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Hanna, Wyoming Underground Coal Gasification Data Base

Volume 2: The Hanna I Field Test

Research Report

August 1985

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OFFICE OF FOSSIL ENERGY
MORGANTOWN ENERGY TECHNOLOGY CENTER
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Hanna, Wyoming Underground Coal Gasification Data Base

Volume 2: The Hanna I Field Test

Research Report

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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 2: Hanna I

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HANNA I

I. INTRODUCTION

Based on the recommendations of A.D. Little, Inc. in a 1971 report prepared for the U.S. Bureau of Mines, the Hanna I test represented the first field test in reestablishing a field program by the U.S. Bureau of Mines.

The test was directed toward comparing results from a thick subbituminous coal seam with those obtained during the field test series conducted at Gorgas, AL, in the 1940's and 1950's. Hanna I was conducted from March 1973 through February 1974.

II. SITE SELECTION AND CHARACTERISTICS

The location within the site for the Hanna I test was chosen such that the depth to the coal would be approximately 400 feet. Based on the information available from previous drilling on the site by the Union Pacific, the area which would meet the criterion was easily established as the site for Hanna I.

Coal quality was determined from cores taken from the first four holes drilled at the site, and seam characteristics and orientation of major fractures determined by oriented cores and impression packers. Additional information was added through logs and cores taken from drilling the additional twelve holes which comprised the initial test well pattern shown in Figure 1. Logs of the wells drilled for the pattern were not located for inclusion in this report.

Figure 1. Hanna I Well Pattern

The analysis of coal from Well 1 is shown in Table 1. In addition, carbonization yields at three different temperatures are shown in Table 2. The dip of the coal was about 9° in the direction N54°E. The overburden consisted of competent sandstones and shales with a single low productivity aquifer about 100 feet above the Hanna No. 1 seam.

III. TEST OBJECTIVES

The objectives of the Hanna I test were as follows:

Successfully reinitiate field tests of underground coal gasification in a thick subbituminous coal seam.

Determine the advantages inherent to thick deep western subbituminous coal over thin shallow eastern swelling bituminous coal.

Determine the relative merits of hydraulic fracturing and reverse combustion as linking techniques.

Produce a low-Btu gas suitable for use as a utility fuel.

IV. FACILITY DESCRIPTION

The well pattern for Hanna I is given in Figure 1. The schematic of surface plant layout is given in Figure 2. The completion schematic for production and ignition wells is shown in Figures 3 and 4. Only Wells 1 and 3 were completed in ignition wells.

All surface piping was either 2 inch or 4 inch Schedule 40. All valves were manual. Pressure measurements were obtained from manual pressure gauges. An orifice meter assembly was used to obtain flow measurements for air injection and production rates. A pressure gauge yielded the static pressure and either a mercury or water manometer yielded the

TABLE 1. Analysis of Coal Taken from Well 1

	As Received	Moisture Free	Moisture and Ash Free
<hr/>			
Proximate analysis:			
Moisture	9.51	-	-
Volatile matter	32.64	36.07	48.91
Fixed carbon	34.09	37.67	51.09
Ash	23.76	26.26	-
	100.00	100.00	100.00
<hr/>			
Ultimate analysis:			
Hydrogen	5.09	4.45	6.04
Carbon	49.60	54.81	74.33
Nitrogen	1.29	1.43	1.94
Oxygen	19.58	12.30	16.67
Sulfur	.68	.75	1.02
Ash	23.76	26.26	-
	100.00	100.00	100.00
<hr/>			
Heating Value (Btu/lb)	8,660	9,580	12,990
<hr/>			

TABLE 2.

Carbonization yields of composite core sample
of Hanna No. 1 coal at various temperatures
(moisture and ash free), weight-percent

Components	Temperature of carbonization, °C		
	500	700	900
Char	65.8	54.6	52.0
Water formed	10.3	13.2	13.3
Tar, dry	14.3	14.8	16.2
Light oil	1.4	1.1	.9
Gas	7.2	14.7	16.8
Hydrogen sulfide	.5	.4	.4
Total	99.5	98.8	99.0

Composition of gas evolved upon carbonization
at several temperatures, volume-percent

Components	Temperature of carbonization, °C		
	500	700	900
CO ₂	29.0	13.8	9.5
Illuminants	.8	.8	.5
CO	11.8	13.7	14.4
H ₂	15.0	38.0	53.3
CH ₄	35.9	31.9	20.8
C ₂ H ₆	7.5	1.8	1.5

Figure 2. Schematic of Hanna I Surface Facilities

Figure 3. Schematic of Production Well Completions

Figure 4. Schematic of Ignition Well Completions

differential pressure. The flows were manually calculated every 2 hours with no temperature correction.

All data gathering was manual. Every 2 hours personnel read the pressure gauges and gathered the flow data necessary to calculate flows. Gas samples were collected in sample bottles every 2 hours for analyses. The gas chromatograph used was a Varian Aerograph with dual columns containing molecular sieve 5B for elution of H_2 , O_2 and Ar as one peak, N_2 , CH_4 , and CO and Carbowax for elution of an air peak (H_2 , O_2 , N_2 , CO, and 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 . Unfortunately, this instrument could not provide a H_2 analysis. Thus, a normalized gas composition could be calculated from the integrated areas for each peak but not an accurate analysis. Samples were also taken every 2 hours for transport to Laramie for mass spectrophotometric analysis. These analyses were used to calculate material and energy balances.

