MASTER

FLASH HYDROLYSIS OF COAL

**QUARTERLY REPORT NO. 3
FOR THE PERIOD JULY 1 TO SEPTEMBER 30, 1977**

October 1977

**PROCESS SCIENCES DIVISION
DEPARTMENT OF ENERGY & ENVIRONMENT**

**BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.**

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TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	1
I. OBJECTIVE AND SCOPE OF WORK	2
II. SUMMARY OF PROGRESS TO DATE	2
III. DETAILED DESCRIPTION OF TECHNICAL PROGRESS	3
A. Task 1. Design and Order Equipment for 1 lb/hr Unit	3
1. Work Accomplished	3
2. Work Forecast	3
B. Task 2. Construction of 1 lb/hr Unit	3
1. Work Accomplished	3
2. Work Forecast	4
C. Task 3. Development of Analytical System	4
1. Work Accomplished	4
a. Product Analysis and Identification	4
b. Material Balance	5
c. Heat of Combustion Measurements	5
2. Work Forecast	5
D. Task 4. Testing of Assembled Unit Including Analytic System	6
1. Work Accomplished	6
2. Work Forecast	6
E. Task 5. Study the Effect and Process Variables on Product Distribution and Yields	6
1. Work Accomplished	6
a. Effect of Temperature and Pressure	6
b. High Pressure Run	6
c. Coal Heat-Up Rate	7
d. Inert Gas Runs	7
e. Coal Particle Residence Time	7
2. Work Forecast	8
IV. CONCLUSIONS	8
V. REFERENCES	9
TABLES	10-16
FIGURES	17-22
APPENDIX	23-53

LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
I	ANALYSIS OF RESIDUE FROM BOILING RANGE DETERMINATION	10
II	INITIAL RESULTS OF 1 LB/HR FLASH HYDROLYSIS EXPERIMENT USING NORTH DAKOTA LIGNITE	11
III	RESULTS OF 1 LB/HR FLASH HYDROLYSIS EXPERIMENT USING NORTH DAKOTA LIGNITE	12
IV	RESULTS OF 1 LB/HR FLASH HYDROLYSIS EXPERIMENT USING NORTH DAKOTA LIGNITE	13
V	RESULTS OF 1 LB/HR FLASH HYDROLYSIS EXPERIMENT USING NORTH DAKOTA LIGNITE	14
VI	FLASH HYDROLYSIS OF LIGNITE AT 750°C AND 4000 PSI	15
VII	CALCULATIONS OF HEATING RATE OF 100 μ LIGNITE PARTICLES IN 1" TUBULAR REACTOR	15
VIII	PYROLYSIS RUNS AT 750°C USING HELIUM AS CARRIER GAS AS COMPARED TO HYDROGEN RUNS UNDER IDENTICAL CONDITIONS	16

LIST OF FIGURES

<u>Figure No.</u>		<u>Page</u>
1	BTX VS TEMPERATURE, PRESSURE 500-3000 PSIG	17
2	BTX VS. PRESSURE, TEMPERATURE 700-800°C	17
3	TOTAL LIQUID AND LIQUID HC ($\geq C_9$) YIELD VS. PRESSURE AT 750°C	18
4	METHANE VS. PRESSURE, TEMPERATURE 700-800°C	18
5	ETHANE VS. TEMPERATURE, PRESSURE 500-4000 PSIG	19
6	TOTAL HC GAS VS. PRESSURE, TEMPERATURE 700-800°C	19
7	TOTAL LIQUID + GAS HC VS. PRESSURE, TEMPERATURE 500-800°C	20

LIST OF FIGURES (CONT'D)

<u>Figure No.</u>		<u>Page</u>
8	CO+CO ₂ VS. TEMPERATURE, PRESSURE 500-3000 PSIG	20
9	TOTAL CARBON CONVERSION TO GASES AND LIQUID VS. PRESSURE, TEMPERATURE 700-800°C	21
10	TOTAL HC AND LIQUID YIELD VS. PRESSURE, COMPARISON OF H ₂ and He, TEMPERATURE 750°C	21
11	BTX AND TOTAL HC VS. RESIDENCE TIME, 2500 PSIG	22
12	MILESTONE CHART	22

ABSTRACT

The program is designed to study the process variables and chemistry of the Flash Hydropyrolysis Process, a rapid gas-phase, non-catalytic coal hydrogenation technique developed at BNL. The equipment used is a 1 lb/hr unit utilizing a 1 inch down flow tubular reactor designed to operate at up to 4000 psi and 800°C. This equipment has been in operation for more than a year with only one major problem, the rupture of the hydrogen preheater. Metallurgical examination of the affected area determined the rupture to have been caused by hydrogen embrittlement of the Inconel 601 alloy used in the fabrication of the preheater. A replacement preheater made of Inconel 617 has been operating successfully for more than 100 hours during the past year.

Coal and char analysis continue to be done on a routine basis. A boiling range determination was made on a sample of the liquid product. Approximately 50% of the liquid was distilled up to temperatures of 210°C before the condenser filled with solids. An analysis of the condenser and flask residues showed them to contain small quantities of both sulfur and nitrogen. A sulfur analyzer has been ordered to allow more rapid and frequent analysis of the liquids and solids.

All the data to date on product yield as a function of temperature and hydrogen pressure is correlated in 4 tables and plotted in a series of 9 figures. The total liquid yields appear to reach a maximum of approximately 20% at 750°C with only slight increases with hydrogen pressures above 2000 psi. Approximately half of this yield is BTX.** The ethane yield also appears to maximize between 700 and 750°C but continues to increase with increased pressure. Methane yields are shown to continue to increase with both temperature and hydrogen pressure. Total carbon conversion under these conditions approximated 60%.

The pyrolysis of lignite using helium in the system shows a five to ten fold decrease in the yields of CH_4 , C_2H_6 and C_6H_6 compared to flash hydropyrolysis under hydrogen pressure.

Preliminary experiments were conducted at 750 and 800°C to determine the effect of coal particle residence time on product yields and distribution. The results indicate that at 750°C both liquid and gaseous yields increase from 45% to 52 % as the residence time is increased by a factor of four from 2.3 to 9.2 seconds. However, at 800°C under similar conditions, little change in total yield (60%) is observed but the liquid yield decreases from approximately 4% to 1% with a corresponding increase in gaseous products.

** BTX - Benzene, toluene, zylene.

I. OBJECTIVE AND SCOPE OF WORK

The program objective is to obtain process chemistry and design information on the Flash Hydropyrolysis Process (FHP), a rapid gas-phase non-catalytic coal hydrogenation technique developed at BNL.^(1, 2) The work includes the design, construction and operation of a 1 lb/hr down flow entrained tubular reactor system capable of operating at up to 800°C and 4000 psi and incorporating on-line product analysis. The experimental unit is used to study the effect of such process variables as temperature, pressure, feed rates, residence time, and coal type on liquid and gaseous yields and to complete mass balances of feed to product.

II. SUMMARY OF PROGRESS TO DATE

The experimental equipment used in these studies has continued to operate satisfactorily with some minor modifications during the progress of the work. Both the operation and reliability of the equipment has improved considerably. Excessive breakage of thermocouples caused a short shut-down for replacement. The replacement thermocouples have a sheathed construction, the problem of breakage and shut down should be much less frequent.

Some clogging of the gas chromatograph product sampling taps continues to be experienced when operating under conditions which tend to produce tar like products. These conditions are generally lower pressures (< 1500 psi) and temperatures (< 700°C). Some runs were conducted in this region in order to insure that all areas of pressure and temperature were explored. Product yields at these conditions never exceed 40% conversion with a maximum of 6% BTX. In some cases, larger quantities of heavier hydrocarbons were produced than BTX, accounting for some of the clogging of sample taps.

Approximately 400 pounds of fresh lignite was received from Baukol-Noonan, Inc., Noonan, North Dakota. The lignite is contained in two 55 gallon drums and is wrapped in plastic to reduce oxidation and to minimize loss of the approximately 30% as-mined moisture content.

With the larger coal hopper (~ 3.5 lb capacity) now installed, the duration of most runs has been extended to allow gas samples to be taken from the reactor sample taps located 2 and 4 feet along the length of the reactor, the sample tap at the char trap and the sample tap located after the two product condensers. Another reactor sample tap, 6 ft down on the reactor, will be put in use as soon as filters become available. Also the volume of these reactor sample taps has been greatly reduced by the insertion of thermocouples. This reduces the residence time of the gases in the taps and allows more direct monitoring of the gas stream temperatures.

3

An analysis of the heavier liquid hydrocarbons ($\geq C_9$) show approximately 20% of the nitrogen in the coal to go to this product and a small percentage of the sulfur to do the same. The failure to account for not more than 98% of the material in two samples indicates there may be oxygen containing compounds in these heavy liquids. These would most likely be in the form of phenols. Both the heavy liquids and the water produced in the experiments will be examined for the presents of phenols.

A LECO Sulfur Determinator has been ordered to allow more frequent and rapid sulfur analysis of both liquid and solid samples.

All the data to date on product yield as a function of pressure and temperature has been plotted and is shown in Figures 1 through 9. The total liquid products, BTX and heavy liquid hydrocarbons ($\geq C_9$), appear to reach a maximum of 20% at approximately 750°C with little increase in yield above 2000 psi. The methane and ethane yields both increase with increased pressure, the methane also increasing with increasing temperature while the ethane reaches a maximum between 715 and 760°C.

Average heat up rates as high as 50,000 °C/sec have been calculated for typical experimental conditions operating at 800°C.

A series of pyrolysis runs conducted using helium as a carrier gas show yields 5 to 10 fold lower than that produced by hydrogenation runs conducted under similar conditions.

III. DETAILED DESCRIPTION OF TECHNICAL PROGRESS

A. Task 1. Design and Order Equipment for 1 lb/hr Unit

1. Work Accomplished

The equipment was fabricated, constructed, installed, tested and is now in full operation.

2. Work Forecast

None. Task 1 has been completed.

B. Task 2. Construction of 1 lb/hr Unit

1. Work Accomplished

Product samples are now routinely taken during experimental runs from any of four locations, at the first and second sample taps on the reactor (2 ft and 4 ft down respectively), at the bottom of the reactor and after the low temperature product condenser. The sample

tap located 6 ft down on the reactor which had previously been removed has been rewelded to the reactor.

The 40,000 SCF hydrogen trailer from which hydrogen is supplied to the experimental facility required minor repairs to the manifolds and valves and refilling. The repairs were made at the corporation which first certified the trailer when placed in use for these experiments and it was then refilled with grade H hydrogen.

Continued breakage of thermocouples has depleted the system of all spares incorporated into the original design. This required the equipment to be shut-down while special sheathed thermocouples previously purchased as replacements be installed. This should eliminate past problems encountered with thermocouple breakage causing the cancellation of experimental runs.

