CaSO ₄	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
317 Inerts	0.296	0.293	0.122	0.138	0.122	0.296	0.212	0.082
318								
319 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
320								
321 PD Composition, wt %								
322 -----								
323 C	73.248	73.195	67.648	66.796	66.796	73.248	70.222	3.015
324 H	0.720	0.657	0.585	0.604	0.585	0.720	0.642	0.052
325 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
326 N	1.553	1.624	1.149	0.987	0.987	1.624	1.328	0.268
327 S	2.189	1.957	1.083	0.727	0.727	2.189	1.489	0.603
328 Ash	15.617	13.232	18.244	19.825	13.232	19.825	16.729	2.517
329 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
330 CaCO ₃	1.952	3.744	5.924	4.705	1.952	5.924	4.081	1.452
331 MgCO ₃	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
332 CaO	3.261	3.747	2.545	4.602	2.545	4.602	3.539	0.748

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	Ill Bit	Ill Bit	Ill Bit	Ill Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
333 MgO	0.082	0.111	0.137	0.110	0.082	0.137	0.110	0.019
334 CaS	1.297	1.634	2.660	1.619	1.297	2.660	1.802	0.513
335 CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
336 Inerts	0.081	0.099	0.025	0.025	0.025	0.099	0.058	0.033
337								
338 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
339								
340 SD Composition, wt %								
341								
342 C	63.666	71.866	69.944	64.092	63.666	71.866	67.392	3.581
343 H	0.624	0.667	0.680	0.548	0.548	0.680	0.630	0.052
344 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
345 N	1.550	1.877	1.037	0.962	0.962	1.877	1.356	0.376
346 S	1.501	1.867	0.858	0.570	0.570	1.867	1.199	0.512
347 Ash	24.942	16.947	19.902	19.779	16.947	24.942	20.392	2.881
348 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
349 CaCO3	1.334	2.795	3.974	6.317	1.334	6.317	3.605	1.824
350 MgCO3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
351 CaO	5.240	2.425	2.568	5.720	2.425	5.720	3.988	1.502
352 MgO	0.103	0.080	0.095	0.138	0.080	0.138	0.104	0.021
353 CaS	0.938	1.406	0.925	1.843	0.925	1.843	1.278	0.379
354 CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
355 Inerts	0.102	0.070	0.017	0.031	0.017	0.102	0.055	0.033
356								
357 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
358								
359 BD Composition, wt %								
360								
361 C	77.053	74.873	71.758	71.498	71.498	77.053	73.796	2.302
362 H	0.702	0.730	0.754	0.595	0.595	0.754	0.695	0.061
363 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
364 N	1.901	1.854	1.124	1.260	1.124	1.901	1.535	0.347
365 S	1.337	2.151	0.761	0.566	0.566	2.151	1.204	0.616

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
366 Ash	15.021	15.916	17.713	19.130	15.021	19.130	16.945	1.591
367 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
368 CaCO ₃	2.029	2.576	3.543	2.077	2.029	3.543	2.556	0.609
369 MgCO ₃	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
370 CaO	0.985	1.804	2.792	3.704	0.985	3.704	2.321	1.023
371 MgO	0.043	0.051	0.102	0.074	0.043	0.102	0.067	0.023
372 CaS	0.886	0.000	1.435	1.079	0.000	1.435	0.850	0.529
373 CaSO ₄	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
374 Inerts	0.043	0.045	0.018	0.017	0.017	0.045	0.031	0.013
375								
376 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
377								
378 Combined Discharges Comp., wt %								
379								
380 C	59.526	57.606	49.216	47.962	47.962	59.526	53.578	5.054
381 H	0.500	0.458	0.442	0.523	0.442	0.523	0.481	0.032
382 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
383 N	1.244	1.208	0.808	0.643	0.643	1.244	0.976	0.257
384 S	2.558	0.928	1.058	0.386	0.386	2.558	1.232	0.806
385 Ash	18.514	16.327	17.027	19.905	16.327	19.905	17.943	1.381
386 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
387 CaCO ₃	10.913	18.759	21.133	9.595	9.595	21.133	15.100	4.940
388 MgCO ₃	0.279	0.369	0.000	0.000	0.000	0.369	0.162	0.165
389 CaO	1.486	1.441	2.577	10.411	1.441	10.411	3.979	3.741
390 MgO	0.040	0.043	0.347	0.306	0.040	0.347	0.184	0.143
391 CaS	4.769	2.666	7.330	10.199	2.666	10.199	6.241	2.819
392 CaSO ₄	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
393 Inerts	0.171	0.194	0.063	0.070	0.063	0.194	0.125	0.059
394								
395 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
396								
397 CD-Char Fraction Composition, wt %								
398								

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
399 C	61.63	69.79	55.52	47.70	47.70	69.79	58.66	8.11
400 H	0.36	0.43	0.39	1.08	0.36	1.08	0.56	0.30
401 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
402 N	1.08	1.21	1.01	0.08	0.08	1.21	0.84	0.45
403 S	4.98	0.00	3.27	0.00	0.00	4.98	2.06	2.15
404 Ash	31.95	28.58	39.81	51.15	28.58	51.15	37.87	8.68
405								
406 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
407 PD-Char Fraction Composition, wt %								
408 -----								
409 C	78.49	80.73	76.26	75.10	75.10	80.73	77.64	2.16
410 H	0.77	0.72	0.66	0.68	0.66	0.77	0.71	0.04
411 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
412 N	1.66	1.79	1.30	1.11	1.11	1.79	1.47	0.27
413 S	2.35	2.16	1.22	0.82	0.82	2.35	1.64	0.64
414 Ash	16.73	14.59	20.57	22.29	14.59	22.29	18.55	3.04
415								
416 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
417 SD Char Fraction Composition, wt %								
418								
419 C	68.99	77.09	75.68	74.57	68.99	77.09	74.08	3.07
420 H	0.68	0.72	0.74	0.64	0.64	0.74	0.69	0.04
421 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
422 N	1.68	2.01	1.12	1.12	1.12	2.01	1.48	0.38
423 S	1.63	2.00	0.93	0.66	0.66	2.00	1.31	0.53
424 Ash	27.03	18.18	21.53	23.01	18.18	27.03	22.44	3.18
425								
426 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
427 BD Char Fraction Composition, wt %								
428 -----								
429 C	80.25	78.38	77.90	76.84	76.84	80.25	78.34	1.23
430 H	0.73	0.76	0.82	0.64	0.64	0.82	0.74	0.07
431 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
432 N	1.98	1.94	1.22	1.35	1.22	1.98	1.62	0.34
433 S	1.39	2.25	0.83	0.61	0.61	2.25	1.27	0.64
434 Ash	15.64	16.66	19.23	20.56	15.64	20.56	18.02	1.96
435								
436 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
437 Combined Disch-Char Frac Comp, wt %								
438 -----								
439 C	72.29	75.28	71.79	69.09	69.09	75.28	72.11	2.19
440 H	0.61	0.60	0.64	0.75	0.60	0.75	0.65	0.06
441 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
442 N	1.51	1.58	1.18	0.93	0.93	1.58	1.30	0.26
443 S	3.11	1.21	1.54	0.56	0.56	3.11	1.60	0.94
444 Ash	22.48	21.33	24.84	28.67	21.33	28.67	24.33	2.81
445								
446 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
447								
448 CD-Sorbent Fraction Composition, wt %								
449 -----								
450 CaCO3	68.41	86.82	70.67	28.70	28.70	86.82	63.65	21.39
451 MgCO3	1.94	1.86	0.00	0.00	0.00	1.94	0.95	0.95
452 CaO	0.00	0.00	4.03	31.57	0.00	31.57	8.90	13.19
453 MgO	0.00	0.00	1.08	1.00	0.00	1.08	0.52	0.52
454 CaS	28.73	10.53	24.03	38.50	10.53	38.50	25.45	10.07
455 CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
456 Inerts	0.92	0.79	0.19	0.23	0.19	0.92	0.53	0.32
457								
458 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
459 PD-Sorbent Fraction Composition, wt %								
460 -----								
461 CaCO3	29.25	40.11	52.47	42.54	29.25	52.47	41.09	8.26
462 MgCO3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
463 CaO	48.87	40.14	22.54	41.61	22.54	48.87	38.29	9.67
464 MgO	1.23	1.19	1.21	0.99	0.99	1.23	1.16	0.09

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	111 Bit	111 Bit	111 Bit	111 Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
465 CaS	19.44	17.50	23.56	14.64	14.64	23.56	18.78	3.24
466 CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
467 Inerts	1.21	1.06	0.22	0.23	0.22	1.21	0.68	0.46
468								
469 total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
470 SD Sorbent Fraction Composition, wt %								
471								
472 CaCO3	17.29	41.25	52.43	44.96	17.29	52.43	38.98	13.16
473 MgCO3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
474 CaO	67.90	35.79	33.88	40.71	33.88	67.90	44.57	13.70
475 MgO	1.33	1.18	1.25	0.98	0.98	1.33	1.19	0.13
476 CaS	12.15	20.75	12.20	13.12	12.15	20.75	14.56	3.60
477 CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
478 Inerts	1.32	1.03	0.22	0.22	0.22	1.32	0.70	0.49
479								
480 total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
481 BD-Sorbent Fraction Composition, wt %								
482								
483 CaCO3	50.90	57.55	44.90	29.88	29.88	57.55	45.81	10.23
484 MgCO3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
485 CaO	24.71	40.30	35.39	53.29	24.71	53.29	38.42	10.27
486 MgO	1.08	1.14	1.29	1.06	1.06	1.29	1.14	0.09
487 CaS	22.23	0.00	18.19	15.52	0.00	22.23	13.98	8.42
488 CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
489 Inerts	1.08	1.01	0.23	0.24	0.23	1.08	0.64	0.40
490								
491 total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
492 Combined Disch-Sorbent Frac Comp, wt %								
493								
494 CaCO3	61.80	79.92	67.20	31.38	31.38	79.92	60.07	17.83
495 MgCO3	1.58	1.57	0.00	0.00	0.00	1.58	0.79	0.79
496 CaO	8.42	6.14	8.19	34.04	6.14	34.04	14.20	11.49
497 MgO	0.22	0.18	1.10	1.00	0.18	1.10	0.63	0.43

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal	Ill Bit	Ill Bit	Ill Bit	Ill Bit				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime				
498 CaS	27.01	11.36	23.31	33.35	11.36	33.35	23.76	8.01
499 CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
500 Inerts	0.97	0.83	0.20	0.23	0.20	0.97	0.56	0.35
501								
502 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
503								
504 Carbonizer Exit Gas Comp., mol %								
505								
506 CO	4.979	5.395	5.580	5.751	4.979	5.751	5.426	0.287
507 CO2	8.674	8.252	10.428	11.635	8.252	11.635	9.747	1.362
508 H2	7.041	6.552	7.084	7.231	6.552	7.231	6.977	0.255
509 H2O	21.750	17.048	17.857	17.756	17.048	21.750	18.603	1.844
510 CH4	1.489	1.594	1.472	1.542	1.472	1.594	1.524	0.048
511 C2H4	0.049	0.045	0.037	0.000	0.000	0.049	0.033	0.019
512 C2H6	0.016	0.018	0.028	0.019	0.016	0.028	0.020	0.005
513 N2	55.204	59.889	56.754	55.413	55.204	59.889	56.815	1.872
514 H2S	0.037	0.380	0.014	0.002	0.002	0.380	0.108	0.157
515 COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
516 NH3	0.285	0.342	0.243	0.138	0.138	0.342	0.252	0.075
517 Ar	0.475	0.484	0.502	0.511	0.475	0.511	0.493	0.014
518								
519 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
520								
521 Orifice Gas Composition, mol %								
522								
523 CO	4.891	5.266	5.496	5.660	4.891	5.660	5.328	0.289
524 CO2	8.520	8.054	10.272	11.451	8.054	11.451	9.574	1.363
525 H2	6.916	6.396	6.978	7.117	6.396	7.117	6.852	0.273
526 H2O	21.363	16.641	17.588	17.475	16.641	21.363	18.267	1.825
527 CH4	1.462	1.556	1.450	1.518	1.450	1.556	1.497	0.043
528 C2H4	0.048	0.044	0.036	0.000	0.000	0.048	0.032	0.019
529 C2H6	0.015	0.018	0.028	0.019	0.015	0.028	0.020	0.005
530 N2	56.002	60.848	57.405	56.119	56.002	60.848	57.593	1.958

Table 3.2 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH ILLINOIS NO. 6 BITUMINOUS COAL

Set Point		TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
Coal		Ill Bit	Ill Bit	Ill Bit	Ill Bit				
Sorbent		LV Lime	LV Lime	LV Lime	LV Lime				
531	H2S	0.036	0.371	0.014	0.002	0.002	0.371	0.106	0.154
532	COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
533	NH3	0.280	0.334	0.239	0.136	0.136	0.334	0.247	0.072
534	Ar	0.467	0.473	0.494	0.503	0.467	0.503	0.484	0.015
535									
536	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
537									
538	Demister Gas Composition, mol %								
539									
540	CO	4.455	4.711	5.124	5.359	4.455	5.359	4.912	0.351
541	CO2	7.761	7.206	9.577	10.841	7.206	10.841	8.846	1.447
542	H2	6.300	5.722	6.506	6.738	5.722	6.738	6.317	0.377
543	H2O	19.460	14.888	16.399	16.545	14.888	19.460	16.823	1.655
544	CH4	1.332	1.392	1.352	1.437	1.332	1.437	1.378	0.040
545	C2H4	0.044	0.039	0.034	0.000	0.000	0.044	0.029	0.017
546	C2H6	0.014	0.016	0.026	0.018	0.014	0.026	0.019	0.005
547	N2	59.921	64.972	60.285	58.455	58.455	64.972	60.908	2.444
548	H2S	0.033	0.332	0.013	0.002	0.002	0.332	0.095	0.137
549	COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
550	NH3	0.255	0.299	0.223	0.129	0.129	0.299	0.227	0.062
551	Ar	0.425	0.423	0.461	0.476	0.423	0.476	0.446	0.023
552									
553	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000

Table 3.3. MEASURED AND DERIVED CARBONIZER DATA WITH
WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
1 Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
2 Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
3 Begin Date	4/21/92	4/22/92	4/22/92	4/22/92	4/23/92	6/10/92	6/11/92	6/11/92				
4 Begin Clock Time, hours	2100	0430	1400	2100	0400	2000	0300	1330				
5 End Clock Time, hours	0100	0830	1800	0100	0800	0100	0800	1730				
6 Steady-State Period Duration, h	4	4	4	4	4	5	5	4	4.0	5.0	4.3	0.4
7 Carbonizer Pressure, psig	145.9	129.8	157.5	191.9	189.6	128.6	132.7	156.5	128.6	191.9	154.1	23.6
8 Carbonizer Pressure, psia	160.6	144.5	172.2	206.6	204.3	143.3	147.4	171.2	143.3	206.6	168.8	23.6
9 Carbonizer Pressure, atm	10.93	9.83	11.72	14.06	13.90	9.75	10.03	11.65	9.75	14.06	11.48	1.61
10 Average Bed Temp, F	1580	1509	1511	1609	1632	1476	1593	1613	1476	1632	1565	54
11 Bed Temp (@7.5 ft), F	1578	1507	1509	1607	1632	1478	1587	1602	1478	1632	1563	53
12 Freeboard Temp (@ 22.5 ft), F	1567	1500	1515	1579	1593	1432	1541	1575	1432	1593	1538	50
13 Freeboard Temp (@ 27.5 ft), F	1515	1453	1462	1549	1563	1396	1492	1533	1396	1563	1495	52
14 Avg Bed T - Freebd T(@22.5 ft), F	13	9	-4	30	39	44	52	38	-4	52	28	18
15 Avg Bed T - Freebd T(@27.5 ft), F	65	56	49	60	69	80	101	80	49	101	70	16
16 Freebd T(@22.5 Ft - @27.5 ft), F	52	47	53	30	30	36	49	42	30	53	42	9
17												
18 Coal Feed Rate, lb/h	330.38	310.58	397.83	443.46	429.56	288.37	283.68	362.84	283.68	443.46	355.84	58.50
19 Sorbent Feed Rate, lb/h	67.82	66.66	44.92	54.98	20.46	37.18	54.46	27.02	20.46	67.82	46.69	16.37
20 Air Feed Rate, lb/h	755.05	656.16	799.76	992.63	970.90	600.15	691.38	823.06	600.15	992.63	786.14	132.17
21 Steam Feed Rate, lb/h	0.00	0.00	0.00	0.00	0.00	46.45	46.47	53.10	0.00	53.10	18.25	23.64
22 N2 Purges to Carbonizer, lb/h	208.35	231.94	176.70	152.02	159.57	224.71	214.74	192.52	152.02	231.94	195.07	27.97
23 N2 Purges to Cyclones + O.M., lb/h	26.55	23.79	25.65	18.00	16.02	164.56	174.74	152.79	16.02	174.74	75.26	69.06
24 N2 Purge to Spray Tower, lb/h	136.66	138.15	129.02	105.66	97.91	131.27	138.58	86.78	86.78	138.58	120.50	19.22
25 Total N2 Purges to System, lb/h	371.56	393.88	331.37	275.68	273.50	520.54	528.06	432.10	273.50	528.06	390.84	92.40
26 Air+Steam+N2 Feed to Carb., lb/h	963.40	888.10	976.46	1144.65	1130.46	871.31	952.59	1068.69	871.31	1144.65	999.46	97.39
27 Air+Steam+N2 Feed to System, lb/h	1126.61	1050.04	1131.13	1268.31	1244.40	1167.15	1265.91	1308.26	1050.04	1308.26	1195.23	83.83
28 Air Feed to Carbonizer, lbmol/h	26.066	22.652	27.609	34.268	33.517	20.718	23.868	28.414	20.718	34.268	27.139	4.563
29 Steam Feed to Carbonizer, lbmol/h	0.000	0.000	0.000	0.000	0.000	2.579	2.580	2.948	0.000	2.948	1.013	1.312
30 N2 Purges to Carbonizer, lbmol/h	7.437	8.279	6.308	5.427	5.696	8.021	7.665	6.872	5.427	8.279	6.963	0.998
31 Carbonizer Drain Rate, lb/h	64.22	70.89	44.51	60.38	19.43	29.99	46.14	21.32	19.43	70.89	44.61	18.43
32 Primary Cyclone Drain Rate, lb/h	45.58	47.37	69.88	50.58	53.28	53.12	35.92	35.82	35.82	69.88	48.94	10.20
33 Secondary-Cyclone Drain Rate, lb/h	3.69	5.80	6.70	1.31	4.51	11.61	4.60	7.62	1.31	11.61	5.73	2.86
34 Baghouse Drain Rate, lb/h	8.11	12.51	8.13	25.59	26.44	2.14	1.43	7.82	1.43	26.44	11.52	9.00
35 Total Drains Rate, lb/h	121.59	136.58	129.22	137.84	103.66	96.86	88.10	72.58	72.58	137.84	110.80	22.56

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
36 Carbonizer Exit Gas, lb/h	1240.2	1128.9	1290.2	1505.4	1477.0	1100.2	1202.8	1386.1	1100.2	1505.4	1291.4	142.6
37 Orifice Gas, lb/h	1266.7	1152.7	1315.8	1523.4	1493.1	1264.7	1377.6	1538.9	1152.7	1538.9	1366.6	131.8
38 Demister Gas, lb/h	1403.4	1290.9	1444.8	1629.1	1591.0	1396.0	1516.2	1625.7	1290.9	1629.1	1487.1	115.4
39 Carbonizer Exit Gas, lbmol/h	47.280	42.937	50.006	57.832	57.063	42.251	45.739	53.347	42.251	57.832	49.557	5.661
40 Orifice Gas, lbmol/h	48.227	43.786	50.921	58.474	57.635	48.124	51.976	58.799	43.786	58.799	52.243	5.212
41 Demister Gas, lbmol/h	53.105	48.717	55.526	62.245	61.129	52.809	56.921	61.897	48.717	62.245	56.543	4.615
42												
43 Carbonizer Gas HHV, Btu/SCF(wet)	79.91	73.62	90.50	90.79	88.85	69.82	68.03	81.97	68.03	90.79	80.44	8.63
44 Carbonizer Gas LHV, Btu/SCF(wet)	68.34	61.83	77.65	78.37	76.52	55.85	55.08	68.16	55.08	78.37	67.72	8.84
45 Carbonizer Gas HHV, Btu/lb	1153.4	1060.0	1328.0	1320.5	1299.6	1015.1	979.4	1194.3	979.4	1328.0	1168.8	131.2
46 Carbonizer Gas LHV, Btu/lb	986.4	890.3	1139.4	1139.8	1119.2	812.1	793.0	993.1	793.0	1139.8	984.2	133.0
47												
48 Bed Density, lb/ft ³	55.45	48.06	38.38	43.43	45.80	26.86	55.00	59.69	26.86	59.69	46.58	9.94
49 Bed Height, ft	20.2	20.7	23.7	15.6	14.5	19.7	17.1	18.1	14.5	23.7	18.7	2.8
50 Bed Weight, lb	849.44	762.44	731.84	496.41	480.58	398.16	693.17	798.14	398.16	849.44	651.27	157.57
51 Bed Weight/Coal Feed Rate, lb/(lb/h)	2.571	2.455	1.840	1.119	1.119	1.381	2.443	2.200	1.119	2.571	1.891	0.574
52 Solids Residence Time, min	793.6	645.3	986.6	493.3	1484.2	796.7	901.4	2246.6	493.3	2246.6	1043.5	530.3
53												
54 Inlet Superficial Vel (D=10 in), ft/s	2.32	2.30	2.12	2.17	2.19	2.31	2.60	2.53	2.12	2.60	2.32	0.16
55 Product Gas Super. Vel (D=10 in), ft/s	3.28	3.20	3.13	3.16	3.19	3.12	3.48	3.53	3.12	3.53	3.26	0.15
56 Product Gas Super. Vel (D=12 in), ft/s	2.28	2.22	2.17	2.20	2.22	2.17	2.42	2.45	2.17	2.45	2.26	0.10
57 Freebd Gas Super. Vel (D=14 in), ft/s	1.66	1.62	1.60	1.59	1.60	1.55	1.73	1.77	1.55	1.77	1.64	0.07
58 Gas Residence Time, s	8.6	9.1	11.2	6.6	6.0	8.7	6.6	6.9	6.0	11.2	8.0	1.6
59												
60 Carbonizer Wall Heat Losses, Btu/h	58984	69279	100370	100483	98317	103924	104647	96186	58984	104647	91524	16225
61 Overhead Heat Losses, Btu/h	312184	273223	111406	120069	121834	227086	252525	255561	111406	312184	209236	74323
62												
63 Moisture in Coal Feed, %	28.17	28.33	27.75	27.60	27.93	29.24	30.67	30.24	27.60	30.67	28.74	1.10
64 Coal Feed (MF), lb/h	237.31	222.58	287.44	321.08	309.58	204.05	196.68	253.13	196.68	321.08	253.98	44.38
65 Carbon in Coal Feed, lb/h	162.23	150.18	193.75	218.08	210.07	138.12	131.56	169.22	131.56	218.08	171.65	30.43
66												
67 H ₂ Content in Freeboard Gas, mol%	7.72	6.83	8.73	7.77	8.45	7.62	7.59	8.93	6.83	8.93	7.96	0.65
68 P(H ₂) in Carbonizer Gas, psia	12.4	9.9	15.0	16.0	17.3	10.9	11.2	15.3	9.9	17.3	13.5	2.6

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
69 Available Hydrogen, lbatom/lbatom	0.732	0.717	0.711	0.708	0.719	0.660	0.657	0.657	0.657	0.732	0.695	0.030
70 CH ₄ Yield, % of Feed Carbon	5.366	5.088	5.535	5.995	5.295	5.529	5.420	6.725	5.088	6.725	5.619	0.484
71 C ₂ H ₄ Yield, % of Feed Carbon	0.220	0.296	0.158	0.069	0.063	0.303	0.177	0.079	0.063	0.303	0.171	0.091
72 C ₂ H ₆ Yield, % of Feed Carbon	0.157	0.296	0.220	0.103	0.077	0.698	0.312	0.395	0.077	0.698	0.282	0.187
73 Total HC Yield, % of Feed Carbon	5.744	5.680	5.913	6.167	5.434	6.530	5.908	7.200	5.434	7.200	6.072	0.526
74 CH ₄ in Freeboard Gas, mol%	1.533	1.482	1.786	1.882	1.623	1.505	1.298	1.776	1.298	1.882	1.611	0.182
75 C ₂ H ₄ in Freeboard Gas, mol%	0.031	0.043	0.026	0.011	0.010	0.041	0.021	0.010	0.010	0.043	0.024	0.013
76 C ₂ H ₆ in Freeboard Gas, mol%	0.022	0.043	0.036	0.016	0.012	0.095	0.037	0.052	0.012	0.095	0.039	0.025
77 Total HC in Freeboard Gas, mol%	1.587	1.568	1.847	1.909	1.644	1.641	1.356	1.839	1.356	1.909	1.674	0.171
78 CH ₄ in Demister Gas, mol%	1.365	1.306	1.608	1.749	1.515	1.204	1.043	1.531	1.043	1.749	1.415	0.215
79 C ₂ H ₄ in Demister Gas, mol%	0.028	0.038	0.023	0.010	0.009	0.033	0.017	0.009	0.009	0.038	0.021	0.011
80 C ₂ H ₆ in Demister Gas, mol%	0.020	0.038	0.032	0.015	0.011	0.076	0.030	0.045	0.011	0.076	0.033	0.019
81 Total HC in Demister Gas, mol%	1.413	1.382	1.663	1.774	1.535	1.313	1.090	1.585	1.090	1.774	1.469	0.202
82												
83 Water Content in Freeboard Gas, mol%	11.73	12.69	12.53	12.57	12.45	16.17	14.83	14.24	11.73	16.17	13.40	1.42
84 P(H ₂ O) in Carbonizer Gas, psia	18.8	18.3	21.6	26.0	25.4	23.2	21.9	24.4	18.3	26.0	22.4	2.7
85 Water-Gas Shift Temp, F	1734	1775	1786	1938	1867	1502	1506	1510	1502	1938	1702	163
86 WGS Temp - Avg Bed Temp, F	154	266	275	329	235	26	-87	-103	-103	329	137	159
87 WGS Temp - Freebd Temp(@22.5 ft), F	167	275	271	359	274	70	-35	-65	-65	359	165	148
88 WGS Temp - Freebd Temp(@27.5 ft), F	219	322	324	389	304	106	14	-23	-23	389	207	146
89												
90 Oxygen in Air Feed, lbmol/h	5.472	4.755	5.796	7.193	7.036	4.349	5.010	5.965	4.349	7.193	5.697	0.958
91 Feed O ₂ /Carbon in Feed, mol/mol	0.405	0.380	0.359	0.396	0.402	0.378	0.457	0.423	0.359	0.457	0.400	0.028
92 Feed Air/Feed Coal, lb/lb	2.285	2.113	2.010	2.238	2.260	2.081	2.437	2.268	2.010	2.437	2.212	0.127
93 Feed Air/Feed Coal, lb/lb(MF)	3.182	2.948	2.782	3.092	3.136	2.941	3.515	3.252	2.782	3.515	3.106	0.210
94 Feed Air/Feed Coal, lb/lb(MAF)	3.461	3.213	3.031	3.369	3.415	3.175	3.817	3.525	3.031	3.817	3.376	0.227
95 Feed Steam/Carbon in Feed, mol/mol	0.000	0.000	0.000	0.000	0.000	0.224	0.235	0.209	0.000	0.235	0.084	0.108
96 Feed Steam/Feed Coal, lb/lb	0.000	0.000	0.000	0.000	0.000	0.161	0.164	0.146	0.000	0.164	0.059	0.076
97 Feed Steam/Feed Coal, lb/lb(MF)	0.000	0.000	0.000	0.000	0.000	0.228	0.236	0.210	0.000	0.236	0.084	0.109
98 Total (Steam+Moist)/Carbon, mol/mol	0.382	0.390	0.380	0.374	0.381	0.631	0.676	0.641	0.374	0.676	0.482	0.130
99 Total (Steam+Moist)/Coal, lb/lb	0.282	0.283	0.277	0.276	0.279	0.453	0.471	0.449	0.276	0.471	0.346	0.086
100 Total (Steam+Moist)/Coal, lb/lb(MF)	0.392	0.395	0.384	0.381	0.388	0.641	0.679	0.643	0.381	0.679	0.488	0.129
101 Bed Drain Char/Coal Feed, lb/lb(MF)	0.0760	0.0648	0.0519	0.0612	0.0334	0.0300	0.0526	0.0453	0.0300	0.0760	0.0519	0.0146

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
102 Total Char/Coal Feed, lb/lb(MF)	0.2894	0.3285	0.3070	0.2746	0.2752	0.3080	0.2309	0.2157	0.2157	0.3285	0.2786	0.0363
103 (Char+Spent Sorb)/(Coal+Sorbent), lb/lb	0.305	0.362	0.292	0.277	0.230	0.298	0.261	0.186	0.186	0.362	0.276	0.049
104 HHV of (Char+Spent Sorb), Btu/lb(MF)	5737	5833	7332	6524	8595	7082	4909	7291	4909	8595	6663	1084
105												
106 Carbon Conversion in CD, %	93.79	92.81	96.32	96.09	98.46	87.25	94.27	99.38	87.25	99.38	94.80	3.55
107 Carbon Conversion in PD, %	40.76	41.20	41.68	46.97	60.90	60.68	67.06	58.38	40.76	67.06	52.21	9.98
108 Carbon Conversion in SD, %	48.68	47.94	57.34	54.37	58.35	68.57	56.17	56.16	47.94	68.57	55.95	5.98
109 Carbon Conversion in BD, %	5.50	38.28	44.10	42.45	53.89	16.10	28.18	53.45	5.50	53.89	35.24	16.28
110 Carbon Conversion in Mixture, %	71.09	65.33	68.15	72.87	72.89	66.23	77.96	80.12	65.33	80.12	71.83	4.95
111 Hydrogen Conversion in Mixture, %	97.11	95.88	96.00	97.07	97.28	95.22	97.51	97.12	95.22	97.51	96.65	0.77
112 Oxygen Conversion in Mixture, %	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
113 Nitrogen Conversion in Mixture, %	65.35	59.38	68.13	75.75	72.28	74.04	86.27	87.56	59.38	87.56	73.59	9.10
114 Sulfur Conversion in Mixture, %	45.00	51.13	58.10	66.36	52.66	95.92	81.46	73.99	45.00	95.92	65.58	16.20
115												
116 Coal Hydrogen Released, %	97.11	95.88	96.00	97.07	97.28	95.22	97.51	97.12	95.22	97.51	96.65	0.77
117 Coal Nitrogen Released, %	65.34	59.38	68.13	75.75	72.28	74.04	86.27	87.58	59.38	87.56	73.59	9.10
118 Released Nitrogen Going to NH ₃ , %	60.08		88.32	77.10	46.26	86.13	93.11	84.70	46.26	93.11	76.53	15.86
119 Coal Nitrogen Going to NH ₃ , %	39.26		60.17	58.41	33.44	63.76	80.33	74.17	33.44	80.33	58.50	15.81
120 NH ₃ Concentration in Freeboard, ppm	1876	4459	3287	3078	1725	2612	2912	2970	1725	4459	2865	800
121												
122 Coal Sulfur Released, %	44.99	51.13	58.10	66.36	52.66	95.92	81.46	73.99	44.99	95.92	65.58	16.20
123 Sulfur Remaining in Chars Frac., %	55.01	48.87	41.90	33.64	47.34	4.08	18.54	26.01	4.08	55.01	34.42	16.20
124 Organic Sulfur in Chars Fraction, %	61.63	47.77	43.40	34.86	48.47	36.79	44.87	35.86	34.86	61.63	44.21	8.27
125 Sulfur in Freeboard Gas, % Coal S	15.02	2.18	5.75	5.82	3.38	92.57	63.62	29.64	2.18	92.57	27.25	31.35
126 Sulfur in Solids Discharges, % Coal S	84.98	97.82	94.25	94.18	96.62	7.43	36.38	70.36	7.43	97.82	72.75	31.35
127 Sulfur in Freeboard Gas, % Rel S	33.38	4.27	9.90	8.77	6.42	96.51	78.09	40.06	4.27	96.51	34.68	33.07
128 Sulfur Capture by Sorbent, % Rel S	66.62	95.73	90.10	91.23	93.58	3.49	21.91	59.94	3.49	95.73	65.32	33.07
129 Feed Ca/feed S Ratio, mol/mol	9.791	9.699	5.021	5.539	2.203	6.027	9.584	3.806	2.203	9.791	6.459	2.730
130 Feed Ca/Released S Ratio, mol/mol	21.760	18.971	8.643	8.347	4.184	6.284	11.765	5.144	4.184	21.760	10.637	6.067
131 H ₂ S Concentration in Freeboard, ppm	213	34	100	97	54	1312	772	383	34	1312	371	423
132 Sorbent Ca Conversion/Utilization, %	3.50	5.51	10.88	11.35	22.84	1.16	2.38	12.22	1.16	22.84	8.73	6.69
133 CaS in Solids Discharges as CaSO ₄ , %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
135 O/C in Coal Feed, lbatom/lbatom	0.1796	0.1905	0.1921	0.1849	0.1860	0.2018	0.2084	0.2106	0.1796	0.2106	0.1942	0.0107
136 H/C in Coal Feed, lbatom/lbatom	0.866	0.860	0.855	0.847	0.858	0.811	0.813	0.814	0.811	0.866	0.841	0.022
137 H/C in Combined Disch, lbatom/lbatom	0.087	0.102	0.107	0.092	0.086	0.115	0.092	0.118	0.086	0.118	0.100	0.012
138 N/C in Coal Feed, lbatom/lbatom	0.017	0.017	0.017	0.017	0.017	0.015	0.015	0.015	0.015	0.017	0.016	0.001
139 N/C in Combined Disch, lbatom/lbatom	0.020	0.020	0.017	0.015	0.017	0.012	0.009	0.009	0.009	0.020	0.015	0.004
140 S/C in Coal Feed, lbatom/lbatom	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.000
141 S/C in Combined Disch, lbatom/lbatom	0.009	0.008	0.007	0.007	0.009	0.001	0.004	0.006	0.001	0.009	0.006	0.003
142 Char(N/C)/Coal(N/C) - molar basis	1.199	1.172	1.001	0.894	1.022	0.769	0.623	0.626	0.623	1.199	0.913	0.211
143 Char(S/C)/Coal(S/C) - molar basis	1.903	1.410	1.316	1.240	1.746	0.121	0.841	1.308	0.121	1.903	1.236	0.518
144												
145 Mg/Ca in Sorbent, lbmol/lbmol	0.021	0.016	0.020	0.021	0.018	0.029	0.021	0.028	0.016	0.029	0.022	0.004
146 Ca/Mg in Sorbent, lbmol/lbmol	46.864	61.987	50.025	46.700	54.993	35.079	47.025	36.143	35.079	61.987	47.352	8.342
147 Mg/Ca in Sorbent, lb/lb	0.013	0.010	0.012	0.013	0.011	0.017	0.013	0.017	0.010	0.017	0.013	0.002
148 Ca/Mg in Sorbent, lb/lb	77.280	102.219	82.494	77.010	90.685	57.846	77.546	59.601	57.846	102.219	78.085	13.757
149 MgCO ₃ /CaCO ₃ in Sorbent Feed, mol/mol	0.0214	0.0162	0.0201	0.0215	0.0183	0.0287	0.0214	0.0278	0.0162	0.0287	0.0219	0.0040
150 CaS/CaCO ₃ in Sorbent Feed, mol/mol	0.00463	0.00474	0.00475	0.00475	0.00390	0.00611	0.00554	0.00551	0.00390	0.00611	0.00499	0.00064
151												
152 Coal Feed HHV, Btu/lb (MF)	11831	11730	11750	11646	11744	11541	11403	11418	11403	11831	11633	151
153												
154 HHV of Gas/HHV of Coal, %	50.95	45.84	50.73	53.16	52.80	47.42	52.53	57.27	45.84	57.27	51.34	3.32
155 HHV of Gas/(HHV of Coal-HCALC), %	51.90	46.74	51.25	53.76	53.03	48.00	53.52	57.68	46.74	57.68	51.98	3.22
156 LHV of Gas/LHV of Coal, %	47.06	41.58	46.94	49.51	49.08	41.02	46.14	51.62	41.02	51.62	46.62	3.48
157 LHV of Gas/(LHV of Coal-HCALC), %	48.01	42.47	47.46	50.11	49.31	41.56	47.08	52.02	41.56	52.02	47.25	3.37
158												
159 HHV of Coal Char/HHV of Coal, %	25.22	30.23	27.74	23.88	23.64	30.00	19.48	17.72	17.72	30.23	24.74	4.27
160 HHV of Drains/(HHV of Coal-HCALC), %	25.31	31.12	28.34	24.32	24.61	29.48	19.64	18.44	18.44	31.12	25.16	4.20
161 LHV of Coal Char/LHV of Coal, %	27.12	32.48	29.75	25.65	25.40	32.24	21.04	19.09	19.09	32.48	26.60	4.56
162 LHV of Drains/(LHV of Coal-HCALC), %	27.25	33.49	30.42	26.14	26.46	31.71	21.24	19.88	19.88	33.49	27.07	4.48
163												
164 Feed - CaCO ₃ /(CaCO ₃ +CaO), mole %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
165 CD - CaCO ₃ /(CaCO ₃ +CaO), mole %	51.4	96.5	100.0	92.0	100.0	100.0	47.0	0.9	0.9	100.0	73.5	34.4
166 PD - CaCO ₃ /(CaCO ₃ +CaO), mole %	44.2	64.1	60.8	58.0	100.0	45.6	88.5	67.0	44.2	100.0	66.0	18.2
167 SD - CaCO ₃ /(CaCO ₃ +CaO), mole %	58.6	50.1	64.7	46.2	45.7	51.8	57.0	62.3	45.7	64.7	54.5	6.7

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Time	LV Time	LV Time	LV Time	LV Time	LV Time	LV Time	LV Time				
168 BD - CaCO ₃ /(CaCO ₃ +CaO), mole %	65.7	100.0	44.1	53.7	67.3	93.8	100.0	64.3			73.6	20.2
169 Mixt - CaCO ₃ /(CaCO ₃ +CaO), mole %	51.1	93.3	86.7	84.9	91.3	81.3	52.1	23.0			93.3	23.7
170												
171 Feed - MgCO ₃ /(MgCO ₃ +MgO), mole %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
172 CD - MgCO ₃ /(MgCO ₃ +MgO), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	33.1
173 PD - MgCO ₃ /(MgCO ₃ +MgO), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
174 SD - MgCO ₃ /(MgCO ₃ +MgO), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
175 BD - MgCO ₃ /(MgCO ₃ +MgO), mole %	0.0	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	25.0	43.3
176 Mixt - MgCO ₃ /(MgCO ₃ +MgO), mole %	0.0	2.4	0.0	0.0	0.0	64.2	0.3	0.0	0.0	64.2	8.4	21.1
177												
178 Feed - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	0.5	0.5	0.5	0.5	0.4	0.6	0.6	0.5	0.4	0.6	0.5	0.1
179 CD - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	2.5	5.1	12.2	10.6	7.4	0.5	2.1	8.3	0.5	12.2	6.1	4.0
180 PD - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	12.3	8.9	8.0	16.5	48.2	2.2	4.3	23.5	2.2	48.2	15.5	13.9
181 SD - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	5.0	4.2	11.7	11.3	12.4	2.6	4.6	4.1	2.6	12.4	7.0	3.8
182 BD - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	4.2	8.1	5.3	9.4	16.5	3.2	0.5	10.0	0.5	16.5	7.2	4.7
183 Mixt - CaS/(CaCO ₃ +CaO+CaS+CaSO ₄),mole %	3.5	5.5	10.8	11.3	22.8	1.2	2.4	12.2	1.2	22.8	8.7	6.7
184												
185 Feed - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
186 CD - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
187 PD - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
188 SD - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
189 BD - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190 Mixt - CaSO ₄ /(CaS+CaSO ₄), mole %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
191												
192 Actual PCO ₂ , psia	15.39	13.42	16.07	19.14	18.59	15.80	17.13	20.25	13.42	20.25	16.97	2.10
193 Equilibrium PCO ₂ (Squires), psia	8.37	4.39	4.47	10.75	13.05	3.20	9.37	11.12	3.20	13.05	8.09	3.41
194 Equilibrium PCO ₂ (IGT/B&K), psia	17.84	9.19	9.37	23.08	28.17	6.64	20.04	23.90	6.64	28.17	17.28	7.46
195 Equilibrium PCO ₂ (H&W), psia	8.21	4.47	4.55	10.41	12.50	3.32	9.14	10.75	3.32	12.50	7.92	3.19
196												
197 Actual PCO ₂ Equil PCO ₂ (Squires), psia	7.02	9.03	11.59	8.39	5.54	12.60	7.76	9.13	5.54	12.60	8.88	2.16
198 Actual PCO ₂ Equil PCO ₂ (IGT/B&K), psia	-2.45	4.23	6.70	-3.94	-9.59	9.15	-2.91	-3.65	-9.59	9.15	-0.31	5.93
199 Actual PCO ₂ Equil PCO ₂ (H&W), psia	7.17	8.95	11.52	8.73	6.09	12.48	7.99	9.51	6.09	12.48	9.06	1.99
200												

