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FLASH HYDROLYSIS OF COAL

QUARTERLY REPORT NO. 2
FOR PERIOD APRIL 1 TO JUNE 30, 1977

July 1977

PROCESS TECHNOLOGY DIVISION
DEPARTMENT OF APPLIED SCIENCE

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

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ABSTRACT

The experimental equipment is functioning well and the program is progressing. The vibrator portion of the coal feeder has been replaced with a rotary device but the load cell and coal hopper have been retained. Present experimental runs are being conducted at approximately 1 lb/hr of hydrogen and 1.5 lb/hr of coal. The capacity of the coal hopper is being increased to allow operation at these feed rates for up to two hours. With the combination of low hydrogen to coal ratio, high coal feed rate and larger total quantity of coal fed, considerable liquid product is being condensed and collected. Problems have occurred with the on-line measurement of hydrocarbons $\geq C_9$ due to the high boiling points of these compounds and low maximum temperature at which the process gas chromatograph may operate. Modifications to the analytic system to correct this problem are under consideration although on-line measurement of these compounds has become less necessary since they are now collected and measured directly in most cases.

Experimental runs conducted at 750°C and 800°C at pressures up to 3000 psi of hydrogen show overall hydrocarbon yields and particularly gaseous hydrocarbon yields to increase with pressure to approximately 60% at 3000 psi. At 750°C approximately one third (20%) of this yield is in the form of liquid products (half BTX and half $\geq C_9$) while at 800°C the yield is almost all methane with < 3% of liquids produced.

Preliminary results of the effect of residence time on product yield and distribution shows that at 3000 psi of hydrogen and 800°C, gaseous product yield increase and liquid yields decrease as the residence time is increased from 2.3 to 9.2 seconds. Under almost identical conditions at 750°C, all product yields increased with approximately the same increase in residence time.

A sample of Inconel 617 alloy removed from the reactor system after an excess of 100 hours exposure to hydrogen at up to 800°C and 3000 psi was examined metallurgically for hydrogen embrittlement. No change in the original structure of that portion of the alloy exposed to hydrogen could be found. The original hydrogen preheater, constructed of Inconel 601 alloy had ruptured after approximately 18 hours use. The cause has since been determined to have been hydrogen embrittlement.

Economic studies of the Flash Hydropyrolysis Process (FHP) are continuing. A detailed analysis of a 25,000 ton/day coal conversion plant utilizing FHP shows the discounted cash flow (DCF) to be strongly dependent upon the operating pressure of the reactor, increasing by almost a factor of two as the pressure is reduced from 4000 psi to 500 psi. The DCF is also shown to be influenced by the distribution of products, increasing as the yields of liquids increase.

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). 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 and the experimental program is progressing with few problems. Present experiments are being conducted at approximately 1 lb/hr of H_2 and 1.5 lb/hr of coal. The original helical vibrator portion of the coal feeder has been replaced by a rotary displacement feeder which has significantly improved the reliability. The coal hopper and load cell design has been retained. The capacity of the coal hopper is being increased to approximately 3 pounds to allow experimental runs of at least 2 hours at the present feed rate.

Failure of the original hydrogen preheater constructed of Inconel 601 is now considered to have been caused by hydrogen embrittlement. The preheater now in use is fabricated of Inconel 617, the same alloy used in the reactor tube and reactor sample taps. Examination of a sample of the Inconel 617 alloy taken from one of the reactor sample taps in use in the system in excess of 100 hours at up to 800°C and 3000 psi showed no detectable indication of hydrogen embrittlement.

Preliminary data on the effect of residence time on product distribution and yields indicate significant changes occur in both distribution of products and yields when the residence time is increased approximately a factor of four from 2.3-2.4 seconds to 9.2-9.6 seconds at a pressure of 2500 psi and temperatures of 750°C and 800°C. At 2500 psi and 800°C, an appreciable increase in CH_4 yield and decrease in liquid yield is observed with increased residence time. At 2500 psi and 750°C both CH_4 and liquid yields were observed to increase with residence time. Two series of runs conducted at 750°C and 800°C and up to 3000 psi hydrogen pressure show overall hydrocarbon yields to increase with increasing pressure and yields of approximately 60% was obtained at the maximum pressure of 3000 psi. At 750°C, approximately one-third of this yield is in the form of liquid products while at 800°C the yield is almost exclusively methane with only small amounts of liquid produced.

A mathematical parametric evaluation of the economics of a full scale flash hydrolysis plant for conversion of coal to liquid and gaseous hydrocarbon products was completed and printed in a report entitled, "An Economic Analysis of Flash Hydrolysis Plant", by B. Bhatt, P. T. Fallon and M. Steinberg published in May 1977, BNL 22912 (1). The study indicates that obtaining carbon conversions in the hydrolyzer closer to the plant carbon balance point at lower pressure with higher proportions of liquids will make the Flash Hydrolysis Process more economical.

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

All construction of the experimental equipment has been completed and the system is operational. Modifications are being made as necessary to improve the safety, reliability and ease of data gathering.

A stress accidentally applied to the third process gas sampling tap, located 6 feet down on the reactor, caused a small crack in the 3/8" Inconel 617 tubing from which the tap is fabricated. The crack occurred adjacent to the weld attaching the tap to the reactor wall and was found while leak checking the system with helium prior to operation with hydrogen. The sample tap was temporarily removed for metallurgical examination of the fracture and the opening left in the reactor was welded shut. Since this tap was located close to the bottom of the reactor, it has not been used to date and its temporary removal does not hamper operation of the equipment. Metallurgical examination of this tap for hydrogen embrittlement was considered important because the tap had been subjected to hydrogen in excess of 100 hours at up to 800°C and 3000 psi. Also, the reactor and hydrogen preheater are fabricated from the same Inconel 617 alloy as the tap. It is recalled that the original preheater, fabricated from Inconel 601, had ruptured due to hydrogen embrittlement after less than 30 hours use. No metallurgical change of the Inconel 617 sample tap could be found in the area of the fracture or in the area exposed to hydrogen. Some oxidation of the outer surface was observed but this was to be expected since

the area was exposed to air during heating.