The new coal feeder hopper which can hold up to approximately 3.5 lb of coal has been installed and is working well. The load cell which monitors the weight of this hopper failed and a new cell was ordered. Failure of the manufacturer to deliver the replacement part when promised caused cancellation of the order. A similar and much less expensive device which is an off-the-shelf item has been ordered as a replacement.

The product condensers continue operating efficiently and liquid products are collected for most runs. The efficiency of BTX removal, determined by analysis of product streams before and after the condensers, was found to be approximately 96% at 1000 psi and 97% at 3000 psi. Since the heavier hydrocarbons ($\geq C_9$) have a lower vapor pressure than BTX, the efficiency of removal for these products should be greater.

2. Work Forecast

The sample tap located 6 ft down on the reactor will be put into service as soon as filters ordered for the sample line are received. The device to replace the load cell will be calibrated and installed when it is received. In conjunction with replacement of the thermocouples, three 1/8" O.D. thermocouples will be inserted into the reactor through the sample taps. This will allow more direct monitoring of the gas stream temperature by reducing the holdup volume and therefore the sample residence time in the sample taps.

C. Task 3. Development of Analytical System

1. Work Accomplished

a. Product Analysis and Identification

A boiling range determination was made on a 100 ml sample of total liquid product collected from the product condensers. The first drop of liquid appeared at 79°C and 40 ml had been collected by the

time the temperature reached 117°C. After approximately 48 ml had been collected, solids started to collect at the delivery end of the condenser. At approximately 210°C, 49 ml had been collected and solid started to collect throughout the condenser and the distillation was stopped. The material deposited in the condenser was a slightly yellow crystalline solid, probably naphthalene, but not as yet positively identified. The material remaining in the flask was a combination of solids and viscous black liquid the sum of which resembled a black paste. An elemental analysis of both the flask and the condenser residues are shown in Table I. 98.21% of the flask residue and 98.16% of the condenser residue were accounted for, the remainder is probably oxygen in the form of phenols in the products. The analysis also included the measurement of trace metal as shown.

b. Material Balance

When the nitrogen found in the residue is added to that remaining in the char from a typical run, approximately 40% of the nitrogen can be accounted for. Samples of water produced during a number of runs have consistently been found to have a pH of approximately 9 and the cation has been identified as NH_4 which probably accounts for the remaining nitrogen.

A Leco IR-33 Sulfur Determinator for coal and coke has been ordered. This instrument will allow sulfur and carbon determination of coal and char samples in two minutes. The present method being used takes approximately one-half man day per determination.

c. Heat of Combustion Measurements

Measurements were made of the heat of combustion of two char samples. The results, 11,040 and 11,500 BTU/lb, agree within 5% of predicted heats of combustion calculated from the carbon and hydrogen content of the chars. Similar results have been observed in the past with the heat of combustion of the lignite (10,000 BTU/lb) used in these experiments and as with the char, the calculated heats were always slightly lower than the measured values.

2. Work Forecast

Further boiling range determinations will be made on products produced under varying conditions. These products will also be examined closely for the presents of phenols to determine if there are oxygen bearing compounds in the products. The water produced will also be examined for the presents of phenols plus NH_4 and H_2S in an attempt to close the material balance on N_2 and S.

The char will be studied for remaining volatile matter and analysis of other coals to be used in the near future will also be made.

D. Task 4. Testing of Assembled Unit Including Analytic System

1. Work Accomplished

The experimental equipment has been tested as described in the first quarterly report and is now in operation.

2. Work Forecast

None. This task is completed.

E. Task 5. Study the Effect of Process Variables on Product Distribution and Yields

1. Work Accomplished

a. Effect of Temperature and Pressure

All the data to date on product yield as a function of pressure and temperature is given in Tables II, III, IV and V and is plotted as shown in Figures 1 through 9. From Figures 1 and 2, it appears that the BTX yield reaches a maximum of approximately 10% of the available carbon in the coal at a temperature of 750-775°C and that no significant increase in yield is observed above 2000 psi. Since the heavier liquid hydrocarbons ($> C_9$) have been difficult to measure, limited information is available. Figure 3 shows the results of a series of runs conducted at 750°C where sufficient liquids were produced to allow collection and measurement. The decrease in yield with increased pressure further confirms the observation made when the chromatograph sample lines plugged that more heavy liquid products are produced at low pressure. Figure 4 shows the methane yield to continue to increase substantially with both temperature and pressure. As indicated in Figure 5, the ethane yield reaches a maximum between 715 and 760°C and as with the methane, continues to increase with increasing pressure. Figure 6 is a plot of the total hydrocarbon gases, methane to ethane, and Figure 7 a plot of the total hydrocarbon yield less the heavy liquids ($> C_9$). Figure 8 shows that except for the very early runs conducted at 1500 psi, the CO yield decreases with pressure as is to be expected. Also, little if any CO₂ is produced at the higher temperatures which again is to be expected. Figure 9 is a plot of the total conversion including all hydrocarbons plus oxides of carbon.

b. High Pressure Run

One run was conducted at 750°C and 4000 psi, the highest hydrogen pressure used in the system under experimental conditions. The results are shown in Table VI. An overall carbon conversion of 81.3% was obtained, 53% of which was methane. Liquid yields were only about 10%

total (4.3% BTX and 5.7% $> C_9$). Except for almost 14% ethane produced, the product distribution is very similar to that obtained at 3000 psi and 800°C, meaning large quantities of methane were produced and less liquids.

c. Coal Heat-Up Rate

Calculations were made of the heating rate of the coal particles when contacted with hot hydrogen. The model used was that of a uniform sphere of coal, 100 microns in diameter heated from room temperature (27°C) to 700°C and 800°C by forced convection in hydrogen of the same temperature (700°C and 800°C). The average heating rates calculated (30,000 to 50,000 °C/sec) are shown in Table VII. At approximately 500°C the lignite used in these experiments begins to devolatilize causing simultaneous heat and mass transfer in opposing directions and the model used becomes less precise. Also, the devolatilization is endothermic, causing additional error to the model. When the average heating rate is calculated for the same coal particles heated in the same manner to 500°C, the region in which the model is most precise, the rates are considerably greater, approximately 150,000 °C/sec. A calculation of the effect of the radiant heat transfer showed it to be very small, in the order of 2,000 °C/sec.

d. Inert Gas Runs

Table VIII contains a summary of the results of pyrolysis runs using helium as compared to experimental runs using hydrogen. A comparison of the total hydrocarbon and total liquid yields is shown in Figure 10. Except for the heavier hydrocarbons, ($> C_9$) which are difficult to measure in small quantities, little change in any yields was observed for the pyrolysis runs as the pressure was increased from 1500 psi to 2500 psi. When compared with the hydrogen runs, a five- to ten-fold increase is observed in the three major products CH_4 , C_2H_6 and C_6H_6 . The CO_2 yield in the pyrolysis runs agrees well with the 13-10% carbon reported(3) as carboxyl groups, assuming the CO_2 to originate as a carboxyl group.

e. Coal Particle Residence Time

Figure 11 is a plot of the BTX and total hydrocarbons produced in two runs conducted at 2500 psi and 750 and 800°C. Samples of the products were taken from the first reactor tap located two feet down the reactor and at the char trap. These represent approximately 2-2.5 second and 9-10 second reactor residence times respectively. This shows a marked decrease of BTX with increased residence time at 800°C while the total HC yield remains almost constant, indicating the BTX to be decomposing and further hydrogenating to methane. This is confirmed by a large increase in methane yield at the longer residence time. At 750°C, both the total HC and BTX yields continue to increase with increased residence time. This could

mean even greater yields are possible if the residence time were longer than 10 seconds. Further study will be necessary to determine if the reaction has gone to completion or if additional product can be produced.

2. Work Forecast

The parametric study of the effect of process variables will continue with emphasis placed on those conditions which appear to be most economically attractive. Further studies will be made at 4000 psi, particularly at temperatures down to 600°C. Emphasis will also be placed on determining yield as a function of residence time. The number of exploratory runs will be increased and will include sub-bituminous coal, char and coal mixes, catalyst, high hydrogen to coal feed ratio (short residence time) and low hydrogen to coal feed ratio (dense phase).

With the addition of the larger coal hopper, the extended to allow an increase in the use of the reactor sample taps. This enables the effect of varying residence time to be studied in almost every run.

F. Task 6. Process Design and Economic Evaluation

1. Work Accomplished

The economic evaluation is continuously updated with regard to current experimental results. No major endeavors have been made in this task since the last report period.

2. Work Forecast

An attempt will be made to correlate all the data plotted into empirical expressions relating product distribution and yield to reactor operating conditions of temperature and pressure. This in turn will be used to re-evaluate the economics of the process.

IV. CONCLUSIONS

The experimental equipment continues to operate satisfactorily. Problems such as that encountered with the thermocouples are happening less frequently and the use of the new sheathed thermocouples should eliminate any further problem in this area. The added capacity of the new coal hopper has allowed longer duration experimental runs resulting in more data obtained from each run particularly with regard to the effect of residence time on the yield of products.

Before the material balances of all the minor components of the coal can be completed, more information is needed on the distribution of the nitrogen sulfur and oxygen in the products. Also needed, is a

greater understanding of the conditions under which compounds containing these components are most likely to form.

Although the average heating rates calculated are from a somewhat imperfect model, they do indicate the coal particles are reaching a temperature at which some reaction can be expected ($\approx 700^{\circ}\text{C}$) in fractions of a second, particularly when heated by 800°C hydrogen.

Plotting all the data has shown extremely important trends of product as functions of hydrogenation temperature and pressure. These data should now be correlated into both theoretical models and empirical expressions. The data can also be incorporated into the process design and economic evaluations and assessment for further direction of the experimental work

Future experiments with the uncatalyzed lignite should emphasize the effects of gas and solids residence times. Further exploratory experiments should be conducted such as the use of catalysis, recycled char and other coals to determine whether further increases in liquid and gaseous yields can be obtained.