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
201 Actual PCO ₂ /Equil PCO ₂ (Squires), psia	1.84	3.06	3.59	1.78	1.42	4.93	1.83	1.82	1.42	4.93	2.53	1.14
202 Actual PCO ₂ /Equil PCO ₂ (IGT/B&K), psia	0.86	1.46	1.71	0.83	0.66	2.38	0.85	0.85	0.66	2.38	1.20	0.56
203 Actual PCO ₂ /Equil PCO ₂ (H&W), psia	1.87	3.00	3.53	1.84	1.49	4.76	1.87	1.88	1.49	4.76	2.53	1.06
204												
205 Sulfur in Coal Feed, lb/h	2.154	2.146	2.785	3.086	2.899	1.920	1.779	2.210	1.779	3.086	2.372	0.453
206 Sulfur in Combined Char Discharge, lb/h	1.185	1.049	1.167	1.038	1.373	0.078	0.330	0.575	0.078	1.373	0.849	0.433
207 H ₂ S Without Sorbent Feed, lbmol/h	0.0302	0.0342	0.0505	0.0639	0.0476	0.0575	0.0452	0.0510	0.0302	0.0639	0.0475	0.0104
208 Carbonizer Exit Gas, lbmol/h	47.2797	42.9373	50.0057	57.8321	57.063	42.2507	45.7392	53.3465	42.2507	57.8321	49.5568	5.6606
209 H ₂ S Without Sorbent Feed, ppm	639	797	1009	1105	835	1360	988	956	639	1360	961	203
210												
211 * For Reaction: CaO+H ₂ S=CaS+H ₂ O												
212 Equilibrium Constant (= H ₂ O/H ₂ S)	688.071	890.504	883.834	622.439	576.006	1010.394	657.605	614.027	576.006	1010.394	742.860	151.020
213 Equilibrium H ₂ S Concentration, ppm	170.5	142.5	141.8	201.9	216.1	160.0	225.6	231.9	141.8	231.9	186.3	34.6
214 Approach to Equilibrium Conc.(1), %	79.87	418.71	141.87	208.46	403.47	12.19	29.23	60.56	12.19	418.71	169.30	151.43
215 Approach to Equilibrium Capture(1), %	90.84	116.58	104.82	111.64	126.28	3.95	28.39	79.14	3.95	126.28	82.71	41.24
216												
217 * For Reaction: CaCO ₃ +H ₂ S=CaS+H ₂ O+CO ₂												
218 Equilibrium Const (=CO ₂ *H ₂ O*P/H ₂ S)	391.787	266.067	269.086	455.381	511.561	220.132	419.336	464.775	220.132	511.561	374.766	101.541
219 Equilibrium H ₂ S Concentration, ppm	313.5	435.6	509.1	359.4	307.8	789.5	412.4	422.2	307.8	789.5	443.7	144.9
220 Approach to Equilibrium Conc.(2), %	146.89	1279.62	509.45	371.07	574.58	60.15	53.45	110.28	53.45	1279.62	388.19	387.22
221 Approach to Equilibrium Capture(2), %	130.70	211.09	181.85	135.24	148.25	8.31	37.60	107.37	8.31	211.09	120.05	63.92
222												
223 Diff. in Apprch to Equil Conc (2-1), %	67.01	860.91	367.58	162.61	171.11	47.96	24.22	49.71	24.22	860.91	218.89	264.23
224 Diff. in Apprch to Equil Capt (2-1), %	39.86	94.51	77.02	23.60	21.97	4.36	9.22	28.23	4.36	94.51	37.35	30.08
225												
226 Coal Feed Temp, F	76.0	76.0	76.0	76.0	76.0	76.0	75.9	75.9	75.9	76.0	76.0	0.0
227 Sorbent Feed Temp, F	76.0	76.0	76.0	76.0	76.0	76.0	75.9	75.9	75.9	76.0	76.0	0.0
228 Air Feed Temp, F	85.7	85.4	84.0	90.1	88.5	83.3	76.8	86.3	76.8	90.1	85.0	3.7
229 Steam Feed Temp, F	387.6	387.6	387.6	387.6	387.6	386.9	387.2	386.9	386.9	387.6	387.4	0.3
230 Purge N ₂ Temp, F	147.6	153.3	150.2	152.3	154.5	151.1	143.4	138.2	138.2	154.5	148.8	5.2
231												
232 Orifice Temp, F	788	763	1267	1354	1367	770	822	963	763	1367	1012	254
233 Orifice Pressure, psig	143.1	127.3	154.3	188.2	186.0	128.2	132.2	156.1	127.3	188.2	151.9	22.7

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
234 Orifice Diameter, in	0.49	0.49	0.49	0.49	0.49	0.54	0.54	0.54	0.49	0.54	0.51	0.02
235 Bed Density DP (DH = 3.0 ft), in H2O	31.974	27.716	22.133	25.046	26.411	15.488	31.719	34.423	15.488	34.423	26.864	5.732
236 Bed Level DP (PDI-3057), in H2O	193.913	172.784	160.084	114.094	109.820	91.539	160.272	185.159	91.539	193.913	148.458	35.695
237												
238 Carbonizer Drain, % of Total Drains	52.81	51.91	34.44	43.80	18.74	30.96	52.37	29.37	18.74	52.81	39.30	11.97
239 Primary-Cyclone Drain, %	37.48	34.68	54.08	36.69	51.40	54.84	40.78	49.35	34.68	54.84	44.91	7.82
240 Secondary-Cyclone Drain, %	3.04	4.25	5.19	0.95	4.35	11.99	5.23	10.50	0.95	11.99	5.69	3.48
241 Baghouse Drain, %	6.67	9.16	6.29	18.56	25.51	2.21	1.63	10.78	1.63	25.51	10.10	7.67
242												
243 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
244												
245 CD Char, lb/h	18.04	14.42	14.93	19.65	10.33	6.11	10.35	11.47	6.11	19.65	13.16	4.17
246 CD Sorbent, lb/h	46.18	56.47	29.58	40.73	9.10	23.87	35.79	9.84	9.10	56.47	31.45	15.71
247 PD Char, lb/h	40.62	42.81	60.77	44.76	47.40	45.13	29.97	30.06	29.97	60.77	42.69	9.25
248 PD Sorbent, lb/h	4.95	4.57	9.11	5.82	5.89	7.99	5.95	5.76	4.57	9.11	6.25	1.43
249 SD Char, lb/h	3.21	4.95	5.82	1.06	3.75	9.60	3.81	6.44	1.06	9.60	4.83	2.38
250 SD Sorbent, lb/h	0.49	0.85	0.88	0.25	0.76	2.01	0.80	1.18	0.25	2.01	0.90	0.49
251 BD Char, lb/h	6.80	10.93	6.72	22.69	23.73	1.99	1.28	6.61	1.28	23.73	10.10	8.08
252 BD Sorbent, lb/h	1.30	1.58	1.41	2.90	2.71	0.14	0.16	1.21	0.14	2.90	1.43	0.95
253 Mixt Char, lb/h	68.67	73.11	88.24	88.15	85.20	62.84	45.40	54.59	45.40	88.24	70.78	14.97
254 Mixt Sorbent, lb/h	52.92	63.46	40.98	49.69	18.46	34.02	42.69	17.99	17.99	63.46	40.03	15.02
255												
256 Char in Carbonizer Drain, %	28.09	20.34	33.54	32.55	53.17	20.39	22.43	53.81	20.34	53.81	33.04	12.73
257 Char in Primary-Cyclone Drain, %	89.13	90.36	86.96	88.49	88.95	84.96	83.43	83.93	83.43	90.36	87.03	2.45
258 Char in Secondary-Cyclone Drain, %	86.83	85.42	86.86	81.15	83.13	82.67	82.71	84.57	81.15	86.86	84.17	1.96
259 Char in Baghouse Drain, %	83.91	87.38	82.71	88.68	89.73	93.24	89.08	84.52	82.71	93.24	87.41	3.29
260 Char in Total Drains, %	56.48	53.53	68.29	63.95	82.19	64.88	51.54	75.21	51.54	82.19	64.51	9.97
261												
262 Sorbent in Carbonizer Drain, %	71.91	79.66	66.46	67.45	46.83	79.61	77.57	46.19	46.19	79.66	66.96	12.73
263 Sorbent in Primary-Cyclone Drain, %	10.87	9.64	13.04	11.51	11.05	15.04	16.57	16.07	9.64	16.57	12.97	2.45
264 Sorbent in Secondary-Cyclone Drain, %	13.17	14.58	13.14	18.85	16.87	17.33	17.29	15.43	13.14	18.85	15.83	1.96
265 Sorbent in Baghouse Drain, %	16.09	12.62	17.29	11.32	10.27	6.76	10.92	15.48	6.76	17.29	12.59	3.29
266 Sorbent in Total Drains, %	43.52	46.47	31.71	36.05	17.81	35.12	48.46	24.79	17.81	48.46	35.49	9.97

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
267												
268 Coal Feed Composition, wt %												
269 -----												
270 C	49.103	48.355	48.702	49.178	48.904	47.898	46.374	46.639	46.374	49.178	48.144	1.024
271 H	3.571	3.489	3.496	3.494	3.523	3.262	3.165	3.188	3.165	3.571	3.398	0.154
272 O	11.748	12.273	12.464	12.110	12.114	12.877	12.872	13.082	11.748	13.082	12.443	0.435
273 N	0.958	0.954	0.962	0.963	0.960	0.841	0.819	0.825	0.819	0.963	0.910	0.064
274 S	0.652	0.691	0.700	0.696	0.675	0.666	0.627	0.609	0.609	0.700	0.664	0.031
275 Ash	5.797	5.907	5.929	5.964	5.895	5.217	5.475	5.422	5.217	5.964	5.700	0.268
276 Moisture	28.171	28.332	27.748	27.595	27.930	29.240	30.669	30.236	27.595	30.669	28.740	1.098
277 -----												
278 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
279 MF Coal Feed Composition, wt %												
280 -----												
281 C	68.362	67.471	67.406	67.922	67.856	67.691	66.888	66.852	66.852	68.362	67.556	0.483
282 H	4.971	4.868	4.838	4.825	4.888	4.610	4.565	4.569	4.565	4.971	4.767	0.150
283 O	16.356	17.125	17.251	16.726	16.809	18.198	18.566	18.752	16.356	18.752	17.473	0.850
284 N	1.334	1.331	1.331	1.330	1.332	1.188	1.181	1.182	1.181	1.334	1.276	0.071
285 S	0.908	0.964	0.969	0.961	0.937	0.941	0.904	0.873	0.873	0.969	0.932	0.032
286 Ash	8.070	8.241	8.205	8.236	8.179	7.372	7.896	7.771	7.372	8.241	7.996	0.285
287 -----												
288 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
289 -----												
290 Sorbent Feed Composition, wt %												
291 -----												
292 CaCO3	97.073	97.480	97.167	97.054	97.477	97.181	97.708	97.159	97.054	97.708	97.287	0.222
293 MgCO3	1.753	1.331	1.644	1.759	1.499	2.348	1.760	2.277	1.331	2.348	1.796	0.329
294 CaO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
295 MgO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
296 CaS	0.324	0.333	0.333	0.332	0.274	0.428	0.390	0.386	0.274	0.428	0.350	0.045
297 CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
298 Inerts	0.850	0.856	0.856	0.855	0.750	0.043	0.142	0.178	0.043	0.856	0.566	0.348
299 -----												

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
300 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
301												
302 CD Composition, wt %												
303 -----												
304 C	9.296	7.104	7.477	7.607	5.920	10.919	7.143	2.645	2.645	10.919	7.264	2.259
305 H	0.018	0.015	0.024	0.023	0.009	0.029	0.015	0.029	0.009	0.029	0.020	0.007
306 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
307 N	0.303	0.313	0.309	0.247	0.166	0.115	0.059	0.070	0.059	0.313	0.198	0.102
308 S	0.795	0.840	0.984	1.049	0.607	0.000	0.501	1.080	0.000	1.080	0.732	0.336
309 Ash	17.677	12.069	24.744	23.619	46.465	9.325	14.711	49.990	9.325	49.990	24.825	14.402
310 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
311 CaCO3	44.934	73.958	59.389	58.016	43.599	77.403	46.032	0.614	0.614	77.403	50.493	22.352
312 MgCO3	0.000	0.000	0.000	0.000	0.000	1.869	0.000	0.000	0.000	1.869	0.234	0.618
313 CaO	23.834	1.492	0.000	2.827	0.000	0.000	29.055	39.850	0.000	39.850	12.132	15.137
314 MgO	0.770	0.525	0.544	0.608	0.345	0.000	0.856	0.872	0.000	0.872	0.565	0.272
315 CaS	1.591	2.978	5.936	5.385	2.528	0.306	1.484	4.706	0.306	5.936	3.114	1.900
316 CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
317 Inerts	0.782	0.706	0.593	0.619	0.361	0.034	0.144	0.143	0.034	0.782	0.423	0.271
318												
319 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
320												
321 PD Composition, wt %												
322 -----												
323 C	71.457	72.423	69.635	70.309	65.195	65.230	60.386	63.881	60.386	72.423	67.314	3.972
324 H	0.548	0.687	0.643	0.548	0.466	0.663	0.498	0.627	0.466	0.687	0.585	0.076
325 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
326 N	1.652	1.504	1.331	1.048	1.271	0.937	0.691	0.742	0.691	1.652	1.147	0.327
327 S	1.237	0.703	0.820	0.508	1.923	0.066	0.217	0.833	0.066	1.923	0.788	0.551
328 Ash	14.239	15.045	14.536	16.079	20.099	18.068	21.641	17.844	14.239	21.641	17.194	2.526
329 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
330 CaCO3	5.483	6.649	8.729	6.824	6.497	8.688	14.782	9.854	5.483	14.782	8.438	2.755
331 MgCO3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
332 CaO	3.886	2.088	3.151	2.770	0.000	5.812	1.072	2.718	0.000	5.812	2.687	1.644

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
333 MgO	0.122	0.074	0.125	0.121	0.092	0.224	0.149	0.214	0.074	0.224	0.140	0.050
334 CaS	1.253	0.727	0.894	1.670	4.361	0.304	0.539	3.252	0.304	4.361	1.625	1.348
335 CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
336 Inerts	0.123	0.100	0.137	0.124	0.096	0.008	0.025	0.035	0.008	0.137	0.081	0.047
337												
338 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
339												
340 SD Composition, wt %												
341												
342 C	68.389	66.828	65.807	62.607	62.902	60.318	64.143	65.658	60.318	68.389	64.581	2.431
343 H	0.552	0.570	0.573	0.486	0.414	0.579	0.517	0.559	0.414	0.579	0.531	0.053
344 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
345 N	1.329	1.441	1.041	1.015	1.060	0.635	0.629	0.674	0.629	1.441	0.978	0.292
346 S	0.827	0.898	0.663	0.402	0.556	0.243	0.139	0.269	0.139	0.898	0.500	0.263
347 Ash	15.730	15.681	18.778	16.638	18.202	20.899	17.277	17.409	15.681	20.899	17.577	1.615
348 Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
349 CaCO3	8.827	8.812	8.863	9.953	8.755	10.959	11.512	10.945	8.755	11.512	9.828	1.089
350 MgCO3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
351 CaO	3.498	4.927	2.706	6.504	5.835	5.708	4.865	3.712	2.706	6.504	4.719	1.226
352 MgO	0.136	0.119	0.125	0.209	0.160	0.249	0.181	0.204	0.119	0.249	0.173	0.043
353 CaS	0.574	0.563	1.308	1.973	1.949	0.401	0.706	0.537	0.401	1.973	1.001	0.610
354 CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
355 Inerts	0.138	0.161	0.136	0.213	0.168	0.009	0.030	0.033	0.009	0.213	0.111	0.071
356												
357 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
358												
359 BD Composition, wt %												
360												
361 C	71.970	70.733	65.383	71.169	68.937	80.037	73.929	66.348	65.383	80.037	71.063	4.311
362 H	0.731	0.620	0.709	0.615	0.541	0.999	0.988	0.761	0.541	0.999	0.746	0.158
363 O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
364 N	1.236	1.483	1.011	1.341	1.459	1.107	1.020	0.515	0.515	1.483	1.147	0.294
365 S	0.986	0.545	1.371	0.558	0.775	0.709	0.992	0.327	0.327	1.371	0.783	0.306

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL.

Set Point		TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal		Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent		LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
366	Ash	8.990	13.998	14.237	14.995	18.021	10.389	12.152	16.570	8.990	18.021	13.669	2.839
367	Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
368	CaCO3	11.767	11.602	9.396	6.828	6.793	6.282	10.670	10.616	6.282	11.767	9.244	2.135
369	MgCO3	0.000	0.172	0.000	0.000	0.000	0.000	0.192	0.000	0.000	0.192	0.046	0.079
370	CaO	3.436	0.000	6.663	3.297	1.850	0.233	0.000	3.299	0.000	6.663	2.347	2.161
371	MgO	0.160	0.000	0.181	0.121	0.089	0.079	0.000	0.204	0.000	0.204	0.104	0.072
372	CaS	0.561	0.737	0.852	0.953	1.442	0.162	0.042	1.326	0.042	1.442	0.759	0.467
373	CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
374	Inerts	0.163	0.110	0.197	0.123	0.093	0.003	0.015	0.034	0.003	0.197	0.092	0.066
375													
376	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
377													
378	Combined Discharges Comp., wt %												
379	-----												
380	C	38.568	38.126	47.760	42.931	54.941	48.154	32.918	46.349	32.918	54.941	43.718	6.557
381	H	0.280	0.327	0.430	0.330	0.397	0.464	0.254	0.459	0.254	0.464	0.368	0.076
382	O	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
383	N	0.902	0.881	0.944	0.751	1.103	0.650	0.362	0.513	0.362	1.103	0.763	0.228
384	S	0.974	0.768	0.903	0.753	1.324	0.081	0.374	0.792	0.081	1.324	0.746	0.352
385	Ash	15.750	13.431	18.253	19.186	24.428	15.531	17.629	27.102	13.431	27.102	18.914	4.346
386	Moisture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
387	CaCO3	26.839	42.133	26.226	29.277	13.624	30.181	30.910	7.337	7.337	42.133	25.816	10.090
388	MgCO3	0.000	0.016	0.000	0.000	0.000	0.579	0.003	0.000	0.000	0.579	0.075	0.191
389	CaO	14.380	1.708	2.264	2.928	0.726	3.877	15.908	13.790	0.726	15.908	6.948	6.083
390	MgO	0.467	0.303	0.273	0.335	0.142	0.154	0.519	0.405	0.142	0.519	0.325	0.128
391	CaS	1.365	1.889	2.649	3.167	3.168	0.313	1.035	3.186	0.313	3.186	2.097	1.041
392	CaSO4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
393	Inerts	0.474	0.418	0.298	0.341	0.148	0.016	0.087	0.066	0.016	0.474	0.231	0.163
394													
395	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
396													
397	CD-Char Fraction Composition, wt %												
398	-----												

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
399 C	33.09	34.92	22.29	23.37	11.13	53.56	31.85	4.92	4.92	53.56	26.89	14.16
400 H	0.06	0.07	0.07	0.07	0.02	0.14	0.07	0.05	0.02	0.14	0.07	0.03
401 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
402 N	1.08	1.54	0.92	0.76	0.31	0.56	0.26	0.13	0.13	1.54	0.70	0.44
403 S	2.83	4.13	2.93	3.22	1.14	0.00	2.23	2.01	0.00	4.13	2.31	1.20
404 Ash	62.93	59.33	73.78	72.57	87.39	45.74	65.59	92.89	45.74	92.89	70.03	14.23
405												
406 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
407 PD-Char Fraction Composition, wt %												
408												
409 C	80.17	80.15	80.07	79.45	73.29	76.77	72.38	76.11	72.38	80.17	77.30	2.97
410 H	0.61	0.76	0.74	0.62	0.52	0.78	0.60	0.75	0.52	0.78	0.67	0.09
411 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
412 N	1.85	1.66	1.53	1.18	1.43	1.10	0.83	0.88	0.83	1.85	1.31	0.35
413 S	1.39	0.78	0.94	0.57	2.16	0.08	0.26	0.99	0.08	2.16	0.90	0.62
414 Ash	15.98	16.65	16.71	18.17	22.59	21.27	25.94	21.26	15.98	25.94	19.82	3.29
415												
416 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
417 SD-Char Fraction Composition, wt %												
418												
419 C	78.76	78.24	75.76	77.15	75.66	72.96	77.56	77.64	72.96	78.76	76.72	1.75
420 H	0.64	0.67	0.66	0.60	0.50	0.70	0.63	0.66	0.50	0.70	0.63	0.06
421 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
422 N	1.53	1.69	1.20	1.25	1.28	0.77	0.76	0.80	0.76	1.69	1.16	0.33
423 S	0.95	1.05	0.76	0.50	0.67	0.29	0.17	0.32	0.17	1.05	0.59	0.30
424 Ash	18.12	18.36	21.62	20.50	21.89	25.28	20.89	20.59	18.12	25.28	20.91	2.10
425												
426 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
427 BD-Char Fraction Composition, wt %												
428												
429 C	85.77	80.95	79.05	80.26	76.82	85.84	82.99	78.50	76.82	85.84	81.27	3.11
430 H	0.87	0.71	0.86	0.69	0.60	1.07	1.11	0.90	0.60	1.11	0.85	0.17
431 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
432 N	1.47	1.70	1.22	1.51	1.63	1.19	1.15	0.61	0.61	1.70	1.31	0.33
433 S	1.18	0.62	1.66	0.63	0.86	0.76	1.11	0.39	0.39	1.66	0.90	0.38
434 Ash	10.71	16.02	17.21	16.91	20.08	11.14	13.64	19.60	10.71	20.08	15.67	3.32
435												
436 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
437 Combined Disch-Char Frac Comp, wt %												
438												
439 C	68.29	71.22	69.94	67.13	66.84	74.22	63.87	61.62	61.62	74.22	67.89	3.75
440 H	0.50	0.61	0.63	0.52	0.48	0.72	0.49	0.61	0.48	0.72	0.57	0.08
441 O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
442 N	1.60	1.65	1.38	1.17	1.34	1.00	0.70	0.68	0.68	1.65	1.19	0.35
443 S	1.73	1.43	1.32	1.18	1.61	0.12	0.73	1.05	0.12	1.73	1.15	0.49
444 Ash	27.89	25.09	26.73	30.00	29.72	23.94	34.21	36.03	23.94	36.03	29.20	3.95
445												
446 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
447												
448 CD-Sorbent Fraction Composition, wt %												
449												
450 CaCO3	62.49	92.84	89.36	86.01	93.09	97.23	59.34	1.33	1.33	97.23	72.71	30.11
451 MgCO3	0.00	0.00	0.00	0.00	0.00	2.35	0.00	0.00	0.00	2.35	0.29	0.78
452 CaO	33.14	1.87	0.00	4.19	0.00	0.00	37.46	86.28	0.00	86.28	20.37	28.83
453 MgO	1.07	0.66	0.82	0.90	0.74	0.00	1.10	1.89	0.00	1.89	0.90	0.49
454 CaS	2.21	3.74	8.93	7.98	5.40	0.38	1.91	10.19	0.38	10.19	5.09	3.38
455 CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
456 Inerts	1.09	0.89	0.89	0.92	0.77	0.04	0.19	0.31	0.04	1.09	0.64	0.37
457												
458 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
459 PD Sorbent Fraction Composition, wt %												
460												
461 CaCO3	50.46	68.99	66.96	59.29	58.82	57.78	89.23	61.31	50.46	89.23	64.10	10.89
462 MgCO3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
463 CaO	35.76	21.66	24.17	24.07	0.00	38.65	6.47	16.91	0.00	38.65	20.96	12.34
464 MgO	1.12	0.77	0.96	1.05	0.83	1.49	0.90	1.33	0.77	1.49	1.06	0.23

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
465 CaS	11.53	7.54	6.86	14.51	39.48	2.02	3.25	20.23	2.02	39.48	13.18	11.41
466 CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
467 Inerts	1.13	1.04	1.05	1.08	0.87	0.05	0.15	0.22	0.05	1.13	0.70	0.44
468												
469 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
470 SD-Sorbent Fraction Composition, wt %												
471												
472 CaCO3	67.01	60.43	67.46	52.80	51.91	63.25	66.57	70.93	51.91	70.93	62.54	6.56
473 MgCO3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
474 CaO	26.55	33.79	20.60	34.50	34.59	32.94	28.13	24.06	20.60	34.59	29.40	5.01
475 MgO	1.03	0.82	0.95	1.11	0.95	1.44	1.05	1.32	0.82	1.44	1.08	0.19
476 CaS	4.36	3.86	9.96	10.47	11.56	2.31	4.08	3.48	2.31	11.56	6.26	3.48
477 CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
478 Inerts	1.05	1.10	1.04	1.13	1.00	0.05	0.17	0.21	0.05	1.13	0.72	0.45
479												
480 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
481 BD-Sorbent Fraction Composition, wt %												
482												
483 CaCO3	73.15	91.93	54.35	60.31	66.16	92.94	97.72	68.58	54.35	97.72	75.64	15.36
484 MgCO3	0.00	1.36	0.00	0.00	0.00	0.00	1.76	0.00	0.00	1.76	0.39	0.68
485 CaO	21.36	0.00	38.54	29.12	18.02	3.45	0.00	21.31	0.00	38.54	16.47	13.27
486 MgO	0.99	0.00	1.05	1.07	0.87	1.17	0.00	1.32	0.00	1.32	0.81	0.48
487 CaS	3.49	5.84	4.93	8.42	14.04	2.40	0.38	8.57	0.38	14.04	6.01	4.02
488 CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
489 Inerts	1.01	0.87	1.14	1.09	0.91	0.04	0.14	0.22	0.04	1.14	0.68	0.43
490												
491 Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
492 Combined Disch-Sorbent Frac Comp, wt %												
493												
494 CaCO3	61.66	90.67	82.71	81.21	76.51	85.94	63.78	29.60	29.60	90.67	71.51	18.48
495 MgCO3	0.00	0.03	0.00	0.00	0.00	1.65	0.01	0.00	0.00	1.65	0.21	0.54
496 CaO	33.04	3.68	7.14	8.12	4.08	11.04	32.83	55.64	3.68	55.64	19.44	17.71
497 MgO	1.07	0.65	0.86	0.93	0.80	0.44	1.07	1.63	0.44	1.63	0.93	0.33

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point		TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal		Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent		LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
498	CaS	3.14	4.07	8.36	8.79	17.79	0.89	2.13	12.86	0.89	17.79	7.25	5.47
499	CaSO4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
500	Inerts	1.09	0.90	0.94	0.95	0.83	0.05	0.18	0.27	0.05	1.09	0.65	0.39
501													
502	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
503													
504	Carbonizer Exit Gas Comp., mol %												
505	-----												
506	CO	9.819	8.280	10.957	11.921	11.685	5.398	6.222	7.832	5.398	11.921	9.014	2.313
507	CO2	9.582	9.287	9.331	9.264	9.098	11.024	11.625	11.831	9.098	11.831	10.130	1.084
508	H2	7.718	6.831	8.732	7.769	8.451	7.623	7.590	8.929	6.831	8.929	7.955	0.652
509	H2O	11.729	12.692	12.531	12.569	12.448	16.167	14.833	14.239	11.729	16.167	13.401	1.417
510	CH4	1.533	1.482	1.786	1.882	1.623	1.505	1.298	1.776	1.298	1.882	1.611	0.182
511	C2H4	0.031	0.043	0.026	0.011	0.010	0.041	0.021	0.010	0.010	0.043	0.024	0.013
512	C2H6	0.022	0.043	0.036	0.016	0.012	0.095	0.037	0.052	0.012	0.095	0.039	0.025
513	N2	58.841	60.399	55.747	55.696	55.946	57.295	57.517	54.496	54.496	60.399	56.992	1.801
514	H2S	0.021	0.003	0.010	0.010	0.005	0.131	0.077	0.038	0.003	0.131	0.037	0.042
515	COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
516	NH3	0.188	0.446	0.329	0.308	0.172	0.261	0.291	0.297	0.172	0.446	0.286	0.080
517	Ar	0.516	0.494	0.516	0.554	0.550	0.459	0.488	0.498	0.459	0.554	0.509	0.030
518													
519	Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
520													
521	Orifice Gas Composition, mol %												
522	-----												
523	CO	9.626	8.120	10.760	11.790	11.569	4.739	5.476	7.106	4.739	11.790	8.648	2.545
524	CO2	9.394	9.107	9.163	9.162	9.008	9.679	10.230	10.734	9.008	10.734	9.559	0.580
525	H2	7.566	6.699	8.575	7.683	8.367	6.693	6.679	8.101	6.679	8.575	7.546	0.730
526	H2O	11.498	12.446	12.306	12.431	12.324	14.194	13.053	12.918	11.498	14.194	12.646	0.730
527	CH4	1.503	1.453	1.753	1.862	1.607	1.321	1.142	1.612	1.142	1.862	1.532	0.216
528	C2H4	0.031	0.042	0.025	0.011	0.010	0.036	0.019	0.009	0.009	0.042	0.023	0.012
529	C2H6	0.022	0.042	0.035	0.016	0.012	0.083	0.033	0.047	0.012	0.083	0.036	0.021
530	N2	59.650	61.167	56.543	56.183	56.383	62.507	62.614	58.716	56.183	62.614	59.220	2.525

Table 3.3 (cont). MEASURED AND DERIVED CARBONIZER DATA
WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime	LV Lime				
531 H2S	0.021	0.003	0.010	0.010	0.005	0.115	0.068	0.035	0.003	0.115	0.033	0.037
532 COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
533 NH3	0.184	0.437	0.323	0.304	0.171	0.229	0.256	0.269	0.171	0.437	0.272	0.080
534 Ar	0.505	0.484	0.507	0.548	0.544	0.403	0.429	0.452	0.403	0.548	0.484	0.049
535												
536 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000
537												
538 Demister Gas Composition, mol %												
539 -----												
540 CO	8.742	7.298	9.868	11.076	10.908	4.319	5.000	6.750	4.319	11.076	7.995	2.413
541 CO2	8.531	8.185	8.403	8.607	8.493	8.820	9.341	10.197	8.185	10.197	8.822	0.610
542 H2	6.871	6.021	7.864	7.218	7.889	6.099	6.099	7.696	6.021	7.889	6.970	0.763
543 H2O	10.442	11.186	11.285	11.678	11.620	12.935	11.919	12.272	10.442	12.935	11.667	0.700
544 CH4	1.365	1.306	1.608	1.749	1.515	1.204	1.043	1.531	1.043	1.749	1.415	0.215
545 C2H4	0.028	0.038	0.023	0.010	0.009	0.033	0.017	0.009	0.009	0.038	0.021	0.011
546 C2H6	0.020	0.038	0.032	0.015	0.011	0.076	0.030	0.045	0.011	0.076	0.033	0.019
547 N2	63.356	65.097	60.147	58.837	58.876	65.833	65.863	60.782	58.837	65.863	62.349	2.845
548 H2S	0.019	0.003	0.009	0.009	0.005	0.105	0.062	0.033	0.003	0.105	0.031	0.034
549 COS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
550 NH3	0.167	0.393	0.296	0.286	0.161	0.209	0.234	0.256	0.161	0.393	0.250	0.071
551 Ar	0.459	0.435	0.465	0.515	0.513	0.367	0.392	0.429	0.367	0.515	0.447	0.049
552												
553 Total	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	0.000

Figure 3.1. CARBONIZER AVERAGE BED TEMPERATURE DURING STEADY-STATE PERIODS

Figure 3.2. CARBONIZER PRESSURE DURING STEADY-STATE PERIODS

Figure 3.3. SULFUR CONTENT IN COAL FEED DURING STEADY-STATE PERIODS

Figure 3.4. COAL FEED RATE TO CARBONIZER DURING STEADY-STATE PERIODS

Figure 3.5. SORBENT FEED RATE TO CARBONIZER DURING STEADY-STATE PERIODS

Figure 3.7. CALCIUM-TO-SULFUR RATIO IN FEED DURING STEADY-STATE PERIODS
WITH SUBBITUMINOUS COAL FEED

1.30 to 2.78 lb-mol/lb-mol (average = 2.09 lb-mol/lb-mol), and for Wyoming coal from 2.20 to 9.79 lb-mol/lb-mol (average = 6.46 lb-mol/lb-mol).

Figure 3.8 shows the air feed rate during different set points. The air feed rate ranged for Pittsburgh coal from 538 to 960 lb/h, for Illinois coal from 513 to 936 lb/h, and for Wyoming coal from 600 to 993 lb/h. Figure 3.9 shows the air-to-coal feed ratio for different set points. The air-to-coal feed ratio ranged for Pittsburgh coal from 1.39 to 3.67 lb/lb (average = 2.43 lb/lb), for Illinois coal from 2.17 to 2.41 lb/lb (average = 2.24 lb/lb), and for Wyoming coal from 2.01 to 2.44 lb/lb (average = 2.21 lb/lb). Usually, the air-to-coal ratio was between 2.0 and 2.5. Because of the high surface-to-volume ratio of the pilot-scale carbonizer and the cooling effect of the nitrogen from pressure-tap purges and the internal drain cooler, the pilot-scale unit needs a higher air-to-coal ratio to reach the desired temperature for a commercial plant.

Figure 3.10 shows the steam feed rate for different set points. The steam feed rate ranged for Pittsburgh coal from 0 to 143 lb/h, for Illinois coal from 59 to 145 lb/h, and for Wyoming coal from 0 to 53 lb/h. Figure 3.11 shows the steam-to-coal feed ratio for different set points. The steam-to-coal ratio ranged for Pittsburgh coal from 0.0 to 0.46 lb/lb, for Illinois coal from 0.25 to 0.37 lb/lb, and for Wyoming coal from 0.0 to 0.15 lb/lb. The steam was fed to the carbonizer during several set points to simulate feeding coal as a paste in a commercial carbonizer.

Figure 3.12 shows the purge nitrogen flow rate to the carbonizer. This flow rate ranged for Pittsburgh coal from 125 to 381 lb/h, for Illinois coal from 178 to 209 lb/h, and for Wyoming coal from 152 to 232 lb/h. Figure 3.13 shows the purge nitrogen flow rate to the system (it includes purges to the carbonizer, cyclones, cyclone diplegs, opacity meter, and spray tower) for different set points. This flow rate ranged for Pittsburgh coal from 306 to 694 lb/h, for Illinois coal from 285 to 331 lb/h, and for Wyoming coal from 274 to 528 lb/h.

Figure 3.14 shows the total solids drains (it includes bed drain, first-cyclone fines, second-cyclone fines, and baghouse/cross-flow filter fines) rate for different set points. This rate ranged for Pittsburgh coal from 125 to 388 lb/h, for Illinois coal from 151 to 235 lb/h, and for Wyoming coal from 73 to 138 lb/h. The rates are significantly lower for set points with Wyoming coal feed due to the lower sorbent feed rates and relatively higher carbon conversions. Figure 3.15 shows the carbonizer product gas flow rate for different set points. This flow rate ranged for Pittsburgh coal from 884 to 1517 lb/h, for Illinois coal from 882 to 1543 lb/h, and for Wyoming coal from 1100 to 1505 lb/h.

Figure 3.16 shows the bed density for different set points. The bed density was calculated from ΔP measured in the bed (PDI 3059); the pressure taps were located 3 ft apart, and the lower pressure tap was located 8 ft above the top of the feed pipe. The bed density ranged for Pittsburgh coal from 11.7 to 21.3 lb/ft³ (average = 15.1 lb/ft³), for Illinois coal from 11.8 to 30.0 lb/ft³ (average = 17.3 lb/ft³), and for Wyoming coal from 26.9 to 59.7 lb/ft³ (average = 46.6 lb/ft³). The bed density was significantly higher for set points with the Wyoming coal feed. The average sorbent-to-char ratios in the carbonizer drains were 0.86, 0.93, and 2.03 for the Pittsburgh coal, Illinois coal, and Wyoming coal, respectively. Furthermore, the average ash contents of the char fraction of the carbonizer drains were 32%, 38%, and 70% for the Pittsburgh coal, Illinois coal, and Wyoming coal, respectively. The larger amount of sorbent content and higher ash content of the char in the bed material result in higher bed density for the Wyoming coal.

Figure 3.17 shows the bed height for different set points. The bed height was calculated using the measured ΔP across the entire bed (PDI 3057) and ΔP measured within the bed (which was used to

Figure 3.8. AIR FEED RATE TO CARBONIZER DURING STEADY-STATE PERIODS

Figure 3.9. AIR-TO-COAL FEED RATIO DURING STEADY-STATE PERIODS

Figure 3.10. STEAM FEED RATE TO CARBONIZER DURING STEADY-STATE PERIODS

Figure 3.11. STEAM-TO-COAL FEED RATIO DURING STEADY-STATE PERIODS

Figure 3.12. PURGE NITROGEN FEED RATE TO CARBONIZER DURING STEADY-STATE PERIODS

Figure 3.13. PURGE NITROGEN FEED RATE TO SYSTEM DURING STEADY-STATE PERIODS

Figure 3.14. TOTAL SOLIDS DRAINS RATE FROM CARBONIZER DURING STEADY-STATE PERIODS

Set Point

Figure 3.16. BED DENSITY IN CARBONIZER DURING STEADY-STATE PERIODS

Figure 3.17. BED HEIGHT IN CARBONIZER DURING STEADY-STATE PERIODS

calculate the bed density, as described above). The bed height ranged for Pittsburgh coal from 14.9 to 26.5 ft (average = 18.5 ft), for Illinois coal from 15.4 to 18.3 ft (average = 17.0 ft), and for Wyoming coal from 14.5 to 23.7 ft (average = 18.7 ft). The bed height usually ranged between 14 and 18 ft. It should be noted that above 19 ft, the bed diameter increases from 12 to 14 inches.