Air compression equipment consisted of two Atlas-Copcos, one Gardner-Denver 1000, and a high pressure booster compressor -- all government surplus. The booster compressor was capable of pressures up to 1500 psig at flows up to 250 scfm. The low pressure compressors had a total capacity of 1800 scfm but reliably only produced 700 to 1000 scfm at pressures up to 100 psig.

V. PRE-OPERATION TESTS

Air acceptance tests were conducted at Wells 1 and 3. Well 1 accepted 24 scfm at 253 psig and Well 3 accepted 40 scfm at 242 psig. Due to the low acceptance rates, it was decided to hydraulically fracture Well 3. The fracturing treatment consisted of a 6,000 gal. pad of fresh water followed by 26,000 gal. of gelled water containing 16,000 lb. of sand as a proppant followed by 3,000 gal. of fresh water to flush the wellbore. Maximum pressure was 525 psig.

After fracturing, Well 3 accepted 204 scfm at 262 psig. An oriented impression packer run into Well 3 showed 4 induced major vertical fractures at the following directions and widths: S25°42'W, 1.3 inches; N16°42'W, 0.5 inches; N72°32'E, 0.25 inches, and S74°45'E, 0.125 inch. The largest fracture was aligned with the updip direction and lead to the decision to gasify toward Wells 5, 6, 7 and 8 to take advantage of the induced fracture.

VI. TEST OPERATIONS SUMMARY

A. Significant Events Summary

March 29, 1973	Coal ignited at Well 3
March 29 - April 11	Air injection at Well 3, production from Well 6, tar plugging in forward combustion mode.
May 30 - June 22	Reverse combustion linking completed to Wells 7 and 5.
June 22 - Sept 20	Injection at and production from Wells 3, 5, and 7 for various times.
Sept 20	Simultaneous high pressure air injection begun at Wells 9 and 15.
Sept 28	Link completed to Well 9
Oct 5	Link completed to Well 15
Oct 5 - Feb 1, 1974	Gasification from Wells 9 and 15 toward Wells 3, 5, 6, 7 and 8
Jan 15 - Feb 1	Linking to Well 12
Feb 1-28	Gasification from Well 12 to center wells
Mar 1	Test terminated

B. Average Operating Parameters

The data from the Hanna I test was inadvertently destroyed prior to initiation of this contract. Therefore, average operating data are not available other than for the period September 16 - February 28. Those data are presented in Table 3. Plots prepared for papers and presentations showing air injection rates, gas production rates, heating value and injection pressure are shown in Figures 5 through 8.

Material balance calculations yield a total coal utilization of 4,000 tons during Hanna I and a thermal efficiency of 60% -- largely due to the low air injection rates.

C. Tar and Water Production

No measurements were made during Hanna I.

D. Instrumentation Responses

No downhole instrumentation was installed for Hanna I.

VII. POST TEST ACTIVITY

A total of 8 wells were drilled to determine the area gasified during Hanna I (Figure 9). The results of that drilling are given in Table 4. In addition, a shear wave seismic survey was run over the site to determine cavity boundaries. Figure 10 shows the comparison between the drilling and seismic results. No extensive analyses of samples were obtained to determine thermal effects on overburden and coal samples recovered.

TABLE 3.
Average Operating Parameters
for the Period September 16, 1973 through February 28, 1974

<u>Period</u>	<u>Injection Rate</u> (<u>MCF/day</u>)	<u>Gas Produced</u> (<u>MCF Dry Gas/day</u>)	<u>Heating Value</u> (<u>Btu/scf</u>)
1973			
Sep 16 - Sep 30	907	1225	111
Oct 01 - Oct 15	1054	1721	155
Oct 16 - Oct 31	1055	1639	141
Nov 01 - Nov 15	0871	1367	135
Nov 16 - Nov 30	1265	1824	124
Dec 01 - Dec 15	1162	1724	124
Dec 16 - Dec 31	1242	1798	113
1974			
Jan 01 - Jan 15	902	1120	65
Jan 16 - Jan 31	765	1010	96
Feb 01 - Feb 15	1224	1981	165
Feb 16 - Feb 28	<u>1394</u>	<u>2224</u>	<u>157</u>
Average Value	1076	1602	126

Figure 5. Hanna I Operating Parameters (April - December 1973)

Figure 6. Hanna I Air Injection Rate

Figure 7. Hanna I Production Rate

Figure 8. Hanna I Heating Value

Figure 9. Intercepts of Seismic Anomaly Forming Outline of Roof Fall.

TABLE 4. Results of Post-Test Drilling, Hanna I

<u>Hole #</u>	<u>Depth to Solid Coal</u>	<u>Orig. Depth of Coal</u>	<u>Ft. of Coal Burned</u>	<u>% of Seam*</u>
1	389.0	375	14	48
2	382.0	375	10	34
3	380.0	364	16	55
4	383.0	367	16	55
5	368.0	366	2	7
6	356.0	356	0	0
7	372.5	359	13.5	47
8	388.3	366	22.3	77
			Avg.:	14.5
				50

* Based on 29 ft. seam thickness

Figure 10. Composite Plot of Seismic and Drilling Interpretation of Burned Area.

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