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Table I

ANALYSIS OF RESIDUE FROM LIQUID PRODUCT BOILING
RANGE DETERMINATION

	<u>Flask</u>	<u>Condenser</u>
Carbon	91.9%	91.7%
Hydrogen	5.69	6.2
Nitrogen	0.38	0.20
Sulfur	<u>0.24</u>	<u>0.06</u>
	98.21	98.16
Si	10 ppm	10 ppm
Cu	1	10
Fe	5	5
Ni	3	0.1
Mg	0.1	0.1
Al	0.5	0.8

Table II

Initial Results of 1 lb/hr Flash Hydropyrolysis Experiment Using North Dakota Lignite

Run No.	Temp., °C	Press., psi	Coal feed rate, lb/hr	H ₂ flow rate, lb/hr	H ₂ /coal ratio, lb/lb	Fraction of Carbon Contained in the Coal Converted to Products											Total carbon oxide	Total C conv. ⁽¹⁾	Total C conv. to HC ⁽²⁾
						CH ₄	C ₂ H ₆	Total H-C gas CH ₄ +C ₂ H ₆	B	T	X	Total BTX	CO	CO ₂					
5	700	1500	0.21	0.71	3.38	0.122	0.0602	0.1822	0.0526	0.0045	0	0.0571	0.0874	0	0.0874	0.3267	0.2393		
7	700	1500	0.54	0.75	1.39	0.0943	0.0436	0.1379	0.0360	0.0036	0	0.0396	0.0864	0.0107	0.0971	0.2746	0.1775		
8	700	1500	0.25	1.45	5.80	0.1347	0	0.1347	0.0598	0.0066	0	0.0664	0.1304	0.0221	0.1525	0.3535	0.2010		
9	650	1500	0.66	1.45	2.20	0.0573	0.0319	0.0892	0.0060	0.0065	0.0030	0.0155	0.0757	0.0238	0.0995	0.2042	0.1047		
10	700	2000	0.50	0.74	1.48	0.1188	0.0632	0.1820	0.0578	0.0034	0	0.0612	0.1091	0.0068	0.1159	0.3591	0.2432		
11	600	1500	0.40	1.45	3.63	0.0266	0.0160	0.0426	0.0205	0.0041	0	0.0246	0.0571	0.0303	0.0878	0.1544	0.0666		
12	475	1500	0.26	1.26	4.85	0.0198	0.0113	0.0311	0	0.0016	0	0.0016	0.0492	0.0461	0.0952	0.1275	0.0323		
13a	650	1500	0.24	1.35	5.63	0.0853	0.0457	0.1310	0.0129	0.0102	0.0033	0.0269	0.1381	0.0166	0.1547	0.3121	0.1574		
13b	650	1500	1.39	1.25	0.90	0.0702	0.0389	0.1091	0.0034	0.0079	0.0035	0.0198	0.0815	0.0101	0.0916	0.2204	0.1288		
14	775	1500	0.60	1.4	2.33	0.2190	0.0809	0.2999	0.0959	0.0008	0	0.0967	0.1048	0	0.1048	0.5013	0.3965		
15	815	1500	0.50	1.4	2.8	0.2626	0.0517	0.3143	0.0850	0	0	0.0850	0.1300	0	0.1300	0.5292	0.3992		
16a	775	1500	1.32	1.3	0.98	0.1766	0.0582	0.2342	0.0738	0.0006	0	0.0749	0.0839	0.0017	0.0856	0.3941	0.3085		
16b	775	1500	0.93	1.3	1.40	0.1558	0.0531	0.2089	0.0680	0.0004	0	0.0684	0.0726	0.0008	0.0734	0.3507	0.2773		
16c	775	1500	0.85	1.3	1.53	0.2373	0.0769	0.3142	0.1023	0.0007	0	0.1030	0.0936	0.0008	0.0944	0.5115	0.4171		
17	765	1500	1.32	1.25	0.95	0.2754	0.0920	0.3674	0.1189	0.0010	0	0.1199	0.1227	0.0021	0.1248	0.6121	0.4873		
18a	745	2100	0.94	1.2	1.28	0.3164	0.1422	0.4586	0.1612	0.0023	0	0.1635	0.1359	0.0019	0.1378	0.7598	0.6220		
18b	745	2100	1.22	1.2	0.98	0.2911	0.1386	0.4279	0.1490	0.0026	0	0.1516	0.1412	0.0019	0.1427	0.7225	0.5798		
18c	745	2100	1.27	1.2	0.95	0.3195	0.1464	0.4659	0.1605	0.0026	0	0.1631	0.1572	0.0016	0.1588	0.7878	0.6290		

1) Does not include char and light oils.

2) Does not include hydrocarbons $\geq C_9$ (light oils).

Table III

RESULTS OF 1 lb/hr FLASH HYDROLYSIS EXPERIMENT USING NORTH DAKOTA LIGNITE
Fraction of Carbon Contained in the Coal Converted to Products

Run No.	Temp., °C	Press., psi	Coal feed rate, lb/hr	H ₂ flow rate, lb/hr	H ₂ /Coal ratio, lb/lb	CH ₄	C ₂ H ₆	Total HC gas CH ₄ +C ₂ H ₆	C ₆ H ₆	C ₇ H ₈	Total ETX	Light oils ≥ C ₉	Total HC liquids	CO	CO ₂	Total carbon oxides	Total C conv.	Total C conv. to HC
21	725	200C	0.70	0.87	1.24	0.1492	0.0762	0.2254	0.0728	0.0014	0.0742	0.0460	0.1202	0.0803	0.0017	0.0820	0.4276	0.3545
22	750	200C	0.82	1.08	1.32	0.1593	0.0804	0.2497	0.0833	0.0	0.0833	0.0676	0.1509	0.0741	0.0	0.0741	0.4747	0.4006
23	785	200C	0.63	0.92	1.46	0.1650	0.0494	0.2144	0.0689	0.0	0.0689	0.1117	0.1806	0.0527	0.0	0.0527	0.4477	0.3950
24	805	200C	0.29	1.05	3.62	0.2786	0.0556	0.3342	0.0779	0.0	0.0779	0.1275	0.2054	0.0533	0.0	0.0533	0.5929	0.5396
25	725	200C	0.49	1.10	2.24	0.1283	0.0653	0.1936	0.0597	0.0032	0.0629	0.0460	0.1089	0.0790	0.0	0.0790	0.3815	0.3025
26	700	200C	0.50	1.10	2.20	0.0995	0.0537	0.1532	0.0377	0.0082	0.0459	0.0805	0.1264	0.0751	0.0054	0.0805	0.3601	0.2796
27	735	200C	0.60	1.10	1.83	0.1226	0.0640	0.1866	0.0626	0.0043	0.0674	0.0518	0.1192	0.0810	0.0	0.0810	0.3868	0.3058
28	770	200C	0.47	1.10	2.34	0.1626	0.0648	0.2344	0.0890	0.0	0.0890	0.0385	0.1275	0.0758	0.0	0.0758	0.4377	0.3619
29	770	150C	0.52	1.00	1.92	0.1350	0.0564	0.1914	0.0617	0.0	0.0617	0.0204	0.0821	0.0849	0.0	0.0849	0.3584	0.2735
30	750	200C	0.69	1.05	1.52	0.2113	0.0787	0.2910	0.1020	0.0	0.1020	0.0196	0.1216	0.0570	0.0	0.0570	0.4696	0.4126
31	800	200C	0.71	1.05	1.48	0.2557	0.0658	0.3245	0.0974	0.0	0.0974	0.0082	0.1356	0.0515	0.0	0.0515	0.4816	0.4301
32	785	200C	0.94	1.05	1.12	0.1959	0.0633	0.2622	0.0806	0.0	0.0806	0.0105	0.0921	0.0724	0.0	0.0724	0.4267	0.3543
33	750	250C	0.20	1.20	6.00	0.1953	0.0749	0.2712	0.1183	0.0	0.1183	0.0441	0.1524	0.0533	0.0	0.0533	0.4869	0.4336
34 ⁽¹⁾	750	300C	0.19	1.70	8.95	0.3321	0.1763	0.5134	0.2117	0.0	0.2117	0.0670	0.2787	0.1034	0.0	0.1034	0.8955	0.7921
35	750	300C	0.58	1.35	2.33	0.1627	0.0856	0.2543	0.0792	0.0	0.0792	0.0156	0.0348	0.0758	0.0078	0.0836	0.4327	0.3491
36	700	300C	0.45	1.40	3.11	0.1593	0.0952	0.2545	0.0700	0.0054	0.0754	0.0318	0.1372	0.0769	0.0116	0.0885	0.4502	0.3617
37	790	300C	0.61	1.35	2.21	0.3044	0.1003	0.4047	0.0758	0.0	0.0758	0.0068	0.0326	0.0589	0.0	0.0589	0.5462	0.4873
38	800	300C	1.32	1.0	0.76	0.3117	0.0931	0.4048	0.0847	0.0	0.0847	0.0009	0.0356	0.0468	0.0	0.0468	0.5372	0.4904
39	730	300C	0.93	1.1	1.18	0.1415	0.0889	0.2304	0.0827	0.0	0.0827	0.0022	0.0349	0.0241	0.0	0.0241	0.3394	0.3153
40	725	300C	0.89	1.1	1.24	0.1915	0.1269	0.3184	0.1030	0.0	0.1030	0.0034	0.1364	0.0534	0.0024	0.0558	0.4806	0.4248

1) Short run, system did not equilibrate.

Table IV
RESULTS OF 1 lb/hr FLASH HYDROLYSIS EXPERIMENT USING NORTH DAKOTA LIGNITE
Fraction of Carbon Contained in the Coal Converted to Products

