30
12-9-85 ST (1)

I-24078

(3)

DR-1434-6

MORGANTOWN ENERGY TECHNOLOGY CENTER

DOE/METC-85/2014
(DE85013698)

Hanna, Wyoming Underground Coal Gasification Data Base

Volume 4: The Hanna II, Phases II and III Field Test

Research Report

August 1985

DO NOT MICROFILM
COVER

U. S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
MORGANTOWN ENERGY TECHNOLOGY CENTER
MORGANTOWN, WEST VIRGINIA

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work performed 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.

This report has been reproduced directly from the best available copy.

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, VA 22161.

Price: Printed copy A04
Microfiche A01

Codes are used for pricing all publications. The code is determined by the number of pages in the publication. Information pertaining to the pricing codes can be found in the current issues of the following publications, which are generally available in most libraries: *Energy Research Abstracts (ERA)*, *Government Reports Announcements and Index (GRA and I)*; *Scientific and Technical Abstract Reports (STAR)*; and publication NTIS-PR- 360 available from NTIS at the above address.

DO NOT MICROFILM
COVER

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.

Hanna, Wyoming Underground Coal Gasification Data Base

Volume 3: The Hanna II, Phase I Field Test

Research Report

By
**T.C. Bartke¹, D.D. Fischer ²,
S.B. King², R.M. Boyd², and
A.E. Humphrey²**

U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Laramie Project Office
P.O. Box 1189
Laramie, Wyoming 82070

August 1985

¹ U.S. DOE, Morgantown Energy Technology Center, Laramie Project Office

² World Energy, Inc., Laramie, Wyoming

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED
EB

MASTER

PREFACE

This report is part of a seven-volume series on the Hanna, Wyoming, underground coal gasification field tests. Volume 1 is a summary of the project and each of Volumes 2 through 6 describes a particular test. Volume 7 is a compilation of all the data for the tests in Volumes 2 through 6. The reports in this series include:

Hanna, Wyoming Underground Coal Gasification Data Base, Volume 1: General Information and Executive Summary (DE85013695).

Hanna, Wyoming Underground Coal Gasification Data Base, Volume 2: The Hanna I Field Test (DE85013696).

Hanna, Wyoming Underground Coal Gasification Data Base, Volume 3: The Hanna II, Phase I Field Test (DE85013697).

Hanna, Wyoming Underground Coal Gasification Data Base, Volume 4: The Hanna II, Phases II and III Field Test (DE85013698).

Hanna, Wyoming Underground Coal Gasification Data Base, Volume 5: The Hanna III Field Test (DE85013699)..

Hanna, Wyoming Underground Coal Gasification Data Base, Volume 6: The Hanna IVA and IVB Field Test (DE85013700).

Hanna, Wyoming Underground Coal Gasification Data Base, Volume 7: Appendices (DE85013701).

These reports are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia, 22161.

Volume 3: Hanna II, Phase I

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
I. Introduction	1
II. Site Selection and Characteristics	1
III. Test Objectives	4
IV. Facilities Description	6
V. Pre-Operational Testing	15
VI. Test Operations Summary	22
A. Significant Events Summary	22
B. Average Operating Parameters	26
C. Tar and Water Production	28
D. Instrumentation Responses	28
VII. Post-Test Activity	42
VIII. Bibliography	42

Appendix (See the following sections in Volume 7)

 Logs from Wells

 Raw Hourly Data

 Post-Test Coring Analyses

List of Figures

<u>Figure</u>	<u>Page</u>
1 Hanna II, Phase I Well Pattern and Surface Facilities Schematic ..	3
2 Hanna II, Phase I Well Completion Schematic	7
3 Hanna II, Phase I Injection and Production Flow Rates	29
4 Hanna II, Phase I Injection and Production Pressures	30
5 Hanna II, Phase I Injection and Production Flow Temperatures	31
6 Hanna II, Phase I Product Gas Heating Value	32
7 Hanna II, Phase I Product Gas Composition (Major Components)	33
8 Hanna II, Phase I Product Gas Composition (Minor Components)	34
9 Hanna II, Phase I Product Gas Nitrogen Content	35
10 Corehole Locations at Hanna II, Phase I	44
11 Cross Section C - C' of Hanna II, Phase I Reactor Cavity	45

List of Tables

<u>Table</u>	<u>Page</u>
1 Summary of Hanna II, Phase I Drilling	2
2 Hanna II, Phase I Coal Composition	5
3 Instrument Locations, Hanna II, Phase I	9
4 Phase IB Thermocouple Channels Connected to LERC Data System	14
5 Core Analysis Results	16
6 Pre-Test Air Acceptance Results	23
7 Hanna II, Phase IA Average Operating Parameters	27
8 Hanna II, Phases IA and IB Gas Compositions and Phase IB Daily Average Operating Parameters	36

HANNA II, PHASE I

I. INTRODUCTION

Hanna II, Phase I was conducted during the spring and summer of 1975, at a site about 700 feet up dip (to the southwest) of the Hanna I test. The test was conducted in two stages -- Phase IA and IB. Phase IA consisted of linking and gasification operations between Wells 1 and 3 and Phase IB of linking from the 1-3 gasification zone to Well 2 followed by a short period of gasification from Well 2 to Well 3 over a broad range of air injection rates in order to determine system turndown capabilities and response times.

II. SITE SELECTION AND CHARACTERISTICS

The site for Hanna II, Phase I, was chosen at a location approximately 700 feet southwest and updip from the Hanna I site. This location was chosen basically for two reasons -- the depth to the Hanna I coal seam was about 275 feet compared to about 400 feet at the Hanna I site thereby reducing drilling and operating costs and it was assessed to be sufficiently remote from the Hanna I site such that no detrimental leakage of air or product gas would result.

The drilling summary for the process wells is shown in Table 1. Due to casing separations in Wells 3 and 4, these wells were plugged from total depth to surface with cement and new wells 3 and 4 drilled. The new well 3 was 52.5 feet from Well 1 rather than 60 feet. The new Well 4 was at an angle of 100° rather than 90° off the Wells 1-3 line.

The dip of the coal is approximately 10-11° from Well 3 toward Well 1 (See Figure 1). The only aquifer encountered other than the Hanna No. 1 coal seam was at 213 feet (62 feet above the top of the coal seam) as

Table 1. Summary of Hanna II, Phase I Drilling

Well No.	1	2	3	4	3	4
Date Started	12/13/74	1/16/75	1/13/75	1/6/75	3/26/75	2/25/75
Date Completed	12/20/74	1/20/75	1/24/75	1/24/75	-	-
Elevation (ft)	7025.01	7026.36	7026.02	7026.21	-	-
Total Depth (ft)	312	306	306	307	315	-
Top of Coal (ft)	275.6	275.6	265	272.8	265	267
Bottom of Coal (ft)	304	305.2	299	297.4	297	297
Seam Thickness (ft)	28.4	29.5	34	24.6	32	30
Casing Bottom (ft)	292	295	298	287	312.5	287
Casing Size (In. ID)	6	6	6	6	6	6
Completion Type	Open Hole - 10 feet from bottom of coal				Perf. Bottom 10 ft.	Open Hole Bottom 10 ft.
Coring (ft)	265* to 302.5 & 302.5 to 312	265 to 306.5	265.8 to 305.8	265 to 298.2	-	-

* Oriented core taken from Well 1 from 265 - 302.5. Remaining cores taken from other wells were standard cores. Core from Well 4 was sent to MERC for ultimate, proximate, heating value, sulfur forms, and trace element analyses.

