FLASH HYDROLYSIS OF COAL

QUARTERLY REPORT NO. 4
FOR THE PERIOD OCTOBER 1 TO DECEMBER 31, 1977

February 1978

PROCESS SCIENCES DIVISION
DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

UNDER CONTRACT NO. EY-76-C-02-0016 WITH THE
UNITED STATES DEPARTMENT OF ENERGY

DISCLAIMER

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

DISCLAIMER

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

FLASH HYDROLYSIS OF COAL

QUARTERLY REPORT NO. 4
FOR THE PERIOD OCTOBER 1 TO DECEMBER 31, 1977

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

February 1978

MEYER STEINBERG, HEAD
PETER FALLON, Project Leader

PROCESS SCIENCES DIVISION
DEPARTMENT OF ENERGY AND ENVIRONMENT

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy (DOE), nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Price: Printed Copy \$5.25; Microfiche \$3.00

May 1978

400 copies

TABLE OF CONTENTS

	<u>Page No.</u>
ABSTRACT	1
I. OBJECTIVE AND SCOPE OF WORK	3
II. SUMMARY OF PROGRESS TO DATE	3
III. DETAILED DESCRIPTION OF TECHNICAL PROGRESS	4
A. Task 1. Design and Order Equipment for 1 lb/hr Unit	4
1. Work Accomplished	4
2. Work Forecast	4
B. Task 2. Construction and Operation of 1 lb/hr Unit	5
1. Work Accomplished	5
2. Work Forecast	6
C. Task 3. Development of Analytical System	6
1. Work Accomplished	6
a. Product Analysis and Identification	6
b. Material Balance	7
2. Work Forecast	7
D. Task 4. Testing of Assembled Unit Including Analytic System	7
1. Work Accomplished	7
2. Work Forecast	7
E. Task 5. Study the Effect and Process Variables on Product Distribution and Yields	8
1. Work Accomplished	8
a. Effect of Temperature, Pressure & Residence Time	8
b. Exploratory Runs	9
2. Work Forecast	10
F. Task 6. Process Design & Economic Evaluation	10
1. Work Accomplished	10
2. Work Forecast	10
IV. CONCLUSIONS	10
V. REFERENCES	11
TABLES	12-13
FIGURES	14-20
APPENDIX	18-58

LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
I	FRACTION CARBON CONVERTED AT 4000 PSIG AND 700°C	12
II	EFFECT OF CHAR ADDITION TO LIGNITE FEED-FRACTION CARBON CONVERTED AT 750°C AND 2000 PSIG (BASED ON LIGNITE ONLY)	12
III	A CAKING BITUMINOUS COAL TREATED WITH CaO-FRACTION CARBON CONVERTED AT 2000 PSIG AND 750°C	13
IV	EFFECT OF TREATING LIGNITE WITH Fe_2O_3 -FRACTION CARBON CONVERTED AT 2000 PSIG AND 750°C	13

LIST OF FIGURES

<u>Figure No.</u>		<u>Page</u>
1	BOILING RANGE OF FLASH HYDROLYSIS LIQUID HYDROCARBON PRODUCT % WT. LOSS VS. TEMPERATURE	14
2	FLASH HYDROLYSIS OF LIGNITE FRACTION CARBON CONVERTED VS. RESIDENCE TIME TEMPERATURE 750°C, PRESSURE 500 PSIG	15
3	FLASH HYDROLYSIS OF LIGNITE FRACTION CARBON CONVERTED VS. RESIDENCE TIME TEMPERATURE 775°C, PRESSURE 2500 PSIG HYDROGEN NOT PREHEATED	15
4	FLASH HYDROLYSIS OF LIGNITE AND CHAR (50-50) FRACTION CARBON CONVERTED VS. RESIDENCE TIME TEMPERATURE 750°C, PRESSURE 2000 PSIG	16
5	FLASH HYDROLYSIS OF SUB-BITUMINOUS FRACTION CARBON CONVERTED VS. RESIDENCE TIME TEMPERATURE 750°C, PRESSURE 2000 PSIG	16
6	FLASH HYDROLYSIS OF LIGNITE FRACTION CARBON CONVERTED VS. RESIDENCE TIME TEMPERATURE 800°C, PRESSURE 2000 PSIG	17
7	FLASH HYDROLYSIS OF LIGNITE FRACTION CARBON CONVERTED VS. RESIDENCE TIME TEMPERATURE 850°C, PRESSURE 2000 PSIG	17

ABSTRACT

The principal objective of this program is to experimentally study the process variables and chemistry of the Flash Hydropyrolysis Process, a rapid gas-phase, non-catalytic coal hydrogenation technique developed at BNL for the conversion to gaseous and liquid fuels. The experimental equipment used for this purpose is a highly instrumented 1 inch down-flow tubular reactor originally designed to operate at up to 4000 psi and 800°C, with coal feed up to 1 lb/hr. These conditions are being extended to include temperatures to 900°C at pressures $\leq$ 2500 psi and coal feed to 2 lbs/hr. The equipment has been operated for more than a year with only one major problem, the failure of the original electric resistance hydrogen preheater. This has been replaced with one fabricated from a superior alloy.

Coal and char analysis are continuing to be performed on a routine basis. The water produced in the hydrogenation reaction and collected with the liquid hydrocarbon product is being studied for such components as phenols and ammonia in order to further close the material balances. The possibility of phenols in the aqueous phase has become of particular interest since in two analyses performed by other laboratories on the collected liquid hydrocarbons produced, phenols were reported by one and not the other.

A second distillation curve was performed on the total organic liquid product, this time extending the distillation temperature range to 350°C. The results were similar to the first curve indicating that the liquid contains approximately 50% BTX (benzene, toluene, xylene) and 50% heavier hydrocarbons. A sulfur analyzer has been received, assembled and tested and found to be reproducible to within $\pm 1.2\%$ for analysis of sulfur in coal, coke and char.

Attempts to operate the experimental equipment at its maximum design pressure, 4000 psi, during this quarter has had limited success. Most of the problems were associated with leaks in the process gas sampling taps, requiring some modifications to this system.

A major portion of the experimental effort was devoted to the study of the effect of coal particle residence time. In some cases, the total hydrocarbon yields were observed to decrease with increased residence time and in most cases, the carbon monoxide increased with increasing residence time. The reduction in hydrocarbon yield occurred in different runs conducted at low pressure (500 psi) and in runs conducted at temperatures of $\geq 800^\circ\text{C}$. At 500 psi as much as a 40% reduction in methane was observed as the residence time increased from approximately 1 to 4.5 seconds. A loss in hydrocarbon yield could only be caused by the products either coking or forming a product such as the heavier liquid hydrocarbons ($\geq \text{C}_9$) which are not measured by the on-line chromatograph.

A number of exploratory runs were also conducted including the use of a Battelle Treated Coal (BTC-caking coal treated with CaO), a New Mexico sub-bituminous coal, a mixture of lignite and lignite char and a lignite impregnated with iron. The BTC ran well in the reactor with no caking and gives a total hydrocarbon yield of 51% with 20% liquids based on conversion of the carbon feed. Although the sub-bituminous coal produced a total hydrocarbon yield of only 41.8% with 13.7% liquids, the experimental conditions used were those found to give substantial yields for lignite and may not be ideal for sub-bituminous. The lignite-char mixture gave improved results, 12.2% BTX and a total hydrocarbon yield of 64.6%. These results were calculated on the carbon in the fresh coal feed and some of the yields could have originated from unreacted portions of the char. The result of significance for the experiment using iron was a 61% increase in BTX yield (from 7.6% to 12.2% carbon conversion), an 80% increase in ethane yield (from 5.5% to 9.9%) and a 49% decrease in light oils. These results need repetition for confirmation.

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

Some minor operating problems were encountered with the experimental equipment. None involved the safety of the personnel or the equipment or resulted in the loss of any appreciable time and all have been corrected. The modifications necessary included the installation of additional filters, the increase in the torque of the sample valve actuators and the replacement of these valves with ones of higher pressure rating. With these changes, the reliability of the system continues to improve and is presently operating very satisfactorily.

The LECO Sulfur Analyzer has been received and tested. The instrument is being used to analyze sulfur in the coal and char products. The analysis of a standard coal sample supplied with the equipment gave results reproducible to within $\pm 1.2\%$ of each other and the average value was within 0.01% of the stated sulfur content of the sample. Also, an analysis requires only 15 minutes as compared to approximately a day using the Eschka method. A new column has been developed and installed in the research gas chromatograph (not the on-line process gas chromatograph). This column allows the identification of additional components of the liquid product removed from the cold traps after a run. Initially it is being used to determine the ratio of BTX (benzene, toluene, xylene) to heavier compounds in the condensed liquid product. A second column is being sought for determination of other hydrocarbon, particularly phenols that may be present in the water produced and collected during hydrogenation. This aqueous phase has already been found to contain ammonia in concentrations representing approximately 25% of the nitrogen in the coal feed.

A large portion of the experimental effort was devoted to the study of the effect of residence time on the products by use of the reactor sample taps along the length of this reactor tube. In almost every run, the CO was found to increase with increasing residence time; in one case by as much as a factor of four. The BTX was observed to increase with increased residence time at temperatures of 775°C and below and to decrease at temperature of 800°C or greater. The ethane followed the

same trend as the BTX except with less change. At 850°C and 2000 psi, the methane yield was seen to reach a maximum of 53% of the carbon feed at approximately 6 second residence time after which it decreased to 49% at 7.5 second residence time. Approximately the same results were observed at 800°C but less overall conversion. At 775°C and 2500 psi, no maximum was observed, most of the products continuing to increase with increased residence time. Although the maximum methane yield obtained at 750°C and 500 psi was only 14%, this was measured at the shortest residence time, approximately 1 second. As the residence time increased to the maximum of 4.5 seconds, the methane yield decreased to 10%.

A number of exploratory runs were conducted including the use of a Battelle Treated Coal (BTC - caking coal treated with CaO), a New Mexico sub-bituminous coal, a mixture of lignite and lignite char and a lignite impregnated with 5% iron by weight. The BTC fed well through the system without caking, producing yields of approximately 2% CO, 21% methane, 10% ethane, 9% BTX and 11% heavier liquid hydrocarbons for a total conversion of 53%. The sub-bituminous coal produced only approximately 45% total conversion including the CO, 7.4% of the yield being BTX and 6.3% heavier liquid hydrocarbons. The operating conditions of the reactor used for this run were those found to give substantial yields using lignite which may not be ideal for sub-bituminous. Further runs using sub-bituminous coal are indicated.

The lignite-char mixture produced greater yields than lignite alone, especially in BTX and ethane. The BTX increased approximately 61% (12.2% vs 7.6%) and the ethane increased approximately 118% (12% vs 5.5%). This may have been due to unreacted portions of the char. The iron impregnated coal also gave greater yields of BTX and ethane. The BTX increasing approximately 61% (12.2% vs 7.6%) and the ethane increasing approximately 80% (9.9% vs 5.5%). The heavier liquid hydrocarbons decreased approximately 50% (5% vs 10%). These liquids are known to be aromatic and may have been cracked accounting for the increase in BTX. Again, further study is indicated to increase the confidence in the encouraging results of these runs.