Figure 3.18 shows the inlet superficial velocity (calculated in the 10-in.-diameter section at the average bed temperature and pressure, and based on the total gas feed to the carbonizer, namely, the feed air + steam + purge nitrogen flow rate). The inlet velocity ranged from 1.90 to 3.24 ft/s (average = 2.56 ft/s). Because the coal is fed (along with air) at the bottom of the carbonizer, and it is devolatilized soon after it enters, it is reasonable to assume that most of the gas is produced near the bottom of the reactor (the rest of the bed essentially helps in tar cracking and sulfur capture). Figure 3.19 shows the gas superficial velocity in the 10-in.-diameter section based on the carbonizer exit gas. This velocity ranged from 2.54 to 4.01 ft/s (average = 3.22 ft/s). As seen from the figure, most of the set points were conducted at a velocity of about 3 ft/s. The product gas velocity in the 12-in.-diameter expanded bed section is shown in Figure 3.20. This velocity ranged from 1.77 to 2.78 ft/s (average = 2.23 ft/s). Finally, the product gas velocity in the freeboard section (diameter = 14 in.) is shown in Figure 3.21. The freeboard velocity ranged from 1.27 to 2.01 ft/s (average = 1.62 ft/s). The freeboard velocity was about 1.5 ft/s during most of the set points. Figures 3.18 through 3.21 have the same scale range on the y-axis; this has been done intentionally to allow one to compare these velocities with each other. Figure 3.22 shows the gas residence time for different set points. The gas residence time has been estimated by the bed height and product gas velocity in the different sections. The gas residence time ranged for Pittsburgh coal from 5.4 to 16.1 s (average = 8.4 s), for Illinois coal from 5.1 to 8.8 s (average = 6.9 s), and for Wyoming from 6.0 to 11.2 s (average = 8.0 s).

Figures 3.23 and 3.24 show the ratio of calcium in sorbent feed-to-released coal sulfur for different set points with bituminous coals and subbituminous coal feed, respectively. This ratio ranged for Pittsburgh coal from 1.10 to 7.38 lb-mol/lb-mol (average = 2.65 lb-mol/lb-mol), for Illinois coal from 2.04 to 3.47 lb-mol/lb-mol (average = 2.81 lb-mol/lb-mol), and for Wyoming coal from 4.18 to 21.76 lb-mol/lb-mol (average = 10.64 lb-mol/lb-mol).

The carbonizer data have been analyzed rigorously to develop necessary correlations for updating the existing model. For bituminous coals, the correlations were developed based on 24 set points obtained with the Pittsburgh coal; these correlations were then applied to 4 set points with the Illinois coal feed also for model verification. For subbituminous coals, the correlations were developed based on 8 set points obtained with the Wyoming coal. For data analysis, all the solids drains (it includes bed drain, first-cyclone fines, second-cyclone fines, and baghouse/cross-flow filter fines) were combined and treated as one stream.

Figure 3.25 is a plot of carbon conversion versus the average bed temperature. The best fit lines for the Pittsburgh coal, Illinois coal, and Wyoming coal are also shown in the figure. As shown in the figure, the carbon conversion is higher while the bed temperature is lower for the Wyoming coal relative to the bituminous coals, which is expected. The carbon conversion is also plotted against oxygen in air-to-carbon in the coal feed in Figure 3.26. It shows that the carbon conversion relates quite well to the ratio of oxygen in air feed-to-carbon in coal feed. In this case, Pittsburgh and Illinois coal data fall on one line while Wyoming coal data fall on another line. This relationship should be used in the model, however, this form is unsuitable for the existing model.

The organic carbon in the char, which is used to calculate the carbon conversion, is not a measured value; it is determined by the difference between the total carbon measurement and the carbonate carbon measurement, thus contributing to some inaccuracy. Furthermore, although the bed drain samples were

Figure 3.19. PRODUCT GAS SUPERFICIAL VELOCITY IN 10-INCH-DIAMETER CARBONIZER SECTION DURING STEADY-STATE PERIODS

Figure 3.20. PRODUCT GAS SUPERFICIAL VELOCITY IN 12-INCH-DIAMETER CARBONIZER SECTION DURING STEADY-STATE PERIODS

Figure 3.21. FREEBOARD GAS SUPERFICIAL VELOCITY DURING STEADY-STATE PERIODS

Figure 3.22. GAS RESIDENCE TIME DURING STEADY-STATE PERIODS

Figure 3.23. RATIO OF FEED CALCIUM-TO-RELEASED COAL SULFUR DURING STEADY-STATE PERIODS WITH BITUMINOUS COAL FEEDS

Feed Ca/Released S, lbmol/lbmol

Figure 3.24. RATIO OF FEED CALCIUM-TO-RELEASED COAL SULFUR DURING STEADY-STATE PERIODS WITH SUBBITUMINOUS COAL FEED

Figure 3.25. RELATIONSHIP BETWEEN CARBON CONVERSION AND BED TEMPERATURE

Figure 3.26. RELATIONSHIP BETWEEN CARBON CONVERSION AND RATIO OF OXYGEN IN AIR-TO-CARBON IN COAL FEED

collected using a thief (a solids-sampling device), getting a uniform representative sample was a problem in the pilot plant because it contains two distinct types of particles, namely, coal char and spent sorbent. Because of the differences in the particle sizes and densities of these two components, they tend to separate very easily, thus making it difficult to get a representative sample. This affects the organic carbon content of the sample, and thus the measured carbon conversion calculation as well.

Figure 3.27 is a plot of coal nitrogen released versus the average bed temperature. For a given temperature, the nitrogen released is highest for the Wyoming subbituminous coal, followed by Illinois coal, and then Pittsburgh coal. The coal nitrogen released relates very well to carbon conversion for each coal, as shown in Figure 3.28. Figure 3.29 is a plot of nitrogen-to-carbon ratio in the coal char in all the solids drains combined versus the average bed temperature. The relationships can be expressed as -

for Pittsburgh coal:

$$N/C = -1.6173 \times 10^{-5} T_{\text{Bed}} + 0.04843 \quad (3.1)$$

and for Wyoming coal:

$$N/C = -1.8974 \times 10^{-5} T_{\text{Bed}} + 0.04458 \quad (3.2)$$

where -

$$\begin{aligned} N/C &= \text{nitrogen-to-carbon ratio in coal char, lb-mol/lb-mol} \\ T_{\text{Bed}} &= \text{average bed temperature, } ^\circ\text{F} \end{aligned}$$

Although the relationships shown in Figures 3.27 and 3.28 are much better than those shown in Figure 3.29, the forms of correlations are not compatible with those present in the existing model, and thus cannot be used for model update. Equations 3.1 and 3.2 are in appropriate forms for the existing model.

Figure 3.30 is a plot of coal sulfur released versus the average bed temperature. These data show a lot of scatter, and no trend is obvious. The coal sulfur released relates reasonably well to carbon conversion for each type of coal feed, as shown in Figure 3.31. Figure 3.32 is a plot of sulfur-to-carbon ratio in the coal char in all the solids drains combined versus the average bed temperature. These relationships can be expressed as -

for Pittsburgh coal:

$$S/C = -2.3497 \times 10^{-5} T_{\text{Bed}} + 0.04588 \quad (3.3)$$

and for Wyoming coal:

$$S/C = -8.7911 \times 10^{-6} T_{\text{Bed}} + 0.02059 \quad (3.4)$$

where -

$$\begin{aligned} S/C &= \text{sulfur-to-carbon ratio in coal char, lb-mol/lb-mol} \\ T_{\text{Bed}} &= \text{average bed temperature, } ^\circ\text{F} \end{aligned}$$

Although the relationships shown in Figure 3.31 are better compared to those shown in Figure 3.32, only the relationships of equations 3.3 and 3.4 could be used because of the model constraints.

Figure 3.27. RELATIONSHIP BETWEEN COAL NITROGEN RELEASED AND BED TEMPERATURE

Figure 3.28. RELATIONSHIP BETWEEN COAL NITROGEN RELEASED AND CARBON CONVERSION

Figure 3.29. RELATIONSHIP BETWEEN RATIO OF NITROGEN-TO-CARBON IN COAL CHAR
IN COMBINED SOLIDS DRAINS AND BED TEMPERATURE

Figure 3.30. RELATIONSHIP BETWEEN COAL SULFUR RELEASED AND BED TEMPERATURE

Figure 3.32. RELATIONSHIP BETWEEN RATIO OF SULFUR-TO-CARBON IN COAL CHAR
IN COMBINED SOLIDS DRAINS AND BED TEMPERATURE

The correlations for the coal sulfur released are somewhat poor. The possible reasons are described below.

- Several coal feed samples were collected during a test run, and an average coal feed composition, based on all these samples, was calculated. This average composition was then used in the material and energy balances for all the set points achieved during the test run. As shown in Table 3.4, the sulfur content in these samples often varied a lot. For example, the sulfur content in the Pittsburgh coal feed ranged from 3.74% to 6.22% with an average value of 4.51% during the Test Run TR2. Similarly, the sulfur content in the Wyoming coal ranged from 0.58% to 0.90% with an average value of 0.72% during Test Run TR6. As shown in Table 3.4, the sulfur content was significantly higher in the samples taken during the beginning of the Test Run TR6 as compared to the samples collected later. Thus, using an average value for all the set points caused the BALAID program to adjust the sulfur content of the species in the product streams, which may not be true.
- The organic sulfur in the char is not a measured value; it is determined by the difference between the total sulfur and the sum of sulfate sulfur and sulfide sulfur, thus contributing to some inaccuracy.
- The sulfur closures were quite poor in the raw material and energy balances based on the true measurements; the sulfur closures ranged from 37.4% to 265.5% (Figure 3.33) with an average value of 78.7% and a standard deviation of 40.6%. Thus, adjustments made in the measurements during reconciliation of data, with respect to sulfur, may also be somewhat ambiguous. The details of these adjustments have been given in Volume 1 of this report.

Figure 3.34 is a plot of coal hydrogen released versus the average bed temperature. For a given temperature, the hydrogen released is higher for the subbituminous coal relative to the bituminous coals. The coal hydrogen released related reasonably well to carbon conversion for each type of coal, as shown in Figure 3.35. Figure 3.36 is a plot of hydrogen-to-carbon ratio in the coal char in all the solids drains combined versus the average bed temperature. The relationships are expressed as -

for Pittsburgh coal:

$$H/C = -1.4510 \times 10^{-4} T_{\text{Bed}} + 0.3260 \quad (3.5)$$

and for Wyoming coal:

$$H/C = -1.6842 \times 10^{-4} T_{\text{Bed}} + 0.3596 \quad (3.6)$$

where -

H/C = hydrogen-to-carbon ratio in coal char, lb-mol/lb-mol

T_{Bed} = average bed temperature, °F

The relationships shown in Figures 3.34 and 3.35 are better than those shown in Figures 3.36; however, the existing model was developed based on relationships expressed in equations 3.5 and 3.6, and are therefore retained here also.

During devolatilization, the oxygen present in the coal forms CO , CO_2 , and H_2O . The correlations used in the existing model indicate that the total coal oxygen conversion to CO , CO_2 , and H_2O

Table 3.4. VARIATION OF SULFUR IN COAL FEED SAMPLES

Run No.	Set Points	Coal Type	Sulfur in Coal Feed, wt%
TR1	1, 2, 3, 4	Pittsburgh	3.24, 3.05, 3.70, 3.02, 3.11, 3.27, 2.84, 3.05, 3.27, 3.33, 3.03
TR2	1, 2, 3, 4, 5	Pittsburgh	3.96, 3.74, 4.94, 4.67, 3.88, 4.12, 6.22, 5.20, 4.83, 4.06, 3.94
TR4	1, 2, 3, 4, 5, 6, 7, 8	Pittsburgh	3.78, 3.16, 3.52, 2.96, 3.49, 3.18, 3.40
TR5	1, 2, 3	Pittsburgh	1.85, 1.86, 2.01, 1.81
TR6	1, 2, 3, 4, 5	Wyoming	0.90, 0.83, 0.68, 0.58, 0.60
TR6	6, 7	Illinois	2.72, 3.37
TR8	1, 2, 3	Wyoming	0.70, 0.56, 0.76
TR8	4, 5	Illinois	2.80, 3.26
TR8	6/7, 8, 9, 10	Pittsburgh	4.44, 3.81, 3.96

Set Point

Figure 3.33. SULFUR CLOSURE IN RAW MATERIAL BALANCES FOR DIFFERENT SET POINTS

Figure 3.34. RELATIONSHIP BETWEEN COAL HYDROGEN RELEASED AND BED TEMPERATURE

Figure 3.35. RELATIONSHIP BETWEEN COAL HYDROGEN RELEASED AND CARBON CONVERSION

Figure 3.36. RELATIONSHIP BETWEEN RATIO OF HYDROGEN-TO-CARBON IN COAL CHAR IN COMBINED SOLIDS DRAINS AND BED TEMPERATURE

is approximately 80%; thus about 20% remains in the char. Based on the carbonizer data, the oxygen remaining in the char is negligible. Thus, the yields of CO and CO₂ were increased equally (based on oxygen in the species) such that the total oxygen conversion is about 95%. The coal oxygen conversion can be expressed as -

$$Y_{H_2O} = 0.375 \quad (3.7)$$

$$Y_{CO} = 0.358 \quad (3.8)$$

$$Y_{CO_2} = 0.242 - 0.0017 (O/C) \quad (3.9)$$

where -

$$\begin{aligned} Y_{H_2O}, Y_{CO}, \text{ and } Y_{CO_2} &= \text{fraction of feed coal oxygen converted to } H_2O, CO, \text{ and } CO_2, \\ &\quad \text{lb-atom O/lb-atom O in feed coal} \\ O/C &= \text{ratio of O to C in feed coal, lb-atom/lb-atom} \end{aligned}$$

Figure 3.37 is a plot of methane yield versus the average bed temperature. As expected, the methane yield decreases as the temperature increases. The methane yield was correlated to the available hydrogen, average bed temperature, and carbonizer pressure according to the form in the existing model. Thus,

$$Y_{CH_4} = (0.226 H_{avail} - 1.004 \times 10^{-2} T_{Bed} + 20.245) [0.148 \log_{10}(P) + 1] \quad (3.10)$$

where -

$$\begin{aligned} H_{avail} &= \text{available hydrogen, lb-atom H/lb-atom C in coal} \\ Y_{CH_4} &= \text{feed coal carbon converted to methane, \%} \\ T_{Bed} &= \text{average bed temperature, } ^\circ\text{F} \\ P &= \text{carbonizer pressure, atm} \end{aligned}$$

The available hydrogen (H_{avail}) is the excess coal hydrogen over what is required for water formation (see equation 3.7) and can be expressed as -

$$H_{avail} = H/C - 2 (H_2O/C) \quad (3.11)$$

where -

$$\begin{aligned} H/C &= \text{atomic ratio of H to C in coal, lb-atom H/lb-atom C in coal} \\ H_2O/C &= \text{water yield, lb-mol } H_2O/\text{lb-atom C in coal} \end{aligned}$$

Combining equations 3.7 and 3.11 gives -

$$H_{avail} = H/C - (2.0) (0.375) (O/C) \quad (3.12)$$

where H/C and O/C have been defined above. Equation 3.10 is drawn in Figure 3.37 with average values of the H_{avail} (= 0.738 lb-atom/lb-atom) and the carbonizer pressure (= 151.8 psig).

Figure 3.38 shows a comparison of the measured and calculated (using equation 3.10) values of the methane yield. The correlation is somewhat poor primarily because the measured yields show a lot of

Figure 3.37. RELATIONSHIP BETWEEN METHANE YIELD AND BED TEMPERATURE FOR BITUMINOUS COALS

scatter, and often it has not been possible to logically explain the measured yields, thereby making it difficult to correlate.

The methane yield for the Wyoming subbituminous coal is shown in Figure 3.39. A simple correlation was developed for this coal because only 8 data points are available. The methane yield can be expressed as -

$$Y_{CH_4} = -1.875 \times 10^{-3} T_{Bed} + 8.3438 \quad (3.13)$$

where Y_{CH_4} and T_{Bed} have been defined above.

Figure 3.40 is a plot of ethylene yield versus the average bed temperature. As expected, the ethylene yield decreases as temperature increases. The ethylene yield has been correlated as follows:

for Pittsburgh coal:

$$Y_{C_2H_4} = -2.8098 \times 10^{-3} T_{Bed} + 4.8217 \quad (T_{Bed} < 1716^\circ F) \quad (3.14)$$

$$Y_{C_2H_4} = 0.0 \quad (T_{Bed} \geq 1716^\circ F) \quad (3.15)$$

and for Wyoming coal:

$$Y_{C_2H_4} = -1.6474 \times 10^{-3} T_{Bed} + 2.7463 \quad (T_{Bed} < 1667^\circ F) \quad (3.16)$$

$$Y_{C_2H_4} = 0.0 \quad (T_{Bed} \geq 1667^\circ F) \quad (3.17)$$

where -

$Y_{C_2H_4}$ = feed coal carbon converted to ethylene, %

T_{Bed} = average bed temperature, °F

Figure 3.41 is a plot of ethane yield versus the average bed temperature. The ethane yields of 0.99% and 2.14% of carbon in the coal feed, reported for set points TR1-4 and TR2-2, respectively, are unusually high and are not included in this figure (off scale). As expected, the ethane yield decreases as temperature increases. The ethane yield has been correlated as follows:

for Pittsburgh coal:

$$Y_{C_2H_6} = -1.0360 \times 10^{-3} T_{Bed} - 1.8099 \quad (T_{Bed} < 1747^\circ F) \quad (3.18)$$

$$Y_{C_2H_6} = 0.0 \quad (T_{Bed} \geq 1747^\circ F) \quad (3.19)$$

and for Wyoming coal:

$$Y_{C_2H_6} = -2.0113 \times 10^{-3} T_{Bed} - 3.3609 \quad (T_{Bed} < 1671^\circ F) \quad (3.20)$$

$$Y_{C_2H_6} = 0.0 \quad (T_{Bed} \geq 1671^\circ F) \quad (3.21)$$

Figure 3.39. RELATIONSHIP BETWEEN METHANE YIELD AND BED TEMPERATURE FOR SUBBITUMINOUS COAL

Figure 3.40. RELATIONSHIP BETWEEN ETHYLENE YIELD AND BED TEMPERATURE

Figure 3.41. RELATIONSHIP BETWEEN ETHANE YIELD AND BED TEMPERATURE

where -

$$Y_{C_2H_6} = \text{feed coal carbon converted to ethane, \%}$$

$$T_{\text{Bed}} = \text{average bed temperature, } ^\circ\text{F}$$

Figure 3.42 is a plot of coal nitrogen forming ammonia versus the average bed temperature. Although the data show a lot of scatter, the amount of ammonia formed is much higher with the Wyoming subbituminous coal feed. The data show that about 20% and 60% of coal nitrogen is converted to ammonia with Pittsburgh coal and Wyoming coal, respectively. The correlations are -

for Pittsburgh coal:

$$Y_{\text{NH}_3} = 20.0 \quad (3.22)$$

and for Wyoming coal:

$$Y_{\text{NH}_3} = 60.0 \quad (3.23)$$

where -

$$Y_{\text{NH}_3} = \text{coal nitrogen converted to ammonia, \%}$$

Figure 3.43 is a plot of released coal nitrogen forming ammonia versus the average bed temperature. The data show a lot of scatter.

Figure 3.44 is a plot of coal sulfur appearing as H_2S in the freeboard gas versus the average bed temperature. Figure 3.45 shows these data with an expanded y-axis range (0% to 20% only) to show the details more clearly. Usually less than 6% of the coal sulfur escaped as H_2S in the freeboard gas; however, a significantly large amount of H_2S was measured during some of the set points, although the sorbent was also fed to the carbonizer. The balance of the released coal sulfur is captured by the sorbent and discharged as CaS . This sulfur capture is based on thermodynamic equilibrium; the details are given below.

Depending upon the partial pressure of CO_2 in the carbonizer, the CaCO_3 in the sorbent either stays as CaCO_3 or gets calcined to CaO . This also determines whether the H_2S will react with CaCO_3 or CaO . The extent of sulfur capture is determined by its approach to the appropriate reaction equilibrium. The following reactions show the calcination of CaCO_3 , the reaction of H_2S with CaO , and the reaction of H_2S with CaCO_3 .

Determining equilibrium decomposition pressures of calcite (Equation 3.24) has proved a durable problem, and dubious values have appeared in the literature. The following correlation (Squires, 1967) is often recommended:

$$\log_{10} (P_{\text{CO}_2}) = -8799.7/T_K - 7.521 \quad (3.27)$$

Figure 3.42. RELATIONSHIP BETWEEN COAL NITROGEN CONVERTED TO AMMONIA AND BED TEMPERATURE

Figure 3.43. RELATIONSHIP BETWEEN RELEASED COAL NITROGEN CONVERTED TO AMMONIA AND BED TEMPERATURE

Figure 3.44. PLOT OF HYDROGEN SULFIDE IN FREEBOARD GAS (Range: 0% to 100% of Coal Sulfur) VERSUS BED TEMPERATURE

Figure 3.45. PLOT OF HYDROGEN SULFIDE IN FREEBOARD GAS (Range: 0% to 20% of Coal Sulfur) VERSUS BED TEMPERATURE

where -

$$\begin{aligned} P_{\text{CO}_2} &= \text{equilibrium decomposition partial pressure of CO}_2 \text{ in gas, atm} \\ T_K &= \text{temperature, K} \end{aligned}$$

This correlation is shown graphically in Figure 3.46.

The equilibrium for the above reactions (3.25) and (3.26) are given by the following equations (Squires *et al.* 1971):

$$\log_{10} [(H_2O)/(H_2S)] = 3519.2/T_K - 0.268 \quad (3.28)$$

$$\log_{10} [(H_2O)(CO_2)(P)/(H_2S)] = 7.253 - 5280.5/T_K \quad (3.29)$$

where -

$$\begin{aligned} P &= \text{total system pressure, atm} \\ (H_2O) &= \text{mole fraction of H}_2\text{O in gas, dimensionless} \\ (CO_2) &= \text{mole fraction of CO}_2 \text{ in gas, dimensionless} \\ (H_2S) &= \text{mole fraction of H}_2\text{S in gas, dimensionless} \\ T_K &= \text{temperature, K} \end{aligned}$$

Equations 3.28 and 3.29 are shown graphically in Figure 3.47. As shown in the figure, if the CaCO_3 is not calcined, then the concentration of H_2S decreases as temperature increases. On the other hand, if the CaCO_3 is calcined to CaO , then the concentration of H_2S increases as temperature increases (note the partial pressure of H_2S is in the denominator on the y-axis).

Figure 3.48 is a plot of the partial pressure of CO_2 in the carbonizer exit gas [in the form of the $\log_{10} (P_{\text{CO}_2})$] versus the inverse of the bed temperature. The CaCO_3 content (in mol %) of the solids drains [as $\text{CaCO}_3 \times 100/(\text{CaCO}_3 + \text{CaO})$] is also listed in the figure for each of the set points. The Squires correlation for equilibrium (given by equation 3.27) is also plotted in this figure. Neither the data follow the Squires correlation, nor can a new correlation of the same form be developed from the data. Furthermore, according to the Squires correlation, the CaCO_3 should not be calcined during only 8 set points out of a total of 24 set points for the Pittsburgh coal. However, the pilot plant data show that the CaCO_3 content exceeded 75% during 17 of the set points, and it exceeded 50% during 21 of the set points. Also, at these operating temperatures, the MgCO_3 in the sorbent feed should always be calcined; however, the data show that the MgCO_3 content exceeded 25% during 8 of the set points.

Equation 3.28 can be used to determine the equilibrium concentration of H_2S in the carbonizer gas, if CaCO_3 in the sorbent is calcined. Figure 3.49 is a plot of approach to equilibrium H_2S capture versus the average bed temperature. The approach to equilibrium capture is defined as follows:

$$\text{Approach to H}_2\text{S equilibrium capture} = \frac{(H_2S)_{\text{ns}} - (H_2S)_{\text{a}}}{(H_2S)_{\text{ns}} - (H_2S)_{\text{eq}}} \times 100 \quad (3.30)$$

where -

$$\begin{aligned} (H_2S)_{\text{ns}} &= \text{H}_2\text{S content in the gas if no H}_2\text{S is captured by the sorbent, lb-mol} \\ (H_2S)_{\text{a}} &= \text{actual (measured) H}_2\text{S content in the gas, lb-mol} \\ (H_2S)_{\text{eq}} &= \text{equilibrium H}_2\text{S content in the gas, lb-mol} \end{aligned}$$

Partial Pressure of CO_2 , atm

Figure 3.46. RELATIONSHIP BETWEEN EQUILIBRIUM PARTIAL PRESSURE OF CO_2 AND TEMPERATURE FOR CALCINATION OF CaCO_3

$$K = \frac{P_{H_2O}}{P_{H_2S}}$$

(Thousands)

(Thousands)
 $K = \frac{P_{CO_2} \cdot P_{H_2O}}{P_{H_2S}}$

Figure 3.47. RELATIONSHIP BETWEEN EQUILIBRIUM CONSTANTS FOR SULFUR CAPTURE REACTIONS AND TEMPERATURE

Figure 3.48. CALCINATION STATUS OF CARBONIZER PILOT PLANT DATA

Approach to Equilibrium H₂S Capture, %

* Assuming CaCO₃ is calcined.

**Figure 3.49. PLOT OF APPROACH TO EQUILIBRIUM H₂S CAPTURE
VERSUS BED TEMPERATURE (CaCO₃ is Calcined)**

The data show that the approach to equilibrium capture is usually 100% for the bituminous coals, however, the Wyoming coal data show some departure. As shown in Figure 3.50 for the Pittsburgh coal, most of the data lie within $\pm 10\%$, indicating that it is reasonable to assume that the H_2S content in the freeboard gas can be calculated by equilibrium (equation 3.28), if the $CaCO_3$ is calcined. Figures 3.51 and 3.52 are similar plots except that they are based on the assumption that $CaCO_3$ is not calcined. These figures again show that most of the data lie within $\pm 10\%$ of the 100% approach to equilibrium H_2S capture with the Pittsburgh coal (Wyoming coal data show a significant variation). Furthermore, for the bituminous coals, the calculated approach to the equilibrium H_2S capture is not very sensitive to the status of the $CaCO_3$ calcination. Thus, for bituminous coals, the H_2S content in the carbonizer product gas can be determined by equilibrium. No conclusion can be drawn for the Wyoming subbituminous coal due to the data scatter. It should be noted that the pilot plant data show that the solids drains usually contained a significant amount of $CaCO_3$.

The water-gas shift reaction is -

The equilibrium relationship for this reaction is given by -

$$\log_e \left[\frac{(CO_2)(H_2)}{(CO)(H_2O)} \right] = 7506/T_R - 3.8637 \quad (3.32)$$

This relationship is shown graphically in Figure 3.53. Essentially, as temperature increases, the CO and H_2O contents in the gas increase while the CO_2 and H_2 contents decrease.

Thus the equivalent water-gas shift temperature of a given gas composition can be calculated as follows:

$$T_F = \frac{7506}{\log_e \left[\frac{(CO_2)(H_2)}{(CO)(H_2O)} \right] + 3.8637} - 459.7 \quad (3.33)$$

where -

- (CO) = mole fraction CO in gas, dimensionless
- (CO_2) = mole fraction CO_2 in gas, dimensionless
- (H_2) = mole fraction H_2 in gas, dimensionless
- (H_2O) = mole fraction H_2O in gas, dimensionless
- T_R = temperature, $^{\circ}R$
- T_F = temperature, $^{\circ}F$

Figure 3.54 is a plot of the equivalent water-gas shift temperature versus the freeboard temperature (measured at the 22.5-ft level). Figure 3.55 shows the same data but plotted as the difference in the water-gas shift and the freeboard temperatures versus the freeboard temperature. The data show that the carbonizer product gas is in water-gas shift equilibrium at a temperature of $200^{\circ}F$ above the freeboard temperature. It is realized that the best fit line in these figures could be drawn differently, however, it should be noted that the product gas composition is not too sensitive to the water-gas shift temperature.

* Assuming CaCO₃ is calcined.

Figure 3.50. PLOT OF APPROACH TO EQUILIBRIUM H₂S CAPTURE VERSUS BED TEMPERATURE FOR PITTSBURGH COAL (CaCO₃ is Calcined)

Approach to Equilibrium H₂S Capture, %

* Assuming CaCO₃ is not calcined.

Figure 3.51. PLOT OF APPROACH TO EQUILIBRIUM H₂S CAPTURE VERSUS BED TEMPERATURE (CaCO₃ is not Calcined)

* Assuming $CaCO_3$ is not calcined.

Figure 3.52. PLOT OF APPROACH TO EQUILIBRIUM H_2S CAPTURE VERSUS BED TEMPERATURE FOR PITTSBURGH COAL ($CaCO_3$ is not Calcined)

$$K = \frac{(\text{CO}_2)(\text{H}_2)}{(\text{CO})(\text{H}_2\text{O})}$$

Figure 3.53. RELATIONSHIP BETWEEN EQUILIBRIUM CONSTANT FOR WATER-GAS SHIFT REACTION AND TEMPERATURE

Figure 3.54. RELATIONSHIP BETWEEN WATER-GAS SHIFT TEMPERATURE
AND FREEBOARD TEMPERATURE

Figure 3.55. PLOT OF DIFFERENCE IN WATER-GAS SHIFT AND FREEBOARD TEMPERATURES VERSUS FREEBOARD TEMPERATURE

Figure 3.56 is a plot of the difference between the water-gas shift and the freeboard temperatures versus partial pressure of H_2O in the carbonizer gas; no trend is observed.

Figure 3.57 is a plot of the carbonizer wall heat losses versus the average bed temperature. No trend with the bed temperature is observed. As shown in the figure, the average value of the carbonizer wall heat loss is 97,000 Btu/h.

It is assumed that the oxygen in the air feed reacts with the char carbon, forming CO or CO_2 , thereby releasing necessary heat while contributing to the carbon conversion. All the set points were simulated as described in the following Section 4, except that the fraction of char carbon forming CO by reaction with oxygen in the air feed was determined iteratively such that the predicted carbon conversion was identical to the measured carbon conversion. Figure 3.58 is a plot of the factor $CO/(CO + CO_2)$ resulting from the reaction of oxygen in the air feed with carbon in the coal char versus the average bed temperature. The correlations developed are as follows:

for Pittsburgh coal:

$$R_{CO} = 2.6820 \times 10^{-3} T_{Bed} - 4.2429 \quad (3.34)$$

and for Wyoming coal:

$$R_{CO} = 1.1591 \times 10^{-3} T_{Bed} - 1.2532 \quad (3.35)$$

where -

R_{CO} = ratio of $CO/(CO + CO_2)$ produced by the reaction of oxygen in the air feed with carbon in coal char, lb-mol/lb-mol

T_{Bed} = average bed temperature, °F

As expected, the relative amount of CO increases as temperature increases.

3.2. Model Update

Prior to the carbonizer pilot plant testing at FWDC, an extensive literature search was conducted; and correlations were developed for predicting yields of various species as a function of coal properties and carbonizer operating parameters. Although there were a lot of data available on the subject of pyrolysis at the time of this model development, only a small amount of this information was applicable for the type of coal processing used here. Much of the data for coal pyrolysis were obtained in a heated grid reactor where the coal was subjected to the desired temperature from a fraction of a second to about 2 seconds, usually yielding only a fraction of the pyrolysis product. On the other hand, in a fluidized-bed reactor, coal is subjected to a sufficiently long residence time (a gas residence time over 5 seconds and a solids residence time of several minutes), so the maximum yield is typically obtained. The data available in this category were used to develop the correlations for the coal carbonization product yields and their compositions. These correlations were developed for bituminous coals as well as for lignites to cover a wide range of feedstock properties. Based on these correlations, a computer model for the carbonizer was developed. This model could simulate a bubbling or a circulating fluidized-bed reactor with or without fines recycle in which the coal and sorbent could be introduced into the fluidized-bed region and/or into the freeboard region of the carbonizer. The details of the development of these correlations and the model have been given by Rehmat and Goyal (1987) in a DOE report.

Figure 3.56. PLOT OF DIFFERENCE IN WATER-GAS SHIFT AND FREEBOARD TEMPERATURES VERSUS PARTIAL PRESSURE OF H₂O IN FREEBOARD GAS

Figure 3.58. RELATIONSHIP BETWEEN $\text{CO}/(\text{CO} + \text{CO}_2)$ RATIO RESULTING FROM CHAR CARBON-OXYGEN REACTION AND BED TEMPERATURE

The original FWDC carbonizer test plan called for operating the carbonizer with Pittsburgh coal at a bed temperature of around 1500°F coal, with a possibility of operating up to 1600°F. The literature search was thus conducted with these operating temperatures in mind; correlations were developed based on data primarily up to 1500°F, with some data up to 1600°F. The limited data available in the literature showed a significant amount of tars/oils and higher hydrocarbons were generated at these temperatures. However, later in the program, it was decided to operate the carbonizer at relatively higher temperatures. The bed temperature ranged from 1482° to 1797°F with an average value of 1671°F and a standard deviation of 69°F for set points with the Pittsburgh bituminous coal feed (the bed temperature for each of the set points is shown in Figure 3.1). The original correlations cannot usually be extrapolated to these higher operating temperatures.

The data obtained in the carbonizer pilot plant were rigorously analyzed, and correlations were developed that could be used in a computer model to predict the performance of a carbonizer. During these efforts, several excellent correlations were developed, which have been discussed in Section 3.1. However, many of these correlations are not in the forms present in the existing model. Incorporation of these new forms of correlations in the model requires significant changes in the existing computer code, which could not be accomplished at this time due to the lack of time and funding. These new correlations, recommended for incorporation in the model to improve its predictive capabilities, are discussed in Section 5.0.

The permissible solids and gas species in the existing model along with their molecular weights and chemical enthalpies are given in Tables 3.5 and 3.6, respectively. The following changes were made in the existing carbonizer model.

1. The existing model contains correlations for yields prediction from bituminous coals and lignites only (no correlations were developed earlier for yields from a subbituminous coal). Thus, in parallel with the bituminous coal and lignite, a subroutine was added to the computer model for predicting yields from a subbituminous coal.
2. For the bituminous coal feed, the existing correlations for several parameters were replaced as shown in Table 3.7. For the subbituminous coal feed, the correlations utilized are also identified in this table.
3. The correlations used to predict the yields of CH_4 , C_2H_4 , and C_2H_6 are specified above. Because no other hydrocarbons and tars/oils were detected in the product gas during the carbonizer pilot plant testing, the yields of tars/oils and all other hydrocarbons are specified as 0.0. These hydrocarbons include acetylene (C_2H_2), propane (C_3H_8), propylene (C_3H_6), butane (C_4H_{10}), benzene (C_6H_6), toluene (C_7H_8), naphthalene (C_{10}H_8), and phenol ($\text{C}_6\text{H}_5\text{OH}$).

The original carbonizer model, developed for relatively lower operating bed temperature, utilized the concept of initial formation of tars followed by cracking of the tars. Because no tar formation was observed during any of the set points, it is difficult to quantitatively verify the original concept. Instead it has been decided to specify no tar formation under the operating temperatures of interest.

4. The existing model utilizes correlations for the coal sulfur released as H_2S as a function of temperature. Instead, now the S/C ratio in the char is determined by equations 3.3 and 3.4 for bituminous coal and subbituminous coal, respectively, and the H_2S yield is determined accordingly.

Table 3.5. SPECIES ALLOWED IN A SOLIDS STREAM IN THE CARBONIZER MODEL

No.	Species	Formula	Molecular Weight*	Chemical Enthalpy, Btu/lb
1	Carbon	C	12.011	14544.0
2	Hydrogen	H	1.008	62028.0
3	Oxygen	O	15.999	-7753.5
4	Nitrogen	N	14.007	0.0
5	Sulfur	S	32.060	4050.0
6	Chlorine	Cl	35.453	0.0
7	Ash	—	—	0.0
8	Moisture	H ₂ O	18.015	0.0
9	Calcium Carbonate	CaCO ₃	100.088	-786.8
10	Magnesium Carbonate	MgCO ₃	84.313	-508.3
11	Calcium Oxide	CaO	56.079	0.0
12	Magnesium Oxide	MgO	40.304	0.0
13	Calcium Sulfide	CaS	72.140	2703.2
14	Calcium Sulfate	CaSO ₄	136.136	-1535.0
15	Inert	—	—	0.0

* Atomic Weight of Ca = 40.080, Mg = 24.305.

Table 3.6. SPECIES ALLOWED IN A GAS STREAM IN THE CARBONIZER MODEL

No.	Species	Formula	Molecular Weight	Chemical Enthalpy, Btu/lb-mole
1	Carbon Monoxide	CO	28.010	121745
2	Carbon Dioxide	CO ₂	44.009	0
3	Hydrogen	H ₂	2.016	122971
4	Water	H ₂ O	18.015	18935
5	Methane	CH ₄	16.043	383036
6	Ethane	C ₂ H ₆	30.070	671076
7	Oxygen	O ₂	31.998	0
8	Nitrogen	N ₂	28.014	0
9	Hydrogen Sulfide	H ₂ S	34.076	242077
10	Carbonyl Sulfide	COS	60.070	236092
11	Ammonia	NH ₃	17.031	164729
12	Hydrogen Cyanide	HCN	27.026	286759
13	Hydrogen Chloride	HCl	36.461	21772
14	Ethylene	C ₂ H ₄	28.054	607023
15	Acetylene	C ₂ H ₂	26.038	559108
16	Propane	C ₃ H ₈	44.097	955090
17	Propylene	C ₃ H ₆	42.081	885577
18	N-Butane	C ₄ H ₁₀	58.124	1238369
19	Benzene	C ₆ H ₆	78.114	1420352
20	Toluene	C ₇ H ₈	92.141	1698450
21	Naphthalene	C ₁₀ H ₈	128.174	2249765
22	Phenol	C ₆ H ₅ OH	94.113	1345598

**Table 3.7. REPLACEMENT CORRELATIONS FOR THE
UPDATED CARBONIZER MODEL**

Parameter	Equation(s)	
	Bituminous Coal	Subbituminous Coal
N/C ratio in char	3.1	3.2
H/C ratio in char	3.5	3.6
CH ₄ yield	3.10	3.13
C ₂ H ₄ yield	3.14, 3.15	3.16, 3.17
C ₂ H ₆ yield	3.18, 3.19	3.20, 3.21
NH ₃ yield	3.22	3.23
CO yield during primary devolatilization	3.8	3.8
CO ₂ yield during primary devolatilization	3.9	3.9

5. Because no COS is reported in the carbonizer gas (it is usually very small, if any), it is assumed that no COS is formed in the carbonizer.
6. The program utilizes the concept that the oxygen in the air feed reacts with the char carbon, forming CO and CO₂. The split between CO and CO₂ formed is given by equations 3.34 and 3.35 for bituminous coal and subbituminous coal, respectively (in the existing model, the correlation for the ratio of CO/CO₂ is used rather than the fraction of CO, as defined now).
7. The product gas is in water-gas shift equilibrium at a temperature which is 200°F higher than the freeboard temperature (the user can easily override this correlation by specifying any desired water-gas shift temperature). An appropriate message to this effect is also printed by the program.
8. Some other minor changes have also been made in the program, such as printing the page number on the top of each page, printing H₂S concentrations in ppm, yields of CH₄, C₂H₄, and C₂H₆ as a percentage of coal carbon, etc.

4. MODEL VERIFICATION FOR CARBONIZER PILOT PLANT

The computer model developed earlier (Rehmat and Goyal, 1987) was updated based on the correlations and other information provided in the previous section. Then the carbonizer reactor was simulated for each of the 36 steady-state periods to confirm the validity of the model. The results of these simulations are presented in this section.

Based on the results of the data analysis presented in the previous section, the following assumptions were made for the simulation.

1. The carbonizer product gas is in water-gas shift equilibrium at 200 °F above the freeboard temperature.
2. MgCO_3 in the sorbent feed is always calcined.
3. An appropriate correlation could neither be found in the literature nor developed from the carbonizer data that could predict the calcination status of CaCO_3 in the sorbent feed under the carbonizer operating conditions (details given earlier in Section 3.1, Figure 3.48). Thus, if the carbonizer data show that CaCO_3 content exceeded 50% of total ($\text{CaCO}_3 + \text{CaO}$) in the combined solids drains, then it is assumed in the simulation that CaCO_3 is fully calcined during the set point and vice versa (the model does not permit partial calcination of CaCO_3).
4. The approach to H_2S equilibrium capture is 100%. (As shown in Figure 3.51, the Wyoming coal data show a lot of departure from this; however, no trend is observed, and thus 100% approach to the equilibrium capture is assumed to be valid for the Wyoming coal also.)
5. The carbonizer wall heat losses are 97,000 Btu/h.

