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**Advancement of Flash Hydrogasification:
Task VIII--Performance Testing****Topical Report**

By
A.Y. Falk
M.D. Schuman
D.R. Kahn

June 1986

Work Performed Under Contract No.: DE-AC21-78ET10328

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Rockwell International
Rocketdyne Division
Canoga Park, California

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June 1986

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ABSTRACT

This topical report documents the technical effort completed on Task VIII, Performance Testing, of the Rockwell International Advancement of Flash Hydrogasification Program for the Department of Energy (DOE). The overall objective of this phase of the program was to generate the experimental data required to investigate and verify the reaction chemistry associated with the Rockwell Advanced Flash Hydrolysis (AFHP) concept for the production of substitute natural gas (SNG) from coal. The AFHP concept is based on the reaction of pulverized coal with hot pyrolysis gases at elevated temperatures (1400 to 2000°F) in a single-stage, short-residence-time, entrained-flow reactor. In the current phase, an existing 1-ton/h coal hydroliquefaction process development unit (PDU) at the Rockwell facilities was modified for use as a hydrogasification test facility so that reaction residence times would be in the range of 2 to 8 s when coal was fed at a nominal 1/2 ton/h into reactors at 1000-psig pressure.

Test hardware fabrication and PDU modifications were completed in July 1984. System activation was completed and testing initiated in August 1984. The testing phase of the program ended in February 1985, with 5 preburner performance evaluation tests (14 test conditions) and 11 coal-fed reactor tests (19 test conditions) having been conducted. A Kentucky No. 9 high-volatile A bituminous (hvAb) coal pulverized to 90% <200 mesh was used as feedstock for the reactor testing. The reactor test parameters investigated spanned exit temperatures from 1775 to 2050°F, residence times from 2 to 8 s, inlet gas-to-coal ratios from 0.15 to 0.27 lb-mole/lb, and inlet-steam-to-H₂ mole ratios from 0.15 to 0.86. One test was conducted to investigate the effect of CH₄ addition to the hydrogen feed stream (22 mole % CH₄), with subsequent partial oxidation of the CH₄ to CO_x in the preburner system, on the AFHP reactor chemistry and product gas composition.

Overall carbon conversion and total carbon conversion to gases (namely, CH_4 , C_2H_6 , CO , and CO_2) ranged from 53 to 68% and 35 to 68%, respectively. Both increased with increasing temperature, residence time, inlet steam concentration, and gas-to-coal ratio. The gas produced was primarily CH_4 (31 to 53% carbon conversion to CH_4). Carbon conversion to total liquids was strongly dependent on reactor exit temperature and to a lesser extent on residence time, with values ranging from about 20% at 1775°F and 2-s residence time to zero at 1975°F and residence times greater than 5 s. Carbon conversion to C_6H_6 as high as 11.2% was obtained. Significant heterogeneous steam/char and homogeneous steam/hydrocarbon reactions leading to CO_x formation were observed at long-residence-time, high-steam-concentration, and high-reactor-temperature conditions. Carbon conversion to CO_x ranged from 3.5 to 29.4%. Methane addition was found not to significantly affect the AFHP reactor chemistry.

As a result of the Task VIII performance testing program, Rockwell has expanded its data base and significantly improved its correlation model describing the processes occurring during flash hydrolysis. The model is based on Kentucky No. 9 hvAb coals and consists of all past Rockwell FHP data and the present AFHP test data totaling 530 individual data points. The correlation provides an excellent tool for subsequent process evaluations to determine the economic potential of the Rockwell coal hydrogasification process.

FOREWORD

This document is a topical report summarizing work performed by Rockwell International for the U.S. Department of Energy, Morgantown Energy Technology Center (METC), under Contract No. DE-AC21-78ET10328,* Advancement of Flash Hydrogasification -- Task VIII, Performance Testing. The period of performance for the Task VIII technical effort was from December 23, 1983, through August 2, 1985.

The Rockwell Program Manager was Dr. Daniel R. Kahn. Technical administration of the program for DOE-METC was provided by Mr. Gary R. Friggens.

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* This basic contract has been modified several times since its inception in 1978. Formerly, it was referred to as "Coal Hydrogasification Process Development" under DOE Contract Nos. ET-78-C-01-3125 and DE-AC01-78ET10328.

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The technical work on Task VIII, Performance Testing, of the Advancement of Flash Hydrogasification Program (Contract DE-AC21-78ET10328) was organized by and conducted under the direction of a Rockwell project engineer, Dr. Arthur Falk. Several other Rockwell technical personnel contributed greatly to the successful performance of this task. Their efforts, noted below, are gratefully acknowledged.

Mr. Joseph Lecce, systems/development engineer, was responsible for organizing and conducting the reactor testing effort. Dr. Victor Dayan, analytical chemist, was responsible for the chemical analysis of the coal feedstock and reactor products. Over 40 years of combined experience of these two individuals enabled them to provide outstanding testing, sampling, and chemical analysis support. Mr. Mark Marko, engineering design specialist, was responsible for the test hardware design, while Messrs. Chris Erickson and Merlin Schuman, combustion and reactor modeling experts, respectively, performed the data reduction and analysis tasks. Mr. Schuman's contribution in analyzing and correlating of the AFHP/FHP test data was invaluable.

The financial support and encouragement given by the Department of Energy are acknowledged with Rockwell's appreciation.

The support and encouragement of the cost-sharing industrial participants in the AFHP program are also gratefully acknowledged by Rockwell. The industrial consortium comprised (1) British Gas Corporation (United Kingdom), (2) Gaz de France (France), (3) SNAM, S.p.A. (Italy), (4) Lummus Crest Inc. (U.S.A.), and (5) Mitsubishi Corporation leading a consortium of Japanese companies consisting of the New Energy Development Organization (NEDO), Tokyo Gas Company, Osaka Gas Company, Toho Gas Company, Nippon Steel Corporation, and Mitsubishi Heavy Industries.