A regression analysis was made on the data on total carbon converted as a function of pressure at 750°C. The best correlation coefficient (0.76) was obtained with a third order fit.

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 and Operation of 1 lb/hr Experimental Reactor

1. Work Accomplished

A small crack developed in the hydrogen preheater close to where the hydrogen enters the reactor. The area in which the crack occurred was approximately 1" from a heavy walled coupling located between the preheater and the reactor. Although the exact cause of the failure has not been determined as yet, it appears to have been localized excess heating. As previously reported, the failure of the original Inconel 601 preheater after approximately 18 hours use was determined to have been caused by hydrogen embrittlement. The replacement preheater, fabricated from Inconel 617 had been in use for approximately one year with an excess of 100 hrs of operation at temperatures up to 815°C and pressures to 4000 psi. Samples of the same alloy, in the system for approximately the same length of time, on metallurgical examination showed no deterioration due to hydrogen embrittlement. The area of the failure, located down stream just prior to the hydrogen entering the reactor, would be the hottest section of the preheater. Also, the failure occurred on the underside where the affected area may have received additional heating from the top reactor heater. A further study will be made of the cause of the failure. Meanwhile, the preheater has been replaced with a spare on hand with only a slight delay in operations.

Additional Inconel 617 tubing used in the hydrogen preheater has been ordered. Although no problems have been experienced and none are anticipated with the present 1.5" OD x ½" wall Inconel 617 reactor, we have been unable to find a 13 ft. length of this tubing for fabrication of a replacement reactor. All that is available are 3 and 4 ft. lengths which would require joining by welding. Since some of these welds would be exposed to the maximum operating conditions of the system (4000 psi and 850°C) we are investigating the quality of the welds we could expect to obtain before ordering the shorter lengths. A number of trial electron beam welds were made on a 6 inch piece of tubing left from the original reactor. None of the welds were satisfactory and we are now investigating using an automatic inert gas welding machine.

Some problems were encountered when operating the equipment at 4000 psi. These have been due to the inability to operate the remote sampling valves against this higher pressure and the leakage of small quantities of gas from around the valve stems. To correct these, the torque of the valves remote actuations have been increased approximately 50% and the valves have been replaced with ones designed for 6000 psi service.

Additional in-line filters for the sample taps have been received and installed and all the taps are now functional. Whenever an experimental run is of sufficient duration, samples are taken from as many of these taps as possible. The order of priority is the tap at the char trap, the three taps located 2, 4 and 6 ft down the reactor length and finally the tap after the low temperature condenser.

Three thermocouples were placed in the reactor through the three reactor sample taps. These thermocouples both allow the monitoring of the process gas stream inside the reactor and reduce the volume of the sample lines thus reducing the gas residence time. Previously, all reactor temperature measurements were made on the outside wall of the vessel. Comparisons of the internal and external temperatures of the reactor during a few experimental runs showed no significant difference except at the 2 ft. tap. At this tap, the internal temperature tended to increase slightly at the beginning of the runs, probably due to the exothermic coal hydrogenation reaction.

2. Work Forecast

Some clogging of the filter located in the char trap has been experienced when conducting runs at low temperatures due to the production of a tar like product at these conditions. In order to clean the filter, the char trap must be removed and resealed with the loss of considerable time. Ideally, this filter should be located outside the char trap but no commercial filter has been found with the necessary capacity and rated at the pressures for which the system is designed. This will require the development of a suitable filter to meet the needs of the system. No other modification to the equipment is presently foreseen.

C. Task 3. Development of Analytical System

1. Work Accomplished

a. Product Analysis and Identification

The results of an analysis performed by the Institute of Gas Technology (IGT) on the liquid hydrocarbon product were very similar to those obtained by Oak Ridge National Laboratory (ORNL) on a similar liquid product. The only significant difference appears to be that IGT reported the presence of 3.26% oxygen containing compounds (1.78% Phenol) while ORNL reported finding none of these compounds. A new chromatographic column was placed in the Hewlett-Packard 5750 Gas Chromatograph used for product identification and analytic procedures being established. This will allow the in-house determination of phenols and other compounds suspected to be in the liquid hydrocarbon product. A second column is being sought which can be used to identify phenols in the water produced in the hydrogenation and collected in the condenser traps with the liquid hydrocarbons. Since phenols are soluble in alkali media and the water is highly alkaline, if phenols are present in the hydrocarbon phase, they should also be present in the aqueous phase.

A boiling range determination was made on a 100 CC sample of the liquid hydrocarbon product using an air cooled condenser. The results are shown in Figure 1. The first drop of liquid appeared at 78.5°C and the last at 314°C after 84% of the material had distilled over. The lack of smoothness in the distillation curve is probably due to the almost 50-50 split in the sample between BTX and the two ring and greater polynuclear aromatic hydrocarbons.

b. Material Balance

The Leco Sulfur Analyzer, an approved ASTM method for analysis of sulfur in coal and coke, has been received and placed into operation. The principle of operation is to oxidize the sulfur to SO_2 in an oxygen atmosphere, further oxidize the SO_2 to SO_3 with hydrogen peroxide, absorb the SO_3 in water and titrate the H_2SO_4 produced. Coals, cokes, chars and ash containing chlorine require that corrections be made. None of the coals anticipated to be used in this program contain any appreciable amounts of chlorine. Six determinations were made on a coal of a known sulfur content of 2.54%. The average result obtained was $2.53 \pm 0.03\%$, which is equivalent to a precision of $\pm 1.2\%$, thus indicating excellent agreement. Each determination took approximately 15 minutes as compared to the ESCHKA method previously used which took approximately a day for one analysis. These were the first determinations to be made on this instrument and the reproducibility can be expected to improve with continued use.

Analysis of the water produced during hydrogenation of lignite showed it to contain 2.26% by weight NH_4 . This accounts for the high pH of 9 previously reported for similar water samples and approximately 25% of the nitrogen contained in the coal feed. Another 25% of the nitrogen was found in the char leaving 50% which presently is believed to appear as N_2 in the gas effluent.

2. Work Forecast

The sulfur analyzer will be used for routine analysis of both coal and char samples to further close the sulfur material balance.

The aqueous phase will be examined for dissolved phenols and other hydrocarbons and an effort will be made to identify other unknown compounds found in this phase.

The new chromatograph column will be used to both identify as many of the major constituents of the liquid hydrocarbon product collected whenever sufficient product is collected and to determine the ratio of BTX to heavier liquids ($\geq \text{C}_9$). This ratio together with the analysis from the on-line gas chromatograph can then be used to determine the total quantity of heavier liquids produced thus allowing for a more accurate closure of the carbon balance.

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, Pressure and Residence Time

Attempts to complete the series of runs started at 4000 psi have been unsuccessful due to problems both related and unrelated to the high operating pressure. Some data was collected at 700°C but the yields were very low as shown in Table 1. Of significance is the fact that only small amounts of liquids were produced at this low temperature. The same observation was made in a previous run conducted at 750°C possibly indicating liquid yields to either decrease at these higher pressures or their formation to be more favorable at other temperatures.

A number of runs were conducted while sampling the product gas stream from the reactor sample taps and the char trap at the base of the reactor. These give product distribution and yield information as a function of residence time. The results of some of these runs are given in Figure 2 to 7. In most cases, the feed coal was lignite except for one run using a 50-50 lignite char mixture and another using a New Mexico sub-bituminous coal. Figure 2 shows the results of a run conducted at 750°C and 500 psig using lignite. The BTX yield appears to increase slightly with increased residence time while the ethane yield remains approximately the same and the methane decreases approximately 50%. The greatest change observed was that of the oxides of carbon (CO_x) which increased a factor of two as the residence time increased from 1.15 seconds to 4.6 seconds. The heavier liquid hydrocarbons ($\geq \text{C}_9$) are not reported in either this plot or the others as a completely satisfactory method of on-line measurement has not been developed. They can only be measured after the run when collected from the cold traps. From past experience, these liquids are known to be present in approximately the same concentration as the BTX. A method is being developed of incorporating the heavier hydrocarbons in the total yield by separate analysis.

Figure 3 shows the results of another run using lignite at 775°C and 2500 psig. In this run, the hydrogen was not preheated before entering the reactor. All products are shown to increase with increased residence time, except for the ethane yield which remained approximately constant at 10%. The total hydrocarbon yield was 53% without the inclusion of the heavier liquids which would probably bring the total to greater than 60%. As in the previously mentioned run and in another run conducted at 750°C and 1500 psig not shown, the oxides of carbon increase substantially with increased residence time.

Figure 4 shows the results of a run made using a 50-50 mixture of lignite and a lignite char from a previous run. The conditions used were 750°C and 2000 psig. Again the heavier liquids ($\geq \text{C}_9$) are not reported for the reason previously mentioned. The trends of yields

are similar to those of runs conducted using only lignite except that the yields were slightly greater. Table 2 shows the comparison between the char addition run and a standard lignite run. The BTX increased 61% (from 7.6% to 12.2%) and the ethane increased 118% (from 5.5% to 12.0%). This could be attributed to either a catalytic effect of the char or since the yields were calculated on the carbon contained in the coal feed only, some of the yield could have come from the char itself. Again a significant increase in oxides of carbon is seen with increased residence time.

Figure 5 shows the results of one run conducted using a New Mexico sub-bituminous coal at conditions of 750°C and 2000 psi. These results are very similar to those obtained when using lignite except for the greater yield of ethane ($\approx 15\%$) and the smaller quantity of CO_x produced ($\approx 3.5\%$) which also did not increase with residence time as it did with the lignite.

Figures 6 and 7 show the effect of residence time on two runs conducted at 2000 psi using lignite, one run at 800°C and the other at 850°C. In neither case are the heavy ($\geq \text{C}_9$) hydrocarbons included. The most significant observation is the fact that the hydrocarbon yields appear to reach a maximum and decrease with increased residence time. For this to happen, some of the lighter products would have to be decomposing (coking) or polymerizing going to a heavier compound which are not taken into account in the present analysis. Again the carbon monoxide is seen to increase with increased residence time. It is surprising to note that the methane also decreases with residence time even though methane is very stable at higher temperatures. Further study of this residence time effect is necessary.

The run conducted at 850°C (Fig. 7) is one of a new series of runs to be conducted at temperatures greater than 800°C. These are designed mainly to study the production of gaseous hydrocarbons, principally methane and ethane. Comparison with equilibrium calculations would be helpful here.

b. Exploratory Runs

A sample of Battelle Treated Coal (BTC) was run, at 2000 psi and 750°C, conditions known to produce substantial yields using lignite. This coal is a caking bituminous from Pittsburgh No. 8 seam, impregnated with CaO to reduce the caking properties. The coal fed well into the system and no caking was observed. The yields (Table 3) were similar to those obtained using lignite except for a slight increase in the production of ethane.