Figure 1. Hanna II, Phase I Well Pattern and Surface Facilities Schematic

determined from the resistivity log from Well 1. No testing was done to determine any characteristics of either aquifer.

Copies of logs from the wells drilled during Hanna II, Phase I are included in the appendix to this report. For information on the lithology at the Hanna II, Phase I site, see the description and results given in the section entitled Post Test Activity which presents the later coring results from this test site.

A full-seam core was submitted to the Morgantown Energy Technology Center for coal, ash, and trace element analyses. A total of 60 samples were analyzed from the core which was collected over a depth interval of 267.5 to 297.5 feet from Well 4. These 60 samples consisted of 3-inch subsections of the core. Thus, only 15 feet of the total 30 feet of core were subjected to analyses. The results from analyses of these 60 samples were weight averaged to yield a composite analysis. The composite analysis for the core from Well 4 is shown in Table 2.

In addition, 8 subsamples taken at random intervals were analyzed for trace elements. The ranges of and weighted average concentrations are shown in Table 2.

III. TEST OBJECTIVES

Hanna II, Phase I was designed to implement the knowledge gained both during the operation of and after evaluation of the results from Hanna I to improve overall process operations. The specific objectives were the following:

Determine whether analyses of an oriented core for directional permeability could be utilized to determine the most effective well pattern orientation.

Table 2. Hanna II, Phase I Coal Composition

<u>Determination</u> ¹	<u>Average (wt %)</u> ²
Total Carbon	49.62
Volatiles	34.65
High Temperature Ash (750°C)	31.65
Total Sulfur	0.75
Organic S	0.39
Pyritic S	0.34
Sulfate S	0.21
Fixed Carbon	33.68
Hydrogen	4.03
Moisture	8.62
Nitrogen	1.25
Oxygen (by difference)	12.70
Heating Value (As received, Btu/lb)	7649
Trace Element Analyses: ³	
<u>Component</u>	<u>Concentration Range</u> ⁴ <u>Average</u> ⁴
As	0.98 - 29.0 8.8
Be	0.03 - 0.3 0.24
Cd	0.05 - 0.25 0.16
F	70.0 - 700 320
Pb	0.12 - 2.4 0.7
Se	0.20 - 2.9 0.68
Te	below 0.11 below 0.11
Hg ⁵	0.03 - 0.08 0.05

¹All values are on a moisture-free basis with the exception of Heating Value

²Weighted average for the entire coal interval

³Determined by spark-source mass spectrometry

⁴Reported as parts per million on a weight basis

⁵Determined by flameless atomic fluorescence

Determine the utility of subsurface instrumentation for monitoring the in situ process.

Demonstrate the effectiveness of a computerized data acquisition system for large scale data storage and real time data access as part of a process control system.

Determine the effect of higher air injection rates than those available during Hanna I on gas composition.

Determine whether linking could be achieved through long term high pressure air injection.

IV. FACILITIES DESCRIPTION

The well pattern, surface piping, and location of site buildings are shown in Figure 1. The spacing was 52.5 feet between Wells 1 and 3 and 60 feet between the 1-2 and 1-4 pairs. The reduced spacing on the 1-3 line was due to casing separation in the original Well 3. Efforts to correct this problem were unsuccessful and the decision was made to abandon the original Well 3. It was cemented to the surface and a new well was drilled 7.5 feet closer to Well 1 on the same line. The original Well 4 also was discovered to have a casing separation. It was also cemented to the surface and a new Well 4 drilled 10 feet to the east along the 60-foot radius arc from Well 1. Wells 1, 2, original 3, original 4, and new 3 were all constructed in the same manner. Figure 2 shows the well construction of these wells with Well 1 as the example. The new Well 3 was cased to a total depth of 312.5 feet (15.5 feet below the bottom of the coal seam), cemented to surface, drilled out, and perforated over a 10-foot interval from 287 to 297 feet which corresponds to the bottom 10 feet of the coal seam. The perforating consisted of 4- $\frac{1}{2}$ " diameter shots per foot.

O-1
STARTED -13-12-74
FINISHED -20-12-74
292' OF CASING
SET AT 6733' ELEV.

Figure 2. Hanna II; Phase I Well Completion Schematic

The air compression equipment available for Hanna II, Phase I consisted of two Atlas-Copcos capable of producing up to 500 scfm of air at 125 psig and one Gardner-Denver 1000 capable of 900 scfm at 125 psig -- all diesel powered. In addition, one electrically powered Ingersoll-Rand XLE capable of 550 scfm at pressures up to 265 psig was utilized for pneumatic and reverse combustion linking operations. All of these compressors were housed at the shop facilities east of the Hanna I site. A 6" line was laid from a manifold connecting all of these compressors to the Hanna II, Phase I site -- a distance of approximately 1000 feet.

Based on the air injectivity tests (which are described in Section V, Pre-operation Tests) conducted prior to initiating the Phase I test, both Wells 1 and 3 were connected for air injection and Well 1 was connected for production. All lines were 4" Schedule 40 pipe. Ignition was accomplished at Well 1 using a downhole electrical resistance heater which was lubricated into Well 1 on wire line cable.

Flow measurement was accomplished with conventional orifice plate meter run assemblies. Both American Meter pen recorders and Beckman 8600 pressure transmitters to obtain static and differential pressure measurements were used to monitor flow. A Chromel-Alumel (Type K) thermocouple was installed at the meter run to monitor flow temperature for flow calculations.

Instrumentation fielded by Sandia Laboratories consisted of downhole thermocouples, one in seam gas sampling canister and pressure measurement device, geophones, and an array of shallow subsurface resistivity probes and deeper resistivity probes in the coal seam. Table 3 gives the numbers of each type of instrumentation and the respective locations of each in the 4 instrument wells AA, BB, CC, and DD. No data from the instrumentation were gathered by LERC with the exception of downhole temperatures from Wells AA and BB during Hanna II, Phase IB. The instrument strings were secured to a $\frac{1}{2}$ " steel messenger cable, lowered into the uncased instrument wells, and grouted in place

Table 3. Instrument Locations, Hanna II, Phase I

Well No.	AA	BB	CC	DD
Installation Date	2/22/75	2/19/75	2/17/75	2/21/75
Well Collar to Reference (ft)*	305.2	304.7	303.0	300.8
Geophones	57.0	223.0	57.0	57.0
	40.0	140.0	40.0	40.0
	21.0	57.0	21.0	21.0
	6.0	40.0	6.0	6.0
	-5.0	21.0	-1.0	-1.0
	-	6.0	-	-
	-	-5.0	-	-
Resistivity Probes	32.0	32.0	32.0	32.0
	13.0	13.0	13.0	13.0
	-1.0	-1.0	-1.0	-1.0
Thermocouples	79.8	80.1	79.0	80.3
	44.9	45.0	44.9	44.9
	34.9	35.0	34.9	35.0
	30.0	30.0	30.0	30.0
	24.9	27.5	25.0	25.1
	20.0	25.0	20.0	20.1
	15.0	22.4	15.0	15.0
	-	20.2	5.0	-
	-	18.0	-	-
	-	15.0	-	-
	-	5.0	-	-
Gas Sampling Canister	-	17.5	-	-

* All instrument locations are referenced to the bottom of the coal seam in each well. Positive numbers are above reference; negative numbers are below reference.

in a 2-stage procedure. In the first stage, a coal-filled grout designed to match the coal seam properties was pumped through plastic hose to fill the hole to just slightly above the top of the coal seam. The second stage consisted of pumping conventional pozzolen cement to complete grouting to the surface.