The high pressure electrical fitting on the coal feeder developed a leak after operation at 3000 psi in excess of 25 hours. The trouble was found to be failure of the ceramic insulators brazed to the fitting. The problem was resolved by the fabrication of a new fitting and installation of a "Conax" high pressure seal rated at 10,000 psi.

The new coal feeder was installed and calibrated under operating conditions and is now in operation. This feeder has been completely dependable and the coal feed rate is reproducible to within approximately $\pm 4\%$. With this increase in reliability, most experimental runs are now of at least an hours duration, feeding approximately 1.5 lb of coal. Also with the increased quantity of coal being fed, considerable amounts of liquid product are now collected in the cold traps.

Coal is moved in the new coal feeder by the rotation of a spring inside a horizontal tubular hole in a manner similar to a screw feeder but with less packeting and a smoother flow. Packeting has been further reduced by careful design of the exit port.

2. Work Forecast

A method is being developed to concentrate the products contained in a sample of the process gas stream. A fixed sample of approximately 300 ml will be drawn through a column of gas chromatograph packing material held at liquid nitrogen temperature. This column is then heated to release the products into a gas chromatograph for identification. This should enable the detection of products such as H_2S which are believed to be present in the process gas stream below the detectable limits of the on-line gas chromatograph.

A new coal hopper is being fabricated which will hold approximately 3 lbs of coal, allowing the experimental runs to be extended to 2-3 hours, depending upon the coal feed rate.

C. Task 3. Development of Analytical System

1. Work Accomplished

a. On-Line Gas Chromatograph

The system developed for integrated determination of all hydrocarbons $\geq C_9$ has not proven to be completely satisfactory. Due to the use of teflon in the construction of the gas chromatograph sampling valves, the maximum temperature at which the sampling system can be maintained is $175^\circ C$. This is not always sufficient to keep all of the heavier hydrocarbons produced in the gaseous phase and some material has been found to be condensing in the sampling lines. The need for

on-line determination of these heavier liquid products does not appear to be as great as it had been since in most experimental runs these liquids are now being collected in the condensers and are measured directly.

b. Material Balance

Sulfur analysis of coal and char samples show approximately 50% of the sulfur content of the coal to be lost to the process gas stream. A trace of H_2S was found in the water produced but a distribution of most of the sulfur lost remains to be determined.

Material balances continue to be made on each run and coal and char analysis continue to be performed routinely.

2. Work Forecast

Improved methods of on-line determination of the $\geq C_9$ hydrocarbons will be investigated. These liquids will also be further characterized by boiling range and tests for sulfur, nitrogen and trace elements.

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

Figures 1 and 2 show the results of two series of runs, conducted at 2000 psi and 3000 psi of hydrogen between the temperature of 700 and 800°C. In comparing the two sets of data, the greatest change in yields is observed in the gaseous hydrocarbons (CH_4 and C_2H_6). At 2000 psi these same products increased from 25% to 41% of the carbon under the same conditions. Some slight increase in BTX was observed in going from 2000 to 3000 psi and also with increasing temperature at either of these pressures. As previously mentioned there have been problems with measurement of the hydrocarbon $\geq C_9$ using the gas chromatograph and these were not measured during the series of runs conducted at

3000 psi.

Figures 3 and 4 show the effect of pressure on product yield and distribution as a function of hydrogen pressure at 750°C and 800°C. While overall yields did not differ greatly at the two temperatures, a significant change in the distribution was observed. At 750°C, total liquid and BTX yields both increased with pressure, reaching a maximum between 2000 and 2500 psi of about 19%. At 800°C, liquid product yields decreased considerably to as low as 2.5% with increased hydrogen pressure and the gaseous hydrocarbon yield were observed to increase to approximately 55%. In the runs conducted at 800°C, very little heavier hydrocarbons $\geq C_9$ were measured on the gas chromatograph due either to the previously mentioned heavy liquid problem or that little of these products were actually produced.

b. Effect of Residence Time

In order to observe the effect of residence time on product distribution and yield, analysis of the process gas stream for most experimental runs is being conducted at both the first sample tap located two feet down on the reactor wall and at the sample tap located at the char trap. Only in the few cases where the experimental runs are of insufficient duration to allow equilibration at both taps is this procedure not followed. Although there is at present insufficient information to report fully on the results, data taken at 2500 psi and 750 and 800°C shown in Table 1 indicate considerable change in both product yield and distribution occurring along the length of the reactor. At 750°C the yields of all products except CO appear to increase somewhat (about 25 to 30%) with increased residence time. At 800°C, only the CO₂ and CH₄ yields appear to increase with residence time but at the expense of the liquid yields which show a decrease with the same residence time. The greatest increase appears to be in the CH₄ yield when increasing the temperature from 750°C to 800°C. At both 750°C and 800°C the CO₂ appears to decrease with residence time. If the CO₂ originates from the mineral matter contained in the coal as is sometimes thought, this could be explained as a reduction of the CO₂ with longer residence time caused by reaction with hydrogen.

