A minerals and materials contract report
MARCH 1985

DOE/ET/10205--T1-Vol.5

DE86 010830

FIXED-BED GASIFICATION RESEARCH USING U.S. COALS, VOLUME 5 GASIFICATION OF STAHLMAN STOKER BITUMINOUS COAL

Contract H0222001

Black, Sivalls, and Bryson, Incorporated

BUREAU OF MINES
UNITED STATES DEPARTMENT OF THE INTERIOR

This document is
PUBLICLY RELEASABLE

Sam Steeb
Authorizing Official

Date: 2-23-07

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No.
4. Title and Subtitle Fixed-Bed Gasification Research Using U.S. Coals, Volume 5, Gasification of Stahlman Stoker Bituminous Coal			5. Report Date March 31, 1985
7. Author(s) David Thimsen, Rolf E. Maurer, Albert R. Pooler, David Pui, Ben Liu, David Kittelson			8. Performing Organization Rept. No. BSB-ES-8504
9. Performing Organization Name and Address Black, Sivalis & Bryson, Incorporated BS&B Energy Systems 7324 Southwest Freeway Houston, TX 77074			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) H0222001 (G)
12. Sponsoring Organization Name and Address U.S. Department of the Interior Bureau of Mines P. O. Box 1660 Twin Cities, MN 55111			13. Type of Report & Period Covered Contract Report
14.			
15. Supplementary Notes This research was partially funded by U.S. DOE under Interagency Agreement No. DE-A121-7ET10205.			
16. Abstract (Limit 200 words) A single-staged, fixed-bed Wellman-Galusha gasifier coupled with a hot, raw gas combustion system and scrubber has been used to gasify numerous coals from throughout the United States. The gasification test program is organized as a cooperative effort by private industrial participants and governmental agencies. The consortium of participants is organized under the Mining and Industrial Fuel Gas (MIFGa) Group. This report is the fifth volume in a series of reports describing the atmospheric pressure, fixed-bed gasification of U.S. coals. This specific report describes the gasification of Stahlman Stoker bituminous coal from Clarion county, PA. The period of the gasification test was April 30 to May 4, 1983.			
17. Document Analysis a. Descriptors Fixed-bed gasification, alternate fuels, coal gasification, Wellman-Galusha, Stahlman Stoker bituminous coal b. Identifiers/Open-Ended Terms MIFGA, Wellman-Galusha c. COSATI Field/Group			
18. Availability Statement Unlimited		19. Security Class (This Report) Unclassified	21. No. of Pages 106
		20. Security Class (This Page) Unclassified	22. Price

MASTER

FOREWORD

This report was prepared by Black, Sivalls, and Bryson, Inc., Houston, Texas under USBM contract number H0222001. The contract was administered under the technical direction of the Twin Cities Research Center with Mr. Robert Zahl acting as Technical Project Officer. Mr. Frank Pavlich was the contract administrator for the Bureau of Mines. This report is a partial summary of the work recently completed as a part of this contract during the period June 1982 to May 1984. This final report was submitted by the authors on March 31, 1985.

Funding for this contract was through USBM/USDOE Interagency Agreement DE-A121-7ET10205.

The University of Minnesota, Particle Technology Laboratory, Minneapolis, Minnesota, a subcontractor to Black, Sivalls, and Bryson, Inc., participated in preparation of this report.

The Stahlman Stoker bituminous coal gasified during the operations described here was donated by C & K Coal Company, Clarion, Pennsylvania.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

FIGURES

- 3-1 Location of Stahlman Stoker Mine
- 4-1 Coal Gasifier Process Flow Schematic, U.S. Bureau of Mines, Twin Cities Research Center.
- 4-2 Schematic Diagram of the Gas Sampling and Conditioning System
- 7-1 Physical Characteristics of the Gasifier Operation.
- 7-2 Feed Coal Size Distribution Analysis
- 7-3 Geometrical Mean Coal Particle Size
- 7-4 Ash Size Distribution Analysis
- 7-5 Geometrical Mean Ash Particle Size
- 7-6 Ash Characteristics and Operating Conditions
- 7-7 Major Gas Species Measured by the Gas Chromatograph.
- 7-8 Minor Gas Species Measured by the Gas chromatograph.
- 7-9 Dry gas HHV, Major Gas Species and Gasifier Operational Parameters.
- 7-10 Tar/Oil Yield and Water Yield with Operating Conditions
- 7-11 Comparison of the Geometrical Grate Performance Model with Daily Average Ash Removal Rates.
- 7-12 Tar/oil Yield - Volatile Matter-Oxygen Correlation
- 7-13 Tar/oil Yield - Volatile BTU Correlation

INTRODUCTION

The United States Department of Interior, Bureau of Mines, Twin Cities Research Center, Minneapolis, Minnesota is the site of a 6.5 foot diameter Wellman-Galusha gasifier, installed in 1977-78. This gasifier, combustor/incinerator, and flue gas scrubber system in the past had been operated jointly by Bureau of Mines personnel, personnel from member companies of the Mining and Industrial Fuel Gas Group (MIFGa), and United States Department of Energy (DOE) personnel-consultants. Numerous tests using a variety of coals have to date been performed.

In May of 1982, Black, Sivalls & Bryson, Incorporated (BS&B) was awarded the contract to plan, execute, and report gasification test performance data from this small industrial fixed-bed gasification test facility. BS&B is responsible for program administration, test planning, test execution, and all documentation of program activities and test reports. The University of Minnesota, Particle Technology Laboratory (UMPTL) is subcontractor to BS&B to monitor process parameters, and provide analysis for material inputs and outputs.

This report is the fifth volume in a series of reports describing the fixed-bed gasification of U.S. coals at the Bureau of Mines, Twin Cities Research Center. This report covers the test period identified as BOM/FGT-004, gasification of Stahlman Stoker bituminous coal. The time period covered is April 30 - May 4, 1983.

Section 1 gives a brief summary of test. Section 2 identifies test objectives. Section 3 contains a description of the fuels. Sections 4 and 5 describe the facility and monitoring systems. Sections 6 and 7 describe the conduct and results of the tests. Section 8 presents conclusions. Test data is included in the Appendices.

TABLE OF CONTENTS

	Tables.....	6
	Figures.....	7
	Introduction.....	8
Section 1	Test Summary.....	9
Section 2	Test Objectives	
2.1	Selection of Coal to be Tested.....	11
2.2	Test Objectives.....	11
2.3	Test Plan.....	11
Section 3	Description of Fuel Tested.....	12
Section 4	Facility Description	
4.1	Test Facility.....	16
4.2	Gas Sampling and Conditioning System.....	16
4.3	Gas Analysis Equipment.....	19
Section 5	Test Procedures	
5.1	Test Teams.....	21
5.2	Sampling, Analysis and Data Acquisition Procedures.....	22
Section 6	Conduct of Test.....	24
Section 7	Test Results	
7.1	Data Summary	
7.1.1	Continuous Output Transducer Data..	27
7.1.2	Coal, Ash, and Cyclone Dust.....	27
7.1.3	Gas Analysis Data.....	38
7.1.4	Tar and Water Yield Data.....	38
7.2	Grate Performance Model.....	42
7.3	Material Balance and Thermal Efficiency Calculations.....	42
7.4	Tar/oil yield Correlations.....	46
Section 8	Conclusions and Recommendations.....	51
	References.....	53
	Appendices.....	55

TABLES

- 1-1 Maximum Throughput Operating Characteristics for Gasification of Stahlman Stoker Coal
- 3-1 Average Analysis of Stahlman Stoker Coal
- 3-2 Characteristics of Stahlman Stoker coal with Regard to the Coal Test Objective Matrix.
- 4-1 Principle features of the HP 5880A Gas chromatograph.
- 7-1 Summary of Coal, Ash, and Cyclone Dust Analyses Performed
- 7-2 Physical and Chemical Properties of Coal and Cyclone Dust
- 7-3 Chemical Analyses of Moisture-free Ash
- 7-4 Condensed Material Analyses
- 7-5 Material Balance and Thermal Efficiency Calculation
.49 tn/hr
- 7-6 Material Balance and Thermal Efficiency Calculation
Stahlman Stoker Overall Average

SECTION 1

TEST SUMMARY

The Stahlman Stoker bituminous coal gasified during BOM/FGT-004 is a high-swelling western Pennsylvania coal. Testing of this coal expands the fixed-bed gasification data base with regard to highly swelling coals. The coal is a low-moisture, low-ash, high-ash fusion temperature coal typical of the high-swelling eastern U. S. coals.

The testing of Stahlman Stoker bituminous coal involved gasification of the coal in a 6.5 foot I.D. Wellman-Galusha atmospheric pressure, air-blown, fixed-bed gas producer equipped with an internal agitator to control coal agglomeration. The hot, raw gas was partially cleaned of dust in a cyclone and incinerated in a cylindrical combustion chamber. The products of combustion were quenched and cleaned of particles and sulfur dioxide in a wet caustic scrubber.

The coal gasified poorly. Only modest throughputs were achievable due to excessive channeling. This was primarily due to agglomeration of the coal into large masses through which gas could not move. The agitator with which the retort is equipped was not able to successfully control coal agglomeration. Gas quality was poor due to the short gas residence time caused by channeling through relatively small cross sections.

Dry gas higher heating value was approximately 100 BTU/dscf during the relatively steady periods of operation. Gas analysis indicated incomplete reduction of the combustion zone products due to insufficient residence time. Table 1-1 gives the performance of this coal at the highest achieved coal throughput.

This coal is not recommended as a deep, fixed-bed gasifier feedstock with the existing agitator design due to limited throughput and low gas quality observed during this test.

Table 1-1

Design Point Characteristics for Gasification
of Stahlman Stoker BituminousxCoal

Coal Throughput - .49 tons/hour (29.5 lb/hr/sq ft grate)		
Air/Coal	4.44	lb/lb
Steam/Coal	.721	lb/lb
Blast Saturation Temperature	141	deg F
Gas Offtake Temperature	1033	deg F
Wet Gas/Coal	92.9	scf/lb
Gas Dewpoint	135	deg F
Tar Yield	4.4	lb/100lb coal
Tar Analysis		
HHV (dry)	12905	Btu/lb
Pourpoint	45	deg F
Viscosity (210 F)	91.0	SUS
Specific Gravity (60/60 F)	1.1033	
Dry Gas Composition (mol%)		
Hydrogen	12.4	
Carbon Monoxide	13.4	
Methane	1.28	
Ethane	0.081	
Ethylene	0.162	
Propane	0.020	
Propylene	0.030	
Carbon Dioxide	12.57	
Nitrogen	59.1	
Water	9.65	lb/1000 dscf
Dry Gas HHV	102	Btu/dscf
Dry Gas LHV	94	Btu/dscf
Thermal Efficiencies		
Hot, Raw	82 %	
Cold, with Tar	63 %	
Cold, without Tar	59 %	

SECTION 2

TEST OBJECTIVES

2.1 Selection of Coal to be Tested

Stahlman Stoker bituminous coal is typical of the highest swelling western Pennsylvania coals. Its free swelling index was indicated to be 8 1/2 or greater. The highly agglomerating characteristics of these types of coals present potentially critical problems with regard to air flow distribution in the retort when using the coal as a fixed-bed gasifier fuel. The preliminary coal analysis indicated very high ash fusion temperatures (+2700 F) minimizing potential clinkering problems. This coal was donated to the program by C & K coal company double screened at 1 inch x 3/8 inch.

2.2 Test Objectives

- A. Evaluate the suitability of a highly agglomerating coal (FSI = 8 1/2) for gasification in a deep, fixed-bed gasifier with agitation.
- B. Determine preliminary gasifier performance (including throughput and conversion efficiency) gasifying this highly agglomerating coal.
- C. Identify operational requirements for gasifying highly agglomerating coals.

2.3 Test Plan

This test was limited to gasification of a 100 ton delivery of this coal, and was to serve as a screening test. If the screening test showed acceptable performance, a longer test would be undertaken. The coal throughput was to be maintained near 1 ton per hour for the entire test. Variations in blast saturation temperature (steam/air ratio), agitator speed and vertical travel, and coal screen size were left to the facility manager's judgment based on conditions observed during the test. Ash depth was to be maintained at 12 inches plus or minus 3 inches.

The spacings between the three grate levels were unchanged from BOM/FGT-003, gasification of Leucite Hills subbituminous coal, and were 6 inches plus or minus 1/8 inch for both spacings.

SECTION 3

DESCRIPTION OF FUEL TESTED

The Stahlman Stoker bituminous coal tested during BOM/FGT-004 is a highly-swelling, high-volatile A bituminous coal. The coal is strip mined from the Kittaning seam in Clarion County, Pennsylvania as indicated in Figure 3-1. The coal is blended from mines at several locations. Mine reserves are greater than 50,000,000 tons with annual production greater than 1,500,000 tons. The total mine output is currently used as steam coal.

The coal is routinely washed and double screened at 1 3/4 inch by 3/8 inch. The coal gasified during BOM/FGT-004 was so treated. Approximately 100 tons of the coal was shipped by rail from Corsica, Pennsylvania on April 20, 1983. It arrived in the Twin Cities and was transported by truck to the test site on April 27.

A complete analysis of the coal is given in Table 3-1. The results shown are for analysis of one sample composited from individual samples collected over the test period. Table 3-2 shows how the coal fits into the coal test objective matrix.

The coal held together well during transportation and handling.

Contact for this coal is:

C & K Coal Company
PO Box 69
Clarion, Pennsylvania 16214
(814) 226-6911

Table 3-2

Characteristics of Stahlman Stoker Coal with regard to the
Coal Test Objective Matrix

COAL TEST OBJECTIVE MATRIX									
PHYSICAL CHARACTERISTICS		COAL RANK							
TYPE	RANGE	BITUMINOUS	SUB - BITUMINOUS			LIGNITE	PEAT/BIO MASS	PETROLEUM COKE	BRIQUETTES
			A	B	C				
ASH CONTENT	H + 20%								
	M 10 - 20%								
	L - 10%	004							
ASH FUSION	H + 2700 F	004							
	M 2300-2700 F								
	L - 2300 F								
FREE SWELLING INDEX	H 3 +	004							
	M 1 - 3								
	L 0 - 1								
MOISTURE CONTENT	H + 15%								
	M 5 - 15%								
	L - 5%	004							
FRIABILITY (GRINDABILITY)	H								
	M								
	L	004							

SECTION 4

FACILITY DESCRIPTION

The USBM/TCRC gasification facility is described in detail in Volume 1 of this series (Thimsen, Maurer et al, 1984). A brief description of the equipment and monitoring systems is given here.

4.1 Test Facility

The gasification test facility includes a 6.5 foot diameter Wellman-Galusha gas producer, a combustion chamber and a wet caustic scrubber. The site also includes an iron ore pelletizing kiln which was not used during this test. The entire stream of producer gas was consumed in the combustion chamber. A process flow schematic is shown in Figure 4-1. A bottom size screen removes fine material prior to transport to the overhead storage bin by bucket elevator.

The facility is equipped with standard industrial monitoring equipment for measurement of temperatures, pressures, flows, and process conditions. These are recorded by an automatic data acquisition system for subsequent process analysis.

4.1.1 Gas Producer

The gas producer is a 6.5 foot ID Wellman-Galusha, single-staged, fixed-bed, atmospheric pressure gasifier. The gasifier has a gravity fuel feed system, a water-cooled agitator, and an eccentric step type grate for ash removal. The retort is water jacketed and has no refractory lining. Steam generated in the water jacket is mixed with blast air. Steam/air ratio in the blast is measured and controlled by the temperature of the saturated steam/air mixture. Steam is imported if that generated in the water jacket is not adequate.

4.1.2 Gas Combustor

The gas combustor includes a baffle burner and a refractory-lined combustion chamber, and is designed to burn the full gas output of the gasifier at a rated capacity of 30 MMBTU/hour. The combustion products exhaust through an impingement tray-type wet caustic scrubber for sulfur dioxide and particulate removal. An induced draft fan is used to exhaust the scrubbed products of combustion through a flue stack.

4.2 Gas Sampling and Conditioning System

Figure 4-2 is a schematic of the gas sampling and conditioning system. The sampling port is thermally insulated to prevent condensation. The hot producer gas is quenched rapidly upon

Figure 3-1
Location of Stahlman Stoker Mine

Table 3-1

Average Analysis of Stahlman Stoker Bituminous Coal

Proximate Analysis (%)		
Volatile Matter		31.73
Fixed Carbon		56.94
Ash		8.07
Moisture		3.25
Sulfur		0.97
Heating Value (Btu/lb)		13355
Ultimate Analysis (%)		
Carbon		74.22
Hydrogen		4.99
Nitrogen		1.45
Sulfur		0.97
Oxygen		6.55
Ash		8.07
Moisture		3.25
Ash Fusion Temperatures (deg F):		
	Oxidizing	Reducing
Initial deformation	2790	2725
Softening	+2800	+2800
Hemispherical	--	--
Fluid	--	--
Free Swelling Index:	8 1/2	

Figure 4-1

Coal Gasifier Process Flow Schematic
U.S. Bureau of Mines, Twin Cities Research Center

Figure 4-2

Schematic Diagram of the Gas Sampling and Conditioning System

sample is determined from milled samples submitted by the monitoring team to the USBM Twin Cities Research Center Laboratories. The ash samples on which detailed analyses are performed by the USBM Twin Cities Research Center are composited over the same time periods used for compositing the coal samples.

5.2.6 Dust Data

Samples of cyclone dust are grabbed from the dust accumulation bin. Samples of duct dust are removed from an access port near a right angle turn in the main gas duct where the dust accumulates.

SECTION 6

CONDUCT OF THE TEST

BOM/FGT-004, gasification of Stahlman Stoker bituminous coal, began at 8:00 am April 30, 1983. At this time the retort was full of Leucite Hills subbituminous coal, and BOM/FGT-003 was concluding. The Stahlman Stoker coal, screened at a bottom size of 1/2 inch, entered the retort at 9:00 am and fully occupied the retort by about 2:00 pm. Saturation air flow at this point was 1100 cfm with a blast saturation temperature of 138 F (59 C). The agitator was set for a vertical travel from 36 inches to 40 inches below the top of the retort access ports (RAP) at a sweep rate of 7 sweeps per hour (3.5 rph).

During the period that the Leucite Hills coal was being displaced by the Stahlman Stoker the following observations were noted: 1.) A crust formed on the top of the retort at all poke hole locations. The crust could be easily broken by poking, but could not be permanently removed. 2.) Fire loss pressure increased from 12 in wg to more than 22 in wg. 3.) Saturation temperature became difficult to control. Water rate through the jacket had to be increased beyond 30 gpm to bring the blast saturation temperature down to desired levels. 4.) The distance from the top of the coal bed to the RAP tops decreased steadily from 39 inches to 23 inches indicating expansion of the coal bed upwards. 5.) The dry gas higher heating value decreased from 170 BTU/scf to less than 40 BTU/scf.

At 2:00 pm the gas quality was so low that the main flame in the combustion chamber went out. The saturation air flow was set at 400 scfm while the product gas was exhausted through the flare. One attempt to relight the combustor at 4:00 pm was unsuccessful. A second attempt at 5:15 was successful, but gas quality was still very low (approximately 60 Btu/dscf). During the 3 hours that the combustor was shut down the agitator was maintained at 7 sweeps per hour resulting in the coal bed rising to 18 inches below the RAP tops at 5:30 pm.

After the combustor was relit the saturation air flow was brought to 1100 scfm. Blast saturation temperature remained difficult to control. Water flows up to 50 gpm were required to keep the blast saturation temperature below 151 F (66 C). Fire loss pressure continued to climb until it reached more than 30 in wg at about 9:00 pm. At this point the saturation air flow began to drop out of control; the fan had reached its pressure limits. The coal bed top had risen to less than 15 inches below the RAP tops.

A pressure probing of the retort was performed at 10:00 pm and at midnight. Both probings showed that the bulk of the pressure drop was occurring between 18 inches and 30 inches below the RAP tops. The agitator could not be brought up this high to break

SECTION 5

TEST PROCEDURES

Test procedures are described in detail in Volume 1 of this series (Thimsen, Maurer et al, 1984). The following is a summary of the procedures including specific procedures used in this test only.

5.1 Test Teams

5.1.1 Gasifier Operation and Overall Coordination

The gasifier operations team was organized by Black, Sivals & Bryson, Incorporated (BS&B) and consisted of the facility manager, facility engineers, three shift lead operators and additional helpers as required. The gasifier was staffed with a lead operator and two helpers, three shifts each day.