Run No.	Temp., °C	Press., psi	Coal feed rate, lb/hr	H ₂ flow rate, lb/hr	H ₂ /Coal ratio lb/hr	CH ₄	C ₂ H ₆	Total HC gas CH ₄ +C ₂ H ₆	C ₆ H ₆	C ₇ H ₈	Total BTX	Light oils > C ₉	Total (3) HC liquids	CO	CO ₂	Total carbon oxides	Total (3) C conv.	Total (3) C conv. to HC
46	775	2000	2.645	1.1	.42	.2754	.0589	.3343	.0914	0.0	.0914	.0012	.0926	.0778	.0065	.0843	.5112	.4269
47	785	2000	.9257	1.05	1.13	.1668	.0992	.2660	.1018	0.0	.1018	.0287	.1305	.0708	0.0	.0708	.4673	.3965
48	775	1500	1.752	1.15	.66	.1373	.0580	.1953	.0531	.0010	.0541	.0108	.0649	.0613	.0039	.0652	.3254	.2602
49	780	1500	1.031	1.0	.97	.3546	.0660	.4206	.1173	0.0	.1173	.0085	.1258	.0888	.0018	.0906	.6370	.5464
50a ⁽¹⁾	800	1500	1.19	1.08	.91	.1927	.0551	.2478	.0743	0.0	.0743	.0151	.0894	.0684	.0011	.0695	.4067	.3372
50b ⁽¹⁾	800	2500	1.018	1.04	1.04	.4529	.0448	.4977	.0353	0.0	.0353	.0043	.0396	.0529	.0013	.0542	.5915	.5373
51a ⁽¹⁾	800	2000	.9257	1.0	1.08	.3173	.0473	.3646	.0752	0.0	.0752	.0019	.0771	.0619	0.0	.0619	.5036	.4417
51b ⁽¹⁾	800	3000	.767	.97	1.27	.5082	.0576	.5658	.0203	0.0	.0203	.0019	.0222	.0459	0.0	.0459	.6339	.5880
52	750	3000	1.217	1.08	.89	.3264	.0955	.4219	.0958	0.0	.0958	.0114	.1072	.0577	0.0	.0577	.5868	.5291
53	775	3000	.767	1.02	1.33	.3104	.0872	.3976	.0618	0.0	.0618	0.0	.0618	.0224	0.0	.0224	.4818	.4594
55	800	3000	1.801	.97	.51	.5378	.0045	.5423	.0075	0.0	.0075	.0083	.0158	.0500	.0030	.0530	.6111	.5581
56	750	3000	.9654	.85	.88	.1828	.0727	.2555	.0741	0.0	.0741	.0070	.0811	.0473	.0008	.0481	.3847	.3366
57	740	3000	.7326	.9	1.23	.2107	.1023	.3130	.1002	0.0	.1002	.0180	.1182	.0604	0.0	.0604	.4916	.4312
58	750	2000	1.521	.8	.53	.2745	.0547	.3292	.0758	0.0	.0758	.0072	.0830	.0812	.0032	.0844	.4966	.4122
59	750	1500	1.455	.88	.61	.2402	.0677	.3079	.0729	0.0	.0729	.0227	.0956	.0701	.0044	.0745	.4780	.4035
60a	800	2500	1.342	.835	.64	.5456	.0190	.5646	.0071	0.0	.0071	.0019	.0090	.0524	.0014	.0538	.6274	.5736
60b ⁽²⁾	800	2500	1.342	.835	.64	.5026	.0208	.5234	.0371	0.0	.0371	.0001	.0372	.0382	.0022	.0394	.6000	.5606
61a	750	2500	1.316	.82	.62	.2686	.0826	.3512	.0898	0.0	.0898	.0090	.0988	.0659	.0026	.0685	.5185	.4500
61b ⁽²⁾	750	2500	1.316	.82	.62	.2025	.0708	.2733	.0770	0.0	.0770	.0480	.1250	.0523	.0034	.0557	.4540	.3983
62a ⁽²⁾	750	3000	1.382	.8	.58	.3792	.0916	.4708	.0807	0.0	.0807	.0473	.1280	.0623	.0016	.0639	.6627	.5988
62b ⁽²⁾	750	3000	1.382	.8	.58	.3943	.1006	.4949	.0848	0.0	.0848	.0526	.1374	.0623	.0017	.0640	.6963	.6323
63	750	1000	1.44	.875	.61	.1429	.0593	.2022	.0618	0.0	.0618	0.0	.0618	.0868	.0027	.0895	.3535	.2640
64	750	500	1.35	.93	.69	.1000	.0447	.1447	.0388	0.0	.0388	0.0	.0388	.0832	.0028	.0860	.2695	.1835

1) Pressure changed during run.

2) Sample taken from first sample tap located 2 ft down on reactor.

3) Light oils (> C₉) not collected for most runs.

Table V

RESULTS OF 1 lb/hr FLASH HYDROLYSIS EXPERIMENT USING NORTH DAKOTA LIGNITE
 Fraction of Carbon Contained in the Coal Converted to Products

Run No.	Temp., °C	Press., psi	Coal feed rate lb/hr	H ₂ flow rate, lb/hr	H ₂ /Coal ratio lb/hr	CH ₄	C ₂ H ₆	Total HC gas CH ₄ +C ₂ H ₆	C ₆ H ₆	C ₇ H ₈	Total BTX	Light oils > C ₉	Total HC liquids	CO	CO ₂	Total carbon oxides	Total C conv.	Total C conv. to HC
65	700	1000	1.426	.84	.59	.104C	.0540	.1580	.0374	.0060	.0434	0.0	.0434	.0740	.0035	.0775	.2789	.2014
66	800	1000	1.176	.84	.71	.2292	.0246	.2538	.0613	0.0	.0613	0.0	.0613	.0781	.0020	.0801	.3952	.3151
67a	800	500	1.279	.82	.64	.1243	.0323	.1566	.0437	0.0	.0437	.0218	.0655	.0769	.0017	.0786	.3007	.2221
67b ⁽¹⁾	800	500	1.279	.82	.64	.196C	.0398	.2358	.0371	.0006	.0377	.0305	.0682	.0476	.0043	.0519	.3559	.3040
68a	700	500	1.203	.86	.72	.0711	.0398	.1109	.0150	.0063	.0213	.0729	.0942	.0691	.0051	.0742	.2793	.2051
68b ⁽¹⁾	700	500	1.203	.86	.72	.125C	.0493	.1743	.0202	.0071	.0288	.0637	.0925	.0581	.0053	.0634	.3302	.2668
72	750	2500	1.521	.82	.54	.220C	.1016	.3224	.0938	.001	.0948	.0256	.1204	.0539	.0030	.0569	.4997	.4428
73a	750	4000	1.396	.77	.55	.5283	.1384	.6667	.0432	0.0	.0432	.0574	.1005	.0447	.0024	.0471	.8144	.7673
73b ⁽¹⁾	750	4000	1.396	.77	.55	.3145	.1157	.4302	.0910	.0011	.0921	.0452	.1373	.0259	.0025	.0284	.5959	.5675
74a ⁽¹⁾	800	1000	1.3	.8	.62	.2585	.0467	.3052	.0891	.0013	.0904	0.0	.0904	.0794	.0049	.0843	.4799	.3956
74b	800	1000	1.3	.8	.62	.2245	.0267	.2512	.0653	0.0	.0653	.0200	.0853	.0750	.0018	.0768	.4133	.3365
75a ⁽¹⁾	800	1000	1.219	.82	.67	.2359	.0546	.2905	.0652	0.0	.0652	.0335	.0987	.0443	.0042	.0485	.4377	.3892
75b	800	1000	1.219	.82	.67	.2405	.0376	.2781	.072	0.0	.0720	.0248	.0963	.0821	.0017	.0838	.4587	.3749
76	750	1000	1.289	.825	.64	.1434	.0534	.1968	.057	.0009	.0579	.0138	.0717	.0779	.0016	.0795	.3480	.2685
77	725	1000	1.37	.83	.61	.1522	.0676	.2198	.06	.0016	.0616	.0123	.0739	.0945	.0029	.0974	.3911	.2937
78	725	500	1.23	.9	.73	.099C	.0544	.1542	.0306	.0064	.0370	.0175	.0545	.0965	.0033	.0998	.3085	.2087
79	725	1000	1.23	.955	.78	.133C	.0664	.2000	.0529	.0023	.0552	.0156	.0703	.0979	.0024	.1003	.3711	.2708
80	725	1500	1.149	.9	.78	.1795	.0816	.2611	.0767	.0018	.0785	0.0	.0785	.0945	.0020	.0965	.4361	.3396
81 ⁽¹⁾	725	2000	1.28	.71	.56	.170C	.0671	.2371	.0706	.0011	.0717	0.0	.0717	.0628	.0016	.0644	.3732	.3058
82a ⁽¹⁾	725	1500	1.072	.95	.89	.1797	.0778	.2575	.0554	.0018	.0572	0.0	.0572	.0631	.0026	.0657	.3804	.3147
82b	725	1500	1.072	.95	.89	.156C	.0787	.2353	.0601	.0018	.0619	0.0	.0619	.0842	0.0	.0842	.3814	.2972

1) Sample taken from first sample tap located 2 ft down on reactor.

2) Light oils (> C₉) not collected for most runs.

Table VI

FLASH HYDROLYSIS OF LIGNITE
AT 750°C AND 4000 PSI

<u>Products</u>	<u>% Carbon Conv. to Product</u>	
Gaseous HC's ($\leq C_5$)		
CH ₄	52.8	
C ₂ H ₆	<u>13.8</u>	
Total Gaseous HC's		66.6
Liquid HC's ($\geq C_6$)		
BTX	4.3	
Oils ($> C_9$)	<u>5.7</u>	
Total Liquid HC's		10.0
Oxides of Carbon		
CO _x (CO+CO ₂)	<u>4.7</u>	<u>4.7</u>
Total Gaseous and Liquid Products		81.3
Char and Unreacted Coal		18.7

Table VII

CALCULATION OF HEATING RATE OF 100 μ LIGNITE PARTICLES
in 1" TUBULAR REACTOR

Temperature °C	Pressure psig	Heating Rate °C/sec
700	500	32,000
800	500	35,100
700	4000	44,900
800	4000	48,300

Table VIII

FLASH HYDROLYSIS OF LIGNITE

Pyrolysis Runs at 750°C Using Helium as Carrier Gas as
Compared to Hydrogen Runs Under Identical Conditions

Pressure (psi)	1500		2000		2500	
	He	H ₂	He	H ₂	He	H ₂
Run No.	69	59	70	58	71	61
Coal Feed Rate (lb/hr)	1.23	1.46	1.26	1.52	1.31	1.32
Gas Feed Rate (lb/hr)	1.60	0.88	1.62	0.80	1.72	0.82
Residence Time (sec.)	12.3	7.4	14.3	8.7	15.2	9.6
% Carbon Converted						
CO	*	7.01	*	8.12	*	6.6
CO ₂	7.76	0.44	8.18	0.32	7.74	0.26
CH ₄	4.28	24.0	5.45	27.5	4.99	26.9
C ₂ H ₆	0.69	6.8	0.64	5.5	0.66	8.3
C ₆ H ₆	0.97	7.3	1.11	7.6	0.90	9.0
C ₇ H ₈	0.12	--	0.13	--	0.14	--
≥ C ₉	<u>0.58</u>	<u>2.3</u>	<u>2.27</u>	<u>10.4</u>	<u>2.07</u>	<u>9.5</u>
Total	14.40	47.85	17.78	59.44	16.50	60.56
Total HC	6.64	40.4	9.6	51.0	8.76	53.7

* CO could not be measured as it has approximately the same retention time in the gas chromatograph as the helium.

Figure 1. Flash hydrolysis of lignite, BTX vs. temperature, press. 500 - 3000 psig.

Figure 2. Flash hydrolysis of lignite, BTX vs. pressure, temp. 700 - 800°C.

Figure 3. Flash hydrolysis of lignite, total liquid and liquid HC ($\geq C_9$) yields vs. pressure at 750°C.

Figure 4. Flash hydrolysis of lignite, methane vs. pressure, temp. 700 - 800°C.

Figure 5. Flash hydrolysis of lignite, ethane vs. temperature, press. 500 - 4000 psig.

Figure 6. Flash hydrolysis of lignite, total HC gas vs. pressure, temp. 700° - 800°C.

Figure 7. Flash hydrolysis of lignite, total liquid + gas HC vs. pressure, temp. 500 - 800°C.

Figure 8. Flash hydrolysis of lignite, CO + CO₂ vs. temperature, press. 500 - 3000 psig.