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I. EXECUTIVE SUMMARY

The continuation of Department of Energy (DOE) contract DE-AC21-78ET10328, "Advancement of Flash Hydrogasification," was initiated on 23 December 1983 and involved two principal tasks: Hardware Fabrication and PDU Modifications (Task VII) and Performance Testing (Task VIII). An overall program schedule outlining these tasks is shown in Figure 1. The primary objective of this phase of the program was to generate the experimental data required to investigate and verify the reactor chemistry associated with the Rockwell Advanced Flash Hydrolysis (AFHP) concept for the production of substitute natural gas (SNG) from coal. This topical report highlights Task VIII and analyzes in detail the performance testing phase of Task VIII.

The Rockwell AFHP concept applies Rockwell short-residence-time rocket reactor technology experience to a method that injects finely pulverized coal into an entrained-flow gasifier and rapidly mixes it with a reactive gas mixture (predominantly hydrogen and steam) to produce methane, the major constituent of natural gas. Under certain conditions, a high-quality benzene coproduct is also formed in the reaction. From an overall process standpoint, the major goals of the AFHP concept are to minimize the cost of makeup hydrogen production, free the process from dependence on other developmental technologies (e.g., char oxygasification), and simplify the downstream processing of product gas.

Relevant to Task VII, test hardware was fabricated and an existing 1-ton/h hydroliquefaction process development unit (PDU) located at the Rockwell Santa Susana Field Laboratory (SSFL) was modified, in accordance with designs previously completed in Task VI of the contract, to allow testing in a mode that simulated the AFHP preferred reactor operating conditions. Specifically, the PDU was modified to (1) accommodate hydrogasification reactors (2- to 8-s residence time), (2) provide the required reactor feed systems (coal, O_2 , H_2 , CH_4 , and water for steam generation), and (3) provide for on-line gas chromatographic (GC) analysis of the injected and reactor product

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Figure 1. Overall Program Schedule for Advancement of Flash Hydrogasification

gases. The key new test hardware component fabricated was a preburner assembly. This unit furnished the required hot-gas mixture to the coal/hot-gas injector at the inlet to the AFHP reactor. This was accomplished by the partial oxidation of injected methane to carbon monoxide and the generation of steam by the in situ evaporation of hot water. Task VII was completed in July 1984.

The initial Task VIII activities involved test planning and system activation. Testing began in late August 1984 and continued through February 1985. Five preburner performance evaluation tests (14 test conditions) and 11 coal-fed reactor tests (19 test conditions) were conducted during this period. A Kentucky No. 9 high-volatile A bituminous (hvAb) coal was used as feedstock for the reactor testing. The nominal coal flow rate and reactor pressure for all reactor tests were 1/2-ton/h and 1000 psig, respectively. The reactor test parameters investigated spanned exit temperatures from 1775 to 2050°F, residence times from 2 to 8 s, inlet gas-to-coal ratios from 0.15 to 0.27 lb.mole/lb, and inlet steam-to-hydrogen mole ratios from 0.15 to 0.86. One test was conducted to investigate the effect of CH₄ addition to the hydrogen feed stream (22 mole % CH₄). Analysis and correlation of the test data were completed in May 1985.

In general, the test hardware and PDU performed well and according to design. The preburner assembly was capable of producing the required hot reactor inlet gas mixtures. The coal/hot-gas main injector and reactor were successfully operated with reactor injected-gas temperatures up to ~2600°F and reactor exit temperatures up to ~2050°F. Operation of the PDU was generally smooth, with excellent average as-collected carbon (98.2%), hydrogen (105.4%), and ash (100.3%) balances achieved during the reactor tests.

The preburner performance characterization tests succeeded in achieving several key goals. These included (1) demonstrating the operability and performance of the preburner assembly, involving reliable preburner and main burner ignition, successful steam generation, and high conversion of CH₄ to CO_x (primarily CO); and (2) defining the PDU system control and operating

characteristics. The latter resulted in successful checkout of all gas feed, product, and on-line GC systems, and smooth, easily controllable PDU operation over the desired operating ranges.

Overall carbon conversion (to gases and liquids) and total carbon conversion to gases (CH_4 , C_2H_6 , CO , and CO_2) for the 11 reactor tests ranged from 53.4 to 68.4% and 35.0 to 68.4%, respectively. Both increased with increasing temperature, residence time, inlet steam concentration, and gas-to-coal ratio. The product gas produced was primarily CH_4 , with a carbon conversion to CH_4 that ranged from 30.7 to 53.3%. The effect of steam concentration was most significant at high steam concentrations (~45 mole %), long residence times (>5 s), and high reactor exit temperatures (>1900°F). Carbon conversion to CO_x (primarily CO) ranged from 3.5 to 29.4%. High levels of CO_x production resulted from both heterogeneous steam/char reactions and the effect of steam on liquid breakup.

Carbon conversion to liquids (benzene and nonbenzene light oils) was found to be strongly dependent on reactor temperature and, to a lesser extent, on residence time, with liquids production decreasing with increasing reactor temperature and residence time. Steam concentration and gas-to-coal ratio had a negligible effect on the carbon conversion to liquids. Carbon conversion to total liquids varied from about 20% at 1775°F and 2-s residence time to zero at >1975°F and residence times >5 s, while that to benzene decreased from 11.2% to zero over this same range of test conditions.

On average, the BTX (benzene-toluene-xylene) steam-stripped from the PDU activated carbon bed was composed of 97% benzene, 1.2% toluene, and 1.5% unidentified light ends. The average calorific value and carbon, hydrogen, sulfur, and nitrogen contents of the BTX were 29,325 Btu/lb, 91.6%, 7.84%, 0.55%, and 0.02%, respectively. Light oil recovered from the PDU system light oil decanter contained between 39 and 46% benzene. Its average calorific value and carbon, hydrogen, sulfur, and nitrogen contents were 25,890 Btu/lb, 93.2%, 6.4%, 0.28%, and 0.15%, respectively.