The gasifier operations team was responsible for overall operation of the gasifier and associated process equipment and coordination of all activities. This includes: gasifier start up, coal gas handling and incineration, exhaust gas cleanup, coal addition and sample collection, fire bed monitoring, process equipment maintenance and repair, operation of the boiler, changes in process conditions, sampling of waste streams, and measurement of retort temperature and pressure profiles.

5.1.2 Gasifier Monitoring

The gas sampling and data retrieval/monitoring team was organized by the University of Minnesota Particle Technology Laboratory, and consisted of persons with individual responsibility for:

- 1) sample gas cleanup
- 2) gas chromatograph
- 3) continuous gas analysis and SIGMA continuous calorimeter
- 4) data acquisition system

and such equipment operators as were necessary. The monitoring systems were staffed 24 hours per day.

The monitoring team was responsible for recording continuous process signals, operations of the gas chromatographs and continuous gas analysis equipment, operation of the gas sampling and conditioning system, collection of tar and oil samples, analysis of coal, ash, and cyclone dust samples, retort exhaust particle sampling and evaluation of health and safety measures.

5.2 Gasifier Sampling and Data Acquisition Procedures

5.2.1 Continuous Data

An Analog Devices, Incorporated MACSYM 2 data acquisition system was used for this test. Process signals are sampled once a minute. Ten-minute signal averages are recorded on magnetic tape. Thirty-minute signal averages are printed by line printer. The operations team also logs these signals hourly along with some twenty parameters not sampled by the data acquisition system.

5.2.2 Gas Analysis Data

The continuous gas analyzers are calibrated daily, according to the manufacturer's recommendations. Output signals are recorded by the data acquisition system.

The HP 5880A gas chromatograph is calibrated using a mixture of oxygen, carbon monoxide, carbon dioxide, hydrogen, methane, ethane, ethylene, propane, propylene, and nitrogen at concentrations which nearly duplicate the gasifier offgas. Another calibration mixture with the concentrations of all the species except nitrogen increased by about 50%, and the nitrogen correspondingly reduced, is used to check the linearity of the detectors.

5.2.3 Tar and Oil Data

The condensed tar, oil, and water are removed from the accumulation reservoirs twice daily. Water collected in the surface condenser and sample electrostatic precipitator is decanted from the tar and combined with the water from the refrigerator. Tar from the surface condenser is combined with tar and oil collected in the sample electrostatic precipitator. Condensate yields are measured by weighing both the tar/oil sample and the water sample.

5.2.4 Coal Data

Coal samples are taken from each of the two weigh bin legs by the operations team during coal addition to the lock hopper four times each shift. These four samples are stored in a sealed bucket and submitted as a composite shift sample for each weigh bin leg. Detailed chemical analysis of the coal is performed on a composite of the shift samples.

5.2.5 Ash Data

An ash sample is taken by the operations team each time ash is discharged, and stored in a sealed container. For each ash sample the bulk density, particle size distributions, and carbon, sulfur, and moisture content of the ash are tabulated by the monitoring team. The carbon and sulfur content of each

entering the surface condenser, which is cooled by cold water or cold, compressed air. The rapid quenching causes tar, oil, and water to condense on the inner surface of the condenser tube. The tar fog generated during cooling is removed in the electrostatic precipitator. The detarred gas is refrigerated and dessicated to remove water remaining in the gas stream. The dry, detarred gas is metered and transported to the instruments. Condensate samples are collected from traps in the condenser, electrostatic precipitator, and refrigerator.

4.3 Gas Analysis Equipment

Carbon dioxide and carbon monoxide concentrations are continuously measured with individual Beckman 864 non-dispersive infrared (NDIR) analyzers. Oxygen is monitored continuously with a Beckman 755 paramagnetic oxygen analyzer. Higher heating value of the sample gas is measured with a SIGMA continuous flow calorimeter. These signals are all recorded by the automatic data acquisition system.

Detailed gas composition is determined every 30 minutes with a Hewlett-Packard model 5880A gas chromatograph. The principal features of this chromatograph are listed in Table 4-1.

Table 4-1

Principle Features of the
HP 5880A Gas chromatograph.

1. Columns used:
 - a. 1-10 ft x 1/8 inch SS Porapak Q
 - b. 1-10 ft x 1/8 inch SS Molecular Sieve 5A
 - c. 2-18 ft x 1/8 inch SS 2% OV-101 on WHP
2. Dual detectors - flame ionization detector in series with thermal conductivity detector
3. Set up for analysis of the following species:
Hydrogen, Carbon dioxide, Ethylene, Ethane, Propane, Propylene, Oxygen, Nitrogen, Methane, and Carbon monoxide
4. Argon Carrier Gas - flow rate of 28 ml/min
5. Programmed Temperature from 75 C to 165 C to 135 C
6. 1.0 ml sample
7. 23 minute analysis time

SECTION 7

TEST RESULTS

7.1 Data Summary

7.1.1 Continuous Output Transducer Data

The data acquisition system operated continuously with minor outages of less than 1 hour duration. Ten-minute averages of continuously logged signals are available for essentially all of the test period.

Figure 7-1 gives the offtake temperature, fire loss pressure, dry gas higher heating value along with the operational parameters. The offtake temperature was not strongly affected by the blast saturation temperature or saturation air flow. It was much more a function of blowing through and channeling in the retort.

Fire loss pressure was very high during the first 24 hours of the test. The data from approximately noon to 8:00 pm April 30 are erroneous due to accumulation of water in the ashpit pressure sensing port. Fire loss pressures during this period were, in fact, very high. After the agitator rate was adjusted to maintain a constant coal bed height on May 1 to the end of the test, the fire loss pressure varied, but was not erratic. The large increase the evening of May 2 was due to the added mass flux of water vapor caused by the very high blast saturation temperatures in use.

After the initial difficulties the dry gas higher heating value was higher on May 1 and relatively poorer the rest of the test as indicated in Figure 7-1. This parameter does not seem to be strongly related to any of the other operational parameters.

7.1.2 Coal, Ash, and Dust Data

A complete list of the tests performed on the bulk coal, ash, and cyclone dust samples collected during BOM/FGT-004, together with the number of samples analyzed, is presented in Table 7-1.

7.1.2.1 Coal Data

The mass fraction of coal less than each of five indicated mesh sizes and the mean particle size are presented in Figures 7-2 and 7-3. The only significant feature of these data is the increase in mean coal particle size on May 3 corresponding to the replacement of the 1/2 inch screen with a 3/4 inch mesh screen to remove undersize material.

As indicated by these data the coal entering the gasifier had a significant fraction less than the screen mesh size. During the

Figure 7-1

Physical Characteristics of the Gasifier Operation.

up the agglomeration. Repeated poking through the RAPs was required. The top of the coal bed was almost to the top of the retort. The bottom coal valve was closed at 10:00 pm to cut off coal flow to the retort in an attempt to reduce the coal bed height by consuming the coal without replacement.

Between 10:00 pm April 30 and 12:30 pm May 1 the lower coal valve was opened only when the offtake temperature began to rise significantly indicating loss of feed from the coal pipes. During this period the agitator rate was increased to 20 sweeps per hour in an attempt to break up agglomeration. Despite these efforts the coal bed height remained high and above the maximum upper agitator height until later in the morning of May 1. Saturation air flows of 900 to 1000 scfm were maintained during the last half of this period. Blast saturation temperature remained difficult to keep down due to high rates of heat transfer to the jacket. During the latter part of this period dry gas higher heating value increased to about 150 BTU/scf indicating successful gasification of the coal.

As the agitator was slowed from 20 sweeps/hour to 10 sweeps per hour the top of the coal bed dropped from 15 to 33 inches below the RAP tops and the fire loss pressure dropped to under 10 in wg. For the remainder of the test the distance from the RAP tops to the coal bed top was maintained at 30 to 35 inches by adjustment of the agitator rate. This was for the most part successful. Beginning 12:30 pm May 1 the normal method of feeding coal to the retort was resumed.

Operation stabilized somewhat at a saturation air flow of 1000 scfm and a blast saturation temperature of 142 F (61 C) from 12:30 pm May 1 to 8:00 am May 2. Coal consumption during this period was 0.4 to 0.5 tons/hour. Blast saturation temperature continued to be difficult to control. Gas quality was poor (100 BTU/dscf).

An attempt was made to increase throughput by increasing the saturation air flow during the morning and afternoon of May 2. This attempt resulted in increased burning through and a rise in offtake temperature, and the saturation air flow had to be reduced back to 1000 cfm.

At 5:45 pm May 2 the grate drive gear adjustment band malfunctioned and the grate rotated near maximum rate for about 15 minutes. As the ash depth was at minimum the fire was brought down onto the grate as indicated by a quick fire test. The blast saturation temperature was increased to 176 F (80 C) and saturation air flow decreased to 550 cfm. An ash dump at 7:00 pm showed carbon chunks, but they were not glowing; the saturation air flow was increased to 750 cfm. At 8:00 the main flame went out and the vent was opened and the gas flared. The blast saturation temperature was decreased to 147 F (61 C) and the flame was relit at 9:35 pm. The saturation air flow was raised to 1000 cfm over a two hour period. These efforts

were successful in keeping the grate cool and raising the incandescent zone.

The 1/2 inch coal screen was replaced with a 3/4 inch mesh screen to see if coal sizing had any effect of gasifier performance with this coal. The +3/4 inch screened coal entered the retort at 8:45 May 3. Use of the larger sized coal over the next 24 hours did not improve operation appreciably. Maximum coal throughput was limited to 0.5 tons/hour by high offtake temperatures and burning through. The test was terminated at 7:50 am May 4.

Large amounts of cyclone dust were removed throughout the test. Much of the dust floated on the surface of the water seal. Significant amounts of the dust blew through the cyclone and dropped out in the downstream ductwork.

The ash zone was relatively resistant to clinkering. The main difficulty in managing the ash was the fact that the grate spacings (6 inches, 6 inches) were too wide for this low ash content coal. The spacings were necessary for the high ash content Leucite Hills coal gasified during BOM/FGT-003. Consequently the grate had to be operated at speeds lower than would be normally desirable for this coal in order to keep enough ash above the grate. The ash discharged was reddish and granular with occasional large fused pieces.

Almost all of the firetests indicated very little fire under hole number 7 at the center of the retort. Occasionally there was an indication of fire very high on the rod at this hole. This indicates that there was likely an agglomeration of coal just under the coal feed pipes that never participated in the gasification/combustion reactions and, indeed, did not move. There was no gas flow through this agglomeration for most of the test. The blast was forced by the agglomeration to the outside of the retort. This is consistent with the excessive heat loss to the water jacket.

On several occasions attempts were made to send the agitator deep to break up this agglomeration, but the torque exerted on the agitator by the coal was excessive to the point that the agitator would not advance. These attempts were abandoned. The agitator, as currently designed and installed, could not be operated deeper than about 6 - 9 inches below the coal surface.

Figure 7-3

Geometrical Mean Coal Particle Size

test samples were also taken at the conveyor discharge to the screen and at the screen discharge. The size distributions of these samples (Appendix C) indicated that the undersize coal entering the gasifier was predominantly carried over from the screen, and not generated during handling between the screen and the gasifier.

The results of the chemical and physical analyses of a single coal sample composited over the entire test period are given in Table 7-2.

7.1.2.2 Ash Data

The mass fraction of ash less than each of five indicated mesh sizes and the mean ash particle size are presented in Figures 7-4 and 7-5. The dry basis mean ash particle size, ash bulk density, carbon content, sulfur content, and operating conditions are shown in Figure 7-6. The quality of the physical ash data for this test is suspect as most ash dumps were predominantly water blown from the water jacket into the ashpit. No strong trends are evident except that sulfur content tracks carbon content fairly well.

Table 7-3 shows the results of the chemical analysis of a single ash sample composited from samples collected at each ash dump excluding ash that was predominantly Leucite Hills ash.

Note: When comparing the ash data to the continuous output data associated with gasifier operating conditions, one must consider the fact that the ash data are presented as a function of the time of ash dump. Since several ash dumps are usually required to transport material from the top of the ash layer to the ashpit, any changes in gasifier operating conditions which affect the ash will not be reflected in the reported ash data until 4 - 6 hours later.

7.1.2.3 Cyclone Dust Data

The dry basis chemical analysis of one dust sample composited over the entire test period is shown in Table 7-2. The volatile matter to fixed carbon ratio of the dust is 0.177 lb/lb compared to 0.557 lb/lb for the feed coal. This substantial reduction in volatile matter is consistent with partial devolatilization of the dust in the high temperatures of the upper retort and offtake duct.

The ash to fixed carbon ratio of the dust is 0.213 lb/lb compared to 0.142 lb/lb for the feed coal. This 50% increase in ash content suggests that higher ash materials are preferentially blown out the top of the retort. The source of these materials is undetermined, but may be the ash layer or other regions near the bottom of the retort.

Table 7-1

Summary of Coal, Ash, and Cyclone Dust Analyses Performed

Material	Type of Analysis	Samples Collected and Analyzed	Composite Samples Analyzed
Coal	Particle Size Distribution	17	-
	Proximate Analysis	-	1
	Ultimate Analysis	-	1
	Heating Value	-	1
	Ash Fusion Temperatures	-	1
	Free Swelling Index	-	1
Ash	Particle Size Distribution	24	-
	Bulk Density	24	-
	Moisture Content	24	-
	Carbon Content	24	1
	Sulfur Content	24	1
	Chemical Analysis	-	1
Cyclone Dust	Proximate Analysis	-	1
	Ultimate Analysis	-	1

Figure 7-2

Feed Coal Size Distribution Analysis

Figure 7-5
Geometrical Mean Ash Particle Size

Figure 7-6

Ash Characteristics and Operating Conditions

Table 7-2

Physical and Chemical Properties of Coal and Cyclone Dust

Material	Coal	Cyclone Dust (*)
Type of Analysis		
Proximate Analysis (wt %)		
Moisture	3.25	---
Volatile Matter	31.73	12.84
Ash	8.07	14.50
Fixed Carbon	56.94	72.62
Sulfur	0.97	0.94
Ultimate Analysis (wt %)		
Hydrogen	4.99	1.58
Carbon	74.22	73.17
Nitrogen	1.45	1.37
Sulfur	0.97	0.94
Oxygen	6.55	8.43
Ash	8.07	14.50
Moisture	3.25	---
Heating Value (Btu/lb)	13355	11356
Ash Fusion Temperatures (deg F)		
Oxidizing Atmosphere		
Initial Deformation	2790	-
Softening	+2800	-
Hemispherical	-	-
Fluid	-	-
Reducing Atmosphere		
Initial Deformation	2725	-
Softening	+2800	-
Hemispherical	-	-
Fluid	-	-
Free Swelling Index	8 1/2	

(*) Dry basis analysis

Figure 7-4

Ash Size Distribution Analysis

Figure 7-5

Geometrical Mean Ash Particle Size

Figure 7-6

Ash Characteristics and Operating Conditions

Table 7-3
Chemical Analysis of Moisture-Free Ash

Element (*)	Mass Fraction (%)
Fe	7.4
Fe2+	2.1
Si	18.0
Al	12.5
C	28.0
Ca	0.77
Mg	0.27
K	0.42
P	.01
Na	.021
S	.023
Ti	0.7

(*) Unaccounted for mass is presumed to be oxygen bound in metal oxides.

The higher heating value of the dust is lower than the higher heating value of the feed coal even on a dry, ash-free basis.

7.1.3 Gas Analysis Data

The NDIR carbon monoxide and carbon dioxide analyzers and the paramagnetic oxygen meter operated well during the test. The SIGMA continuous flow gas calorimeter was operated during the test, but data collected from this analyzer are questionable as there was a 10-15% calibration drift from day to day. All heating values reported are calculated from the dry gas composition given by the gas chromatograph.

Gas chromatograms were obtained every 30 minutes throughout the test. The individual analyses are tabulated in Appendix H. There are no significant gaps in GC data.

During most of the test the oxygen concentration in the gas was indistinguishable from zero. When the steam sealed retort access ports were opened during fire tests and freeboard measurements, however, oxygen concentrations were greater than zero. These devices, while sealing against gas leaks out of the retort, apparently aspirate some air into the product gas. All oxygen concentrations reported to be greater than zero result from this ingestion of air into the freeboard of the gasifier.

The concentrations of species measured by the gas chromatograph are given in Figures 7-7 and 7-8. The gap in this data on May 2 is due to the gas sampling system being shut down for non-routine maintenance (see Section 7.1.4). Carbon dioxide concentrations were very high and hydrogen/carbon monoxide concentrations low for most of the test. This indicates incomplete reduction of the gases leaving the combustion zone. The minor gas species concentrations were higher during the upset period April 30 - May 1. This is consistent with the increase in retort coal inventory noted during this period with associated increase in devolatilization.

The major active species and gasifier operating conditions are shown in Figure 7-9. A period of relatively better gasification can be seen on May 1. The blast saturation temperature during this period was somewhat lower than during the rest of the test, but it would be difficult to attribute the improved gas quality to this fact.

7.1.4 Tar and Water Yield Data

The gas sampling and conditioning system performed well during the test. There was a short shut-down on May 2. A minor clogging was found between the gas duct and the condensor which was removed by steam cleaning. Condensate traps were drained every 12 hours but were combined to 24 hour samples because of insufficient material in each sample. One set of composited condensate samples was submitted for analysis. The results of

Figure 7-7

Major Gas Species Measured by the Gas Chromatograph.

Figure 7-8

Minor Gas Species Measured by the Gas chromatograph.

Figure 7-9

Dry gas HHV, Major Gas Species and Gasifier Operational Parameters.

the analyses are given in Table 7-4.

The tar and water yields for the entire test are shown in Figure 7-10 along with gasifier operating conditions. The resolution of the condensate yield data is not fine enough to draw qualitative correlations.

7.2 Grate Performance Model

A simple grate performance model has been developed to calculate the ash removal rate from the gasifier. The model is based entirely on geometrical considerations. The model is described more fully in Volume 1 of this series (Thimsen, Maurer et al, 1984). Figure 7-11 gives the comparison of this model with ash rejected during BOM/FGT-004. The model predicts the ash rejection generally, but some data points deviate significantly. Much of the deviation is due to uncertainties in ash weight measurements due to the large amount of water blown into the ashpit from the water jacket.

7.3 Material and Energy Balances

The material and energy balance calculation procedures are described in Volume 1 of this series (Thimsen, Maurer et al, 1984). A brief description follows.

The measured data used to calculate material and energy balances around the gasifier include process temperatures, pressures, and flows, tar/water yields, material ultimate analyses and gas compositions. The calculations for this test also include the following assumptions:

- A. Dust carryover is estimated to be 2% of the coal feed rate based on operator observations.
- B. Coal bound sulfur not reporting to the tar or ash is reported as hydrogen sulfide in the gas. No measurements of gas phase sulfur or dust bound sulfur were taken during this test.
- C. Coal gas flow and blast air flow are calculated assuming a simultaneous nitrogen and carbon balance around the gasifier. The air flow signal was also reproducible but felt to be less precise than the coal flows recorded.
- D. The total gas analysis is normalized to 99.9 %.
- E. Ash discharge is calculated to be the ash associated with the measured coal consumption plus the carbon and sulfur analyzed for each ash sample.

The continuous process variables of interest are the saturation

Table 7-4
Condensed Material Analyses

	As Received	Dry Basis
Water		
Total Organics %	0.15 %	
Tar		
Heating Value (Btu/lb)	10237	12905
Flash Point (deg F)	231	
Water by Distillation %	20.68	
Specific Gravity 60/60 F	1.1033	
Pour Point (deg F)	45	
Cold (Solid) Point (deg F)	40	
Viscosity at		
122 F Saybolt Furol (s)	186.4	
122 F Kinematic (cstokes)	394.9	
210 F Saybolt Universal (s)	91.0	
210 F Kinematic (cstokes)	18.37	
Ultimate Analysis		
Hydrogen	6.37	8.03
Carbon	55.03	69.38
Nitrogen	0.91	1.15
Oxygen (by difference)	16.49	20.79
Sulfur	0.48	0.61
Moisture, Total	20.68	--
Ash	0.03	0.04

Figure 7-10

Tar/Oil Yield and Water Yield with Operating Conditions

Figure 7-11

Comparison of the Geometrical Grate Performance Model
with Daily Average Ash Removal Rates.

air flow, blast saturation temperature, offtake temperature, ambient temperature, cooling water inlet and outlet temperatures, cooling water flow and saturation steam imported. Ten-minute averages are available for all of these parameters except the cooling water flow and saturation steam imported. Hourly totals and flow rates logged by the operators are used for these parameters.

Condensable yields in the gas stream were obtained from the gas sampling and conditioning system.