Figure 9. Flash hydrolysis of lignite, total carbon conversion to gases and liquids vs. pressure, temp. 700 - 800°C.

Figure 10. Flash hydrolysis of lignite, total HC and liquid yield vs. pressure, temp. = 750°C.

Figure 11. Flash hydrolysis of lignite, BTX and total HC vs. residence time, 2500 psig.

Figure 12. Flash hydrolysis of coal.

APPENDIX
Experimental Runs Conducted During Report Period

RUN NO. 64

SAMPLE NO. 1

DATE 7 -1 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	3.600	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.350	LB/HR	COAL FED	600.0	GRAMS
HYDROGEN FLOW RATE	.9300	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	1.358	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	500.0	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8820E-03	8.324	12.54
CARBON DIOXIDE	.4600E-04	.2763	.6539
METHANE	.6070E-03	10.00	8.629
ETHYLENE	0.	0.	0.
ETHANE	.2540E-03	4.466	3.611
BENZENE	.1910E-03	3.878	2.715
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.4490E-03	0.	6.383

TOTAL	26.95	34.53
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TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.88	4.58	0.	0.	0.	2.72
HYDROCARBON GASES	14.5	63.1	0.	0.	0.	12.2
CARBON OXIDES	8.60	0.	26.5	0.	0.	13.2
WATER	0.	15.4	19.7	0.	0.	6.38
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	26.9	89.0	46.1	100.	100.	36.8

HYDROGEN CONSUMPTION-	-.4613E-02	LB HYDROGEN/LB COAL
	-.9367E-01	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	26.95	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	25.43	PERCENT

RUN NO. 65 SAMPLE NO. 1 DATE 7 -12 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.400 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.426	LB/HR	COAL FED	549.6	GRAMS
HYDROGEN FLOW RATE	.8400	LB/HR	CHAR	262.0	GRAMS
HYDROGEN VELOCITY	.4018	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	700.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	700.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1000.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.9160E-03	7.395	11.14
CARBON DIOXIDE	.6800E-04	.3494	.8269
METHANE	.7380E-03	10.40	8.975
ETHYLENE	0.	0.	0.
ETHANE	.3590E-03	5.400	4.366
BENZENE	.2150E-03	3.735	2.615
TOLUENE	.3500E-04	.6013	.4256
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.5030E-03	0.	6.117
TOTAL		27.88	34.46

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	4.34	5.22	0.	0.	0.	3.04
HYDROCARBON GASES	15.8	68.3	0.	0.	0.	13.3
CARBON OXIDES	7.74	0.	24.1	0.	0.	12.0
WATER	0.	14.8	18.8	0.	0.	6.12
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	52.1
TOTAL	27.9	94.2	43.0	100.	100.	88.8

HYDROGEN CONSUMPTION- -.2429E-02 LB HYDROGEN/LB COAL
 -.4932E-01 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 27.88 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 27.16 PERCENT

RUN NO. 66

SAMPLE NO. 1

DATE 7 -13 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	6.400	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.176	LB/HR	COAL FED	515.5	GRAMS
HYDROGEN FLOW RATE	.8400	LB/HR	CHAR	231.8	GRAMS
HYDROGEN VELOCITY	.4483	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	800.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1000.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.7980E-03	7.812	11.77
CARBON DIOXIDE	.3200E-04	.1994	.4719
METHANE	.1341E-02	22.92	19.77
ETHYLENE	0.	0.	0.
ETHANE	.1350E-03	2.462	1.991
BENZENE	.2910E-03	6.129	4.291
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.5150E-03	0.	7.594
TOTAL		39.52	45.89

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.13	7.24	0.	0.	0.	4.29
HYDROCARBON GASES	25.4	117.	0.	0.	0.	21.8
CARBON OXIDES	8.01	0.	24.5	0.	0.	12.2
WATER	0.	18.4	23.4	0.	0.	7.59
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	49.1
TOTAL	39.5	149.	47.9	100.	100.	97.3

HYDROGEN CONSUMPTION-	.2038E-01	LB HYDROGEN/LB COAL
	.4139	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	39.52	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	45.12	PERCENT

RUN NO. 67

SAMPLE NO. 1

DATE 7 -14 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	4.600	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.279	LB/HR	COAL FED	618.7	GRAMS
HYDROGEN FLOW RATE	.8200	LB/HR	CHAR	245.2	GRAMS
HYDROGEN VELOCITY	.8650	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	800.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	500.0	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8750E-03	7.687	11.50
CARBON DIOXIDE	.3100E-04	.1733	.4102
METHANE	.8100E-03	12.43	10.72
ETHYLENE	0.	0.	0.
ETHANE	.1970E-03	3.225	2.607
BENZENE	.2310E-03	4.367	3.057
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1150E-03	2.175	1.522
WATER	.1800E-03	0.	2.382
TOTAL		30.05	32.28

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.54	7.70	0.	0.	0.	4.58
HYDROCARBON GASES	15.7	70.1	0.	0.	0.	13.3
CARBON OXIDES	7.86	0.	24.0	0.	0.	12.0
WATER	0.	5.77	7.34	0.	0.	2.38
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	43.3
TOTAL	30.1	89.5	31.3	100.	100.	77.8

HYDROGEN CONSUMPTION-	-.4406E-02	LB HYDROGEN/LB COAL
	-.8947E-01	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	30.05	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	30.48	PERCENT

RUN NO. 67

SAMPLE NO. 2

DATE 7 -14 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	1.150	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.279	LB/HR	TOTAL ACCUMULATED WTS.		
HYDROGEN FLOW RATE	.8200	LB/HR	COAL FED	618.7	GRAMS
HYDROGEN VELOCITY	.8650	FT/SEC	CHAR	245.2	GRAMS
REACTOR TEMP.	800.0	DEG C	LIGHT OILS	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	BTX	0.	GRAMS
HYDROGEN PRESSURE	500.0	PSI	WATER	0.	GRAMS

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT.	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.5420E-03	4.762	7.173
CARBON DIOXIDE	.7600E-04	.4249	1.006
METHANE	.1278E-02	19.60	16.91
ETHYLENE	0.	0.	0.
ETHANE	.2430E-03	3.978	3.216
BENZENE	.1960E-03	3.705	2.594
TOLUENE	.3000E-05	.5609E-01	.3970E-01
XYLENE	0.	0.	0.
LIGHT OIL	.1610E-03	3.045	2.131
WATER	.8540E-03	0.	11.30
TOTAL		35.58	44.37

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.81	8.02	0.	0.	0.	4.76
HYDROCARBON GASES	23.6	107.	0.	0.	0.	20.1
CARBON OXIDES	5.19	0.	16.7	0.	0.	8.18
WATER	0.	27.4	34.8	0.	0.	11.3
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	43.3
TOTAL	35.6	148.	51.6	100.	100.	89.9

HYDROGEN CONSUMPTION-	.2015E-01	LB HYDROGEN/LB COAL
	.4092	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	35.58	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	42.95	PERCENT

RUN NO. 68

SAMPLE NO. 1

DATE 7 -14 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	4.700	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.203	LB/HR	COAL FED	646.2	GRAMS
HYDROGEN FLOW RATE	.8600	LB/HR	CHAR	335.6	GRAMS
HYDROGEN VELOCITY	.8226	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	700.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	700.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	500.0	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.7060E-03	6.913	10.41
CARBON DIOXIDE	.8200E-04	.5110	1.209
METHANE	.4160E-03	7.112	6.135
ETHYLENE	0.	0.	0.
ETHANE	.2180E-03	3.977	3.215
BENZENE	.7100E-04	1.496	1.047
TOLUENE	.3000E-04	.6251	.4425
XYLENE	0.	0.	0.
LIGHT OIL	.3460E-03	7.293	5.103
WATER	.4570E-03	0.	6.740

TOTAL	27.93	34.31
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TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.41	11.2	0.	0.	0.	6.59
HYDROCARBON GASES	11.1	47.7	0.	0.	0.	9.35
CARBON OXIDES	7.42	0.	23.7	0.	0.	11.6
WATER	0.	16.3	20.8	0.	0.	6.74
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	56.8
TOTAL	27.9	81.1	44.4	100.	100.	93.3

HYDROGEN CONSUMPTION-	-.7946E-02	LB HYDROGEN/LB COAL
	-.1613	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	27.93	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	26.07	PERCENT

RUN NO: 68

SAMPLE NO. 2

DATE 7 -14 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	1.180	SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.203	LB/HR	COAL FED	646.2	GRAMS
HYDROGEN FLOW RATE	.8600	LB/HR	CHAR	335.6	GRAMS
HYDROGEN VELOCITY	.8226	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	700.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	700.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	500.0	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.5930E-03	5.806	8.746
CARBON DIOXIDE	.8500E-04	.5297	1.254
METHANE	.7310E-03	12.50	10.78
ETHYLENE	0.	0.	0.
ETHANE	.2700E-03	4.925	3.982
BENZENE	.9600E-04	2.022	1.416
TOLUENE	.3400E-04	.7084	.5015
XYLENE	.7000E-05	.1447	.1032
LIGHT OIL	.3020E-03	6.366	4.454
WATER	.8340E-03	0.	12.30
TOTAL		33.00	43.54

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.24	11.0	0.	0.	0.	6.47
HYDROCARBON GASES	17.4	76.5	0.	0.	0.	14.8
CARBON OXIDES	6.34	0.	20.5	0.	0.	10.0
WATER	0.	29.8	37.9	0.	0.	12.3
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	56.8
TOTAL	33.0	123.	58.4	100.	100.	103.