2. Work Forecast

Product yield and distribution will continue to be studied at temperatures up to 800°C and pressures to 4000 psi. As previously mentioned, the coal feeder hopper is being enlarged to allow runs of longer duration. Present plans are to run at approximately 1.5 lb/hr of coal for up to 2 hours. This should provide sufficient time to sample the process gas stream from the four positions along the length of the reactor and to check the efficiency of the product condenser. Also with the high coal feed rate and large total quantity of coal fed, considerable amounts of liquid products should

be produced and collected under most experimental conditions.

F. Task 6. Process Design and Economic Evaluation

1. Work Accomplished

a. Economic Evaluation

Further evaluation of the economics of the Flash Hydropyrolysis Process has been published in an informal BNL report (1). Figure 5 taken from the report shows the variation of discounted cash flow (DCF) with total carbon converted to product at various pressures. Pressure seems to be an important variable and operating at lower pressures improves the economics due to a reduction in both operating costs and capital investment. The DCF is shown to increase very rapidly as the percent carbon converted to product increases until approximately 57.5% conversion. At this point, just sufficient carbon remains in the char for the production of hydrogen for conversion to products. Beyond this "balance" point additional coal must be used for the production of hydrogen by gasification. Thus beyond the balance point, the overall coal conversion fed to the plant remains approximately constant as the yield or conversion to the coal to hydrocarbons in the hydropyrolyzer increases. This mathematical parameter study of the economics of a full scale plant indicates that obtaining carbon conversions near the balance point at lower pressure with higher proportions of liquids makes the Flash Hydropyrolysis Process more economical.

2. Work Forecast

The economic evaluation and process design will be periodically re-evaluated with regard to current experimental results.

IV. CONCLUSIONS

The reliability of the experimental equipment has improved considerably and the experimental program is progressing on schedule. All problems with the system have either been resolved or are in the process of being resolved with the possible exception of finding a completely satisfactory method of on-line measurement of hydrocarbon $\geq C_9$. Present experiments are being conducted at approximately 1 lb/hr of hydrogen and 1.5 lb/hr of coal. Under these conditions, considerable liquid product is collected from most experimental runs, reducing the need for on-line determination of these heavier hydrocarbon products.

Present experiments indicate that at least approximately 20% liquid and 45% methane yields can be achieved at 750°C and 55% methane with less than 3% liquids at 800°C. At the maximum temperature studied, 800°C, it appears that longer residence times in the reactor cause an increase in methane production at the expense of liquid yields while at approximately 750°C all yields increase with residence time.

Much additional information on product yield and distribution must be obtained. Although maximum yields appear to be produced between 700-800°C, temperatures both below and above these must be investigated to insure complete examination of all possible operating conditions. Short residence times in the region of 1 second must also be studied to provide a further understanding of the process and to allow the calculation of FHP reaction rates.

The economics of the Flash Hydrolysis Process indicate it continues to be competitive with other more developed coal conversion processes, particularly when applied to the production of chemical stocks.

V. REFERENCES

1. Bhatt, B., Fallon, P. T., and Steinberg, M., "Economic Analysis of Flash Hydrolysis", BNL Report 22912 (May 1977).

Table 1

Percent Carbon Converted to Product as a Function of Temperature and Residence Time				
Pressure	2500		2500	
Temperature	750		800	
Coal Feed Rate (lb/hr)	1.32		1.34	
H ₂ Feed Rate (lb/hr)	0.82		0.855	
Residence Time (Sec)	2.4	9.6	2.3	9.2
% Carbon Converted				
CO	5.23	6.59	3.82	5.24
CO ₂	0.34	0.26	0.21	0.14
CH ₄	20.25	26.9	50.26	54.6
C ₂ H ₆	7.08	8.26	2.08	1.9
C ₆ H ₆	7.70	8.98	3.7	0.71
≥ C ₉	4.80	0.9	0.001	0.19
Total	45.4	51.89	60.07	62.78

Figure 1. Product yield vs. temperature at 2000 psi.

Figure 2. Product yield vs. temperature at 3000 psi.

Figure 3. Product yield vs. pressure at 750°C.

Figure 4. Product yield vs. pressure at 800°C.

Figure 5. % DCF vs. C conversion for various reactor pressures.

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APPENDIX
Experimental Runs Conducted During Report Period

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 0. SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	.5025	LB/HR	COAL FED	100.0	GRAMS
METHANE FLOW RATE	2.260	LB/HR	CHAR	0.	GRAMS
METHANE PRESSURE	2000.	PSI	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	825.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	825.0	DEG C	WATER	0.	GRAMS

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	57.10	0.
HYDROGEN	4.300	0.
OXYGEN	26.30	0.
NITROGEN	.8000	0.
SULFUR	1.200	0.
ASH	10.30	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	0.	0.	0.
CARBON DIOXIDE	.3570E-03	1.826	4.259
METHANE	0.	0.	0.
ETHYLENE	.7000E-05	.1123	.8350E-01
ETHANE	.4060E-03	6.078	4.843
BENZENE	.2210E-03	3.821	2.636
TOLUENE	.3900E-04	.6669	.4652
XYLENE	0.	0.	0.
LIGHT OIL	.5900E-04	1.021	.7038
WATER	.2470E-03	0.	2.947

TOTAL 13.52 15.94

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	5.51	6.23	0.	0.	0.	3.81
HYDROCARBON GASES	6.14	20.6	0.	0.	0.	4.93
CARBON OXIDES	1.83	0.	10.6	0.	0.	4.26
WATER	0.	6.83	8.93	0.	0.	2.95
AMMONIA	0.	3.99	0.	100.	0.	1.08
HYDROGEN SULFIDE	0.	1.74	0.	0.	100.	1.42
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	13.5	39.4	19.5	100.	100.	18.4

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 0. SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	.9389	LB/HR	COAL FED	100.0	GRAMS
NITROGEN FLOW RATE	5.750	LB/HR	CHAR	0.	GRAMS
NITROGEN PRESSURE	2000.	PSI	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	800.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS

	COAL ANALYSIS,%	CHAR ANALYSIS,%
CARBON	57.10	0.
HYDROGEN	4.300	0.
OXYGEN	26.30	0.
NITROGEN	.8000	0.
SULFUR	1.200	0.
ASH	10.30	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	0.	0.	0.
CARBON DIOXIDE	.2080E-03	.8277	1.931
METHANE	.2200E-04	.2402	.2042
ETHYLENE	0.	0.	0.
ETHANE	0.	0.	0.
BENZENE	.3000E-05	.4036E-01	.2785E-01
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.1600E-03	0.	1.485
TOTAL		1.108	3.648

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	.404E-01	.450E-01	0.	0.	0.	.278E-01
HYDROCARBON GASES	.240	1.07	0.	0.	0.	.204
CARBON OXIDES	.828	0.	4.79	0.	0.	1.93
WATER	0.	3.44	4.50	0.	0.	1.49
AMMONIA	0.	3.99	0.	100.	0.	1.08
HYDROGEN SULFIDE	0.	1.74	0.	0.	100.	1.42
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	1.11	10.3	9.29	100.	100.	6.15

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 9.900 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	2.645	LB/HR	COAL FED	100.0	GRAMS
HYDROGEN FLOW RATE	1.100	LB/HR	CHAR	0.	GRAMS
HYDROGEN PRESSURE	2000.	PSI	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	775.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	785.0	DEG C	WATER	0.	GRAMS

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	48.90	0.
HYDROGEN	3.900	0.
OXYGEN	36.70	0.
NITROGEN	.7000	0.
SULFUR	1.200	0.
ASH	8.600	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1130E-02	7.782	9.710
CARBON DIOXIDE	.1480E-03	.6487	1.272
METHANE	.2290E-02	27.54	19.68
ETHYLENE	0.	0.	0.
ETHANE	.4590E-03	5.889	3.944
BENZENE	.6170E-03	9.143	5.302
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.8000E-05	.1186	.6874E-01
WATER	.6680E-03	0.	5.740
TOTAL		51.12	45.71

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.26	9.74	0.	0.	0.	5.37
HYDROCARBON GASES	33.4	134.	0.	0.	0.	23.6
CARBON OXIDES	8.43	0.	16.1	0.	0.	11.0
WATER	0.	14.9	12.7	0.	0.	5.74
AMMONIA	0.	3.85	0.	100.	0.	.930
HYDROGEN SULFIDE	0.	1.92	0.	0.	100.	1.39
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	51.1	165.	28.8	100.	100.	40.0

HYDROGEN CONSUMPTION-	.2532E-01	LB HYDROGEN/LB COAL
	.6215	MOLE HYDROGEN/MOLE CARBON

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 8.300 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	.9257	LB/HR	COAL FED	100.0	GRAMS
HYDROGEN FLOW RATE	1.050	LB/HR	CHAR	0.	GRAMS
HYDROGEN PRESSURE	2000.	PSI	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	785.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	785.0	DEG C	WATER	0.	GRAMS

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	57.10	0.
HYDROGEN	4.300	0.
OXYGEN	26.30	0.
NITROGEN	.8000	0.
SULFUR	1.200	0.
ASH	10.30	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.4400E-03	7.078	10.51
CARBON DIOXIDE	0.	0.	0.
METHANE	.5940E-03	16.68	14.18
ETHYLENE	0.	0.	0.
ETHANE	.3310E-03	9.920	7.904
BENZENE	.2940E-03	10.18	7.020
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.8300E-04	2.874	1.982
WATER	.6080E-03	0.	14.52
TOTAL		46.73	56.12
TOTAL MATERIAL BALANCE, %			

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	13.0	14.5	0.	0.	0.	9.00
HYDROCARBON GASES	26.6	108.	0.	0.	0.	22.1
CARBON OXIDES	7.08	0.	20.5	0.	0.	10.5
WATER	0.	33.6	44.0	0.	0.	14.5
AMMONIA	0.	3.99	0.	100.	0.	1.08
HYDROGEN SULFIDE	0.	1.74	0.	0.	100.	1.42
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	46.7	161.	64.5	100.	100.	58.6

HYDROGEN CONSUMPTION- .3641E-01 LB HYDROGEN/LB COAL
.5549 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 46.73 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 50.92 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.500 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.752	LB/HR	COAL FED	400.0	GRAMS
HYDROGEN FLOW RATE	1.150	LB/HR	CHAR	180.0	GRAMS
HYDROGEN VELOCITY	.4000	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	775.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	785.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1500.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	76.40
HYDROGEN	4.660	2.500
OXYGEN	26.42	3.050
NITROGEN	.9200	.7000
SULFUR	.9400	.8500
ASH	7.460	16.50

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.6870E-03	6.126	9.201
CARBON DIOXIDE	.6800E-04	.3859	.9107
METHANE	.8820E-03	13.73	11.81
ETHYLENE	0.	0.	0.
ETHANE	.3490E-03	5.798	4.674
BENZENE	.2770E-03	5.314	3.710
TOLUENE	.5000E-05	.9488E-01	.8896E-01
XYLENE	0.	0.	0.
LIGHT OIL	.5600E-04	1.075	.7500
WATER	.9190E-03	0.	12.31

TOTAL 32.53 43.43
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.48	6.96	0.	0.	0.	4.53
HYDROCARBON GASES	19.5	77.6	0.	0.	0.	16.5
CARBON OXIDES	6.51	0.	20.7	0.	0.	10.1
WATER	0.	27.2	38.3	0.	0.	12.3
AMMONIA	0.	2.78	0.	65.8	0.	.794
HYDROGEN SULFIDE	0.	.748	0.	0.	59.3	.640
CHAR	57.7	24.1	5.19	34.2	40.7	40.6
TOTAL	90.2	139.	64.2	100.	100.	85.5