Ultimate analyses and heating values of the coal and moisture-free tar samples were used for the carbon-nitrogen balance calculations as well as the dry gas compositions from the gas chromatograph.

Table 7-5 is a calculation made over a relatively stable period of operation. Table 7-6 is a calculation made over the entire test period. As can be seen by these results, substantial amounts of heat were rejected to the water jacket. This is consistent with the observations made by the operators and described in Section 6.

7.4 Tar/Oil Yield Correlations

The overall average tar yield measured during this test was 8.7 lb/100 lb coal. This tar yield can be compared with tar and oil yields reported for Fischer-Schrader Assays of similar coals (Selvig and Ode, 1957). There is no Fischer-Schrader assay available for this coal.

Figures 7-12 and 7-13 show the average tar yield observed during fixed-bed gasification of this coal plotted against parameters that correlate well with Fischer-Schrader assay tar and oil yields (Ode and Selvig, 1944, Gomez et al, 1958). As can be seen in these figures, the overall average tar yield observed during this test is somewhat lower than that predicted by either correlation. This may be due to the severe devolatilization conditions associated with the gas channeling observed during the test which are significantly different from the conditions of the assay.

Table 7-5

Material Balance and Thermal Efficiency Calculation
+3/4 inch, 0.49 tn/hr, 141 F

Input Data

Time period: 5/ 3/83 00:00 - 5/ 4/83 00:00 (24.0 hours)

Gasifier Operation:

Coal feed, Ton/hour = 0.49
Blast air flow (dry) , Scfm = 979.
Saturated air temperature, F= 141.
Steam/Air Ratio (lb./lb.) = 0.16
Ambient air temperature, F = 59.
Off-take temperature, F =1033.

Coal Data:

Type = Stahlman Stoker
Mass Fraction Carbon % = 74.2
Mass Fraction Fixed Carbon = 56.94
Mass Fraction Moisture % = 3.25
Mass Fraction nitrogen % = 1.45
Mass Percent sulfur = 0.97
Heating value, Btu/lb = 13355

Tar and Water Yield (dry basis):

Water yield, lb./1000 SCF = 9.65
Tar yield, lb/1000 SCF = 0.57
Carbon in Tar (percent) = 69.4
Sulfur in Tar (percent) = 0.60
Tar HHV, thou. Btu/lb = 12.91

Ash and Dust Data:(dry basis)

Ash discharge ,lb/hour = 29.
Ash carbon ,percent = 18.1
Ash sulfur ,percent = 0.12
Ash moisture (wet),percent = 50.9
Cyclone dust,lb/hour(est.) = 19.

Gas Composition (Dry): (normalized to 99.90)

H2 % = 12.4	CH4 % = 1.28	H2S (est ppm) = 1402
CO % = 13.4	C2H4 % = 0.162	
CO2 % = 12.57	C2H6 % = 0.081	
N2 % = 59.1	C3H6 % = 0.030	
O2 % = 0.00	C3H8 % = 0.020	
Molec. Weight= 26.46	Argon(est. %)= 0.705	HHV, Btu/SCF = 102
		LHV, Btu/SCF = 94

Calculation Results (based on nitrogen and carbon balance)

Material Balance (Percent unaccounted for: -1.95)

Input,	lb/hr	% Total	Output,	lb/hr	% Total
Coal	= 970.	16.2	Dry gas	= 5219.	85.6
Steam (total)	= 699.	11.7	Water in gas	= 722.	11.8
Air(calc,dry)	= 4309.	72.1	Oil and tar	= 43.	0.7
			Ash(calc,dry)	= 92.	1.5
			Dust	= 19.	0.3
Total	= 5978.		Total	= 6095.	

Energy Balance (Percent unaccounted for: 0.57)

Input,	MM BTU/hr	Output,	MM Btu/hr	% Total
Coal	= 13.0	Dry coal gas	= 7.7	59.1
Air	= -0.001	Oil and tar	= 0.55	4.3
Steam(import)	= 0.282	Sensible	= 1.75	13.5
Cooling water	= -0.208	Latent	= 0.769	5.9
		Ash	= 0.238	1.8
		Dust	= 0.213	1.6
		Cooling water	= 1.769	13.7
Total	= 13.0	Total	= 13.0	

Performance Data

Cold gas efficiency, percent = 58.7
Cold gas with tar efficiency, percent = 63.0
Hot gas without tar efficiency percent = 77.6
Hot gas with tar efficiency, percent = 82.3
Air/Coal (lb./lb.) = 4.443
Steam/Coal (lb./lb.) = 0.721
Air/Fixed Carbon (lb./lb.) = 7.802
Coal/Gasifier Area (lb./hr./sqft) = 29.2
Fixed Carbon/Area (lb./hr./sqft) = 16.6
Producer Gas/Coal (SCF/lb.) = 92.9
Producer Gas/Fixed Carbon (SCF/lb.) = 163.1
Tar Yield (lb./lb. coal) = 0.044

Table 7-6

Material Balance and Thermal Efficiency Calculation
Overall Average

Input Data

Time period: 4/30/83 8:00 - 5/04/83 7:00 (95.0 hours)

Gasifier Operation:

Coal feed, Ton/hour = 0.52
Blast air flow (dry) , Scfm = 942.
Saturated air temperature, F = 141.
Steam/Air Ratio (lb./lb.) = 0.16
Ambient air temperature, F = 55.
Off-take temperature, F = 925.

Coal Data:

Type = Stahlman Stoker
Mass Fraction Carbon % = 74.2
Mass Fraction Fixed Carbon = 56.94
Mass Fraction Moisture % = 3.25
Mass Fraction nitrogen % = 1.45
Mass Percent sulfur = 0.97
Heating value, Btu/lb = 13355

Tar and Water Yield (dry basis):

Water yield, lb./1000 SCF = 8.12
Tar yield, lb/1000 SCF = 1.23
Carbon in Tar (percent) = 69.4
Sulfur in Tar (percent) = 0.60
Tar HHV, thou. Btu/lb = 12.91

Ash and Dust Data:(dry basis)

Ash discharge ,lb/hour = 123.
Ash carbon ,percent = 18.2
Ash sulfur ,percent = 0.14
Ash moisture (wet),percent = 40.3
Cyclone dust,lb/hour(est.) = 21.

Gas Composition (Dry): (normalized to 99.90)

H2	%	= 13.3	CH4	%	= 1.38	H2S	(est ppm)	= 1485
CO	%	= 15.5	C2H4	%	= 0.147			
CO2	%	= 11.57	C2H6	%	= 0.109			
N2	%	= 57.0	C3H6	%	= 0.038			
O2	%	= 0.00	C3H8	%	= 0.030	HHV,	Btu/SCF	= 113
Molec. Weight	=	26.08	Argon(est. %)	=	0.680	LHV,	Btu/SCF	= 105

Calculation Results (based on nitrogen and carbon balance)

Material Balance (Percent unaccounted for: -1.13)

Input,	lb/hr	% Total	Output,	lb/hr	% Total
Coal	= 1048.	18.0	Dry gas	= 5087.	86.2
Steam (total)	= 673.	11.5	Water in gas	= 601.	10.2
Air(calc,dry)	= 4113.	70.5	Oil and tar	= 91.	1.5
			Ash(calc,dry)	= 100.	1.7
			Dust	= 21.	0.4
Total	= 5835.		Total	= 5900.	

Energy Balance (Percent unaccounted for: 1.19)

Input,	MM BTU/hr	Output,	MM Btu/hr	% Total
Coal	= 14.0	Dry coal gas	= 3.4	60.5
Air	= -0.005	Oil and tar	= 1.17	8.4
Steam(import)	= 0.272	Sensible	= 1.53	11.0
Cooling water	= -0.211	Latent	= 0.645	4.6
		Ash	= 0.259	1.9
		Dust	= 0.230	1.7
		Cooling water	= 1.651	11.9
Total	= 14.1	Total	= 13.9	

Performance Data

Cold gas efficiency, percent = 59.7
Cold gas with tar efficiency, percent = 68.1
Hot gas without tar efficiency percent = 74.5
Hot gas with tar efficiency, percent = 83.4
Air/Coal (lb./lb.) = 3.923
Steam/Coal (lb./lb.) = 0.642
Air/Fixed Carbon (lb./lb.) = 6.890
Coal/Gasifier Area (lb./hr./sqft) = 31.6
Fixed Carbon/Area (lb./hr./sqft) = 18.0
Producer Gas/Coal (SCF/lb.) = 82.8
Producer Gas/Fixed Carbon (SCF/lb.) = 145.4
Tar Yield (lb./lb. coal) = 0.087

Figure 7-12

Tar/Oil Yield - Volatile Matter-Oxygen Correlation

(Selvig and Ode, 1944)

Figure 7-13

Tar/Oil Yield - Volatile BTU Correlation

(Gomez et al, 1958)

SECTION 8

CONCLUSIONS AND RECOMMENDATIONS

1. The maximum coal throughput observed was 980 lb/hr (29.5 lb/hr/sq ft grate). Attempts to increase coal throughput beyond this level were met with excessive channeling and burning through. Based on this throughput and a blast saturation temperature of 141 F (60.6 C) the following material and energy flows can be expected:

Material Input		Energy Input (MMBTU/hr)	
lb air/lb coal	4.44	Coal	13.0
lb steam/lb coal	.72	Steam (import)	.28
Material Output		Energy Output (MMBTU/hr)	
lb dry gas/lb coal	5.38	Dry Coal Gas	7.7
lb tar-oil/lb coal	.044	Tar and Oil	.55
lb water/lb coal	.744		
lb dust/lb coal (est)	.020	Dust	.213
lb ash/lb coal	.095	Ash	.238
		Sensible and	
		Latent Heat	2.52
		Cooling Water	1.77

Hot, Raw Gas Energy Conversion Efficiency - 82 %

2. There did not appear to be any change in gasifier performance when the process screen was changed from 1/2 inch to 3/4 inch.
3. Blast Saturation temperatures between 133 F (56 C) and 151 F (66 C) were used. There did not seem to be any effect on the ash due to varying blast saturation temperatures.
4. The mass weighted average tar/oil production was 6.5 lb/100 coal. This represents 8% of the energy in the coal.
5. The ash removal rate of the rotating grate is generally predicted by a geometrical grate model.
6. Significant accumulations of agglomerated coal char were detected in the retort. These agglomerations were the cause of the extremely poor air distribution noted. This poor air distribution is probably the cause of the poor gas quality due to insufficient residence time in the gasifier to reduce the carbon dioxide and steam to carbon monoxide and hydrogen.
7. Excessive amounts of heat were rejected to the jacket water consistent with the poor reduction described above.
8. The only period of higher gas quality occurred while batch

feeding coal to the gasifier.

9. The agitator in this gasifier was not adequate to be sent deep into the bed to break up agglomerations. The torque exerted by the coal on the agitator was the limiting factor.
10. The low gas quality and restricted throughput do not recommend this coal as a deep, fixed-bed gasifier fuel based on the results of this test. A different agitator design may improve gas quality and increase throughput by breaking up coal agglomerates in the top of the retort. This would improve gas distribution, increase gas residence time, and minimize channeling and blowing through.

REFERENCES

- Gomez, M., Goodman, J.B., Parry, V.F.; "General Properties of Low Temperature Tar"; USBM Bulletin 569; 1958
- Ode, W.H., Selvig, W.A.; "Low Temperature Distillation Yields of Primary Tar and Light Oil from Coals of Various Ranks and Types"; USBM R.I. 3748; March 1944
- Selvig, W. A., Ode, W. H.; "Low Temperature Carbonization Assays of North American Coals"; USBM Bulletin 571; 1957
- Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 1 - Program and Facility Description. BuMines Contract HO222001 Final Report. October 1984

OTHER PUBLICATIONS UNDER BUMINES CONTRACT HO222001

- Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 2 - Gasification of Jetson Bituminous Coal. BuMines Contract HO222001 Final Report. March 1985
- Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 3 - Gasification of Rosebud Subbituminous Coal. BuMines Contract HO222001 Final Report. March 1985
- Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 4 - Gasification of Leucite Hills Subbituminous Coal. BuMines Contract HO222001 Final Report. March 1985
- Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 5 - Gasification of Stahlman Stoker Bituminous Coal. BuMines Contract HO222001 Final Report. March 1985
- Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 6 - Gasification of Delayed Petroleum Coke. BuMines Contract HO222001 Final Report. May 1985
- Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 7 - Gasification of Piney Tipple Bituminous Coal. BuMines Contract HO222001 Final Report. May 1985

Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 8 - Gasification of River King Illinois #6 Bituminous Coal. BuMines Contract HO222001 Final Report. May 1985

Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 9 - Gasification of Elkhorn Bituminous Coal. BuMines Contract HO222001 Final Report. May 1985

Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 10 - Gasification of Benton Lignite. BuMines Contract HO222001 Final Report. May 1985

Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 11 - Gasification Minnesota Peat. BuMines Contract HO222001 Final Report. May 1985

Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 12 - Gasification Absaloka Subbituminous Coal. BuMines Contract HO222001 Final Report. May 1985

Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 13 - Gasification Blind Canyon Bituminous Coal. BuMines Contract HO222001 Final Report. May 1985

Thimsen, D., R. E. Maurer, A. R. Pooler, D. Y. H. Pui, B. Y. H. Liu, D. B. Kittelson. Fixed-Bed Gasification Research Using U. S. Coals, Volume 14 - Gasification Kemmerer Subbituminous Coal. BuMines Contract HO222001 Final Report. May 1985

APPENDICES

A. Gasifier Operator's Log.....	A-1
B. Weather Data for Testing Days.....	B-1
C. Coal Analysis Data.....	C-1
D. Coal Addition Log.....	D-1
E. Ash Analysis Data.....	E-1
F. Ash Removal Log.....	F-1
G. Operator Logged Data.....	G-1
H. Gas Chromatograph Data.....	H-1
I. Continuous Output Transducer Data.....	I-1

APPENDIX A

Gasifier Operator's Log

These are the comments recorded by the gasifier operators during the course of the test.

BOM/FGT 004 STAHLMAN STOKER

April 30, 1983

0800 Freeboard shows the bed to be 39.3 inch average. The fire test average is 14.4 inches. The bed was loose. Increased the grate speed to 4/2.50.

0820 The coal legs are at 27 degrees C.

0830 The coal legs are still choked and the temperature is down to 26 degrees C.

0840 The coal leg temperature is back up to 27 degrees C. The south leg is emptying out and it rings hollow.

0845 Dropping the first of the Stahlman Stoker into the lower bin (11.91 tons). Total drop of 3.94 tons. The temperature in the coal legs is now 28 degrees C. The south leg is empty.

0850 Decreased the saturation air flow to 1000 cfm and leaving the saturation temperature at 58 degrees C until the Leucite Hills has completely left the system.

0900 The freeboard averaged 39.3 inches. Dumped the ash and found more large chunks followed by a fine material from the grate underside. (Used the upper nozzles) This appears to work better as it cleans out the accumulation from the grate.

0915 Finished the first Stahlman Stoker coal up at 12.23 tons.

0920 The offtake temperature has reached 303 degrees C. Making an adjustment to the agitator so it will give a depth of 36-40" below the poke holes.

0925 Fire loss and offtake temperature continues to rise.

0930 Increased the agitator speed to 7 sweeps/hour. Dumped the cyclone. Found large chunks of floating material. They are flat and 4-5 inches in diameter.

0950 The offtake temperature is 438 degrees C.

1000 During the fire test, it was noted that the bed was crusty on top and the average is 12.7". The grate speed is 4/2.50.

1010 Increased the jacket water flow to 10, and then increased again to 12, as the delta p and offtake temperature continued to rise. The saturation temperature is 61 degrees C.

1012 Increased the agitator speed to 10.0 sweeps/hour.

1015 While taking the freeboard, noticed a flash through on # 6 hole. Gas and forced air ignited.

1025 Pressure across the bed and offtake temperature continue to rise. Attempts to control the saturation temperature with steam alone are not adequate. Offtake temperature is 451 degrees C and the pressure across the bed is 18.0". Saturation temperature is up to 64 degrees C. Put the steam on manual and the water on automatic. Increased the jacket water flow to 35 gallons per minute. The offtake appears to level off at 450 degrees C. Saturation temperature will not decrease.

1030 The coal feed hits 1.27 tons, but the saturation temperature is still at 64 degrees C. Increased the water pressure to the saturation water from 25 psi to 40 psi. Jacket water flow still peaked at something over 35 gallons per minute with the water saturation temperature valve on automatic. Hopefully the saturation temperature will respond. Dumped the cyclone and found larger chunks but more fine dust.

1040 Saturation temperature hits 67 degrees C. Gas quality is much poorer. Closed the steam valve all the way as the water is being boiled off. The offtake temperature is 450 degrees C. Jacket water flow continues to be over 35 gallons/minute.

1050 The saturation temperature is finally responding to flow changes. The saturation temperature is down to 61 degrees C. The jacket water flow is down to 27 gallons/ minute on automatic.

1100 Still have offtake gas ignition on # 6 hole. Dumped 580 pounds of ash. Noticed much larger chunks of ash. Continuing the use of the upper nozzles. Cleaned the combustion burner as it was clogged. We will rod the combustion burner twice each shift.

1115 The saturation temperature is remaining between 61 and 62 degrees C. The offtake temperature is 456 degrees C. The fire loss is 18.2 inches.

1125 Checked the downcomer trap. It is taking 1/2 hour to clean out. The accululation is 1 foot thick.

1130 Saturation water valve is wide open at 40 psi. Saturation temperature is 63.5 degrees C. Increased the pressure to 5 psi, which gives us just over 20 gallons/minute.

1140 Increased the pressure to 60 psi. This will give us 21 gallons/minute. Saturation temperature is 63 degrees C and it is not responding. We are attempting to reach 1000 cfm at 62 degrees C.

1200 The fire test average is 12.7 inches. Hit heavy crust on holes # 3 & 5. The bars had poor fire zone definition. The entire bed is very sticky.

1210 The saturation temperature is up to 65 degrees C. The

offtake temperature is 451 degrees C. Opened the bypass to allow 27 gallons per minute in the water jacket.

1215 Speed up the agitator to 13.0 s/hr in attempt to lower the offtake temperature, which is now 454 degrees C. Dumped 1250 pounds of ash. Found it to be mostly water.

1220 Speeding up the agitator to 13 sweeps/hour has brought the saturation temperature to 62 degrees C. for a short time only. It continues to fluctuate between 63 & 64 degrees C.

1225 Ash indicator is back up to 800 pounds in 10 minutes. This means the ash pit is being saturated as we are pouring 27 gallons per minute through the water jacket.

1228 Increased the saturation air flow to 1200 cfm and got an immediate saturation temperature drop to 60 de-grees C. The offtake tgemperature is 439 degrees C. It looks like we will have to increase the load and decrease the water to control the saturation temperature.

1235 Dumped 1400 pounds of ash and found it to be all water. We are presently putting 25 gallons of water per minute at 66 psi through the system. Saturation temperature is 74 degrees C., but the offtake temperature is 435 degrees C. The gas quality is horrendous. The CO is 8.2% and the CO₂ is 11.9%.

1245 The saturation water pipe was plugged with rust. It was cleaned out and the water in ash problem seems to be solved. The water is going into the trap now.

1300 The freeboard average is 24 inches. The ash appears to be building up at a normal rate. New plan of attack: We are lowering the saturation air flow to 800 cfm and slowing the agitator to 5.7 sweeps/hr.

1305 The saturation temperature is 70 degrees C. and the offtake temperature is 461 degrees C. We can not push any more water through the system. We are now at 35 gallons per minute at 45 psi.

1310 After 10 minutes, the saturation temperature is down to 59 degrees C. The offtake is still around 460 degrees C. With the agitator slowed down to 5.7 sweeps per hour, the freeboard keeps getting smaller.

1320 The water jacket flow is down to a trickle as the bypass is closed. The saturation temperature is down to 58 degrees C. Wondering if the automatic water saturation temperature control will take over?

1323 The valve is beginning to open. The saturation temperature is up to 68 degrees C. and is slowly moving down.

1325 The saturation temperature is 66 degrees C. The offtake

temperature is 456 degrees C.

1330 Dumped the cyclone and noticed very finely divided particulate.

1345 The saturation temperature is at 66 degrees C. The automatic control has opened 100% allowing 35+ gallons per minute to pass through the water jacket.

1350 The saturation air control butterfly valve was at 20% open. Closed up the blast plate until the valve is at 20% open. This in conjunction with lowering the water flow might bring the saturation temperature under control at or around 62 degrees C.

1354 Automatic is taking control again with the saturation temperature heading towards 60 degrees C.

1358 The duct pressure is up to 2.8 inches from 0.7 inches by closing the gas control valve to 0.9%.

1400 Flame out! Poor quality gas will not ignite in the combustor. Shut down procedure is followed. Either the above mentioned factor or too much particulate in the gas is reaching the combustor to ignite.