HYDROGEN CONSUMPTION-	.9741E-02	LB HYDROGEN/LB COAL
	.1978	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	33.00	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	35.19	PERCENT

RUN NO. 69

SAMPLE NO. 1

DATE 7 -18 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
 CALCULATED 12.30 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.226	LB/HR	COAL FED	602.4	GRAMS
HELIUM FLOW RATE	1.600	LB/HR	CHAR	316.7	GRAMS
HELIUM VELOCITY	.2682	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	50.00	GRAMS
HELIUM PRESSURE	1500.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	0.	0.	0.
CARBON DIOXIDE	.1352E-02	7.755	18.35
METHANE	.2720E-03	4.280	3.693
ETHYLENE	0.	0.	0.
ETHANE	.4100E-04	.6884	.5566
BENZENE	.5000E-04	.9696	.6788
TOLUENE	.6000E-05	.1151	.8145E-01
XYLENE	0.	0.	0.
LIGHT OIL	.3000E-04	.5821	.4073
WATER	.4100E-04	0.	.5566

TOTAL	14.39	24.33
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TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	1.67	1.98	0.	0.	0.	1.17
HYDROCARBON GASES	4.97	22.7	0.	0.	0.	4.25
CARBON OXIDES	7.75	0.	46.3	0.	0.	18.4
WATER	0.	1.35	1.71	0.	0.	.557
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	57.5
TOTAL	14.4	31.9	48.0	100.	100.	84.0

HYDROGEN CONSUMPTION- -.2860E-01 LB HYDROGEN/LB COAL
 -.5806 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 14.39 PERCENT
 EFFECTIVE ENERGY EFFICIENCY- 9.207 PERCENT

RUN NO. 69

SAMPLE NO. 2

DATE 7 -18 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	3.100	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.226	LB/HR	TOTAL ACCUMULATED WTS.		
HELIUM FLOW RATE	1.600	LB/HR	COAL FED	602.4	GRAMS
HELIUM VELOCITY	.2682	FT/SEC	CHAR	316.7	GRAMS
REACTOR TEMP.	750.0	DEG C	LIGHT OILS	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	BTX	0.	GRAMS
HELIUM PRESSURE	1500.	PSI	WATER	50.00	GRAMS

COAL ANALYSIS, %

CHAR ANALYSIS, %

CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

PRODUCT CONC. IN	% CARBON CONV.	% MAF COAL CONV.
GAS, LB/C. FT	TO PRODUCT	TO PRODUCT

CARBON MONOXIDE	0.	0.	0.
CARBON DIOXIDE	.1713E-02	9.825	23.25
METHANE	.2400E-03	3.777	3.258
ETHYLENE	0.	0.	0.
ETHANE	.3600E-04	.6045	.4887
BENZENE	.3700E-04	.7175	.5023
TOLUENE	.1200E-04	.2301	.1629
XYLENE	0.	0.	0.
LIGHT OIL	.9300E-04	1.804	1.263
WATER	.2850E-03	0.	3.869

TOTAL	16.96	32.80
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TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	2.75	3.27	0.	0.	0.	1.93
HYDROCARBON GASES	4.38	20.0	0.	0.	0.	3.75
CARBON OXIDES	9.83	0.	58.6	0.	0.	23.3
WATER	0.	9.36	11.9	0.	0.	3.87
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	57.5
TOTAL	17.0	38.5	70.5	100.	100.	92.5

HYDROGEN CONSUMPTION-	-.2581E-01	LB HYDROGEN/LB COAL
	-.5241	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	16.96	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	9.429	PERCENT

RUN NO. 70

SAMPLE NO. 1

DATE 7 -19 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	14.30	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.262	LB/HR	COAL FED	582.2	GRAMS
HELIUM FLOW RATE	1.620	LB/HR	CHAR	321.8	GRAMS
HELIUM VELOCITY	.2037	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	20.00	GRAMS
HELIUM PRESSURE	2000.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	0.	0.	0.
CARBON DIOXIDE	.1450E-02	8.183	19.37
METHANE	.3520E-03	5.450	4.701
ETHYLENE	0.	0.	0.
ETHANE	.3900E-04	.6443	.5209
BENZENE	.5800E-04	1.107	.7747
TOLUENE	.7000E-05	.1321	.9349E-01
XYLENE	0.	0.	0.
LIGHT OIL	.1190E-03	2.272	1.589
WATER	.1600E-04	0.	.2137

TOTAL	17.79	27.26
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TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.51	4.15	0.	0.	0.	2.46
HYDROCARBON GASES	6.09	28.0	0.	0.	0.	5.22
CARBON OXIDES	8.18	0.	48.8	0.	0.	19.4
WATER	0.	.517	.658	0.	0.	.214
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	60.4
TOTAL	17.8	38.6	49.5	100.	100.	89.9

HYDROGEN CONSUMPTION-	-.2578E-01	LB HYDROGEN/LB COAL
	-.5235	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	17.79	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	13.00	PERCENT

RUN NO. 70

SAMPLE NO. 2

DATE 7 -19 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 3.600 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.262	LB/HR	COAL FED	582.2	GRAMS
HELIUM FLOW RATE	1.620	LB/HR	CHAR	321.8	GRAMS
HELIUM VELOCITY	.2037	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	20.00	GRAMS
HELIUM PRESSURE	2000.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	0.	0.	0.
CARBON DIOXIDE	.1614E-02	9.108	21.56
METHANE	.2520E-03	3.901	3.366
ETHYLENE	0.	0.	0.
ETHANE	.5200E-04	.8590	.6945
BENZENE	.4700E-04	.8967	.6277
TOLUENE	.1900E-04	.3585	.2538
XYLENE	0.	0.	0.
LIGHT OIL	.1140E-03	2.176	1.523
WATER	.2070E-03	0.	2.765

TOTAL 17.30 30.79

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.43	4.09	0.	0.	0.	2.40
HYDROCARBON GASES	4.76	21.5	0.	0.	0.	4.06
CARBON OXIDES	9.11	0.	54.3	0.	0.	21.6
WATER	0.	6.69	8.52	0.	0.	2.76
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	60.4
TOTAL	17.3	38.2	62.8	100.	100.	93.4

HYDROGEN CONSUMPTION- -.2596E-01 LB HYDROGEN/LB COAL
-.5271 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 17.30 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 10.56 PERCENT

RUN NO. 71 SAMPLE NO. 1 DATE 7 -20 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 15.20 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.309	LB/HR	COAL FED	574.0	GRAMS
HELIUM FLOW RATE	1.720	LB/HR	CHAR	324.7	GRAMS
HELIUM VELOCITY	.1730	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	18.00	GRAMS
HELIUM PRESSURE	2500.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	0.	0.	0.
CARBON DIOXIDE	.1341E-02	7.742	18.32
METHANE	.3150E-03	4.990	4.304
ETHYLENE	0.	0.	0.
ETHANE	.3900E-04	.6592	.5329
BENZENE	.4600E-04	.8979	.6286
TOLUENE	.7000E-05	.1351	.9566E-01
XYLENE	0.	0.	0.
LIGHT OIL	.1060E-03	2.070	1.448
WATER	.2800E-04	0.	.3826
TOTAL		16.49	25.72

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.10	3.67	0.	0.	0.	2.17
HYDROCARBON GASES	5.65	25.9	0.	0.	0.	4.84
CARBON OXIDES	7.74	0.	46.2	0.	0.	18.3
WATER	0.	.926	1.18	0.	0.	.383
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	61.8
TOTAL	16.5	36.4	47.4	100.	100.	89.8

HYDROGEN CONSUMPTION- -.2670E-01 LB HYDROGEN/LB COAL
 -.5421 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 16.49 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 11.87 PERCENT

RUN NO. 71

SAMPLE NO. 2

DATE 7 -20 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
 CALCULATED 3.800 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.309	LB/HR	COAL FED	574.0	GRAMS
HELIUM FLOW RATE	1.720	LB/HR	CHAR	324.7	GRAMS
HELIUM VELOCITY	.1730	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	18.00	GRAMS
HELIUM PRESSURE	2500.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	0.	0.	0.
CARBON DIOXIDE	.1399E-02	8.077	19.12
METHANE	.2470E-03	3.912	3.375
ETHYLENE	0.	0.	0.
ETHANE	.4800E-04	.8113	.6559
BENZENE	.3700E-04	.7222	.5056
TOLUENE	.1600E-04	.3089	.2186
XYLENE	.3000E-05	.5744E-01	.4100E-01
LIGHT OIL	.6300E-04	1.230	.8609
WATER	.1200E-03	0.	1.040

TOTAL	15.12	26.41
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TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	2.32	2.80	0.	0.	0.	1.63
HYDROCARBON GASES	4.72	21.4	0.	0.	0.	4.03
CARBON OXIDES	8.08	0.	48.2	0.	0.	19.1
WATER	0.	3.97	5.05	0.	0.	1.64
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	61.8
TOTAL	15.1	34.0	53.2	100.	100.	90.5

HYDROGEN CONSUMPTION- -.2770E-01 LB HYDROGEN/LB COAL
 -.5624 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 15.12 PERCENT
 EFFECTIVE ENERGY EFFICIENCY- 9.276 PERCENT

RUN NO. 72 SAMPLE NO. 1 DATE 7 -21 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 9.500 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.	
COAL FEED RATE	1.521	LB/HR	COAL FED	640.0 GRAMS
HYDROGEN FLOW RATE	.8200	LB/HR	CHAR	0. GRAMS
HYDROGEN VELOCITY	.1649	FT/SEC	LIGHT OILS	0. GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0. GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	0. GRAMS
HYDROGEN PRESSURE	2500.	PSI		

	COAL ANALYSIS,%	CHAR ANALYSIS,%
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.7300E-03	5.300	8.123
CARBON DIOXIDE	.6400E-04	.3009	.7122
METHANE	.1712E-02	22.08	19.05
ETHYLENE	0.	0.	0.
ETHANE	.7380E-03	10.16	8.212
BENZENE	.5900E-03	9.378	6.565
TOLUENE	.6300E-05	.9904E-01	.7011E-01
XYLENE	0.	0.	0.
LIGHT OIL	.1610E-03	2.560	1.792
WATER	.3320E-03	0.	3.694
 TOTAL		 49.97	 48.22

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	12.0	14.2	0.	0.	0.	8.43
HYDROCARBON GASES	32.2	140.	0.	0.	0.	27.3
CARBON OXIDES	5.69	0.	17.9	0.	0.	8.84
WATER	0.	8.94	11.4	0.	0.	3.69
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	0.
 TOTAL	 50.0	 169.	 29.3	 100.	 100.	 50.5

HYDROGEN CONSUMPTION- .2913E-01 LB HYDROGEN/LB COAL
 .5915 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 49.97 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 60.26 PERCENT

RUN NO. 73

SAMPLE NO. 1

DATE 7 -26 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 11.40 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.396	LB/HR	COAL FED	654.6	GRAMS
HYDROGEN FLOW RATE	.7700	LB/HR	CHAR	164.9	GRAMS
HYDROGEN VELOCITY	.9680E-01	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	4000.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.5920E-03	4.472	6.737
CARBON DIOXIDE	.5000E-04	.2404	.5690
METHANE	.4005E-02	52.83	45.58
ETHYLENE	0.	0.	0.
ETHANE	.9830E-03	13.84	11.19
BENZENE	.2660E-03	4.324	3.027
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.3530E-03	5.741	4.017
WATER	.1700E-04	0.	.1935

TOTAL 81.44 71.30

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	10.1	11.8	0.	0.	0.	7.04
HYDROCARBON GASES	66.7	299.	0.	0.	0.	56.8
CARBON OXIDES	4.71	0.	14.8	0.	0.	7.31
WATER	0.	.468	.596	0.	0.	.193
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	27.5
TOTAL	81.4	317.	15.4	100.	100.	101.