The last reactor test was conducted specifically to investigate the effect of CH_4 addition, with its subsequent partial oxidation to CO in the preburner assembly, on reactor coal carbon conversions and product slate. Within the experimental accuracy, the level of methane added (22 mole % methane in the hydrogen feed stream) did not appear to affect the overall reactor performance.

Several important aspects of reactor chemistry were noted by comparing measured reactor exit compositions with partial equilibrium predictions. For most test conditions, CO_2 was in partial equilibrium with CO. At the lower reactor exit temperatures, however, the CO concentration at the reactor exit was much less than that based on partial equilibrium and the measured CH_4 concentration. Therefore, under these conditions, equilibrium does not restrict the homogeneous steam/hydrocarbon reactions, and a large potential exists for further homogeneous CO production from CH_4 .

One significant conclusion resulting from the reactor testing was that the simultaneous production of high levels of CO_x and benzene does not appear to be feasible when a Kentucky No. 9 hvAb coal is used. High CO_x production is favored by high reactor exit temperatures, high steam concentrations, and long residence times. However, these are just the conditions that promote the hydrocracking of the benzene to light gases.

The average overall hydrogen, sulfur, nitrogen, and chlorine elemental conversions for the 11 reactor tests were 93.5, 82.4, 74.6, and 67.4%, respectively. Each of these elemental conversions is higher than the average overall carbon conversion (59.3%) for the reactor tests. These elemental conversions increased slightly with increasing reactor exit temperature and did not appear to be affected by reactor residence time.

The carbon content of the solid char produced (~74 to 78 wt. %) was nearly the same as that of the parent coal (~74 wt. %). However, the char's hydrogen, sulfur, and nitrogen percentages are substantially lower. The char is relatively free of oxygen, and its ash content (~20 wt. %) is more than twice that

of the coal fed, while the heating value of the char is about 85% that of the coal. The true (solids) density of the chars was about 1.25 times that of the parent coal (82.4 lb/ft³), whereas, the bulk/compacted density was only about 45% that of the coal. This indicates that the char is considerably more porous than the coal. The mass median diameter of the coal particles was in the range of 50 to 60 μ m with about 90% <200 mesh. The char had a mass median diameter about twice that of the parent coal.

Trace species analyses were performed to establish the concentrations of H₂S, NH₃, COS, HCN, and CS₂ in the product gas stream. The H₂S and NH₃ concentrations were determined experimentally during three reactor tests. Equilibrium estimates of COS, HCN, and CS₂ concentrations were made using a chemical equilibrium program developed by NASA. Both H₂S and NH₃ concentrations ranged from 3,000 to 5,000 ppm, depending on the test conditions. In general, the concentration of H₂S was slightly greater than that of NH₃. The estimated equilibrium concentrations were approximately 6 to 15 ppm for COS, 1 to 4 ppm for HCN, and <0.05 ppm for CS₂. All concentration levels are given on a dry gas volume basis and tend to increase with increasing reactor severity.

In summary, the reactor testing completed during Task VIII of the program was successful in establishing a sound data base for verifying the AFHP reactor chemistry. These data were used to expand and significantly improve the Rockwell correlation model describing the processes occurring during flash hydrolysis (FHP). The model analysis included 580 individual points from all past Rockwell hydrogasification and hydroliquefaction testing using Kentucky No. 9 hvAb coal, including the present AFHP gasification data. The method employed involved defining a set of phenomenological reactions representing the processes occurring during AFHP/FHP and then applying a nonlinear multiple regression analysis to the set of equations derived according to the kinetics of those reactions. The resulting correlation provides an excellent tool for subsequent process design evaluations to determine the economic potential of the Rockwell coal hydrogasification process.

II. INTRODUCTION

Under DOE sponsorship, Rockwell International has been developing a process for coal FHP based on the reaction of pulverized solid carbonaceous feedstocks with hot pyrolysis gas at elevated temperatures (1400 to 2000°F) in a single-stage, short-residence-time, entrained-flow reactor. Gases and liquids, if desired, are produced in the reactor, and unreacted material forms a dry, free-flowing char. Following quenching of the reactor products, liquid products are separated and gases are processed for recycle and product recovery. By varying the reactor operating conditions, the product composition can be controlled over a broad range--from predominantly a syncrude oil with SNG by-product, to SNG with a relatively pure (~98 wt. %) benzene by-product, to SNG alone as the sole hydrocarbon product. The hydrogasification process operates in one of the latter two product regimes, such that a large fraction of the feedstock carbon is converted directly to methane.

On 10 May 1983, Rockwell initiated work on Task VI (Design of PDU Modifications) of the Coal Hydrogasification Process Development program under DOE contract DE-AC21-78ET10328. The objective of this task was to design the test hardware and facility modifications necessary to convert an existing 1-ton/h coal hydroliquefaction PDU at Rockwell facilities for use as a hydrogasification test facility. This conversion would provide the capability for subsequent engineering-scale testing to address key questions on reactor chemistry associated with the advancement of flash hydrogasification.

The Task VI design effort was conducted over a 5-month period ending in September 1983. Test hardware and facility modifications were designed such that the PDU would be capable of accommodating hydrogasifier testing over a wide range of operating conditions. The modified facility would enable short-duration (1 to 2 h) hydrogasification testing and preburner performance evaluation testing to be performed to fulfill specific program objectives. The design included provisions for separate supplies of coal, hydrogen, oxygen, CH₄, CO, and water (for steam generation). In general, the modified facility was designed to accommodate both 10- and 20-ft-long hydrogasifier reactors

so that residence times would be in the range of 2 to 8 s when coal was fed at a nominal 1/2 ton/h into reactors at 1000-psia pressure. Provisions were also made for real-time analysis of the product gases by using an on-line GC system.