1420 The freeboard average is 23.3"

1430 Rechecked the fire test. The bed is cold. Left the bars in for 5 minutes and could not get a reading.

1438 The saturation air valve is closed, saturation blower is on...start up procedure is under way. Changing the duct pressure may have also caused the flame out. Attempts to relight the combustor were unsuccessful. The pilot flame could not be lit, but gas was not high enough quality to ignite. The cyclone was flooded again.

1510 The saturation blower was turned on to 300 cfm, the gas quality was too low to support flame at the coal leg test port. Will wait until we can get a good flame before sending it to the combustor. The saturation temperature is 5 degrees C.

1535 Good fire at test port, will begin to drain the cyclone.

1556 Gas to the combustor, but it would not ignite. Shut down again.

1615 The saturation fan is on at 200 cfm. Will do a complete fire test. The saturation temperature is 38 degrees C.

1630 Good fire test with an even ash depth. Gas at the test port will not light.

1700 Cleaned T-705. Found some accumulation of dust in the offtake pipe. Coal leg test port flame is lousy, but burning.

1705 The Induced draft fan is on. Pilot flame is on. Saturation temperature is 58 degrees C. Offtake temperature is 213 degrees C. Saturation air flow is 200 cfm. The agitator speed is 7.4 sweeps/hour. Primary is 1000 cfm and the secondary is 0. Draining the cyclone and closing the vent valve slowly. The I.D. fan is at 138.

1715 The flame has been lit.

1717 The saturation air flow is at 800 cfm.

1720 The primary air flow is 1000 cfm and the secondary air flow is 2000 cfm.

1722 The saturation air flow is 1000 cfm. The primary combustor air flow is 1400 cfm and the secondary is still at 2000 cfm.

1730 Saturation air temperature is 75 degrees C. Opened the jacket water valve to 30 gallons per minute to bring the temperature down.

1732 Saturation temperature is still at 67 degrees C., and is falling slowly. The small valve bypass is wide open at 30 gallons per minute.

1734 No glowing or burning through is evident.

1735 Slowed the agitator to 3.7. We are trying to maintain a 35 inch freeboard average.

1740 Side thermcouple is buried in dust. Wired the top thermocouple only. The offtake temperature is now reading 560 degrees C.

1745 The offtake temperature thermocouple had loose wires. Tightening these up gives a reading of 410 degrees C.

1745 Upon the increase of saturation air flow at 1722 cfm, fire loss pressure went to 30 inches w.g. Saturation temperature is steady at 67 degrees C. It will not go down further.

1800 Dumped ash, but took no sample as it was mostly water and 400 pounds ash.

1830 Disconnected ash pit air inlet to trap investigate reason for low ashpit pressure. Water comes out of the saturation pipe.

1837 Turned the jacket water off to install a valve in the jacket overflow trap. Saturation temperature went from 64 degrees C to 58 degrees C. right away. Then it rose to 84 degrees C.

1842 Ash pit air inlet pressure sensing port is reconnected.

Ash pit pressure now reads 22.5 inches w.g.

1843 The jacket water is back on. The overflow trap was filled with crud. We have been blowing almost all the jacket water over into the saturation pipe, none through the overflow. This has been the source of problems with the blast saturation temperature control.

1850 The CO is going down from 6% and the CO₂ and offtake is going up. Will test all poke holes.

1855 Poking seemed to help, but when it stopped, the offtake temperature went back up. Will try sending the agitator deeper into the bed. Blast saturation temperature is varying substantially between 62 & 71 degrees C.

1900 Holes number 2, 3, 4 & 5 are glowing on top. Bars are very sticky. Agitator speed is increased to 32 sweeps/hour.

1914 Adding more water to the water jacket.

1945 A trap was installed in the P-702 ash pit tap point to aid in moving liquid to the drain. P-702 readings should be more reliable now.

2010 Increased the saturation air flow to 1050 cfm

2045 Increased the saturation air flow to 1150 cfm.

2047 Dumped 1000 pounds of ash.

2115 The saturation fan is at max. The ashpit pressure is 31.7 inches w.g. Saturation air pressure is at 33.4 inches w.g.

2130 Adjusted the agitator travel to bring it up to the draft arrestor. There is char right under the poke holes. Freeboard is nil. Would like the agitator to clear the freeboard area. The fan is still at max. The saturation air flow is still varying from 600 cfm to 1000 cfm with ashpit pressure. Offtake temperature is approximatedly 352 degrees C. It has dropped some during the last 15 minutes.

2150 Pressure probe is in hole #5. Delta p from the ash pit is as follows:

	18 inches	26.0 inches w.g.
24 inches	24.7 inches w.g.	
30 inches	18.8 inches w.g.	
36 inches	10.1 inches w.g.	
42 inches	10.0 inches w.g.	
48 inches	6.9 inches w.g.	
54 inches	6.5 inches w.g.	
60 inches	6.0 inches w.g.	
66 inches	6.0 inches w.g.	
72 inches	5.9 inches w.g.	

84 inches	5.9 inches w.g.
90 inches	5.9 inches w.g.
96 inches	5.4 inches w.g.
102 inches	5.3 inches w.g.
108 inches	5.2 inches w.g.
114 inches	4.9 inches w.g.
120 inches	0.2 inches w.g.

The bulk of the pressure drop occurs between 18 inches and 36 inches below the poke hole top. The bulk of this is unavailable to agitation.

2200 Slowing the grate down after the fire test to 2/1.05.

2205 Will shut the bottom coal valve to reduce the coal feed and freeboard. The agitator will not rise above 38 inches from the top of the poke hole.

2300 Saturation control is set on the steam loop. T-703a is set at 55 degrees C. and holding relatively stable. This allows steam control at 60 degrees C.

2307 T-703a went back up to 70 degrees C, will have to open the water full.

2315 Coal valve was rotated so both upper and lower valves are closed. There was a gas leak on the coal bin level.

2325 The agitator was off for 5 minutes to retract a bar during the fire test. Restart was successful.

2350 Cyclone dump - no floating but substantial sunken dust.

May 1, 1983

0015 Turned the saturation air flow to 50 cfm to stabilize for the pressure probe.

0020 The pressure probe indicated that all but 10 inches w.g. is dropping from 36 inches below the top of the poke holes. This is 20 inches w.g. for a total delta p of 30 inches w.g.

0040 Poked all seven holes and opened the offtake. The saturation air flow is up to 1150 cfm and the ash pit is 25.9. The fire loss is 22.3 and gas offtake is 3.2. The offtake temperature is 480 degrees C.

0045 Dumped the cyclone and found a large amount of particulate. Cycled the coal valve drive.

0110 Increased the primary air fan to 3000 cfm and the secondary to 8000 cfm. Closed the gas control valve to maintain 1 inch in w.c. gas offtake pressure. Beautiful flame in the combustor.

0113 The CO is going down. Reduced the primary air fan to 2000

cfm.

0115 Dumped the cyclone and found some floatinig particulate.

0131 The saturtion air flow is no longer under control. The fan is at maximum. Will poke to reduce the fire loss pressure.

0140 Reduced the primary air fan to 1500 cfm and the secondary air fan to 2000 cfm. Saturation air flow is at 700 cfm.

0200 During the fire test, the bar went in hard. The coal feels spongy for the first 3-4 feet in.

0215 Flushed the cyclone and found a large amount of floating material. Poked the offtake. Saturation air flow changed from 650 to 1050 cfm.

0320 Poked the offtake. Found some build up.

0335 Poked all holes. The saturation air flow went from 925 to 1234 cfm. Ashpit pressure is 22.5 inches w.g., fire loss pressure is 20.2 inches w.g. and the gas offtake is 2.2 inches w.g.

0340 Dumped the cyclone. Found the cyclone to be plugged, raked and flushed again. Large amount of particu-ate came out.

0345 Dumped ash, but found mostly water.

0415 Poked the hole on the gas offtake. The saturation air flow is 1225 cfm. The freeboard has been averaging 16 inches throughout the shift. Saturation steam temperature has been stable at 57 degrees C for at least 3 hours on automatic. Water flow is 2400 gallons/hour.

0445 Dumped the cyclone. Found the cyclone to be plugged from the bottom of the tank up through the pipe. Went to rake the bottom of the tank and the tank overflowed water and particulate everywhere.

0450 Dumped 1125 pounds of ash. Took no sample as it was 99% water.

0600 Burning through on holes number 2, 3, 4, 5 & 6. The offtake temperature is 605 degrees C. Saturation air flow is 800 cfm. Dropping the offtake temperature.

0630 Advised not to use normal coal feed procedure. Adding coal only as the offtake temperature rises, then feed coal to cool the bed. The offtake temperature is currently at 434 degrees C. Add coal when it reaches 450 degrees C.

0650 Dumped the cyclone. Took 10 minutes of raking before flushing. Took 20-25 rake fulls off the bottom.

0655 Dumped 1250 pounds of ash. Found some small chunks but mostly water. Added .52 tons to the bed as the offtake had hit 454 degrees C.

0700 Freeboard is increasing slightly.

0705 The offtake temperature is at 422 degrees C.

0730 Checked the downcomer trap and found it to be packed tight with 8-10 inches of tar. There was little liquid on top.

0830 The offtake temperature hits 604 degrees C. The freeboard is now averaging approximately 18 inches. We cannot use the offtake temperature as an indicator for coal feed. All we have accomplished is to choke the legs and the agitator is pushing the coal up around the outer edges. Slowed the agitator speed to 20 sweeps/hour. Increased the grate speed to 2/1.50.

0845 The offtake temperature peaked at 600 degrees and has started down. Finished dumping water (was supposed to be ash). (2120 pounds) Still appear to be having water troubles. Installing high pressure or heavy duty hose to water jacket trap valve. If we can open the valve, the temperature should come down to more reasonable levels.

0915 Poked all six holes to break up the crust. There appears to be two layers of crust.

0920 Agitator outlet temperature is up to 115 degrees C. Increasing the water to 4.5 gallons/minute.

0930 Agitator outlet temperature is now 70 degrees C.

0940 Agitator outlet temperature is 63 degrees C. Dumped the cyclone. Still raking and have not hit bottom yet. Using a rod to poke the bottom particulate free. Cycled the valves twice and are getting large pieces. Repoking all six holes to break up the coal build up.

0945 Cut back on the water. Closed the bypass valve to allow steam valve (on automatic) to control the saturation temperature. It had been swinging mildly between 52 & 56 degrees C. It immediately rose to over 62 degrees C. and is beginning to swing between 58 & 62 degrees C.

0950 Repositioned the jacket flow control valve bypass to a trickle. Now the saturation temperature is between 56 & 60 degrees. Reduced the steam valve to 80% open.

1015 Increased the grate speed to 4/2.50. Dumped 1200 pounds of ash and found it to be all water except 2 cups of floating brown rust colored ash.

1025 Slowed the agitator down to 9.0 sweeps/hour from 20. Reduced the fire loss pressure to 7.5 inches from 8.5 inches.

The offtake temperature is now at 494 degrees C.

1030 Increased the saturation air flow to 850 cfm.

1035 The coal leg temperatures have risen from 36 to 75 degrees over the last hour and the offtake temperature is now going up again. The offtake is now 530 degrees C. The south coal leg is still cool, while the north coal leg is hot and smoking.

1040 The coal leg is now at 80 degrees C. and the offtake temperature is now 569 degrees C. Dropped .67 tons of coal.

1100 Increased the saturation air flow to 900 cfm. at 57 degrees C. Slowing the agitator to 7.0 sweeps/hour.

1115 Coal up by the standard method. Dropped 3.5 tons of coal. Will check the freeboard on the 1/2 hour. We will keep the load at this level until everything stabilizes.

1130 Leaving the agitator at 7.0 sweeps/hour.

1150 Attempting to slow down the excessive water through the jacket. We are now at 25 gallons/minute. Will reduce 1 gallon/minute every 5 minutes until the jacket air exhaust is up to 45 degrees C.

1200 Increased the grate speed to 4/2.70. Increased the agitator speed to 9 sweeps/hour.

1230 First regular coal feed after loading the lower bin and choking the coal pipes. Dropped .67 ton. Dumped the cyclone and cycled 3 times. The bottom is getting cleaned out. Increased the agitator speed to 12.0 sweeps/hour to aid in maintaining a 34 inch freeboard.

1250 Reduced the water jacket flow to 21 gallons/minute. T-703A is up to 4 degrees C. Turned the jacket trap valve off and are draining through the upper trap.

1300 Agitator speed is 12 sweeps/hour.

1305 Start coaling up at 4.52 tons.

1325 Stop coaling up 1.14 tons.

1330 Dumped the cyclone and noticed large floating masses 1" X 4" X 6" among fine silt.

1400 Increased the grate to 6/2.75 after the fire test.

1410 Reduced the agitator speed to 11 sweeps/hour.

1420 Increased the saturation air flow to 950 cfm and raised the saturation air temperature to 62 degrees C.

1500 Increased the load to 1000 cfm. Dumped 1000 pounds of ash.
1514 Dropped the saturation air flow to 950 cfm.
1524 Lowered the saturation air temperature to 60 degrees C.
1200 Dumped ash.
1800 Slowed the grate to 5 teeth after the fire test.
1900 Saturation temperature is wandering all over. We are now using 30 gallons /minute.
1930 Saturation temperature is dropping slightly. Opened the drain valve. The 3/8" jacket control valve bypass line is wide open.
2000 Slowed the grate to 2/1.0
2030 Increased the grate to 2/2.50
2230 Dumped 1100 pounds of ash. It was all water, however.
2240 Dumped the cyclone and found a small amount of particulate on the bottom of the tank.
2245 The grate speed is 3/2.00 and the agitator is 8.1.
2330 Slowed the agitator to 5.0 Holes number 2 & 5 were glowing on top.

May 2, 1983

0000 Coal bed is still glowing on top. Slowed the grate to 3/1.50
0030 Dumped the cyclone. There was 1/2" of particulate on top of the water. Two sweeps with the rake were needed to clean the bottom of the tank.
0100 Dumped 1075 pounds of ash (500 pounds of which was water)
0115 Increased the agitator to 7.5
0230 Dumped the cyclone. There was 1 inch of particulate and some chunks floating on the water.
0300 Dumped 910 pounds of ash. (650 pounds were actually ash). Increased the agitator to 9.5 to aid in maintaining a 30 inch freeboard. We are trying to neutralize the dirty bars.
0400 Slowed the grate to 2/1.50. Noticed part of one dog on the grate drive is broken off.

0435 Dumped the cyclone and found mostly surface particulate.

0535 Increased the saturation air flow to 1000 cfm.

0550 Increased the saturation air flow to 1050 cfm.

0555 Dumped 800 pounds of ash and water.

0700 Slowed the agitator to 1.6 sweeps/hour. Poked all six holes and found no clinkers or agglomeration, only a small crust on the top and bottom.

0710 Dumped ash (mostly water). We have been pushing 30+ gallons/minute through the jacket to help control the saturation temperature.

0730 Increased the agitator to 3.0 sweeps/hour

0750 Increased the grate speed for 10 minutes prior to the fire test to 2/3.0.

0800 Increased the agitator to 7 sweeps/hour. Leaving the grate at 2/3.0.

0850 Dumped 2400 pounds of ash. This again was mostly water, with only 15" of ash in the bottom of the hopper. Found about 1/3 of it was unburned material.

0900 Leaving the agitator at 7.0 sweeps per hour.

0915 Checked the downcomer and found only dry tar dust. It was basically clean. Increased the furnace pressure to 4.5 inches as the gas control valve can open no further.

0930 Started the change over to the 3/4 inch screen from 1/2 inch. Will let the upper bin empty out and try to restructure the fire bed with the larger screening. Increased the load to 1100 cfm. Increased the grate speed to 2/3.28 (10%). Will increase the agitator after the 1000 fire test, as increasing the grate speed will draw the bed down.

0945 The gas offtake pressure is back over 5.6 inches w.c.

1000 The bars for the fire test are going in very hard. Leaving the agitator at 7.0 sweeps/hour.

1030 Increased the saturation air flow to 1150 cfm. Increased the grate to 2/3.35.

1100 Increase the saturation air flow to 1200 cfm.

1115 The offtake pressure is at 6.8-7.0 inches. The offtake temperature is 585 degrees C.

1130 Dumped the cyclone and found 2-3 inch chunks of floating

material, finely divided. No large chunks. Dumped 2200 pounds of ash. Found much the same mixture of old coke and oxidized or crystallized chunks. Poked the combustor and found it to be tightly packed at the lip of the combustor.

1210 Manually increasing the water supply. Want to maintain a saturation temperature of 58 degrees C.

1220 Increase the saturation air flow to 1250 cfm. The saturation temperature is reacting to more water. It is now down to 59 degrees C.

1225 Opened the bypass a little farther. We are now running 45+ gallons/minute through the system and cannot seem to get the saturation temperature below 59 degrees C.

1230 Increase the grate to 2/3.87

1250 Increased the saturation air flow to 1300 cfm.

1255 Raised the agitator to 33"/35"

1300 Dumped the cyclone and ash.

1330 Increased the agitator to 10 sweeps/hour. Bumped the grate up to 2/4.00 Trying for more throughput to use up the coal so we can switch to the 3/4" fuel.

1350 The offtake temperature is 619 degrees C.

1400 Increased the speed to 12 sweeps/hour

1405 Cleaned the downcomer again.

1500 Dropped the saturation air flow to 950 cfm. The saturation temperature is 60 degrees C. Maintaining a 34 inch freeboard average. The agitator height is 35/37. The grate speed is 2/2.50. Dumped 1998 pounds of ash.

1730 The caustic line broke.

1745 The grate bar for the number of teeth jammed and bent allowing the grate to run at 10 teeth. This ground out the ash.

1800 Raised the saturation temperature to 70 degrees C. and increase the steam to 100%. Dropped the water flow to 8 gallons/minute. The saturation temperature went to 80 degrees C.

1830 Repaired the grate and set it at 1/1.00 as slow as it goes. Set the agitator at 5.2.

1900 Ash dump produced carbon chunks. Increased the saturation air flow to 600 cfm.

2000 Main flame out. Flooded the cyclone. Opened the vent.

2030 Cycled the vent valve.

2035 Closed off the steam. Saturation air temperature is 60 degrees C. Saturation air flow will remain 500 cfm for 1/2 hour to heat the fire so we can read the fire zones. Still venting.

2113 Vent valve cycled.

2120 Increasing the saturation air flow to 550 cfm.

2125 Draining the cyclone. The agitator is off.

2135 Main flame has been lit. We are back in business!

2230 Increased the saturation air flow to 700 cfm.

2245 Increased the saturation air flow to 750 cfm. Cyclone was left closed. Then opened and flushed to find only a small amount of particulate.

2300 Increased the saturation air flow to 800 cfm.

2310 Started the agitator at 2.0

2315 Increased the saturation air flow to 850 cfm

2330 Increased the saturation air flow to 900 cfm.

2335 Increased the agitator to 5.0. Increased the water flow to the jacket so steam saturation will have more control.

2345 Increased the saturation air flow to 950 cfm. Increased the saturation temperature to 60 degrees C. Dumped 1125 pounds of ash (800+ pounds of it was water).

May 3, 1983

0110 Dumped the cyclone and found 2" of floating material. Slowed the agitator to 2.5.

0135 The offtake temperature is 600 degrees C. After poking, the offtake temperature was 520 degrees C. Bed texture is varied (some hard spots and some very soft).

0145 Changed the caustic barrel. CO2 has risen 4% after poking the fire.

0200 Increased the grate to 7.0. Offtake temperature is 475 degrees C.

0215 Made the rounds outside. The fire in the combustion burner is stronger. Primary air is 2000 cfm.

0230 Coal bin weight is .11 ton. Started coaling up with the 3/4 inch screen.

0300 Agitator is 5.0 The offtake temperature is 605 degrees C.

0345 Coal bin weight is 10.21 (3/4 X 1 3/8 sized coal. Flushed the cyclone and found 1-2 inches of floating material. Checked the top of the upper bin. It was empty. Took the sample down. Number 9 should be number 8.

0430 Increased the agitator to 7.0. Flushed the cyclone and found 2 inches of floating material, and one rakefull on the bottom.

0445 Dumped 460 pounds of ash. Some clinker 3 inches in size were found, but mostly 1 inch diameter.

0630 Coal legs are still full. T-714 is still at 26 degrees C.

0700 Poked all 7 holes.

0710 Dumped 70 pounds of ash and water (610 pounds was water. Same unburned coke chunks and oxidized materials were found. Pieces were up to 2 inches in diameter.