HYDROGEN CONSUMPTION- .1836E-01 LB HYDROGEN/LB COAL
.3697 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 32.53 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 35.97 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.800 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED MTS.		
COAL FEED RATE	1.031	LB/HR	COAL FED	220.0	GRAMS
HYDROGEN FLOW RATE	1.000	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.3500	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	780.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	785.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1500.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.6740E-03	8.878	13.33
CARBON DIOXIDE	.2100E-04	.1760	.4154
METHANE	.1542E-02	35.46	30.51
ETHYLENE	0.	0.	0.
ETHANE	.2690E-03	6.601	5.322
BENZENE	.4140E-03	11.73	8.190
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.3000E-04	.8506	.5935
WATER	.5980E-03	0.	11.83

TOTAL 63.70 70.19
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	12.6	13.5	0.	0.	0.	8.78
HYDROCARBON GASES	42.1	173.	0.	0.	0.	35.8
CARBON OXIDES	9.05	0.	27.7	0.	0.	13.7
WATER	0.	26.1	36.8	0.	0.	11.8
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	63.7	219.	64.6	100.	100.	72.5

HYDROGEN CONSUMPTION- .5526E-01 LB HYDROGEN/LB COAL
1.113 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 58.69 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 71.33 PERCENT

COAL TYPE- NORTH DAKOTA LIGHTITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.800 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.190	LB/HR	COAL FED	230.0	GRAMS
HYDROGEN FLOW RATE	1.080	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.3800	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	1500.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.5550E-03	6.842	10.28
CARBON DIOXIDE	.1400E-04	.1098	.2592
METHANE	.8950E-03	19.27	16.57
ETHYLENE	0.	0.	0.
ETHANE	.2400E-03	5.513	4.444
BENZENE	.2800E-03	7.427	5.185
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.5700E-04	1.513	1.055
WATER	.5000E-03	0.	9.250

TOTAL 40.67 47.05
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	8.94	9.58	0.	0.	0.	6.24
HYDROCARBON GASES	24.8	100.	0.	0.	0.	21.0
CARBON OXIDES	6.95	0.	21.2	0.	0.	10.5
WATER	0.	20.4	28.8	0.	0.	9.26
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	40.7	136.	50.0	100.	100.	49.3

HYDROGEN CONSUMPTION- .1675E-01 LB HYDROGEN/LB COAL
.3373 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 40.67 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 46.92 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 8.800 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.018	LB/HR	COAL FED	205.0	GRAMS
HYDROGEN FLOW RATE	1.060	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.2200	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	2500.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3740E-03	5.289	7.945
CARBON DIOXIDE	.1400E-04	.1260	.2974
METHANE	.1834E-02	45.29	38.96
ETHYLENE	0.	0.	0.
ETHANE	.1700E-03	4.479	3.614
BENZENE	.1160E-03	3.530	2.464
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1400E-04	.4263	.2974
WATER	.4730E-03	0.	10.05

TOTAL 59.14 63.62

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.96	4.24	0.	0.	0.	2.76
HYDROCARBON GASES	49.8	209.	0.	0.	0.	42.6
CARBON OXIDES	5.42	0.	16.7	0.	0.	8.24
WATER	0.	22.2	31.3	0.	0.	10.0
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	59.1	241.	47.9	100.	100.	65.9

HYDROGEN CONSUMPTION- .6559E-01 LB HYDROGEN/LB COAL
1.321 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 57.79 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 79.24 PERCENT

COAL TYPE- NORTH DAKOTA LIGHTITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 8.100 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	.9257	LB/HR	COAL FED	215.0	GRAMS
HYDROGEN FLOW RATE	1.000	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.2600	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	2000.	PSI			

TOTAL ACCUMULATED MTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.4220E-03	6.194	9.303
CARBON DIOXIDE	0.	0.	0.
METHANE	.1238E-02	31.73	27.29
ETHYLENE	0.	0.	0.
ETHANE	.1730E-03	4.731	3.814
BENZENE	.2380E-03	7.516	5.246
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.6000E-05	.1896	.1323
WATER	.4870E-03	0.	9.413
TOTAL		50.35	55.20

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	7.71	8.27	0.	0.	0.	5.38
HYDROCARBON GASES	36.5	151.	0.	0.	0.	31.1
CARBON OXIDES	6.19	0.	18.6	0.	0.	9.30
WATER	0.	20.8	29.3	0.	0.	9.41
AMMONIA	0.	4.27	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	50.4	186.	47.9	100.	100.	57.5

HYDROGEN CONSUMPTION- .4005E-01 LB HYDROGEN/LB COAL
.8064 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 50.35 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 63.98 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 9.500 SECONDS

NOMINAL CONDITIONS

			TOTAL ACCUMULATED MTS.		
COAL FEED RATE	.7670	LB/HR	COAL FED	190.0	GRAMS
HYDROGEN FLOW RATE	.9700	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.1700	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	3000.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.2670E-03	4.588	6.890
CARBON DIOXIDE	0.	0.	0.
METHANE	.1694E-02	50.82	43.72
ETHYLENE	0.	0.	0.
ETHANE	.1800E-03	5.762	4.645
BENZENE	.5500E-04	2.033	1.419
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.5000E-05	.1849	.1290
WATER	.3820E-03	0.	9.858