For bituminous coals, the correlations were developed based primarily on the Pittsburgh coal data. For model verification, these correlations were then also applied to 4 steady-state periods obtained with Illinois coal feed.

Table 4.1 shows a comparison of measured and model predicted parameters for the steady-state periods for Pittsburgh No. 8 bituminous coal. Tables 4.2 and 4.3 give similar information for the steady-state periods with the Illinois No. 6 bituminous coal and Wyoming Eagle Butte subbituminous coal, respectively. These tables list the measured value of a parameter, model predicted value of the parameter, algebraic difference between the measured and predicted values, and absolute difference between the measured and predicted values. The tables also include the minimum, maximum, average, and standard deviation for each of the above items (the significance of standard deviation has been given earlier in Section 2.3 and Figure 2.3). Actually, one should look at the average and standard deviation of the "absolute difference" rather than the "algebraic difference" between the measured and model predicted values to evaluate the performance of the model, and thus such values have been included in these tables.

Table 4.4 lists the minimum and maximum values, average value, and standard deviation value of the measured value of a parameter, model predicted value of the parameter, algebraic difference between the measured and predicted values, and absolute difference between the measured and predicted values based on all 36 set points. This table is therefore a true measure of the overall model performance.

**Table 4.1. COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED**

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
Begin Clock Time, hours	0300	0200	1000	2100	0100	1300	0100	1000	1600	2030	0430	0230
End Clock Time, hours	0700	0600	1400	2330	0500	1700	0500	1400	1800	0030	0830	0630
Steady-State Period Duration, h	4	4	4	2.5	4	4	4	4	2	4	4	4
Carbonizer Pressure, psig	152.6	132.9	144.7	125.4	139.8	128.3	138.1	191.8	198.6	153.3	155.9	125.2
Average Bed Temp, F	1584	1681	1608	1482	1698	1598	1797	1784	1679	1663	1608	1708
Freeboard Temp (@ 22.5 Ft), F	1553	1651	1581	1440	1652	1567	1705	1738	1675	1626	1573	1643
Coal Feed to Carbonizer, lb/h	337.88	238.72	341.93	386.68	235.47	327.62	181.25	373.85	489.06	232.76	270.66	202.43
Sorbent Feed to Carbonizer, lb/h	82.26	66.14	96.47	98.66	115.08	88.54	79.56	97.18	151.10	97.18	89.93	85.90
Air Feed to Carbonizer, lb/h	622.98	570.82	611.04	537.71	676.99	555.83	664.43	959.48	955.79	666.39	644.25	600.46
Steam Feed to Carbonizer, lb/h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	55.56	118.30	96.28
Purge N2 Feed to Carbonizer, lb/h	364.39	291.71	281.81	184.84	378.49	380.92	366.88	339.94	306.02	307.89	289.90	125.01
Bed Density, lb/ft3	14.41	13.70	13.43	15.23	15.45	12.61	14.39	13.53	14.56	17.17	16.17	21.33
Bed Height, ft	25.7	17.7	25.8	26.5	15.6	16.9	16.5	17.0	22.9	15.1	16.0	14.9
Bed Weight, lb	305.62	178.99	286.69	336.30	176.50	156.88	174.43	168.89	265.90	188.35	188.94	231.19
Measured:CD - CaCO3/(CaCO3+CaO), mole%	100.0	100.0	100.0	81.8	100.0	100.0	100.0	100.0	100.0	77.6	100.0	52.1
:Mixt - CaCO3/(CaCO3+CaO),mole%	100.0	100.0	100.0	77.8	100.0	100.0	99.3	99.8	100.0	74.4	95.3	51.1
Measured:CD - MgCO3/(MgCO3+MgO), mole%	65.0	13.6	50.3	0.0	1.6	49.5	22.3	40.2	28.9	0.0	41.5	0.0
:Mixt - MgCO3/(MgCO3+MgO),mole%	69.3	14.5	49.3	0.0	9.4	48.2	11.6	41.0	32.1	0.0	29.6	0.0
Measured Carbon Conversion, %	30.74	39.77	36.03	27.01	49.85	33.38	60.96	49.27	37.64	51.31	42.68	47.70
Predicted Carbon Conversion, %	36.49	48.19	36.88	26.68	53.02	33.20	83.38	52.71	37.71	46.27	38.59	53.20
Predicted - Measured	5.75	8.42	0.85	-0.33	3.17	-0.18	22.42	3.44	0.07	-5.04	-4.09	5.50
ABS*(Predicted - Measured)	5.75	8.42	0.85	0.33	3.17	0.18	22.42	3.44	0.07	5.04	4.09	5.50

* ABS = Absolute Value.

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
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Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	Al Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
Begin Clock Time, hours	1600	0530	1300	2200	0200	1100	1900	0500	2100	0200	0800	1430
End Clock Time, hours	2000	0930	1700	0200	0600	1500	2300	0900	0100	0600	1230	1930
Steady-State Period Duration, h	4	4	4	4	4	4	4	4	4	4	4.5	5
Carbonizer Pressure, psig	129.1	193.2	175.8	177.9	182.2	134.3	154.8	147.4	156.0	143.5	135.0	126.5
Average Bed Temp, F	1607	1720	1713	1601	1618	1693	1701	1706	1699	1707	1713	1729
Freeboard Temp (@ 22.5 Ft), F	1568	1691	1681	1582	1600	1653	1662	1667	1675	1683	1683	1697
Coal Feed to Carbonizer, lb/h	227.83	329.15	333.34	412.24	347.37	203.82	224.12	220.30	375.66	342.85	337.02	337.71
Sorbent Feed to Carbonizer, lb/h	94.64	106.13	106.09	181.55	149.89	59.40	108.12	70.09	119.98	79.47	79.93	39.76
Air Feed to Carbonizer, lb/h	544.25	895.50	819.21	769.56	751.59	636.08	707.45	676.01	879.66	823.02	782.67	661.67
Steam Feed to Carbonizer, lb/h	78.08	142.76	85.09	51.75	53.48	90.68	90.19	100.14	99.78	90.48	55.54	55.72
Purge N2 Feed to Carbonizer, lb/h	243.84	167.09	161.94	295.83	302.20	203.46	198.38	211.03	261.87	273.86	275.95	263.09
Bed Density, lb/ft ³	17.31	13.58	14.44	14.04	16.49	11.72	11.88	12.71	16.06	16.68	18.81	16.48
Bed Height, ft	15.9	18.8	18.7	23.4	17.2	17.5	18.2	16.8	18.5	16.1	15.5	17.1
Bed Weight, lb	201.39	189.09	199.37	263.62	208.81	151.04	159.23	156.99	219.04	197.22	212.55	207.02
Measured:CD - CaCO ₃ /(CaCO ₃ +CaO), mole%	100.0	78.9	75.5	100.0	100.0	40.7	18.4	17.2	52.6	100.0	38.1	100.0
:Mixt - CaCO ₃ /(CaCO ₃ +CaO),mole%	98.9	82.7	75.7	96.9	99.1	44.4	26.0	24.0	52.4	87.7	53.3	88.7
Measured:CD - MgCO ₃ /(MgCO ₃ +MgO), mole%	22.2	0.0	0.0	8.3	2.6	0.0	0.0	0.0	0.0	49.2	0.0	49.6
:Mixt - MgCO ₃ /(MgCO ₃ +MgO),mole%	21.6	2.0	1.8	7.3	5.6	0.0	1.3	0.0	0.0	38.7	5.1	37.6
Measured Carbon Conversion, %	42.86	51.41	47.06	33.14	36.77	59.74	54.01	49.69	39.94	42.08	41.01	35.35
Predicted Carbon Conversion, %	42.09	46.75	40.70	31.63	38.17	51.26	54.79	53.95	40.61	42.05	41.03	40.50
Predicted - Measured	-0.77	-4.66	-6.36	-1.51	1.40	-8.48	0.78	4.26	0.67	-0.03	0.02	5.15
ABS (Predicted - Measured)	0.77	4.66	6.36	1.51	1.40	8.48	0.78	4.26	0.67	0.03	0.02	5.15

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	Minimum	Maximum	Average	Std Dev
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Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
Begin Clock Time, hours				
End Clock Time, hours	(No. of Set Points = 24)			
Steady-State Period Duration, h	2.0	5.0	3.9	0.6
Carbonizer Pressure, psig	125.2	198.6	151.8	22.6
Average Bed Temp, F	1482	1797	1671	69
Freeboard Temp (@ 22.5 Ft), F	1440	1738	1635	64
Coal Feed to Carbonizer, lb/h	181.25	489.06	304.57	77.14
Sorbent Feed to Carbonizer, lb/h	39.76	181.55	97.63	30.10
Air Feed to Carbonizer, lb/h	537.71	959.48	708.87	124.01
Steam Feed to Carbonizer, lb/h	0.00	142.76	52.66	45.54
Purge N2 Feed to Carbonizer, lb/h	125.01	380.92	269.85	69.86
Bed Density, lb/ft ³	11.72	21.33	15.09	2.20
Bed Height, ft	14.9	26.5	18.5	3.5
Bed Weight, lb	151.04	336.30	209.34	48.28
Measured:CD - CaCO ₃ /(CaCO ₃ +CaO), mole%	17.159	100.000	80.534	27.533
:Mist - CaCO ₃ /(CaCO ₃ +CaO),mole%	24.021	100.000	80.307	24.345
Measured:CD - MgCO ₃ /(MgCO ₃ +MgO), mole%	0.000	64.981	18.523	21.663
:Mist - MgCO ₃ /(MgCO ₃ +MgO),mole%	0.000	69.274	17.742	19.914
1 Measured Carbon Conversion, %	27.01	60.96	43.31	8.72
Predicted Carbon Conversion, %	26.68	83.38	44.58	11.02
Predicted - Measured	-8.48	22.42	1.27	5.94
ABS (Predicted - Measured)	0.02	22.42	3.89	4.67

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR1-1		TR1-2		TR1-3		TR1-4		TR2-1		TR2-2		TR2-3		TR2-4		TR2-5		TR4-1		TR4-2		TR4-3	
Coal	Pitt	Bit	Pitt	Bit	Pitt	Bit	Pitt	Bit	Pitt	Bit	Pitt	Bit	Pitt	Bit	Pitt	Bit	Pitt	Bit	Pitt	Bit	Pitt	Bit	Pitt	Bit
Sorbent	PR	Dolo	PR	Dolo	PR	Dolo	PR	Dolo	PR	Dolo	PR	Dolo	PR	Dolo	PR	Dolo	PR	Dolo	PR	Dolo	PR	Dolo	PR	Dolo
2 Measured Air Feed to Carbonizer, lb/h	623.0		570.8		611.0		537.7		677.0		555.8		664.4		959.5		955.8		666.4		644.2		600.5	
Predicted Air Feed to Carbonizer, lb/h	703.5		649.9		650.4		442.7		711.1		623.3		779.6		989.0		978.1		611.3		598.5		631.9	
Predicted - Measured	80.5		79.1		39.4		-95.0		34.1		67.5		115.2		29.5		22.3		-55.1		-45.7		31.4	
ABS (Predicted - Measured)	80.5		79.1		39.4		95.0		34.1		67.5		115.2		29.5		22.3		55.1		45.7		31.4	
(Predicted/Measured-1)*100, %	12.9		13.9		6.4		-17.7		5.0		12.1		17.3		3.1		2.3		-8.3		-7.1		5.2	
ABS (Predicted/Measured-1)*100, %	12.9		13.9		6.4		17.7		5.0		12.1		17.3		3.1		2.3		8.3		7.1		5.2	
3 Measured Air/Coal, lb/lb	1.844		2.391		1.787		1.391		2.875		1.697		3.666		2.567		1.954		2.863		2.380		2.966	
Predicted Air/Coal, lb/lb	2.082		2.722		1.902		1.145		3.020		1.903		4.301		2.645		2.000		2.626		2.211		3.122	
Predicted - Measured	0.238		0.331		0.115		-0.246		0.145		0.206		0.635		0.079		0.046		-0.237		-0.169		0.155	
ABS (Predicted - Measured)	0.238		0.331		0.115		0.246		0.145		0.206		0.635		0.079		0.046		0.237		0.169		0.155	
4 Measured Air/Coal, lb/lb(MF)	1.884		2.445		1.829		1.424		2.942		1.736		3.752		2.627		2.002		2.931		2.438		3.033	
Predicted Air/Coal, lb/lb(MF)	2.128		2.783		1.947		1.172		3.091		1.946		4.403		2.708		2.049		2.689		2.265		3.191	
Predicted - Measured	0.244		0.339		0.118		-0.252		0.148		0.211		0.650		0.081		0.047		-0.242		-0.173		0.159	
ABS (Predicted - Measured)	0.244		0.339		0.118		0.252		0.148		0.211		0.650		0.081		0.047		0.242		0.173		0.159	
5 Measured Coal Nitrogen Released, %	29.00		47.56		41.06		26.49		49.86		36.41		63.00		55.80		40.96		52.70		49.21		48.52	
Predicted Coal Nitrogen Released, %	38.96		53.41		42.13		25.69		59.27		37.34		86.68		61.76		45.68		51.11		41.76		57.71	
Predicted - Measured	9.96		5.85		1.07		-0.80		9.41		0.93		23.68		5.96		4.72		-1.59		-7.45		9.19	
ABS (Predicted - Measured)	9.96		5.85		1.07		0.80		9.41		0.93		23.68		5.96		4.72		1.59		7.45		9.19	
6 Measured Coal Sulfur Released, %	80.07		73.65		73.16		41.21		86.37		80.49		92.07		86.75		83.99		82.50		85.74		78.38	
Predicted Coal Sulfur Released, %	71.10		81.78		72.76		54.44		88.77		77.73		97.59		92.52		84.07		80.01		72.79		84.82	
Predicted - Measured	-8.97		8.13		-0.40		13.23		2.40		-2.76		5.52		5.77		0.08		-2.49		-12.95		6.44	
ABS (Predicted - Measured)	8.97		8.13		0.40		13.23		2.40		2.76		5.52		5.77		0.08		2.49		12.95		6.44	
7 Measured H2S in Freeboard Gas, ppm	218		323		171		248		1622		591		477		104		195		140		928		167	
Predicted H2S in Freeboard Gas, ppm	177		75		170		338		68		134		24		51		157		204		444		226	
Predicted - Measured	-41		-248		-1		90		-1554		-457		-453		-53		-38		64		-484		59	
ABS (Predicted - Measured)	41		248		1		90		1554		457		453		53		38		64		484		59	
(Predicted/Measured-1)*100, %	-18.7		-76.8		-0.6		36.1		-95.8		-77.3		-95.0		-50.8		-19.5		45.5		-52.1		35.0	
ABS (Predicted/Measured-1)*100, %	18.7		76.8		0.6		36.1		95.8		77.3		95.0		50.8		19.5		45.5		52.1		35.0	

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
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Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	Al Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
2 Measured Air Feed to Carbonizer, lb/h	544.3	895.5	819.2	769.6	751.6	636.1	707.5	676.0	879.7	823.0	782.7	661.7
Predicted Air Feed to Carbonizer, lb/h	564.7	858.5	725.8	693.6	816.0	645.3	769.7	738.3	834.0	775.7	738.5	714.1
Predicted - Measured	20.5	-37.0	-93.4	-76.0	64.4	9.2	62.2	62.3	-45.7	-47.3	-44.2	52.4
ABS (Predicted - Measured)	20.5	37.0	93.4	76.0	64.4	9.2	62.2	62.3	45.7	47.3	44.2	52.4
(Predicted/Measured-1)*100, %	3.8	-4.1	-11.4	-9.9	8.6	1.4	8.8	9.2	-5.2	-5.8	-5.6	7.9
ABS (Predicted/Measured-1)*100, %	3.8	4.1	11.4	9.9	8.6	1.4	8.8	9.2	5.2	5.8	5.6	7.9
3 Measured Air/Coal, lb/lb	2.389	2.721	2.458	1.867	2.164	3.121	3.157	3.069	2.342	2.401	2.322	1.959
Predicted Air/Coal, lb/lb	2.479	2.608	2.177	1.683	2.349	3.166	3.434	3.351	2.220	2.263	2.191	2.115
Predicted - Measured	0.090	-0.112	-0.280	-0.184	0.185	0.045	0.278	0.283	-0.122	-0.138	-0.131	0.155
ABS (Predicted - Measured)	0.090	0.112	0.280	0.184	0.185	0.045	0.278	0.283	0.122	0.138	0.131	0.155
4 Measured Air/Coal, lb/lb(MF)	2.448	2.787	2.522	1.911	2.211	3.173	3.205	3.117	2.411	2.475	2.393	2.019
Predicted Air/Coal, lb/lb(MF)	2.540	2.671	2.234	1.723	2.400	3.219	3.487	3.404	2.286	2.332	2.258	2.179
Predicted - Measured	0.092	-0.115	-0.288	-0.189	0.189	0.046	0.282	0.287	-0.125	-0.142	-0.135	0.160
ABS (Predicted - Measured)	0.092	0.115	0.288	0.189	0.189	0.046	0.282	0.287	0.125	0.142	0.135	0.160
5 Measured Coal Nitrogen Released, %	44.27	50.79	52.86	34.46	41.14	68.65	62.96	58.09	58.62	55.61	56.12	53.37
Predicted Coal Nitrogen Released, %	45.17	53.16	48.31	34.81	39.77	56.84	60.04	59.41	43.57	45.42	44.69	44.93
Predicted - Measured	0.90	2.37	-4.55	0.35	-1.37	-11.81	-2.92	1.32	-15.05	-10.19	-11.43	-8.44
ABS (Predicted - Measured)	0.90	2.37	4.55	0.35	1.37	11.81	2.92	1.32	15.05	10.19	11.43	8.44
6 Measured Coal Sulfur Released, %	78.31	83.02	85.64	66.24	58.10	89.63	70.10	73.00	59.67	62.41	53.74	49.15
Predicted Coal Sulfur Released, %	74.19	83.89	81.63	68.92	72.41	69.05	71.82	71.73	84.12	85.03	84.95	85.88
Predicted - Measured	-4.12	0.87	-4.01	2.68	14.31	-20.58	1.72	-1.27	24.45	22.62	31.21	36.73
ABS (Predicted - Measured)	4.12	0.87	4.01	2.68	14.31	20.58	1.72	1.27	24.45	22.62	31.21	36.73
7 Measured H2S in Freeboard Gas, ppm	381	67	91	294	991	1238	70	0	83	21	0	1243
Predicted H2S in Freeboard Gas, ppm	339	320	250	368	317	327	308	332	227	186	132	109
Predicted - Measured	-42	253	159	74	-674	-911	238	332	144	165	132	-1134
ABS (Predicted - Measured)	42	253	159	74	674	911	238	332	144	165	132	1134
(Predicted/Measured-1)*100, %	-11.0	378.8	175.0	25.1	-68.0	-73.6	338.9		175.0	782.8		-91.2
ABS (Predicted/Measured-1)*100, %	11.0	378.8	175.0	25.1	68.0	73.6	338.9		175.0	782.8		91.2

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----
Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
2 Measured Air Feed to Carbonizer, lb/h	537.7	959.5	708.9	124.0
Predicted Air Feed to Carbonizer, lb/h	442.7	989.0	718.5	121.0
Predicted - Measured	-95.0	115.2	9.6	59.5
ABS (Predicted - Measured)	9.2	115.2	54.6	25.5
(Predicted/Measured-1)*100, %	-17.7	17.3	1.8	8.9
ABS (Predicted/Measured-1)*100, %	1.4	17.7	8.0	4.3
3 Measured Air/Coal, lb/lb	1.391	3.666	2.431	0.538
Predicted Air/Coal, lb/lb	1.145	4.301	2.488	0.654
Predicted - Measured	-0.280	0.635	0.057	0.219
ABS (Predicted - Measured)	0.045	0.635	0.192	0.119
4 Measured Air/Coal, lb/lb(MF)	1.424	3.752	2.488	0.547
Predicted Air/Coal, lb/lb(MF)	1.172	4.403	2.546	0.664
Predicted - Measured	-0.288	0.650	0.058	0.224
ABS (Predicted - Measured)	0.046	0.650	0.196	0.122
5 Measured Coal Nitrogen Released, %	26.49	68.65	49.06	10.48
Predicted Coal Nitrogen Released, %	25.69	86.68	49.07	11.84
Predicted - Measured	-15.05	23.68	0.00	8.41
ABS (Predicted - Measured)	0.35	23.68	6.31	5.56
6 Measured Coal Sulfur Released, %	41.21	92.07	73.89	13.39
Predicted Coal Sulfur Released, %	54.44	97.59	78.83	9.09
Predicted - Measured	-20.58	36.73	4.94	13.13
ABS (Predicted - Measured)	0.08	36.73	9.74	10.09
7 Measured H ₂ S in Freeboard Gas, ppm	0	1622	403	449
Predicted H ₂ S in Freeboard Gas, ppm	24	444	220	112
Predicted - Measured	-1554	332	-183	468
ABS (Predicted - Measured)	1	1554	325	383
(Predicted/Measured-1)*100, %	-95.8	782.8	57.4	204.5
ABS (Predicted/Measured-1)*100, %	0.6	782.8	123.8	172.6

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
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Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
8 Measured Sulfur in Gas,% of Coal S	2.54	4.83	1.95	2.20	21.20	5.05	7.69	1.10	1.59	2.55	15.21	2.91
Predicted Sulfur in Gas,% of Coal S	2.23	1.21	2.02	2.73	0.92	1.23	0.43	0.56	1.32	3.53	7.03	4.07
Predicted - Measured	-0.31	-3.62	0.07	0.53	-20.28	-3.82	-7.26	-0.54	-0.27	0.98	-8.18	1.16
ABS (Predicted - Measured)	0.31	3.62	0.07	0.53	20.28	3.82	7.26	0.54	0.27	0.98	8.18	1.16
9 Measured NH3 in Freeboard Gas, ppm	1871	1685	2001	1697	484	1710	796	2969	3256	2628	3479	1100
Predicted NH3 in Freeboard Gas, ppm	1970	1600	2190	3360	1420	2090	1050	1740	2310	1490	1640	1440
Predicted - Measured	99	-85	189	1663	936	380	254	-1229	-946	-1138	-1839	340
ABS (Predicted - Measured)	99	85	189	1663	936	380	254	1229	946	1138	1839	340
(Predicted/Measured-1)*100, %	5.3	-5.0	9.5	98.0	193.3	22.2	32.0	-41.4	-29.1	-43.3	-52.9	30.9
ABS (Predicted/Measured-1)*100, %	5.3	5.0	9.5	98.0	193.3	22.2	32.0	41.4	29.1	43.3	52.9	30.9
10 Measured CH4 yield, % of Coal Carbon	4.627	3.153	5.312	5.235	4.451	5.192	2.647	4.780	5.617	4.437	5.141	2.755
Predicted CH4 yield, % of Coal Carbon	5.222	4.065	4.926	6.343	3.877	5.012	2.731	2.929	4.167	4.299	4.944	3.740
Predicted - Measured	0.595	0.912	-0.386	1.108	-0.574	-0.180	0.084	-1.851	-1.450	-0.138	-0.197	0.985
ABS (Predicted - Measured)	0.595	0.912	0.386	1.108	0.574	0.180	0.084	1.851	1.450	0.138	0.197	0.985
11 Measured C2H4 yield, % of Coal Carbon	0.387	0.131	0.399	0.657	0.063	0.642	0.000	0.012	0.094	0.078	0.195	0.015
Predicted C2H4 yield, % of Coal Carbon	0.371	0.098	0.304	0.658	0.051	0.332	0.000	0.000	0.104	0.149	0.304	0.023
Predicted - Measured	-0.016	-0.033	-0.095	0.001	-0.012	-0.310	0.000	-0.012	0.010	0.071	0.109	0.008
ABS (Predicted - Measured)	0.016	0.033	0.095	0.001	0.012	0.310	0.000	0.012	0.010	0.071	0.109	0.008
12 Measured C2H6 yield, % of Coal Carbon	0.142	0.000	0.158	0.988	0.032	2.136	0.090	0.000	0.113	0.039	0.139	0.000
Predicted C2H6 yield, % of Coal Carbon	0.169	0.068	0.144	0.275	0.051	0.154	0.000	0.000	0.071	0.087	0.144	0.040
Predicted - Measured	0.027	0.068	-0.014	-0.713	0.019	-1.982	-0.090	0.000	-0.042	0.048	0.005	0.040
ABS (Predicted - Measured)	0.027	0.068	0.014	0.713	0.019	1.982	0.090	0.000	0.042	0.048	0.005	0.040
13 Measured Total HC yield,% of Coal C	5.156	3.284	5.869	6.881	4.546	7.970	2.736	4.792	5.824	4.553	5.475	2.770
Predicted Total HC yield,% of Carbon	5.762	4.231	5.374	7.276	3.979	5.498	2.731	2.929	4.342	4.535	5.392	3.803
Predicted - Measured	0.606	0.947	-0.495	0.395	-0.567	-2.472	-0.005	-1.863	-1.482	-0.018	-0.083	1.033
ABS (Predicted - Measured)	0.606	0.947	0.495	0.395	0.567	2.472	0.005	1.863	1.482	0.018	0.083	1.033

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
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Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	PR DoLo	Al Lime	PR DoLo	PR DoLo	PR DoLo	PR DoLo
8 Measured Sulfur in Gas,% of Coal S	6.11	1.05	1.24	3.48	13.21	42.91	2.33	0.00	0.95	0.25	0.00	12.72
Predicted Sulfur in Gas,% of Coal S	5.53	4.89	3.17	4.14	4.43	11.17	10.84	11.81	2.57	2.19	1.49	1.19
Predicted - Measured	-0.58	3.84	1.93	0.66	-8.78	-31.74	8.51	11.81	1.62	1.94	1.49	-11.53
ABS (Predicted - Measured)	0.58	3.84	1.93	0.66	8.78	31.74	8.51	11.81	1.62	1.94	1.49	11.53
9 Measured NH3 in Freeboard Gas, ppm	2035	1615	1091	1607	1464	2679	2281	2324	1032	1043	1272	1357
Predicted NH3 in Freeboard Gas, ppm	1590	1700	2040	2310	1850	1450	1420	1410	1750	1680	1770	1820
Predicted - Measured	-445	85	949	703	386	-1229	-861	-914	718	637	498	463
ABS (Predicted - Measured)	445	85	949	703	386	1229	861	914	718	637	498	463
(Predicted/Measured-1)*100, %	-21.9	5.2	87.0	43.8	26.4	-45.9	-37.7	-39.3	69.6	61.1	39.1	34.1
ABS (Predicted/Measured-1)*100, %	21.9	5.2	87.0	43.8	26.4	45.9	37.7	39.3	69.6	61.1	39.1	34.1
10 Measured CH4 yield, % of Coal Carbon	4.880	4.066	5.119	4.766	5.450	3.872	5.731	3.565	3.580	3.730	3.621	4.411
Predicted CH4 yield, % of Coal Carbon	4.910	3.678	3.779	5.057	4.865	3.915	3.851	3.783	3.871	3.762	3.682	3.486
Predicted - Measured	0.030	-0.388	-1.340	0.291	-0.585	0.043	-1.880	0.218	0.291	0.032	0.061	-0.925
ABS (Predicted - Measured)	0.030	0.388	1.340	0.291	0.585	0.043	1.880	0.218	0.291	0.032	0.061	0.925
11 Measured C2H4 yield, % of Coal Carbon	0.348	0.000	0.011	0.219	0.148	0.016	0.000	0.000	0.043	0.051	0.038	0.042
Predicted C2H4 yield, % of Coal Carbon	0.306	0.000	0.017	0.323	0.275	0.065	0.042	0.028	0.048	0.025	0.009	0.000
Predicted - Measured	-0.042	0.000	0.006	0.104	0.127	0.049	0.042	0.028	0.005	-0.026	-0.029	-0.042
ABS (Predicted - Measured)	0.042	0.000	0.006	0.104	0.127	0.049	0.042	0.028	0.005	0.026	0.029	0.042
12 Measured C2H6 yield, % of Coal Carbon	0.139	0.076	0.000	0.146	0.095	0.000	0.000	0.000	0.043	0.062	0.049	0.070
Predicted C2H6 yield, % of Coal Carbon	0.145	0.028	0.038	0.151	0.134	0.056	0.048	0.043	0.050	0.041	0.035	0.019
Predicted - Measured	0.006	-0.048	0.038	0.005	0.039	0.056	0.048	0.043	0.007	-0.021	-0.014	-0.051
ABS (Predicted - Measured)	0.006	0.048	0.038	0.005	0.039	0.056	0.048	0.043	0.007	0.021	0.014	0.051
13 Measured Total HC yield,% of Coal C	5.368	4.142	5.131	5.131	5.693	3.888	5.731	3.565	3.665	3.843	3.707	4.523
Predicted Total HC yield,% of Carbon	5.361	3.706	3.834	5.531	5.274	4.036	3.941	3.854	3.969	3.828	3.726	3.505
Predicted - Measured	-0.007	-0.436	-1.297	0.400	-0.419	0.148	-1.790	0.289	0.304	-0.015	0.019	-1.018
ABS (Predicted - Measured)	0.007	0.436	1.297	0.400	0.419	0.148	1.790	0.289	0.304	0.015	0.019	1.018

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	Minimum	Maximum	Average	Std Dev
Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
8 Measured Sulfur in Gas,% of Coal S	0.00	42.91	6.38	9.31
Predicted Sulfur in Gas,% of Coal S	0.43	11.81	3.78	3.27
Predicted - Measured	-31.74	11.81	-2.60	8.80
ABS (Predicted - Measured)	0.07	31.74	5.48	7.36
9 Measured NH3 in Freeboard Gas, ppm	484	3479	1811	763
Predicted NH3 in Freeboard Gas, ppm	1050	3360	1795	446
Predicted - Measured	-1839	1663	-16	849
ABS (Predicted - Measured)	85	1839	708	470
(Predicted/Measured-1)*100, %	-52.9	193.3	18.4	56.2
ABS (Predicted/Measured-1)*100, %	5.0	193.3	44.8	38.6
10 Measured CH4 yield, % of Coal Carbon	2.647	5.731	4.422	0.873
Predicted CH4 yield, % of Coal Carbon	2.731	6.343	4.204	0.793
Predicted - Measured	-1.880	1.108	-0.218	0.797
ABS (Predicted - Measured)	0.030	1.880	0.606	0.562
11 Measured C2H4 yield, % of Coal Carbon	0.000	0.657	0.150	0.193
Predicted C2H4 yield, % of Coal Carbon	0.000	0.658	0.147	0.168
Predicted - Measured	-0.310	0.127	-0.002	0.082
ABS (Predicted - Measured)	0.000	0.310	0.049	0.066
12 Measured C2H6 yield, % of Coal Carbon	0.000	2.136	0.188	0.449
Predicted C2H6 yield, % of Coal Carbon	0.000	0.275	0.083	0.065
Predicted - Measured	-1.982	0.068	-0.105	0.419
ABS (Predicted - Measured)	0.000	1.982	0.143	0.407
13 Measured Total HC yield,% of Coal C	2.736	7.970	4.760	1.231
Predicted Total HC yield,% of Carbon	2.731	7.276	4.434	1.020
Predicted - Measured	-2.472	1.033	-0.326	0.888
ABS (Predicted - Measured)	0.005	2.472	0.671	0.667

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR1-1	TR1-2	TR1-3	TR1-4	TR2-1	TR2-2	TR2-3	TR2-4	TR2-5	TR4-1	TR4-2	TR4-3
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Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo
14 Measured FB Gas LHV, Btu/SCF(wet)	51.3	50.4	64.3	75.6	48.8	64.2	42.2	66.5	69.8	48.5	47.7	47.9
Predicted FB Gas LHV, Btu/SCF(wet)	53.9	53.8	60.4	92.7	48.8	55.1	56.3	70.5	67.8	46.7	45.5	52.5
Predicted - Measured	2.6	3.5	-3.9	17.1	-0.0	-9.1	14.2	4.0	-2.0	-1.7	-2.2	4.6
ABS (Predicted - Measured)	2.6	3.5	3.9	17.1	0.0	9.1	14.2	4.0	2.0	1.7	2.2	4.6
(Predicted/Measured-1)*100, %	5.0	6.9	-6.1	22.6	-0.1	-14.2	33.6	6.0	-2.9	-3.6	-4.5	9.5
ABS (Predicted/Measured-1)*100, %	5.0	6.9	6.1	22.6	0.1	14.2	33.6	6.0	2.9	3.6	4.5	9.5
15 Measured Freeboard Gas LHV, Btu/lb	722.4	705.8	909.2	1086.6	668.0	895.0	573.5	930.5	980.3	680.8	692.0	698.3
Predicted Freeboard Gas LHV, Btu/lb	750.6	747.5	849.8	1365.3	668.9	771.4	773.6	1001.6	962.0	661.5	665.4	764.9
Predicted - Measured	28.2	41.7	-59.4	278.7	0.9	-123.6	200.1	71.1	-18.3	-19.3	-26.6	66.6
ABS (Predicted - Measured)	28.2	41.7	59.4	278.7	0.9	123.6	200.1	71.1	18.3	19.3	26.6	66.6
(Predicted/Measured-1)*100, %	3.9	5.9	-6.5	25.6	0.1	-13.8	34.9	7.6	-1.9	-2.8	-3.8	9.5
ABS (Predicted/Measured-1)*100, %	3.9	5.9	6.5	25.6	0.1	13.8	34.9	7.6	1.9	2.8	3.8	9.5
16 Meas. LHV Content of FB Gas, Btu/h	813404	693740	957871	961025	806747	973430	666646	1411943	1484020	807072	831378	665949
Pred. LHV Content of FB Gas, Btu/h	923886	806633	938312	1073008	837366	897807	1013075	1569078	1488222	739267	765983	755172
Predicted - Measured	110482	112893	-19558	111983	30619	-75623	346429	157133	4202	-67804	-65395	89223
ABS (Predicted - Measured)	110482	112893	19558	111983	30619	75623	346429	157133	4202	67804	65395	89223
(Predicted/Measured-1)*100, %	13.6	16.3	-2.0	11.7	3.8	-7.8	52.0	11.1	0.3	-8.4	-7.9	13.4
ABS (Predicted/Measured-1)*100, %	13.6	16.3	2.0	11.7	3.8	7.8	52.0	11.1	0.3	8.4	7.9	13.4

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	TR4-4	TR4-5	TR4-6	TR4-7	TR4-8	TR5-1	TR5-2	TR5-3	TR8-67	TR8-8	TR8-9	TR8-10
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Coal	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit	Pitt Bit
Sorbent	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	PR Dolo	Al Lime	PR Dolo	PR Dolo	PR Dolo	PR Dolo
14 Measured FB Gas LHV, Btu/SCF(wet)	49.4	63.1	67.3	58.0	58.3	63.7	55.1	49.8	50.2	50.5	53.8	58.0
Predicted FB Gas LHV, Btu/SCF(wet)	45.0	58.7	66.1	62.6	53.5	47.8	49.2	48.9	56.3	55.1	58.5	61.6
Predicted - Measured	-4.5	-4.4	-1.2	4.6	-4.7	-15.9	-5.9	-0.9	6.0	4.6	4.7	3.6
ABS (Predicted - Measured)	4.5	4.4	1.2	4.6	4.7	15.9	5.9	0.9	6.0	4.6	4.7	3.6
(Predicted/Measured-1)*100, %	-9.0	-7.0	-1.7	8.0	-8.2	-25.0	-10.8	-1.8	12.0	9.1	8.7	6.2
ABS (Predicted/Measured-1)*100, %	9.0	7.0	1.7	8.0	8.2	25.0	10.8	1.8	12.0	9.1	8.7	6.2
15 Measured Freeboard Gas LHV, Btu/lb	712.2	931.4	976.8	830.7	830.9	928.3	780.5	719.5	721.8	727.3	767.7	841.9
Predicted Freeboard Gas LHV, Btu/lb	643.9	871.2	980.5	905.0	757.8	685.6	695.9	701.2	818.0	799.7	843.0	896.7
Predicted - Measured	-68.3	-60.2	3.7	74.3	-73.1	-242.7	-84.6	-18.3	96.2	72.4	75.3	54.8
ABS (Predicted - Measured)	68.3	60.2	3.7	74.3	73.1	242.7	84.6	18.3	96.2	72.4	75.3	54.8
(Predicted/Measured-1)*100, %	-9.6	-6.5	0.4	8.9	-8.8	-26.1	-10.8	-2.5	13.3	10.0	9.8	6.5
ABS (Predicted/Measured-1)*100, %	9.6	6.5	0.4	8.9	8.8	26.1	10.8	2.5	13.3	10.0	9.8	6.5
16 Meas. LHV Content of FB Gas, Btu/h	709779	1322322	1248804	1104099	1070752	992226	903827	806394	1042694	988264	988915	946363
Pred. LHV Content of FB Gas, Btu/h	656407	1193008	1142642	1131485	1031636	733490	854706	838677	1142681	1056685	1050693	1076435
Predicted - Measured	-53372	-129314	-106162	27386	-39116	-258736	-49121	32283	99987	68421	61777	130073
ABS (Predicted - Measured)	53372	129314	106162	27386	39116	258736	49121	32283	99987	68421	61777	130073
(Predicted/Measured-1)*100, %	-7.5	-9.8	-8.5	2.5	-3.7	-26.1	-5.4	4.0	9.6	6.9	6.2	13.7
ABS (Predicted/Measured-1)*100, %	7.5	9.8	8.5	2.5	3.7	26.1	5.4	4.0	9.6	6.9	6.2	13.7

Table 4.1 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH PITTSBURGH NO. 8 BITUMINOUS COAL FEED

Set Point	Minimum	Maximum	Average	Std Dev
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Coal	----Pittsburgh No. 8 Bituminous----			
Sorbent	Plum Run Dolomite/Longview Limestone			
14 Measured FB Gas LHV, Btu/SCF(wet)	42.2	75.6	56.4	8.4
Predicted FB Gas LHV, Btu/SCF(wet)	45.0	92.7	57.0	10.1
Predicted - Measured	-15.9	17.1	0.5	6.8
ABS (Predicted - Measured)	0.0	17.1	5.2	4.4
(Predicted/Measured-1)*100, %	-25.0	33.6	1.4	12.0
ABS (Predicted/Measured-1)*100, %	0.1	33.6	9.3	7.7
15 Measured Freeboard Gas LHV, Btu/lb	573.5	1086.6	804.6	123.8
Predicted Freeboard Gas LHV, Btu/lb	643.9	1365.3	815.9	153.5
Predicted - Measured	-242.7	278.7	11.2	103.2
ABS (Predicted - Measured)	0.9	278.7	77.4	69.2
(Predicted/Measured-1)*100, %	-26.1	34.9	1.8	12.5
ABS (Predicted/Measured-1)*100, %	0.1	34.9	9.6	8.3
16 Meas. LHV Content of FB Gas, Btu/h	665949	1484020	966569	219193
Pred. LHV Content of FB Gas, Btu/h	656407	1569076	988181	221267
Predicted - Measured	-258736	346429	21612	117936
ABS (Predicted - Measured)	4202	346429	93629	74897
(Predicted/Measured-1)*100, %	-26.1	52.0	3.3	14.3
ABS (Predicted/Measured-1)*100, %	0.3	52.0	10.5	10.2

Table 4.2. COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH ILLINOIS NO. 6 BITUMINOUS COAL FEED

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
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Coal	Ill Bit	Ill Bit	Ill Bit	Ill Bit				
Sorbent	Al Lime	Al Lime	Al Lime	Al Lime				
Begin Clock Time, hours	1800	2300	2100	0700				
End Clock Time, hours	2200	0330	0200	1100				
Steady-State Period Duration, h	4	4.5	5	4	4.0	5.0	4.4	0.4
Carbonizer Pressure, psig	143.5	122.4	113.2	160.6	113.2	160.6	134.9	18.4
Average Bed Temp, F	1600	1599	1652	1715	1599	1715	1642	48
Freeboard Temp (@ 22.5 Ft), F	1573	1573	1623	1680	1573	1680	1612	44
Coal Feed to Carbonizer, lb/h	291.83	236.17	302.41	388.05	236.17	388.05	304.62	54.35
Sorbent Feed to Carbonizer, lb/h	35.94	38.73	75.62	101.16	35.94	101.16	62.86	27.10
Air Feed to Carbonizer, lb/h	634.07	512.72	668.53	935.47	512.72	935.47	687.70	154.31
Steam Feed to Carbonizer, lb/h	112.70	58.64	96.68	144.66	58.64	144.66	103.17	30.97
Purge N2 Feed to Carbonizer, lb/h	186.67	186.32	177.90	209.21	177.90	209.21	190.02	11.62
Bed Density, lb/ft ³	12.58	11.81	14.63	30.02	11.81	30.02	17.26	7.44
Bed Height, ft	16.6	18.3	17.8	15.4	15.4	18.3	17.0	1.1
Bed Weight, lb	153.39	159.20	192.47	337.90	153.39	337.90	210.74	74.92
Measured:CD - CaCO ₃ /(CaCO ₃ +CaO), mole%	100.0	100.0	90.8	33.7	33.749	100.000	81.127	27.612
:Mist - CaCO ₃ /(CaCO ₃ +CaO),mole%	80.4	87.9	82.1	34.1	34.054	87.941	71.142	21.593
Measured:CD - MgCO ₃ /(MgCO ₃ +MgO), mole%	100.0	100.0	0.0	0.0	0.000	100.000	50.000	50.000
:Mist - MgCO ₃ /(MgCO ₃ +MgO),mole%	77.1	80.4	0.0	0.0	0.000	80.356	39.375	39.391
1 Measured Carbon Conversion, %	42.71	41.61	46.18	52.62	41.61	52.62	45.78	4.29
Predicted Carbon Conversion, %	42.30	44.43	35.68	42.11	35.68	44.43	41.13	3.28
Predicted - Measured	-0.41	2.82	-10.50	-10.51	-10.51	2.82	-4.65	5.97
ABS*(Predicted - Measured)	0.41	2.82	10.50	10.51	0.41	10.51	6.06	4.53

* ABS = Absolute Value.