Two pounds of freshly ground lignite was impregnated with ferric oxalate $[\text{Fe}_2(\text{C}_2\text{O}_4)_3]$ to produce a coal containing 5% by weight iron. Since the oxalate decomposes to ferric oxide (Fe_2O_3) at approximately 100°C, the treated coal was baked for a day at 110°C. About half of this coal was then run in the reactor at 2000 psi of hydrogen and 750°C. The resulting yields were very low and the internal temperature of the reactor during the run were observed to be approximately 100°C below the wall temperature.

This was thought to have been caused by the incomplete decomposition of the oxalate. To correct this, the remaining coal was baked for approximately a week in a vacuum oven at 120°C and again run in the reactor under the same conditions. The results obtained with this coal were slightly greater than those obtained with untreated coal run at the same conditions (Table 4) except for an increase in BTX (+61%) at the expense of the light oils (-49%) and a large increase in ethane (+80%).

2. Work Forecast

A few runs will be conducted at 4000 psi to finish this series. By use of the reactor sampling taps, residence time effects will be studied on as many runs as possible while continuing to study the effect of temperature and pressure. The operating conditions for the reactor will be extended to 900°C at pressures $\leq$ 2000 psi to investigate optimizing the production of gaseous methane and ethane.

F. Task 6. Process Design and Economic Evaluation

1. Work Accomplished

An attempt at updating the economic evaluation is being made, however lack of funds preclude a new process design and evaluation for production of liquid fuel distillates and pipeline gas as coproducts.

A regression analysis was made on some of the data for the total carbon converted versus pressure at 750°C. The first order or linear fit gave a correlation coefficient of 0.62. This did not improve with the second order fit but did improve to 0.76 with the third order.

2. Work Forecast

Further correlation of the data will be made to develop empirical expressions relating product distribution and yield to reactor operating conditions. When sufficient information is available, the distribution and yields will also be related to coal particle residence times.

When funds become available a new process design and economic evaluation will be made on production of coproduct liquid fuel distillate and pipeline gas based on later experimental results of the FHP lignite process.

IV. CONCLUSIONS

The experimental equipment is operating very satisfactorily. The new sampling valves corrected the problems encountered with the sampling system and all taps are operational.

The Leco sulfur analyzer will allow more frequent and rapid analysis of sulfur in char and coal for better sulfur material balances. With the new gas chromatograph column, we can now measure the quantity of heavier liquid hydrocarbon products ($\geq C_9$) whenever sufficient

product is collected. The water produced during hydrogenation requires further study for the presence of any materials that may help to better close the C, N & S material balances.

Coal particle and gas stream residence times in the reaction zone is shown to have a significant effect on both the product yields and the distribution of these products. In some cases, especially at higher temperatures ($\geq 800^{\circ}\text{C}$) the yields appeared to be decreasing with additional residence time after having reached a maximum. This would mean some of the product is decomposing and going to higher hydrocarbons (coking) and CO or that the product is polymerizing to a heavy liquid which is not measured. Since some of the product disappearing is methane which is rather stable, this should be studied further. Comparisons with calculations of the equilibrium concentrations of products to be expected under reactor operating conditions should be helpful.

The effect of recycled char and iron oxide addition to the coal feed tend to improve the overall carbon conversion and the BTX and liquid hydrocarbon yield.

V. REFERENCES

1. Steinberg, M. and Fallon, P., "Coal Liquefaction by Rapid Gas Phase Hydrogenation", BNL Report 19507 (November 1974) presented at 169th National American Chemical Society Meeting, Philadelphia, Pa., (April 6-11, 1975).
2. Fallon, P. and Steinberg M., "Flash Hydropyrolysis of Coal, The Design, Construction, Operation and Initial Results of a Flash Hydropyrolysis Experimental Unit", BNL Report 22519 (January 1977) presented at 173rd National American Chemical Society Meeting, New Orleans, La., (March 20-25, 1977).

OTHER PUBLISHED REPORTS

1. Fallon, P. and Steinberg, M., "Flash Hydropyrolysis of Coal, Quarterly Report No. 1, January 1-March 31, 1977, BNL 50677.
2. Steinberg, M. and Fallon, P., "Flash Hydropyrolysis of Coal, Quarterly Report No. 2, April 1-June 30, 1977, BNL 50707.
3. Steinberg, M. and Fallon, P., "Flash Hydropryolysis of Coal", Fossil Energy/ERDA Crosscut Meeting, BNL 23282 (September 15, 1977).
4. Steinberg, M. and Fallon, P., "Flash Hydropryolysis of Coal", Quarterly Report No. 3, July 1 to September 30, 1977, BNL 50779.
5. Bhatt, B., Fallon, P., and Steinberg, M., "Economic Analysis of Flash Hydropryolysis", BNL 22912 (May 1977).
6. Steinberg, M. and Fallon, P., "Safety Analysis on the Brookhaven Coal Flash Hydropryolysis Experiment", BNL 21919 (Oct. 1976).

Table 1

FLASH HYDROLYSIS OF LIGNITE

Fraction Carbon Converted at 4000 psig and 700°C

CO	0.014
CH ₄	0.200
C ₂ H ₆	0.081
BTX	0.023
Light Oils	<u>0.015</u>
	0.333 Total

Table 2

FLASH HYDROLYSIS OF LIGNITE

EFFECT OF CHAR ADDITION TO LIGNITE FEED

Fraction Carbon Converted at 750°C and 2000 psig (Based on Lignite Only)

	<u>100% Lignite Feed</u>	<u>50% Lignite-50% Char</u> *	<u>% Change over 100% Lignite</u>
CO	0.081	0.041	-49%
CH _X	0.275	0.293	+7%
C ₂ H ₆	0.055	0.120	+118%
BTX	0.076	0.122	+61%
Light Oils	<u>0.104</u>	<u>0.070</u>	<u>-33%</u>
	0.591	0.646	

* Char added to lignite obtained from previous runs.

Table 3

FLASH HYDROLYSIS OF BATTELLE TREATED COAL
A CAKING BITUMINOUS COAL TREATED WITH CAO

Fraction Carbon Converted at 2000 psig and 750°C

CO	0.024
CH ₄	0.213
C ₂ H ₆	0.097
BTX	0.088
Light Oils	<u>0.112</u>
	0.534 Total

Table 4

FLASH HYDROLYSIS LIGNITE
EFFECT OF TREATING LIGNITE WITH Fe_2O_3

Fraction Carbon Converted at 2000 psig and 750°C

	<u>No addition of Fe</u>	<u>5 wt% Fe added to Lignite</u>	<u>Fe addition % Change over untreated</u>
CO	0.081	0.052	-36%
CH ₄	0.275	0.302	+10%
C ₂ H ₆	0.055	0.099	+80%
BTX	0.076	0.122	+61%
Light Oils	<u>0.104</u>	<u>0.051</u>	<u>-49%</u>
	0.591	0.626

Figure 1. Boiling range of flash hydrolysis liquid hydrocarbon product. % wt. loss vs. temperature.

Figure 2. Flash hydrolypyrolysis of Lignite Fraction Carbon converted vs. residence time temperature 750°C, pressure 500 psig.

Figure 3. Flash hydrolypyrolysis of lignite fraction carbon converted vs. residence time temperature 775°C, pressure 2500 psig. Hydrogen not preheated.

Figure 4. Flash hydrolysis of lignite and char (50-50) fraction carbon converted vs. residence time temperature 750°C, pressure 2000 psig.

Figure 5. Flash hydrolysis of sub-bituminous fraction carbon converted vs. residence time temperature 750°C, pressure 2000 psig.

Figure 6. Flash hydrolysis of lignite fraction carbon converted vs. residence time temperature 800°C, pressure 2000 psig.

Figure 7. Flash hydrolysis of lignite fraction carbon converted vs. residence time temperature 850°C, pressure 2000 psig.

RUN NO. 84

SAMPLE NO. 1

DATE 10 -11 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	2.250	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.325	LB/HR	COAL FED	1042.	GRAMS
HYDROGEN FLOW RATE	1.030	LB/HR	CHAR	312.0	GRAMS
HYDROGEN VELOCITY	.2122	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	775.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	25.00	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.
28.39

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

CARBON MONOXIDE	.3740E-03	3.983	6.000
CARBON DIOXIDE	.1500E-04	.1017	.2406
METHANE	.1062E-02	19.75	17.04
ETHYLENE	0.	0.	0.
ETHANE	.4770E-03	9.465	7.652
BENZENE	.2540E-03	5.820	4.075
TOLUENE	.5100E-04	1.156	.8182
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	0.	0.	0.

TOTAL

40.27

35.82

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.98	8.43	0.	0.	0.	4.89
HYDROCARBON GASES	29.2	127.	0.	0.	0.	24.7
CARBON OXIDES	4.08	0.	12.5	0.	0.	6.24
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.	23.4
TOTAL	40.3	141.	12.5	100.	100.	61.5

HYDROGEN CONSUMPTION-

.1729E-01
.3510

LB HYDROGEN/LB COAL
MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-

40.27

PERCENT

EFFECTIVE ENERGY EFFICIENCY-

49.22

PERCENT

RUN NO. 85.

SAMPLE NO. 1

DATE 10 -13 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	6.300	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.570	LB/HR	COAL FED	285.0	GRAMS
HYDROGEN FLOW RATE	.9600	LB/HR	CHAR	149.3	GRAMS
HYDROGEN VELOCITY	.4945	FT/SEC.	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	775.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	775.0	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	16.23

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.6570E-03	5.505	8.292
CARBON DIOXIDE	.1700E-04	.9066E-01	.2146
METHANE	.7160E-03	10.48	9.037
ETHYLENE	0.	0.	0.
ETHANE	.2500E-03	3.903	3.155
BENZENE	.3040E-03	5.481	3.837
TOLUENE	.4000E-05	.7133E-01	.5049E-01
XYLENE	0.	0.	0.
LIGHT OIL	.5500E-04	.9921	.6942
WATER	.1640E-03	0.	2.070
TOTAL		26.52	27.35

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.54	7.73	0.	0.	0.	4.58
HYDROCARBON GASES	14.4	63.3	0.	0.	0.	12.2
CARBON OXIDES	5.60	0.	17.0	0.	0.	8.51
WATER	0.	5.01	6.38	0.	0.	2.07
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.	47.9
TOTAL	26.5	82.0	23.3	100.	100.	77.5

HYDROGEN CONSUMPTION-	-.7572E-02	LB HYDROGEN/LB COAL
	-.1538	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	26.52	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	28.16	PERCENT

RUN NO. 86 SAMPLE NO. 1 DATE 10 -18 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 1.750 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.120	LB/HR	COAL FED	728.7	GRAMS
HYDROGEN FLOW RATE	.9400	LB/HR	CHAR	259.9	GRAMS
HYDROGEN VELOCITY	.3252	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			

	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	23.83

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1530E-03	1.759	2.650
CARBON DIOXIDE	.1700E-04	.1244	.2944
METHANE	.9310E-03	18.69	16.12
ETHYLENE	0.	0.	0.
ETHANE	.3560E-03	7.626	6.166
BENZENE	.1760E-03	4.354	3.048
TOLUENE	.5900E-04	1.444	1.022
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.5130E-03	0.	8.885
TOTAL		34.00	38.19