A. PROGRAM OBJECTIVES AND SCOPE

On 23 December 1983, DOE and Rockwell International mutually agreed to further amend the contract statement of work to incorporate two additional tasks: Task VII — Hardware Fabrication and PDU Modifications, and Task VIII — Performance Testing. The overall objective of the modified program was to investigate and verify the reactor chemistry associated with the Rockwell AFHP concept for the production of SNG from coal. Specific objectives involved:

- Fabricating test hardware and modifying an existing 1-ton/h hydroliquefaction PDU to allow it to be operated in a mode that simulates the preferred reactor operating conditions.
- Operating the modified facility to develop the data base required to verify the reactor chemistry associated with the advancement of flash hydrogasification.

Further reflecting this modification of the scope of work, the contract title was changed to "Advancement of Flash Hydrogasification."

The Rockwell AFHP concept involves adding steam and methane to the hydrogen gas feed stream. The aim is to promote the occurrence of significant steam/char/hydrocarbon reactions in the FHP reactor to produce CO. Significant process improvements, such as higher overall process thermal efficiencies and lower capital and operating costs, may thereby result. The major goals of AFHP are to reduce the cost of makeup hydrogen production, free the process from dependence on other developmental technologies (e.g., char oxygasification), and simplify downstream product processing.

Test hardware fabrication and PDU modifications (Task VII) were performed during the period from January to July 1984. The test hardware was fabricated specifically to study the reactor chemistry and was not intended to represent a design or configuration of hardware for use in a commercial process. The test facility was modified for the purposes of the test program and consisted of the hydrolysis reactor, a system to simulate the gas fed to the reactor under full-scale process conditions, and a means for capturing the products of reaction for subsequent measurement and analysis.

The testing phase of the program spanned 7 months and ended in February 1985. A total of 5 preburner characterization tests (14 test conditions) and 11 coal-fed reactor tests (19 test conditions) were conducted. A Kentucky No. 9 hvAb coal pulverized to 90% <200 mesh was used as the feedstock for the reactor testing. The primary test variables and respective ranges investigated were as follows:

- Reactor exit temperature (1775 to 2050°F)
- Inlet gas steam concentration (13 to 46%)
- Residence time (2 to 8 s)
- Hydrogen feed gas CH₄ concentration (0 and 22%).

It should be emphasized that the tests described in this report focused only on studying the reactor chemistry associated with AFHP and did not involve the entire process of making substitute natural gas from coal.

B. BACKGROUND

Rockwell International has been developing the FHP of carbonaceous feedstocks under several DOE contracts since 1975. The basic Rockwell process concept and its flexibility in controlling the product slate are noted above.

A key element of the FHP reactor concept is the injector/reactor technology pioneered and developed by Rockwell. This technology, first used in liquid-fueled rocket engines, has several distinctive features that make it

superior to alternative means of achieving the hydrolysis of carbonaceous feedstocks. These include extremely rapid mixing and heating of reactants (10 to 20 ms), precise and uniform control of temperature and reaction time, rapid reactor startup and shutdown, unrestricted choice of feedstock, and direct scaleup. In addition, because the reactions occur in a short-residence-time (20 ms to 8 s), high-pressure (500 to 1500 psig), entrained-flow mode, the reactor is inherently compact. This compactness permits the shop fabrication of even commercial-scale hardware, with cost and reliability advantages over field fabrication. Reliability also benefits from the mechanically simple design and because it is economically possible to use high-quality materials in a more compact unit. The small reactor size contributes to rapid startup, stable operation, and facile process control. The small reactor size and modularity also make the process more readily maintainable and make the incorporation of any spare reactors more cost effective. These factors would all tend to increase the projected availability of a commercial plant system and thus significantly benefit overall process economics. It should be recognized, however, that Rockwell has not yet performed an FHP reactor test of more than 2 h in duration. Long-duration testing on scaled-up FHP injector/reactor hardware will be required to demonstrate the above inherent features and verify the potential economic benefits.

The first Rockwell International coal hydrogasification project, which began in March 1977 as a joint effort with Cities Service Company under DOE contract EX-77-C-01-2518, involved a 20-month bench- and engineering-scale study.¹ Subsequently, Rockwell undertook the current development program under DOE contract DE-AC-01-78ET10328.

The initial engineering-scale hydrogasification tests conducted at Rockwell¹ were performed in a 1/4-ton/h facility originally developed for hydroliquefaction testing. Forty-three successful tests were conducted. These consisted of 30 tests with three types of coal (Montana Rosebud subbituminous, Kentucky hvAb, and Illinois hvCb) and 13 tests with Minnesota peat. Reactor pressures ranged from 500 to 1500 psig, temperatures from 1000 to 2000°F, and residence times from 500 to 5500 ms. Carbon conversions to gases as high as

71% with coal and 84% with peat were achieved. Tests were also run with hydrogen feed gases containing 15 to 20% CH₄, simulating a potential recycle process gas. After 1 year, testing was moved to a 1-ton/h PDU facility to allow running longer duration tests (1 to 2 h). Tests were conducted with the bituminous coals used in the smaller-scale facility experiments.

At the conclusion of these test activities, the second DOE contract²⁻⁴ was initiated. This effort consisted of testing in a 3/4-ton/h engineering-scale test unit (ETU), together with the design and construction of an 18-ton/day integrated process development unit (IPDU).

In the first year of testing under the second contract, both Montana Rosebud subbituminous and Kentucky hvAb coals were used in the ETU. During the second year, 32 additional tests were completed, primarily with Kentucky No. 9 hvAb coal at a reactor pressure of 1000 psia. Injectors demonstrated stable operation with high carbon conversion to gas at low hydrogen-to-coal ratios (0.2 to 0.4 by weight). Significantly, three replicate runs (tests 318-36, -37, and -50) were performed under nearly identical conditions and produced results with high reproducibility. This demonstrated the advance of the hydrogasification process to the stage of reliable test operations. These runs also demonstrated a high carbon conversion to BTX (~11%) and subsequently served as the design point for a commercial plant conceptual design performed by the Lummus Company Inc. under subcontract to Rockwell. The BTX produced from the reactor is 98 to 99% benzene and can be readily upgraded to chemical-grade purity using existing commercial technology.