HYDROGEN CONSUMPTION- .9104E-01 LB HYDROGEN/LB COAL
1.848 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 61.39 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 83.95 PERCENT

RUN NO. 73 SAMPLE NO. 2 DATE 7 -26 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 2.850 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.396	LB/HR	COAL FED	654.6	GRAMS
HYDROGEN FLOW RATE	.7700	LB/HR	CHAR	164.9	GRAMS
HYDROGEN VELOCITY	.9680E-01	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	4000.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3430E-03	2.591	3.903
CARBON DIOXIDE	.5200E-04	.2500	.5917
METHANE	.2384E-02	31.45	27.13
ETHYLENE	0.	0.	0.
ETHANE	.8220E-03	11.57	9.354
BENZENE	.5600E-03	9.102	6.373
TOLUENE	.7000E-05	.1125	.7966E-01
XYLENE	0.	0.	0.
LIGHT OIL	.2780E-03	4.521	3.164
WATER	.5360E-03	0.	6.099
 TOTAL		59.59	56.69

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	13.7	16.2	0.	0.	0.	9.62
HYDROCARBON GASES	43.0	190.	0.	0.	0.	36.5
CARBON OXIDES	2.84	0.	9.22	0.	0.	4.49
WATER	0.	14.8	18.8	0.	0.	6.10
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	27.5
 TOTAL	59.6	226.	28.0	100.	100.	86.5

HYDROGEN CONSUMPTION- .5309E-01 LB HYDROGEN/LB COAL
1.078 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 57.89 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 76.36 PERCENT

RUN NO. 74

SAMPLE NO. 1

DATE 7 -29 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	1.700	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.300	LB/HR	COAL FED	442.7	GRAMS
HYDROGEN FLOW RATE	.8000	LB/HR	CHAR	182.6	GRAMS
HYDROGEN VELOCITY	.4219	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	800.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1000.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	20.60

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.9420E-03	7.943	11.96
CARBON DIOXIDE	.9200E-04	.4937	1.168
METHANE	.1756E-02	25.85	22.30
ETHYLENE	0.	0.	0.
ETHANE	.2970E-03	4.666	3.772
BENZENE	.4910E-03	8.908	6.236
TOLUENE	.7000E-05	.1256	.8891E-01
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.1127E-02	0.	14.31
TOTAL		47.99	59.85

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.03	10.7	0.	0.	0.	6.33
HYDROCARBON GASES	30.5	139.	0.	0.	0.	26.1
CARBON OXIDES	8.44	0.	26.6	0.	0.	13.1
WATER	0.	34.6	44.1	0.	0.	14.3
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	35.8
TOTAL	48.0	190.	70.7	100.	100.	97.9

HYDROGEN CONSUMPTION-	.3775E-01	LB HYDROGEN/LB COAL
	.7666	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	47.99	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	55.43	PERCENT

RUN NO. 74 SAMPLE NO. 2 DATE 7 -29 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.600 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.300	LB/HR	COAL FED	442.7	GRAMS
HYDROGEN FLOW RATE	.8000	LB/HR	CHAR	182.6	GRAMS
HYDROGEN VELOCITY	.4219	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	800.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1000.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	20.60

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8900E-03	7.504	11.30
CARBON DIOXIDE	.3300E-04	.1771	.4191
METHANE	.1525E-02	22.45	19.37
ETHYLENE	0.	0.	0.
ETHANE	.1700E-03	2.671	2.159
BENZENE	.3600E-03	6.531	4.572
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1100E-03	1.997	1.397
WATER	.5600E-03	0.	7.113
TOTAL		41.33	46.33

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.53	10.1	0.	0.	0.	5.97
HYDROCARBON GASES	25.1	115.	0.	0.	0.	21.5
CARBON OXIDES	7.68	0.	23.4	0.	0.	11.7
WATER	0.	17.2	21.9	0.	0.	7.11
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	35.8
TOTAL	41.3	149.	45.3	100.	100.	84.4

HYDROGEN CONSUMPTION- .2045E-01 LB HYDROGEN/LB COAL
 .4153 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 41.33 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 47.32 PERCENT

RUN NO. 75

SAMPLE NO. 1

DATE 8 -2 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	1.600	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.219	LB/HR	TOTAL ACCUMULATED WTS.		
HYDROGEN FLOW RATE	.8200	LB/HR	COAL FED	553.0	GRAMS
HYDROGEN VELOCITY	.4325	FT/SEC	CHAR	237.5	GRAMS
REACTOR TEMP.	800.0	DEG C	LIGHT OILS	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	BTX	0.	GRAMS
HYDROGEN PRESSURE	1000.	PSI	WATER	0.	GRAMS

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	19.80

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.4810E-03	4.432	6.676
CARBON DIOXIDE	.7100E-04	.4164	.9855
METHANE	.1466E-02	23.59	20.35
ETHYLENE	0.	0.	0.
ETHANE	.3180E-03	5.459	4.414
BENZENE	.3290E-03	6.523	4.566
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1690E-03	3.352	2.346
WATER	.7960E-03	0.	11.05
TOTAL		43.77	50.38

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.88	11.6	0.	0.	0.	6.91
HYDROCARBON GASES	29.0	131.	0.	0.	0.	24.8
CARBON OXIDES	4.85	0.	15.7	0.	0.	7.66
WATER	0.	26.7	34.0	0.	0.	11.0
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	37.6
TOTAL	43.8	175.	49.7	100.	100.	90.3

HYDROGEN CONSUMPTION-	.3152E-01	LB HYDROGEN/LB COAL
	.6399	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	43.77	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	54.31	PERCENT

RUN NO. 75 SAMPLE NO. 2 DATE 8 -2 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.500 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.219	LB/HR	COAL FED	553.0	GRAMS
HYDROGEN FLOW RATE	.8200	LB/HR	CHAR	237.5	GRAMS
HYDROGEN VELOCITY	.4325	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	800.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1000.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	19.80

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8910E-03	8.210	12.37
CARBON DIOXIDE	.2900E-04	.1701	.4025
METHANE	.1495E-02	24.05	20.75
ETHYLENE	0.	0.	0.
ETHANE	.2190E-03	3.760	3.040
BENZENE	.3630E-03	7.197	5.038
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1250E-03	2.480	1.735
WATER	.3120E-03	0.	4.330
TOTAL		45.87	47.66

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.68	11.4	0.	0.	0.	6.77
HYDROCARBON GASES	27.8	127.	0.	0.	0.	23.8
CARBON OXIDES	8.38	0.	25.5	0.	0.	12.8
WATER	0.	10.5	13.3	0.	0.	4.33
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	37.6
TOTAL	45.9	155.	38.8	100.	100.	87.5

HYDROGEN CONSUMPTION- .2299E-01 LB HYDROGEN/LB COAL
 .4668 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 45.87 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 52.48 PERCENT

RUN NO. 76

SAMPLE NO. 1

DATE 8 -4 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	6.600	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.289	LB/HR	COAL FED	556.8	GRAMS
HYDROGEN FLOW RATE	.8250	LB/HR	CHAR	225.8	GRAMS
HYDROGEN VELOCITY	.4149	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1000.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	21.00

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8890E-03	7.794	11.74
CARBON DIOXIDE	.2900E-04	.1618	.3830
METHANE	.9370E-03	14.34	12.37
ETHYLENE	0.	0.	0.
ETHANE	.3270E-03	5.341	4.318
BENZENE	.3020E-03	5.696	3.988
TOLUENE	.5000E-05	.9328E-01	.6603E-01
XYLENE	0.	0.	0.
LIGHT OIL	.7300E-04	1.378	.9640
WATER	.1450E-03	0.	1.915
TOTAL		34.81	35.75

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	7.17	8.47	0.	0.	0.	5.02
HYDROCARBON GASES	19.7	86.7	0.	0.	0.	16.7
CARBON OXIDES	7.96	0.	24.2	0.	0.	12.1
WATER	0.	4.63	5.90	0.	0.	1.91
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	35.0
TOTAL	34.8	106.	30.1	100.	100.	73.0

HYDROGEN CONSUMPTION-	.2390E-02	LB HYDROGEN/LB COAL
	.4853E-01	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	34.81	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	36.74	PERCENT

RUN NO. 77 SAMPLE NO. 1 DATE 8 -4 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.500 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.370	LB/HR	COAL FED	623.2	GRAMS
HYDROGEN FLOW RATE	.8300	LB/HR	CHAR	302.3	GRAMS
HYDROGEN VELOCITY	.4072	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	725.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	725.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1000.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	17.50

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1138E-02	9.446	14.23
CARBON DIOXIDE	.5500E-04	.2905	.6877
METHANE	.1050E-02	15.22	13.13
ETHYLENE	0.	0.	0.
ETHANE	.4370E-03	6.758	5.464
BENZENE	.3360E-03	6.001	4.201
TOLUENE	.9000E-05	.1590	.1125
XYLENE	0.	0.	0.
LIGHT OIL	.6900E-04	1.233	.8627
WATER	.2120E-03	0.	2.651
TOTAL		39.10	41.34

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	7.39	8.74	0.	0.	0.	5.18
HYDROCARBON GASES	22.0	95.8	0.	0.	0.	18.6
CARBON OXIDES	9.74	0.	29.9	0.	0.	14.9
WATER	0.	6.42	8.17	0.	0.	2.65
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	43.7
TOTAL	39.1	117.	38.1	100.	100.	87.3

HYDROGEN CONSUMPTION- .7099E-02 LB HYDROGEN/LB COAL
 .1441 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 39.10 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 40.13 PERCENT

RUN NO. 78

SAMPLE NO. 1

DATE 8 -9 -- 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 4.700 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.230	LB/HR	COAL FED	520.7	GRAMS
HYDROGEN FLOW RATE	.9000	LB/HR	CHAR	276.8	GRAMS
HYDROGEN VELOCITY	.8830	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	725.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	725.0	DEG C	WATER	75.00	GRAMS
HYDROGEN PRESSURE	500.0	PSI			

TOTAL ACCUMULATED WTS.