Gas analyses were provided by the same equipment used during the Hanna I test. A daily sample was collected for mass spectrometer analysis in Laramie and on-site analyses were performed on a Varian Aerograph gas chromatograph. The Varian GC could not provide H_2 analysis but gave sufficient results for other components to indicate any substantial changes in gas composition.

The Varian GC contained a Molecular Sieve 5A for elution of H_2 , O_2 and Argon as one peak, N_2 , CH_4 and CO. Due to the use of Helium as a carrier gas and the relative thermal conductivity of H_2 vs. He, the H_2 peak was detected as a negative peak by the strip chart recorder and integrator. (This problem was resolved in later tests with the use of mixed carrier gas of H_2 in He.) The second column, Carbowax, provided for the elution of an air peak (H_2 , O_2 , N_2 , CO, & CH_4 combined), CO_2 , C_2H_6 , C_2H_4 , C_3H_6 , C_3H_8 , $n-C_4H_{10}$, $i-C_4H_{10}$ and H_2S . Through the use of the integrated areas and a pocket calculator, a normalized analysis was reported (bearing in mind the inaccurate H_2 concentration). These analyses were never entered into the computer's data base and the GC analyses were never corrected to account for the mass spec results for H_2 . Mass spec analyses were used as daily averages to complete material and energy balance calculations.

The Hanna II Phase IA test was the first attempt to use a computer for collecting, storing and retrieving data generated during an in situ coal gasification test. The equipment selected was a Hewlett-Packard 2100 minicomputer with selected peripherals, most of which were also HP products. The HP2100 CPU contained 64K bytes of core memory and slots for up to 14 I/O ports for peripheral devices. Additional I/O ports

were available through the use of an HP 2155A I/O extender. The primary mass storage device was an HP 7900 cartridge disc drive providing 4.9 Mega-bytes of storage and an average access time of 30 milliseconds. An HP 7970B 9-track magnetic tape (800 bpi) was used for disc back-up and transfer of data files to other systems with compatible tape drives. Analog to Digital conversion of low level (0-20ma) and high level (0-5 volt) signals from data transmitters was achieved through the use of an HP 2313 A/D subsystem. Additional peripherals were an HP 2615 CRT for use as a system console, HP 2607 matrix 200-lpm line printer for hardcopy generation, an HP 7210 flat bed plotter for graphic display of data, and finally a paper tape photoreader and paper tape punch used primarily for system generations.

The operating system software was the HP RTE-II (Real Time Executive) which is a disc-based system. RTE-II allows for memory organization where user programs may either be memory based (retained in core) or disc based (retrieved from the disc when called for execution). The disc based programs could operate in one of two partitions, foreground or background. The operating system also allowed for program swapping and, with the use of a time-based generator, the scheduling of any user program could be implemented.

The use of this system greatly improved the accuracy of recorded data over manually reading and recording data as was the case in Hanna I. The automatic sampling of data through the computer system and the immediate display of current and previous operating data relieved operating personnel from interruption during the performance of other duties, allowed greater emphasis on real time data interpretation, and maintained proper control of the ongoing experiment.

A brief description of the user programs follows to explain the method used to collect data and give the reader an understanding of what the data represented. With the use of the RTE-II operating system, a program was scheduled to execute every 5 minutes. This program would

interrogate the HP 2313 A/D subsystem requesting voltages on the incoming analog signals from the instrument transmitters located throughout the test facility. These voltages were then converted, depending on their origin, to appropriate values (°F for example). Some of these values were subsequently used to calculate other process parameters such as flow rates. The resulting values, temperature, static pressures, differential pressures and flow rates were then added to the corresponding running sum for the current hour. When the last 5 minute reading for the hour had been completed and converted, the number of readings for the hour (typically 12) was divided into the accumulated sum for each parameter giving the resulting hour's average reading. This group of the hour's averages was then written into a disc file for the current day's readings. The resulting data base showed a separate file for each day during the test with each file containing 48 records or 2 records for each hour. The only information contained in the data base that was entered manually (through the use of a program written to interact with operating personnel) was the GC analyses that was mentioned previously.

Additional programs were scheduled by the master 5 minute program that outputted to the line printer an hourly report indicating those measured parameters. An 8-hour shift summary was also computed and printed. Another program copied all data files from disc to magnetic tape every 8 hours as a backup in case of disc failure. Later in the test, this tape backup was modified to include not only data files but also the operating system based on the disc and all sources for user programs.

The file structure and supporting data acquisition programs allowed for the accumulation of a maximum of 63 days of data on the disc drive before a new cartridge was installed and initialized. The operational personnel were provided with a list of available programs to access the data in various ways. The following is a list of the options made available:

1. Display the last 5 minute reading of all flow parameters.
2. Display or modify current factors (i.e. orifice factors, offsets, etc.) used by the master program to convert voltage readings to dimensional values.
3. Display an hourly average of data from the current day or past day (if residing on disc).
4. Display the hourly average for a specific parameter for a specified range of days.
5. Graphically display on flat bed plotter any stored parameter plotted vs. time to depict trends or changes.

Instrumentation was primarily restricted to thermal and pressure data. The use of orifice plate flow meters in conjunction with temperature compensation, static and differential pressure measurements provide the basis for all flow measurements. All thermal data was provided through use of Chromal-Alumel (Type K) thermocouples which proved to be very reliable for most surface measurements and about as cost effective and durable as any other type for subsurface measurements. The surface thermocouples (installed by U.S. Bureau of Mines personnel) were all of the conventional single junction type. The subsurface thermocouples (installed by Sandia Laboratories Albuquerque (SLA)) were the leg-branched type which allowed direct diagnostic emf (noise) and loop resistance plus redundant temperature measurements along alternate circuit paths. Table 4 shows the SLA thermocouples connected to the computer data acquisition system for Hanna II Phase IB. None of the downhole thermocouples were connected to the LERC data system during Phase IA. Because of the inconvenience caused by such an arrangement, these data channels were connected for Phase IB and all subsequent field tests which included SLA downhole thermocouples.

Table 4. Phase IB Thermocouple Channels Connected to LERC Data System

<u>Well #</u>	<u>LERC Channel #</u>	<u>Feet Above Coal Bottom</u>
AA	18	45
AA	19	35
AA	20	30
AA	21	25
AA	22	20
AA	23	15
BB	24	35
BB	25	30
BB	26	25
BB	27	20
BB	28	15
BB	29	5

Surface pressure measurements on flow lines were all done with Beckman Series 8600 transmitters employing a variable-reluctance method of measurement. These were calibrated with a 4-20mA signal and, with the use of different capsules could measure differential pressures from 0-10" to 0-600" of water and static pressures from 0-10 to 0-600 psig.