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	5.80	7.09	0.	0.	0.	4.07
HYDROCARBON GASES	26.3	115.	0.	0.	0.	22.3
CARBON OXIDES	1.88	0.	5.99	0.	0.	2.94
WATER	0.	21.5	27.4	0.	0.	8.89
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.	29.7
TOTAL	34.0	150.	33.4	100.	100.	70.1

HYDROGEN CONSUMPTION- .2092E-01 LB HYDROGEN/LB COAL
 .4248 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 34.00 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 43.63 PERCENT

RUN NO. 87

SAMPLE NO. 1

DATE 10 -19 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	1.150	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.243	LB/HR	TOTAL ACCUMULATED WTS.	
HYDROGEN FLOW RATE	.8950	LB/HR	COAL FED	649.2 GRAMS
HYDROGEN VELOCITY	.9001	FT/SEC	CHAR	242.0 GRAMS
REACTOR TEMP.	750.0	DEG C	LIGHT OILS	0. GRAMS
PREHEAT TEMP.	750.0	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	22.80

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3970E-03	3.916	5.899
CARBON DIOXIDE	.3450E-04	.2166	.5126
METHANE	.8200E-03	14.12	12.18
ETHYLENE	0.	0.	0.
ETHANE	.2610E-03	4.797	3.878
BENZENE	.1272E-03	2.700	1.890
TOLUENE	.3060E-04	.6424	.4547
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.6590E-03	0.	9.792
TOTAL		26.40	34.61

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.34	4.05	0.	0.	0.	2.34
HYDROCARBON GASES	18.9	83.7	0.	0.	0.	16.1
CARBON OXIDES	4.13	0.	13.0	0.	0.	6.41
WATER	0.	23.7	30.2	0.	0.	9.79
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.	31.5
TOTAL	26.4	117.	43.1	100.	100.	68.3

HYDROGEN CONSUMPTION-	.7301E-02	LB HYDROGEN/LB COAL
	.1482	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	26.40	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	31.08	PERCENT

RUN NO. 89

SAMPLE NO. 1

DATE 10 -25 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE + CHAR (50-50)

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	2.100	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	.3914	LB/HR	COAL FED	395.9	GRAMS
HYDROGEN FLOW RATE	.9600	LB/HR	CHAR	0.	GRAMS
HYDROGEN VELOCITY	.2414	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	59.10	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	.2900E-04	.9745	1.468
CARBON DIOXIDE	0.	0.	0.
METHANE	.4710E-03	27.63	23.84
ETHYLENE	0.	0.	0.
ETHANE	.2160E-03	13.52	10.93
BENZENE	.9800E-04	7.085	4.960
TOLUENE	.1900E-04	1.359	.9617
XYLENE	0.	0.	0.
LIGHT OIL	.2800E-04	2.025	1.417
WATER	.2660E-03	0.	13.46
TOTAL		52.60	57.04

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	10.5	12.6	0.	0.	0.	7.34
HYDROCARBON GASES	41.2	178.	0.	0.	0.	34.8
CARBON OXIDES	.974	0.	2.91	0.	0.	1.47
WATER	0.	32.6	41.5	0.	0.	13.5
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	52.6	230.	44.4	100.	100.	59.3

HYDROGEN CONSUMPTION-	.5439E-01	LB HYDROGEN/LB COAL
	1.104	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	52.60	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	70.44	PERCENT

RUN NO. 90

SAMPLE NO. 1

DATE 11 -9 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	11.80	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.219	LB/HR	COAL FED	267.5	GRAMS
HYDROGEN FLOW RATE	.7200	LB/HR	CHAR	60.00	GRAMS
HYDROGEN VELOCITY	.8830E-01	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	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	37.90

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1720E-03	1.392	2.096
CARBON DIOXIDE	0.	0.	0.
METHANE	.1140E-02	16.10	13.89
ETHYLENE	0.	0.	0.
ETHANE	.6340E-03	9.557	7.727
BENZENE	.1330E-03	3.186	2.230
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1300E-04	.2264	.1584
WATER	0.	0.	0.
TOTAL		30.46	26.10

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.41	4.03	0.	0.	0.	2.39
HYDROCARBON GASES	25.7	110.	0.	0.	0.	21.6
CARBON OXIDES	1.39	0.	4.15	0.	0.	2.10
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.	15.2
TOTAL	30.5	120.	4.15	100.	100.	43.6

HYDROGEN CONSUMPTION-	.8346E-02	LB HYDROGEN/LB COAL
	.1695	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	30.46	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	41.26	PERCENT

RUN NO. 91

SAMPLE NO. 1

DATE 11 -17 - 1977

COAL TYPE- BATTELLE TREATED COAL

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	2.100	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	.5964	LB/HR	COAL FED	342.2	GRAMS
HYDROGEN FLOW RATE	.9100	LB/HR	CHAR	147.8	GRAMS
HYDROGEN VELOCITY	.2288	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	64.10	0.
HYDROGEN	4.200	0.
OXYGEN	13.20	0.
NITROGEN	1.200	0.
SULFUR	1.100	0.
ASH	16.20	37.50

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8800E-04	1.696	3.026
CARBON DIOXIDE	0.	0.	0.
METHANE	.6700E-03	22.55	23.04
ETHYLENE	0.	0.	0.
ETHANE	.2770E-03	9.947	9.524
BENZENE	.1840E-03	7.631	6.326
TOLUENE	.1700E-04	.6973	.5845
XYLENE	0.	0.	0.
LIGHT OIL	.6000E-04	2.490	2.063
WATER	.2250E-03	0.	7.736
TOTAL		45.01	52.30

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	10.8	14.0	0.	0.	0.	8.97
HYDROCARBON GASES	32.5	154.	0.	0.	0.	32.6
CARBON OXIDES	1.70	0.	11.0	0.	0.	3.03
WATER	0.	17.1	43.7	0.	0.	7.74
AMMONIA	0.	6.12	0.	100.	0.	1.74
HYDROGEN SULFIDE	0.	1.64	0.	0.	100.	1.39
CHAR	0.	0.	0.	0.	0.	32.2
TOTAL	45.0	193.	54.6	100.	100.	87.6

HYDROGEN CONSUMPTION-	.3889E-01	LB HYDROGEN/LB COAL
	.7280	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	45.01	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	63.82	PERCENT

RUN NO. 92

SAMPLE NO. 1

DATE 11 -18 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE WITH 5 % FE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	2.150	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	.9402	LB/HR	COAL FED	442.8	GRAMS
HYDROGEN FLOW RATE	.8500	LB/HR	CHAR	142.3	GRAMS
HYDROGEN VELOCITY	.2137	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	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	26.50

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1140E-03	1.412	2.127
CARBON DIOXIDE	0.	0.	0.
METHANE	.4600E-03	9.948	8.582
ETHYLENE	0.	0.	0.
ETHANE	.1810E-03	4.177	3.377
BENZENE	.6300E-04	1.679	1.175
TOLUENE	.3000E-04	.7907	.5597
XYLENE	0.	0.	0.
LIGHT OIL	.6800E-04	1.813	1.269
WATER	.3630E-03	0.	6.773

TOTAL	19.82	23.86
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	4.28	5.17	0.	0.	0.	3.00
HYDROCARBON GASES	14.1	61.8	0.	0.	0.	12.0
CARBON OXIDES	1.41	0.	4.21	0.	0.	2.13
WATER	0.	16.4	20.9	0.	0.	6.77
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.	25.8
TOTAL	19.8	89.3	25.1	100.	100.	51.9

HYDROGEN CONSUMPTION-	-.4503E-02	LB HYDROGEN/LB COAL
	-.9143E-01	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	19.82	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	24.77	PERCENT

RUN NO. 88

SAMPLE NO. 1

DATE 10 -20 - 1977

COAL TYPE- NEW MEXICO SUB-BITUMINOUS

COAL RESIDENCE TIME-MEASURED 0. SECONDS
 CALCULATED 2.150 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.120	LB/HR	COAL FED	584.8	GRAMS
HYDROGEN FLOW RATE	.8700	LB/HR	CHAR	286.6	GRAMS
HYDROGEN VELOCITY	.2137	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	64.21	0.
HYDROGEN	4.860	0.
OXYGEN	12.26	0.
NITROGEN	1.410	0.
SULFUR	.6100	0.
ASH	16.65	33.97

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3050E-03	2.987	5.367
CARBON DIOXIDE	.3600E-04	.2244	.6335
METHANE	.6775E-03	11.59	11.92
ETHYLENE	0.	0.	0.
ETHANE	.5000E-03	9.125	8.799
BENZENE	.1600E-03	3.372	2.816
TOLUENE	.2600E-04	.5419	.4575
XYLENE	0.	0.	0.
LIGHT OIL	.4000E-04	.8435	.7039
WATER	.3020E-03	0.	5.314
TOTAL		28.68	36.01

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	4.76	5.35	0.	0.	0.	3.98
HYDROCARBON GASES	20.7	81.7	0.	0.	0.	20.7
CARBON OXIDES	3.21	0.	24.0	0.	0.	6.00
WATER	0.	10.1	32.1	0.	0.	5.31
AMMONIA	0.	6.22	0.	100.	0.	2.05
HYDROGEN SULFIDE	0.	.784	0.	0.	100.	.778
CHAR	0.	0.	0.	0.	0.	38.8
TOTAL	28.7	104.	56.1	100.	100.	77.7

HYDROGEN CONSUMPTION- .2046E-02 LB HYDROGEN/LB COAL
 .3823E-01 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 28.68 PERCENT
 EFFECTIVE ENERGY EFFICIENCY- 37.53 PERCENT

RUN NO. 93

SAMPLE NO. 1

DATE 11 -21 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	11.30	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.199	LB/HR	COAL FED	349.4	GRAMS
HYDROGEN FLOW RATE	.9600	LB/HR	CHAR	99.10	GRAMS
HYDROGEN VELOCITY	.1177	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	725.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	30.00	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	30.00

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1850E-03	2.029	3.056
CARBON DIOXIDE	0.	0.	0.
METHANE	.1796E-02	34.39	29.67
ETHYLENE	0.	0.	0.
ETHANE	.4410E-03	9.010	7.285
BENZENE	.6300E-04	1.486	1.041
TOLUENE	.3600E-04	.8401	.5947
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	0.	0.	0.