Table 4.2 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH ILLINOIS NO. 6 BITUMINOUS COAL FEED

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Ill Bit	Ill Bit	Ill Bit	Ill Bit				
Sorbent	Al Lime	Al Lime	Al Lime	Al Lime				
2 Measured Air Feed to Carbonizer, lb/h	634.1	512.7	668.5	935.5	512.7	935.5	687.7	154.3
Predicted Air Feed to Carbonizer, lb/h	661.8	587.1	520.6	754.6	520.6	754.6	631.0	87.1
Predicted - Measured	27.7	74.4	-147.9	-180.9	-180.9	74.4	-56.7	109.6
ABS (Predicted - Measured)	27.7	74.4	147.9	180.9	27.7	180.9	107.7	60.2
(Predicted/Measured-1)*100, %	4.4	14.5	-22.1	-19.3	-22.1	14.5	-5.6	15.5
ABS (Predicted/Measured-1)*100, %	4.4	14.5	22.1	19.3	4.4	22.1	15.1	6.8
3 Measured Air/Coal, lb/lb	2.173	2.171	2.211	2.411	2.171	2.411	2.241	0.099
Predicted Air/Coal, lb/lb	2.268	2.486	1.722	1.945	1.722	2.486	2.105	0.293
Predicted - Measured	0.095	0.315	-0.489	-0.466	-0.489	0.315	-0.136	0.350
ABS (Predicted - Measured)	0.095	0.315	0.489	0.466	0.095	0.489	0.341	0.157
4 Measured Air/Coal, lb/lb(MF)	2.451	2.432	2.453	2.686	2.432	2.686	2.505	0.105
Predicted Air/Coal, lb/lb(MF)	2.558	2.785	1.910	2.167	1.910	2.785	2.355	0.339
Predicted - Measured	0.107	0.353	-0.543	-0.519	-0.543	0.353	-0.151	0.390
ABS (Predicted - Measured)	0.107	0.353	0.543	0.519	0.107	0.543	0.381	0.174
5 Measured Coal Nitrogen Released, %	52.33	51.00	61.35	72.40	51.00	72.40	59.27	8.56
Predicted Coal Nitrogen Released, %	39.57	41.45	28.84	39.28	28.84	41.45	37.29	4.95
Predicted - Measured	-12.76	-9.55	-32.51	-33.12	-33.12	-9.55	-21.98	10.89
ABS (Predicted - Measured)	12.76	9.55	32.51	33.12	9.55	33.12	21.98	10.89
6 Measured Coal Sulfur Released, %	48.25	80.82	75.68	92.06	48.25	92.06	74.20	16.11
Predicted Coal Sulfur Released, %	73.17	74.86	74.50	82.02	73.17	82.02	76.14	3.45
Predicted - Measured	24.92	-5.96	-1.18	-10.04	-10.04	24.92	1.94	13.64
ABS (Predicted - Measured)	24.92	5.96	1.18	10.04	1.18	24.92	10.53	8.88
7 Measured H2S in Freeboard Gas, ppm	369	3802	142	21	21	3802	1083	1574
Predicted H2S in Freeboard Gas, ppm	509	341	305	493	305	509	412	90
Predicted - Measured	140	-3461	163	472	-3461	472	-671	1616
ABS (Predicted - Measured)	140	3461	163	472	140	3461	1059	1393
(Predicted/Measured-1)*100, %	38.0	-91.0	115.5	2196.8	-91.0	2196.8	564.8	945.1
ABS (Predicted/Measured-1)*100, %	38.0	91.0	115.5	2196.8	38.0	2196.8	610.3	916.4

Table 4.2 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH ILLINOIS NO. 6 BITUMINOUS COAL FEED

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Ill Bit	Ill Bit	Ill Bit	Ill Bit				
Sorbent	Al Lime	Al Lime	Al Lime	Al Lime				
8 Measured Sulfur in Gas,% of Coal S	5.93	57.08	2.17	0.36	0.36	57.08	16.39	23.58
Predicted Sulfur in Gas,% of Coal S	8.30	5.47	4.06	7.32	4.06	8.30	6.29	1.64
Predicted - Measured	2.37	-51.61	1.89	6.96	-51.61	6.96	-10.10	24.05
ABS (Predicted - Measured)	2.37	51.61	1.89	6.96	1.89	51.61	15.71	20.82
9 Measured NH3 in Freeboard Gas, ppm	2650	3424	2428	1384	1384	3424	2522	746
Predicted NH3 in Freeboard Gas, ppm	1480	1450	1660	1480	1450	1660	1518	83
Predicted - Measured	-1370	-1974	-768	96	-1974	96	-1004	765
ABS (Predicted - Measured)	1370	1974	768	96	96	1974	1052	698
(Predicted/Measured-1)*100, %	-48.1	-57.7	-31.6	6.9	-57.7	6.9	-32.6	24.6
ABS (Predicted/Measured-1)*100, %	48.1	57.7	31.6	6.9	6.9	57.7	36.1	19.2
10 Measured CH4 yield, % of Coal Carbon	4.267	4.395	4.030	4.599	4.030	4.599	4.323	0.206
Predicted CH4 yield, % of Coal Carbon	5.021	4.994	4.335	3.678	3.678	5.021	4.507	0.552
Predicted - Measured	0.754	0.599	0.305	-0.921	-0.921	0.754	0.184	0.658
ABS (Predicted - Measured)	0.754	0.599	0.305	0.921	0.305	0.921	0.645	0.227
11 Measured C2H4 yield, % of Coal Carbon	0.282	0.246	0.203	0.000	0.000	0.282	0.183	0.109
Predicted C2H4 yield, % of Coal Carbon	0.326	0.329	0.180	0.003	0.003	0.329	0.210	0.134
Predicted - Measured	0.044	0.083	-0.023	0.003	-0.023	0.083	0.027	0.040
ABS (Predicted - Measured)	0.044	0.083	0.023	0.003	0.003	0.083	0.038	0.030
12 Measured C2H6 yield, % of Coal Carbon	0.090	0.101	0.155	0.115	0.090	0.155	0.115	0.025
Predicted C2H6 yield, % of Coal Carbon	0.152	0.153	0.098	0.033	0.033	0.153	0.109	0.049
Predicted - Measured	0.062	0.052	-0.057	-0.082	-0.082	0.062	-0.006	0.064
ABS (Predicted - Measured)	0.062	0.052	0.057	0.082	0.052	0.082	0.063	0.011
13 Measured Total HC yield,% of Coal C	4.639	4.742	4.387	4.714	4.387	4.742	4.621	0.140
Predicted Total HC yield,% of Carbon	5.499	5.476	4.613	3.714	3.714	5.499	4.826	0.734
Predicted - Measured	0.860	0.734	0.226	-1.000	-1.000	0.860	0.205	0.735
ABS (Predicted - Measured)	0.860	0.734	0.226	1.000	0.226	1.000	0.705	0.292

Table 4.2 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH ILLINOIS NO. 6 BITUMINOUS COAL FEED

Set Point	TR6-6	TR6-7	TR8-4	TR8-5	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Ill Bit	Ill Bit	Ill Bit	Ill Bit				
Sorbent	Al Lime	Al Lime	Al Lime	Al Lime				
14 Measured FB Gas LHV, Btu/SCF(wet)	51.1	54.3	52.8	53.2	51.1	54.3	52.8	1.1
Predicted FB Gas LHV, Btu/SCF(wet)	46.0	45.6	51.9	53.5	45.6	53.5	49.2	3.5
Predicted - Measured	-5.1	-8.7	-0.9	0.2	-8.7	0.2	-3.6	3.6
ABS (Predicted - Measured)	5.1	8.7	0.9	0.2	0.2	8.7	3.7	3.4
(Predicted/Measured-1)*100, %	-10.0	-16.0	-1.7	0.5	-16.0	0.5	-6.8	6.6
ABS (Predicted/Measured-1)*100, %	10.0	16.0	1.7	0.5	0.5	16.0	7.0	6.4
15 Measured Freeboard Gas LHV, Btu/lb	766.6	797.0	770.7	772.2	766.6	797.0	776.6	11.9
Predicted Freeboard Gas LHV, Btu/lb	681.7	657.7	777.6	797.0	657.7	797.0	728.5	59.8
Predicted - Measured	-84.9	-139.3	6.9	24.8	-139.3	24.8	-48.1	67.1
ABS (Predicted - Measured)	84.9	139.3	6.9	24.8	6.9	139.3	64.0	52.2
(Predicted/Measured-1)*100, %	-11.1	-17.5	0.9	3.2	-17.5	3.2	-6.1	8.5
ABS (Predicted/Measured-1)*100, %	11.1	17.5	0.9	3.2	0.9	17.5	8.2	6.6
16 Meas. LHV Content of FB Gas, Btu/h	833778	702714	859266	1191730	702714	1191730	896872	180301
Pred. LHV Content of FB Gas, Btu/h	760466	631730	731210	1071740	631730	1071740	798786	164658
Predicted - Measured	-73312	-70984	-128056	-119990	-128056	-70984	-98085	26107
ABS (Predicted - Measured)	73312	70984	128056	119990	70984	128056	98085	26107
(Predicted/Measured-1)*100, %	-8.8	-10.1	-14.9	-10.1	-14.9	-8.8	-11.0	2.3
ABS (Predicted/Measured-1)*100, %	8.8	10.1	14.9	10.1	8.8	14.9	11.0	2.3

Table 4.3. COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR STEADY-STATE PERIODS WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL FEED

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime				
Begin Clock Time, hours	2100	0430	1400	2100	0400	2000	0300	1330				
End Clock Time, hours	0100	0830	1800	0100	0800	0100	0800	1730				
Steady-State Period Duration, h	4	4	4	4	4	5	5	4	4.0	5.0	4.3	0.4
Carbonizer Pressure, psig	145.9	129.8	157.5	191.9	189.6	128.6	132.7	156.5	128.6	191.9	154.1	23.6
Average Bed Temp, F	1580	1509	1511	1609	1632	1476	1593	1613	1476	1632	1565	54
Freeboard Temp (@ 22.5 Ft), F	1567	1500	1515	1579	1593	1432	1541	1575	1432	1593	1538	50
Coal Feed to Carbonizer, lb/h	330.38	310.58	397.83	443.46	429.56	288.37	283.68	362.84	283.68	443.46	355.84	58.50
Sorbent Feed to Carbonizer, lb/h	67.82	66.66	44.92	54.98	20.46	37.18	54.46	27.02	20.46	67.82	46.69	16.37
Air Feed to Carbonizer, lb/h	755.05	656.16	799.76	992.63	970.90	600.15	691.38	823.06	600.15	992.63	786.14	132.17
Steam Feed to Carbonizer, lb/h	0.00	0.00	0.00	0.00	0.00	46.45	46.47	53.10	0.00	53.10	18.25	23.64
Purge N2 Feed to Carbonizer, lb/h	208.35	231.94	176.70	152.02	159.57	224.71	214.74	192.52	152.02	231.94	195.07	27.97
Bed Density, lb/ft ³	55.45	48.06	38.38	43.43	45.80	26.86	55.00	59.69	26.86	59.69	46.58	9.94
Bed Height, ft	20.2	20.7	23.7	15.6	14.5	19.7	17.1	18.1	14.5	23.7	18.7	2.8
Bed Weight, lb	849.44	762.44	731.84	496.41	480.58	398.16	693.17	798.14	398.16	849.44	651.27	157.57
Measured:CD - CaCO ₃ /(CaCO ₃ +CaO), mole%	51.4	96.5	100.0	92.0	100.0	100.0	47.0	0.9	0.856	100.000	73.472	34.364
:Mist - CaCO ₃ /(CaCO ₃ +CaO),mole%	51.1	93.3	86.7	84.9	91.3	81.3	52.1	23.0	22.964	93.253	70.454	23.740
Measured:CD - MgCO ₃ /(MgCO ₃ +MgO), mole%	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.000	100.000	12.500	33.072
:Mist - MgCO ₃ /(MgCO ₃ +MgO),mole%	0.0	2.4	0.0	0.0	0.0	64.2	0.3	0.0	0.000	64.170	8.360	21.109
1 Measured Carbon Conversion, %	71.09	65.33	68.15	72.87	72.89	66.23	77.96	80.12	65.33	80.12	71.83	4.95
Predicted Carbon Conversion, %	76.90	68.04	60.09	72.12	72.98	66.00	84.10	80.29	60.09	84.10	72.57	7.34
Predicted - Measured	5.81	2.71	-8.06	-0.75	0.09	-0.23	6.14	0.17	-8.06	6.14	0.74	4.18
ABS*(Predicted - Measured)	5.81	2.71	8.06	0.75	0.09	0.23	6.14	0.17	0.09	8.06	2.99	3.01

* ABS = Absolute Value.

Table 4.3 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR STEADY-STATE PERIODS WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL FEED

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime				
2 Measured Air Feed to Carbonizer, lb/h	755.1	656.2	799.8	992.6	970.9	600.1	691.4	823.1	600.1	992.6	786.1	132.2
Predicted Air Feed to Carbonizer, lb/h	827.1	683.7	747.1	1001.2	961.1	611.1	726.0	867.6	611.1	1001.2	803.1	127.1
Predicted - Measured	72.0	27.5	-52.7	8.6	-9.8	11.0	34.6	44.5	-52.7	72.0	17.0	35.2
ABS (Predicted - Measured)	72.0	27.5	52.7	8.6	9.8	11.0	34.6	44.5	8.6	72.0	32.6	21.5
(Predicted/Measured-1)*100, %	9.5	4.2	-6.6	0.9	-1.0	1.8	5.0	5.4	-6.6	9.5	2.4	4.5
ABS (Predicted/Measured-1)*100, %	9.5	4.2	6.6	0.9	1.0	1.8	5.0	5.4	0.9	9.5	4.3	2.8
3 Measured Air/Coal, lb/lb	2.285	2.113	2.010	2.238	2.260	2.081	2.437	2.268	2.010	2.437	2.212	0.127
Predicted Air/Coal, lb/lb	2.503	2.201	1.878	2.258	2.237	2.119	2.559	2.391	1.878	2.559	2.268	0.205
Predicted - Measured	0.218	0.089	-0.132	0.019	-0.023	0.038	0.122	0.123	-0.132	0.218	0.057	0.100
ABS (Predicted - Measured)	0.218	0.089	0.132	0.019	0.023	0.038	0.122	0.123	0.019	0.218	0.096	0.064
4 Measured Air/Coal, lb/lb(MF)	3.182	2.948	2.782	3.092	3.136	2.941	3.515	3.252	2.782	3.515	3.106	0.210
Predicted Air/Coal, lb/lb(MF)	3.485	3.072	2.599	3.118	3.104	2.995	3.691	3.427	2.599	3.691	3.187	0.318
Predicted - Measured	0.304	0.124	-0.183	0.027	-0.032	0.054	0.176	0.176	-0.183	0.304	0.081	0.139
ABS (Predicted - Measured)	0.304	0.124	0.183	0.027	0.032	0.054	0.176	0.176	0.027	0.304	0.134	0.089
5 Measured Coal Nitrogen Released, %	65.34	59.38	68.13	75.75	72.28	74.04	86.27	87.56	59.38	87.56	73.59	9.10
Predicted Coal Nitrogen Released, %	79.85	69.87	62.50	76.67	78.14	62.56	84.93	81.84	62.50	84.93	74.55	8.04
Predicted - Measured	14.51	10.49	-5.63	0.92	5.86	-11.48	-1.34	-5.72	-11.48	14.51	0.95	8.26
ABS (Predicted - Measured)	14.51	10.49	5.63	0.92	5.86	11.48	1.34	5.72	0.92	14.51	6.99	4.51
6 Measured Coal Sulfur Released, %	44.99	51.13	58.10	66.36	52.66	95.92	81.46	73.99	44.99	95.92	65.58	16.20
Predicted Coal Sulfur Released, %	68.90	56.27	45.85	66.10	67.39	50.29	79.32	74.18	45.85	79.32	63.54	10.92
Predicted - Measured	23.91	5.14	-12.25	-0.26	14.73	-45.63	-2.14	0.19	-45.63	23.91	-2.04	19.42
ABS (Predicted - Measured)	23.91	5.14	12.25	0.26	14.73	45.63	2.14	0.19	0.19	45.63	13.03	14.55
7 Measured H2S in Freeboard Gas, ppm	213	34	100	97	54	1312	772	383	34	1312	371	423
Predicted H2S in Freeboard Gas, ppm	283	423	613	363	305	774	335	252	252	774	419	171
Predicted - Measured	70	389	513	266	251	-538	-437	-131	-538	513	48	359
ABS (Predicted - Measured)	70	389	513	266	251	538	437	131	70	538	324	162
(Predicted/Measured-1)*100, %	32.6	1142.7	513.4	274.7	469.4	-41.0	-56.6	-34.2	-56.6	1142.7	287.6	389.0
ABS (Predicted/Measured-1)*100, %	32.6	1142.7	513.4	274.7	469.4	41.0	56.6	34.2	32.6	1142.7	320.6	362.3

Table 4.3 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL FEED

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	At Lime	At Lime	At Lime	At Lime	At Lime	At Lime	At Lime	At Lime				
8 Measured Sulfur in Gas,% of Coal S	15.02	2.18	5.75	5.82	3.38	92.57	63.62	29.64	2.18	92.57	27.25	31.35
Predicted Sulfur in Gas,% of Coal S	20.96	27.85	33.29	21.91	19.15	55.01	30.25	20.17	19.15	55.01	28.57	11.10
Predicted - Measured	5.94	25.67	27.54	16.09	15.77	-37.56	-33.37	-9.47	-37.56	27.54	1.33	23.87
ABS (Predicted - Measured)	5.94	25.67	27.54	16.09	15.77	37.56	33.37	9.47	5.94	37.56	21.42	10.62
9 Measured NH3 in Freeboard Gas, ppm	1876	4459	3287	3078	1725	2612	2912	2970	1725	4459	2865	800
Predicted NH3 in Freeboard Gas, ppm	2720	2880	3480	3140	3110	2440	2100	2320	2100	3480	2774	438
Predicted - Measured	844	-1579	193	62	1385	-172	-812	-650	-1579	1385	-91	881
ABS (Predicted - Measured)	844	1579	193	62	1385	172	812	650	62	1579	712	527
(Predicted/Measured-1)*100, %	45.0	-35.4	5.9	2.0	80.3	-6.6	-27.9	-21.9	-35.4	80.3	5.2	36.8
ABS (Predicted/Measured-1)*100, %	45.0	35.4	5.9	2.0	80.3	6.6	27.9	21.9	2.0	80.3	28.1	24.3
10 Measured CH4 yield, % of Coal Carbon	5.366	5.088	5.535	5.995	5.295	5.529	5.420	6.725	5.088	6.725	5.619	0.484
Predicted CH4 yield, % of Coal Carbon	5.381	5.514	5.511	5.327	5.284	5.576	5.357	5.319	5.284	5.576	5.409	0.102
Predicted - Measured	0.015	0.426	-0.024	-0.668	-0.011	0.047	-0.063	-1.406	-1.406	0.426	-0.210	0.531
ABS (Predicted - Measured)	0.015	0.426	0.024	0.668	0.011	0.047	0.063	1.406	0.011	1.406	0.333	0.465
11 Measured C2H4 yield, % of Coal Carbon	0.220	0.296	0.158	0.069	0.063	0.303	0.177	0.079	0.063	0.303	0.171	0.091
Predicted C2H4 yield, % of Coal Carbon	0.143	0.260	0.257	0.096	0.058	0.315	0.122	0.089	0.058	0.315	0.168	0.090
Predicted - Measured	-0.077	-0.036	0.099	0.027	-0.005	0.012	-0.055	0.010	-0.077	0.099	-0.003	0.051
ABS (Predicted - Measured)	0.077	0.036	0.099	0.027	0.005	0.012	0.055	0.010	0.005	0.099	0.040	0.032
12 Measured C2H6 yield, % of Coal Carbon	0.157	0.296	0.220	0.103	0.077	0.698	0.312	0.395	0.077	0.698	0.282	0.187
Predicted C2H6 yield, % of Coal Carbon	0.183	0.326	0.322	0.125	0.079	0.392	0.157	0.117	0.079	0.392	0.213	0.109
Predicted - Measured	0.026	0.030	0.102	0.022	0.002	-0.306	-0.155	-0.278	-0.306	0.102	-0.070	0.145
ABS (Predicted - Measured)	0.026	0.030	0.102	0.022	0.002	0.306	0.155	0.278	0.002	0.306	0.115	0.113
13 Measured Total HC yield,% of Coal C	5.744	5.680	5.913	6.167	5.434	6.530	5.908	7.200	5.434	7.200	6.072	0.526
Predicted Total HC yield,% of Carbon	5.707	6.100	6.090	5.548	5.421	6.283	5.636	5.525	5.421	6.283	5.789	0.301
Predicted - Measured	-0.037	0.420	0.177	-0.619	-0.013	-0.247	-0.272	-1.675	-1.675	0.420	-0.283	0.601
ABS (Predicted - Measured)	0.037	0.420	0.177	0.619	0.013	0.247	0.272	1.675	0.013	1.675	0.433	0.505

Table 4.3 (cont). COMPARISON OF MEASURED AND MODEL PREDICTED PARAMETERS FOR
STEADY-STATE PERIODS WITH WYOMING EAGLE BUTTE SUBBITUMINOUS COAL FEED

Set Point	TR6-1	TR6-2	TR6-3	TR6-4	TR6-5	TR8-1	TR8-2	TR8-3	Minimum	Maximum	Average	Std Dev
Coal	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub	Wy Sub				
Sorbent	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime	Al Lime				
14 Measured FB Gas LHV, Btu/SCF(wet)	68.3	61.8	77.7	78.4	76.5	55.9	55.1	68.2	55.1	78.4	67.7	8.8
Predicted FB Gas LHV, Btu/SCF(wet)	68.0	62.1	70.2	76.2	77.5	54.2	59.0	64.3	54.2	77.5	66.5	7.6
Predicted - Measured	-0.3	0.3	-7.4	-2.2	1.0	-1.6	4.0	-3.9	-7.4	4.0	-1.3	3.2
ABS (Predicted - Measured)	0.3	0.3	7.4	2.2	1.0	1.6	4.0	3.9	0.3	7.4	2.6	2.3
(Predicted/Measured-1)*100, %	-0.4	0.5	-9.6	-2.8	1.3	-2.9	7.2	-5.7	-9.6	7.2	-1.5	4.7
ABS (Predicted/Measured-1)*100, %	0.4	0.5	9.6	2.8	1.3	2.9	7.2	5.7	0.4	9.6	3.8	3.1
15 Measured Freeboard Gas LHV, Btu/lb	986.4	890.3	1139.4	1139.8	1119.2	812.1	793.0	993.1	793.0	1139.8	984.2	133.0
Predicted Freeboard Gas LHV, Btu/lb	980.5	894.5	1029.8	1112.6	1137.3	790.5	856.7	939.4	790.5	1137.3	967.7	113.8
Predicted - Measured	-5.9	4.2	-109.6	-27.2	18.1	-21.6	63.7	-53.7	-109.6	63.7	-16.5	47.9
ABS (Predicted - Measured)	5.9	4.2	109.6	27.2	18.1	21.6	63.7	53.7	4.2	109.6	38.0	33.5
(Predicted/Measured-1)*100, %	-0.6	0.5	-9.6	-2.4	1.6	-2.7	8.0	-5.4	-9.6	8.0	-1.3	4.9
ABS (Predicted/Measured-1)*100, %	0.6	0.5	9.6	2.4	1.6	2.7	8.0	5.4	0.5	9.6	3.8	3.2
16 Meas. LHV Content of FB Gas, Btu/h	1223325	1005084	1470025	1715900	1653109	893456	953851	1376539	893456	1715900	1286411	297679
Pred. LHV Content of FB Gas, Btu/h	1283257	1035930	1253325	1677761	1668106	874397	1057680	1345732	874397	1677761	1274523	270914
Predicted - Measured	59932	30846	-216701	-38139	14996	-19059	103829	-30807	-216701	103829	-11888	89543
ABS (Predicted - Measured)	59932	30846	216701	38139	14996	19059	103829	30807	14996	216701	64289	63453
(Predicted/Measured-1)*100, %	4.9	3.1	-14.7	-2.2	0.9	-2.1	10.9	-2.2	-14.7	10.9	-0.2	6.9
ABS (Predicted/Measured-1)*100, %	4.9	3.1	14.7	2.2	0.9	2.1	10.9	2.2	0.9	14.7	5.1	4.7

Table 4.4. OVERALL CARBONIZER MODEL PERFORMANCE

Set Point	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----
Coal	----Pittsburgh/Illinois/Wyoming----			
Sorbent	Plum Run Dolomite/Longview Limestone			
Begin Clock Time, hours				
End Clock Time, hours	(No. of Set Points = 36)			
Steady-State Period Duration, h	2.0	5.0	4.0	0.5
Carbonizer Pressure, psig	113.2	198.6	150.4	23.1
Average Bed Temp, F	1476	1797	1644	77
Freeboard Temp (@ 22.5 Ft), F	1432	1738	1611	72
Coal Feed to Carbonizer, lb/h	181.25	489.06	315.97	74.23
Sorbent Feed to Carbonizer, lb/h	20.46	181.55	82.44	35.01
Air Feed to Carbonizer, lb/h	512.72	992.63	723.69	133.93
Steam Feed to Carbonizer, lb/h	0.00	144.66	50.63	46.43
Purge N2 Feed to Carbonizer, lb/h	125.01	380.92	244.36	68.87
Bed Density, lb/ft ³	11.72	59.69	22.33	14.14
Bed Height, ft	14.5	26.5	18.4	3.2
Bed Weight, lb	151.04	849.44	307.70	203.52
Measured:CD - CaCO ₃ /(CaCO ₃ +CaO), mole%	0.856	100.000	79.031	29.349
:Mist - CaCO ₃ /(CaCO ₃ +CaO),mole%	22.964	100.000	77.099	24.347
Measured:CD - MgCO ₃ /(MgCO ₃ +MgO), mole%	0.000	100.000	20.682	30.776
:Mist - MgCO ₃ /(MgCO ₃ +MgO),mole%	0.000	80.356	18.061	24.643
1 Measured Carbon Conversion, %	27.01	80.12	49.92	14.00
Predicted Carbon Conversion, %	26.68	84.10	50.41	15.34
Predicted - Measured	-10.51	22.42	0.49	5.89
ABS*(Predicted - Measured)	0.02	22.42	3.93	4.42

* ABS = Absolute Value.

Table 4.4 (cont). OVERALL CARBONIZER MODEL PERFORMANCE

Set Point	Minimum	Maximum	Average	Std Dev
Coal	-----Pittsburgh/Illinois/Wyoming-----			
Sorbent	Plum Run Dolomite/Longview Limestone			
2 Measured Air Feed to Carbonizer, lb/h	512.7	992.6	723.7	133.9
Predicted Air Feed to Carbonizer, lb/h	442.7	1001.2	727.6	128.6
Predicted - Measured	-180.9	115.2	3.9	66.6
ABS (Predicted - Measured)	8.6	180.9	55.6	36.9
(Predicted/Measured-1)*100, %	-22.1	17.3	1.1	9.5
ABS (Predicted/Measured-1)*100, %	0.9	22.1	8.0	5.3
3 Measured Air/Coal, lb/lb	1.391	3.666	2.361	0.456
Predicted Air/Coal, lb/lb	1.145	4.301	2.397	0.568
Predicted - Measured	-0.489	0.635	0.035	0.227
ABS (Predicted - Measured)	0.019	0.635	0.187	0.133
4 Measured Air/Coal, lb/lb(MF)	1.424	3.752	2.627	0.525
Predicted Air/Coal, lb/lb(MF)	1.172	4.403	2.667	0.640
Predicted - Measured	-0.543	0.650	0.040	0.243
ABS (Predicted - Measured)	0.027	0.650	0.203	0.140
5 Measured Coal Nitrogen Released, %	26.49	87.56	55.65	14.20
Predicted Coal Nitrogen Released, %	25.69	86.68	53.42	15.85
Predicted - Measured	-33.12	23.68	-2.23	11.16
ABS (Predicted - Measured)	0.35	33.12	8.20	7.88
6 Measured Coal Sulfur Released, %	41.21	95.92	72.08	14.79
Predicted Coal Sulfur Released, %	45.85	97.59	75.13	11.05
Predicted - Measured	-45.63	36.73	3.06	15.09
ABS (Predicted - Measured)	0.08	45.63	10.56	11.20
7 Measured H ₂ S in Freeboard Gas, ppm	0	3802	471	705
Predicted H ₂ S in Freeboard Gas, ppm	24	774	286	156
Predicted - Measured	-3461	513	-186	709
ABS (Predicted - Measured)	1	3461	406	610
(Predicted/Measured-1)*100, %	-95.8	2196.8	171.2	444.5
ABS (Predicted/Measured-1)*100, %	0.6	2196.8	227.3	418.6

Table 4.4 (cont). OVERALL CARBONIZER MODEL PERFORMANCE

Set Point	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----
Coal	----Pittsburgh/Illinois/Wyoming----			
Sorbent	Plum Run Dolomite/Longview Limestone			
8 Measured Sulfur in Gas,% of Coal S	0.00	92.57	12.13	20.32
Predicted Sulfur in Gas,% of Coal S	0.43	55.01	9.57	11.77
Predicted - Measured	-51.61	27.54	-2.56	15.88
ABS (Predicted - Measured)	0.07	51.61	10.16	12.47
9 Measured NH3 in Freeboard Gas, ppm	484	4459	2124	892
Predicted NH3 in Freeboard Gas, ppm	1050	3480	1982	602
Predicted - Measured	-1974	1663	-143	901
ABS (Predicted - Measured)	62	1974	747	524
(Predicted/Measured-1)*100, %	-57.7	193.3	9.8	52.2
ABS (Predicted/Measured-1)*100, %	2.0	193.3	40.1	34.9
10 Measured CH4 yield, % of Coal Carbon	2.647	6.725	4.677	0.905
Predicted CH4 yield, % of Coal Carbon	2.731	6.343	4.505	0.835
Predicted - Measured	-1.880	1.108	-0.172	0.742
ABS (Predicted - Measured)	0.011	1.880	0.550	0.527
11 Measured C2H4 yield, % of Coal Carbon	0.000	0.657	0.158	0.167
Predicted C2H4 yield, % of Coal Carbon	0.000	0.658	0.159	0.151
Predicted - Measured	-0.310	0.127	0.001	0.073
ABS (Predicted - Measured)	0.000	0.310	0.046	0.057
12 Measured C2H6 yield, % of Coal Carbon	0.000	2.136	0.201	0.381
Predicted C2H6 yield, % of Coal Carbon	0.000	0.392	0.115	0.093
Predicted - Measured	-1.982	0.102	-0.086	0.351
ABS (Predicted - Measured)	0.000	1.982	0.128	0.338
13 Measured Total HC yield,% of Coal C	2.736	7.970	5.036	1.176
Predicted Total HC yield,% of Carbon	2.731	7.276	4.779	1.039
Predicted - Measured	-2.472	1.033	-0.258	0.833
ABS (Predicted - Measured)	0.005	2.472	0.622	0.611

Table 4.4 (cont). OVERALL CARBONIZER MODEL PERFORMANCE

Set Point	Minimum	Maximum	Average	Std Dev
	-----	-----	-----	-----
Coal	----Pittsburgh/Illinois/Wyoming----			
Sorbent	Plum Run Dolomite/Longview Limestone			
14 Measured FB Gas LHV, Btu/SCF(wet)	42.2	78.4	58.5	9.5
Predicted FB Gas LHV, Btu/SCF(wet)	45.0	92.7	58.2	10.4
Predicted - Measured	-15.9	17.1	-0.3	6.1
ABS (Predicted - Measured)	0.0	17.1	4.5	4.1
(Predicted/Measured-1)*100, %	-25.0	33.6	-0.2	10.6
ABS (Predicted/Measured-1)*100, %	0.1	33.6	7.8	7.1
15 Measured Freeboard Gas LHV, Btu/lb	573.5	1139.8	841.4	141.6
Predicted Freeboard Gas LHV, Btu/lb	643.9	1365.3	839.9	156.1
Predicted - Measured	-242.7	278.7	-1.5	92.3
ABS (Predicted - Measured)	0.9	278.7	67.2	63.2
(Predicted/Measured-1)*100, %	-26.1	34.9	0.2	11.2
ABS (Predicted/Measured-1)*100, %	0.1	34.9	8.1	7.6
16 Meas. LHV Content of FB Gas, Btu/h	665949	1715900	1029901	273123
Pred. LHV Content of FB Gas, Btu/h	631730	1677761	1030769	268987
Predicted - Measured	-258736	346429	868	111987
ABS (Predicted - Measured)	4202	346429	87604	69766
(Predicted/Measured-1)*100, %	-26.1	52.0	0.9	12.9
ABS (Predicted/Measured-1)*100, %	0.3	52.0	9.4	8.9

Figure 4.1 shows a comparison of the measured and model predicted values of the carbon conversion. An analysis of these data indicates that the average value of the absolute difference between the predicted and measured values of the carbon conversion is 3.93% with a standard deviation of 4.42% (see Table 4.4). The organic carbon in the char, which is used to calculate the carbon conversion, is not a measured value; it is determined by the difference between the total carbon measurement and the carbonate carbon measurement, thus contributing to some inaccuracy. Furthermore, although the bed drain samples were collected using a thief (a solids-sampling device), getting a uniform representative sample has been a problem in the pilot plant because it contains two distinct types of particles, namely, coal char and spent sorbent. Because of the differences in the particle sizes and densities of these two components, they tend to separate very easily, thus making it difficult to get a representative sample. This affects the organic carbon content of the sample, and thus the measured carbon conversion calculation as well. The prediction of the carbon conversion is the most important one, as any deviation from the measured value affects the prediction of other important parameters, such as air feed rate, coal nitrogen released, coal sulfur released, and product gas LHV.

Figure 4.2 shows a comparison of the measured and model predicted values of air feed to the carbonizer. The data indicate that the average value of the absolute difference between the predicted and measured values of the air feed is 8.0% with a standard deviation of 5.3% (see Table 4.4). It should be noted that the required air feed is a function of carbon conversion, and thus any deviation in the prediction of the carbon conversion is also reflected in the prediction of air feed to the carbonizer. Figure 4.3 shows a comparison of the measured and model predicted values of the air-to-coal feed ratio. The data show that the average value of the absolute difference between the predicted and measured values of the air-to-coal feed ratio is 0.187 lb/lb with a standard deviation of 0.133 lb/lb. Because of the high surface-to-volume ratio of the pilot-scale carbonizer and the cooling effect of the nitrogen from pressure-tap purges and the internal drain cooler, the pilot-scale unit needs a higher air-to-coal ratio compared to that required for a commercial plant to reach a certain temperature.

Figure 4.4 shows a comparison of the measured and model predicted values of the coal nitrogen released. The data show that the average value of the absolute difference between the predicted and measured values of the coal nitrogen released is 8.20% with a standard deviation of 7.88%; these predictions are compounded by the uncertainty in the carbon conversion prediction (see Table 4.4). The predicted coal nitrogen released for the Illinois coal is poor compared to that predicted for the Pittsburgh coal because the N/C ratio in the Illinois coal is lower (0.0206 lb-mol/lb-mol) compared to that in the Pittsburgh coal (0.0235 lb-mol/lb-mol), and the estimated value of the N/C ratio in the char does not account for this fact (see equation 3.1). If another form of correlation is used as recommended in the next section, then this prediction would improve significantly.

Figure 4.5 shows a comparison of the measured and model predicted values of the coal sulfur released. The data show that the average value of the absolute difference between the predicted and measured values of the coal sulfur released is 10.56% with a standard deviation of 11.20%. The prediction of coal sulfur released has been poor partly because the sulfur closures were quite poor in the raw material and energy balances based on the true measurements (see Figure 3.33); the sulfur closures ranged from 37.4% to 265.5% with an average value of 78.7% and a standard deviation of 40.6%. Thus, the adjustments made in the measurements during reconciliation of data, with respect to sulfur, may be somewhat unrealistic. (The details have been given in Volume 1 of this report.) Furthermore, the sulfur content of the Pittsburgh coal feed varied a lot (from 1.88% to 4.70%; see Table 2.5). As a result, the S/C ratio in the coal feed also varied a lot (from 0.009 to 0.025 lb-mol/lb-mol); however, the estimated value of S/C in the char does not account for this fact. If another form of correlation is used as recommended in the

Figure 4.1. COMPARISON OF MEASURED AND MODEL
PREDICTED CARBON CONVERSIONS

Figure 4.2. COMPARISON OF MEASURED AND MODEL
PREDICTED AIR FEED RATES TO CARBONIZER

Figure 4.3. COMPARISON OF MEASURED AND MODEL
PREDICTED AIR-TO-COAL FEED RATIOS

Figure 4.4. COMPARISON OF MEASURED AND MODEL PREDICTED COAL NITROGEN RELEASED

**Figure 4.5. COMPARISON OF MEASURED AND MODEL
PREDICTED COAL SULFUR RELEASED**

next section, then this prediction would definitely improve. Also, the predictions are compounded by the uncertainty in the carbon conversion prediction.