Design of the IPDU facility was completed in May 1980, and construction at the Rockwell Santa Susana Field Laboratory (SSFL) near Los Angeles proceeded until being halted by DOE at about 60% completion. The facility is designed for continuous operation for periods up to 30 days and has provisions for on-site coal storage, coal pulverization and drying, pneumatic lock hopper pressurization of the pulverized coal feed, lock hopper letdown of the char produced, and work-around (versus remote) facility operation.

Rockwell has also performed extensive modeling studies and has developed a detailed coal FHP reactor model for the correlation and prediction of FHP hydrogasification and hydroliquefaction test results. The modeling method used involved defining a set of phenomenological reactions representing the processes occurring during FHP and then applying a nonlinear multiple regression technique to a set of equations derived according to the kinetics of those reactions.⁴

As an integral part of the Rockwell Coal Hydrogasification Process Development Program, the Lummus Company (now Lummus Crest Inc.), with the concurrence of DOE, prepared under subcontract to Rockwell a preliminary conceptual design of a complete 250 billion Btu/day commercial-scale SNG-from-coal plant based on the Rockwell Coal Hydrogasification Process. This 18-month study culminated in the issuance of a predesign report, submitted to Rockwell in May 1981.⁵ In addition to the 250 billion Btu/day of SNG, the baseline plant was designed to produce 5310 bbl/day of chemical-grade benzene as a coproduct. The plant showed excellent economic potential: using the economic methodology developed by C F Braun⁶ for DOE, Lummus estimated the cost of gas at \$3.68 per million Btu in mid-1979 dollars. Total plant investment was estimated at \$1331 million, including a 15% project contingency.

Beyond the DOE-sponsored programs, Rockwell continued its efforts to advance FHP technology and studied process alternatives with potential for improving the process, increasing its efficiency, and reducing capital requirements and operating costs. These in-house Rockwell studies were aimed primarily at alleviating the expensive burden of makeup hydrogen production, freeing the process from dependence on other developmental technologies, and simplifying downstream product processing. These efforts yielded a new Rockwell process concept termed Advanced Flash Hydropyrolysis.

A Rockwell coal FHP reactor model was used extensively in developing the AFHP process. Coal conversion levels and reactor effluent compositions were predicted by the model as functions of reactor operating conditions. Combining these results with parallel analyses of downstream processing led to the establishment of desired process operating points. Various process designs were subsequently developed and their economics evaluated. This Rockwell process design effort provided the basis for further proposed experimental testing and led to the present modification of contract DE-AC21-78ET10328 to investigate and verify the reactor chemistry associated with the AFHP concept.

III. DESCRIPTION OF TEST FACILITY

The Rockwell 1-ton/h coal hydroliquefaction PDU was modified as part of Task VII to accommodate reactor testing under operating conditions characteristic of flash hydrogasification. Facility modifications consisted primarily of (1) modifying the facility structure to accommodate testing with nominal 10- and 20-ft-long reactor trains, (2) installing and/or modifying various feed systems, and (3) installing an on-line GC system for analysis of both injected and reactor product gases. The PDU is located at the SSFL Energy Bowl Area test facility on a former rocket engine test stand.

Figure 2 presents a simplified schematic of the hydrogasification PDU. Pulverized coal is fed from the high-pressure coal feeder in dense-phase flow

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Figure 2. Simplified Schematic of Coal Hydrogasification PDU

using nitrogen as the pressurant/carrier gas. Hydrogen or in some cases a hydrogen/methane mixture is fed initially to the head end of the preburner assembly and heated by a gas-fired heat exchanger to about 1200°F. Oxygen is then added for partial combustion to supply required process heat, as necessary, to convert any added CH_4 to CO. Hot water (~200°F) and ambient temperature hydrogen may be injected into the steam generator portion of the preburner assembly to generate required steam and provide the desired preburner assembly exit-gas composition and temperature (~1500°F).

The PDU design included an option to install a gaseous CO feed system that could be used to add CO to the preburner assembly exit gas, as required. It was not necessary to install this system because of the efficiency of the preburner assembly in converting CH_4 to CO.

In the coal/hot-gas 4-on-1 main injector assembly, additional oxygen is added to the preburner exit gas to provide the requisite process heat, and the coal feedstock is subsequently thoroughly mixed with this hot-gas mixture. After being allowed to react for the desired residence time, the reactions are quenched at the reactor exit by cooling the reaction products to the desired temperature (~850°F) using a direct water spray quench. During earlier coal liquefaction testing,^{7,8} both direct and indirect heat exchanger quench units had been successfully employed.

Three stages of char/vapor separation are included: an initial gravity-settling separation within the main char receiver followed by two cyclone separators in series. Char is removed from these systems after each test.

The vapor phase material is further cooled and condensed in a shell-and-tube condenser to about 70°F by heat exchange against ambient temperature water. The condensate is recovered in a vapor/liquid separator and flows through an accumulator, a pressure letdown valve, and a flash drum and then into a light-oil/water decanter. The water in the product gases also is condensed in this light-oil condenser. The light-oil/water mixture is separated by decantation and removed from the decanter after each test.

The product gases from the light-oil vapor/liquid separator pass through a pressure letdown valve, a carbon bed BTX adsorber, and a venturi flowmeter and then past a gas-sampling station into a scrubber system before being vented to a flare stack. The BTX adsorption, product-gas flowmeter, and gas-sampling portions of the system are operated at ~60 psig. After the test, steam is passed through the BTX adsorber bed to desorb the BTX, whereupon the BTX and steam are condensed and separated by decanting. A conventional propane-fired packaged boiler is used to generate the steam required for stripping.