0720 Poked the combustor. There was a 6 inch pile at the lip. We will continue to poke the combustor twice a shift.

0730 Burning through on number 4. The coal legs are still choked.

0745 There is a slight ringing on both the north and south coal legs. T-714 is at 27 degrees C. Will let it empty out more before adding the +3/4 inch coal into the lower bin.

0800 The bed is fairly loose. Changed the grate to 2/1.50. The agitator is at 6.9 sweeps/hour.

0810 The south coal leg is empty. A hollow ringing is evident. The digital now reads 28 degrees C.

0810 Dropped the + 3/4 coal into the lower bin. It took 3.38 tons. Will resume normal feed on the half hour. Leaving the saturation air flow at 950 cfm. The saturation temperature is 60 degrees C.

0815 Opened the bypass slightly to bring the jacket outlet temperature down to steam saturation temperature or below. The steam valve is 20% open. We are maintaining a 60 degree C saturation temperature.

0830 Noticed a slight glowing on holes 4 & 5.

0900 Dumped 1700 pounds of ash.

0920 Offtake pressure is at 6.0 inches. The gas valve is at 100%. Decreasing the furnace pressure. Vane valve open to 38%. Dropped the offtake to 4.2 inches.

0930 Took 1/2 ton of coal on the coal feed. The offtake temperature is 600 degrees C.

0940 Checked the downcomer and found 2 feet of dry cinderlike accumulation that was full of dust chunks like black styrofoam.

1000 Fire test showed the bed to be level, with a moderate crust halfway down. Reduce the grate to 2/1.40.

1045 Changed the grate to 1/2.00.

1055 Dumped 1900 pounds of ash.

1130 Poked the combustor again. Begin installing #1 scrubber pump and motor.

1140 Bed continues to glow on numbers 2, 3, 5 & 6.

1230 Cut back on the water. 52 gallons/minute through the jacket. Saturation temperature is 59 degrees C.

1245 Increase the grate to 2/2.00. Dumped 2000+ pounds of ash and water.

1300 Slowed the agitator to 6.0 sweeps/hour. The offtake pressure is over 5 inches again. Increasing the furnace pressure to 120.

1345 Number 1 scrubber motor is wired in, but need proper sized bolts to seat and tighten the unit down.

1400 Fire test showed a slight crust. Reduced the grate to 2/1.50.

1500 Dumped 1260 pounds of ash and water. Decreased the agitator speed to 4.0 sweeps/hour.

1530 Increased the agitator to 6.0 sweeps/hour.

1600 Decreased the agitator to 4.0 sweeps/hour. Increased the grate to 2/3.00.

1615 Increased the saturation air flow to 1000 cfm.

1715 Finished loading the rest of the Stahlman Stoker coal (8.09 tons).

1745 Slowed the agitator to 2.0 sweeps/hour

1800 The bed was a little sticky on this fire test.

1830 Increased the agitator to 6.0 sweeps/hour.

2000 Decreased the grate speed to 2/2.50

2030 Dump 792 pounds of ash and water (750 pounds of water).

2230 Coal leg temperature is 71 degrees C.

2240 Poked all 7 holes. Increased the agitator to 7.0 sweeps and decreased the grate. Flushed the cyclone and found 1 inch of floating material.

2330 Coal leg temperature is 48 degrees C. Rapped on them and they sounded empty and were hot. Coaled up .66 tons.

2335 Dumped ash and water (800 pounds). Flushed the cyclone. Increased the agitator to 10.0.

May 4, 1983

0000 Slowed the agitator down to 7.0 sweeps/hour. Slowed the grate down to 1/1.10.

0100 Dumped 1247 pounds of ash and water. Appeared to be 90% water. Opened the valve for the water jacket. The coal leg temperature is 29 degrees C.

0200 The number 7 bar on this fire test came out so cold you could hold it with your bare hand where the fire should be.

0230 Dumped 1150 pounds of ash and water (875 pounds was water)

0400 Flushed the cyclone and found a large amount of floating material, some of which was pretty good size chunks.

0435 Made the rounds outside. The belts are squeeling, but everything else seems o.k.

0500 Found some klinkers between holes number 1 & 2 this fire test.

0515 Flushed the cyclone and found 1/2 inch of fine floating material.

0630 Dumped the cyclone and found a small amount of floating matter and some small chunks on the bottom.

0700 Checked the ash and found there was only 300 pounds. Cracked the bottom valve on the ash cone to allow water to run out. The offtake temperature is up to 600 degrees C.

0730 The offtake temperature is now 636 degrees C. Burning

through on numbers 2 & 5. Feeding coal. It initially hung up after .2 tons, but finally dropped .82 tons.

0740 Cleaned out the downcomer. Hot tar in the barrel ignited the gas immediately upon opening the valve. Ignition with flame 5 feet all around resulted. High pressure emptied out the downcomer. Must find a round barrel which can be sealed. Shutting down BOM/FGT 004.

0750 Cyclone valve is closed. Flooding the cyclone in preparation for shut down. Closed the lower valve on the ash cone. When the P-706 starts to drop, will turn off the saturation blower.

0755 Closed the jacket water overflow valve.

0758 Closed the vane valve to 30%.

0801 Opened the vent valve manually. Shut off primary and secondary air fans. Let the scrubber system and I.D. fan run to clear out the system. Shut off the agitator. Turn off the saturation blower interlocks.

0807 Cyclone is flooded and the water is left at a trickle.

0810 Open both ash valves. Used upper nozzles to flush the underside. Turned off the combustor pilot light. Reduced jacket water to 10 gallons per minute.

0815 Turned off the steam valve to the saturation system. Closed the vane valve all the way. Turn all the breakers off, with the exception of the grate and I.D. fan. Turn off the oil to the gasifier.

0830 Jacket water is 63 degrees C.

0845 Shut off the main steam valve. Put the boiler on low level.

0848 Turn off I.D. fan and grate drive. Open the downcomer completely. Cut down the scrubber tank blowdown hoses to a trickle. Turned off the caustic pump. Rechecked the cyclone. The water is at a trickle with the trap overflowing to maintain a seal.

END OF BOM/FGT 004 STAHLMAN STOKER

APPENDIX B

Weather Data for Testing Days

These data were taken from NOAA weather station 72658
approximately 3 miles from the test site.

Note: Barometric pressure has been adiabatically normalized to
sea level from 840 feet elevation and ambient temperature.

Temperature in degrees Farenheit

Relative Humidity in %

Barometric Pressure in inches mercury

Precipitation in inches

HOUR	TEMP	RELATIVE HUMIDITY	BAROMET PRESS	RAIN SNOW
------	------	-------------------	---------------	-----------

DATE: MAY 1, 1983

1	48	61	29.065	
2	46	65	29.065	
3	46	68	29.065	
4	46	70	29.075	
5	45	70	29.075	
6	46	73	29.065	
7	49	71	29.025	
8	51	66	29.025	
9	53	57	29.025	
10	55	47	28.995	
11	56	40	28.945	
12	57	38	28.910	
13	57	37	28.860	
14	60	36	28.820	
15	60	36	28.760	
16	61	36	28.730	
17	60	42	28.730	T
18	52	74	28.730	.12
19	50	89	28.725	.22
20	49	89	28.715	.23
21	46	79	28.715	.29
22	44	79	28.695	.18
23	44	82	28.665	.15
24	42	88	28.655	.07

General Conditions: Clear sunrise and cloudy sunset. 645 minutes of sunshine(75%). Maximum wind speed-33mph.

HOUR	TEMP	RELATIVE HUMIDITY	BAROMET PRESS	RAIN SNOW
------	------	-------------------	---------------	-----------

DATE: MAY 2, 1983

1	41	82	28.635	.02
2	40	76	28.625	T
3	41	73	28.635	.03
4	41	67	28.645	.01
5	40	79	28.655	T
6	39	79	28.685	.02
7	40	79	28.705	.01
8	43	76	28.715	.01
9	49	77	28.730	
10	52	69	28.750	
11	59	62	28.760	
12	60	53	28.760	
13	63	41	28.770	
14	64	37	28.790	
15	65	37	28.790	
16	64	35	28.800	
17	64	31	28.820	
18	63	32	28.820	
19	61	33	28.840	
20	57	36	28.860	
21	54	43	28.870	
22	53	41	28.880	
23	51	44	28.880	
24	51	42	28.890	

General Conditions: Cloudy sunrise and cloudy sunset. 616 minutes of sunshine(72%). Maximum wind speed-24mph.

HOUR	TEMP	RELATIVE HUMIDITY	BAROMET PRESS	RAIN SNOW
------	------	-------------------	---------------	-----------

DATE: MAY 3, 1983

1	48	48	28.890	
2	48	46	28.890	
3	46	49	28.890	
4	44	58	28.900	
5	42	62	28.920	
6	44	60	28.920	
7	46	63	28.935	
8	51	48	28.935	
9	54	43	28.925	
10	56	37	28.920	
11	59	34	28.910	
12	62	28	28.890	
13	64	31	28.870	
14	66	33	28.850	
15	66	32	28.830	
16	67	33	28.820	
17	67	34	28.810	
18	66	36	28.790	
19	65	37	28.790	T
20	57	59	28.780	T
21	55	64	28.780	
22	59	51	28.800	
23	57	40	28.810	
24	54	45	28.830	

General Conditions: Cloudy sunrise and cloudy sunset. 646 minutes of sunshine(75%). Maximum wind speed-21mph.

HOUR	TEMP	RELATIVE HUMIDITY	BAROMET PRESS	RAIN SNOW
------	------	-------------------	---------------	-----------

DATE: MAY 4, 1983

1	51	54	28.860	
2	49	50	28.880	
3	45	53	28.900	
4	43	60	28.920	
5	41	67	28.935	
6	41	67	28.925	
7	44	62	28.965	
8	46	63	28.970	
9	48	58	28.985	
10	50	56	28.995	
11	50	56	29.000	
12	53	52	28.995	
13	54	52	28.995	
14	55	47	28.995	
15	57	42	28.990	
16	57	42	28.985	
17	57	39	28.985	
18	55	43	28.985	
19	55	40	28.985	
20	54	41	28.995	
21	52	46	29.005	
22	52	44	28.995	
23	47	60	29.000	
24	48	66	29.015	T

General Conditions: Cloudy and cloudy sunrise. 730 minutes of sunshine(85%). Maximum wind speed-21mph.

APPENDIX C

Coal Analysis Data

- C-1 Gasifier Feed Coal Sizing Data
- C-2 Screen Feed Coal Sizing Data
- C-3 After Screen Coal Sizing Data

Table C-1

Feed Coal Size Distribution for BOM/FGT-004

Sample Number	Date	Shift Start Time	Screen Mesh Size inch	Cumulative Mass Fraction, % <u>less than stated mesh size, inch</u>				
				1/4	1/2	3/4	1	1 1/2
1	4/30/84	8:00	1/2	2.1	20.0	74.0	94.1	100.0
2	4/30/84	16:00	1/2	1.9	20.2	65.1	90.3	100.0
3	5/ 1/84	0:00	1/2	4.0	28.8	73.8	93.0	100.0
4	5/ 1/84	8:00	1/2	1.6	15.6	51.1	83.2	98.5
5	5/ 1/84	16:00	1/2	1.7	13.6	63.8	90.4	100.0
6	5/ 2/84	0:00	1/2	1.6	16.4	64.5	92.1	100.0
7	5/ 2/84	8:00	1/2	0.7	13.8	57.3	87.4	100.0
8	5/ 2/84	16:00	1/2	2.7	15.9	66.7	90.8	100.0
9	5/ 3/84	0:00	1/2	10.0	37.8	83.9	97.4	100.0
10	5/ 3/84	8:00	1/2	2.1	7.6	31.7	74.4	100.0
11	5/ 3/84	16:00	1/2	3.0	9.0	34.6	79.5	100.0
12	5/ 4/84	0:00	1/2	3.2	7.0	30.5	76.7	100.0
13	5/ 4/84	8:00	1/2	2.2	5.8	23.6	77.7	100.0
AVERAGE				2.8	16.3	55.4	86.8	99.9

Table C-2

Coal Size Distribution as Fed to Screen

Sample Number	Date	Screen Mesh Size inch	Cumulative Mass Fraction, % <u>less than stated mesh size, inch</u>				
			1/4	1/2	3/4	1	1 1/2
1	4/30	3/4	11.9	51.8	82.1	94.8	100.0
2	5/01	3/4	7.3	34.8	67.8	93.1	100.0
Average			9.6	43.3	74.9	93.9	100.0

Table C-3

Coal Size Distribution After Screen

Sample Number	Date	Screen Mesh Size inch	Cumulative Mass Fraction, % <u>less than stated mesh size, inch</u>				
			1/4	1/2	3/4	1	1 1/2
1	4/30	3/4	0.7	20.8	70.7	91.6	100.0
2	5/01	3/4	0.4	7.4	50.1	82.3	100.0
Average			0.6	14.1	60.4	86.9	100.0

APPENDIX D

Coal Consumption Log

Coal Weights are given in short tons.

DATE	TIME	SAMPLE NUMBER	SCREEN IN	WASH?	START WT.	STOP WT.	NET WT.
04-30	0845	004-C1	.50	NO	11.91	7.97	3.94
04-30	0930	004-C1	.50	NO	12.23	11.40	.83
04-30	1030	004-C1	.50	NO	11.40	10.13	1.27
04-30	1130	004-C1	.50	NO	10.13	9.21	.92
04-30	1230	004-C1	.50	NO	9.21	8.46	.75
04-30	1330	004-C1	.50	NO	8.45	7.90	.55
04-30	1800	004-C1	.50	NO	7.92	6.75	1.17
04-30	1930	004-C1	.50	NO	6.72	5.99	.73
04-30	2030	004-C1	.50	NO	5.98	5.44	.54
04-30	2130	004-C1	.50	NO	5.44	5.14	.30
05-01	0530	004-C3	.50	NO	11.31	10.81	.50
05-01	0655	004-C3	.50	NO	10.81	10.28	.53
05-01	0748	004-C4	.50	NO	10.31	9.61	.70
05-01	0819	004-C4	.50	NO	9.64	9.34	.30
05-01	1045	004-C4	.50	NO	9.37	8.70	.67
05-01	1115	004-C4	.50	NO	8.70	5.19	3.51
05-01	1230	004-C4	.50	NO	5.19	4.52	.67
05-01	1330	004-C4	.50	NO	11.15	10.28	.87
05-01	1430	004-C3	.50	NO	10.27	9.37	.90
05-01	1530	004-C4	.50	NO	9.36	8.50	.86
05-01	1630	004-C4	.50	NO	8.50	7.66	.84
05-01	1730	004-C4	.50	NO	7.66	6.94	.72
05-01	1830	004-C4	.50	NO	6.92	6.30	.62
05-01	1930	004-C4	.50	NO	6.30	5.75	.55
05-01	2030	004-C4	.50	NO	5.75	5.45	.30
05-01	2130	004-C4	.50	NO	11.77	11.54	.23
05-01	2230	004-C4	.50	NO	12.11	11.62	.49
05-01	2330	004-C5	.50	NO	11.62	11.09	.53
05-02	0030	004-C5	.50	NO	11.09	10.71	.38
05-02	0130	004-C5	.50	NO	10.71	10.24	.47
05-02	0230	004-C5	.50	NO	10.24	9.75	.49
05-02	0330	004-C5	.50	NO	9.75	9.22	.53
05-02	0430	004-C5	.50	NO	9.22	8.73	.49
05-02	0530	004-C5	.50	NO	8.73	8.26	.47
05-02	0630	004-C5	.50	NO	8.26	7.98	.28
05-02	0730	004-C6	.50	NO	7.98	7.72	.26
05-02	0830	004-C6	.50	NO	7.72	7.17	.55
05-02	0930	004-C6	.50	NO	7.17	6.65	.52
05-02	1030	004-C6	.50	NO	6.65	6.11	.54
05-02	1130	004-C6	.50	NO	6.11	5.51	.60
05-02	1230	004-C6	.50	NO	5.51	4.81	.70
05-02	1330	004-C6	.50	NO	4.81	4.17	.64
05-02	1430	004-C6	.50	NO	4.16	3.56	.60
05-02	1530	004-C7	.50	NO	3.55	3.13	.42
05-02	1630	004-C7	.50	NO	3.11	2.82	.29
05-02	1730	004-C7	.50	NO	2.81	2.35	.46
05-02	1830	004-C7	.50	NO	2.35	1.69	.66
05-02	1930	004-C7	.50	NO	1.69	1.51	.18
05-02	2030	004-C7	.50	NO	1.51	1.41	.10
05-02	2130	004-C7	.50	NO	1.41	1.33	.08
05-02	2230	004-C7	.50	NO	1.33	1.27	.06
05-02	2330	004-C9	.50	NO	1.27	1.13	.14

DATE	TIME	SAMPLE NUMBER	SCREEN IN	WASH?	START WT.	STOP WT.	NET WT.
05-03	0030	004-C9	.50	NO	1.13	.90	.23
05-03	0130	004-C9	.50	NO	.90	.81	.09
05-03	0230	004-C9	.50	NO	.81	.11	.70
05-03	0810	004-C10	.50	NO	10.21	6.83	3.38
05-03	0830	004-C10	.50	NO	6.83	6.71	.12
05-03	0930	004-C10	.50	NO	6.71	6.23	.48
05-03	1030	004-C10	.50	NO	6.23	5.82	.41
05-03	1130	004-C10	.50	NO	5.82	5.40	.42
05-03	1230	004-C10	.50	NO	5.40	4.97	.43
05-03	1330	004-C10	.50	NO	4.97	4.56	.41
05-03	1430	004-C11	.50	NO	4.56	4.18	.38
05-03	1530	004-C11	.50	NO	4.77	4.37	.40
05-03	1630	004-C11	.50	NO	5.73	5.30	.43
05-03	1730	004-C11	.50	NO	8.09	7.74	.35
05-03	1830	004-C11	.50	NO	7.74	7.25	.49
05-03	1930	004-C11	.50	NO	7.24	6.79	.45
05-03	2030	004-C11	.50	NO	6.79	6.37	.42
05-03	2130	004-C11	.50	NO	6.37	5.86	.51
05-03	2230	004-C11	.50	NO	5.86	5.33	.53
05-03	2330	004-C12	.50	NO	5.33	4.69	.64
05-04	0030	004-C12	.50	NO	4.69	4.20	.49
05-04	0130	004-C12	.50	NO	4.20	3.69	.51
05-04	0230	004-C12	.50	NO	3.69	3.14	.55
05-04	0330	004-C12	.50	NO	3.14	2.57	.57
05-04	0430	004-C12	.50	NO	2.57	2.15	.42
05-04	0530	004-C12	.50	NO	2.15	1.58	.57
05-04	0630	004-C12	.50	NO	1.58	1.34	.24
05-04	0730	004-C12	.50	NO	1.34	.52	.82

APPENDIX E
Ash Analysis Data

ASH ANALYSIS FOR BOM/FGI-004

Sample Number	Date	Time	Cumulative Mass Fraction, % less than stated size, inch					Bulk Density gm/cc	Moisture content %	Carbon content %	Sulfur content %
			1/4	1/2	3/4	1	2				
1	4/30/84	9:00	45.2	64.6	74.5	76.8	78.4	0.71	22	4.3	0.09
2	4/30/84	11:00	38.8	53.7	59.3	64.6	70.0	---	27	2.7	0.07
3	4/30/84	12:10	88.5	94.6	95.7	96.9	100.0	---	45	5.0	0.10
7	5/ 1/84	10:14	7.9	12.4	15.3	16.6	28.2	0.57	22	0.3	0.05
5	4/30/84	22:35	---	---	---	---	---	---	---	18.0	0.12
8	5/ 1/84	11:10	9.9	21.4	35.3	48.6	92.1	0.50	34	32.6	0.19
9	5/ 1/84	13:00	22.4	45.2	62.5	74.5	100.0	0.44	36	14.0	0.10
10	5/ 1/84	15:00	17.6	32.3	44.3	49.7	70.0	0.55	36	20.1	0.12
11	5/ 1/84	17:00	38.2	57.8	69.5	79.9	98.9	0.48	43	22.4	0.16
12	5/ 1/84	18:45	43.3	67.3	81.2	88.1	100.0	0.52	58	31.0	0.29
13	5/ 1/84	20:29	11.8	21.8	30.6	39.4	70.2	0.57	36	16.1	0.12
14	5/ 2/84	3:00	22.2	35.4	49.9	62.1	100.0	0.54	40	21.2	0.16
15	5/ 2/84	2:00	5.5	11.2	21.4	32.2	46.5	---	41	18.6	0.14
16	5/ 2/84	8:50	48.9	60.6	68.0	78.1	92.4	0.61	0	10.9	0.10
17	5/ 2/84	11:30	14.9	31.8	48.6	60.5	94.2	---	69	26.2	0.15
18	5/ 2/84	13:00	26.7	35.5	46.2	58.8	90.9	0.55	32	25.6	0.18
19	5/ 3/84	15:00	27.2	38.1	47.7	59.6	82.4	0.56	39	28.1	0.17
20	5/ 2/84	18:20	15.3	29.3	45.8	65.7	97.7	0.48	32	30.7	0.25
23	5/ 3/84	9:00	20.4	45.9	63.2	77.7	100.0	0.48	32	14.6	0.12
22	5/ 3/84	7:09	22.0	39.1	53.6	65.2	85.6	0.59	33	20.7	0.13
21	5/ 3/84	4:55	16.0	34.6	52.7	64.2	84.7	0.59	35	20.3	0.13
24	5/ 3/84	11:00	17.2	37.1	51.3	62.3	86.3	0.59	28	5.9	0.06
25	5/ 3/84	12:44	14.4	34.0	51.0	61.1	84.4	0.49	30	20.1	0.12
26	5/ 3/84	15:00	15.6	32.1	50.4	64.0	85.1	0.48	166	27.2	0.18
27	5/ 3/84	20:29	16.0	38.3	60.0	73.3	100.0	0.51	32	18.0	0.12

APPENDIX F

Ash Removal Log

Ash weights are given in pounds.
(multiply by 1.24 to obtain corected load cell readings.)