V. PRE-OPERATIONAL TESTING.

Conventional wisdom prior to initiation of the Hanna UCG test series stated that directional permeability measurements made on an oriented core should be utilized to determine well pattern orientation. As a check of this, an oriented core (full seam) was taken from Well 1. Samples were taken from this core at 4 separate locations after marking to indicate orientation and sent to Core Laboratories, Inc. for directional permeability measurements. The results of the analysis are shown in Table 5. Two of the samples did not have sufficient strength to withstand the test procedure. The two samples for which data were obtained were located at mid-seam and about 6 feet from the bottom of the seam, respectively. The sample collected from the mid-seam location showed major permeability in the quadrant from N60°W to N70°W. The sample collected 6 feet from seam bottom did not yield any obvious major permeability direction. It was thus decided to drill wells 2, 3 and 4 in a 90° arc updip from Well 1 with Well 2 located along the major permeability direction of N60°W, with Well 3 along the dip direction of S60°W, and Well 4 along a line perpendicular to the 1-2 line, i.e., along the line bearing S30°W. Due to the casing separation in the original Well 4, the new Well 4 was drilled along the line bearing S20°W on the arc 60 feet from Well 1.

After plumbing Wells 2, 3, and 4 with siphon jets to remove water that might collect in the wellbore and with 2" meter run assemblies with American Meterrecords to measure air production from each well, air injection was initiated at Well 1 on JD97 (April 7). Injection pressure was about 240 psig with injection of about 130scfm. In addition, water

Table 5. CORE ANALYSIS RESULTS

Company U.S. BUREAU OF MINES Formation HANNA File RP-4-3205
 Well 0-1 Core Type CONV 3" Date Report 12-28-74
 Field HANNA COAL Drilling Fluid _____ Analysts KB
 County CARBON State WYOMING Elev. _____ Location SEC 29-22N-81W

Lithological Abbreviations

SAND - SD SHALE - SH LIME - LM	DOLOMITE - DOL CHERT - CH GYPSUM - GYP	ANHYDRITE - ANHY CONGLOMERATE - CONG FOSSILIFEROUS - FOSS	SANDY - SDY SHALY - SHY LIMY - LMY	FINE - FN MEDIUM - MED COARSE - CSE	CRYSTALLINE - ELM GRAIN - GRN GRANULAR - GRNL	BROWN - BRN GRAY - GRV VUGGY - VGY	FRACTURED - FRAC LAMINATION - LAM STYLOLITIC - STY	SLIGHTLY - VERY - V/ WITH - W/
--------------------------------------	--	---	--	---	---	--	--	--------------------------------------

SAMPLE NUMBER	DEPTH FEET	DIRECTION	PERMEABILITY MILLIDARCYS	SAMPLE DESCRIPTION AND REMARKS
0-1	289.8-290.5	NOW	SOE	0.48
		SOE	NOW	0.53
		N5W	S5E	1.2
		S5E	N5W	0.82
		N10W	S10E	1.5
		S10E	N10W	1.0
		N15W	S15E	1.1
		S15E	N15W	0.82
		N20W	S20E	1.2
		S20E	N20W	0.91
		N25W	S25E	3.1
		S25E	N25W	2.4
		N30W	S30E	2.9
		S30E	N30W	2.6
		N35W	S35E	1.8
		S35E	N35W	1.4
		N40W	S40E	4.0
		S40E	N40W	5.2
		N45W	S45E	4.5
		S45E	N45W	3.8
		N50W	S50E	4.0
		S50E	N50W	3.3
		N55W	S55E	2.9
		S55E	N55W	2.5
		N60W	S60E	6.4
		S60E	N60W	4.2
		N65W	S65E	12
		S65E	N65W	11
		N70W	S70E	8.4
		S70E	N70W	6.8
		N75W	S75E	1.4
		S75E	N75W	1.1
		N80W	S80E	2.8
		S80E	N80W	3.1
		N85W	S85E	3.6
		S85E	N85W	3.1
		N90W	S90E	11
		S90E	N90W	7.7
		N05E	S05W	4.9
		S05W	N05E	6.9
		N10E	S10W	2.6
		S10W	N10E	1.4

These analyses, opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all errors and omissions excepted), but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations, as to the productivity, proper operations, or profitability of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 2

Table 5. CORE ANALYSIS RESULTS (Continued)

Company U.S. BUREAU OF MINES Formation HANNA File RP-4-3205
Well 0-1 Core Type CONV 3" Date Report 12-28-74
Field HANNA COAL Drilling Fluid _____ Analysts KB
County CARBON State WYOMING Elev. _____ Location SEC 29-22N-81W

Lithological Abbreviations

SAND-SO	DOLOMITE-DOL	ANHYDRITE-ANHY	SANDY-SOY	FINE-FN	CRYSTALLINE-XLM	BROWN-BRN	FRACTURED-FRAC	SLIGHTLY-SL
SHALE-SM	CHEST-CN	CONGLOMERATE-CONG	SHALY-SHY	MEDIUM-MED	GRAIN-GRN	GRAY-GY	LAMINATION-LAM	VERY-V/
LIME-LM	GYPSEUM-GYP	FOSSILIFEROUS-FOSS	LIMY-LMY	COARSE-CSE	GRANULAR-GRNL	VUGGY-VGY	STYLOLITIC-STY	WITH-W/

SAMPLE NUMBER	DEPTH FEET	DIRECTION		PERMEABILITY MILLIDARCYS	SAMPLE DESCRIPTION AND REMARKS
0-1 (Con't)	289.8-290.5	N15E	S15W	1.8	
		S15W	N15E	1.7	
		N20E	S20W	2.7	
		S20W	N20E	3.2	
		N25E	S25W	4.3	
		S25W	N25E	3.9	
		N30E	S30W	5.4	
		S30W	N30E	4.6	

0-1 305.5-306.1 Vertical Permeability: 0.32

NOTE: Missing angles were due to sample failure

Table 5. CORE ANALYSIS RESULTS (Continued)

Company U.S. BUREAU OF MINES Formation HANNA File RP-4-3205
 Well 0-1 Core Type CONV 3" Date Report 12-28-74
 Field HANNA COAL Drilling Fluid _____ Analysts KB
 County CARBON State WYOMING Elev. _____ Location SEC 29-22N-81W

Lithological Abbreviations

SAND - SD
SHALE - SH
LIME - LMDOLOMITE - DOL
CHERT - CH
GYPSUM - GYPANHYDRITE - ANHY
CONGLOMERATE - CONG
FOSSILIFEROUS - FOSSSANDY - SDY
SHALY - SHY
LIMY - LMYFINE - FN
MEDIUM - MED
COARSE - CSECRYSTALLINE - XLN
GRAIN - GRN
GRANULAR - GRNLBROWN - BRN
GRAY - GR
VUGGY - VGYFRACTURED - FRAC
LAMINATION - LAM
STYLOLITIC - STYSLIGHTLY - SL/
VERY - V/
WITH - W/

SAMPLE NUMBER	DEPTH FEET	DIRECTION	PERMEABILITY MILLIDARCYS	SAMPLE DESCRIPTION AND REMARKS
------------------	---------------	-----------	-----------------------------	-----------------------------------

0-2 285.3-286.2

NOTE: No readings were due to sample failure

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 4

Table 5. CORE ANALYSIS RESULTS (Continued)

Company U.S. BUREAU OF MINES Formation HANNA File RP-4-3205
Well 0-1 Core Type CONV 3" Date Report 12-28-74
Field HANNA COAL Drilling Fluid _____ Analysts KB
County CARBON State WYOMING Elev. _____ Location SEC 29-22N-81W