TOTAL 63.39 66.66
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	2.22	2.38	0.	0.	0.	1.55
HYDROCARBON GASES	56.6	237.	0.	0.	0.	48.4
CARBON OXIDES	4.59	0.	13.8	0.	0.	6.89
WATER	0.	21.7	30.7	0.	0.	9.86
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	63.4	266.	44.5	100.	100.	68.9

HYDROGEN CONSUMPTION- .7751E-01 LB HYDROGEN/LB COAL
1.561 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 58.63 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 82.95 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 9.500 SECONDS

NOMINAL CONDITIONS				TOTAL ACCUMULATED WTS.	
COAL FEED RATE	1.217	LB/HR	COAL FED	315.0	GRAMS
HYDROGEN FLOW RATE	1.080	LB/HR	CHAR	0.	GRAMS
HYDROGEN PRESSURE	3000.	PSI	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	WATER	0.	GRAMS

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.4780E-03	5.765	8.659
CARBON DIOXIDE	0.	0.	0.
METHANE	.1550E-02	32.64	28.08
ETHYLENE	0.	0.	0.
ETHANE	.4250E-03	9.550	7.699
BENZENE	.3690E-03	9.575	6.684
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.4400E-04	1.142	.7970
WATER	.4790E-03	0.	8.677

TOTAL 58.67 60.59
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	10.7	11.5	0.	0.	0.	7.48
HYDROCARBON GASES	42.2	171.	0.	0.	0.	35.8
CARBON OXIDES	5.76	0.	17.3	0.	0.	8.66
WATER	0.	19.1	27.0	0.	0.	8.68
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	58.7	207.	44.3	100.	100.	62.9

HYDROGEN CONSUMPTION- .4986E-01 LB HYDROGEN/LB COAL
1.004 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 57.69 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 73.83 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 9.500 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	.7670	LB/HR	COAL FED	310.0	GRAMS
HYDROGEN FLOW RATE	1.020	LB/HR	CHAR	0.	GRAMS
HYDROGEN PRESSURE	3000.	PSI	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	775.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	775.0	DEG C	WATER	0.	GRAMS

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1240E-03	2.240	3.365
CARBON DIOXIDE	0.	0.	0.
METHANE	.9840E-03	31.04	26.70
ETHYLENE	0.	0.	0.
ETHANE	.2590E-03	8.718	7.028
BENZENE	.1590E-03	6.181	4.315
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.2540E-03	0.	6.893

TOTAL 48.18 48.30
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.18	6.63	0.	0.	0.	4.31
HYDROCARBON GASES	39.8	161.	0.	0.	0.	33.7
CARBON OXIDES	2.24	0.	6.73	0.	0.	3.36
WATER	0.	15.2	21.5	0.	0.	6.89
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	48.2	189.	28.2	100.	100.	50.6

HYDROGEN CONSUMPTION- .4131E-01 LB HYDROGEN/LB COAL
.8318 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 48.18 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 66.69 PERCENT

COAL TYPE- NORTH DAKOTA LIGHTITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 9.500 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.801	LB/HR	COAL FED	700.0	GRAMS
HYDROGEN FLOW RATE	.9100	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.1600	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	3000.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.7290E-03	5.004	7.516
CARBON DIOXIDE	.6880E-04	.3006	.7093
METHANE	.4488E-02	53.78	46.27
ETHYLENE	0.	0.	0.
ETHANE	.3540E-04	.4527	.3650
BENZENE	.5090E-04	.7517	.5248
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.5600E-04	.8275	.5774
WATER	0.	0.	0.

TOTAL 61.12 55.96
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	1.58	1.69	0.	0.	0.	1.10
HYDROCARBON GASES	54.2	232.	0.	0.	0.	46.6
CARBON OXIDES	5.30	0.	16.8	0.	0.	8.23
WATER	0.	0.	0.	0.	0.	0.
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.03
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	61.1	240.	16.8	100.	100.	58.2

HYDROGEN CONSUMPTION- .6502E-01 LB HYDROGEN/LB COAL
1.309 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 58.20 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 82.45 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 10.00 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	.9654	LB/HR	COAL FED	387.0	GRAMS
HYDROGEN FLOW RATE	.8500	LB/HR	CHAR	52.31	GRAMS
HYDROGEN VELOCITY	.1425	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	3000.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3950E-03	4.725	7.097
CARBON DIOXIDE	.1000E-04	.7613E-01	.1797
METHANE	.8750E-03	18.28	15.72
ETHYLENE	0.	0.	0.
ETHANE	.3260E-03	7.266	5.857
BENZENE	.2880E-03	7.413	5.175
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.2700E-04	.6953	.4851
WATER	.3910E-03	0.	7.025

TOTAL 38.45 41.54
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	8.11	8.69	0.	0.	0.	5.66
HYDROCARBON GASES	25.5	102.	0.	0.	0.	21.6
CARBON OXIDES	4.80	0.	14.7	0.	0.	7.28
WATER	0.	15.5	21.9	0.	0.	7.03
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	14.6
TOTAL	38.5	132.	36.5	100.	100.	58.4

HYDROGEN CONSUMPTION- .1469E-01 LB HYDROGEN/LB COAL
.2959 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 38.45 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 46.79 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 9.900 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	.7326	LB/HR	TOTAL ACCUMULATED WTS.		
HYDROGEN FLOW RATE	.9000	LB/HR	COAL FED	371.3	GRAMS
HYDROGEN VELOCITY	.1494	FT/SEC	CHAR	130.1	GRAMS
REACTOR TEMP.	740.0	DEG C	LIGHT OILS	0.	GRAMS
PREHEAT TEMP.	740.0	DEG C	BTX	0.	GRAMS
HYDROGEN PRESSURE	3000.	PSI	WATER	0.	GRAMS