Flush water is given in gallons.

DATE	TIME	SAMPLE NUMBER	INITIAL DRY	FINAL DRY	NET DRY	INITIAL WET	FINAL WET	NET WET	NET DRY +NET WET	FLUSH WATER
04-30	0900	004-1	420	95	325	405	55	350	675	30
04-30	1100	004-2	540	60	480	390	55	335	815	30
04-30	1210	004-3	1365	71	1294	420	91	329	1623	25
04-30	2100	004-4	1115	65	1050	---	---	---	---	--
04-30	2230	004-5	832	167	665	542	48	494	1159	30
05-01	0335	004-6	1030	67	963	JUST	WATER	NO	ASH	
05-01	0630	---	1250	67	1183	JUST	WATER	NO	ASH	
05-01	0830	---	1240	79	1161	JUST	WATER	NO	ASH	
05-01	0845	---	880	142	738	JUST	WATER	NO	ASH	
05-01	1015	004-7	1187	71	1101	LESS	THAN 1	POUND	ASH	
05-01	1110	004-8	675	70	605	540	72	468	1073	30
05-01	1300	004-9	1003	65	938	607	64	543	1481	30
05-01	1500	004-10	948	65	883	455	61	394	1277	30
05-01	1700	004-11	1190	64	1126	445	62	383	1509	30
05-01	1845	004-12	898	62	836	525	58	467	1303	30
05-01	2030	004-13	1268	68	1200	430	68	362	1562	30
05-02	0300	004-14	634	63	571	43	65	378	949	30
05-02	0700	004-15	622	64	58	403	65	338	896	30
05-02	0850	004-16	2425	69	2356	620	61	559	2915	30
05-02	1130	004-17	2222	70	2152	586	76	510	2662	30
05-02	1300	004-18	2372	69	2303	820	72	743	3051	30
05-02		004-19	360	62	298	370	60	310	608	30
05-02	1320	004-20	980	74	906	348	64	284	1190	30
05-03	0455	004-21	460.	57	403	387	52	335	738	30
05-03	0710	004-22	186	63	123	417	56	361	484	30
05-03	0900	004-23	165	635	100	250	67	183	283	30
05-03	1100	004-24	159	64	95	260	60	200	295	30
05-03	1300	004-25	160	67	93	225	45	180	273	30
05-03	1500	004-26	974	70	904	397	67	330	1234	30
05-03	2030	004-27	792	60	732	490	64	426	1158	30

APPENDIX G
Operator Logged Data

Included are three tables of data:

G-1. Freeboard Data

G-2. Firetest Data

G-3. Miscellaneous Operator Logged Data

Water flows in gpm.

Water totals in gallons.

Steam flows in lb/min.

Agitator counter in (total revolutions * 2)

G-4. Grate operation Data

Grate Gear counter in (total grate revolutions * 116)

Further description of these data are given in Volume 1 of this series (Thimsen et al, 1984).

Table G-1

FREEBOARD DATA

DATE	TIME	#1	#2	#3	#4	#5	#6	AVE
04-30	0800	38	38	40	39	41	40	39.3
04-30	0900	40	41	39	38	40	38	39.3
04-30	1000	37	39	39	38	40	39	38.7
04-30	1100	35		38		37		36.7
04-30	1200		27		24		24	25.0
04-30	1300	24		23		23		23.3
04-30	1400	24	22	25	21	23	25	23.3
04-30	1730	21	16	18	20	18	20	18.8
04-30	1900	17	16	21	20	23	22	19.8
04-30	1940	17	16	21	20	23	22	19.8
04-30	2100	19	13	13	16	14	13	14.7
04-30	2230		15			17		16.0
04-30	2300			11			11	11.0
04-30	2330	16			15			15.5
05-01	0030			30			10	20.0
05-01	0100	29			31			30.0
05-01	0130		20			18		19.0
05-01	0200			17			17	17.0
05-01	0230	16			17			16.5
05-01	0300		15			15		15.0
05-01	0330			16			16	16.0
05-01	0400	16			18			17.0
05-01	0430		19			18		18.5
05-01	0500			15			15	15.0
05-01	0530	16			18			17.0
05-01	0600		25			26		25.5
05-01	0630	19	18	18	16	21	19	18.5
05-01	0700	21	19	18	16	20	22	19.3
05-01	0800	17	21	20	22	18	17	19.2
05-01	0830	17	17	18	20	19	17	18.0
05-01	0900	19	21	13	16	21	19	18.2
05-01	1000	20	20	18	17	18	18	18.5
05-01	1100	27	27	23	21	25	26	24.8
05-01	1130	27	28	31	30	29	27	28.7
05-01	1200	34	33	36	37	36	36	35.3
05-01	1230	33	33	35	33	30	32	32.7
05-01	1300	33	34	37	34	33	36	34.5
05-01	1330	34	31	36	34	34	36	34.2
05-01	1400	32	33	33	34	35	34	33.5
05-01	1430	35	32	34	35	29	35	33.3
05-01	1500	31	35	36	34	31	35	33.7
05-01	1600	36	32	32	35	36	34	34.2
05-01	1630	34	29	34	35	35	34	33.5
05-01	1700	29	34	34	24	32	33	31.8
05-01	1730	27	26	36	31	32	33	30.8
05-01	1800	30	31	29	32	32	30	30.7
05-01	1830	27	29	28	29	31	29	28.8
05-01	1900	29	31	25	25	28	27	27.5
05-01	1930	26	25	24	23	26	22	24.3

DATE	TIME	#1	#2	#3	#4	#5	#6	AVE
05-01	2000	26	26	31	30	25	32	28.3
05-01	2030	26	25	26	25	28	28	26.3
05-01	2100	28	30	31	30	31	38	31.3
05-01	2130		33			36		34.5
05-01	2200			37			37	37.0
05-01	2230	37			34			35.5
05-01	2300		34			35		34.5
05-01	2330			33			33	33.0
05-02	0000	32			33			32.5
05-02	0030		34			36		35.0
05-02	0100			36			37	36.5
05-02	0130	36				34		35.0
05-02	0200		34		35			34.5
05-02	0230			32			34	33.0
05-02	0300	36				35		35.5
05-02	0330		33				36	34.5
05-02	0400	34			33			33.5
05-02	0430		32			34		33.0
05-02	0500			31			32	31.5
05-02	0530	31			32			31.5
05-02	0600		32			31		31.5
05-02	0630	27	25	25	24	26	23	25.0
05-02	0700			27			27	27.0
05-02	0730	36			37			36.5
05-02	0800		38	39		41	40	39.5
05-02	0830		37			36		36.5
05-02	0900	33		33	36		36	34.5
05-02	1000		33.5	33		34.5	34	33.75
05-02	1030		35			33.5		34.25
05-02	1100			34.5			34.5	34.5
05-02	1130	36	37		36	35		36.0
05-02	1200	35		36	34		37	35.5
05-02	1230	37	36		35	33		35.25
05-02	1300	35			33			34.0
05-02	1330			34			36	35.0
05-02	1400		33			35		34.0
05-02	1430	22				33		32.5
05-02	1500		33			31		32.0
05-02	1530			33			36	34.5
05-02	1600	34			34			34.0
05-02	1700		33			34		33.5
05-02	1800			42			41	41.5
05-02	1900	33			27			30.0
05-02	1930		32			31		31.5
05-02	2000			24			23	23.5
05-02	2100			30			22	26.0
05-02	2130	27				23		25.0
05-02	2230		29		33			31.0
05-02	2300			36			35	35.5
05-02	2330	37			39			38.0
05-03	0000		34			33		33.5
05-03	0030			37			34	35.5
05-03	0100	32			33			32.5

DATE	TIME	#1	#2	#3	#4	#5	#6	AVE
05-03	0130		32			32		32.0
05-03	0200			40			42	41.0
05-03	0230	38			39			38.5
05-03	0300		34			33		33.5
05-03	0330			34			30	32.0
05-03	0400	36			36			36.0
05-03	0430		35			37		36.0
05-03	0500			35			35	35.0
05-03	0530	36			35			35.5
05-03	0600		32			32		32.0
05-03	0630			33			34	33.5
05-03	0700	34			35			34.5
05-03	0730		34			33		33.5
05-03	0800			32			34	33.0
05-03	0830	33			32			32.5
05-03	0900		30			33		31.5
05-03	0930			33			33	33.0
05-03	1000	30			30			30.0
05-03	1030		33			32		32.5
05-03	1100			31			32	31.5
05-03	1130	30			31			30.5
05-03	1200		28			29		28.5
05-03	1230			32			31	31.5
05-03	1300		28			32		30.0
05-03	1330	33			31			32.0
05-03	1400	32			33			32.5
05-03	1430		33			34		33.5
05-03	1500			33			29	31.0
05-03	1530	35			34			34.5
05-03	1600		31			33		32.0
05-03	1630	35			33			34.0
05-03	1700		34			33		33.5
05-03	1730			33			29	31.0
05-03	1800	36			35			35.5
05-03	1830		34			36		35.0
05-03	1900			35			33	34.0
05-03	1930	34			34			34.0
05-03	2000		31			35		33.0
05-03	2030			34			34	34.0
05-03	2100	36			35			35.5
05-03	2130		35			37		36.0
05-03	2230			30			31	30.5
05-03	2300	36			34			35.0
05-03	2330		36			38		37.0
05-04	0000			31			30	30.5
05-04	0030	34			38			36.0
05-04	0100		32			33		33.5
05-04	0130			35			37	36.0
05-04	0200	34			36			35.0
05-04	0230		34			35		34.5
05-04	0300			31			30	30.5
05-04	0330	35			33			34.0
05-04	0400		31			32		31.5

DATE	TIME	#1	#2	#3	#4	#5	#6	AVE
05-04	0430			33			32	32.5
05-04	0500	33			32			32.5
05-04	0530	34			34			34.0
05-04	0600		33			32		32.5
05-04	0630			33			34	33.5
05-04	0700		32			33		32.5
05-04	0730	32			29			30.5

Table G-2

FIRETEST DATA

Date	Time	Insertion Time (min)	#1	#2	#3	#4	#5	#6	#7	Average
04-30	0800	2	21	18	8	12	10	26d	6	14.4
04-30	1000	2	14	16	11	13	13	13	9	12.7
04-30	1200	2	14d	15	14	21c	10c	14	1	12.7
04-30	1400	2	16			18				17.0
04-30	1625	2	10	9	11	12	10	13	6	9.0
04-30	1745	2	14	11	9	11	8	12	3	9.7
04-30	2000	2	8	10	5	10	11	13	6	9.0
04-30	2200	2	3	1	2	2	2	3	3	2.3
05-01	0000	2	2	1	0	3d	6	6	c	2.6
05-01	0200	2	4	9	5	7	1	1	c	3.9
05-01	0400	2	5	6	3	4d	8	9	5c	5.0
05-01	0600	2	7	4	5d	5d	3	7d	21d	7.4
05-01	0800	2	5	9d	29	17	5d	7d	4	10.9
05-01	1000	2	9d	8d	35	38	2d	5	39	19.4
05-01	1200	2	16d	17	18d	19	18	14c	1d	14.7
05-01	1400	2	14d	13	26	13d	14d	11d	16	15.3
05-01	1600	2	14	12	14	17	8d	10c	8	11.9
05-01	1800	2	7	9	3	27	10d	2	4	8.9
05-01	2000	2	6	5	0	3	8	2	3	3.9
05-01	2200	2	5	2	0	4	3	1	4	2.7
05-02	0000	2	3	3	5c	3	4	0	5c	3.3
05-02	0200	2	0	0d	22	29	2d	0d	c	7.6
05-02	0400	2	2	1	1d	1d	2	2	c	1.3
05-02	0600	2	0	3d	1d	1d	0d	0d	4c	1.3
05-02	0800	2	2	3d	19d	1	5c	6d	2c	5.4
05-02	1000	2	7c	6	1.5d	0d	1.5	2d	6	3.4
05-02	1200	2	1d	8	7c	2	2d	2d	3c	3.6
05-02	1400	2	10c	3	1d	1d	1d	3	3c	3.1
05-02	1600	2	0	2	40	9	1	1	3c	8.0
05-02	1800	2	0	0	0	1	3	0	0	.6
05-02	1900	2	1	3	3	2	3	1	4	2.1
05-02	2000	2	27	2	2	1	1	1	1	5.0
05-02	2100	2	1	1	1	2	26	25	0	8.0
05-02	2200	2	2	7	1	2	2	0	0	2.0
05-03	0000	2	2d	1d	1d	1d	6d	1d	0c	1.7
05-03	0200	2	2d	2d	2d	5d	7d	3	21c	6.0
05-03	0400	2	3d	0d	8d	11d	13	4	8	6.7
05-03	0600	2	6	7	9	11	13	4	0	7.1
05-03	0800	2	11	11	15c	8	5	9	2	8.7
05-03	1000	2	4	8d	9	6	5	8d	5	6.4
05-03	1200	2	8d	7	8	39	8	6d	5c	11.6
05-03	1400	2	8d	7d	6	4	7	4	5c	5.9
05-03	1600	2	12d	6	8c	7d	4d	9	3c	7.0
05-03	1800	2	8	3	13	5	3	4	0	5.1
05-03	2000	2	3	3	2d	0	1d	3d	0c	1.7
05-03	2200	2	0	2d	3	46	40	2d	0c	13.3
05-04	0000	2	8c	3	1d	2d	1d	1d	0c	2.3
05-04	0200	2	5d	1d	4	2	2	6	0c	2.9

Date	Time	Insertion Time (min)	#1	#2	#3	#4	#5	#6	#7	Average
05-04	0400	2	6	3	4d	9	9	7d	9c	6.7
05-04	0600	2	8	11	7	7	14	11	0c	8.3

END OF BOM/FGT 004 STAHLMAN STOKER

DATE	TIME	AGIT	JACKT	JACKT	JACKT	SATURATED STEAM					AGIT	AGIT	AGIT	AGIT
		WATER	WATER	WATER	WATER	STEAM	METER	INLET	OUTLET	VALVE	COUNT	HRLY	DRIVE	DEPTH
		FLOW	FLOW	FLOW	HRLY	RATE	INLET	VALVE	VALVE	POSIT	RONG	SWPS	SEING	SMP/HR
				TOTAL	USAGE	FLOW	PRESS	PRESS	PRESS	%				
04-30	0730	3	6	3919		2	12.0	11.1	1.8	18	250		5.7	36.5
04-30	0830	3	6	3924	500	2	11.9	11.0	2.0	20	256	6	5.7	37
04-30	0930	3	8	3929	500	2	11.6	11.4	0.1	15	262	7	10.0	38.5
04-30	1030	3	18	3935	600	PUT SAT. TEMP. ON WATER CONTROL					269	7	10.0	36/40
04-30	1130	3	20	3945	1000						279	10	10.0	36/40
04-30	1230	3	25	3690	1500						290	11	13.0	36/40
04-30	1330	3	35+	3975	1000						298	8	5.8	35/40
04-30	1430	3	15	3988	1300						303	5	3.8	36/40
04-30	1930	3	35+	4069	71						337	6.8	2.3	
04-30	2030	3	—	4093							335			
04-30	2230	3	6	4133		<2.42				0	392			
04-30	2330	3	30	4149	1600	<2.42	12	12	0	10	407	15		
05-01	0030	3	30+	4167	1800	<2.42	12	11	2	18	427	20		
05-01	0130	3	30+	4188	2100	<2.42	0	0	0	0	454	27		
05-01	0230	3	30+	4215	2700	<2.42	12	11.5	2	18	471	12		
05-01	0330	3	30+	4238	2300	<2.42	12	11	2	20	492	21		
05-01	0430	3	30+	4263	2500	5	12	11.5	4.5	28	516	11		
05-01	0530	3	30+	4287	2400	5	11.5	10.8	5	30	540	24		
05-01	0630	3	30+	4315	2800	6.2	11.7	10.5	8.9	44	565	25	32.0	33/48
05-01	0730	3	30+	4341	2600	7.0	11.5	11.0	10.1	66	///	25/30	32.0	38/48
05-01	0830	3	30+	4365	2400	7.5	11.8	11.0	11.0	100	577	20/25	29.0	35/48
05-01	0930	4.5	30+	4391	2600	7.8	11.6	11.0	10.8	10	596	19	20.0	36/48
05-01	1030	5	30+	4413	2200	7.8	1.6	11.0	8.7	44	612	16	9.0	36/48
05-01	1130	6	30+	4427	1400	7.9	11.5	11.0	9.5	50	619	7	7.0	35/37
05-01	1230	5	22	4444	1700	7.6	11.9	11.5	7.0	34	627	8	7.0/9.0	35/37
05-01	1330	5	21	4456	1200	5.7	12.0	11.5	4.0	26	638	11	12.0	35/37
05-01	1430	5	21	4468	1200	5.0	11.5	11.0	6.0	32	648	10	11.0	35/37
05-01	1530	5	22	4470	1200	5.0	11.5	10.0	6.0	32	658	10	11.0	35/37
05-01	1630	5	23	4492	2800	2.42	11.5	11.5	1.0	18	670	12	11.0	35/37
05-01	1730	5	24	4508	1600	2.42	11.5	11.5	1.0	18	681	1	11.0	35/37
05-01	1830	5	22	4523	1500	1	0	0	0	3	693	12	11.0	35/37
05-01	1930	5	30	4541	1800	1.5	0	0	0	0	704	11	11.0	
05-01	2030	5	30	4566	2500	1.5	11.0	11.0	0	0	708	4	3.5	
05-01	2130	5	30	4592	2500	3.5	11.5	11.5	3.5	20	712	4	3.5	
05-01	2230	5	30+	4617	2500	2.42	12.2	10.5	1	18	717	5	2.0	8.1
05-01	2330	5	30+	4643	2600	2.42	12	11.5	2	22	725	8		
05-02	0030	5	30+	4669	2600	2.42	12	11	2.5	22	730	5		
05-02	0130	5	30+	4695	2600	4	12.3	10.5	4.0	28	736	6	7.5	
05-02	0230	5	30+	4721	2600	4	12	11.5	2	20	744	8		
05-02	0330	5	30+	4747	2600	3	12	11	2	20	752	8	9.5	
05-02	0430	5	30+	4773	2600	3	12	11.5	2	20	761	9		
05-02	0530	5	30+	4799	2600	<2.42	12.5	11.5		18	771	10	3.7	
05-02	0630	5	30+	4825	2600	2	12.0	11.5	0.4	19	775	4	3.7	35/37
05-02	0730	5	30+	4852	2700	2.43	12.0	11.4	3.0	24	777	2	1.6	35/37
05-02	0830	5	30+	4878	2600	2.42	11.8	11.5	1.6	18	781	4	3.0/7.0	35/37
0502	0930	5	30+	4903	2500	2.42	11.9	11.8	1.4	19	788	7	7.0	35/37
0502	1030	5	30+	4929	2600	2.43	11.9	11.3	2.5	22	795	7	7.0	35/37
0502	1130	5	30+	4957	2800	2.43	12.0	11.2	1.3	22	802	7	7.0	35/37
0502	1230	5	30+	4983	2600	2.43	12.1	11.7	1.0	22	809	7	7.0	35/37