TOTAL	47.75	41.64
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	2.33	2.89	0.	0.	0.	1.64
HYDROCARBON GASES	43.4	194.	0.	0.	0.	37.0
CARBON OXIDES	2.03	0.	6.05	0.	0.	3.06
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.	21.7

TOTAL	47.8	203.	6.05	100.	100.	65.6
-------	------	------	------	------	------	------

HYDROGEN CONSUMPTION-	.4332E-01	LB HYDROGEN/LB COAL
	.8797	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	47.75	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	66.96	PERCENT

RUN NO. 94 SAMPLE NO. 1 DATE 11 -22 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 1.850 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.199	LB/HR	COAL FED	609.6	GRAMS
HYDROGEN FLOW RATE	2.070	LB/HR	CHAR	236.5	GRAMS
HYDROGEN VELOCITY	.4164	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	21.90

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8000E-04	1.892	2.849
CARBON DIOXIDE	0.	0.	0.
METHANE	.4200E-03	17.34	14.96
ETHYLENE	0.	0.	0.
ETHANE	.1610E-03	7.093	5.734
BENZENE	.5900E-04	3.002	2.101
TOLUENE	.1640E-04	.8252	.5841
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.2750E-03	0.	9.795
TOTAL		30.15	36.02

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.83	4.66	0.	0.	0.	2.69
HYDROCARBON GASES	24.4	107.	0.	0.	0.	20.7
CARBON OXIDES	1.89	0.	5.64	0.	0.	2.85
WATER	0.	23.7	30.2	0.	0.	9.79
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.	33.1
TOTAL	30.2	141.	35.8	100.	100.	71.4

HYDROGEN CONSUMPTION- .1735E-01 LB HYDROGEN/LB COAL
 .3523 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 30.15 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 39.45 PERCENT

RUN NO. 95

SAMPLE NO. 1

DATE 11 -23 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	2.600	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.199	LB/HR	COAL FED	395.5	GRAMS
HYDROGEN FLOW RATE	.4800	LB/HR	CHAR	183.4	GRAMS
HYDROGEN VELOCITY	.9660E-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	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	18.30

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.6740E-03	3.696	5.567
CARBON DIOXIDE	.1136E-03	.3964	.9382
METHANE	.1843E-02	17.64	15.22
ETHYLENE	0.	0.	0.
ETHANE	.7370E-03	7.529	6.087
BENZENE	.4180E-03	4.931	3.452
TOLUENE	.1800E-04	.2100	.1487
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	0.	0.	0.

TOTAL	34.41	31.41
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	5.14	6.10	0.	0.	0.	3.60
HYDROCARBON GASES	25.2	110.	0.	0.	0.	21.3
CARBON OXIDES	4.09	0.	13.4	0.	0.	6.50
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.	41.4
TOTAL	34.4	122.	13.4	100.	100.	75.1

HYDROGEN CONSUMPTION-	.9256E-02	LB HYDROGEN/LB COAL
	.1879	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	34.41	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	42.46	PERCENT

RUN NO. 98

SAMPLE NO. 1

DATE 12 -14 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 2.110 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.140	LB/HR	TOTAL ACCUMULATED WTS.		
HYDROGEN FLOW RATE	.9200	LB/HR	COAL FED	802.6	GRAMS
HYDROGEN VELOCITY	.2426	FT/SEC	CHAR	309.7	GRAMS
REACTOR TEMP.	800.0	DEG C	LIGHT OILS	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	BTX	0.	GRAMS
HYDROGEN PRESSURE	2000.	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	22.00

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3890E-03	4.301	6.479
CARBON DIOXIDE	0.	0.	0.
METHANE	.1257E-02	24.27	20.94
ETHYLENE	0.	0.	0.
ETHANE	.3400E-03	7.005	5.663
BENZENE	.4630E-03	11.02	7.712
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1700E-03	4.047	2.832
WATER	.2610E-02	0.	43.47
TOTAL		50.64	87.10

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	15.1	17.7	0.	0.	0.	10.5
HYDROCARBON GASES	31.3	139.	0.	0.	0.	26.6
CARBON OXIDES	4.30	0.	12.8	0.	0.	6.48
WATER	0.	105.	134.	0.	0.	43.5
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.	32.9
TOTAL	50.6	268.	147.	100.	100.	122.

HYDROGEN CONSUMPTION- .7070E-01 LB HYDROGEN/LB COAL
1.436 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 50.64 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 62.78 PERCENT

RUN NO. 99

SAMPLE NO. 1

DATE 12 -15 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE WITH 5 % FE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 2.140 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	.7882	LB/HR	COAL FED	433.0	GRAMS
HYDROGEN FLOW RATE	.8500	LB/HR	CHAR	158.0	GRAMS
HYDROGEN VELOCITY	.2137	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			

	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	23.30

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8600E-04	1.271	1.914
CARBON DIOXIDE	0.	0.	0.
METHANE	.1207E-02	31.14	26.86
ETHYLENE	0.	0.	0.
ETHANE	.3930E-03	10.82	8.747
BENZENE	.3290E-03	10.46	7.323
TOLUENE	.2200E-04	.6918	.4897
XYLENE	0.	0.	0.
LIGHT OIL	.8900E-04	2.831	1.981
WATER	.1700E-03	0.	3.784
TOTAL		57.21	51.10

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	14.0	16.6	0.	0.	0.	9.79
HYDROCARBON GASES	42.0	185.	0.	0.	0.	35.6
CARBON OXIDES	1.27	0.	3.79	0.	0.	1.91
WATER	0.	9.16	11.7	0.	0.	3.78
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.	30.6
TOTAL	57.2	217.	15.4	100.	100.	83.9

HYDROGEN CONSUMPTION- .4918E-01 LB HYDROGEN/LB COAL
.9985 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 57.21 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 76.61 PERCENT

RUN NO. 100

SAMPLE NO. 1

DATE 12 -19 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	1.920	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.399	LB/HR	COAL FED	861.0	GRAMS
HYDROGEN FLOW RATE	.7650	LB/HR	CHAR	375.0	GRAMS
HYDROGEN VELOCITY	.2815	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	850.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	1500.	PSI			

TOTAL ACCUMULATED MTS.

	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	19.52

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3680E-03	2.757	4.153
CARBON DIOXIDE	.4200E-04	.2002	.4739
METHANE	.2984E-02	39.03	33.67
ETHYLENE	0.	0.	0.
ETHANE	.2630E-03	3.671	2.968
BENZENE	.3650E-03	5.883	4.119
TOLUENE	.3000E-05	.4783E-01	.3385E-01
XYLENE	0.	0.	0.
LIGHT OIL	.6300E-04	1.016	.7109
WATER	.1900E-04	0.	.2144
TOTAL		52.61	46.34

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.95	8.20	0.	0.	0.	4.86
HYDROCARBON GASES	42.7	197.	0.	0.	0.	36.6
CARBON OXIDES	2.96	0.	9.42	0.	0.	4.63
WATER	0.	.519	.661	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.	38.3
TOTAL	52.6	212.	10.1	100.	100.	86.9

HYDROGEN CONSUMPTION-	.4704E-01	LB HYDROGEN/LB COAL
	.9551	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	52.61	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	72.65	PERCENT

RUN NO. 101

SAMPLE NO. 1

DATE 12 -21 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	2.050	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.850	LB/HR	COAL FED	491.0	GRAMS
HYDROGEN FLOW RATE	.8800	LB/HR	CHAR	199.0	GRAMS
HYDROGEN VELOCITY	.2429	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	850.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN 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	21.00

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.4960E-03	3.232	4.869
CARBON DIOXIDE	.5400E-04	.2240	.5301
METHANE	.3273E-02	37.24	32.13
ETHYLENE	0.	0.	0.
ETHANE	.2840E-03	3.448	2.788
BENZENE	.3920E-03	5.497	3.848
TOLUENE	.2000E-05	.2774E-01	.1963E-01
XYLENE	0.	0.	0.
LIGHT OIL	.5300E-04	.7436	.5203
WATER	0.	0.	0.
TOTAL		50.42	44.70

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.27	7.40	0.	0.	0.	4.39
HYDROCARBON GASES	40.7	188.	0.	0.	0.	34.9
CARBON OXIDES	3.46	0.	11.0	0.	0.	5.40
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.	35.0
TOTAL	50.4	201.	11.0	100.	100.	81.9

HYDROGEN CONSUMPTION-	.4261E-01	LB HYDROGEN/LB COAL
	.8651	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	50.42	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	68.88	PERCENT

RUN NO. 102 SAMPLE NO. 1 DATE 1 -4 - 1978

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 1.680 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.309	LB/HR	COAL FED	753.0	GRAMS
HYDROGEN FLOW RATE	.7400	LB/HR	CHAR	363.0	GRAMS
HYDROGEN VELOCITY	.4085	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	850.0	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	17.60

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.6780E-03	5.251	7.909
CARBON DIOXIDE	.2900E-04	.1429	.3383
METHANE	.1733E-02	23.43	20.22
ETHYLENE	0.	0.	0.
ETHANE	.2290E-03	3.304	2.671
BENZENE	.2830E-03	4.716	3.301
TOLUENE	.3000E-05	.4944E-01	.3500E-01
XYLENE	0.	0.	0.
LIGHT OIL	.2900E-04	.4835	.3383
WATER	.4400E-04	0.	.5133

TOTAL 37.38 35.32

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	5.25	6.20	0.	0.	0.	3.67
HYDROCARBON GASES	26.7	122.	0.	0.	0.	22.9
CARBON OXIDES	5.39	0.	16.5	0.	0.	8.25
WATER	0.	1.24	1.58	0.	0.	.513
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.	43.4
TOTAL	37.4	136.	18.1	100.	100.	81.0

HYDROGEN CONSUMPTION- .1502E-01 LB HYDROGEN/LB COAL
 .3049 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 37.38 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 46.15 PERCENT

RUN NO. 103

SAMPLE NO. 1

DATE 1 -5 - 1978

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	1.880	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.289	LB/HR	COAL FED	978.0	GRAMS
HYDROGEN FLOW RATE	1.200	LB/HR	CHAR	377.0	GRAMS
HYDROGEN VELOCITY	.3312	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	850.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	2000.	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.
22.10

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

CARBON MONOXIDE	.9400E-04	1.199	1.806
CARBON DIOXIDE	0.	0.	0.
METHANE	.1686E-02	37.54	32.38
ETHYLENE	0.	0.	0.
ETHANE	.2360E-03	5.607	4.533
BENZENE	.2660E-03	7.298	5.109
TOLUENE	.2000E-05	.5427E-01	.3842E-01
XYLENE	0.	0.	0.
LIGHT OIL	.3000E-04	.8235	.5762
WATER	.1900E-04	0.	.3649

TOTAL

52.52

44.81

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	8.18	9.65	0.	0.	0.	5.72
HYDROCARBON GASES	43.1	197.	0.	0.	0.	36.9
CARBON OXIDES	1.20	0.	3.57	0.	0.	1.81
WATER	0.	.883	1.12	0.	0.	.365
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.	32.8
TOTAL	52.5	214.	4.70	100.	100.	79.9

HYDROGEN CONSUMPTION-	.4772E-01	LB HYDROGEN/LB COAL
	.9690	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	52.52	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	74.14	PERCENT

RUN NO. 84

SAMPLE NO. 2

DATE 10 -11 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	4.500	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.325	LB/HR	COAL FED	1042.	GRAMS
HYDROGEN FLOW RATE	1.030	LB/HR	CHAR	312.0	GRAMS
HYDROGEN VELOCITY	.2122	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	775.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	25.00	DEG C	WATER	0.	GRAMS
HYDROGEN PRESSURE	2500.	PSI			

TOTAL ACCUMULATED MTS.