COAL ANALYSIS, %

CARBON	59.10
HYDROGEN	4.200
OXYGEN	26.40
NITROGEN	.9000
SULFUR	.9000
ASH	8.500

CHAR ANALYSIS, %

	0.
	0.
	0.
	0.
	0.
	16.00

PRODUCT CONC. IN
GAS, LB/C. FT% CARBON CONV.
TO PRODUCT% MAF COAL CONV.
TO PRODUCT

CARBON MONOXIDE	.9620E-03	9.645	14.53
CARBON DIOXIDE	.5200E-04	.3318	.7853
METHANE	.5700E-03	9.979	8.609
ETHYLENE	0.	0.	0.
ETHANE	.2910E-03	5.436	4.395
BENZENE	.1420E-03	3.063	2.145
TOLUENE	.3000E-04	.6401	.4531
XYLENE	0.	0.	0.
LIGHT OIL	.8100E-04	1.748	1.223
WATER	.4000E-03	0.	6.041

TOTAL

30.84

38.18

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	5.45	6.53	0.	0.	0.	3.82
HYDROCARBON GASES	15.4	66.4	0.	0.	0.	13.0
CARBON OXIDES	9.98	0.	30.7	0.	0.	15.3
WATER	0.	14.6	18.6	0.	0.	6.04
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	48.8
TOTAL	30.8	93.5	49.4	100.	100.	89.2

HYDROGEN CONSUMPTION- -.2744E-02 LB HYDROGEN/LB COAL
-.5571E-01 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 30.84 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 27.83 PERCENT

RUN NO. 79

SAMPLE NO. 1

DATE 8 -10 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	6.200	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.230	LB/HR	COAL FED	485.1	GRAMS
HYDROGEN FLOW RATE	.9550	LB/HR	CHAR	217.3	GRAMS
HYDROGEN VELOCITY	.4685	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	725.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	725.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1000.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	19.00

	PRODUCT CONC. IN GAS, LB/O. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.9200E-03	9.788	14.74
CARBON DIOXIDE	.3500E-04	.2370	.5609
METHANE	.7190E-03	13.36	11.52
ETHYLENE	0.	0.	0.
ETHANE	.3350E-03	6.640	5.369
BENZENE	.2310E-03	5.288	3.702
TOLUENE	.1000E-04	.2264	.1603
XYLENE	0.	0.	0.
LIGHT OIL	.6800E-04	1.557	1.090
WATER	.2340E-03	0.	3.750
TOTAL		37.09	40.90

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	7.07	8.37	0.	0.	0.	4.95
HYDROCARBON GASES	20.0	86.6	0.	0.	0.	16.9
CARBON OXIDES	10.0	0.	30.6	0.	0.	15.3
WATER	0.	9.08	11.6	0.	0.	3.75
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	39.7
TOTAL	37.1	110.	42.2	100.	100.	82.8

HYDROGEN CONSUMPTION-	.4194E-02	LB HYDROGEN/LB COAL
	.8515E-01	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	37.09	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	36.73	PERCENT

RUN NO. 80

SAMPLE NO. 1

DATE 8 -11 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	7.500	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.149	LB/HR	TOTAL ACCUMULATED WTS.		
HYDROGEN FLOW RATE	.9000	LB/HR	COAL FED	277.6	GRAMS
HYDROGEN VELOCITY	.2943	FT/SEC	CHAR	118.8	GRAMS
REACTOR TEMP.	725.0	DEG C	LIGHT OILS	0.	GRAMS
PREHEAT TEMP.	725.0	DEG C	BTX	0.	GRAMS
HYDROGEN PRESSURE	1500.	PSI	WATER	0.	GRAMS

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	19.90

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8810E-03	9.453	14.24
CARBON DIOXIDE	.2900E-04	.1980	.4687
METHANE	.9580E-03	17.95	15.48
ETHYLENE	0.	0.	0.
ETHANE	.4080E-03	8.157	6.594
BENZENE	.3320E-03	7.665	5.366
TOLUENE	.8000E-05	.1827	.1293
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.1800E-03	0.	2.909

TOTAL	43.60	45.19
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TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	7.85	9.29	0.	0.	0.	5.50
HYDROCARBON GASES	26.1	114.	0.	0.	0.	22.1
CARBON OXIDES	9.65	0.	29.4	0.	0.	14.7
WATER	0.	7.04	8.96	0.	0.	2.91
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	37.5
TOTAL	43.6	136.	38.3	100.	100.	84.9

HYDROGEN CONSUMPTION-	.1509E-01	LB HYDROGEN/LB COAL
	.3064	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	43.60	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	46.55	PERCENT

RUN NO. 81 SAMPLE NO. 1 DATE 8 -15 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 2.300 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.280	LB/HR	COAL FED	460.0	GRAMS
HYDROGEN FLOW RATE	.7100	LB/HR	CHAR	162.6	GRAMS
HYDROGEN VELOCITY	.1741	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	725.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	725.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	2000.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	24.10

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8260E-03	6.277	9.455
CARBON DIOXIDE	.3300E-04	.1596	.3777
METHANE	.1281E-02	17.00	14.66
ETHYLENE	0.	0.	0.
ETHANE	.4740E-03	6.711	5.426
BENZENE	.4320E-03	7.063	4.945
TOLUENE	.7000E-05	.1132	.8013E-01
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.1000E-03	0.	1.145
TOTAL		37.32	36.09

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	7.18	8.49	0.	0.	0.	5.03
HYDROCARBON GASES	23.7	104.	0.	0.	0.	20.1
CARBON OXIDES	6.44	0.	19.7	0.	0.	9.83
WATER	0.	2.77	3.53	0.	0.	1.14
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	29.3
TOTAL	37.3	121.	23.2	100.	100.	67.7

HYDROGEN CONSUMPTION- .8921E-02 LB HYDROGEN/LB COAL
.1811 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 37.32 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 42.53 PERCENT

RUN NO. 82

SAMPLE NO. 1

DATE 8 -19 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	1.900	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.072	LB/HR	COAL FED	462.3	GRAMS
HYDROGEN FLOW RATE	.9500	LB/HR	CHAR	196.6	GRAMS
HYDROGEN VELOCITY	.3107	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	725.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	725.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1500.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	20.00

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.5200E-03	6.311	9.506
CARBON DIOXIDE	.3400E-04	.2626	.6216
METHANE	.8480E-03	17.97	15.50
ETHYLENE	0.	0.	0.
ETHANE	.3440E-03	7.778	6.289
BENZENE	.2120E-03	5.536	3.876
TOLUENE	.7000E-05	.1808	.1280
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	0.	0.	0.
TOTAL		38.04	35.92

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	5.72	6.78	0.	0.	0.	4.00
HYDROCARBON GASES	25.7	112.	0.	0.	0.	21.8
CARBON OXIDES	6.57	0.	20.4	0.	0.	10.1
WATER	0.	0.	0.	0.	0.	0.
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	37.2
TOTAL	38.0	125.	20.4	100.	100.	75.3

HYDROGEN CONSUMPTION-	.1056E-01	LB HYDROGEN/LB COAL
	.2143	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	38.04	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	43.91	PERCENT

RUN NO. 82 SAMPLE NO. 2 DATE 8 -19 -1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 7.500 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.072	LB/HR	COAL FED	462.3	GRAMS
HYDROGEN FLOW RATE	.9500	LB/HR	CHAR	196.6	GRAMS
HYDROGEN VELOCITY	.3107	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	725.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	725.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1500.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	20.00

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.6940E-03	8.423	12.69
CARBON DIOXIDE	0.	0.	0.
METHANE	.7390E-03	15.66	13.51
ETHYLENE	0.	0.	0.
ETHANE	.3480E-03	7.869	6.362
BENZENE	.2300E-03	6.006	4.205
TOLUENE	.7000E-05	.1808	.1280
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	0.	0.	0.
TOTAL		38.14	36.89

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.19	7.33	0.	0.	0.	4.33
HYDROCARBON GASES	23.5	102.	0.	0.	0.	19.9
CARBON OXIDES	8.42	0.	25.1	0.	0.	12.7
WATER	0.	0.	0.	0.	0.	0.
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	37.2
TOTAL	38.1	115.	25.1	100.	100.	76.3

HYDROGEN CONSUMPTION- .6342E-02 LB HYDROGEN/LB COAL
.1288 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 38.14 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 40.92 PERCENT

RUN NO. 83

SAMPLE NO. 1

DATE 8 -30 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
 CALCULATED 2.300 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.150	LB/HR	COAL FED	869.5	GRAMS
HYDROGEN FLOW RATE	.9100	LB/HR	CHAR	316.2	GRAMS
HYDROGEN VELOCITY	.1786	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	725.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	725.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	2500.	PSI			

TOTAL ACCUMULATED WTS.

COAL ANALYSIS, %

CARBON	59.10
HYDROGEN	4.200
OXYGEN	26.40
NITROGEN	.9000
SULFUR	.9000
ASH	8.500

CHAR ANALYSIS, %

	0.
	0.
	0.
	0.
	0.
	23.37

PRODUCT CONC. IN
GAS, LB/C. FT% CARBON CONV.
TO PRODUCT% MAF COAL CONV.
TO PRODUCT

CARBON MONOXIDE	.5190E-03	5.624	8.472
CARBON DIOXIDE	.5000E-04	.3448	.8162
METHANE	.8840E-03	16.73	14.43
ETHYLENE	0.	0.	0.
ETHANE	.4330E-03	8.742	7.068
BENZENE	.2850E-03	6.645	4.652
TOLUENE	.4100E-04	.9455	.6693
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.2720E-03	0.	4.440

TOTAL

39.03

40.55

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	7.59	9.12	0.	0.	0.	5.32
HYDROCARBON GASES	25.5	110.	0.	0.	0.	21.5
CARBON OXIDES	5.97	0.	18.8	0.	0.	9.29
WATER	0.	10.7	13.7	0.	0.	4.44
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	30.5
TOTAL	39.0	136.	32.5	100.	100.	73.2

HYDROGEN CONSUMPTION- .1502E-01 LB HYDROGEN/LB COAL
 .3050 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 39.03 PERCENT
 EFFECTIVE ENERGY EFFICIENCY- 44.40 PERCENT

RUN NO. 83

SAMPLE NO. 2

DATE 8 -30 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	9.300	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.150	LB/HR	COAL FED	869.5	GRAMS
HYDROGEN FLOW RATE	.9100	LB/HR	CHAR	316.2	GRAMS
HYDROGEN VELOCITY	.1736	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	725.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	725.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	2500.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	23.37

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.5640E-03	6.112	9.207
CARBON DIOXIDE	0.	0.	0.
METHANE	.9520E-03	18.01	15.54
ETHYLENE	0.	0.	0.
ETHANE	.4640E-03	9.368	7.574
BENZENE	.3780E-03	8.814	6.170
TOLUENE	.7000E-05	.1614	.1143
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.8000E-04	0.	1.306
TOTAL		42.47	39.91

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	8.98	10.6	0.	0.	0.	6.28
HYDROCARBON GASES	27.4	118.	0.	0.	0.	23.1
CARBON OXIDES	6.11	0.	18.2	0.	0.	9.21
WATER	0.	3.16	4.02	0.	0.	1.31
AMMONIA	0.	4.59	0.	100.	0.	1.19
HYDROGEN SULFIDE	0.	1.34	0.	0.	100.	1.05
CHAR	0.	0.	0.	0.	0.	30.5
TOTAL	42.5	138.	22.2	100.	100.	72.6

HYDROGEN CONSUMPTION-	.1595E-01	LB HYDROGEN/LB COAL
	.3239	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	42.47	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	49.43	PERCENT

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