DATE	TIME	AGIT	JACKT	JACKT	JACKT	SATURATED STEAM					AGIT	AGIT	AGIT	AGIT
		WATER FLOW	WATER FLOW	WATER FLOW TOTAL	WATER HRLY USAGE	STEAM RATE FLOW	METER INLET PRESS	INLET VALVE PRESS	OUTLET VALVE PRESS	VALVE POSIT %	COUNT RONG	HRLY SWPS	DRIVE SEING SWP/HR	DEPTH
0502	1330	5	30+	5012	2900	<2.42	12.0	12.0		14	816	7	7.0	33/35
0502	1430	5	30+	5038	2600	2.42	12.0	12.0		16	825	11	12.0	33/35
0502	1530	5	30+	5068	3000	3.5	12.3	11.5	3.5	24	834	9	2.8	
0502	1630	5	30+	5101		5.0	12.3	11.5	5	30	837	3	2.8	
0502	2230	5	30+	5211		<2.42	12.5	11.5	0	18	854			
0502	2330	5	30+	5228	1700	<2.42	12.5	12	0	14	855	1	5.0	
0503	0030	5	30+	5252	2400	<2.42	12	11.5	0	1	860	5		
0503	0130	5	30+	5276	2400	<2.42	12.5	12	0	20	864	4	2.5	
0503	0230	5	30+	5304	2800	3.0	12.3	1	3	24	870	6	7.0	
0503	0330	5	30+	5325	2100	4.0	12.0	11.5	4.5	28	874	4	5.0	
0503	0430	5	30+	5350	2500	5.0	12.0	11.5	3.5	26	879	5	5.0	
0503	0530	5	30+	5375	2500	4.5	12	11.5	3	24	886	7	7.0	
0503	0630	5	30+	5401	2600	3.9	12.1	11.6	2.1	20	893	7	7.0	33/35
0503	0730	5	30+	5427	2600	3.6	12.2	11.6	2.5	22	900	7	7.0	33/35
0503	0830	5	30/45	5454	2700	12.42	12.0	12.0		18	907	7	7.0	33/35
05-03	0930	5	30/43	5480	2600	12.42	12.3	11.4	2.2	22	914	7	7.0	33/35
05-03	1030	5	30/45	5507	2700	3.0	12.1	11.2	2.8	23	921	7	7.0	33/35
05-03	1130	5	30/43	5533	2600	3.2	12.1	11.1	2.5	26	928	7	7.0	33/35
05-03	1230	5	30/52	5564	3100	4.1	12.1	11.0	4.5	26	935	7	7.0	33/35
05-03	1330	5	30/42	5589	2500	3.5	12.4	11.7	1.6	20	941	6	6.0	33/35
05-03	1430	5	30/42	5612	2300	3.0	12.0	11.5	2.5	21	946	5	6.0	33/35
05-03	1530	5	30/42	5634	2200	3.0	12	1.5	2.0	20	951	5	4.0	32/35
05-03	1630	5	30/41	5659	2500	2.42	12	11.5	1.0	18	957	6	4.0	33/35
05-03	1730	5	30/41	5682	2300	2.42	12.0	11.5	0	12	961	4	4.0	33/35
05-03	1830	5	30/33	5702	2000	2.42	12	11.5	1.5	18	963	4	6.0	33/35
05-03	1930	5	30/41	5727	2500	2	12.5	11	1.5	19	971	6	6.0	33/35
05-03	2030	5	30/43	5753	2600	3	12.5	12	2	23	976	5	4.0	33/35
05-03	2130	5	30/36	5775	2200	3.5	1	1.7	2.4	24	981	5	6.0	33/35
05-03	2230	5	30+	5798	2300	4	12	1	3	24	986	5	6.0	
05-03	2330	5	30+	5822	2400	4	12	11.5	4	26	993	7	7.0	
05-04	0030	5	30+	5846	2400	4	12	11.5	3	24	1001	10	7.0	
05-04	0130	5	30+	5868	2200	5	12	11.5	4	26	1008	7	7.0	
05-04	0230	5	30+	5893	2500	5	12	11	3	26	1017	9	9.0	
05-04	0330	5	30+	5917	2400	5	12	11.5	3	24	1026	9	9.0	
05-04	0430	5	30+	5940	2300	5	12	11.5	4	26	1033	7	6.0	
05-04	0530	5	30+	5965	2500	5	12	11	6	30	1039	7	8.0	
05-04	0630	5	30/38	5988	2300	5.1	12.0	11.0	5.0	28	1047	8	8.2	
05-04	0730	5	30/45	6015	2700	5.0	12.0	11.0	6.1	30	1057	10	8.2	

TABLE G-4

DATE	TIME	GRATE GEAR COUNTER READING	GRATE GEAR RHP	GRATE DRIVE SETNG
04-30	0730	40530	32	4/1.75
04-30	0830	40605	75	4/2.50
04-30	0930	40660	55	4/2.50
04-30	1030	40712	52	4/2.50
04-30	1130	40765	53	4/2.50
04-30	1230	40820	55	4/2.50
04-30	1330	40867	47	4/2.50
04-30	1430	40910	43	5/2.50
04-30	1530		55	
04-30	1830			5/2.25
04-30	1930	41137	227	
04-30	2030	41192	55	5/2.25
04-30	2130			5/2.25
04-30	2230	41313	121	3/1.15
04-30	2330	41324	11	3/1.15
05-01	0030	41334	10	3/1.15
05-01	0130	41346	16	3/1.15
05-01	0230	41358	12	3/1.15
05-01	0330	41368	10	3/1.15
05-01	0430	41379	11	3/1.15
05-01	0530	41390	11	3/1.15
05-01	0630	41402	12	2/1.15
05-01	0730	41414	12	2/1.15
05-01	0830	41424	10	2/1.50
05-01	0930	41440	16	2/1.50
05-01	1030	41475	35	4/2.50
05-01	1130	41516	41	4/2.50
05-01	1230	41576	60	4/2.75
05-01	1330	41632	56	4/2.75
05-01	1430	41693	61	6/2.75
05-01	1530	41777	84	6/2.75
05-01	1630	41862	85	6/2.75
05-01	1830	42049	187	
05-01	1930	42120	71	3/1.75
05-01	2030	42152	32	
05-01	2130	42183	31	
05-01	2230	42222	39	3/2.00
05-01	2330	42254	32	3/2.00
05-02	0030	42284	30	3/1.50
05-02	0130	42307	23	3/1.50
05-02	0230	42331	24	3/1.50
05-02	0330	42355	24	3/1.50
05-02	0430	42377	20	3/1.50
05-02	0530	42393	16	2/1.50
05-02	0630	42408	15	2/1.50
05-02	0730	42429	21	2/1.50
05-02	0830	42453	24	2/3.00

DATE	TIME	GRATE GEAR COUNTER READING	GRATE GEAR RPH	GRATE DRIVE SETNG
05-02	0930	42483	30	2/3.00
05-02	1030	42518	35	2/3.28
05-02	1130	42558	40	2/3.50
05-02	1230	42594	36	2/3.87
05-02	1330	42633	39	2/3.87
05-02	1430	42670	37	2/4.00
05-02	1530	42704	34	2/2.50
05-02	1630	42739	35	2/2.50
05-02	2230	42891	152	1/2.05
05-02	2330	42901	10	1/2.05
05-03	0030	42912	11	1/2.05
05-03	0130	42922	10	1/2.052
05-03	0230	42934	12	1/2.05
05-03	0330	42943	9	1/2.05
05-03	0430	42954	11	1/2.05
05-03	0530	42964	10	1/2.05
05-03	0630	42976	12	1/2.05
05-03	0730	42987	11	1/2.05
05-03	0830	43001	14	2/1.50
05-03	0930	43019	18	2/1.50
05-03	1030	43036	17	2/1.40
05-03	1130	43047	11	1/2.00
05-03	1230	43064	17	1/2.00
05-03	1330	43085	21	2/2.00
05-03	1430	43103	18	2/1.50
05-03	1530	43119	16	2/1.50
05-03	1630	43144	25	2/3.00
05-03	1730	43178	34	2/3.00
05-03	1830	43207	29	2/3.00
05-03	1930	43241	34	2/3.00
05-03	2030	43275	34	2/2.50
05-03	2130	43300	25	
05-03	2230	43324	24	2/2.50
05-03	2330	43341	17	2/1.50
05-04	0030	43354	13	1/1.10
05-04	0130	43360	6	1/1.10
05-04	0230	43366	6	1/1.10
05-04	0330	43372	6	1/1.10
05-04	0430	43377	5	1/1.10
05-04	0530	43383	6	1/1.10
05-04	0630	43389	6	1/1.10
05-04	0730	43396	7	1/1.10

APPENDIX H
Gas Chromatograph Data

GAS CHROMATOGRAPH DATA

DATE TIME	H2 %	CO2 %	C2H4 %	C2H6 %	O2 %	N2 %	CH4 %	CO %	C3H6 %	C3H8 %	HHV BTU/SCF	LHV BTU/SCF	TMP %	MW	S.G. WRT AIR

4/30/1983

6:33	17.420	3.471	0.049	0.129	0.187	45.33	1.432	30.91	0.036	0.032	174.8	164.4	99.00	23.61	0.815
7:03	16.757	3.199	0.047	0.122	0.174	46.37	1.374	30.89	0.034	0.030	171.8	161.7	99.00	23.74	0.820
7:33	16.952	3.448	0.046	0.112	0.180	45.93	1.280	30.99	0.033	0.028	171.5	161.4	99.00	23.74	0.820
8:02	17.014	3.458	0.051	0.129	0.384	46.19	1.424	30.28	0.036	0.031	171.4	161.1	99.00	23.72	0.819
10:18	14.126	5.161	0.031	0.055	0.254	49.86	0.484	28.99	0.016	0.017	146.0	138.3	99.00	24.85	0.858
10:48	14.126	5.163	0.032	0.055	0.254	49.86	0.484	28.99	0.017	0.017	146.0	138.3	99.00	24.85	0.858
11:17	14.320	6.381	0.042	0.062	0.217	50.48	0.561	26.91	0.019	0.018	141.1	133.2	99.00	24.98	0.862
11:47	12.961	7.207	0.066	0.079	0.242	52.88	0.696	24.82	0.026	0.023	132.3	124.9	99.00	25.45	0.879
12:17	12.236	8.763	0.077	0.087	0.327	51.17	6.738	19.55	0.027	0.025	174.4	161.3	99.00	25.17	0.869
12:47	13.015	9.321	0.082	0.092	0.348	54.43	0.861	20.80	0.029	0.027	121.9	114.2	99.00	25.76	0.889
13:16	12.446	10.695	0.147	0.128	0.450	56.53	1.251	17.28	0.042	0.037	114.9	107.0	99.00	26.09	0.901
13:46	11.930	12.099	0.151	0.125	0.761	58.57	1.304	13.98	0.040	0.036	103.2	95.4	99.00	26.46	0.913
18:15	9.606	15.581	0.118	0.142	0.493	64.90	1.300	6.78	0.037	0.042	72.3	65.8	99.00	27.61	0.953
18:45	9.269	15.959	0.143	0.145	0.296	65.15	1.532	6.43	0.040	0.040	72.9	66.3	99.00	27.72	0.957
19:15	9.841	16.499	0.134	0.123	0.268	66.08	1.397	4.58	0.040	0.032	66.7	60.0	99.00	27.67	0.955
19:45	9.781	16.422	0.151	0.169	0.262	65.04	1.602	5.48	0.054	0.043	73.2	66.1	99.00	27.66	0.955
20:15	9.854	16.049	0.139	0.214	0.230	64.18	1.830	6.39	0.053	0.060	79.7	72.3	99.00	27.55	0.951
20:44	11.531	15.236	0.144	0.206	0.306	62.27	1.871	7.32	0.053	0.057	88.4	80.1	99.00	26.98	0.931
21:14	12.430	14.990	0.170	0.214	0.218	60.67	2.050	8.14	0.063	0.057	96.5	87.5	99.00	26.69	0.921
21:44	13.862	13.928	0.179	0.295	0.317	59.28	2.877	8.11	0.064	0.086	111.7	101.0	99.00	26.06	0.899
22:14	12.799	15.088	0.122	0.229	0.218	60.59	2.192	7.65	0.049	0.063	96.9	87.7	99.00	26.59	0.918
22:44	12.520	14.023	0.138	0.234	0.242	60.18	2.162	9.38	0.057	0.066	101.9	92.7	99.00	26.50	0.915
23:14	14.039	13.426	0.104	0.240	0.246	57.80	2.094	10.93	0.046	0.076	110.6	100.8	99.00	26.02	0.898
23:44	12.369	13.964	0.089	0.197	0.305	60.12	1.870	9.99	0.037	0.055	98.2	89.6	99.00	26.56	0.917

5/ 1/1983

0:14	12.317	13.190	0.116	0.231	0.380	59.71	2.251	10.70	0.045	0.066	105.6	96.6	99.00	26.41	0.912
0:44	12.000	13.298	0.103	0.189	0.311	60.05	1.962	11.00	0.038	0.050	101.1	92.6	99.00	26.54	0.916
1:14	12.341	12.586	0.069	0.093	0.299	59.98	1.390	12.19	0.023	0.022	97.0	89.2	99.00	26.39	0.911
1:44	14.687	13.182	0.074	0.157	0.237	56.71	1.392	12.48	0.039	0.044	107.7	98.5	99.00	25.88	0.893
2:14	13.631	11.861	0.107	0.163	0.304	56.78	1.563	14.51	0.043	0.042	113.2	104.3	99.00	25.93	0.895
2:44	13.272	10.257	0.103	0.137	0.464	56.54	1.345	16.81	0.040	0.036	116.4	108.0	99.00	25.80	0.890
3:13	14.450	9.318	0.106	0.220	0.295	53.86	1.792	18.84	0.056	0.064	133.9	124.2	99.00	25.29	0.873
3:43	13.284	10.136	0.087	0.169	0.424	56.19	1.548	17.07	0.041	0.046	120.0	111.3	99.00	25.75	0.889
4:22	15.407	8.275	0.099	0.221	0.308	52.40	1.789	20.38	0.054	0.064	141.8	131.7	99.00	24.87	0.859
4:51	15.829	7.798	0.105	0.191	0.308	51.70	1.793	21.18	0.053	0.050	144.9	134.7	99.00	24.68	0.852
5:21	16.892	8.338	0.129	0.173	0.338	51.72	1.684	19.63	0.051	0.045	142.2	131.5	99.00	24.51	0.846
5:50	16.779	8.049	0.130	0.169	0.414	51.27	1.814	20.28	0.049	0.041	145.0	134.3	99.00	24.48	0.845
6:20	16.245	6.824	0.150	0.172	0.313	50.18	1.620	23.40	0.058	0.043	152.0	141.7	99.00	24.44	0.844
6:49	16.245	6.824	0.150	0.172	0.313	50.18	1.619	23.40	0.058	0.043	151.9	141.6	99.00	24.44	0.844
7:19	16.624	6.460	0.152	0.163	0.327	49.63	1.686	23.86	0.055	0.038	155.1	144.5	99.00	24.27	0.838
7:48	17.229	6.517	0.142	0.173	0.323	49.37	1.705	23.44	0.055	0.045	156.0	145.2	99.00	24.12	0.833
8:18	17.126	6.855	0.450	0.348	0.324	49.55	3.107	21.01	0.142	0.093	173.3	160.3	99.00	24.06	0.831
8:47	18.002	6.745	0.231	0.103	0.345	50.18	1.847	21.49	0.045	0.020	153.0	141.7	99.00	23.94	0.826
9:17	16.399	5.615	0.197	0.153	0.316	49.42	1.573	25.23	0.066	0.037	158.3	148.0	99.00	24.21	0.836

GAS CHROMATOGRAPH DATA

DATE TIME	H2 %	CO2 %	C2H4 %	C2H6 %	O2 %	N2 %	CH4 %	CO %	C3H6 %	C3H8 %	HHV BTU/SCF	LHV BTU/SCF	TMP %	MW	S.G. WRT AIR

5/ 1/1983

9:47	16.736	5.308	0.208	0.145	0.402	49.53	1.700	24.88	0.061	0.033	159.4	148.8	99.00	24.06	0.831
10:16	15.563	5.261	0.171	0.113	0.319	49.81	1.284	26.41	0.047	0.027	154.7	145.2	99.00	24.40	0.842
10:46	16.329	6.395	0.234	0.194	0.329	49.05	1.807	24.52	0.086	0.048	160.3	149.6	99.00	24.33	0.840
11:16	16.112	6.950	0.097	0.071	0.335	50.87	1.068	23.46	0.027	0.015	142.1	132.7	99.00	24.55	0.847
11:45	14.992	6.138	0.103	0.082	0.328	50.54	0.810	25.95	0.036	0.021	144.5	135.9	99.00	24.74	0.854
12:15	15.453	5.413	0.144	0.117	0.338	49.39	1.094	26.97	0.050	0.030	153.9	144.7	99.00	24.48	0.845
12:44	15.632	4.832	0.136	0.113	0.345	48.80	1.046	28.02	0.051	0.028	157.2	147.9	99.00	24.35	0.840
13:14	15.536	5.441	0.112	0.079	0.321	49.43	0.911	27.11	0.037	0.019	151.1	142.1	99.00	24.48	0.845
13:43	15.191	6.114	0.127	0.082	0.315	50.12	0.944	26.04	0.039	0.020	147.2	138.4	99.00	24.67	0.852
14:13	14.844	6.634	0.137	0.093	0.328	50.89	1.082	24.93	0.039	0.024	144.4	135.5	99.00	24.83	0.857
14:43	15.223	6.288	0.121	0.085	0.371	50.67	1.035	25.15	0.034	0.022	145.3	136.3	99.00	24.68	0.852
15:12	16.521	8.480	0.110	0.084	0.335	50.27	0.975	22.17	0.034	0.022	139.1	129.6	99.00	24.70	0.853
15:47	15.282	9.825	0.117	0.090	0.323	52.73	1.055	19.53	0.035	0.023	127.7	118.6	99.00	25.23	0.871
16:17	15.289	9.271	0.111	0.093	0.295	52.96	1.062	19.86	0.032	0.024	128.8	119.8	99.00	25.14	0.868
16:47	14.544	9.656	0.122	0.095	0.460	54.25	1.138	18.68	0.033	0.025	123.6	114.8	99.00	25.39	0.876
17:17	14.547	10.283	0.125	0.098	0.276	54.46	1.135	18.01	0.035	0.026	121.6	112.8	99.00	25.48	0.880
17:47	14.741	9.754	0.120	0.101	0.269	53.93	1.187	18.83	0.033	0.026	125.3	116.4	99.00	25.34	0.875
18:17	14.682	11.114	0.130	0.111	0.271	55.32	1.348	15.96	0.034	0.029	118.0	108.9	99.00	25.56	0.882
18:46	14.218	11.719	0.128	0.119	0.318	56.35	1.343	14.74	0.036	0.031	112.7	103.9	99.00	25.78	0.890
19:16	14.682	11.753	0.139	0.126	0.256	55.46	1.423	15.10	0.037	0.033	116.5	107.3	99.00	25.65	0.885
19:46	13.519	12.665	0.150	0.120	0.273	57.94	1.469	12.80	0.035	0.031	105.8	97.2	99.00	26.09	0.901
20:15	13.366	14.023	0.141	0.107	0.565	55.53	1.360	13.85	0.036	0.027	107.2	98.7	99.00	26.37	0.910
20:45	11.930	12.516	0.126	0.096	0.504	60.20	1.215	12.36	0.032	0.025	95.7	88.1	99.00	26.52	0.915
21:15	12.725	11.927	0.127	0.080	0.319	58.55	1.123	14.10	0.030	0.020	102.5	94.7	99.00	26.22	0.905
21:45	13.205	11.923	0.116	0.064	0.280	57.73	1.014	14.63	0.021	0.017	103.9	96.0	99.00	26.11	0.901
22:14	11.942	13.275	0.133	0.083	0.276	59.92	1.131	12.19	0.029	0.022	94.1	86.6	99.00	26.64	0.920
22:44	11.600	13.735	0.136	0.097	0.272	60.56	1.179	11.36	0.034	0.025	91.3	83.9	99.00	26.80	0.925
23:14	12.177	13.242	0.143	0.105	0.289	59.67	1.272	12.04	0.036	0.027	96.6	88.8	99.00	26.56	0.917
23:44	12.320	13.071	0.141	0.090	0.291	59.37	1.195	12.47	0.031	0.023	97.1	89.4	99.00	26.50	0.915