	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	28.39

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.6300E-03	6.710	10.11
CARBON DIOXIDE	.3200E-04	.2169	.5134
METHANE	.1193E-02	22.18	19.14
ETHYLENE	0.	0.	0.
ETHANE	.4780E-03	9.485	7.668
BENZENE	.2970E-03	6.806	4.765
TOLUENE	.5000E-05	.1133	.8021E-01
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	0.	0.	0.

TOTAL	45.51	42.27
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.92	8.19	0.	0.	0.	4.84
HYDROCARBON GASES	31.7	138.	0.	0.	0.	26.8
CARBON OXIDES	6.93	0.	21.3	0.	0.	10.6
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.	23.4
TOTAL	45.5	152.	21.3	100.	100.	67.9

HYDROGEN CONSUMPTION-	.2205E-01	LB HYDROGEN/LB COAL
	.4476	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	45.51	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	54.03	PERCENT

RUN NO. 86

SAMPLE NO. 2

DATE 10 -18 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	3.500	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.120	LB/HR	TOTAL ACCUMULATED WTS.		
HYDROGEN FLOW RATE	1.000	LB/HR	COAL FED	728.7	GRAMS
HYDROGEN VELOCITY	.3252	FT/SEC	CHAR	259.9	GRAMS
REACTOR TEMP.	750.0	DEG C	LIGHT OILS	0.	GRAMS
PREHEAT TEMP.	750.0	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	23.83

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3650E-03	4.465	6.725
CARBON DIOXIDE	0.	0.	0.
METHANE	.5040E-03	10.76	9.286
ETHYLENE	0.	0.	0.
ETHANE	.2250E-03	5.128	4.146
BENZENE	.1680E-03	4.422	3.095
TOLUENE	.9000E-05	.2343	.1658
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.8500E-04	0.	1.566
TOTAL		25.01	24.98

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	4.66	5.54	0.	0.	0.	3.26
HYDROCARBON GASES	15.9	69.0	0.	0.	0.	13.4
CARBON OXIDES	4.46	0.	13.3	0.	0.	6.73
WATER	0.	3.79	4.83	0.	0.	1.57
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.	29.7
TOTAL	25.0	84.3	18.1	100.	100.	56.9

HYDROGEN CONSUMPTION-	-.6611E-02	LB HYDROGEN/LB COAL
	-.1342	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	25.01	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	28.05	PERCENT

RUN NO. 87

SAMPLE NO. 2

DATE 10 -19 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 2.300 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.243	LB/HR	COAL FED	649.2	GRAMS
HYDROGEN FLOW RATE	.8950	LB/HR	CHAR	242.0	GRAMS
HYDROGEN VELOCITY	.9001	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			

	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	22.80

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.5510E-03	5.435	8.187
CARBON DIOXIDE	.5950E-04	.3735	.8841
METHANE	.7200E-03	12.40	10.70
ETHYLENE	0.	0.	0.
ETHANE	.2910E-03	5.348	4.324
BENZENE	.1686E-03	3.578	2.505
TOLUENE	.3300E-04	.6927	.4904
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.7140E-04	0.	1.061

TOTAL 27.83 28.15

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	4.27	5.16	0.	0.	0.	3.00
HYDROCARBON GASES	17.7	77.5	0.	0.	0.	15.0
CARBON OXIDES	5.81	0.	18.4	0.	0.	9.07
WATER	0.	2.57	3.27	0.	0.	1.06
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.	31.5
TOTAL	27.8	91.2	21.7	100.	100.	61.8

HYDROGEN CONSUMPTION- -.3707E-02 LB HYDROGEN/LB COAL
-.7527E-01 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 27.83 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 30.03 PERCENT

RUN NO. 88

SAMPLE NO. 2

DATE 10 -20 - 1977

COAL TYPE- NEW MEXICO SUB-BITUMINOUS

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	4.300	SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.120	LB/HR	COAL FED	584.8	GRAMS
HYDROGEN FLOW RATE	.8500	LB/HR	CHAR	286.6	GRAMS
HYDROGEN VELOCITY	.2137	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			

	COAL ANALYSIS, %	CHAR ANALYSIS, %
CARBON	64.21	0.
HYDROGEN	4.860	0.
OXYGEN	12.26	0.
NITROGEN	1.410	0.
SULFUR	.6100	0.
ASH	16.65	33.97

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3240E-03	3.101	5.570
CARBON DIOXIDE	.1150E-03	.7004	1.977
METHANE	.9630E-03	16.09	16.56
ETHYLENE	0.	0.	0.
ETHANE	.5770E-03	10.29	9.920
BENZENE	.3020E-03	6.218	5.192
TOLUENE	.1000E-05	.2037E-01	.1719E-01
XYLENE	0.	0.	0.
LIGHT OIL	.3800E-04	.7829	.6533
WATER	.1000E-04	0.	.1719
TOTAL		37.20	40.06

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	7.02	7.78	0.	0.	0.	5.86
HYDROCARBON GASES	26.4	106.	0.	0.	0.	26.5
CARBON OXIDES	3.80	0.	31.4	0.	0.	7.55
WATER	0.	.328	1.04	0.	0.	.172
AMMONIA	0.	6.22	0.	100.	0.	2.05
HYDROGEN SULFIDE	0.	.784	0.	0.	100.	.778
CHAR	0.	0.	0.	0.	0.	38.8
TOTAL	37.2	121.	32.4	100.	100.	81.7

HYDROGEN CONSUMPTION-	.1005E-01	LB HYDROGEN/LB COAL
	.1878	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	37.20	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	49.88	PERCENT

RUN NO. 89

SAMPLE NO. 2

DATE 10 -25 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE + CHAR (50-50)

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	8.300	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	.3914	LB/HR	TOTAL ACCUMULATED MTS.		
HYDROGEN FLOW RATE	.9600	LB/HR	COAL FED	395.9	GRAMS
HYDROGEN VELOCITY	.2414	FT/SEC	CHAR	0.	GRAMS
REACTOR TEMP.	750.0	DEG C	LIGHT OILS	0.	GRAMS
PREHEAT TEMP.	750.0	DEG C	BTX	0.	GRAMS
HYDROGEN PRESSURE	2000.	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	.1230E-03	4.133	6.226
CARBON DIOXIDE	0.	0.	0.
METHANE	.5000E-03	29.34	25.31
ETHYLENE	0.	0.	0.
ETHANE	.1920E-03	12.02	9.718
BENZENE	.1680E-03	12.15	8.503
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.2800E-04	2.025	1.417
WATER	.2000E-04	0.	1.012

TOTAL	59.66	52.18
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	14.2	16.7	0.	0.	0.	9.92
HYDROCARBON GASES	41.4	181.	0.	0.	0.	35.0
CARBON OXIDES	4.13	0.	12.3	0.	0.	6.23
WATER	0.	2.45	3.12	0.	0.	1.01
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	59.7	206.	15.4	100.	100.	54.4

HYDROGEN CONSUMPTION-	.4461E-01	LB HYDROGEN/LB COAL
	.9058	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	57.90	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	73.97	PERCENT

RUN NO. 91

SAMPLE NO. 2

DATE 11 -17 - 1977

COAL TYPE- BATTELLE TREATED COAL

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	8.400	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	.5964	LB/HR	TOTAL ACCUMULATED WTS.	
HYDROGEN FLOW RATE	.9100	LB/HR	COAL FED	342.2 GRAMS
HYDROGEN VELOCITY	.2288	FT/SEC	CHAR	147.8 GRAMS
REACTOR TEMP.	750.0	DEG C	LIGHT OILS	0. GRAMS
PREHEAT TEMP.	750.0	DEG C	BTX	0. GRAMS
HYDROGEN PRESSURE	2000.	PSI	WATER	0. GRAMS

COAL ANALYSIS, %

CHAR ANALYSIS, %

CARBON	64.10	
HYDROGEN	4.200	
OXYGEN	13.20	
NITROGEN	1.200	
SULFUR	1.100	
ASH	16.20	

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

CARBON MONOXIDE	.1270E-03	2.448	4.367
CARBON DIOXIDE	0.	0.	0.
METHANE	.6330E-03	21.30	21.76
ETHYLENE	0.	0.	0.
ETHANE	.2690E-03	9.660	9.249
BENZENE	.2080E-03	8.626	7.152
TOLUENE	.3000E-05	.1230	.1031
XYLENE	0.	0.	0.
LIGHT OIL	.3000E-04	1.245	1.031
WATER	.2000E-04	0.	.6877

TOTAL	43.40	44.35
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.99	12.8	0.	0.	0.	8.29
HYDROCARBON GASES	31.0	146.	0.	0.	0.	31.0
CARBON OXIDES	2.45	0.	15.8	0.	0.	4.37
WATER	0.	1.52	3.88	0.	0.	.688
AMMONIA	0.	6.12	0.	100.	0.	1.74
HYDROGEN SULFIDE	0.	1.64	0.	0.	100.	1.39
CHAR	0.	0.	0.	0.	0.	32.2
TOTAL	43.4	168.	19.7	100.	100.	79.7

HYDROGEN CONSUMPTION-	.2870E-01	LB HYDROGEN/LB COAL
	.5372	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	43.40	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	60.89	PERCENT

RUN NO. 92

SAMPLE NO. 2

DATE 11 -18 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE WITH 5 % FE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	8.600	SECONDS

NOMINAL CONDITIONS

			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	.9402	LB/HR	COAL FED	442.8	GRAMS
HYDROGEN FLOW RATE	.9000	LB/HR	CHAR	142.3	GRAMS
HYDROGEN VELOCITY	.2137	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			

	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	26.50

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1410E-03	1.849	2.785
CARBON DIOXIDE	0.	0.	0.
METHANE	.3520E-03	8.060	6.954
ETHYLENE	0.	0.	0.
ETHANE	.1410E-03	3.445	2.785
BENZENE	.1170E-03	3.301	2.311
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.3400E-04	.9599	.6717
WATER	.1200E-04	0.	.2371
TOTAL		17.62	15.74

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	4.26	5.02	0.	0.	0.	2.98
HYDROCARBON GASES	11.5	50.3	0.	0.	0.	9.74
CARBON OXIDES	1.85	0.	5.51	0.	0.	2.79
WATER	0.	.574	.730	0.	0.	.237
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.	25.8
TOTAL	17.6	61.8	6.24	100.	100.	43.8

HYDROGEN CONSUMPTION-	-.1604E-01	LB HYDROGEN/LB COAL
	-.3258	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	17.62	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	21.55	PERCENT

RUN NO. 95

SAMPLE NO. 2

DATE 11 -23 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 10.40 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.199	LB/HR	COAL FED	395.5	GRAMS
HYDROGEN FLOW RATE	.4800	LB/HR	CHAR	183.4	GRAMS
HYDROGEN VELOCITY	.9660E-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	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	18.30

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.7540E-03	4.134	6.227
CARBON DIOXIDE	0.	0.	0.
METHANE	.1700E-02	16.28	14.04
ETHYLENE	0.	0.	0.
ETHANE	.5820E-03	5.945	4.807
BENZENE	.4190E-03	4.943	3.461
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	0.	0.	0.