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3620E-03	6.042	9.075
CARBON DIOXIDE	0.	0.	0.
METHANE	.7230E-03	21.07	18.12
ETHYLENE	0.	0.	0.
ETHANE	.3290E-03	10.23	8.247
BENZENE	.2790E-03	10.02	6.994
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.5000E-04	1.796	1.253
WATER	.3650E-03	0.	9.150

TOTAL 49.16 52.84
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	11.8	12.7	0.	0.	0.	8.25
HYDROCARBON GASES	31.3	123.	0.	0.	0.	26.4
CARBON OXIDES	6.04	0.	18.2	0.	0.	9.07
WATER	0.	20.2	28.5	0.	0.	9.15
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	37.9
TOTAL	49.2	162.	46.6	100.	100.	93.0

HYDROGEN CONSUMPTION- .2876E-01 LB HYDROGEN/LB COAL
.5791 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 49.16 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 59.07 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 8.700 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.521	LB/HR	COAL FED	631.0	GRAMS
HYDROGEN FLOW RATE	.8000	LB/HR	CHAR	255.5	GRAMS
HYDROGEN VELOCITY	.2011	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	2000.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1136E-02	8.119	12.19
CARBON DIOXIDE	.7000E-04	.3184	.7514
METHANE	.2200E-02	27.45	23.62
ETHYLENE	0.	0.	0.
ETHANE	.4110E-03	5.473	4.412
BENZENE	.4930E-03	7.581	5.292
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.4700E-04	.7231	.5045
WATER	.8690E-03	0.	9.328

TOTAL 49.67 56.10

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	8.30	8.90	0.	0.	0.	5.80
HYDROCARBON GASES	32.9	135.	0.	0.	0.	28.0
CARBON OXIDES	8.44	0.	26.3	0.	0.	12.9
WATER	0.	20.6	29.0	0.	0.	9.33
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	43.8

TOTAL 49.7 170. 55.4 100. 100. 102.

HYDROGEN CONSUMPTION- .3283E-01 LB HYDROGEN/LB COAL
.6610 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 49.67 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 58.96 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 7.400 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.455	LB/HR	COAL FED	548.7	GRAMS
HYDROGEN FLOW RATE	.8800	LB/HR	CHAR	147.5	GRAMS
HYDROGEN VELOCITY	.2950	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	1500.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8530E-03	7.011	10.53
CARBON DIOXIDE	.8400E-04	.4394	1.037
METHANE	.1674E-02	24.02	20.66
ETHYLENE	0.	0.	0.
ETHANE	.4420E-03	6.768	5.456
BENZENE	.4120E-03	7.286	5.086
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1280E-03	2.265	1.580
WATER	.4200E-03	0.	3.185

TOTAL 47.79 49.54
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.55	10.2	0.	0.	0.	6.67
HYDROCARBON GASES	30.8	125.	0.	0.	0.	26.1
CARBON OXIDES	7.45	0.	23.7	0.	0.	11.6
WATER	0.	11.4	16.1	0.	0.	5.18
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	29.0
TOTAL	47.8	152.	39.9	100.	100.	80.9

HYDROGEN CONSUMPTION- .2427E-01 LB HYDROGEN/LB COAL
.4886 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 47.79 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 56.77 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 9.200 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.342	LB/HR	COAL FED	550.0	GRAMS
HYDROGEN FLOW RATE	.8550	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.1804	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	2500.	PSI			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.6060E-03	5.244	7.877
CARBON DIOXIDE	.2600E-04	.1432	.3380
METHANE	.3611E-02	54.56	46.94
ETHYLENE	0.	0.	0.
ETHANE	.1180E-03	1.903	1.534
BENZENE	.3800E-04	.7076	.4939
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1000E-04	.1863	.1300
WATER	.7490E-03	0.	9.736

TOTAL 62.75 67.05
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	.894	.958	0.	0.	0.	.624
HYDROCARBON GASES	56.5	240.	0.	0.	0.	48.5
CARBON OXIDES	5.39	0.	16.6	0.	0.	8.21
WATER	0.	21.5	30.3	0.	0.	9.74
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	62.7	268.	46.9	100.	100.	69.3

HYDROGEN CONSUMPTION- .7842E-01 LB HYDROGEN/LB COAL
1.579 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 58.51 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 82.98 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 2.300 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.342	LB/HR	COAL FED	550.0	GRAMS
HYDROGEN FLOW RATE	.8550	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.1804	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	2500.	PSI			

TOTAL ACCUMULATED WTS.

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	59.60	0.
HYDROGEN	4.660	0.
OXYGEN	26.42	0.
NITROGEN	.9200	0.
SULFUR	.9400	0.
ASH	7.460	0.

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.4410E-03	3.817	5.732
CARBON DIOXIDE	.3900E-04	.2148	.5069
METHANE	.3326E-02	50.26	43.23
ETHYLENE	0.	0.	0.
ETHANE	.1290E-03	2.080	1.677
BENZENE	.1990E-03	3.705	2.587
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.5000E-06	.9315E-02	.6499E-02
WATER	.1580E-03	0.	2.054

TOTAL 60.08 55.80
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.71	3.99	0.	0.	0.	2.59
HYDROCARBON GASES	52.3	222.	0.	0.	0.	44.9
CARBON OXIDES	4.03	0.	12.8	0.	0.	6.24
WATER	0.	4.53	6.39	0.	0.	2.05
AMMONIA	0.	4.23	0.	100.	0.	1.21
HYDROGEN SULFIDE	0.	1.26	0.	0.	100.	1.08
CHAR	0.	0.	0.	0.	0.	0.
TOTAL	60.1	236.	19.2	100.	100.	58.1