As noted in Figure 2, the PDU has provisions for on-line gas sampling at two locations. One sample point, immediately downstream from the 4-on-1 main injector face, was used to sample the injected gas mixture during the pre-burner performance characterization tests as well as before and after coal flow for the reactor tests. The second sample point, just upstream from the light-oil condenser, was used to sample the reactor product gas during the coal tests.

A detailed system plumbing and instrumentation schematic and instrumentation list are included as part of Appendix A. That appendix also describes the data acquisition system (DAS) and the on-line GC system.

IV. DESCRIPTION OF TEST HARDWARE

The test hardware was designed and detailed drawings were prepared during Task VI--Design of PDU Modifications. Fabrication of the hardware was completed from January through June 1984 as part of Task VII--Hardware Fabrication and PDU Modifications. Where possible, maximum use was made of existing PDU components and associated test hardware from prior DOE programs. The test hardware assembly and its components are described briefly in this section.

A. TEST HARDWARE ASSEMBLY

The test hardware was designed to accommodate hydrogasifier testing over the range of operating conditions listed in Table 1 and to permit short-duration (1 to 2 h) hydrogasification tests to be performed. Key test hardware components include (1) a preburner assembly; (2) a 4-on-1 injector assembly; (3) a 10- or 20-ft-long reactor tube; (4) a reactor pressure vessel cap, spools, and service ring; (5) hardware service lines and supports for use within the reactor pressure vessel; and (6) a GC sample line assembly.

The test hardware assembly, shown in Figure 3, comprises the major process components. High-temperature hardware components such as the preburner assembly, injector, and reactor tube are housed within a reactor pressure vessel to provide a pressure-balanced environment. The reactor tube is pressure balanced at the reactor operating pressure, while the upstream components are designed to withstand the differential pressure load resulting from the fluid-flow-induced head losses. A simplified sketch of the test hardware configuration is presented as Figure 4.

The pressure vessel cap is designed to provide ready access to the preburner assembly and service lines for inspection and maintenance. The service ring provides fluid service ports, pressure measurement taps, and thermocouple (T/C) line penetrations. As shown in Figure 3, a manifold for a nitrogen gas purge is provided to keep hydrogen gas from collecting around the

TABLE 1
TEST HARDWARE DESIGN CONDITIONS

Component	Parameter	Design Range
Preburner ^a	Pressure	1500 psia (operating pressure 1100 to 1300 psia)
	H ₂ /CH ₄ mixture (at 1100°F) flow rate	150 to 460 lbm/h
	Ambient temperature O ₂ flow rate	250 to 730 lbm/h
	Hot water (steam) flow rate	180 to 1250 lbm/h
	Ambient temperature H ₂ flow rate	40 to 250 lbm/h
	Coolant water flow rate	10 gal/min (ambient temperature at 1000 psig)
Injector ^a	Pressure	1500 psia (operating pressure 1050 to 1250 psia)
	Coal flow rate	1000 lbm/h
	Hot-gas inlet flow rate	0.20 to 0.25 mole/lbm coal
	Hot-gas inlet temperature	1500°F
	Ambient temperature O ₂ flow rate	55 to 300 lbm/h
	Hot-gas exit flow rate	0.20 to 0.25 mole/lbm coal
Reactor tubes ^a	Hot-gas exit temperature	Up to 2600°F (2000 to 2600°F)
	Pressure	1000 psia (balanced pressure operation)
	Temperature	1800 to 2000°F
Reactor pressure vessel	Residence time	2 to 8 s
	Pressure	1500 psia (operating pressure 1000 psia)
GC sample line assembly ^a	Temperature	650°F (operating temperature ~300°F)
		Designed to cool gas sample from 2000°F to 1000°F (essentially balanced pressure operation)

^aContained within reactor pressure vessel.

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Figure 3. Test Hardware Assembly

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Figure 4. Simplified Sketch of Test Hardware Configuration

oxygen lines and to minimize the migration of char throughout the test hardware internals. The length of the pressure shell can be adjusted to accommodate either 10- or 20-ft-long reactor tubes.

The reactor internals assembly is instrumented with pressure tap sensor lines and T/Cs to provide key operational and performance data. Pressure taps are located at the injector face, in the preburner exit line, and on the reactor pressure vessel wall. T/Cs were located on the reactor tube wall, in the reactor near its inlet and outlet, at various positions in the water coolant for the preburner assembly, and in and on the preburner hot-gas inlet and exit lines. Critical T/Cs located on the preburner assembly exit-gas line, in the preburner assembly throat coolant, and in the reactor stream are redundant. Stream pressures and temperatures are also measured entering and leaving the reactor pressure vessel.

A minimum 0.75-in.-thick Fiber Frax (6-lb/ft³) thermal insulation blanket was wrapped around the reactor tube, injector body, and approximately 1500°F and 1100°F expansion lines to limit process heat losses and pressure shell temperatures to acceptable levels.

The test hardware assembly was designed to facilitate component assembly, checkout of internal pressure connections for leak tightness, and installation into the pressure shell. The preburner assembly, injector, reactor tube, and service ring were assembled, instrumented, insulated, and pressure checked in the test area workshop before the whole assembly was installed inside the reactor pressure vessel on the test stand.

The overall assembly is about 321 in. long by 35 in. in diameter and weighs approximately 700 lb with a nominal 20-ft-long reactor tube attached. With a 10-ft-long reactor tube, the assembly is approximately 201 in. long and weighs approximately 600 lb.