Lithological Abbreviations

SAND-SG SHALE-SH LIME-LM	DOLomite-DOL CHERT-CH GYPSUM-GYP	ANHYDRITE-ANHY CONGLOMERATE-CONG FOSSILIFEROUS-FOSS	SANDY-SDY SHALY-SHY LIMY-LMY	FINE-FN MEDIUM-MED COARSE-COE	CRYSTALLINE-XLN GRAIN-GRN GRANULAR-GRNL	BROWN-BRN GRAY-GY VUGGY-VGY	FRACTURED-FRAC LAMINATION-LAM STYLOLITIC-STY	SLIGHTLY-SL VERY-V/ WITH-W/
--------------------------------	--	---	------------------------------------	-------------------------------------	---	-----------------------------------	--	-----------------------------------

SAMPLE NUMBER	DEPTH FEET	DIRECTION	PERMEABILITY MILLIDARCYS	SAMPLE DESCRIPTION AND REMARKS
0-3	295-295.5	NOTE: No readings were due to sample failure		

Table 5. CORE ANALYSIS RESULTS (Continued)

Company U.S. BUREAU OF MINES Formation HANNA File RP-4-3205
 Well 0-1 Core Type CONV 3" Date Report 12-28-74
 Field HANNA COAL Drilling Fluid Analysts KB
 County CARBON State WYOMING Elev. Location SEC 29-22N-81W

Lithological Abbreviations

SAND - SO SHALE - SH LIME - LM	DOLOMITE - DOL CHERT - CH GYPSUM - GYP	ANHYDRITE - ANHY CONGLOMERATE - CONG FOSSILIFEROUS - FOSS	SANDY - SOY SHALY - SHY LIMY - LMY	FINE - FN MEDIUM - MED COARSE - CSE	CRYSTALLINE - XLN GRAIN - GRN GRANULAR - GRNL	BROWN - BRN GRAY - GRV YUGGY - YGY	FRACTURED - FRAC LAMINATION - LAM STYLOLITIC - STY	SLIGHTLY - S VERY - V/ WITH - W/
--------------------------------------	--	---	--	---	---	--	--	--

SAMPLE NUMBER	DEPTH FEET	DIRECTION	PERMEABILITY MILLIDARCYS	SAMPLE DESCRIPTION AND REMARKS
0-4	298-298.9	NOW SOE	1.3	
		SOE NOW	1.6	
		N5W S5E	3.3	
		S5E N5W	2.5	
		N10W S10E	4.1	
		S10E N10W	4.8	
		N15W S15E	3.1	
		S15E N15W	3.3	
		N20W S20E	4.6	
		S20E N20W	6.4	
		N25W S25E	4.1	
		S25E N25W	2.7	
		N30W S30E	3.3	
		S30E N30W	4.5	
		N35W S35E	4.4	
		S35E N35W	3.5	
		N40W S40E	3.4	
		S40E N40W	4.0	
		N45W S45E	1.6	
		S45E N45W	2.1	
		N50W S50E	1.9	
		S50E N50W	1.6	
		N80W S80E	3.9	
		S80E N80W	5.7	
		N85W S85E	3.5	
		S85E N85W	2.8	
		N90W S90E	2.7	
		S90E N90W	3.5	
		N05E S05W	1.5	
		S05 N05E	1.1	
		N10E S10W	1.6	
		S10W N10E	2.1	
		N15E S15W	2.2	
		S15W N15E	2.1	
		N20E S20W	2.5	
		S20W N20E	3.1	
		N25E S25W	4.1	
		S25W N25E	3.3	
		N30E S30W	1.9	
		S30W N30E	2.7	

These analyses, opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgment of Core Laboratories, Inc. (all efforts and omissions excepted); but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representation as to the productivity, proper operation, or profitability of any oil, gas or other mineral well or sand in connection with which this report is used or relied upon.

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

Page No. 6Table 5. **CORE ANALYSIS RESULTS**(Continued)

Company U.S. BUREAU OF MINES Formation HANNA File RP-4-3205
 Well 0-1 Core Type CONV 3" Date Report 12-28-74
 Field HANNA COAL Drilling Fluid _____ Analysts KB
 County CARBON State WYOMING Elev. _____ Location SEC 29-22N-81W

Lithological Abbreviations

SAND-SO SHALE-SM LIME-LM	DOLOMITE-DOL CHERT-CH GYPSUM-GYP	ANHYDRITE-ANHY CONGLOMERATE-CONG FOSSILIFEROUS-FOSS	SANDY-SOY SHALY-SHY LIMY-LMY	FINE-FM MEDIUM-MED COARSE-CSE	CRYSTALLINE-XLM GRAIN-GRN GRANULAR-GRNL	BROWN-BRN GRAY-GY VUGGY-VGY	FRACTURED-FRAC LAMINATION-LAM STYLOLITIC-STY	SLIGHTLY-S VERY-V/ WITH-W/
--------------------------------	--	---	------------------------------------	-------------------------------------	---	-----------------------------------	--	----------------------------------

SAMPLE NUMBER	DEPTH FEET	DIRECTION	PERMEABILITY MILLIDARCYS	SAMPLE DESCRIPTION AND REMARKS
0-4 (Con't)	298-298.9	N35E S35W	2.0	
		S35W N35E	1.7	
		N40E S40W	1.7	
		S40W N40E	2.1	
		N45E S45W	3.2	
		S45W N45E	2.6	
		N50E S50W	1.6	
		S50W N50E	3.4	
		N55E S55W	3.2	
		S55W N55E	2.3	
		N60E S60W	1.3	
		S60W N60E	3.1	
		N65E S65W	4.6	
		S65W N65E	1.4	
		N70E S70W	0.73	
		S70W N70E	0.52	

NOTE: Missing angles were due to sample failure

meters were hooked to the siphon jets at each well to record total water production at each well. Within 30 minutes of initiating air injection at Well 1, water was produced from Well 3 through the siphon jet. Within 5 hours, Well 3 was producing 16scfm. Table 6 shows the air production rates at each well over the subsequent 10-day injection period. Based on these injection data, it was apparent that the results from analysis of the oriented core were not dependable for determining well pattern orientation at the Hanna site.

Because of air leakage observed at Well CC during this injection period and in order to determine if the permeability between wells could be sufficiently enhanced simply by continued high-pressure air injection, injection was initiated at Well 3 on JD 107 (April 17) with production from Well 1 and with Wells 2 and 4 shut in. Air injection was continued at Well 3 for 33 days with no significant change in the permeability. Reverse combustion linking was initiated from Well 1 to Well 3 on JD 141 (May 21).

VI. TEST OPERATIONS SUMMARY.

A. Significant Events Summary.

1. JD 141. (May 21, 1975). Initiation of ignition at Well 1 using a downhole electric resistance heater at 1345 hrs. Injection at Well 1 with production from Well 3. Wells 2 and 4 shut in.
2. JD 145. (May 25). Heater removed from Well 1. Injection initiated at Well 3 with production from Well 1 to start reverse combustion linking.
3. JD 147. (May 27). 13 psig pressure increase noted at Instrument Well CC.

Table 6. Pre-test Air Acceptance Results

<u>Julian Day</u>	<u>Inj. Rate (scfm)</u>	<u>Injection Pressure (psig)</u>	<u>Production (scfm)</u>		
			<u>Well 2</u>	<u>Well 3</u>	<u>Well 4</u>
97 (4/7)	130	240	-	16	-
98	130	240	1.4	24	3.8
99	133	240	2.0	29	4.8
100	138	240	2.2	30	5.5
101	140	238	2.4	31	6.8
102 *	140	237	2.6	35	9.1
103	153	236.5	3.5	36	9.0
104	160	236	3.6	36	8.9
105 **	13.4	113	0	8.5	0.5
106 **	42	158	0.7	12.5	1.6

* Sandia instrument well CC began producing water to the surface.