5/ 2/1983

0:13	11.256	12.872	0.142	0.093	0.551	61.10	1.193	11.73	0.034	0.023	91.5	84.3	99.00	26.76	0.924
0:43	12.125	13.066	0.128	0.071	0.288	59.49	1.039	12.75	0.026	0.018	95.0	87.7	99.00	26.57	0.917
1:13	12.452	12.725	0.151	0.081	0.293	58.78	1.158	13.31	0.029	0.021	99.8	92.1	99.00	26.42	0.912
1:43	13.142	12.505	0.162	0.084	0.298	58.04	1.249	13.47	0.031	0.022	103.8	95.6	99.00	26.19	0.904
2:12	12.675	12.158	0.159	0.090	0.305	57.95	1.236	14.38	0.031	0.023	105.1	97.2	99.00	26.26	0.906
2:42	12.486	13.268	0.188	0.099	0.302	59.64	1.371	11.58	0.040	0.025	97.8	89.7	99.00	26.47	0.914
3:12	11.500	13.543	0.177	0.097	0.292	60.58	1.320	11.43	0.037	0.024	93.3	85.8	99.00	26.78	0.924
3:42	11.248	14.073	0.185	0.111	0.289	60.90	1.362	10.76	0.044	0.027	91.4	83.9	99.00	26.92	0.929
4:12	11.563	13.286	0.177	0.133	0.394	60.35	1.454	11.56	0.049	0.034	96.4	88.7	99.00	26.71	0.922
4:41	11.997	13.388	0.159	0.122	0.290	59.62	1.421	11.93	0.041	0.031	97.9	90.0	99.00	26.61	0.919
5:11	11.590	13.683	0.152	0.120	0.310	60.29	1.374	11.41	0.041	0.030	94.3	86.7	99.00	26.77	0.924
5:42	11.422	13.352	0.134	0.100	0.284	60.24	1.234	12.18	0.033	0.024	93.9	86.6	99.00	26.78	0.924
6:12	12.289	12.313	0.121	0.080	0.309	58.56	1.091	14.19	0.026	0.020	100.8	93.3	99.00	26.40	0.911
6:42	11.602	12.879	0.108	0.058	0.310	59.74	0.892	13.38	0.021	0.014	93.1	86.2	99.00	26.69	0.921

GAS CHROMATOGRAPH DATA

DATE TIME	H2 %	CO2 %	C2H4 %	C2H6 %	O2 %	N2 %	CH4 %	CO %	C3H6 %	C3H8 %	HHV BTU/SCF	LHV BTU/SCF	TMP %	MW	S.G. WRT AIR

5/ 2/1983

7:12	12.459	11.545	0.106	0.048	0.272	57.59	0.839	16.12	0.017	0.011	103.8	96.5	99.00	26.26	0.906
7:41	12.566	11.790	0.108	0.047	0.281	57.44	0.859	15.89	0.018	0.011	103.6	96.3	99.00	26.27	0.907
8:11	11.182	13.267	0.129	0.070	0.315	60.22	1.005	12.77	0.027	0.018	91.8	84.9	99.00	26.85	0.927
8:41	11.860	13.383	0.127	0.100	0.267	59.72	1.162	12.32	0.036	0.025	95.0	87.5	99.00	26.67	0.921
9:11	12.314	12.861	0.116	0.096	0.226	58.84	1.109	13.38	0.036	0.024	99.0	91.4	99.00	26.48	0.914
9:41	12.065	12.872	0.114	0.077	0.216	59.03	0.987	13.59	0.030	0.019	97.0	89.7	99.00	26.56	0.917
10:11	12.112	12.202	0.141	0.087	0.370	59.17	1.135	13.73	0.036	0.020	99.9	92.4	99.00	26.43	0.912
10:41	12.892	12.058	0.131	0.077	0.236	58.02	1.052	14.48	0.032	0.019	103.5	95.7	99.00	26.20	0.905
11:10	12.820	12.294	0.151	0.085	0.216	57.80	1.160	14.42	0.035	0.021	104.8	96.9	99.00	26.25	0.906
11:40	12.395	12.589	0.153	0.078	0.207	58.65	1.142	13.73	0.033	0.020	100.9	93.2	99.00	26.41	0.912
12:10	12.305	12.339	0.165	0.093	0.333	58.93	1.241	13.53	0.037	0.024	101.6	93.8	99.00	26.39	0.911
14:29	11.203	13.396	0.167	0.097	0.269	61.21	1.332	11.27	0.040	0.023	91.8	84.5	99.00	26.83	0.926
15:29	11.874	12.786	0.169	0.104	0.224	59.89	1.448	12.45	0.037	0.024	99.1	91.3	99.00	26.54	0.916
15:59	11.641	13.432	0.136	0.071	0.236	60.65	1.142	11.65	0.026	0.016	91.1	83.8	99.00	26.74	0.923
16:29	11.852	12.830	0.124	0.052	0.247	60.04	0.989	12.84	0.020	0.012	93.3	86.1	99.00	26.60	0.918
16:59	11.830	12.955	0.163	0.073	0.224	60.13	1.178	12.40	0.031	0.017	95.1	87.7	99.00	26.61	0.918
17:29	12.011	13.156	0.169	0.066	0.263	60.38	1.211	11.70	0.028	0.016	93.6	86.1	99.00	26.59	0.918
21:52	11.928	12.389	0.134	0.072	0.626	60.61	1.308	11.89	0.018	0.024	94.4	86.9	99.00	26.49	0.914
22:22	11.040	13.390	0.140	0.061	0.333	61.30	1.227	11.48	0.017	0.015	89.1	82.1	99.00	26.88	0.928
22:51	11.928	12.390	0.133	0.072	0.626	60.62	1.309	11.89	0.018	0.018	94.3	86.8	99.00	26.49	0.914
23:21	11.069	13.347	0.126	0.046	0.205	61.39	1.054	11.74	0.015	0.011	87.6	80.8	99.00	26.88	0.928
23:50	11.747	12.310	0.130	0.056	0.326	60.12	1.079	13.20	0.021	0.013	95.2	88.0	99.00	26.54	0.916

5/ 3/1983

0:20	12.438	12.188	0.155	0.089	0.199	58.78	1.285	13.81	0.034	0.021	103.0	95.1	99.00	26.31	0.908
0:50	11.949	12.893	0.146	0.084	0.216	59.78	1.274	12.61	0.030	0.020	97.1	89.5	99.00	26.56	0.917
1:19	11.913	13.539	0.154	0.099	0.182	60.24	1.344	11.46	0.039	0.023	94.7	87.0	99.00	26.66	0.920
1:49	11.166	13.473	0.126	0.068	0.186	60.75	1.075	12.11	0.028	0.015	90.2	83.2	99.00	26.87	0.928
2:18	12.241	12.246	0.142	0.072	0.204	58.78	1.138	14.13	0.029	0.016	101.1	93.6	99.00	26.39	0.911
2:48	13.134	11.879	0.136	0.090	0.199	57.34	1.208	14.96	0.031	0.022	107.8	99.7	99.00	26.09	0.901
3:17	12.967	11.556	0.143	0.088	0.190	57.09	1.223	15.69	0.031	0.021	109.8	101.8	99.00	26.08	0.900
3:47	13.370	10.747	0.150	0.075	0.193	56.14	1.163	17.11	0.029	0.018	114.8	106.7	99.00	25.85	0.892
4:17	13.651	10.855	0.142	0.070	0.198	55.79	1.143	17.11	0.025	0.017	115.2	106.9	99.00	25.80	0.891
4:46	13.053	11.104	0.168	0.079	0.198	56.69	1.277	16.38	0.030	0.019	113.0	104.8	99.00	25.98	0.897
5:16	13.008	11.296	0.168	0.088	0.227	57.46	1.334	15.37	0.033	0.021	110.5	102.3	99.00	26.02	0.898
5:46	12.149	11.537	0.133	0.083	0.418	58.97	1.176	14.48	0.030	0.020	102.5	94.9	99.00	26.31	0.908
6:45	12.298	11.801	0.144	0.088	0.247	58.10	1.218	15.05	0.032	0.021	105.6	97.9	99.00	26.30	0.908
7:14	11.870	12.154	0.147	0.087	0.227	59.04	1.196	14.23	0.032	0.021	101.3	93.9	99.00	26.47	0.914
7:44	12.795	12.017	0.148	0.082	0.199	58.14	1.259	14.31	0.028	0.019	105.1	97.1	99.00	26.20	0.904
8:14	11.515	13.331	0.173	0.088	0.186	60.39	1.283	11.98	0.035	0.021	94.4	87.0	99.00	26.74	0.923
8:43	10.284	14.541	0.198	0.088	0.206	63.26	1.404	8.96	0.034	0.021	82.3	75.4	99.00	27.24	0.940
9:13	10.381	14.687	0.171	0.091	0.220	63.49	1.366	8.53	0.036	0.021	80.5	73.6	99.00	27.24	0.940
9:43	10.786	14.092	0.167	0.098	0.231	62.32	1.365	9.88	0.039	0.023	86.3	79.2	99.00	27.04	0.933
10:13	10.712	14.518	0.157	0.093	0.206	62.83	1.263	9.16	0.038	0.021	82.5	75.5	99.00	27.14	0.937
10:43	11.208	14.185	0.150	0.098	0.214	61.92	1.301	9.86	0.036	0.023	86.7	79.4	99.00	26.95	0.930

GAS CHROMATOGRAPH DATA

DATE TIME	H2 %	CO2 %	C2H4 %	C2H6 %	O2 %	N2 %	CH4 %	CO %	C3H6 %	C3H8 %	HHV BTU/SCF	LHV BTU/SCF	TMP %	MW	S.G. WRT AIR

5/ 3/1983

11:13	10.759	14.262	0.140	0.090	0.199	62.37	1.204	9.92	0.035	0.021	84.0	77.1	99.00	27.09	0.935
11:42	11.437	13.659	0.139	0.096	0.192	61.21	1.286	10.93	0.034	0.022	90.4	83.0	99.00	26.81	0.925
12:12	11.721	13.590	0.155	0.091	0.203	60.81	1.296	11.08	0.034	0.021	92.0	84.5	99.00	26.72	0.922
12:42	12.103	13.360	0.167	0.090	0.218	60.14	1.378	11.49	0.032	0.021	95.5	87.7	99.00	26.58	0.917
13:15	12.165	13.078	0.176	0.087	0.205	59.83	1.389	12.01	0.033	0.020	97.6	89.8	99.00	26.52	0.915
13:44	12.835	12.414	0.163	0.081	0.214	58.79	1.355	13.10	0.029	0.019	102.5	94.4	99.00	26.24	0.906
14:14	13.096	11.772	0.160	0.077	0.219	57.81	1.289	14.53	0.030	0.018	107.1	99.0	99.00	26.08	0.900
14:14	13.096	11.771	0.160	0.077	0.219	57.81	1.289	14.53	0.033	0.015	107.1	99.0	99.00	26.08	0.900
15:13	12.730	12.233	0.168	0.070	0.217	58.42	1.243	13.87	0.030	0.016	103.3	95.4	99.00	26.25	0.906
15:43	12.621	11.968	0.160	0.073	0.221	58.29	1.252	14.36	0.029	0.017	104.6	96.7	99.00	26.24	0.906
16:13	12.629	11.918	0.168	0.071	0.213	58.52	1.244	14.19	0.031	0.016	104.1	96.2	99.00	26.23	0.905
16:43	12.100	12.383	0.188	0.082	0.210	59.73	1.337	12.92	0.036	0.019	99.9	92.2	99.00	26.43	0.912
17:12	11.270	13.367	0.170	0.072	0.200	61.32	1.234	11.32	0.033	0.016	90.5	83.3	99.00	26.81	0.926
17:42	11.330	13.393	0.157	0.071	0.213	61.95	1.160	10.68	0.034	0.015	87.6	80.5	99.00	26.81	0.925
18:12	11.378	12.671	0.154	0.075	0.263	61.21	1.176	12.02	0.033	0.016	92.3	85.1	99.00	26.68	0.921
18:42	11.378	12.671	0.155	0.075	0.263	61.21	1.176	12.02	0.033	0.016	92.3	85.1	99.00	26.68	0.921
19:12	12.395	12.441	0.180	0.092	0.205	59.51	1.352	12.76	0.040	0.021	100.7	92.8	99.00	26.36	0.910
19:41	12.513	12.466	0.186	0.097	0.199	59.71	1.419	12.35	0.041	0.022	100.7	92.6	99.00	26.33	0.909
20:11	12.360	12.208	0.167	0.091	0.185	59.08	1.340	13.51	0.037	0.021	102.6	94.7	99.00	26.33	0.909
20:41	12.423	11.624	0.144	0.078	0.258	58.82	1.200	14.40	0.031	0.017	103.4	95.7	99.00	26.24	0.906
21:11	13.208	11.261	0.145	0.070	0.183	57.44	1.138	15.51	0.029	0.016	108.7	100.6	99.00	25.98	0.897
21:40	13.519	11.125	0.152	0.077	0.181	57.03	1.169	15.69	0.033	0.018	111.0	102.7	99.00	25.88	0.893
22:10	13.716	10.956	0.159	0.081	0.186	56.56	1.216	16.07	0.034	0.018	113.5	105.1	99.00	25.79	0.890
22:40	13.497	10.758	0.168	0.094	0.290	57.23	1.363	15.54	0.039	0.020	113.1	104.6	99.00	25.81	0.891
23:10	13.668	11.442	0.195	0.106	0.185	57.00	1.488	14.85	0.045	0.024	113.6	104.8	99.00	25.85	0.892
23:41	14.206	11.071	0.183	0.093	0.198	56.53	1.413	15.25	0.038	0.021	115.2	106.3	99.00	25.66	0.886

5/ 4/1983

0:11	14.152	11.099	0.184	0.098	0.209	56.41	1.453	15.33	0.037	0.023	115.9	106.9	99.00	25.68	0.886
0:40	13.479	11.553	0.187	0.089	0.188	57.03	1.390	15.03	0.035	0.021	111.9	103.3	99.00	25.93	0.895
1:10	14.582	11.038	0.195	0.088	0.183	55.74	1.460	15.65	0.035	0.020	118.2	109.1	99.00	25.55	0.882
1:40	13.654	11.219	0.170	0.086	0.180	56.44	1.300	15.90	0.035	0.020	114.0	105.5	99.00	25.84	0.892
2:10	13.859	11.130	0.169	0.096	0.177	56.26	1.350	15.90	0.038	0.022	115.4	106.7	99.00	25.77	0.889
2:40	14.498	10.794	0.199	0.118	0.225	55.76	1.565	15.77	0.050	0.026	120.5	111.2	99.00	25.53	0.881
3:10	14.161	10.797	0.158	0.083	0.176	55.70	1.252	16.62	0.032	0.019	117.1	108.4	99.00	25.65	0.885
3:39	13.661	11.279	0.160	0.099	0.175	56.56	1.295	15.71	0.039	0.022	113.6	105.0	99.00	25.85	0.892
4:09	14.326	10.797	0.156	0.097	0.176	55.56	1.320	16.51	0.036	0.022	118.4	109.5	99.00	25.60	0.884
4:39	14.797	10.382	0.186	0.092	0.229	55.41	1.364	16.48	0.040	0.020	120.7	111.5	99.00	25.41	0.877
5:09	14.533	10.409	0.161	0.078	0.191	55.02	1.196	17.37	0.034	0.017	120.1	111.3	99.00	25.49	0.880
5:39	14.699	10.190	0.167	0.078	0.180	54.54	1.222	17.87	0.037	0.017	122.7	113.8	99.00	25.41	0.877
6:09	14.411	10.800	0.184	0.097	0.181	55.57	1.375	16.32	0.044	0.021	119.2	110.2	99.00	25.57	0.883
6:39	14.327	10.824	0.179	0.093	0.179	55.50	1.366	16.47	0.039	0.021	119.0	110.1	99.00	25.60	0.884
7:08	14.025	11.338	0.184	0.092	0.180	56.51	1.380	15.24	0.040	0.020	114.3	105.5	99.00	25.75	0.889
7:38	13.565	12.182	0.188	0.093	0.180	57.33	1.346	14.06	0.044	0.020	108.8	100.3	99.00	26.01	0.898

APPENDIX I

Continuous Output Transducer Data

These are averages of the continuous output transducer data averaged for the time periods over which material and energy balance calculations were made (Section 7.2).

AVERAGE FROM PERIOD: 5/ 3/83 0:00 TO 5/ 4/83 0:00

SIGNAL	AVERAGE	UNITS	STD.DEV.
T-701	15.015	DEG C	4.062
T-702	26.419	DEG C	3.793
T-703	61.974	DEG C	0.564
T-710	10.464	DEG C	0.639
T-711	64.346	DEG C	2.756
T-712	10.647	DEG C	0.741
T-713	20.737	DEG C	2.255
T-705	555.960	DEG C	28.925
T-706	418.767	DEG C	17.548
T-707	461.303	DEG C	22.914
T-812	818.591	DEG C	77.197
T-813	--OFF--	DEG C	
T-814	594.828	DEG C	123.727
T-815	-729.087	DEG C	432.722
T-816	740.550	DEG C	69.826
T-817	550.578	DEG C	92.438
T-818	240.139	DEG C	43.690
T-819	689.231	DEG C	58.656
T-820	587.920	DEG C	41.087
T-823	66.322	DEG C	1.914
T-822	66.634	DEG C	1.701
T-806	412.238	DEG C	21.713
T-811	852.379	DEG C	406.639
F-701	979.168	SCFM	85.631
TT2-703	60.955	DEG C	0.167
P-703	10.543	IN WC	1.216
P-704	5.138	IN WC	0.773
P-705	5.404	IN WC	0.857
P-706	5.044	IN WC	0.866
F-707	3178.172	SCFM	2518.677
WT-720	6.121	TONS	2.630
P-707	3.832	IN WC	0.682
P-810	-0.949	IN WC	0.474
F-802	--OFF--	CFM	
F-803	4533.449	CFM	119.691
TT1-703	60.448	DEG C	0.172
CO	13.642	%	2.250
CO2	12.952	%	1.085
O2	-3.057	%	0.410
SIGMA	22.078	BTU/SCF	3.159
T-715	148.806	DEG C	1.171
T-821	533.689	DEG C	36.316
T-703A	57.275	DEG C	2.170
PH	0.000	PH	0.001
AG VEL	0.586	SPH	0.140
GR VEL	0.208	RPD/T	0.049
P-702	1.778	IN WC	3.192

AVERAGE BASE TEMPERATURE 20.173

AVERAGE FROM PERIOD: 4/30/83 8:00 TO 5/ 4/83 7:00

SIGNAL	AVERAGE	UNITS	STD.DEV.
T-701	12.754	DEG C	4.167
T-702	24.167	DEG C	4.008
T-703	61.779	DEG C	4.146
T-710	9.864	DEG C	0.772
T-711	66.229	DEG C	12.734
T-712	10.022	DEG C	0.888
T-713	24.900	DEG C	14.867
T-705	496.144	DEG C	84.934
T-706	383.544	DEG C	53.411
T-707	402.821	DEG C	74.516
T-812	843.611	DEG C	198.431
T-813	--OFF--	DEG C	
T-814	652.883	DEG C	228.119
T-815	128.477	DEG C	1339.751
T-816	777.596	DEG C	200.752
T-817	597.156	DEG C	195.759
T-818	271.629	DEG C	105.856
T-819	739.820	DEG C	172.786
T-820	622.946	DEG C	135.385
T-823	65.824	DEG C	7.932
T-822	66.280	DEG C	7.761
T-806	362.479	DEG C	67.464
T-811	839.796	DEG C	279.872
F-701	942.296	SCFM	184.645
TT2-703	61.074	DEG C	3.615
P-703	12.437	IN WC	5.115
P-704	7.983	IN WC	5.222
P-705	4.216	IN WC	1.920
P-706	3.919	IN WC	1.894
F-707	3030.111	SCFM	2573.653
WT-720	6.676	TONS	2.911
P-707	2.586	IN WC	1.746
P-810	-0.881	IN WC	0.364
F-802	1160.584	CFM	1305.336
F-803	4551.354	CFM	579.421
TT1-703	60.628	DEG C	3.581
CO	14.835	%	6.081
CO2	11.329	%	3.144
O2	-2.142	%	3.306
SIGMA	87.002	BTU/SCF	48.329
T-715	149.165	DEG C	2.276
T-821	534.135	DEG C	154.034
T-703A	55.342	DEG C	8.278
PH	0.000	PH	0.001
AG VEL	0.988	SPH	0.866
GR VEL	0.197	RPD/T	0.080
P-702	4.064	IN WC	7.124

AVERAGE BASE TEMPERATURE 19.613