Figure 4.6 shows a comparison of the measured and model predicted values of the concentration of H_2S in the carbonizer exit gas. During data reconciliation, the accuracy of the H_2S measurement was specified very high, and thus minimal adjustments were made in these values. The measured and predicted values for set point TR6-7 with the Illinois coal were 3802 and 341 ppm, respectively; this data point is off-scale and thus it is not shown in the figure. The set points, in which the absolute difference between the measured and predicted values exceeds 400 ppm, are identified in this figure. As shown in Table 4.4, the average value of the absolute difference between the predicted and measured values of the concentration is 406 ppm with a standard deviation of 610 ppm. During several set points, the measured H_2S concentrations were unusually high and inconsistent with the H_2S concentrations measured during other set points while operating under similar conditions. The operating parameters causing the high concentrations could not be identified. For example, during set points TR6-6 and TR6-7 with the Illinois coal, the bed temperatures were 1600° and 1599°F, and the carbonizer pressures were 144 and 122 psig, respectively; however, the measured H_2S concentrations were 369 and 3802 ppm, respectively. Similarly, during set points TR1-2 and TR2-1 with the Pittsburgh coal, the bed temperatures were 1681° and 1698°F, and the carbonizer pressures were 133 and 140 psig, respectively; however, the measured H_2S concentrations were 323 and 1622 ppm, respectively. If the data for set points TR6-7, TR2-1, and TR8-10 are ignored, then the absolute difference between the predicted and measured values of the H_2S concentration is reduced from 406 to 257 ppm. Figure 4.7 shows a comparison of the measured and model predicted values of the coal sulfur in the carbonizer exit gas as well as coal sulfur in the solids drains (see the scale on the right-hand side). Because most of the data for the bituminous coals are overlapping near the origin (0,0), the region in this vicinity has been expanded and presented in Figure 4.8. The data show that the average value of the absolute difference between the predicted and measured values of the parameter is 10.16% with a standard deviation of 12.47% (Table 4.4). The reasons for the large difference and a relatively high value of the standard deviation have been given above. Furthermore, the average value of the absolute difference between the predicted and measured values for the parameter is 5.48% (Table 4.1) and 21.42% (Table 4.3) for the Pittsburgh coal and Wyoming coal, respectively. The poor prediction for the Wyoming coal is because the Wyoming coal data show a lot of deviation from 100% approach to the H_2S equilibrium capture (see Figure 3.51).

Figure 4.9 shows a comparison of the measured and model predicted values of the concentration of ammonia in the carbonizer exit gas. The accuracy of the ammonia measurement was specified very high, and thus minimal adjustments were made during data reconciliation. The data show that the average value of the absolute difference between the predicted and measured values of the concentration is 747 ppm with a standard deviation of 524 ppm (Table 4.4). The measured ammonia concentrations often varied a lot during different set points, even though the operating conditions were quite similar. The operating parameters causing the variation could not be identified. For example, during set points TR2-1 and TR5-3 with the Pittsburgh coal, the bed temperatures were 1698° and 1706°F, and the carbonizer pressures were 140 and 147 psig, respectively; however, the measured ammonia concentrations were 484 and 2324 ppm, respectively. Similarly, during set points TR6-4 and TR6-5 with the Wyoming coal, the bed temperatures were 1609° and 1632°F, and the carbonizer pressures were 192 and 190 psig, respectively; however, the measured ammonia concentrations were 3078 and 1725 ppm, respectively.

Figure 4.10 shows a comparison of the measured and model predicted values of the methane yield. As shown in Table 4.4, the average value of the absolute difference between the predicted and measured

Figure 4.6. COMPARISON OF MEASURED AND MODEL PREDICTED H₂S CONCENTRATIONS IN CARBONIZER GAS

Figure 4.7. COMPARISON OF MEASURED AND MODEL PREDICTED SULFUR IN CARBONIZER GAS (Range: 0% to 100% of Coal Sulfur)

**Figure 4.8. COMPARISON OF MEASURED AND MODEL PREDICTED
SULFUR IN CARBONIZER GAS FOR BITUMINOUS COALS
(Range: 0% to 22% of Coal Sulfur)**

Figure 4.9. COMPARISON OF MEASURED AND MODEL PREDICTED AMMONIA CONCENTRATIONS IN CARBONIZER GAS

Figure 4.10. COMPARISON OF MEASURED AND MODEL PREDICTED METHANE YIELDS

values of the methane yields is 0.55% of the coal carbon with a standard deviation of 0.53% of the coal carbon.

Figure 4.11 shows a comparison of the measured and model predicted values of the ethylene yield. The average value of the absolute difference between the predicted and measured values of the ethylene yield is 0.046% of the coal carbon with a standard deviation of 0.057% of the coal carbon (Table 4.4). The data point standing by itself in the figure corresponds to set point TR2-2. The operating temperature and pressure during this set point were 1598°F and 128.3 psig, respectively, and the ethylene yield was equal to 0.642% of carbon in the coal feed. This yield is unusually high when compared to those reported for other set points operating under similar conditions.

Figure 4.12 shows a comparison of the measured and model predicted values of the ethane yield. As shown in Table 4.4, the average value of the absolute difference between the predicted and measured values of the ethane yield is 0.128% of the coal carbon with a standard deviation of 0.338% of the coal carbon. The ethane yields for the Wyoming coal show a lot of scatter with respect to the bed temperature, resulting in poor prediction for this coal. Also, during set point TR2-2, the operating temperature and pressure were 1598°F and 128.3 psig, respectively, and the ethane yield was equal to 2.136% of carbon in the coal feed. This value is extremely high when compared to those reported for other set points operating under similar conditions. (The predicted value under these conditions is only 0.15%.) This data point has not been included in the figure because it is off-scale. It has also caused a large increase in the values of the absolute difference and standard deviation reported above.

Figure 4.13 shows a comparison of the measured and model predicted values of the total hydrocarbon yields (namely, methane + ethylene + ethane). The average value of the absolute difference between the predicted and measured values of the total hydrocarbon yields is 0.62% of the coal carbon with a standard deviation of 0.61% of the coal carbon. The prediction of hydrocarbon yields (CH_4 , C_2H_4 , and C_2H_6) has been somewhat poor primarily because the measured yields show a lot of scatter (Figures 3.37 to 3.41) and therefore proper correlations could not be developed. In fact, often it has not been possible to logically explain the measured yields, thereby making it difficult to correlate them. However, for a carbonizer, it is important to be able to predict the LHV of the gas produced rather than its hydrocarbon contents; prediction of the LHV is described later.

With regard to the overall carbonizer test program, at no point were any tars or oil vapors found/condensed from the fuel gas. The tars yield predicted by the model during each of the set points is also 0.0.

Figure 4.14 shows a comparison of the measured and model predicted values of the carbonizer gas LHV in Btu/SCF (wet). As shown in Table 4.4, the average value of the absolute difference between the predicted and measured values is 4.5 Btu/SCF with a standard deviation of 4.1 Btu/SCF. Figure 4.15 shows a comparison of the measured and model predicted values of the carbonizer gas LHV in Btu/lb. The average value of the absolute difference between the predicted and measured values is 67.2 Btu/lb and its standard deviation is 63.2 Btu/lb (Table 4.4). It should be noted that the heating values are directly related to the carbon conversion, and thus any deviation in the prediction of carbon conversion affects the prediction of gas LHV as well. In Figures 4.14 and 4.15, the large difference between the measured and predicted values for several set points is because of the relatively poor carbon conversion prediction during those set points. The data in Figures 4.14 and 4.15 are about equally distributed on either side of the parity line. On an average, the predicted values are about 8% off from the measured values.

Figure 4.11. COMPARISON OF MEASURED AND MODEL PREDICTED ETHYLENE YIELDS

Figure 4.12. COMPARISON OF MEASURED AND MODEL PREDICTED ETHANE YIELDS

Figure 4.13. COMPARISON OF MEASURED AND MODEL PREDICTED TOTAL HYDROCARBON YIELDS

Figure 4.14. COMPARISON OF MEASURED AND MODEL
PREDICTED CARBONIZER GAS LHV (Btu/SCF)

Figure 4.15. COMPARISON OF MEASURED AND MODEL
PREDICTED CARBONIZER GAS LHV (Btu/lb)

During the course of data analysis, several correlations were developed which are much better than those used in the model; however, the forms of those correlations are not compatible to those used in the existing model. Due to the lack of time and funding, the computer program could not be modified to accommodate these new forms of the correlations. A summary of these new correlations is given in the next section. If the program is modified to accommodate them, then the model prediction would improve significantly. Furthermore, the carbonizer data show partial calcination of the sorbent feed, however, the present model does not allow partial calcination.

5. RECOMMENDATIONS FOR CARBONIZER MODEL IMPROVEMENT

Prior to the carbonizer pilot plant testing at FWDC, an extensive literature search was conducted, and correlations were developed for predicting yields of various species as a function of coal properties and carbonizer operating parameters. Although there were a lot of data available on the subject of pyrolysis at the time of this model development, only a small amount of this information was applicable for the type of coal processing used here. Much of the data for coal pyrolysis were obtained in a heated grid reactor where the coal was subjected to the desired temperature from a fraction of a second to about 2 seconds, usually yielding only a fraction of the pyrolysis product. On the other hand, in a fluidized-bed reactor, coal is subjected to a sufficiently long residence time (a gas residence time exceeding 5 seconds and a solids residence time of several minutes), so the maximum yield is typically obtained. The data available in this category were used to develop correlations for the coal carbonization product yields and their compositions. These correlations were developed for bituminous coals as well as for lignites to cover a wide range of feedstock properties. Based on these correlations, a computer model for the carbonizer was developed. This model could simulate a bubbling or a circulating fluidized-bed reactor with or without fines recycle in which the coal and sorbent could be introduced into the fluidized-bed region and/or into the freeboard region of the carbonizer. The details of the development of these correlations and the model have been given by Rehmat and Goyal (1987) in a DOE report.

The original FWDC carbonizer test plan called for operating the carbonizer with the Pittsburgh coal at a bed temperature of about 1500°F, with a possibility of operating up to 1600°F. The literature search was thus conducted with these operating temperatures in mind. Correlations were developed based on data primarily up to 1500°F (especially the higher hydrocarbon yields, the tars yield, and tar cracking data), with some data up to 1600°F. However, later in the program, it was decided to operate the carbonizer at a relatively higher temperature. The bed temperature ranged from 1482° to 1797°F with an average value of 1671°F and a standard deviation of 69°F for set points with the Pittsburgh bituminous coal feed. (The bed temperature for each of the set points is shown in Figure 3.1.) The original correlations cannot usually be extrapolated to these higher operating temperatures.

The data obtained in the carbonizer pilot plant were rigorously analyzed, and correlations were developed that could be used in a computer model to predict the performance of a carbonizer. During these efforts, several excellent correlations were developed, which have been discussed earlier in Section 3.1. However, many of these correlations are not in the form present in the existing model. Incorporation of these new correlations in the model would require significant changes in the existing computer code, which could not be accomplished due to the lack of time and funding. The predictive capabilities of the model can be improved significantly if the following correlations are incorporated in the model:

1. As shown earlier in Figure 3.26 in Section 3.1 (reproduced here as Figure 5.1), the carbon conversion relates very well with the ratio of oxygen in the air feed-to-carbon in the coal feed. The correlations are -

for Pittsburgh coal:

$$X_C = 151.26 R - 2.689 \quad (5.1)$$

and for Wyoming coal:

$$X_C = 193.56 R - 5.521 \quad (5.2)$$

Figure 5.1. RELATIONSHIP BETWEEN CARBON CONVERSION AND RATIO OF OXYGEN IN AIR-TO-CARBON IN COAL FEED

where -

X_C = carbon conversion in coal char, %

R = ratio of oxygen in air feed-to-carbon in coal feed, lb-mol/lb-mol

2. As shown in Figure 5.2 (discussed earlier in Section 3.1, Figure 3.28), the coal nitrogen released relates very well with the carbon conversion. The correlations are -

for Pittsburgh coal:

$$X_N = 1.3378 X_C - 9.507 \quad (5.3)$$

for Illinois coal:

$$X_N = 1.8404 X_C - 24.601 \quad (5.4)$$

and for Wyoming coal:

$$X_N = 1.9110 X_C - 63.514 \quad (5.5)$$

where -

X_N = coal nitrogen released, %

X_C = carbon conversion, %

The carbon conversion can be calculated using equation 5.1 for the Pittsburgh or Illinois coal, or using equation 5.2 for the Wyoming coal.

3. As shown earlier in Figure 3.31 in Section 3.1 (reproduced here as Figure 5.3), the coal sulfur released relates better with the carbon conversion. Although the relationships shown in Figure 5.3 are not as good as desired (reasons given in Section 3.1), they are still an improvement over those used in the model. The correlations are -

for Pittsburgh coal:

$$X_S = 1.4423 X_C + 6.428 \quad (5.6)$$

and for Wyoming coal:

$$X_S = 2.5501 X_C - 124.24 \quad (5.7)$$

where -

X_S = coal sulfur released, %

X_C = carbon conversion, %

The carbon conversion can be calculated using equation 5.1 for the Pittsburgh or Illinois coal, or using equation 5.2 for the Wyoming coal.

Figure 5.2. RELATIONSHIP BETWEEN COAL NITROGEN RELEASED AND CARBON CONVERSION

Figure 5.3. RELATIONSHIP BETWEEN COAL SULFUR RELEASED AND CARBON CONVERSION

4. As shown in Figure 5.4 (discussed earlier in Section 3.1, Figure 3.35), the coal hydrogen released relates very well with the carbon conversion. The correlations are -

for Pittsburgh coal:

$$X_H = 0.12679 X_C + 88.339 \quad (5.8)$$

and for Wyoming coal:

$$X_H = 0.13043 X_C + 87.261 \quad (5.9)$$

where -

X_H = coal hydrogen released, %

X_C = carbon conversion, %

The carbon conversion can be calculated using equation 5.1 for the Pittsburgh or Illinois coal, or using equation 5.2 for the Wyoming coal.

5. As discussed earlier in Section 3.1, Figure 3.48, the calcination status of CaCO_3 in the sorbent feed could neither be predicted from the Squires correlation nor could an appropriate correlation be developed. This subject needs to be explored further, and an improved correlation needs to be developed.

Figure 5.4. RELATIONSHIP BETWEEN COAL HYDROGEN RELEASED AND CARBON CONVERSION

Section 6

CERAMIC BARRIER FILTER

6.1 Cross-Flow Elements

The ceramic cross-flow filter was supplied by W-STC. As shown in Figures 6.1 and 6.2, it consisted of 20 cross-flow elements contained in a 50-in. O.D. by 17 ft-2 in. tall refractory-lined vessel. Each cross-flow element was 12 in. high x 12 in. wide x 4 in. thick, and they were provided in two groupings of five elements on two parallel plenum pipes that hung from a tubesheet. Process gas entered the vessel tangentially and flowed primarily over the top of a cylindered shroud that protected the elements from direct impingement and promoted general downflow over the elements. Filter cake blown off of the elements during pulse cleaning with nitrogen fell to the base of the unit and drained by gravity through a 6-in. Sch 40 outlet. After passing through the elements, the cleaned gas flowed to the top of the unit, collected in the top head plenum, and exited through a 5-in.-I.D. radial outlet.

The cross-flow filter test program involved two test runs (TR-7 and TR-8) during which a total of 171 hours of operating time was accumulated with three coals and two sorbents.

The nominal gas flow through the cross-flow filter was 100 acfm, with the maximum fuel gas temperature in the filter vessel being about 1500°F. the dust loading in the fuel gas was 5,000 to 35,000 ppmw. The objectives of carbonizer cross-flow filter testing are described as follows:

- Demonstrate short-term durability and operability of the cross-flow filter components over a broad range of carbonizer conditions.
- Demonstrate short-term ability to effectively clean the cross-flow filter elements over a broad range of carbonizer conditions.
- Characterize, for each carbonizer condition, the representative filter vessel pressure drop and pulse cleaning frequency behavior.

The cross-flow filter control and operating strategy for the carbonizer test campaign was established prior to testing. The carbonizer test matrix and the required response to various filter performance conditions were factored into the strategy. Filter cleaning was set on a pressure drop mode (DP-mode) and activated by computer control when the ash cake pressure drop reached 7.5 in H₂O above the filter baseline. Cleaning was programmed to switch to a timer mode if the pulse frequency during DP-mode became greater than about once every 5 minutes.

Figure 6.1 Cross-Flow Filter—General Arrangement

The process data recorded by W-STC instrumentation during the filter test include the following:

- Filter tubesheet pressure drop
- Educator pressure drop in each plenum
- Gas temperature in filter vessel (dirty and clean sides)
- Tubesheet temperatures
- Filter element temperatures (4 points)
- Pulse tank pressure change during pulse
- Overpressure in each plenum during cleaning

FWDC instrumentation also provided applicable data that include:

- Total filter vessel pressure drop
- Total gas volumetric and mass flow rate to the filter
- Weight of particulate removed from the filter drain lock hopper (periodic)
- Status of carbonizer conditions and operation
- Inlet dust loading samples
- Outlet dust loading samples
- On-line opacity meter
- Baghouse pressure drop and pulse frequency

Using these data, the following on-line filter condition and performance estimates can be made:

- Face velocity
- Inlet dust loading
- Outlet dust loading
- Filter element permeability
- Cake permeability and cake thickness
- Flow uniformity through the two plenums, and possible leak indication
- Pulse gas delivery
- Pulse intensity and valve open time

Figure 6.2 Cross-Flow Elements

The first hot test of the cross-flow filter (TR-7) began on May 26, 1992; Eagle Butte coal and Longview limestone were the carbonizer feedstocks. Filter pulse cleaning was initiated after completing system preheat, establishment of the carbonizer sorbent bed, ignition with coke, and transition to Eagle Butte coal. Operation continued for approximately 40 hours when a build-up of system pressure indicated a possible pluggage of the downstream choked flow orifice. During this period, the filter operated within predicted parameters exhibiting low pressure drop (13 to 20 in. H₂O) and very stable pulse cleaning (10- to 20-minute cycles).

Following cooldown, the filter elements and dust seals were thoroughly inspected. They were found to be in excellent condition and dust free on the clean side of the filter mounts. The filter cake on the cross-flow elements was found to be soft and loose, with no indication of crust or deposits that would be indicative of condensed tars. Also, there was no fly ash accumulation within the filter shroud, and all of the metal components of the filter internals were in excellent condition.

Inspection of the downstream choked flow orifice confirmed a pluggage that was caused by a section of blanket refractory blown loose from the filter

tubesheet insulation because of a misaligned pulse nozzle. Apparently, the misaligned nozzle did not significantly degrade pulse cleaning of the filters. Following modifications to prevent nozzle misalignment and eroding of the refractory blanket, the filter unit was reassembled and readied for further operation.

Following the repair of the cross-flow filter, Test Run 8 was started on June 8. During the testing, several setpoints were completed with Wyoming Eagle Butte coal, Illinois No. 6 coal, and Pittsburgh No. 8 coal. The filter pressure drops were low again (8 to 20 in. H₂O), pulse-cleaning frequency was at 6- to 50-min intervals, and the filter cake was easily cleaned during the testing, even at dust loadings estimated to be as high as about 35,000 ppm(w). This is a very significant test result, leading to expectations of very effective commercial performance of the carbonizer-filter system. Plant baghouse dust removal, monitoring, isokinetic particle sampling of the fuel gas particulate content, and the clean condition of fuel gas samples withdrawn downstream of the filter indicated that the filter particle-removal performance was very good. After about 100 hours of testing, filter performance data began to indicate a possible leak. Figure 6.3 shows the volumetric gas flow through each of the two cross-flow filter plenums and the divergence of these two flows, with the Plenum 1 flow dropping to near zero, indicating a leak had developed. Carbonizer testing was continued even after it was clear that a significant leak existed somewhere in the filter. The carbonizer test matrix was completed on June 17. The cross-flow filter conditions and performance are summarized in Table 6.1 for the six setpoints recorded during TR-8.

Preliminary inspection of the filter internals after system cooling and removal of the head and internals revealed the following:

- Some of the filter holddown clamps had come loose.
- On five of the mounts, the ceramic gaskets were displaced, bulging on one end and causing a gas path leak.
- On one filter at the bottom of the plenum, the flange compression bars had dropped off the flange; the ceramic gasket and pads were missing from the mount, and the filter flange was broken.
- One other filter element showed evidence of a possible delamination crack.
- No other filters appeared damaged.
- The lowest filter element on each of the two plenums appeared considerably cleaner than the filter elements at higher positions.

The permeability of some of the undamaged cross-flow filter elements was measured after cleaning. A comparison of the new and used cross-flow filter element pressure drops (Figure 6.4) shows that the ratio of the permeability of

Figure 6.3 Gas Flow Through Filter Plenums

Table 6.1 Summary of TR-8 Cross-Flow Filter Conditions and Performance

Conditions	Wyoming Eagle Butte			Illinois No. 6		Pitts- burgh No. 8
Setpoint	1	2	3	4	5	6
Setpoint Duration (h)	5	5	20	5	30	7
Carbonizer Temp. (°F)	1500	1600	1600	1600	1700	1700
Filter Temp. (°F)	1100	1200	1250	1300	1450	1460
Inlet Dust Loading [ppm(w)]	8,420*	3,460*	28,010*	5,692*	26,982 [†]	5,681 [†]
Outlet Loading [ppm(w)]	2 [†]	0 [†]	---	0 [†]	982 [§]	831 [†]
Tubesheet ΔP (in. H ₂ O) [¶]	8	8	9	12	13/18	12
Trigger ΔP (in. H ₂ O)	17	17	18	18	20	20
Pulse cycle time (min)	30	50	20	8	8	240
*Based on filter hopper material collection [†] Based on single alkali probe collection (non-isokinetic) [§] Based on isokinetic particle probe sample (after leak initiation) [¶] 3 to 4 in. H ₂ O pressure loss caused by educator.

Figure 6.4 Comparison of Cross-Flow Permeability

a conditioned filter to a new filter is about 0.2, typical of testing in other field and in-house units. The range of cross-flow filter element pressure drops measured at the nominal face velocity of 1.8 ft/min. during the FWDC carbonizer tests is also superimposed on the figure, after adjustment to low-temperature conditions. This range falls directly on the pressure drop measured for the cleaned, used filter elements, indicating that the pulse cleaning in the FWDC carbonizer filter tests had been very effective.

The carbonizer fines collected in the cross-flow filter showed low flow resistance and appear to be easily cleaned without reentrainment. The baseline pressure drop of 8 to 12 in. H_2O with a nominal pulse cycle of 6 to 50 min is attractive compared with the Texaco entrained gasifier filter performance of 100 to 200 in. H_2O baseline pressure drop with a nominal pulse cycle time of 1 to 3 min. The filter process data (pressure drop record and estimated dust loading) was used to estimate the permeability of the filter cakes generated from the carbonizer fly ash. The Wyoming Eagle Butte operation at an 1100 to 1250°F filter temperature gave a filter cake resistance (inverse of permeability) of from 3×10^{11} to 16×10^{11} ft⁻². These filter cake resistances are 16 to 20 times lower than those measured in previous gasifier filter tests (fluidized bed and entrained) and about 4 times higher than the resistance of circulating PFBC filter cakes.

The carbonizer filter was also pulse cleaned, with pulse intensity much lower than that needed in earlier gasifier testing and only slightly more intense than that used in circulating PFBC filter testing. The data also indicated that there were no signs of re-entrainment of dust in the filter.

Ash Characterization

Southern Research Institute (SRI) completed characterization of two samples of fly ash obtained from the first FWDC carbonizer test series completed prior to installation of the cross-flow filter. One sample was taken from the secondary cyclone catch and the other from the baghouse catch; the cross-flow filter will see a combination of these two fly ashes. A listing of the properties determined by SRI is given in Table 6.2. While SRI concluded that these fly ashes were not as cohesive as many they have characterized, this does not provide a clear basis to judge material.

Table 6.2 Carbonizer Fly Ash Physical Properties (SRI)

Description	Cyclone Ash	Baghouse Ash
Aerodynamic mean diameter, μm	20	---
Volumetric mean diameter, μm	9.5	7.3
True particle density, g/cm^3	2.03	1.96
Compacted bulk porosity, percent	77	66
Estimated dust cake porosity, percent	89	80
Specific surface area, m^2/g	6.8	4.1
Morphology factor	22	9.5
Drag-equivalent diameter, μm	1.30	0.97
Tensile strength, Nt/m^2	0.3	1.1
Relative gas flow resistance, in H_2O -min-ft/lb	2.3	12

W-STC has previously explored the use of a simple tap density test as a means to judge the cohesive nature of powders; this test was applied to several filter fly ashes to provide a database for comparison. In this test, the fly ash is initially loosely packed in a column, followed by mechanical tapping, with the bulk density determined periodically. The ratio of the tap density to the initial loose-packed density is plotted as a function of the number of taps. The general guideline is that if this ratio exceeds 1.4 within 100 taps, the powder can be classified as cohesive. The technique is highly reproducible and simple. The results are shown in Figure 6.5 for (1) an entrained gasifier fly ash, (2) a very non-cohesive fly ash suspected of being reentrained during filter testing, (3) a Grimethorpe PFBC fly ash known to be a very cohesive fly ash and found to be difficult to pulse clean in filter testing, and (4) the two carbonizer fly ashes. The carbonizer fly ashes fall intermediate to the two extremes represented by the entrained gasifier and the PFBC Grimethorpe fly ashes. Other fly ashes having tap-density ratio intermediate to these two have been relatively easily cleaned with little reentrainment. The cyclone catch meets the criteria for a cohesive powder, while the baghouse fly ash becomes cohesive after some consolidation. This cohesive behavior may promote good filter performance, indicating that the filter cake may be relatively easily pulse cleaned with relatively little reentrainment. Other factors, such as the fly ash acid/base characteristics may also need to be considered in this simplified correlation.

There was no dust measured in the filter system gas outlet until after 100 hours of operation, when the filter gasket problems emerged. Thus, the performance of the cross-flow filter with the carbonizer fly ash was very good and is promising for commercial operation.

Examination of the cross-flow filter elements also showed that carbon was deposited on the clean and dirty sides of the filter channels as well as throughout the pores, but this carbon layer had no influence on the filter permeability. We do not know when this carbon deposition occurred during the testing.

Figure 6.5 Dependence of Tap/Bulk Density Ratio on Number of Taps

The conclusion reached after evaluating the filter element clamping incident is that the use of Haynes 556 bolts with a Type 316SS post increased bolt stressing but was not a contributing factor to the gasket loss because of the relatively low filter temperature (1100 to 1450°F). The problem arose because the gaskets were not properly fabricated; the thickness of the two short sides was not uniform, thus preventing uniform loading when the filter elements were installed. Also, the gaskets were not fully captured by the plenum structure.

Such an occurrence should be eliminated by using new, properly fabricated gaskets and by modifying the recess in the existing mounts so that the gasket will be captured/contained. Other modifications to the filter element installation procedure have been identified that will ensure proper gasket integrity.

Ceramic Candle Filter

Upon completion of Test Run 8, the cross-flow filter assembly was removed from the filter vessel and replaced with a 22-candle filter assembly. The assembly consisted of two 180° modules that hung from the tubesheet, and each contained eleven 2.36-in. O.D. by 59-in. long Schumacher candles. The candle pattern is shown in plain view in Figure 6.6, and Figure 6.7 depicts the overall vessel arrangement. As with the cross-flow filter arrangement, process gas entered the vessel tangentially and flowed primarily over the top of a cylindered shroud that protected the candles from direct impingement and promoted general downflow over the candles. Filter cake blown off the candles during pulse cleaning with nitrogen fell to the base of the unit and drained by gravity through a 6-in. Sch 40 outlet. After passing through the candles, the cleaned gas flowed to the top of the unit, collected in the top head plenum, and exited through a 5-in.-I.D. radial outlet.

Figure 6.6 Candle Filter Arrangement—Plan View

While candle filter installation was underway, FWDC converted the carbonizer from a jetting fluidized bed to a circulating fluidized bed configuration. Test Run 9 was the first attempt by FWDC to operate the carbonizer in a circulating bed mode. The main objective was to explore the feasibility of circulating carbonizer operation and to determine if it offered any obvious/significant performance advantages over jetting fluidized bed operation. The conditions to be faced by the candle filter were uncertain with respect to dust loading and the nature of the fly ash. The nominal conditions of the test were:

System pressure:	95 psia
Filter temperature:	1500°F
Fuel gas flow:	250 $\text{aft}^3/\text{min.}$
Filter face velocity:	3.8 ft./min.

TR-9 began with coke ignition at about 1700 hours on August 25. At this point in time, the filter temperature was 600°F. Coal feeding began at about 0300 on August 26, establishing a filter outlet temperature of about 1440°F by 0600. The pressure differential existing across the candle filter tubesheet during the first 12 hours of TR-9 is plotted in Figure 6.8. Based on earlier cross-flow filter tests, initial operation of the candle filter appeared normal with a baseline pressure drop of about 20 in. H_2O . After coal feeding began and flow rates were increased, both the pulse cleaning frequency and the baseline pressure drop began to increase, as is expected with the concomitant rise in dust loading. Dust loadings were high—at least 50,000 ppm(w). The pulse period approached about 5 min. between 0630 and 0830 and then became short enough that the trigger pressure drop was increased, as well as the pulse reservoir pressure (from 300 to 500 psig). Contrary to expectations, this increase in trigger pressure drop did not result in a longer pulse period (time between pulses) even though pulse delivery increased from about 0.5- to 1.0-lb. gas/pulse. At about 1000, after about 7 hours of operation with coal, the vent line of the candle filter lock hopper plugged, and the vessel could not be drained for about 5 hours. After the hopper drain problem was recognized, the feed rates of coal, sorbent, and air to the carbonizer were slowed and eventually stopped. While efforts were made to clear the line, Nitrogen purges remained in the carbonizer and cooled the candle filter at about 200°F/h. After clearing the lock hopper vent line, 1423 lbs. of solids were drained from the hopper using the filter vessel spargers to assist in solids removal.

FWDC measured the bulk density of the 1423 lbs. of solids drained (about 44.5 lb./ft.^3) from the filter vessel and estimated that the accumulation of solids in the filter vessel may have submerged the lower 31 in. of the candles. Of course, the solids level profile within the filter vessel is unknown, but subsequent inspection of the filter internals indicated a fill depth based on the patterns on the candles that confirms this estimate.

The system underwent a "hot" restart at about 1930. While waiting for the establishment of Setpoint 1 test conditions, a baghouse leak developed that forced the shutdown of the carbonizer pilot plant at about 2300 on August 26.

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99	FLANGE	1/2" X 1/2" X 1/2"	1
100	FLANGE	1/2" X 1/2" X 1/2"	1

INSULATING CASTABLE LINING

INSULATING CASTABLE LINING

6.25 IN X 9.75 IN

MAKE FROM .254 THE SET 3K

10.25 IN X 6.25 IN

MAKE TRANSITION PIECE FROM .254 THE SET 3K

16.25

34.00

6.00 DIA. LD.

205.28

INSULATING CASTABLE LINING

BREAKDOWN OF WEIGHTS
(INCL. OF CASTABLE LINING)

VESSEL TOP ENCLOSURE - 2000 LBS

VESSEL BOTTOM SECTION - 2000 LBS

ASSEMBLED TUBESHEET
(WITH 16 ELEMENTS) 3000 LBS

VESSEL LUBE CAN CARRY TOTAL LOAD OF
VESSEL, INCLUSIVE OF ALL INTERNALS

1. DESIGN CONDITIONS 770 PSIG
2. DESIGN TEMPERATURE 150° F / MIN - 350° F / 20° F
3. CONSTRUCTION FRICTION WELDED - DYE PENETRAANT TEST
4. ROOT PASS AND FILL PASS
5. CODE REQUIREMENTS - ASME SECT VIII
6. WELDS QUALIFIED PER ASME CODE SECT IX
7. TESTING - PER CODE
8. STAMPING - PER CODE
9. COMMISSION ALLIANCE - 1025 INCH
10. HYDROTEST WITH TUBE SHEET IN PLACE
11. HYDROSTATIC TEST PRESSURE - 470 PSIG @ 150° F

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Figure 6.8 Candle Filter Tubesheet Pressure Differential During TR-9

After cooldown of the pilot plant, inspections revealed soft insulation and coal char on the screen that protects the choked-flow orifice. Since this is indicative of a filter leak, the vessel was opened. One broken candle, found in Plenum 1, was broken 15 in. below its flanged end. This was candle C-6, at Location 1-11 (see Figure 6.6). The broken piece was found in the hopper. The candle was replaced, and the other candles were visually inspected, checked for tightness in their holders, and found undamaged. Preliminary inspection of the broken candle showed that the break occurred near a "fill line" in the candle, a line formed during manufacture. It is speculation to assert that this resulted in the break. Review of the filter plenum flow data collected during the last half of August 26 is shown in Figure 6.9. The two plenum flow rates, reported as face velocities on each plenum, are shown as a function of time. The two plenum flows are identical until about 1930, during the restart of the test. At this time the plenum flows diverged, with the flow in Plenum 1 rising and the flow through Plenum 2 falling significantly. This is believed to be when the candle broke.

With regard to the increase in pressure differential shown in Figure 6.8, this may be attributed to the filling of the filter vessel with ash (hopper drain bridged/blocked) rather than to the ramping of flow rates. Since problems began after transitioning to coal feed, FWDC speculates that a sticky ash condition may have developed that caused solids to accumulate in the filter vessel and eventually block the vent line of the drain lock hopper below it. Since a sticky ash condition had not been experienced in previous start-ups, the carbonizer solids circulation rate is suspected as having been too low when coal feed began (the mass of hot solids circulating through the carbonizer was not large enough to heat the highly-caking Pittsburgh No. 8 coal through its sticky regime before particulate escaped to the barrier filter).

After locating and plugging the leaking bag in the baghouse filter and completing the inspections and repair of the candle filter, TR-10 was begun.

Preheat of the carbonizer for TR-10 was initiated on August 30. Coke feed was started at about 2145. Prior to coke feeding, the filter established a 20-in. H_2O baseline pressure drop and was pulse cleaned three times over about a 4-hour period at a 50-in. H_2O trigger pressure drop. During coke feeding, the rate of rise of the filter pressure drop indicated the possibility of broken candle elements. Based on the plenum flow measurements, the investigators guessed that at least one filter had broken on Plenum 1, and this could have occurred as early as 1330 on August 31, during the systems preheat and at the very first pulse cleaning event. Operation of the carbonizer continued through September 3, for a total of about 50 hours, with the filter maintaining a pressure drop, but with very infrequent pulse cleaning. Following termination of TR-10 and system cooling, the filter vessel was opened for inspection. The following observations were made:

- The pulse tubes were aligned and not bent.

Figure 6.9 Candle Filter Face Velocities During TR-9

- The tubesheet was loaded with dust up to the top of the expansion web (about 11 in. high).
- The "high side" pressure tap used to measure Plenum 1 flow was broken (eroded). The Plenum 2 tap was intact.
- Ash was tightly packed (bridged) between the candle elements and over their full lengths (except the lower few inches), forming a cylindrical cast. This ash was crusty and had to be physically removed.
- The filter vessel hopper bottom/cone was filled with ash.
- Of the 11 candles on Plenum 1, 7 were broken at the tips (3 to 5 in. from the bottom). The broken candles were at positions 1-7, 1-6, 1-5, 1-3, 1-2, 1-8, and 1-9 on Figure 6.6.
- After cleaning the bridged dust from the candles, the candle assembly was lifted out of the vessel. At this point, one filter on Plenum 2 (at location 2-2 on Figure 6.6) broke off.
- Significant dust was found within all of the candles, broken and unbroken, on both plenums.
- Filling of the filter vessel with ash, as experienced in TR-9, should be prevented. Long-term operation of the filter with no pulse cleaning, as experienced in TR-10, should not be allowed.
- The fact that all of the candle failures occurred on one plenum indicates that the failures were related to various system conditions and were not caused by filter candle properties.
- The conditions that the candle filter was subjected to after the TR-10 broken-candle event were far from design conditions [that is, the dust loading ranged from 50,000 to 200,000 ppm(w)].

Conclusions

Although ceramic filter operating times were relatively short, all collected data and inspections indicate both cross-flow and candle type elements should be acceptable particle filtering devices for carbonizer fuel gases. Additional conclusions include the following:

- There were no indication of tars, carbon deposition plugging, or other deposits on any of the elements.
- Overall, carbonizer fuel gas filtration should be effective and reliable.

- Carbonizer char-sorbent residue shows high permeability relative to other coal-gasifier fly ashes.
- Good pulse cleaning performance was obtained.
- Filter performance parameters fell within projected range.
- There was no indication of ash reentrainment.
- The filter was tolerant of high (variable) inlet dust loadings.

7. Alkali and Isokinetic Particle Sampling:

The alkali content of the carbonizer fuel gas was measured in test runs TR-8 and TR-10. The measurements were taken via probes supplied by W-STC (see Figure 7.1). The probe draws a non-isokinetic sample through a high-temperature filter provided in the tip of the probe for removal of particles, but not alkali vapors. The gas then passes into the cooling section to condense and collect alkalies. Cooling is achieved as a continuous supply of high-pressure gas flows into the concentric tube assembly in the center. The sample gas passes through the outer annulus and cools; vapor condenses on the walls.

After a sufficient sampling time, the entire probe is withdrawn through a double block-and-bleed-valve arrangement. Alkali compounds are collected from the cooling section using a rinse-and-recovery approach. Solid-phase alkalies are extracted from the particle filter. The alkali compounds were characterized to identify water-soluble, acid-soluble, and insoluble components. On-site analysis at FWDC's laboratories were completed by selective-ion electrodes, atomic absorption, or inductively coupled plasma spectroscopy.

Particle sampling measurements were made with the alkali gas sampling probes fitted with a tip specifically designed for isokinetic sampling. The gas sampling locations used for alkali and particle measurements are shown in Figure 7.2

During the test runs, the FWDC test facility was operated over a broad range of operating conditions with several feedstocks. The carbonizer was fed Pittsburgh No. 8 coal during most of the testing, with Plum Run dolomite and GenStar limestone as the primary sulfur sorbents tested. Limited testing was also conducted using Eagle Butte subbituminous coal and Illinois No. 6 coal, both with Longview limestone as the sulfur sorbent. The carbonizer pressure ranged from 56 to 170 psia during the testing, with mid-bed carbonizer temperatures ranging from 1470 to 1720°F. During TR-8, the carbonizer was operated as a jetting fluidized bed carbonizer. During TR-10, the carbonizer was operated as a circulating fluidized bed carbonizer.

Two alkali sampling probes were inserted into the carbonizer fuel gas, one between the primary cyclone and the ceramic barrier filter vessel (Probe A) and the other downstream of the filter vessel (Probe B). The probes were batch sampling devices consisting of a hot filter thimble to remove solids carried by the fuel gas and a gas-cooled cold finger to condense all alkali vapors contained in the fuel gas. Each probe was withdrawn, on line, for analysis after a measured amount of gas had passed through the probe. After it was cleaned, the probe was reinserted for continued sampling. The components of the probe that were analyzed for water-soluble and water-insoluble sodium and potassium species were the collected solids, the thimble, and the cold finger.