** Injection pressure reduced due to increased pressures at wellheads in Hanna I pattern and low flow at several open wells. Air injection terminated until all Hanna I wells could be capped.

4. JD 148. (May 28). Fluid buildup in Well 1 noted. Relieved by requested blow-down of well each 4 hours.
5. JD 149. (May 29). Initial temperature increase observed at mid-seam thermocouple (15' off coal seam bottom) in Well CC.
6. JD 151. (May 31). Temperature at mid-seam in Well CC had increased to about 173°F.
7. JD 152. (June 1). Mid-seam thermocouple in Well CC showed temperature of 194°F. Production and injection rates almost equal (Injection rate = 77scfm @ 249 psig; Production rate = 76 scfm).
8. JD 153. (June 2). Temperature at mid-seam in Well CC increased to 199°F. No temperature increase observed at 5' above mid-seam or 10' below mid-seam.
9. JD 154. (June 3). Production rate (85 scfm) greater than injection rate (79scfm) for first time.
10. JD 155. (June 4). Linkage achieved at 0910 hours. Gasification initiated from Well 3 to Well 1.
11. JD 157. (June 6). Thermocouples at mid-seam level in both Wells CC and DD indicated temperatures between 900°F and 1000°F with the mid-seam level in Well DD failing after measuring a maximum temperature of 1016°F at 1430 hours.
12. JD 159. (June 8). The thermocouples at 20.1' above seam bottom in Well DD reached 970°F -- 40 hours after the comparable increase at mid-seam in Well DD.

13. JD 162. (June 11). Both production meter runs developed leaks due to O-ring failure--presumably due to attack by entrained coal tars, H_2S , etc.
14. JD 166. (June 15). All channels in Well DD from mid-seam to 15' above top of coal seam are showing increasing temperatures as gasification front approaches.
15. JD 168. (June 17). Temperatures in Well DD range from 915°F to 1156°F. All thermocouples from 15' above bottom of seam to 35' above top of seam are in this range. In Well CC the thermocouple at mid-seam is at 1072°F and the one at 20' above the seam bottom is at 194°F. No other levels have shown any increase.
16. JD 169. (June 18). Ingersoll-Rand 2000 Spiroflow compressor put on line.
17. JD 174. (June 23). Production flow measurements appear to be low. Injection rate = approximately 1600 scfm. Production rate = approximately 1950 scfm. May be due to problem with leakage at production meter runs noted in Item 13 of this event summary.
18. JD 181. (June 30). Temperature at 5' off bottom of coal seam in Well CC reached 1185°F.
19. JD 192. (July 11). All thermocouples and geophones below 79' above bottom of coal in Well CC failed due either to burn off within the coal seam or to roof caving. Gasification from Well 3 to Well 1 terminated. High-pressure air injection initiated at Well 2 to link it to existing gasification front.

20. JD 193. (July 12). Injection rate at Well 2 - 276 scfm @ 244 psig, production rate about 500 scfm -- partially due to system bleeddown from 1 - 3 gasification.
21. JD 202. (July 19). Thermocouples in Well BB at 15' and 20' above bottom of coal seam showing slight temperature increase.
22. JD 205. (July 22). Reverse combustion linking completed to Well 2 at 2000 hrs. Gasification from Well 2 to 3 - 1 gasified area initiated.
23. JD 207. (July 24). Injection rate decreased from about 1000 to about 600 scfm to assess turn-down ratio.
24. JD 212. (July 29). Injection rate increased to 1100 scfm from 600 scfm. Production rate stabilized at 2100 scfm within 90 minutes.
25. JD 213. (July 30). Injection rate decreased to 300 scfm after 32 hours at 1100 scfm.
26. JD 234. (August 20). Injection rate increased to 1000 scfm.
27. JD 242. (August 28). Injection rate increased to 1400 scfm. Air injection terminated after 8 hours @ 1400 scfm. Hanna II, Phases IA (Well 3 to Well 1) and IB (Well 2 to 3 - 1 line) completed.

B. Average Operating Parameters.

Table 8 shows the average operating parameters for the Phase I test conducted from JD 155 through JD 192, 1975.

Table 7. Hanna II, Phase IA Average Operating Parameters

<u>Parameter</u>	<u>Average Value</u>
Injection Rate (MMscfd)	1.9
Injection Pressure (Psig)	28
Production Rate (MMscfd)	2.7
Production Pressure (Psig)	9
Product Gas Temperature ($^{\circ}\text{F}$) *	510
Heating Value (Btu/scf)	152
Product Gas Composition (Mole %):	
<u>Component</u>	
H ₂	17.3
CO	14.7
CO ₂	12.4
CH ₄	3.3
N ₂	51.0
Ar	0.6
H ₂ S	0.1
C ₂ - C ₄ 's	0.6
Thermal Efficiency (%)	83
Total Coal Gasified (Tons)	1260

* Measured at meter run rather than at wellhead. Probably 50 - 100 $^{\circ}\text{F}$ higher at wellhead.

Plots of these parameters are included as Figures 3 through 9. The Phase IA and B gas compositions from mass spec samples and the average daily operating parameters for Phase IB are given in Table 9.

C. Tar and Water Production.

No measurement of these parameters was made during Hanna II, Phase I.

D. Instrumentation Responses.

The downhole instrumentation responses in Instrument Wells AA, BB, CC, and DD are given below. No responses were noted in Wells AA or BB during linking or gasification between Wells 1 and 3.

<u>Initial Response Date (JD)</u>	<u>Thermocouple Location</u>	<u>Summary of Response</u>
150	Well CC, 15' off bottom of coal seam	Maximum temperature 1100°F before failure on JD 158
160	Well CC, 20' off bottom of coal seam	Maximum temperature of 450° on JD 171 and on JD 192 at test termination
179	Well CC, 5' off bottom of coal seam	Maximum temperature 1300°F on JD 181

Figure 3. Hanna II, Phase I Injection and Production Flow Rates

Figure 4. Hanna II, Phase I Injection and Production Pressures

Figure 5. Hanna II, Phase I Injection and Production Flow Temperatures

Figure 6. Hanna II, Phase I Product Gas Heating Value

Figure 7. Hanna II, Phase I Product Gas Composition (Major Components)

Figure 8. Hanna II, Phase I Product Gas Composition (Minor Components)

Figure 9. Hanna II, Phase I Product Gas Nitrogen Content

Table 8.