TOTAL 31.30 28.54

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	4.94	5.84	0.	0.	0.	3.46
HYDROCARBON GASES	22.2	97.9	0.	0.	0.	18.8
CARBON OXIDES	4.13	0.	12.3	0.	0.	6.23
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.	41.4

TOTAL 31.3 110. 12.3 100. 100. 72.2

HYDROGEN CONSUMPTION- .4071E-02 LB HYDROGEN/LB COAL
.8266E-01 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 31.30 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 38.23 PERCENT

RUN NO. 98

SAMPLE NO. 2

DATE 12 -14 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	4.220	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.140	LB/HR	COAL FED	802.6	GRAMS
HYDROGEN FLOW RATE	.9200	LB/HR	CHAR	309.7	GRAMS
HYDROGEN VELOCITY	.2426	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 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	22.00

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1690E-03	1.869	2.815
CARBON DIOXIDE	0.	0.	0.
METHANE	.1738E-02	33.56	28.95
ETHYLENE	0.	0.	0.
ETHANE	.3380E-03	6.963	5.630
BENZENE	.3940E-03	9.374	6.563
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1390E-03	3.309	2.315
WATER	.2640E-03	0.	4.397
TOTAL		55.07	50.67

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	12.7	14.9	0.	0.	0.	8.88
HYDROCARBON GASES	40.5	183.	0.	0.	0.	34.6
CARBON OXIDES	1.87	0.	5.57	0.	0.	2.81
WATER	0.	10.6	13.5	0.	0.	4.40
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.	32.9
TOTAL	55.1	215.	19.1	100.	100.	85.8

HYDROGEN CONSUMPTION-	.4816E-01	LB HYDROGEN/LB COAL
	.9779	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	55.07	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	74.66	PERCENT

RUN NO. 100

SAMPLE NO. 2

DATE 12 -19 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	3.790	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.399	LB/HR	COAL FED	861.0	GRAMS
HYDROGEN FLOW RATE	.8000	LB/HR	CHAR	375.0	GRAMS
HYDROGEN VELOCITY	.2944	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	850.0	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	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	19.52

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.6220E-03	4.873	7.340
CARBON DIOXIDE	.6500E-04	.3241	.7670
METHANE	.2561E-02	35.03	30.22
ETHYLENE	0.	0.	0.
ETHANE	.1480E-03	2.160	1.746
BENZENE	.3140E-03	5.293	3.705
TOLUENE	.1000E-05	.1667E-01	.1180E-01
XYLENE	0.	0.	0.
LIGHT OIL	.3900E-04	.6577	.4602
WATER	.5010E-03	0.	5.912

TOTAL	48.36	50.16
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	5.97	7.04	0.	0.	0.	4.18
HYDROCARBON GASES	37.2	173.	0.	0.	0.	32.0
CARBON OXIDES	5.20	0.	16.5	0.	0.	8.11
WATER	0.	14.3	18.2	0.	0.	5.91
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.	38.3
TOTAL	48.4	200.	34.7	100.	100.	90.7

HYDROGEN CONSUMPTION-	.4216E-01	LB HYDROGEN/LB COAL
	.8561	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	48.36	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	63.42	PERCENT

RUN NO. 94

SAMPLE NO. 2

DATE 11 -22 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	3.700	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.199	LB/HR	COAL FED	609.6	GRAMS
HYDROGEN FLOW RATE	2.070	LB/HR	CHAR	236.5	GRAMS
HYDROGEN VELOCITY	.4164	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			

TOTAL ACCUMULATED MTS.

	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	21.90

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.5640E-04	1.334	2.009
CARBON DIOXIDE	0.	0.	0.
METHANE	.5240E-03	21.63	18.66
ETHYLENE	0.	0.	0.
ETHANE	.2185E-03	9.626	7.782
BENZENE	.1125E-03	5.723	4.007
TOLUENE	.6400E-05	.3220	.2280
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.1255E-03	0.	4.470

TOTAL	38.64	37.16
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.05	7.19	0.	0.	0.	4.23
HYDROCARBON GASES	31.3	136.	0.	0.	0.	26.4
CARBON OXIDES	1.33	0.	3.98	0.	0.	2.01
WATER	0.	10.8	13.8	0.	0.	4.47
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.	33.1
TOTAL	38.6	160.	17.7	100.	100.	72.5

HYDROGEN CONSUMPTION-	.2529E-01	LB HYDROGEN/LB COAL
	.5135	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	38.64	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	52.26	PERCENT

RUN NO. 99

SAMPLE NO. 2

DATE 12 -15 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE WITH 5 % FE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	8.560	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	.7882	LB/HR	COAL FED	433.0	GRAMS
HYDROGEN FLOW RATE	.8500	LB/HR	CHAR	158.0	GRAMS
HYDROGEN VELOCITY	.2137	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	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	23.30

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3490E-03	5.157	7.768
CARBON DIOXIDE	0.	0.	0.
METHANE	.1172E-02	30.24	26.09
ETHYLENE	0.	0.	0.
ETHANE	.3580E-03	9.856	7.968
BENZENE	.3830E-03	12.18	8.525
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.6900E-04	2.195	1.536
WATER	.2400E-04	0.	.5342

TOTAL	59.62	52.42
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	14.4	16.9	0.	0.	0.	10.1
HYDROCARBON GASES	40.1	178.	0.	0.	0.	34.1
CARBON OXIDES	5.16	0.	15.4	0.	0.	7.77
WATER	0.	1.29	1.65	0.	0.	.534
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.	30.6
TOTAL	59.6	202.	17.0	100.	100.	85.2

HYDROGEN CONSUMPTION-	.4279E-01	LB HYDROGEN/LB COAL
	.8689	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	57.89	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	72.78	PERCENT

RUN NO. 102 SAMPLE NO. 2 DATE 1 -4 - 1978

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.720 SECONDS

NOMINAL CONDITIONS			TOTAL ACCUMULATED WTS.		
COAL FEED RATE	1.309	LB/HR	COAL FED	753.0	GRAMS
HYDROGEN FLOW RATE	.7400	LB/HR	CHAR	363.0	GRAMS
HYDROGEN VELOCITY	.4085	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	850.0	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	17.60

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.9320E-03	7.218	10.87
CARBON DIOXIDE	.2200E-04	.1084	.2566
METHANE	.1970E-02	26.64	22.98
ETHYLENE	0.	0.	0.
ETHANE	.1060E-03	1.529	1.237
BENZENE	.2830E-03	4.716	3.301
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.2700E-04	.4501	.3150
WATER	.2300E-04	0.	.2683
TOTAL		40.66	39.23

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	5.17	6.09	0.	0.	0.	3.62
HYDROCARBON GASES	28.2	131.	0.	0.	0.	24.2
CARBON OXIDES	7.33	0.	22.2	0.	0.	11.1
WATER	0.	.649	.827	0.	0.	.268
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.	43.4
TOTAL	40.7	144.	23.0	100.	100.	84.9

HYDROGEN CONSUMPTION- .1844E-01 LB HYDROGEN/LB COAL
 .3744 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 40.66 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 48.72 PERCENT

RUN NO. 103

SAMPLE NO. 2

DATE 1 -5 - 1978

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	5.640	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.289	LB/HR	COAL FED	978.0	GRAMS
HYDROGEN FLOW RATE	1.200	LB/HR	CHAR	377.0	GRAMS
HYDROGEN VELOCITY	.3312	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	850.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN 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	22.10

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1820E-03	2.321	3.496
CARBON DIOXIDE	0.	0.	0.
METHANE	.2396E-02	53.35	46.02
ETHYLENE	0.	0.	0.
ETHANE	.1190E-03	2.827	2.286
BENZENE	.1010E-03	2.771	1.940
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.2700E-04	.7412	.5186
WATER	.7900E-04	0.	1.517
TOTAL		62.01	55.78

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	3.51	4.14	0.	0.	0.	2.46
HYDROCARBON GASES	56.2	262.	0.	0.	0.	48.3
CARBON OXIDES	2.32	0.	6.92	0.	0.	3.50
WATER	0.	3.67	4.67	0.	0.	1.52
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.	32.8
TOTAL	62.0	276.	11.6	100.	100.	90.8

HYDROGEN CONSUMPTION-	.7380E-01	LB HYDROGEN/LB COAL
	1.498	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	58.37	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	85.01	PERCENT

RUN NO. 84

SAMPLE NO. 3

DATE 10 -11 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
 CALCULATED 9.000 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.325	LB/HR	COAL FED	1042.	GRAMS
HYDROGEN FLOW RATE	1.030	LB/HR	CHAR	312.0	GRAMS
HYDROGEN VELOCITY	.2122	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	775.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	25.00	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	28.39

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.7290E-03	7.764	11.69
CARBON DIOXIDE	.3200E-04	.2169	.5134
METHANE	.1710E-02	31.80	27.43
ETHYLENE	0.	0.	0.
ETHANE	.5130E-03	10.18	8.230
BENZENE	.4790E-03	10.98	7.684
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.1020E-03	0.	1.636
TOTAL		60.93	57.19

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	11.0	13.0	0.	0.	0.	7.68
HYDROCARBON GASES	42.0	186.	0.	0.	0.	35.7
CARBON OXIDES	7.98	0.	24.4	0.	0.	12.2
WATER	0.	3.96	5.04	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.	23.4
TOTAL	60.9	209.	29.5	100.	100.	82.9

HYDROGEN CONSUMPTION- .4582E-01 LB HYDROGEN/LB COAL
 .9303 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 58.16 PERCENT
 EFFECTIVE ENERGY EFFICIENCY- 70.75 PERCENT

RUN NO. 86

SAMPLE NO. 3

DATE 10 -18 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	7.000	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.120	LB/HR	COAL FED	728.7	GRAMS
HYDROGEN FLOW RATE	.9800	LB/HR	CHAR	259.9	GRAMS
HYDROGEN VELOCITY	.3252	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	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	23.83

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.4620E-03	5.538	8.342
CARBON DIOXIDE	0.	0.	0.
METHANE	.6280E-03	13.14	11.34
ETHYLENE	0.	0.	0.
ETHANE	.2720E-03	6.075	4.911
BENZENE	.2450E-03	6.319	4.424
TOLUENE	.4000E-05	.1020	.7223E-01
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.1400E-04	0.	.2528
TOTAL		31.18	29.34

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	6.42	7.60	0.	0.	0.	4.50
HYDROCARBON GASES	19.2	83.6	0.	0.	0.	16.3
CARBON OXIDES	5.54	0.	16.5	0.	0.	8.34
WATER	0.	.612	.779	0.	0.	.253
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.	29.7
TOTAL	31.2	97.7	17.3	100.	100.	61.3

HYDROGEN CONSUMPTION-	-.9493E-03	LB HYDROGEN/LB COAL
	-.1928E-01	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	31.18	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	34.94	PERCENT

RUN NO. 87

SAMPLE NO. 3

DATE 10 -19 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	4.600	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.243	LB/HR	COAL FED	649.2	GRAMS
HYDROGEN FLOW RATE	.8950	LB/HR	CHAR	242.0	GRAMS
HYDROGEN VELOCITY	.9001	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	22.80