HYDROGEN CONSUMPTION- .6359E-01 LB HYDROGEN/LB COAL
1.280 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 57.99 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 82.37 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 9.600 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.316	LB/HR	COAL FED	577.0	GRAMS
HYDROGEN FLOW RATE	.8200	LB/HR	CHAR	181.0	GRAMS
HYDROGEN VELOCITY	.1649	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	ETX	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	.7720E-03	6.592	9.929
CARBON DIOXIDE	.4700E-04	.2554	.6045
METHANE	.1802E-02	26.86	23.18
ETHYLENE	0.	0.	0.
ETHANE	.5190E-03	8.256	6.675
BENZENE	.4890E-03	8.983	6.289
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.4900E-04	.9007	.6302
WATER	.7640E-03	0.	9.826

TOTAL 51.85 57.13
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.88	11.7	0.	0.	0.	6.92
HYDROCARBON GASES	35.1	156.	0.	0.	0.	29.9
CARBON OXIDES	6.85	0.	21.2	0.	0.	10.5
WATER	0.	23.8	30.3	0.	0.	9.83
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.	34.3
TOTAL	51.9	198.	51.5	100.	100.	93.7

HYDROGEN CONSUMPTION- .4095E-01 LB HYDROGEN/LB COAL
.8315 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 51.85 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 62.88 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 2.400 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.316	LB/HR	COAL FED	577.0	GRAMS
HYDROGEN FLOW RATE	.8200	LB/HR	CHAR	181.0	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	.6130E-03	5.234	7.884
CARBON DIOXIDE	.6200E-04	.3369	.7974
METHANE	.1358E-02	20.25	17.47
ETHYLENE	0.	0.	0.
ETHANE	.4450E-03	7.079	5.723
BENZENE	.4190E-03	7.698	5.389
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.2610E-03	4.797	3.357
WATER	.9150E-03	0.	11.77

TOTAL 45.39 52.38
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	12.5	14.7	0.	0.	0.	8.75
HYDROCARBON GASES	27.3	121.	0.	0.	0.	23.2
CARBON OXIDES	5.57	0.	17.6	0.	0.	8.68
WATER	0.	28.5	36.3	0.	0.	11.8
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.	34.3
TOTAL	45.4	170.	53.9	100.	100.	88.9

HYDROGEN CONSUMPTION- .2932E-01 LB HYDROGEN/LB COAL
.5954 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 45.39 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 54.10 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 2.500 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.382	LB/HR	COAL FED	627.2	GRAMS
HYDROGEN FLOW RATE	.8000	LB/HR	CHAR	198.2	GRAMS
HYDROGEN VELOCITY	.1341	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	3000.	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	.7850E-03	6.226	9.379
CARBON DIOXIDE	.3100E-04	.1565	.3704
METHANE	.2738E-02	37.92	32.71
ETHYLENE	0.	0.	0.
ETHANE	.6200E-03	9.162	7.407
BENZENE	.4730E-03	8.072	5.651
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.2770E-03	4.730	3.309
WATER	.1000E-04	0.	.1195

TOTAL 66.26 58.95

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	12.8	15.1	0.	0.	0.	8.96
HYDROCARBON GASES	47.1	212.	0.	0.	0.	40.1
CARBON OXIDES	6.38	0.	19.5	0.	0.	9.75
WATER	0.	.289	.368	0.	0.	.119
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.	34.5
TOTAL	66.3	233.	19.9	100.	100.	95.7

HYDROGEN CONSUMPTION- .5579E-01 LB HYDROGEN/LB COAL
1.133 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 59.15 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 75.56 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 2.500 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.382	LB/HR	COAL FED	627.2	GRAMS
HYDROGEN FLOW RATE	.8000	LB/HR	CHAR	198.2	GRAMS
HYDROGEN VELOCITY	.1341	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	3000.	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	.7860E-03	6.234	9.391
CARBON DIOXIDE	.3300E-04	.1666	.3943
METHANE	.2847E-02	39.43	34.01
ETHYLENE	0.	0.	0.
ETHANE	.6810E-03	10.06	8.136
BENZENE	.4970E-03	8.482	5.938
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.3080E-03	5.259	3.680
WATER	.9000E-05	0.	.1075

TOTAL 69.63 61.66
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	13.7	16.2	0.	0.	0.	9.62
HYDROCARBON GASES	49.5	222.	0.	0.	0.	42.2
CARBON OXIDES	6.40	0.	19.6	0.	0.	9.78
WATER	0.	.260	.331	0.	0.	.108
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.	34.5
TOTAL	69.6	244.	19.9	100.	100.	98.4

HYDROGEN CONSUMPTION- .6058E-01 LB HYDROGEN/LB COAL
1.230 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 59.72 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 76.50 PERCENT

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.400 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED MTS.		
COAL FEED RATE	1.440	LB/HR	COAL FED	630.0	GRAMS
HYDROGEN FLOW RATE	.8750	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.4400	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			

	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	.1043E-02	8.683	13.08
CARBON DIOXIDE	.5000E-04	.2649	.6270
METHANE	.9830E-03	14.29	12.33
ETHYLENE	0.	0.	0.
ETHANE	.3820E-03	5.925	4.790
BENZENE	.3450E-03	6.179	4.326
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.4730E-03	0.	5.931

TOTAL 35.34 41.08
TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.18	7.29	0.	0.	0.	4.33
HYDROCARBON GASES	20.2	88.5	0.	0.	0.	17.1
CARBON OXIDES	8.95	0.	27.5	0.	0.	13.7
WATER	0.	14.4	18.3	0.	0.	5.93
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	35.3	116.	45.7	100.	100.	43.3

HYDROGEN CONSUMPTION- .6741E-02 LB HYDROGEN/LB COAL
.1369 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 35.34 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 36.37 PERCENT

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