HANNA II, PHASE 1A GAS COMPOSITIONS (FROM MASS SPEC. SAMPLES)

<u>Date</u>	<u>Julian Date</u>	<u>Components (Volume %)</u>									
		<u>H₂</u>	<u>CO</u>	<u>CO₂</u>	<u>N₂</u>	<u>CH₄</u>	<u>C₂'s</u>	<u>C₃'s</u>	<u>C₄'s</u>	<u>Ar</u>	<u>H₂S</u>
6/4/75	155	17.67	11.85	14.06	49.55	4.66	0.72	0.18	0.25	0.60	0.06
6/5	156	21.41	16.55	10.89	45.32	4.40	0.52	0.21	0.11	0.55	0.03
6/6	157	21.78	16.13	11.10	45.35	4.33	0.46	0.20	0.08	0.55	0.03
6/7	158	NO MASS SPEC. SAMPLE TAKEN									
6/8	159	18.48	16.40	11.40	48.12	4.12	0.54	0.21	0.08	0.58	0.06
6/9	160	18.15	15.03	11.93	48.91	4.35	0.59	0.24	0.10	0.60	0.08
6/10	161	18.57	16.35	12.33	47.23	4.10	0.53	0.18	0.09	0.58	0.04
6/11	162	NO MASS SPEC. SAMPLE TAKEN									
6/12	163	18.70	15.93	11.70	48.10	4.04	0.49	0.19	0.21	0.57	0.07
6/13	164	18.21	16.84	11.22	48.20	3.96	0.54	0.20	0.11	0.58	0.13
6/14	165	18.16	16.36	11.47	48.87	3.65	0.49	0.19	0.11	0.58	0.11
6/15	166	NO MASS SPEC. SAMPLE TAKEN									
6/16	167	17.11	14.92	11.10	51.20	3.94	0.59	0.23	0.13	0.61	0.16
6/17	168	16.74	14.79	12.14	50.54	4.00	0.56	0.23	0.12	0.62	0.26
6/18	169	NO MASS SPEC. SAMPLE TAKEN									
6/19	170	17.59	13.44	13.74	49.58	4.14	0.48	0.20	0.09	0.59	0.15
6/20	171	17.95	14.24	12.18	49.62	4.40	0.50	0.20	0.12	0.60	0.19
6/21	172	NO MASS SPEC. SAMPLE TAKEN									
6/22	173	17.98	14.81	12.21	49.34	4.19	0.49	0.10	0.19	0.57	0.11
6/23	174	NO MASS SPEC. SAMPLE TAKEN									
6/24	175	18.13	14.58	12.09	49.81	3.99	0.50	0.08	0.15	0.57	0.10
6/25	176	17.71	14.72	12.22	50.46	3.50	0.47	0.08	0.14	0.58	0.11
6/26	177	17.13	15.24	12.13	50.72	3.42	0.47	0.12	0.08	0.58	0.11
6/27	178	NO MASS SPEC. SAMPLE TAKEN									
6/28	179	16.20	14.73	13.04	52.02	2.72	0.39	0.09	0.07	0.60	0.13
6/29	180	NO MASS SPEC. SAMPLE TAKEN									
6/30	181	18.00	17.40	10.74	50.44	2.32	0.30	0.07	0.06	0.57	0.11
7/1	182	14.49	15.10	12.76	54.49	1.97	0.31	0.08	0.06	0.63	0.12
7/2	183	16.53	14.70	11.26	54.55	1.76	0.32	0.08	0.07	0.61	0.11
7/3	184	16.14	15.10	11.82	53.68	2.06	0.34	0.07	0.06	0.60	0.10
7/4	185	16.25	14.07	12.36	54.00	2.10	0.37	0.08	0.08	0.59	0.09
7/5	186	15.25	14.40	14.36	52.75	2.04	0.35	0.07	0.09	0.61	0.10
7/6	187	15.87	12.52	13.75	54.88	1.91	0.38	0.08	0.10	0.60	0.11

Table 8 (Cont'd)

HANNA II, PHASE 1A GAS COMPOSITIONS (FROM MASS SPEC. SAMPLES)

Date	Julian Date	Components (Volume %)									
		H ₂	CO	CO ₂	N ₂	CH ₄	C ₂ 's	C ₃ 's	C ₄ 's	Ar	H ₂ s
7/7	188	15.50	12.23	14.45	54.70	2.07	0.36	0.08	0.09	0.61	0.11
7/8	189	15.20	11.68	15.10	54.79	2.09	0.32	0.08	0.07	0.58	0.08
7/9	190	14.79	13.67	14.27	53.68	2.39	0.37	0.08	0.06	0.59	0.09
7/10	191	14.50	12.35	13.07	56.85	2.14	0.32	0.06	0.07	0.60	0.10
7/11	192	14.59	13.78	13.68	54.23	2.37	0.34	0.07	0.08	0.59	0.09

HANNA II, PHASE 1B GAS COMPOSITIONS (FROM MASS SPEC. SAMPLES)

7/23	204	19.19	11.01	17.13	43.69	6.90	1.00	0.31	0.10	0.52	0.15
7/24	205	24.24	8.77	15.74	45.06	4.68	0.49	0.19	0.31	0.52	0.0
7/25	206	24.76	7.49	17.13	43.81	4.98	0.72	0.26	0.25	0.51	0.09
7/26	207	24.50	9.17	16.18	44.38	4.11	0.61	0.24	0.24	0.52	0.05
7/27	208	23.44	8.67	16.78	44.93	4.50	0.68	0.28	0.15	0.52	0.06
7/28	209	NO MASS SPEC. SAMPLE TAKEN									
7/29	210	18.46	10.89	15.68	50.15	3.24	0.54	0.25	0.09	0.58	0.0
7/30	211	NO MASS SPEC. SAMPLE TAKEN									
7/31	212	25.52	6.85	19.00	42.79	4.36	0.56	0.20	0.14	0.49	0.07
8/1	213	23.72	7.05	18.67	44.96	4.08	0.53	0.27	0.09	0.52	0.10
8/2	214	24.36	7.21	18.32	44.93	3.74	0.50	0.23	0.07	0.52	0.13
8/3	215	24.76	6.07	19.71	44.31	3.71	0.50	0.24	0.07	0.51	0.11
8/4	216	24.56	7.16	19.68	43.57	3.60	0.49	0.18	0.12	0.52	0.11
8/5	217	25.94	5.80	17.01	45.31	4.31	0.61	0.21	0.33	0.48	0.0
8/6	218	25.21	4.86	16.70	47.72	4.08	0.60	0.16	0.13	0.49	0.05
8/7	219	23.25	7.93	15.21	47.95	4.24	0.64	0.17	0.12	0.49	0.0
8/8	220	NO MASS SPEC. SAMPLE TAKEN									
8/9	221	23.76	7.16	15.15	48.34	4.18	0.58	0.16	0.17	0.49	0.0
8/10	222	23.25	3.49	15.48	51.40	4.75	0.75	0.18	0.20	0.51	0.0
8/11	223	NO MASS SPEC. SAMPLE TAKEN									
8/12	224	24.27	5.45	15.47	48.59	4.61	0.65	0.21	0.25	0.49	0.0
8/13	225	21.48	8.44	12.72	50.83	4.62	0.55	0.14	0.73	0.49	0.0
8/14	226	NO MASS SPEC. SAMPLE TAKEN									
8/15	227	21.06	7.64	12.71	51.57	4.99	0.57	0.30	0.54	0.50	0.0
8/16	228	NO MASS SPEC. SAMPLE TAKEN									
8/17	229	21.13	4.91	15.40	52.13	4.93	0.58	0.22	0.12	0.52	0.0

Table 8 (Cont'd)

HANNA II, PHASE 1B GAS COMPOSITIONS (FROM MASS SPEC. SAMPLES)