Ten steady-state setpoints were established during TR-8 and four during TR-10. During TR-8, 22 alkali samples were withdrawn and analyzed; during TR-10, there were 15. Only four of the samples taken at the barrier filter outlet, with Probe B, were collected during periods when the ceramic barrier filter was functioning normally, so significant particulate loadings were present in most

Figure 7.2 Alkali and Particle Sampling Measurement Locations

A. PITTSBURGH VALVE & FTG. CO.
49 MEADE AVE. P.O. BOX 4155
PITTSBURGH PA. 15202

B. REID TOOL SUPPLY
2265 BLACK CREEK RD.
MUSKEGON, MICHIGAN 49444

C. FRICK & LINDSAY CO.
NEVILLE ISLAND-PGH., PA. 15225

D. SAGINAW STEERING GEAR DIV.
SAGINAW, MICHIGAN 48605

E. LEE SPRING CO.
30 MAIN STREET
BROOKLYN, N.Y. 11201

TITLE ALKALI PROBE ASSEMBLY					
DWG 648CE15 REV 2					
ITEM	DESCRIPTION	UNIT	SIZE	REFERENCE	NOTES
01	PROBE ASST	DWG			202889000
02	BASE	DWG			202889001
03	SIDE RAIL	DWG			202889004
04	SIDE RAIL	DWG			202889002
05	HSG	DWG			202889003
06	BRAKE	DWG			202889004
07	PLATE	DWG			202889005
08	DISC	DWG			202889006
09	HAND E	DWG			202889007
10	BRKT	DWG			202889008
11	BRKT	DWG			202889009
12	BRAKE BASE	DWG			202889010
13	SCREW	DWG			202889011
14	REAR STOP	DWG			202889012
15	FRONT STOP	DWG			202889013
16	BUSHING	DWG			202889014

ITEM	NO.	PART NAME	REF	SIZE REFERENCE INFORMATION	QTY. ASSY EXP. PARTS LIST OR REF. QTY.	REF. QTY.	QTY. ASSY EXP. PARTS LIST OR REF. QTY.	QTY. ASSY EXP. PARTS LIST OR REF. QTY.	QTY. ASSY EXP. PARTS LIST OR REF. QTY.
17		CLAMP	DWG		202885H01	1			
18		BASE	DWG		202885H07	1			
19		STOP HSG	DWG		202885H04	2			
20		STOP	DWG		202885H03	2			
21A		WAVE CONNECTOR	BOS	*SS-1610-1-12		1			
22A		CROSS	BOS	CAJON *SS-12-C5		1			
23A		WAVE CONNECTOR	BOS	CAJON *SS-12-RB-8		2			
24A		WAVE FLANG	BOS	*SS-810-2-8		1			
25A		WAVE CONNECTOR	BOS	CAJON *SS-12-RB-6		1			
26A		WAVE CONNECTOR	BOS	*SS-600-1-6-BT		1			
27A		WAVE RH RTIR	BOS	*SS-600-3TFT		1			
28A		WAVE CONNECTOR	BOS	*SS-200-1-4-BT		1			
29A		UNION	BOS	*SS-200-6		1			
30		CRANK	DWG		202885H07	1			
31		ANGLE DRIVE	BOS	RA1532		1			
32		BALL NUT	BOS	*5703041		1			
33		SCREW		.375-16 X 1.00 LG. 50C HD. CAP SCR.		43			
34		SCREW		.250-20 X .75 LG. 50C HD. CAP SCR.		21			
35		SCREW		.250-20 X 1.00 LG. 50C HD. CAP SCR.		6			
36		SPRING	BOS	*LC-095L-00		3			
37		HANDLE	DWG		202885H07	1			
38		SEAL SPRT	DWG		7213C24G01	1			
39		BASE ADAPTER	DWG		202885H01	1			
40		KEY		.187 50. X 1.50 LG.		1			
41		KEY		.187 50. X 3.00 LG.		1			
42		COUPLING		CS12K		1

Figure 7.1 Westinghouse Alkali Probe

of the samples collected—even at the location downstream of the filter vessel. Three of the Probe B samples were taken with no filter thimble in place during the low dust loading test periods. The alkali sampling probe was normally operated with its sampling tip directed downstream to minimize the collection of particulate. The alkali probes were also used for particle sampling by changing the sampling tip to one capable of isokinetic gas sampling. Isokinetic particle sampling was performed during three of the sampling points in TR-10, all with Probe B, yielding alkali vapor data as well.

Data produced during the testing included analyses of the alkali content of the coals and sulfur sorbents fed during the tests. Samples of solids drained from the carbonizer, the primary cyclone, the barrier filter, and the baghouse were also collected and analyzed for alkali content during some of the test runs.

The testing revealed the following trends:

- The coal/sorbent water-soluble alkali content generally decreased as the series of tests progressed.
- The carbonizer temperature and probe temperatures tended to increase over the series of tests.
- The probe pressure varied from 112 to 168 psig during TR-8 and was significantly lower (52 to 120 psig) during TR-10.
- Probe A was estimated to be about 100 to 200°F cooler than the carbonizer freeboard temperature.
- Probe B was 100 to 200°F cooler than Probe A.
- Except during the early testing in TR-8, when the cross-flow filter was not leaking dust, the Probe A and Probe B sample gas particulate loadings were very similar.
- Except during the early testing in TR-8, the Probe A and Probe B collected solids had very similar water-soluble and water-insoluble alkali contents at each setpoint.
- The alkali content of the probe-collected solids fluctuated around levels that were consistent with the feedstock compositions and the process solids compositions.
- Except during the early testing in TR-8, the Probe A and Probe B measured fuel gas alkali vapor contents were very similar at each setpoint, showing less temperature sensitivity than expected.
- The relative distribution of water-soluble alkali in probe samples was generally (but not always) dominated by the collected solids, relative to the thimble and cold finger:

Water-Soluble Alkali	Sodium (percent)		Potassium (percent)	
	TR-8	TR-10	TR-8	TR-10
Collected Solids	79 - 98.2	7 - 97.4	76 - 97.9	16 - 97.6
Thimble	4 - 1.3	16 - 2.2	14 - 1.7	14 - 2.0
Cold Finger	17 - 0.5	77 - 0.4	10 - 0.4	70 - 0.4

- The range of measured fuel gas alkali vapor content, based on the sum of the thimble and cold finger water-soluble alkali, was:

Sodium, ppb(w)	2 - 448
Potassium, ppb(w)	0.7 - 187
Total, ppb(w)	3 - 487

Figure 7.3 shows the measured fuel gas sodium vapor content as a function of the setpoint number, and Figure 7.4 shows the fuel gas potassium vapor content. The figures give the probe location (A or B) and coal/sorbent feedstock used.

Probe gas temperatures were estimated based on thermocouples located upstream and downstream of each probe (see Figure 7.5). The upperstream thermocouple was located 6.1 ft. above Probe A, whereas, the downstream thermocouples was 9.8 ft. downstream of Probe B; filter inlet and outlet temperatures were determined by thermocouples located in the filter vessel itself in the dirty gas annulus and in the clean gas outlet plenum atop the unit.

- The fuel gas alkali vapor contents tended to be greater when sampling isokinetically, although not enough data were available to confirm this trend conclusively.
- The measured fuel gas alkali vapor content was much lower than equilibrium estimates in the absence of alkali capture by active coal ash and sulfur sorbent components (alumina and silica-based components).
- The alkali sampling data trends were similar to probe data trends from earlier Westinghouse gasifier sampling data, but the alkali levels were much lower and showed less sensitivity to temperature than in the Westinghouse gasifier tests. We attribute this primarily to operating the Westinghouse gasifier without sulfur sorbents whereas the carbonizer utilized sulfur sorbents.

Sodium Vapor (ppmw)

Figure 7.3 Measured Fuel Gas Sodium Vapor

Potassium Vapor (ppmw)

Figure 7.4 Measured Fuel Gas Potassium Vapor

Figure 7.5 Alkali Probe Temperature

The conclusions reached are listed below:

- The alkali probe did not make direct measurements of the fuel gas alkali content at the carbonizer freeboard conditions, but the measurements can be used as an indicator of fuel gas alkali-removal needs. Although the measurements are uncertain in many aspects, the level of uncertainty should not change the overall alkali conclusions.
- The fuel gas alkali contents should have included insoluble alkali collected in the thimble and cold finger, and these were observed to be present in the one probe sample that was analyzed for them.
- There is no indication that the ceramic barrier filter elements removed significant alkali.
- There is clear indication that the coal ash and sulfur sorbent acted as alkali sorbents consistent with prior estimates and experience; they retained 90 to 99.99 percent of the water-soluble alkali that would otherwise be released.
- Alkali retention, as a percentage of the equilibrium alkali content of the fuel gas, was correlated as a function of temperature for the various feedstocks tested. The correlations are shown in Figures 7.6 and 7.7 for sodium vapor and potassium vapor. The Pittsburgh No. 8 coal and Plum Run dolomite had the greatest alkali retention; the other feedstocks were comparable in their retention capability.
- Commercially, for Pittsburgh No. 8 coal and Plum Run dolomite, acceptable alkali content for the carbonizer fuel gas is about 0.46 ppm(w), resulting in 50 ppb(v) in the expansion gas if no alkali is emitted from the CPFBC. The acceptable alkali level in the fuel gas is about 0.057 ppm(w) at expected levels of alkali release from the CPFBC.
- Commercially, for Pittsburgh No. 8 coal and Plum Run dolomite, at carbonizer freeboard temperatures of 1600 to 1700°F, the total alkali vapor content in the fuel gas is expected to be about 0.65 to 1.2 ppm(w). Estimates made for the Wilsonville Power Systems Development Facility carbonizer resulted in higher total alkali because of the Illinois No. 6 feedstock. These estimates are shown in Figure 7.8.
- Commercially, alkali control is expected to be required unless the carbonizer fuel gas temperature is cooled to below 1300°F.

Sodium Retention (%)

Figure 7.6 Sodium Vapor Retention (Percentage of Equilibrium Vapor Content)

Figure 7.7 Potassium Vapor Retention (Percentage of Equilibrium Vapor Content)

Figure 7.8 Commercial and Wilsonville Plants—Total Alkali in Fuel Gas

- The commercial carbonizer alkali vapor content estimated in this evaluation is less than originally assumed in the 1987 Phase 1 commercial plant design study, and the degree of removal required is also less; 30 to 93 percent is the range required. This projection is shown in Figure 7.9. The alkali-removal vessels will be smaller and will operate for longer than indicated in the Phase 1 study.

In future alkali probe sampling, we recommend the following:

- The probe temperature is measured directly, at least at a point in the piping near the probe, but with the thimble temperature at the best location.
- The gas exiting the probe can be passed through a bubbler; analyses of the solution would then confirm that no alkali had escaped the probe. (This bubbler was installed for alkali measurements conducted in the Phase 2 circulating pressurized fluidized bed combustor program that immediately followed the carbonizer tests; the bubbler measurements confirmed that alkali breakthrough was not occurring.)
- Thimble and cold finger water-insoluble alkali analyses are included, and these components are included in the fuel gas alkali vapor estimate.
- Once very high pressure drops across the thimble section have been reached, probe operation should be halted.

The isokinetic particle sampling probe was operated periodically during CPFBC testing to monitor the performance of the candle filter. In most cases, the sample weights collected were too small to make quantitative estimates of the filter outlet dust loading. No particle size distribution information was generated from the collected particle samples.

Figure 7.9 Commercial Plant—Required Fuel Gas Alkali Removal

8. CONCLUSIONS

During the period beginning November 1991 and ending September 1992, a series of tests were conducted in a fluidized-bed coal carbonizer to determine its performance characteristics. The carbonizer was operated for 533 hours in a jetting fluidized-bed configuration during which 36 set points (steady-state periods) were achieved. Testing was completed with four different fuels, namely, Pittsburgh No. 8 bituminous coal, Illinois No. 6 bituminous coal, Wyoming Eagle Butte subbituminous coal, and petroleum coke; a total of 83 tons of feedstock was consumed. In addition, an exploratory carbonizer test in a circulating fluidized-bed configuration entailing four set points and 9.9 tons of two different fuels (Pittsburgh No. 8 bituminous coal and petroleum coke) was completed. Sorbent (dolomite or limestone) was also fed to the carbonizer during each of the set points to capture sulfur. Throughout the program, the carbonizer operation was smooth and controlled. Feedstocks were switched "on the fly" from petroleum coke to subbituminous coal to bituminous coal, and from limestone to dolomite without causing any process upsets or problems.

Extensive data were collected on the feed and product stream compositions, heating values, temperatures, and flow rates. With these data, elemental and energy balances were computed to evaluate and confirm accuracy of the data. The carbonizer data were not as self-consistent as could be desired (balance closure imperfection). A software package, called BALAID, has been developed by Science Ventures, Inc., of California which reconciles the data by applying conservation laws and other equality and inequality constraints. Adjustments are made to all the species flows, temperatures, and variable-species compositions, with the adjustments weighted according to the statistical variance of each variable. A maximum-likelihood set of reconciled values is computed in which all the elemental and energy balances close exactly. This approach takes advantage of all the available measurement information as well as information embodied in the conservation laws and in the estimated quality of the measurements. The program utilizes advanced principles in statistics, numerical techniques, and constrained nonlinear optimization theory. This program was successfully applied to reconcile the carbonizer data.

Prior to the carbonizer pilot plant testing at FWDC, an extensive literature search was conducted and correlations were developed for predicting yields of various species as a function of coal properties and carbonizer operating parameters. Based on these correlations, a computer model for the carbonizer was developed. This model could simulate a bubbling or a circulating fluidized-bed reactor with or without fines recycle in which the coal and sorbent could be introduced into the fluidized-bed region and/or into the freeboard region of the carbonizer.

The reconciled data for the carbonizer, while operating in the jetting fluidized-bed configuration, were rigorously analyzed, correlations were developed, and the model was updated accordingly. The model was then used for simulating each of the 36 steady-state periods achieved in the pilot plant.

Many correlations were also developed which were not in the forms present in the existing model. Incorporation of these new correlations in the model would have required significant change in the computer code, and could have required additional resources. These correlations, if incorporated into the model, could have improved its predictive capabilities.

9. REFERENCES

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APPENDIX A

SAMPLE INPUT/OUTPUT FROM CARBONIZER COMPUTER MODEL

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As an example, a copy of the input data file for set point TR4-2 and the output produced by the carbonizer computer model program, when this data file is processed, is given in this appendix. As seen here, the program generates a tremendous amount of useful information.

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ICAL= 1	ILIME = 1	ICASE = 1	IHHV = 0	ICPASH= 1	ITRGASU= 0	ITRGASL= 0	
IWGSUZ= 1	IWGLSZ= 0	ICALUZ= 1	ICALLZ= 0	IEQH2S= 2	IPRT = 0	IPRTH = 0	IPRTD = 0
IFTAR = 0	IFTARC= 0	IFCHARC= 0	IFSOOTC= 0	IFOXY = 0	IFCAO = 0		
IFLAGG: 0 0 0 0 0		0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0	
COALP = 69.9270	COALP = 4.7940	COALP = 7.6970	COALP = 1.9280	COALP = 3.4100	COALP = .0000	COALP = 12.2450	COALMP= 2.3680
CACO3UA= 1.0000	MGCO3UB= 1.0107	CAOUC = .0000	MGOLD = .0000	CASUE = .0098	CASO4UF= .0000	DOLOUIP= .6490	DOLOUMP= .0000
FINECP= .0000	FINECP= .0000	FINECP= .0000	FINECP= .0000	FINECP= .0000	FINECP= .0000	FINECP= .0000	FINEFCP= .0000
FINEDA= .0000	FINEDB= .0000	FINEDC= .0000	FINEDD= .0000	FINEDE= .0000	FINEDF= .0000	FINEDIP= .0000	FINEFDP= .0000
RECYCP= 50.0000	RECYCP= .0000	RECYCP= .0000	RECYCP= .0000	RECYCP= .0000	RECYCP= .0000	RECYCP= 50.0000	DISCFCP= .0000
RECYDA= .0000	RECYDB= .0000	RECYDC= .0000	RECYDD= .0000	RECYDE= .0000	RECYDF= .0000	RECYDIP= .0000	DISCFDP= .0000
AIRUO2= 4.200	AIRUN2P= 79.008	AIRUMP= .0000					
GASU = .0000	GASU = .0000	GASU = .0000	GASU = 6.5665	GASU = .0000	GASU = .0000	GASU = .0000	GASU = .0000
GASXU = .0000	GASXU = .0000	GASXU = .0000	GASXU = .0000	GASXU = .0000	GASXU = .0000	GASXU = .0000	GASXU = 10.3485
TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000
TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000
TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGASU= .0000	TRGATM= .0000	
TCOAL = 59.9	TDOLOU= 59.9	TFINE = 1573.0	TSOOT = 1573.0	TDISCHU= 1573.0	TDISCHS= 1573.0	TRECYSS= 1573.0	TRECYSL= 1573.0
TAIRU = 78.9	TGASU = 394.4	TGASXU= 115.6	TTRGASU= 60.0	TBEDU = 1608.0	TEXTITU= 1573.0	TSHIFTU= .0	
PIPSIG= 155.90	WCOAL= 270.6600	WDOLOU= 89.9300	WRECY= .0	CHARPR= 50.0000	HVCOAL= 12831.9	HVFINE= .0	HTLSU = 97000.
CAPSP = 40.0000	EQH2S = 100.0000	FO2SO4U= .0000	SCALE = 1.00000				
TARCA = 1.0000	TARHB = .0000	TAROC = .0000	TARNR = .0000	TARSE = .0000	TARCLF= .0000		
CHARHA= .00000	CHARNC= .00000	CHARCLP= .00000					
SOOTHA= .00000	SOOTOB= .00000	SOOTNC= .00000	SOOTSD= .00000	SOOTCLE= .00000			
FCC4H= .0000	FCC2H6= .0000	FCC2H4= .0000	FCC2H2= .0000	FCC3H8= .0000	FCC3H6= .0000		
FC4H10= .0000	FCC6H6= .0000	FCC7H8= .0000	FC10H8= .0000	C6H5OH= .0000	FC7AR = .0000		
FOCO = .0000	FOCO2 = .0000	FOH2O = .0000	FNNH3 = .0000	FNNHCN = .0000	FSH2S = .0000	FSCOS = .0000	
PRTAR = .0000	ZTCH4 = .0000	ZTC2H6= .0000	ZTC2H4= .0000	ZTCOCO2= .0000	YCOCO2= .3000		
TCRACK= .0000	TCH4 = .0000	TC2H6 = .0000	TC2H4 = .0000				
CACO3LA= .0000	MGCO3LB= .0000	CAOLC = .0000	MGOLD = .0000	CASLE = .0000	CASO4LF= .0000	DOLOLIP= .0000	DOLOLMP= .0000
AIRLO2= .000	AIRLN2P= .000	AIRLMP= .0000					
GASL = .0000	GASL = .0000	GASL = .0000	GASL = .0000	GASL = .0000	GASL = .0000	GASL = .0000	GASL = .0000
TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000
TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000
TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGASL= .0000	TRGATM= .0000	
TDOLOL= .0	TDISCHL= .0						
TAIRL = .0	TGASL = .0	TTRGASL= .0	TBEDL = .0	TEXTIL= .0	TSHIFTL= .0		
WDOLOL= .0000	HTLSL = .0	FO2SO4L= .0000	COFRLP= .0000				

Test TR4-2 03/11/92 (0430-0830 Hours) Pitts Coal+Dolomite

05 SEP 94 22:58:32

MATERIAL AND ENERGY BALANCE SPECIFICATIONS

ICOAL = 1 ; FEEDSTOCK IS A BITUMINOUS COAL
ILIME = 1 ; SORBENT IS FED TO THE CARBONIZER
IIHV = 0 ; USE INPUT VALUE OF FEEDSTOCK HEATING VALUE FOR ENERGY BALANCE
ICPASH = 1 ; USE IGT DATABOOK EQUATION FOR SPECIFIC HEAT OF ASH
ITRGASU = 0 ; TRANSPORT GAS FEED TO UPPER ZONE IS GIVEN AS MOLAR FLOW
IWGSUZ = 1 ; REACTOR GAS LEAVING UPPER ZONE IS IN WATER-GAS SHIFT AT TSHIFTU
ICALUZ = 1 ; CaCO₃ IN SORBENT FEED MUST NOT BE CALCINED
IEQH2S = 2 ; H₂S IN THE PRODUCT GAS IS BASED ON APPROACH TO H₂S EQUILIBRIUM CAPTURE

NOTE: THE WATER-GAS SHIFT TEMPERATURE OF THE CARBONIZER EXIT GAS IS NOT SPECIFIED.
IT IS ESTIMATED TO BE 1773.0 DEGREE F, WHICH IS 200.0 DEGREE F ABOVE THE EXIT GAS TEMPERATURE (TEXTU).

CARBONIZER MATERIAL AND ENERGY BALANCE

BY

INSTITUTE OF GAS TECHNOLOGY
CHICAGO, ILLINOIS

(PLEASE SEE LAST PAGE FOR CARBONIZER MATERIAL BALANCE SUMMARY)

STREAMS DESCRIPTIONS

SOLIDS STREAMS

S01	COAL FEED TO CARBONIZER
S02	SORBENT FEED TO CARBONIZER
S03	IGNORE IT
S04	FINES ESCAPING CYCLONE
S05	IGNORE IT
S06	SOLIDS CAPTURED/COLLECTED BY CYCLONE
S07	IGNORE IT
S08	SOLIDS (EXCLUDING SOOT) FROM CARBONIZER TO CYCLONE
S09	IGNORE IT
S10	IGNORE IT
S11	IGNORE IT
S12	DISCHARGED SOLIDS FROM CARBONIZER
S13	SOOT EXITING CARBONIZER
S14	SOOT LEAVING CYCLONE (OR THE SYSTEM)

TARS STREAM

T01	TARS LEAVING CARBONIZER (OR THE SYSTEM)
-----	---

GAS STREAMS

G01	AIR/OXYGEN FEED TO CARBONIZER
G02	PRIMARY GAS FEED TO CARBONIZER
G03	SECONDARY GAS FEED TO CARBONIZER
G04	TRANSPORT GAS FEED TO CARBONIZER
G05	IGNORE IT
G06	IGNORE IT
G07	IGNORE IT
G08	PRODUCT GAS (TARS-FREE) LEAVING CARBONIZER (OR THE SYSTEM)
G09	IGNORE IT

SOLID SPECIES

NO.	SPECIES	MOL.WT.
1	C	12.011
2	H	1.008
3	O	15.999
4	N	14.007
5	S	32.060
6	CL	35.453
7	ASH	1.000
8	MOIS	18.015
9	CACO	100.088
10	MGCO	84.313
11	CAO	56.079
12	MGO	40.304
13	CAS	72.140
14	CASO	136.136
15	INER	1.000

GAS SPECIES

NO.	SPECIES	MOL.WT.	HHV, BTU/SCF	LHV, BTU/SCF
1	CO	28.010	321.3	321.3
2	CO2	44.009	.0	.0
3	H2	2.016	324.9	274.5
4	H2O	18.015	.0	.0
5	CH4	16.043	1012.0	911.2
6	C2H6	30.070	1772.9	1621.6
7	O2	31.998	.0	.0
8	N2	28.014	.0	.0
9	H2S	34.076	638.6	588.2
10	COS	60.070	623.6	623.6
11	NH3	17.031	435.4	359.8
12	HCN	27.026	757.4	732.4
13	HCL	36.461	57.5	32.5
14	C2H4	28.054	1602.9	1502.0
15	C2H2	26.038	1476.2	1425.7
16	C3H8	44.097	2523.0	2321.4
17	C3H6	42.081	2339.0	2187.8
18	C4H1	58.124	3269.6	3017.5
19	C6H6	78.114	3750.6	3599.3
20	C7H8	92.141	4485.2	4283.5
21	C10H	128.174	5939.8	5738.2
22	C6H5	94.113	3554.1	3404.1

(NOTE: 1 LB-MOLE = 378.601 SCF)

SOLIDS STREAMS

STREAM NO.	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12
FLOW RATES, LB/MOLES												
C	15.3845	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	9.4470
H	12.5676	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.8755
O	1.2713	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0392
N	.3637	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.2118
S	.2811	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0765
CL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
ASH	32.3575	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	32.3575
MOIS	.3558	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
CACO	.0000	.4803	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.2955
MGCO	.0000	.4855	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
CAO	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
ML(I)	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.4855
CAS	.0000	.0047	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.1896
CASO	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
INER	.0000	.5836	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.5836
TOT, MOLES*	30.2239	.9705	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	11.6206
TEMP., F	60.	60.	0.	1573.	0.	1573.	1573.	1573.	1573.	1573.	1573.	1573.

STREAM ELEMENTS CONTENTS, LB/ATOMS

C	15.3845	.9658	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	9.7425
H	13.2792	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.8755
O	1.6271	2.8974	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	1.4112
N	.3637	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.2118
S	.2811	.0047	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.2660
CL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
ASH	32.3575	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	32.3575
CA	.0000	.4850	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.4850
MG	.0000	.4855	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.4855
INER	.0000	.5836	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.5836

STREAM ENERGY CONTENTS, BTU

CHEMICAL	3390840.	-57706.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1723786.
SENSIBLE	-1159.	-309.	0.	0.	0.	0.	0.	0.	0.	0.	0.	100263.
TOTAL	3389680.	-58016.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1824049.

* ASH AND INERT FREE BASIS.

SOLIDS STREAMS

STREAM NO. S13 S14

FLOW RATES, LBMOLES

C	.0000	.0000
H	.0000	.0000
O	.0000	.0000
N	.0000	.0000
S	.0000	.0000
CL	.0000	.0000
ASH	.0000	.0000
MOIS	.0000	.0000
CACO	.0000	.0000
MGCO	.0000	.0000
CAO	.0000	.0000
MGO	.0000	.0000
CAS	.0000	.0000
CASO	.0000	.0000
INER	.0000	.0000

TOT, MOLES* .0000 .0000

TEMP., F 1573. 1573.

STREAM ELEMENTS CONTENTS, LBATOMS

C	.0000	.0000
H	.0000	.0000
O	.0000	.0000
N	.0000	.0000
S	.0000	.0000
CL	.0000	.0000
ASH	.0000	.0000
CA	.0000	.0000
MG	.0000	.0000
INER	.0000	.0000

STREAM ENERGY CONTENTS, BTU

CHEMICAL	0.	0.
SENSIBLE	0.	0.
TOTAL	0.	0.

* ASH AND INERT FREE BASIS.

SOLIDS STREAMS

STREAM NO.	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12
FLOW RATES, LBS												
C	184.783	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	113.468
H	12.668	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.883
O	20.339	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.627
N	5.095	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	2.967
S	9.011	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	2.452
Cl	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ASH	32.358	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	32.358
MOIS	6.409	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
CACO	.000	48.075	.000	.000	.000	.000	.000	.000	.000	.000	.000	29.576
MGCO	.000	40.931	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
CAO	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MGO	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	19.566
CAS	.000	.341	.000	.000	.000	.000	.000	.000	.000	.000	.000	13.674
CASO	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
INER	.000	.584	.000	.000	.000	.000	.000	.000	.000	.000	.000	.584
TOTAL, LBS	270.663	89.930	.000	.000	.000	.000	.000	.000	.000	.000	.000	216.155
TEMP., F	60.	60.	0.	1573.	0.	1573.	1573.	1573.	1573.	1573.	1573.	1573.

SOLIDS STREAMS

STREAM NO.	S13	S14
FLOW RATES, LBS		
C	.000	.000
H	.000	.000
O	.000	.000
N	.000	.000
S	.000	.000
CL	.000	.000
ASH	.000	.000
MOIS	.000	.000
CACO	.000	.000
MGCO	.000	.000
CAO	.000	.000
MGO	.000	.000
CAS	.000	.000
CASO	.000	.000
INER	.000	.000

TOTAL, LBS	.000	.000
TEMP., F	1573.	1573.

SOLIDS STREAMS

STREAM NO.	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12
COMPOSITION, WT %												
C	68.270	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	52.494
H	4.680	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.408
O	7.515	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.290
N	1.882	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.373
S	3.329	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.135
Cl	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ASH	11.955	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	14.970
MOIS	2.368	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
CACO	.000	53.458	.000	.000	.000	.000	.000	.000	.000	.000	.000	13.683
MGCO	.000	45.514	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
CAO	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MGO	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	9.052
CAS	.000	.379	.000	.000	.000	.000	.000	.000	.000	.000	.000	6.326
CASO	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
INER	.000	.649	.000	.000	.000	.000	.000	.000	.000	.000	.000	.270
TOTAL	100.000	100.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	100.000
TOTAL,LBS	270.663	89.930	.000	.000	.000	.000	.000	.000	.000	.000	.000	216.155
TEMP., F	60.	60.	0.	1573.	0.	1573.	1573.	1573.	1573.	1573.	1573.	1573.

SOLIDS STREAMS

STREAM NO.	S13	S14
COMPOSITION, WT %		

C	.000	.000
H	.000	.000
O	.000	.000
N	.000	.000
S	.000	.000
Cl	.000	.000
ASH	.000	.000
MOIS	.000	.000
CACO	.000	.000
MGCO	.000	.000
CAO	.000	.000
MGO	.000	.000
CAS	.000	.000
CASO	.000	.000
INER	.000	.000

TOTAL	.000	.000
TOTAL,LBS	.000	.000
TEMP., F	1573.	1573.

SOLIDS STREAMS

STREAM NO.	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12
COMPOSITION, WT %												
CHAR FRACTION:												
C	69.926	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	74.281
H	4.794	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.578
O	7.697	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.411
N	1.928	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.942
S	3.410	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.605
CL	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ASH	12.245	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	21.183
TOTAL	100.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	100.000
TOTAL,LBS	264.253	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	152.755
DULONG												
HHV,BTU/LB	12685.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	11195.00
DATABASE												
HHV,BTU/LB	12500.25	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	11003.32
C CONV., %	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	38.59
H CONV., %	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	93.03
O CONV., %	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	96.92
N CONV., %	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	41.76
S CONV., %	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	72.79
CL CONV., %	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DOLOMITE FRACTION:												
CACO	.000	53.458	.000	.000	.000	.000	.000	.000	.000	.000	.000	46.649
MGCO	.000	45.514	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
CAO	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
MGO	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	30.861
CAS	.000	.379	.000	.000	.000	.000	.000	.000	.000	.000	.000	21.569
CASO	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
INER	.000	.649	.000	.000	.000	.000	.000	.000	.000	.000	.000	.921
TOTAL	.000	100.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	100.000
TOTAL,LBS	.000	89.930	.000	.000	.000	.000	.000	.000	.000	.000	.000	63.400
TEMP., F	60.	60.	0.	1573.	0.	1573.	1573.	1573.	1573.	1573.	1573.	1573.

FEED COAL HHV (USED), BTU/LB = 12831.9

CALCULATED COAL HHV (DULONG FORMULA), BTU/LB = 12685.0 ; DIFFERENCE = 146.9

CALCULATED COAL HHV (DATABASE FORMULA), BTU/LB = 12500.2 ; DIFFERENCE = 331.7

SOLIDS STREAMS

STREAM NO. S13 S14

COMPOSITION, WT %

CHAR FRACTION:

C	.000	.000
H	.000	.000
O	.000	.000
N	.000	.000
S	.000	.000
CL	.000	.000
ASH	.000	.000

TOTAL	.000	.000
-------	------	------

TOTAL, LBS	.000	.000
------------	------	------

DULONG		
HHV, BTU/LB	.00	.00

DATABOOK		
HHV, BTU/LB	.00	.00

TAR STREAM

STREAM NO.	T01
FLOW RATES, LBMOLES	
-----	-----
C	.0000
H	.0000
O	.0000
N	.0000
S	.0000
CL	.0000
ASH	.0000
TOTL, MOLES	.0000

FLOW RATES, LBS

C	.000
H	.000
O	.000
N	.000
S	.000
CL	.000
ASH	.000
TOTAL, LBS	.000

TEMP., F 1573.

STREAM ELEMENTS CONTENTS, LBATOMS

-----	-----
C	.0000
H	.0000
O	.0000
N	.0000
S	.0000
CL	.0000
ASH	.0000
CA	.0000
MG	.0000
INLR	.0000

STREAM ENERGY CONTENTS, BTU

-----	-----
CHEMICAL	0.
SENSIBLE	0.
TOTAL	0.

TAR STREAM

STREAM NO.	T01
COMPOSITION, MOL %	
C	.000
H	.000
O	.000
N	.000
S	.000
CL	.000
ASH	.000
TOTAL	.000

COMPOSITION, WT %	
C	.000
H	.000
O	.000
N	.000
S	.000
CL	.000
ASH	.000
TOTAL	.000

TOTL, MOLES	.0000
TOTAL, LBS	.000

TEMP., F 1573.

DULONG	
HHV, BTU/LB	.00

DATABOOK	
HHV, BTU/LB	.00

TAR HHV (USED), BTU/LB = .0

Test 1R4-2 03/11/92 (0430-0830 Hours) Pitts Coal+Dolomite

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GAS STREAMS

STREAM NO.	FLOW RATES, LBMOLES											
G01	G02	G03	G04	G05	G06	G07	G08	G09				
CO	.0000	.0000	.0000	.0000	.0000	.0000	1.8131	.0000				
CO2	.0000	.0000	.0000	.0000	.0000	.0000	3.9651	.0000				
H2	.0000	.0000	.0000	.0000	.0000	.0000	2.3924	.0000				
H2O	.0000	.0000	.0000	.0000	.0000	.0000	8.6458	.0000				
CH4	.0000	.0000	.0000	.0000	.0000	.0000	.7607	.0000				
C2H6	.0000	.0000	.0000	.0000	.0000	.0000	.0111	.0000				
O2	4.3547	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
N2	16.3898	.0000	10.3485	.0000	.0000	.0000	26.7779	.0000				
H2S	.0000	.0000	.0000	.0000	.0000	.0000	.0197	.0000				
COS	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
NH3	.0000	.0000	.0000	.0000	.0000	.0000	.0727	.0000				
HCN	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
HCL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
C2H4	.0000	.0000	.0000	.0000	.0000	.0000	.0233	.0000				
C2H2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
C3H8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
C3H6	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
C4H1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
C6H6	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
C7H8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
C10H	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
C6H5	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
TOTAL MOLES	20.7445	6.5665	10.3485	.0000	.0000	.0000	44.4819	.0000				
TEMP., F	79.	394.	116.	60.	0.	0.	1573.	1573.				
STREAM ELEMENTS CONTENTS, LBATOMS												
C	.0000	.0000	.0000	.0000	.0000	.0000	6.6077	.0000				
H	.0000	13.1330	.0000	.0000	.0000	.0000	25.5366	.0000				
O	8.7094	6.5665	.0000	.0000	.0000	.0000	18.3891	.0000				
N	32.7796	.0000	20.6970	.0000	.0000	.0000	53.6285	.0000				
S	.0000	.0000	.0000	.0000	.0000	.0000	.0197	.0000				
CL	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
ASH	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
CA	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
MG	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000				
INNER	.0000	.0900	.0000	.0000	.0000	.0000	.0000	.0000				
STREAM ENERGY CONTENTS, BTU												
CHEMICAL	0.	124337.	0.	0.	0.	0.	1008375.	0.				
SENSIBLE	274.	17048.	2775.	0.	0.	0.	546676.	0.				
TOTAL	274.	141386.	2775.	0.	0.	0.	1555051.	0.				

GAS STREAMS

STREAM NO.	G01	G02	G03	G04	G05	G06	G07	G08	G09
FLOW RATES, LBS									
CO	.000	.000	.000	.000	.000	.000	.000	50.785	.000
CO2	.000	.000	.000	.000	.000	.000	.000	174.500	.000
H2	.000	.000	.000	.000	.000	.000	.000	4.823	.000
H2O	.000	118.295	.000	.000	.000	.000	.000	155.754	.000
CH4	.000	.000	.000	.000	.000	.000	.000	12.203	.000
C2H6	.000	.000	.000	.000	.000	.000	.000	.333	.000
O2	139.341	.000	.000	.000	.000	.000	.000	.000	.000
N2	459.144	.000	289.903	.000	.000	.000	.000	750.155	.000
H2S	.000	.000	.000	.000	.000	.000	.000	.673	.000
COS	.000	.000	.000	.000	.000	.000	.000	.000	.000
NH3	.000	.000	.000	.000	.000	.000	.000	1.239	.000
HCN	.000	.000	.000	.000	.000	.000	.000	.000	.000
HCL	.000	.000	.000	.000	.000	.000	.000	.000	.000
C2H4	.000	.000	.000	.000	.000	.000	.000	.655	.000
C2H2	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3H8	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3H6	.000	.000	.000	.000	.000	.000	.000	.000	.000
C4H1	.000	.000	.000	.000	.000	.000	.000	.000	.000
C6H6	.000	.000	.000	.000	.000	.000	.000	.000	.000
C7H8	.000	.000	.000	.000	.000	.000	.000	.000	.000
C10H	.000	.000	.000	.000	.000	.000	.000	.000	.000
C6H5	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL, LBS	598.485	118.295	289.903	.000	.000	.000	.000	1151.121	.000
TEMP., F	79.	394.	116.	60.	0.	0.	0.	1573.	1573.

FEED CARBON TO: CH4 = 4.9444 %, C2H6 = .1440 %, C2H4 = .3035 %
 FEED NITROGEN TO NH3 = 20.0000 %
 FEED SULFUR TO H2S = 7.0256 %

GAS STREAMS

STREAM NO.	G01	G02	G03	G04	G05	G06	G07	G08	G09
COMPOSITION, MOL %									
CO	.000	.000	.000	.000	.000	.000	.000	4.076	.000
CO2	.000	.000	.000	.000	.000	.000	.000	8.914	.000
H2	.000	.000	.000	.000	.000	.000	.000	5.378	.000
H2O	.000	100.000	.000	.000	.000	.000	.000	19.437	.000
CH4	.000	.000	.000	.000	.000	.000	.000	1.710	.000
C2H6	.000	.000	.000	.000	.000	.000	.000	.025	.000
O2	20.992	.000	.000	.000	.000	.000	.000	.000	.000
N2	79.008	.000	100.000	.000	.000	.000	.000	60.200	.000
H2S	.000	.000	.000	.000	.000	.000	.000	.044	.000
COS	.000	.000	.000	.000	.000	.000	.000	.000	.000
NH3	.000	.000	.000	.000	.000	.000	.000	.164	.000
HCN	.000	.000	.000	.000	.000	.000	.000	.000	.000
HCL	.000	.000	.000	.000	.000	.000	.000	.000	.000
C2H4	.000	.000	.000	.000	.000	.000	.000	.052	.000
C2H2	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3H8	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3H6	.000	.000	.000	.000	.000	.000	.000	.000	.000
C4H1	.000	.000	.000	.000	.000	.000	.000	.000	.000
C6H6	.000	.000	.000	.000	.000	.000	.000	.000	.000
C7H8	.000	.000	.000	.000	.000	.000	.000	.000	.000
C10H	.000	.000	.000	.000	.000	.000	.000	.000	.000
C6H5	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL	100.000	100.000	100.000	.000	.000	.000	.000	100.000	.000
TOTL, MOLES	20.7445	6.5665	10.3485	.0000	.0000	.0000	.0000	44.4819	.0000
, LBS	598.485	118.295	289.903	.000	.000	.000	.000	1151.121	.000
MOL WT	28.85032	18.01500	28.01400	.00000	.00000	.00000	.00000	25.87844	.00000
TOTAL DRY GAS, MOLES	20.7445	.0000	10.3485	.0000	.0000	.0000	.0000	35.8360	.0000
HHVBTU/SCF	.000	.000	.000	.000	.000	.000	.000	62.255	.000
HHVBTU/SCI	.000	.000	.000	.000	.000	.000	.000	56.457	.000
TEMP., F	79.	394.	116.	60.	0.	0.	0.	1573.	1573.

UPPER ZONE EXIT GAS (STREAM NO. 8): EQUIVALENT WATER GAS SHIFT TEMPERATURE = 1773.0 DEGREE F; (K = .60514)

CO2 ACTUAL PRESSURE = 1.035 ATM, CO2 EQUILIBRIUM PRESSURE = .725 ATM; THUS CaCO3 MUST NOT BE CALCINED.

THE CaCO3 HAS NOT BEEN CALCINED IN THIS MATERIAL BALANCE, WHICH IS CONSISTENT WITH EQUILIBRIUM CALCULATIONS.