The reactor internals assembly comprises the following components:

- Preburner assembly
- Hot-gas/coal, 4-on-1 impingement, water-cooled injector
- Reactor tube, 10 ft or 20 ft
- Service ring
- Preburner hot-gas (~1100°F) inlet line
- Injector hot-gas (~1500°F) inlet line
- Preburner support
- Injector support
- Service lines (O₂, H₂, H₂O for steam, H₂O coolant, CO, and N₂)
- GC sample line assembly
- Pressure and temperature instrumentation
- Fiber Frax thermal insulation.

Several photographs of the preburner assembly and 4-on-1 injector assembly installed in the service ring are presented as Figures 5 and 6.

Figure 5. Photograph of Preburner Assembly and 4-on-1 Injector Assembly Installed in Service Ring (View from Top of Assembly)

Figure 6. Photograph of Preburner Assembly and 4-on-1 Injector Assembly Installed in Service Ring (View from Bottom of Assembly)

B. TEST HARDWARE COMPONENTS

The major system components (i.e., preburner assembly, 4-on-1 injector, and reactor tubes) are described separately below. The reactor pressure vessel components, injector and preburner supports, service lines, and GC sample line assembly are grouped as "miscellaneous components."

1. Preburner Assembly

The preburner assembly (Figure 3) comprises a $H_2/CH_4/O_2$ preburner and a steam generator, is approximately 24 in. long by 4 in. in diameter, and weighs about 50 lb. Design of the preburner assembly was based on supplying the required hot feed gases to the injector at $\sim 1500^\circ F$. This unit partially oxidizes CH_4 to CO and generates steam in situ by evaporating hot water in the presence of the other reactants. Provisions were made for adding ambient temperature CO to the preburner assembly exit gas upstream from the 4-on-1 injector, as required.

The preburner (P/B) assembly comprises these functional parts:

● $H_2/CH_4/O_2$ coaxial injector	}	$H_2/CH_4/O_2$ preburner
● Combustion chamber		
● Water injector	}	Steam generator (S/G)
● H_2 injector		
● Chamber		
● Exit flange		
● Thermal sleeve		

Designed with a removable injector and flared tube service line connections, the P/B assembly is flanged to the exit line to facilitate assembly, disassembly, and modification or repairs.

Process gas wetted parts are made of Incoloy 800 to withstand the severe environment. The remaining parts are made from 304 or 316 stainless steel, except the oxygen ports, which are oxidation-resistant Inconel 601. The preburner injector face, P/B combustion chamber walls, and most S/G parts (with the exception of the thermal sleeve) are forced-convection-cooled by pressurized water. During testing, the upper portion of the P/B combustion chamber inside wall was modified to increase its cooling. This specific hardware modification is discussed in Section V.C.9.

The function of each of the major components is described below.

a. H₂/CH₄/O₂ Coaxial Injector

The P/B injector design provides for the efficient mixing of a preheated H₂/CH₄ mixture with ambient temperature O₂ before subsequent injection of hot water and ambient temperature H₂ streams into the S/G section of the P/B assembly. Established mixing criteria obtained from Refs. 9 and 10 were used to develop these designs. Because of its good performance capability over a wide fuel/oxidizer flow range, a coaxial element injector scheme was selected for the H₂/CH₄/O₂ injector. The key factor for establishing good mixing effectiveness was determined to be the fuel/oxidizer velocity ratio. Also, a multielement (7-hexagonal pattern array) approach was selected to minimize chamber length (and thus heat losses) and to ensure ignition by surrounding the central element with barrier elements to prevent quenching by the water-cooled wall of the chamber during ignition. Uniform fuel and oxidizer flow to each element is ensured by high-pressure-drop design combined with low plenum inlet and distribution velocities. A face view photograph of the seven-element coaxial preburner injector is shown in Figure 7.

Figure 7. Face View of Seven-Element Coaxial Preburner Injector

b. Preburner Combustion Chamber

Design of the combustion chamber was based on the data from Refs. 9 and 10, which involved determining the effect of combustion interference on shear element cold-flow mixing. These results clearly demonstrated that a significant increase in mixing length was required because of combustion interference. Based on these data, a chamber length was selected to ensure complete combustion. The combustion chamber is 8.25 in. long (from injector face to S/G water orifice plane) and has an ID of 1.31 in.

c. Water Injector and Steam Generator Chamber

The water injector and S/G chamber extends from the water injection orifice plane to the end of the P/B assembly, a distance of 8.13 in. The water necessary to provide the desired steam concentration, which when combined with the downstream hydrogen also cools the process gases from ~3500°F to ~1500°F, is injected at about 200°F through sixteen 0.031-in.-diameter

orifices at a 0.75-in.-diameter throat. The throat is provided to increase the process gas velocity and thus generate 20- μ m water droplets, which rapidly evaporate to minimize the S/G heat losses.

The drop-size analysis was based on the Rockwell experience with gas/liquid cross-flow atomization and the determination of the stream/drop penetration and mixing.¹²⁻¹⁴

d. H₂ Injector

The H₂ injector consists of two sets of orifices: one with four equally spaced 1/8-in.-diameter holes, the second with four equally spaced 1/16-in.-diameter holes. Both sets are located 3.13 in. downstream from the S/G water injection point. The design of this injector is based on the criteria given in Refs. 15, 16, and 17. Two sets of orifices were required to obtain good mixing and penetration over the wide range of hydrogen flows. Good mixing is required to ensure meeting the 1500°F outlet temperature. Only one set of orifices was employed for any given test.

e. Preburner Assembly Exit Flange

A water-cooled flange is provided to facilitate assembly and disassembly of the P/B assembly from the 1500°F exit line.

f. Thermal Sleeve

An Incoloy 800 thermal sleeve is provided in the P/B assembly exit flange to minimize heat and pressure losses.

2. Hot-Gas/Coal Injector Assembly

The injector assembly, a hot-gas/coal 4-on-1 impingement, water-cooled unit, is a modification of a successful design used previously in the Rockwell coal hydroliquefaction program to provide up to 2600°F hot reaction gases.⁷

A photograph of one of the injector assemblies used during that program is presented in Figure 8. A face view of the modified injector is presented in Figure 9. Two liquefaction injector assemblies (one primary unit plus a back-up unit) were modified for use on this program.