<u>Components (Volume %)</u>											
<u>Date</u>	<u>Julian Date</u>	<u>H₂</u>	<u>CO</u>	<u>CO₂</u>	<u>N₂</u>	<u>CH₄</u>	<u>C₂'s</u>	<u>C₃'s</u>	<u>C₄'s</u>	<u>Ar</u>	<u>H₂S</u>
8/18	230	21.25	4.84	16.78	50.58	5.06	0.57	0.20	0.12	0.52	0.0
8/19	231	20.26	7.35	15.32	50.54	4.97	0.60	0.23	0.11	0.54	0.0
8/20	232	22.12	6.29	14.63	50.09	5.39	0.58	0.19	0.11	0.51	0.0
8/21	233	NO MASS SPEC. SAMPLE TAKEN									
8/22	234	17.59	8.25	18.60	49.04	4.62	0.55	0.23	0.45	0.57	0.11
8/23	235	16.12	8.14	16.91	53.72	3.63	0.45	0.10	0.16	0.63	0.14
8/24	236	15.26	6.95	18.62	54.24	3.62	0.41	0.08	0.14	0.63	0.06
8/25	237	18.49	8.71	17.40	49.37	4.66	0.45	0.15	0.07	0.56	0.13
8/26	238	16.78	9.32	17.72	51.16	3.69	0.41	0.12	0.08	0.60	0.11
8/27	239	16.89	5.93	16.13	55.69	3.88	0.40	0.14	0.22	0.66	0.07
8/28	240	16.80	5.85	16.24	55.78	3.84	0.39	0.15	0.21	0.66	0.08

Table 8 (Cont'd)

HANNA II, PHASE 1B DAILY AVERAGE OPERATING PARAMETERS:

<u>Date</u>	<u>Julian Date</u>	<u>Inj. Rate (scfm)</u>	<u>Inj. Pressure (psig)</u>	<u>Prod. Rate (scfm)</u>	<u>Product Gas Temp. (°F)</u>	*
7/12	193	263.6	242.2	602	-	
7/13	194	263.6	239.0	499	-	
7/14	195	278.5	240.0	451	-	
7/15	196	243.6	237.5	389	334	
7/16	197	211.0	240.9	354	299	
7/17	198	200.8	240.5	351	278	
7/18	199	213.5	242.4	355	272	
7/19	200	242.0	241.4	374	292	
7/20	201	309.5	239.7	401	298	
7/21	202	405.3	236.9	452	320	
7/22	203	511.8	212.6	1,055	369	
<u>GASIFICATION PHASE INITIATED</u>						
7/23	204	1,077	41.0	2,265	521	
7/24	205	925	26.4	1,921	492	
7/25	206	586	16.3	1,290	412	
7/26	207	584	16.2	1,258	400	
7/27	208	582	16.0	1,241	395	
7/28	209	587	15.5	1,225	358	
7/29	210	934	24.0	1,837	407	
7/30	211	865	24.0	1,943	392	
7/31	212	314	12.0	747	340	
8/1	213	319	11.4	695	325	
8/2	214	260	9.2	601	309	
8/3	215	221	7.3	505	267	
8/4	216	217	7.0	484	275	
8/5	217	226	7.2	495	275	
8/6	218	296	8.5	592	273	
8/7	219	414	11.6	838	298	
8/8	220	425	12.1	856	315	
8/9	221	471	12.9	848	330	
8/10	222	391	11.4	820	326	
8/11	223	397	11.2	816	308	
8/12	224	395	11.2	806	314	
8/13	225	687	16.1	1,301	338	
8/14	226	1,003	22.5	2,005	338	

Table 8 (Cont'd)

HANNA II, PHASE 1B DAILY AVERAGE OPERATING PARAMETERS:

<u>Date</u>	<u>Julian Date</u>	<u>Inj. Rate (scfm)</u>	<u>Inj. Pressure (psig)</u>	<u>Prod. Rate (scfm)</u>	<u>Product Gas Temp. [*] (°F)</u>
8/15	227	625	15.6	1,255	332
8/16	228	620	15.5	1,230	335
8/17	229	398	11.1	852	320
8/18	230	398	11.2	860	322
8/19	231	399	11.0	863	324
8/20	232	782	19.1	1,672	336
8/21	233	1,045	22.9	2,168	341
8/22	234	1,035	22.8	2,151	345
8/23	235	1,037	22.7	2,139	348
8/24	236	864	20.7	1,778	346
8/25	237	1,101	23.0	2,147	351
8/26	238	1,001	22.7	2,003	354
8/27	239	996	22.7	1,969	360
8/28	240	1,173	23.3	2,176	362

*

Measured at meter run. Temperature at the wellhead probably was about 50 to 75 °F higher.

177	Well CC, 25' off bottom of coal seam	Maximum temperature of 200°F on JD 181 and steady until JD 192
191	Well CC, 30' and 35' off seam bottom	Maximum temperature of 100°F at test termination on JD 192
157	Well DD, 15' above seam bottom	Maximum temperature of 1000°F with failure on JD 157
158	Well DD, 20' above seam bottom	Maximum temperature of 1050°F before failure on JD 160
159	Well DD, 25' above seam bottom	Maximum temperature of 1150°F before failure on JD 168
161	Well DD, 30' above seam bottom	Maximum temperature of 1400°F before failure on JD 178
165	Well DD, 5' above top of coal seam	Maximum temperatue of 1400°F on JD 180 before failure

VII. POST TEST ACTIVITY.

The post test activities for this test consisted of ground water sampling and analyses and coring of the gasified area. The data from the ground water monitoring are included in the appendix to the report entitled "General Information and Executive Summary".

The post test coring activities consisted of drilling and coring 10 wells within the test well pattern. The locations are shown in Figure 10. The results of the data interpretation with regard to cavity dimensions are shown in Figure 11 with a cross-section along the Wells 1-3 line. All of the coring and analyses data are included in the appendix.

VIII. BIBLIOGRAPHY.

Brandenburg, C. F., R. P. Reed, R. M. Boyd, D. A. Northrop, and J. W. Jennings, "Interpretation of Chemical and Physical Measurements from an In Situ Coal Gasification Experiment," SPE No. 5654, presented at the SPE Fall Meeting of AIME, Dallas, TX, Sept. 28 - Oct. 1, 1975.

Eastlack, J. K., "Development of Data Acquisition System for an In Situ Coal Gasification Experiment," M. S. Thesis, Department of Mineral Engineering, University of Wyoming, May 1976.

Estep-Barnes, P. A., and J. J. Kovach, "Chemical and Mineralogical Characterization of Core Samples from Underground Coal

Gasification Sites in Wyoming and West Virginia," Morgantown Energy Research Center, Report No. MERC/RE-75/2, Dec. 1975.

Fischer, D. D., J. E. Boysen, and R. D. Gunn, "An Energy Balance for the Second Underground Coal Gasification Experiment, Hanna, Wyoming," Preprint 77-F-54, AIME National Meeting, Atlanta, GA, March 6-10, 1977.

Northrop, D. A., S. G. Beard, L. C. Bartell, L. W. Beckham, and P. J. Hommert, "Instrumentation for In Situ Coal Gasification: An Assessment of Techniques Evaluated on the Hanna II Experiment," Sandia Laboratories Report, SAND 77--0669, Sept. 1977.

Stoller, H. M., "In Situ Instrumentation Applied to Underground Coal Gasification," Sandia Laboratories Report, SAND 75-0459, Sept. 1975.

Youngberg, A. D., J. E. McClury, and J. E. Schmitt, "Depositional Environments, Subsurface Stratigraphy, and Post-Burn Characterization of the Paleocene-Eocene Hanna Formation at the Hanna, Wyoming, Underground Coal Gasification Site: Hanna II, Phase I Experiment," Report No. DOE/LC/RI-83-2. NTIS Order No. DE83005592.

Figure 10. Core hole locations at Hanna II, Phase I.

Figure 11. Cross section C-C' of Hanna II, Phase 1 reactor cavity.