EQUILIB. H2S (AT 1608. F) = .01975 MOLE(444. PPM), ACTUAL H2S = .01975 MOLE(444. PPM); H2S WITHOUT CAPTURE = .20457 MOLE(4599. PPM) -
THUS APPROACH TO H2S EQUILIBRIUM CONCENTRATION = 100.000 %; APPROACH TO H2S EQUILIBRIUM CAPTURE = 100.000 %

STREAM NO.	601	602	603	604	605	606	607	608	609
CO	.000	.000	.000	.000	.000	.000	.000	4.412	.000
CO2	.000	.000	.000	.000	.000	.000	.000	15.159	.000
H2	.000	.000	.000	.000	.000	.000	.000	.419	.000
H2O	.000	100.000	.000	.000	.000	.000	.000	13.531	.000
CH4	.000	.000	.000	.000	.000	.000	.000	1.060	.000
C2H6	.000	.000	.000	.000	.000	.000	.000	.029	.000
O2	23.282	.000	.000	.000	.000	.000	.000	.000	.000
N2	76.718	.000	100.000	.000	.000	.000	.000	65.167	.000
H2S	.000	.000	.000	.000	.000	.000	.000	.058	.000
COS	.000	.000	.000	.000	.000	.000	.000	.000	.000
NH3	.000	.000	.000	.000	.000	.000	.000	.000	.000
HCN	.000	.000	.000	.000	.000	.000	.000	.000	.000
HCL	.000	.000	.000	.000	.000	.000	.000	.000	.000
C2H4	.000	.000	.000	.000	.000	.000	.000	.057	.000
C2H2	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3H8	.000	.000	.000	.000	.000	.000	.000	.000	.000
C3H6	.000	.000	.000	.000	.000	.000	.000	.000	.000
C4H1	.000	.000	.000	.000	.000	.000	.000	.000	.000
C6H6	.000	.000	.000	.000	.000	.000	.000	.000	.000
C7H8	.000	.000	.000	.000	.000	.000	.000	.000	.000
C10H	.000	.000	.000	.000	.000	.000	.000	.000	.000
C6H5	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL	100.000	100.000	100.000	.000	.000	.000	.000	100.000	.000
TOTAL, LBS	598.485	118.295	289.903	.000	.000	.000	.000	1151.121	.000
TEMP., F	79.	394.	116.	60.	0.	0.	0.	1573.	1573.

SENSIBLE HEAT OF GAS STREAMS AT VARIOUS TEMPERATURES

TEMP., F	G01	G02	G03	G04	G05	G06	G07	G08	G09
77.	0.	0.	0.	0.	0.	0.	0.	0.	0.
100.	3321.	1213.	1653.	0.	0.	0.	0.	7541.	0.
200.	17804.	6521.	8856.	0.	0.	0.	0.	40580.	0.
300.	32387.	11898.	16091.	0.	0.	0.	0.	74065.	0.
400.	47098.	17356.	23372.	0.	0.	0.	0.	108038.	0.
500.	61956.	22908.	30711.	0.	0.	0.	0.	142529.	0.
600.	76980.	28559.	38117.	0.	0.	0.	0.	177561.	0.
700.	92181.	34315.	45597.	0.	0.	0.	0.	213148.	0.
800.	107564.	40178.	53159.	0.	0.	0.	0.	249296.	0.
900.	123135.	46150.	60805.	0.	0.	0.	0.	286004.	0.
1000.	138891.	52229.	68541.	0.	0.	0.	0.	323267.	0.
1100.	154830.	58413.	76367.	0.	0.	0.	0.	361072.	0.
1200.	170947.	64701.	84283.	0.	0.	0.	0.	399404.	0.
1300.	187232.	71087.	92288.	0.	0.	0.	0.	438244.	0.
1400.	203678.	77570.	100379.	0.	0.	0.	0.	477569.	0.
1500.	220275.	84145.	108553.	0.	0.	0.	0.	517355.	0.
1600.	237011.	90810.	116805.	0.	0.	0.	0.	557578.	0.
1700.	253877.	97562.	125127.	0.	0.	0.	0.	598213.	0.
1800.	270863.	104402.	133514.	0.	0.	0.	0.	639235.	0.
1900.	287959.	111328.	141957.	0.	0.	0.	0.	680621.	0.
2000.	305160.	118345.	150446.	0.	0.	0.	0.	722350.	0.

OVERALL SYSTEM BALANCE

	IN	OUT	DIFFERENCE	(DIFF/IN),%
ELEMENTAL BALANCE, LBATOMS*				
C	16.3502	16.3502	.0000	.000
H	26.4122	26.4122	.0000	.000
O	19.8003	19.8003	.0000	.000
N	53.8403	53.8403	.0000	.000
S	.2858	.2858	.0000	.000
CL	.0000	.0000	.0000	.000
ASH	32.3575	32.3575	.0000	.000
CA	.4850	.4850	.0000	.000
MG	.4855	.4855	.0000	.000
INER	.5836	.5836	.0000	.000

ENERGY BALANCE, BTU

CHEMICAL	3457471.	2732161.	725310.	20.978
SENSIBLE	18629.	646939.	-628310.	-3372.727
SUM	3476100.	3379100.	97000.	2.790
WALLLOSS	0.	97000.	-97000.	
TOTAL	3476100.	3476100.	0.	.000

* EXCEPT ASH AND INERT.

UPPER ZONE BALANCE

	IN	OUT	DIFFERENCE	(DIFF/IN),%
ELEMENTAL BALANCE, LBATOMS*				
C	16.3502	16.3502	.0000	.000
H	26.4122	26.4122	.0000	.000
O	19.8003	19.8003	.0000	.000
N	53.8403	53.8403	.0000	.000
S	.2858	.2858	.0000	.000
Cl	.0000	.0000	.0000	.000
ASH	32.3575	32.3575	.0000	.000
CA	.4850	.4850	.0000	.000
MG	.4855	.4855	.0000	.000
INLR	.5836	.5836	.0000	.000

ENERGY BALANCE, BTU

CHEMICAL	3457471.	2732161.	725310.	20.978
SENSIBLE	18629.	646939.	-628310.	-3372.727
SUM	3476100.	3379100.	97000.	2.790
WALLLOSS	0.	97000.	-97000.	
TOTAL	3476100.	3476100.	0.	.000

LOWER ZONE BALANCE

	IN	OUT	DIFFERENCE	(DIFF/IN),%
ELEMENTAL BALANCE, LBATOMS*				
C	.0000	.0000	.0000	.000
H	.0000	.0000	.0000	.000
O	.0000	.0000	.0000	.000
N	.0000	.0000	.0000	.000
S	.0000	.0000	.0000	.000
CL	.0000	.0000	.0000	.000
ASH	.0000	.0000	.0000	.000
CA	.0000	.0000	.0000	.000
MG	.0000	.0000	.0000	.000
INER	.0000	.0000	.0000	.000

* EXCEPT ASH AND INERT.

SPLITTER BALANCE

	IN	OUT	DIFFERENCE	(DIFF/IN),%
ELEMENTAL BALANCE, LBATOMS*				
C	.0000	.0000	.0000	.000
H	.0000	.0000	.0000	.000
O	.0000	.0000	.0000	.000
N	.0000	.0000	.0000	.000
S	.0000	.0000	.0000	.000
CL	.0000	.0000	.0000	.000
ASH	.0000	.0000	.0000	.000
CA	.0000	.0000	.0000	.000
MG	.0000	.0000	.0000	.000
INLR	.0000	.0000	.0000	.000

CYCLONE BALANCE

	IN	OUT	DIFFERENCE	(DIFF/IN),%
ELEMENTAL BALANCE, LBATOMS*				
C	6.6077	6.6077	.0000	.000
H	25.5366	25.5366	.0000	.000
O	18.3891	18.3891	.0000	.000
N	53.6285	53.6285	.0000	.000
S	.0197	.0197	.0000	.000
CL	.0000	.0000	.0000	.000
ASH	.0000	.0000	.0000	.000
CA	.0000	.0000	.0000	.000
MG	.0000	.0000	.0000	.000
INER	.0000	.0000	.0000	.000

ENERGY BALANCE, BTU

CHEMICAL	1008375.	1008375.	0.	.000
SENSIBLE	546676.	546676.	0.	.000
TOTAL	1555051.	1555051.	0.	.000

* EXCEPT ASH AND INERT.

CARBONIZER MATERIAL BALANCE SUMMARY

CARBONIZER FEATURES:

- FEEDSTOCK IS A BITUMINOUS COAL.
- AS REQUESTED, CaCO_3 IN THE SORBENT IS NOT CALCINED.
- COAL AND SORBENT ARE FED INTO THE BED.
- ELutriated Fines ARE WITHDRAWN FROM THE SYSTEM.

CARBONIZER PRESSURE	=	11.608 ATM (155.90 PSIG)
CARBONIZER TEMPERATURE	=	1608.0 DEGREE F
COAL FEED	=	270.66 LBS (AT 60. F)
SORBENT FEED	=	89.93 LBS (AT 60. F)
OXIDANT FEED	=	598.48 LBS OR 20.744 LBMOLES (AT 79. F)
PRIMARY GAS FEED	=	118.30 LBS OR 6.567 LBMOLES (AT 394. F)
SECONDARY GAS FEED	=	289.90 LBS OR 10.349 LBMOLES (AT 116. F)
TRANSPORT GAS FEED	=	.00 LBS OR .000 LBMOLES (AT 60. F)
FINES ESCAPING CYCLONE	=	.00 LBS (AT 1573. F)
FINES CAPTURED/COLLECTED BY CYCLONE	=	.00 LBS (AT 1573. F)
CHAR IN SOLIDS DISCHARGED FROM CARBONIZER	=	152.75 LBS (AT 1573. F)
SPENT SORBENT IN SOLID DISC FROM CARBONIZER	=	63.40 LBS (AT 1573. F)
SOOT LEAVING CARBONIZER SYSTEM	=	.000 LBS (AT 1573. F)
PRODUCT GAS (TARS-FREE) LEAVING CARBONIZER	=	1151.12 LBS OR 44.482 LBMOLES (AT 1573. F)
TARS LEAVING CARBONIZER	=	.000 LBS (AT 1573. F)
PRODUCT GAS (TARS-FREE) HHV (LHV)	=	733.77 BTU/LB (665.43 BTU/LB)
TARS HHV (LHV)	=	.0 BTU/LB (.0 BTU/LB)
FEEDSTOCK HHV (LHV)	=	12831.9 BTU/LB (12377.9 BTU/LB)
TOTAL (PRODUCT GAS+TARS) HHV/FEEDSTOCK HHV	=	24.91 %
TOTAL (PRODUCT GAS+TARS) LHV/FEEDSTOCK LHV	=	23.42 %
PRODUCT GAS (TAR-FREE) HHV (LHV)	=	62.26 BTU/SCF (56.46 BTU/SCF)
FEEDSTOCK CARBON CONVERSION TO GAS	=	38.59 %
FEEDSTOCK CARBON CONVERSION TO GAS + TARS	=	38.59 %
MAF COAL CONVERSION TO GAS	=	48.08 %
MAF COAL CONVERSION TO GAS + TARS	=	48.08 %
CA/S MOLAR RATIO - BASED ON FEED SULFUR	=	1.71
CA/S MOLAR RATIO - BASED ON RELEASED SULFUR	=	2.35
APPROACH TO H_2S EQUILIBRIUM CONCENTRATION	=	100.000 %
APPROACH TO H_2S EQUILIBRIUM CAPTURE	=	100.000 %
SULFUR CAPTURE BY SORBENT	=	65.76 % OF FEED COAL SULFUR
SULFUR APPEARING IN (PRODUCT GAS + TARS)	=	7.03 % OF FEED COAL SULFUR
PRODUCT GAS SHIFT TEMPERATURE	=	1773.0 DEGREE F
HEAT LOSS FROM CARBONIZER	=	97000. BTU

APPENDIX B

FEEDSTOCK CHARACTERIZATION

B.1 COALS AND PETROLEUM COKE

Three different coals and petroleum coke were the fuels used in the carbonizer test program. The bulk of the testing was done with highly caking, 3 percent sulfur Pittsburgh No. 8 bituminous coal, the fuel being used in American Electric Power Science Corp's first generation PFB Tidd Plant. The other coals were Illinois No. 6 (bituminous) and Eagle Butte (subbituminous) the fuels planned for use in Southern Company Services Inc., Power Systems Development Facility in Wilsonville, Alabama. Elemental analysis for all coal samples taken during each setpoint period are provided in Section 3 of this report. Typical analysis of sulfur forms, proximate analysis, free swelling index (FSI), and bulk density for a small selection of the total coal samples taken are shown in Table B.1.1. A comparison of the range of percent of total coal sulfur analyzed as pyritic for the three candidate coals tested (i.e., Pittsburgh No. 8, Illinois No. 6, and Wyoming Eagle Butte) is shown in Table B.1.7. Also provided for a limited selection of coal samples are ash fusion temperatures, size distribution, and ash chemistry. These are listed respectively in Tables B.1.2, B.1.3, and B.1.4.

A fuel analysis for two samples of the coke used in the start-up of the unit are provided in Table B.1.5. Their respective size distributions are listed in Table B.1.6.

Table B.1.1 Feedstock Sulfur Forms/ Proximate Analysis/ FSI/ Bulk Density (as received)

Test Run	Coal Type	F.W.I.D No.	Total Sulfur, Wt%	Pyritic Sulfur, Wt%	Fixed Carbon Wt%	Volatile Matter, Wt%	Free Swelling Index	Bulk Density, g/ml
TR-1	Pitts. No. 8	910865	3.24	2.30	49.79	32.58	—	0.94
TR-1	Pitts. No. 8	910867	3.36	2.17	50.23	33.77	—	—
TR-1	Pitts. No. 8	910870	3.34	1.91	51.87	34.80	—	—
TR-1	Pitts. No. 8	910874	3.88	1.77	49.59	33.92	—	—
TR-2	Pitts. No. 8	911021	3.74	2.28	51.17	33.92	—	0.88
TR-2	Pitts. No. 8	911022	4.94	3.15	49.27	34.34	—	0.80
TR-2	Pitts. No. 8	911024	3.88	2.32	51.73	35.33	—	0.85
TR-2	Pitts. No. 8	911026	6.22	3.75	49.27	34.04	—	0.84
TR-2	Pitts. No. 8	911028	4.83	2.65	49.33	34.53	—	0.83
TR-2	Pitts. No. 8	911030	3.94	2.38	52.11	35.57	—	0.84
TR-4	Pitts. No. 8	920340	3.78	2.12	51.17	35.88	6 1/2	0.88
TR-4	Pitts. No. 8	920341	3.16	2.30	50.38	33.68	6 1/2	0.85
TR-4	Pitts. No. 8	920342	—	—	51.30	35.96	6 1/2	0.82
TR-4	Pitts. No. 8	920343	3.94	2.65	52.15	32.95	6 1/2	0.93
TR-4	Pitts. No. 8	920344	—	—	53.27	34.79	6 1/2	0.87
TR-4	Pitts. No. 8	920345	3.18	2.26	53.15	35.50	6 1/2	0.85
TR-4	Pitts. No. 8	920346	—	—	52.05	34.94	6 1/2	0.85
TR-5	Pitts. No. 8	920412	1.85	1.16	53.70	33.59	6 1/2	0.85
TR-5	Pitts. No. 8	920413	—	—	56.38	32.68	6 1/2	0.91
TR-5	Pitts. No. 8	920414	2.01	1.34	53.76	33.02	6 1/2	0.85
TR-5	Pitts. No. 8	920415	1.81	1.03	55.54	33.51	6 1/2	0.90

Table B.1.1 (continued) Forms/ Proximate Analysis/ FSI/ Bulk Density (as received)

Test Run	Coal Type	F.W.I.D No.	Total Sulfur, Wt%	Pyritic Sulfur, Wt%	Fixed Carbon Wt%	Volatile Matter, Wt%	Free Swelling Index	Bulk Density, g/ml
TR-6	Wy. Eagle Butte	920542	0.54	0.08	35.31	33.23	0	—
TR-6	Wy. Eagle Butte	920543	0.73	0.13	34.58	30.86	0	—
TR-6	Wy. Eagle Butte	920544	0.55	0.12	33.52	30.94	0	—
TR-6	Wy. Eagle Butte	920280	0.51	0.10	34.11	30.92	—	—
TR-6	Wy. Eagle Butte	920564	0.90	—	36.30	30.56	0	0.81
TR-6	Wy. Eagle Butte	920565	0.83	—	36.19	30.68	0	0.83
TR-6	Wy. Eagle Butte	920566	0.68	—	34.88	30.90	0	0.81
TR-6	Wy. Eagle Butte	920567	0.58	—	37.01	32.55	0	0.83
TR-6	Wy. Eagle Butte	920568	0.60	—	36.41	32.26	0	0.81
TR-6	Illinois No. 6	920536	2.80	0.88	44.68	34.67	2 1/2	—
TR-6	Illinois No. 6	920537	3.11	0.98	47.00	32.69	3 1/2	—
TR-6	Illinois No. 6	920538	3.40	1.08	45.62	35.31	4 1/2	—
TR-6	Illinois No. 6	920569	2.72	—	44.57	33.38	3	0.81
TR-6	Illinois No. 6	920570	3.37	—	45.54	33.59	5	0.82
TR-8	Wy. Eagle Butte	920894	0.69	—	33.18	32.80	0	0.69
TR-8	Wy. Eagle Butte	920895	0.80	—	34.00	32.94	0	0.73
TR-8	Wy. Eagle Butte	920896	0.84	—	37.32	32.59	0	0.74
TR-8	Illinois No. 6	920897	2.80	1.27	50.20	31.08	1 1/2	0.84
TR-8	Illinois No. 6	920898	3.26	1.24	43.99	34.26	2	0.80
TR-8	Pitts. No. 8	920899	4.44	2.45	49.24	33.84	6 1/2	0.84
TR-8	Pitts. No. 8	920900	3.81	2.58	49.86	33.90	6 1/2	0.88
TR-8	Pitts. No. 8	920901	3.96	2.80	50.39	34.19	6 1/2	0.89

Table B.1.1 (continued) Forms/ Proximate Analysis/ FSI/ Bulk Density (as received)

Test Run	Coal Type	F.W.I.D No.	Total Sulfur, Wt%	Pyritic Sulfur, Wt%	Fixed Carbon Wt%	Volatile Matter, Wt%	Free Swelling Index	Bulk Density, g/ml
TR-10	Pitts. No. 8	921057	3.17	1.83	—	—	—	—
TR-10	Pitts. No. 8	921058	3.41	1.97	—	—	—	—
TR-10	Pitts. No. 8	921059	3.10	1.76	—	—	—	—
TR-10	Pitts. No. 8	921196	3.35	—	50.77	34.68	6 1/2	0.87
TR-10	Pitts. No. 8	921197	3.13	—	51.16	35.15	6 1/2	0.86
TR-10	Pitts. No. 8	921198	3.02	—	52.35	35.69	6 1/2	0.87
TR-10	Pitts. No. 8	921199	3.34	—	50.39	35.30	6 1/2	0.93

Table B.1.2 Coal Ash Fusion Temperature, °F

Test Run	Coal Type	FWID No.	Reduction				Oxidation			
			Initial Deformation	Soft Temp. Spherical	Soft Temp. Hemispherical	Fluid Temp.	Initial Deformation	Soft Temp. Spherical	Soft Temp. Hemispherical	Fluid Temp.
TR-4	Pitt. No. 8	920340	1943	2011	2155	2333	2250	2447	2488	2505
TR-4	Pitt. No. 8	920341	2076	2141	2288	2370	2439	2470	2497	2522
TR-4	Pitt. No. 8	920342	2013	2100	2134	2173	2461	2501	2518	2535
TR-4	Pitt. No. 8	920343	2113	2186	2236	2310	2453	2486	2516	2560
TR-4	Pitt. No. 8	920344	1992	2082	2206	2296	2445	2481	2516	2531
TR-4	Pitt. No. 8	920345	1966	2068	2119	2172	2328	2428	2493	2507
TR-4	Pitt. No. 8	920346	2025	2101	2156	2288	2454	2488	2502	2522
TR-5	Pitt. No. 8	920412	2130	2204	2290	2392	2349	2390	2440	2453
TR-5	Pitt. No. 8	920413	2152	2226	2337	2421	2414	2456	2482	2515
TR-5	Pitt. No. 8	920414	2317	2370	2410	2504	2450	2512	2567	2588
TR-5	Pitt. No. 8	920415	2145	2330	2393	2467	2432	2480	2508	2547
TR-6	Eagle Butte	920564	2043	2076	2112	2155	2127	2145	2185	2216
TR-6	Eagle Butte	920565	2025	2065	2109	2200	2094	2147	2185	2236
TR-6	Eagle Butte	920566	2043	2087	2109	2149	2102	2124	2159	2288
TR-6	Eagle Butte	920567	2058	2102	2123	2153	2098	2124	2146	2227
TR-6	Eagle Butte	920568	2061	2091	2107	2115	2105	2205	2269	2377
TR-6	Ill. No. 6	920569	1988	2049	2224	2241	2209	2250	2285	2351
TR-6	Ill. No. 6	920570	1964	2027	2130	2227	2208	2213	2310	2396

Table B.1.2 (continued) Coal Ash Fusion Temperature, °F)

Test Run	Coal Type	FWID No.	Reduction				Oxidation			
			Initial Deformation	Soft Temp. Spherical	Soft Temp. Hemispherical	Fluid Temp.	Initial Deformation	Soft Temp. Spherical	Soft Temp. Hemispherical	Fluid Temp.
TR-8	Eagle Butte	920894	2084	2121	2135	2151	2106	2122	2139	2145
TR-8	Eagle Butte	920895	2038	2078	2092	2115	2118	2148	2168	2215
TR-8	Ill. No. 6	920897	2043	2152	2279	2321	2189	2324	2421	2488
TR-8	Ill. No. 6	920898	1998	2072	2149	2248	2248	2269	2344	2425
TR-8	Pitt. No. 8	920899	1971	2051	2104	2279	2007	2073	2226	2290
TR-8	Pitt. No. 8	920900	1998	2015	2046	2100	2016	2026	2055	2089
TR-8	Pitt. No. 8	920901	2019	2086	2129	2272	2025	2107	2177	2271
TR-10	Pitt. No. 10	921196	2021	2112	2223	2307	2370	2390	2419	2487
TR-10	Pitt. No. 10	921197	2085	2118	2232	2325	2425	2462	2462	2464
TR-10	Pitt. No. 10	921198	2082	2113	2242	2325	2438	2439	2481	2506
TR-10	Pitt. No. 10	921199	2045	2123	2217	2340	2397	2430	2455	2499

**Table B.1.3A Typical Pittsburgh No. 8 Coal Size Distribution
Nominal 3/16 In.—Bag No. 1 (F.W.I.D. No. 910493)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
No. 4	4760	25.39	74.61
No. 8	2380	23.90	50.70
No. 16	1190	16.47	34.24
No. 30	595	11.40	22.83
No. 50	297	8.67	14.16
No. 100	149	4.83	9.33
No. 200	74	3.76	5.58
No. 325	44	1.85	3.73
-325	00	3.73	0.00

**Table B.1.3B Typical Pittsburgh No. 8 Coal Feed Size Distribution
Nominal 3/16 In.—Bag No. 2 (F.W.I.D. No. 910494)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
No. 4	4760	28.36	71.64
No. 8	2380	22.60	49.04
No. 16	1190	14.69	34.35
No. 30	595	10.74	23.61
No. 50	297	8.53	15.08
No. 100	149	5.29	9.79
No. 200	74	3.78	6.02
No. 325	44	1.84	4.18
-325	00	4.18	0.00

**Table B.1.3C Typical Pittsburgh No. 8 Coal Feed Size Distribution
Nominal 3/16 In.—Bag No. 3 (F.W.I.D. No. 910495)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
No. 4	4760	33.27	66.73
No. 8	2380	21.75	44.99
No. 16	1190	13.13	31.86
No. 30	595	9.79	22.08
No. 50	297	8.20	13.87
No. 100	149	4.95	8.92
No. 200	74	3.76	5.16
No. 325	44	1.82	3.34
-325	00	3.34	0.00

**Table B.1.3D Typical Pittsburgh No. 8 Coal Feed Size Distribution
Nominal 3/16 In.—Bag No. 4 (F.W.I.D. No. 910496)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
No. 4	4760	26.59	73.41
No. 8	2380	22.42	50.99
No. 16	1190	16.28	34.71
No. 30	595	10.49	24.21
No. 50	297	7.88	16.33
No. 100	149	4.89	11.44
No. 200	74	4.00	7.44
No. 325	44	2.07	5.37
-325	00	5.37	0.00

**Table B.1.3E Typical Pittsburgh No. 8 Coal Feed Size Distribution
Nominal 3/16 In.—Bag No. 5 (F.W.I.D. No. 910497)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
No. 4	4760	0.00	100.00
No. 8	2380	18.35	81.65
No. 16	1190	21.80	59.85
No. 30	595	17.78	42.07
No. 50	297	15.79	26.28
No. 100	149	10.73	15.55
No. 200	74	7.90	7.65
No. 325	44	3.33	4.32
-325	00	4.32	0.00

**Table B.1.3F Typical Pittsburgh No. 8 Coal Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 911022)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
5/16 In.	8000	0.00	100.00
1/4 In.	6300	0.00	100.00
No. 4	4760	2.54	97.46
No. 6	3350	8.06	89.40
No. 8	2380	11.38	78.03
No. 12	1700	10.60	67.42
No. 14	1400	8.44	58.97
No. 16	1190	6.43	52.55
No. 18	1000	8.01	44.54
No. 20	850	6.05	38.50
No. 25	710	5.97	32.53
No. 30	595	5.36	27.17
No. 50	297	16.43	10.74
No. 100	149	5.80	4.95
No. 140	105	1.38	3.57
No. 200	74	0.76	2.81
No. 325	44	0.64	2.16
-325	00	2.16	0.00

**Table B.1.36 Typical Pittsburgh No. 8 Coal Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 920899)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
5/16 In.	8000	0.00	100.00
1/4 In.	6300	0.00	100.00
No. 4	4760	5.78	94.22
No. 6	3350	13.77	80.46
No. 8	2380	15.90	64.56
No. 12	1700	14.12	50.44
No. 14	1400	5.08	45.36
No. 16	1190	6.31	39.05
No. 18	1000	3.26	35.79
No. 20	850	6.05	29.73
No. 25	710	3.78	25.96
No. 30	595	3.51	22.45
No. 50	297	9.74	12.71
No. 100	149	6.78	5.92
No. 140	105	2.16	3.76
No. 200	74	1.55	2.21
No. 325	44	0.09	2.12
-325	00	2.12	0.00

**Table B.1.3H Typical Illinois No. 6 Coal Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 920897)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
5/16 In.	8000	0.00	100.00
1/4 In.	6300	0.00	100.00
No. 4	4760	0.05	99.95
No. 6	3350	0.35	99.60
No. 8	2380	1.71	97.89
No. 12	1700	3.90	93.99
No. 14	1400	2.56	91.43
No. 16	1190	4.23	87.20
No. 18	1000	2.58	84.63
No. 20	850	6.84	77.78
No. 25	710	5.46	72.33
No. 30	595	5.85	66.47
No. 50	297	23.52	42.96
No. 100	149	20.47	22.48
No. 140	105	7.04	15.44
No. 200	74	5.25	10.20
No. 325	44	3.09	7.11
-325	00	7.11	0.00

**Table B.1.3I Typical Eagle Butte Feed Coal Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 920894)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
5/16 In.	8000	0.00	100.00
1/4 In.	6300	0.00	100.00
No. 4	4760	0.11	99.89
No. 6	3350	0.36	99.53
No. 8	2380	3.81	95.72
No. 12	1700	9.59	86.13
No. 14	1400	5.19	80.94
No. 16	1190	8.03	72.91
No. 18	1000	4.40	68.51
No. 20	850	9.60	58.91
No. 25	710	6.75	52.16
No. 30	595	6.47	45.70
No. 50	297	20.88	24.82
No. 100	149	15.02	9.80
No. 140	105	7.94	1.85
No. 200	74	0.51	1.34
No. 325	44	0.61	0.74
-325	00	0.74	0.00

Table B.1.4A Typical Feed Coal Ash Chemistry—Pittsburgh No. 8

Element as Oxide	Weight Percent		
	F.W.I.D. No. 920899	F.W.I.D. No. 920900	F.W.I.D. No. 920911
SiO ₂	42.2	43.8	40.5
Al ₂ O ₃	20.5	21.3	22.5
TiO ₂	1.0	1.0	1.0
Fe ₂ O ₃	31.9	28.1	29.9
CaO	1.2	2.0	2.3
MgO	0.5	0.6	0.8
Na ₂ O	0.3	0.2	0.2
K ₂ O	1.4	1.6	1.5
SO ₃	1.0	1.3	1.3
P ₂ O ₅	---	0.1	---

Table B.1.4B Typical Feed Coal Ash Chemistry—Illinois No. 6

Element as Oxide	Weight Percent	
	F.W.I.D. No. 920897	F.W.I.D. No. 920898
SiO ₂	49.1	49.6
Al ₂ O ₃	23.4	21.2
TiO ₂	1.1	1.0
Fe ₂ O ₃	16.1	15.5
CaO	4.5	6.0
MgO	1.0	1.0
Na ₂ O	0.4	0.4
K ₂ O	2.1	2.2
SO ₃	2.2	3.0
P ₂ O ₅	0.1	0.1

Table B.1.4C Typical Feed Coal Ash Chemistry—Wyoming Eagle Butte

Element as Oxide	Weight Percent		
	F.W.I.D. No. 920894	F.W.I.D. No. 920895	F.W.I.D. No. 920896
SiO ₂	29.4	33.8	34.5
Al ₂ O ₃	16.8	18.7	18.4
TiO ₂	1.3	1.3	1.3
Fe ₂ O ₃	7.6	10.3	10.2
CaO	23.3	17.7	17.1
MgO	4.7	3.9	3.4
Na ₂ O	0.8	0.7	0.6
K ₂ O	0.4	0.8	0.9
SO ₃	15.1	12.3	13.1
P ₂ O ₅	0.6	0.5	0.4

Table B.1.5 Typical Coke Analysis—Tulsa

Description	F.W.I.D.	
	No. 911019	No. 910471
Proximate Analysis, Weight Percent (As Received)		
Fixed Carbon	83.96	83.63
Vol. Matter	14.97	15.26
Ash	0.94	0.87
Moisture	0.13	0.24
Ultimate Analysis, Weight Percent (As Received)		
Carbon	89.89	90.94
Hydrogen	4.42	4.47
Oxygen	0.73	0.00
Nitrogen	2.30	1.74
Sulfur	1.59	1.74
Ash	0.94	0.87
Moisture	0.13	0.24
HHV, Btu/lb	15,743	15,645
Elemental Ash Analysis, Weight Percent		
Ni as NiO	1.5	---
V as V ₂ O ₅	4.5	---
Zn as ZnO	0.7	---
Pb as PbO	0.2	---
Bulk Density, g/ml	0.77	0.76
FSI	---	2

Table B.1.6A Typical Tulsa Coal Feed Size Distribution (F.W.I.D. No. 911019)

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
5/16 In.	8000	1.69	98.31
1/4 In.	6300	0.27	98.04
No. 4	4760	0.00	98.04
No. 6	3350	0.02	98.02
No. 8	2380	7.73	90.29
No. 12	1700	12.08	78.21
No. 14	1400	7.36	70.85
No. 16	1190	5.41	65.44
No. 18	1000	7.07	58.37
No. 20	850	4.10	54.27
No. 25	710	4.35	49.92
No. 30	595	3.65	46.27
No. 50	297	15.96	30.31
No. 100	149	10.09	20.22
No. 140	105	6.14	14.08
No. 200	74	9.21	4.87
No. 325	44	2.20	2.67
-325	00	2.67	0.00

**Table B.1.6B Typical Tulsa Coal Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 910471)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
No. 4	4760	0.00	100.00
No. 8	2380	5.60	94.40
No. 16	1190	17.63	76.77
No. 30	595	19.58	57.19
No. 50	297	19.16	38.03
No. 100	149	14.20	23.82
No. 200	74	15.79	8.03
No. 325	44	6.88	1.15
-325	00	1.15	0.00

Table B.1.7 Pyritic Sulfur Range Summary

Coal Type	Percent Sulfur as Pyritic Sulfur
Pittsburgh No. 8	60 to 70
Illinois No. 6	30 to 40
Wyoming Eagle Butte	15 to 20

B.2 SORBENTS

Plum Run dolomite purchased from the Highland Stone Div. of Davon Inc. in Hillsboro, Ohio, and Longview limestone from Longview Lime Co. in Saginaw, Alabama, were the sorbents used in the carbonizer test program. These particular sorbents were selected for testing because the former is being used in the American Electric Power Science Corporation's first generation PFB Tidd Plant and the latter will be used in the Southern Company Service's Power System Development Facility in Wilsonville, Alabama. Component analyses for all sorbent samples taken during each setpoint period are provided in **Section 3**. Typical data including a more definitive analysis and a component breakdown of the ash, are shown for Plum Run Dolomite in Table B.2.1A and Longview Alabama Limestone in Table B.2.1B.

Typical feed size distributions are tabulated in Tables B.2.2A through D for Plum Run Dolomite and in Tables B.2.2E through H for Longview Alabama Limestone. A listing of bulk density measurements made for several Plum Run Dolomite samples is provided in Table B.2.3.

Table B.2.1A Typical Sorbent Chemistry—Plum Run Dolomite

Element as Oxide	Weight Percent								
	F.W.I.D. No.								
	920347	920348	920349	920350	920351	920352	920893	921431	921432
SiO ₂	---	---	---	---	---	---	---	---	---
Al ₂ O ₃	---	---	---	---	---	---	0.3	0.7	0.6
TiO ₂	---	---	---	---	---	---	---	---	---
Fe ₂ O ₃	1.0	1.0	1.0	1.0	1.1	1.1	0.8	0.7	0.7
CaO	58.0	57.6	57.0	54.8	56.8	57.5	60.3	60.8	60.2
MgO	40.0	40.5	41.0	43.2	41.1	40.3	37.4	36.6	37.2
Na ₂ O	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.3
K ₂ O	---	---	---	---	---	---	---	---	---
SO ₃	0.8	0.7	0.8	0.8	0.8	0.9	1.1	1.0	1.0
P ₂ O ₅	0.1	0.1	0.1	0.1	0.1	---	---	---	---

Table B.2.1B Typical Sorbent Chemistry—Longview Alabama Limestone

Element as Oxide	Weight Percent								
	F.W.I.D. No.								
	920571	920572	920573	920574	920888	920889	920890	921891	921892
SiO ₂	0.7	---	0.7	0.2	---	---	---	0.1	---
Al ₂ O ₃	0.5	0.4	0.5	0.2	0.2	---	0.2	0.2	0.2
TiO ₂	---	---	---	---	---	---	---	---	---
Fe ₂ O ₃	0.5	0.4	0.5	0.5	---	---	---	0.1	0.1
CaO	95.1	97.4	96.1	97.0	97.5	98.1	97.5	96.8	95.7
MgO	2.2	1.1	1.3	1.2	1.5	1.1	1.4	1.9	3.1
Na ₂ O	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
K ₂ O	---	---	---	---	---	---	---	---	---
SO ₃	0.7	0.5	0.7	0.7	0.7	0.7	0.8	0.8	0.8
P ₂ O ₅	0.1	0.1	0.1	0.1	---	---	---	---	---

**Table B.2.2A Typical Plum Run Dolomite Sorbent Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 910914)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.49	99.51
3/8 In.	9525	0.00	99.51
No. 4	4760	8.02	91.49
No. 8	2380	56.67	34.82
No. 16	1190	26.66	8.16
No. 30	595	2.15	6.02
No. 50	297	0.28	5.74
No. 100	149	0.65	5.08
No. 200	74	1.20	3.88
No. 325	44	1.05	2.83
-325	00	2.83	0.00

**Table B.2.2B Typical Plum Run Dolomite Sorbent Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 910915)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
No. 4	4760	0.11	99.89
No. 8	2380	9.58	90.32
No. 16	1190	50.66	39.66
No. 30	595	32.42	7.24
No. 50	297	6.78	0.47
No. 100	149	0.15	0.32
No. 200	74	0.11	0.21
No. 325	44	0.13	0.09
-325	00	0.09	0.00

**Table B.2.2C Typical Plum Run Dolomite Sorbent Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 910916)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
No. 4	4760	0.92	99.08
No. 8	2380	22.36	76.72
No. 16	1190	54.37	22.35
No. 30	595	18.97	3.38
No. 50	297	2.50	0.87
No. 100	149	0.19	0.68
No. 200	74	0.09	0.60
No. 325	44	0.07	0.53
-325	00	0.53	0.00

**Table B.2.2D Typical Plum Run Dolomite Sorbent Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 910917)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
No. 4	4760	0.00	100.00
No. 8	2380	5.91	94.08
No. 16	1190	28.06	66.03
No. 30	595	25.43	40.60
No. 50	297	22.51	18.08
No. 100	149	10.43	7.66
No. 200	74	3.97	3.68
No. 325	44	1.43	2.25
-325	00	2.24	0.00

**Table B.2.2E Typical Longview Alabama Limestone Sorbent Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 920571)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
5/16 In.	8000	0.00	100.00
1/4 In.	6300	8.40	91.60
No. 4	4760	17.61	73.99
No. 6	3350	11.37	62.62
No. 8	2380	4.86	57.77
No. 12	1700	2.95	54.82
No. 14	1400	0.78	54.04
No. 16	1190	1.74	52.30
No. 18	1000	0.91	51.39
No. 20	850	2.62	48.77
No. 25	710	2.00	46.76
No. 30	595	2.38	44.38
No. 50	297	9.94	34.44
No. 100	149	13.10	21.34
No. 140	105	6.88	14.46
No. 200	74	6.81	7.65
No. 325	44	6.16	1.49
-325	00	1.49	0.00

**Table B.2.2F Typical Longview Alabama Limestone Sorbent Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 920572)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
5/16 In.	8000	0.00	100.00
1/4 In.	6300	0.59	99.41
No. 4	4760	4.29	95.12
No. 6	3350	25.68	69.44
No. 8	2380	12.86	56.58
No. 12	1700	7.87	48.71
No. 14	1400	2.11	46.60
No. 16	1190	4.29	42.31
No. 18	1000	1.96	40.35
No. 20	850	6.49	33.86
No. 25	710	4.24	29.62
No. 30	595	4.32	25.30
No. 50	297	14.01	11.29
No. 100	149	8.66	2.63
No. 140	105	1.19	1.44
No. 200	74	0.49	0.95
No. 325	44	0.47	0.48
-325	00	0.48	0.00

**Table B.2.2G Typical Longview Alabama Limestone Sorbent Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 920573)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
5/16 In.	8000	0.00	100.00
1/4 In.	6300	0.15	99.85
No. 4	4760	1.19	98.66
No. 6	3350	8.81	89.85
No. 8	2380	6.60	83.25
No. 12	1700	5.01	78.25
No. 14	1400	1.71	76.54
No. 16	1190	3.52	73.02
No. 18	1000	1.60	71.42
No. 20	850	6.04	65.38
No. 25	710	4.71	60.66
No. 30	595	5.17	55.49
No. 50	297	19.34	36.15
No. 100	149	21.29	14.86
No. 140	105	6.65	8.20
No. 200	74	4.68	3.53
No. 325	44	1.40	2.13
-325	00	2.13	0.00

**Table B.2.2H Typical Longview Alabama Limestone Sorbent Feed Size Distribution
Nominal 1/8 In. (F.W.I.D. No. 920574)**

Screen	Microns	Percent On	Percent Thru
3 In.	76200	0.00	100.00
2-1/2 In.	63500	0.00	100.00
2 In.	50800	0.00	100.00
1-1/2 In.	38100	0.00	100.00
1-1/4 In.	31750	0.00	100.00
1 In.	25400	0.00	100.00
3/4 In.	19050	0.00	100.00
1/2 In.	12700	0.00	100.00
3/8 In.	9525	0.00	100.00
5/16 In.	8000	0.00	100.00
1/4 In.	6300	0.33	99.67
No. 4	4760	2.07	97.61
No. 6	3350	13.91	83.70
No. 8	2380	8.99	74.71
No. 12	1700	5.82	68.90
No. 14	1400	1.78	67.12
No. 16	1190	3.46	63.66
No. 18	1000	2.33	61.33
No. 20	850	4.96	56.37
No. 25	710	4.56	51.82
No. 30	595	4.52	47.29
No. 50	297	17.92	29.37
No. 100	149	14.60	14.77
No. 140	105	3.86	10.91
No. 200	74	5.80	5.11
No. 325	44	3.37	1.74
-325	00	1.74	0.00

Table B.2.3 Typical Sorbent Bulk Density-Plum Run Dolomite

F.W.I.D. No.	Size (Nominal)	Bulk Density g/ml
910318	1/8 In.	1.44
920075	1/8 In.	1.59
920076	1/8 In.	1.59
920077	1/8 In.	1.60