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8450E-03	8.336	12.56
CARBON DIOXIDE	.2700E-04	.1695	.4012
METHANE	.5640E-03	9.714	8.381
ETHYLENE	0.	0.	0.
ETHANE	.2640E-03	4.852	3.923
BENZENE	.2000E-03	4.245	2.972
TOLUENE	.1550E-04	.3254	.2303
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.1150E-03	0.	1.709
TOTAL		27.64	30.17

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	4.57	5.45	0.	0.	0.	3.20
HYDROCARBON GASES	14.6	63.1	0.	0.	0.	12.3
CARBON OXIDES	8.51	0.	25.9	0.	0.	13.0
WATER	0.	4.14	5.26	0.	0.	1.71
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.	31.5
TOTAL	27.6	78.6	31.1	100.	100.	63.9

HYDROGEN CONSUMPTION-	-.8994E-02	LB HYDROGEN/LB COAL
	-.1826	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	27.64	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	25.87	PERCENT

RUN NO. 88

SAMPLE NO. 3

DATE 10 -20 - 1977

COAL TYPE- NEW MEXICO SUB-BITUMINOUS

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	8.600	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.120	LB/HR	COAL FED	584.8	GRAMS
HYDROGEN FLOW RATE	.8500	LB/HR	CHAR	286.6	GRAMS
HYDROGEN VELOCITY	.2137	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	64.21	0.
HYDROGEN	4.860	0.
OXYGEN	12.26	0.
NITROGEN	1.410	0.
SULFUR	.6100	0.
ASH	16.65	33.97

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3320E-03	3.177	5.708
CARBON DIOXIDE	.3500E-04	.2132	.6018
METHANE	.1103E-02	18.43	18.96
ETHYLENE	0.	0.	0.
ETHANE	.5300E-03	9.450	9.112
BENZENE	.3600E-03	7.413	6.189
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.2800E-04	.5768	.4814
WATER	.2300E-04	0.	.3954
TOTAL		39.26	41.45

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	7.99	8.85	0.	0.	0.	6.67
HYDROCARBON GASES	27.9	113.	0.	0.	0.	28.1
CARBON OXIDES	3.39	0.	25.1	0.	0.	6.31
WATER	0.	.753	2.39	0.	0.	.395
AMMONIA	0.	6.22	0.	100.	0.	2.05
HYDROGEN SULFIDE	0.	.784	0.	0.	100.	.778
CHAR	0.	0.	0.	0.	0.	38.8
TOTAL	39.3	130.	27.5	100.	100.	83.1

HYDROGEN CONSUMPTION-	.1447E-01	LB HYDROGEN/LB COAL
	.2703	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	39.26	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	53.68	PERCENT

RUN NO. 94

SAMPLE NO. 3

DATE 11 -22 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 7.400 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.199	LB/HR	COAL FED	609.6	GRAMS
HYDROGEN FLOW RATE	2.070	LB/HR	CHAR	236.5	GRAMS
HYDROGEN VELOCITY	.4164	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			

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	21.90

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.1660E-03	3.925	5.912
CARBON DIOXIDE	0.	0.	0.
METHANE	.3580E-03	14.78	12.75
ETHYLENE	0.	0.	0.
ETHANE	.1523E-03	6.709	5.425
BENZENE	.1170E-03	5.952	4.167
TOLUENE	.4000E-06	.2013E-01	.1425E-01
XYLENE	0.	0.	0.
LIGHT OIL	0.	0.	0.
WATER	.4900E-04	0.	1.745

TOTAL	31.39	30.01
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	5.97	7.05	0.	0.	0.	4.18
HYDROCARBON GASES	21.5	93.6	0.	0.	0.	18.2
CARBON OXIDES	3.93	0.	11.7	0.	0.	5.91
WATER	0.	4.22	5.38	0.	0.	1.75
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.	33.1
TOTAL	31.4	111.	17.1	100.	100.	65.4

HYDROGEN CONSUMPTION- .4529E-02 LB HYDROGEN/LB COAL
.9196E-01 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 31.39 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 37.96 PERCENT

RUN NO. 98

SAMPLE NO. 3

DATE 12 -14 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 6.330 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.140	LB/HR	COAL FED	802.6	GRAMS
HYDROGEN FLOW RATE	.9200	LB/HR	CHAR	309.7	GRAMS
HYDROGEN VELOCITY	.2426	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 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	22.00

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3610E-03	3.992	6.013
CARBON DIOXIDE	.2300E-04	.1619	.3831
METHANE	.1878E-02	36.26	31.28
ETHYLENE	0.	0.	0.
ETHANE	.2560E-03	5.274	4.264
BENZENE	.2830E-03	6.733	4.714
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1250E-03	2.976	2.082
WATER	.2430E-03	0.	4.047

TOTAL 55.40 52.78

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	9.71	11.4	0.	0.	0.	6.80
HYDROCARBON GASES	41.5	190.	0.	0.	0.	35.5
CARBON OXIDES	4.15	0.	12.9	0.	0.	6.40
WATER	0.	9.80	12.5	0.	0.	4.05
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.	32.9
TOTAL	55.4	217.	25.3	100.	100.	87.9

HYDROGEN CONSUMPTION- .4918E-01 LB HYDROGEN/LB COAL
.9986 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 55.40 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 73.55 PERCENT

RUN NO. 100

SAMPLE NO. 3

DATE 12 -19 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	7.670	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.399	LB/HR	COAL FED	861.0	GRAMS
HYDROGEN FLOW RATE	.7650	LB/HR	CHAR	375.0	GRAMS
HYDROGEN VELOCITY	.2815	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	850.0	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	59.10	0.
HYDROGEN	4.200	0.
OXYGEN	26.40	0.
NITROGEN	.9000	0.
SULFUR	.9000	0.
ASH	8.500	19.52

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.8590E-03	6.435	9.693
CARBON DIOXIDE	.1600E-04	.7628E-01	.1805
METHANE	.2909E-02	38.05	32.83
ETHYLENE	0.	0.	0.
ETHANE	.1530E-03	2.135	1.726
BENZENE	.2250E-03	3.627	2.539
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.5400E-04	.8709	.6094
WATER	.1600E-04	0.	.1805
TOTAL		51.19	47.76

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	4.50	5.30	0.	0.	0.	3.15
HYDROCARBON GASES	40.2	187.	0.	0.	0.	34.6
CARBON OXIDES	6.51	0.	19.6	0.	0.	9.87
WATER	0.	.437	.556	0.	0.	.181
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.	38.3
TOTAL	51.2	199.	20.2	100.	100.	88.3

HYDROGEN CONSUMPTION-	.4156E-01	LB HYDROGEN/LB COAL
	.8438	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	51.19	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	66.63	PERCENT

RUN NO. 103

SAMPLE NO. 3

DATE 1 -5 - 1978

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED	0.	SECONDS
CALCULATED	7.520	SECONDS

NOMINAL CONDITIONS

COAL FEED RATE	1.289	LB/HR	COAL FED	978.0	GRAMS
HYDROGEN FLOW RATE	1.200	LB/HR	CHAR	377.0	GRAMS
HYDROGEN VELOCITY	.3312	FT/SEC	LIGHT OILS	0.	GRAMS
REACTOR TEMP.	850.0	DEG C	BTX	0.	GRAMS
PREHEAT TEMP.	800.0	DEG C	WATER	0.	GRAMS
HYDROGEN 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	22.10

	PRODUCT CONC. IN GAS, LB/C. FT	% CARBON CONV. TO PRODUCT	% MAF COAL CONV. TO PRODUCT
CARBON MONOXIDE	.3690E-03	4.705	7.088
CARBON DIOXIDE	0.	0.	0.
METHANE	.2190E-02	48.76	42.06
ETHYLENE	0.	0.	0.
ETHANE	.4900E-04	1.164	.9412
BENZENE	.4600E-04	1.262	.8836
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.2000E-04	.5490	.3842
WATER	.9000E-05	0.	.1729

TOTAL	56.44	51.53
-------	-------	-------

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	1.81	2.13	0.	0.	0.	1.27
HYDROCARBON GASES	49.9	234.	0.	0.	0.	43.0
CARBON OXIDES	4.71	0.	14.0	0.	0.	7.09
WATER	0.	.418	.533	0.	0.	.173
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.	32.8
TOTAL	56.4	243.	14.6	100.	100.	86.6

HYDROGEN CONSUMPTION-	.6002E-01	LB HYDROGEN/LB COAL
	1.219	MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION-	56.44	PERCENT
EFFECTIVE ENERGY EFFICIENCY-	79.21	PERCENT

RUN NO. 98

SAMPLE NO. 4

DATE 12 -14 - 1977

COAL TYPE- NORTH DAKOTA LIGNITE

COAL RESIDENCE TIME-MEASURED 0. SECONDS
CALCULATED 8.440 SECONDS

NOMINAL CONDITIONS

COAL FEED RATE 1.140 LB/HR
HYDROGEN FLOW RATE .9200 LB/HR
HYDROGEN VELOCITY .2426 FT/SEC
REACTOR TEMP. 800.0 DEG C
PREHEAT TEMP. 800.0 DEG C
HYDROGEN PRESSURE 2000. PSI

TOTAL ACCUMULATED WTS.

COAL FED 802.6 GRAMS
CHAR 309.7 GRAMS
LIGHT OILS 0. GRAMS
BTX 0. GRAMS
WATER 0. GRAMS

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.
22.00

PRODUCT CONC. IN
GAS, LB/C. FT

% CARBON CONV.
TO PRODUCT

% MAF COAL CONV.
TO PRODUCT

CARBON MONOXIDE	.4570E-03	5.053	7.612
CARBON DIOXIDE	0.	0.	0.
METHANE	.1653E-02	31.91	27.53
ETHYLENE	0.	0.	0.
ETHANE	.2830E-03	5.830	4.714
BENZENE	.2850E-03	6.781	4.747
TOLUENE	0.	0.	0.
XYLENE	0.	0.	0.
LIGHT OIL	.1620E-03	3.856	2.698
WATER	.4660E-03	0.	7.762

TOTAL 53.44 55.07

TOTAL MATERIAL BALANCE, %

	CARBON	HYDROGEN	OXYGEN	NITROGEN	SULFUR	MAF COAL
LIQUIDS	10.6	12.5	0.	0.	0.	7.45
HYDROCARBON GASES	37.7	171.	0.	0.	0.	32.2
CARBON OXIDES	5.05	0.	15.1	0.	0.	7.61
WATER	0.	18.8	23.9	0.	0.	7.76
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.	32.9
TOTAL	53.4	209.	39.0	100.	100.	90.2

HYDROGEN CONSUMPTION- .4562E-01 LB HYDROGEN/LB COAL
.9264 MOLE HYDROGEN/MOLE CARBON

EFFECTIVE CARBON CONVERSION- 53.44 PERCENT
EFFECTIVE ENERGY EFFICIENCY- 68.58 PERCENT