The injector consists of three basic elements:

- 4-on-1 impingement configuration
- Main burner, recessed coaxial elements
- Water-cooled face and coal tube.

a. Hot-Gas/Coal Mixing

The hot-gas/coal mixing performance of the 4-on-1 impingement injector is based on the cold-flow test results cited in Refs. 1 and 11. These results are shown in Figure 10 with the range of operation for this program superimposed. The mixing efficiency term in Figure 10, E_m , is derived from an analysis of two-phase gas/coal flow based on mixing criteria developed for characterizing rocket engine injectors. Specifically, the mixing efficiency represents the sum of mass-weighted deficiencies in the flow field and is calculated as the sum of local ratios of mass fluxes when summed over the regions in which fractional mass fluxes are deficient relative to the spatial average values.¹¹ Thus, at a given point downstream from the injector face, 100% mixing efficiency represents completely uniform mixing of the injected gas/coal mixture with no radial variations in species mass fluxes. The Elverum-Morey parameter (the abscissa in Figure 10) is appropriate for comparing data from injectors of different designs;¹ it consists of a combination of gas/coal mass flow rate, density, and orifice area ratios.

The diameter of the coal tube ($D_c = 0.281$ -in. ID) was chosen to provide optimum mixing at the nominal hot-gas flow rate for the required gas port diameter ($D_g = 0.302$ in.). The spread in mixing efficiencies is caused by the hot-gas flow rate and density variations throughout the planned test matrix at a nominal 1000-lb/h coal flow rate.

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Figure 8. Photograph of Liquefaction Injector Before Modification for Use on AFHP Program

Figure 9. Face View of 4-on-1 Injector Assembly

Figure 10. 4-on-1 Injector Mixing Efficiency Correlation

b. Main Burner

The four main burner coaxial elements, which are contained in the injector body, are designed to provide optimal mixing at a hot-gas outlet temperature of 2100°F. At higher temperatures, mixing will be poorer, and hence the wall heat flux will remain low because of a hydrogen-rich gas film along the wall, which will be cooler than the bulk temperature. This reduced heat flux combined with the 0.83-in. recess results in acceptable performance and injector body temperatures.

The fuel annulus in the hydroliquefaction injector body was increased to 0.266 in. to provide good mixing at an acceptable fuel side pressure drop (i.e., approximately 100 psid). The O₂ posts (0.062-in. ID) were redesigned to provide for operation at an inlet gas temperature of approximately 1500°F. This change was required because the post/body was originally designed for operation at an inlet gas temperature of only about 1200°F.

c. Water-Cooled Injector Face and Coal Tube

Water cooling of the injector face and coal tube is provided to ensure a coal tube temperature less than 350°F, thus preventing coal from sticking to and blocking the coal exit port as well as keeping the copper sealing gasket and reactor tube mating flange and bolts at acceptable temperatures.

The water coolant for the coal tube is extended through the 1500°F expansion coil, as shown in Figure 3, to provide a low-temperature, cooled support for the injector and reactor tube. These components are supported from the service ring by a bolted cantilever.

3. Reactor Tubes

Although the modified facility was designed to accommodate both 10- and 20-ft-long hydrogasifier reactors, it was decided to control reactor residence time by changing reactor diameter rather than length. Accordingly, two nominal 20-ft-long reactor tubes were used to meet the 2- to 8-s gas residence-time requirements of the program. An 8-in.-diameter pipe is the maximum permissible for the ~12-in.-ID pressure vessel shell while still having enough room for thermal insulation and installation clearance. The upper (inlet) end of the reactor tubes is flanged and copper-gasket-sealed to the water-cooled face of the 4-on-1 injector body for ease of changeout.

The reactor tubes were fabricated from 304 stainless steel, which, based on previous Rockwell coal hydrogasification test experience, has sufficient strength and corrosion resistance under the temperature and reaction environment for the proposed test durations. A simplified sketch of the reactor tubes is presented in Figure 11. The diverging/converging sections in the reactors were required to obtain the desired residence time within the physical constraints of the reactor test system. Reactor wall thickness varied from 0.065 to 0.120 in. The long cylindrical sections of long- and short-residence-time reactors were 8- and 5-1/2-in. Schedule 5 pipe, respectively.

Figure 11. Sketch of Reactor Tubes

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4. Miscellaneous Components

a. Reactor Pressure Vessel Components

Three new reactor pressure vessel components--a cap, a spool, and a service ring--were designed for use during this program. The cap was designed to house the preburner assembly and to provide ready access to the preburner and its service lines for inspection and maintenance as required. This can be accomplished by removing only the pressure vessel cap, since all service lines penetrate the service ring. Because the test program required use of reactor tubes longer than previously employed, a 10-ft-long spool assembly was added. The service ring was made from a 14-in., 1500-lb blind flange with a 13.5-in.-diameter bore and an R-63 ring groove seal in its top surface. The service ring provides for all the fluid service, pressure measurement tap, and T/C line penetrations and provides locations for attaching injector and preburner supports.

The pressure vessel components were designed for conditions of 1500 psig and 650°F. This design basis provided a substantial margin above the nominal operating level of 1000 psig and ~300°F, thereby minimizing the need to activate the pressure relief system during operation.

b. Injector and Preburner Supports

Two carbon-steel cantilever brackets were designed to support the hardware within the reactor pressure vessel. The first supports the injector and reactor tube assembly. This support is designed to limit the lateral deflection of the reactor tube at its exit flange to avoid hard contact between the tube and the pressure shell during heatup of the reactor. To facilitate assembly and disassembly, the support is bolted to both the service ring and coal coolant tube. The second bracket is bolted between the water-cooled exit flange on the preburner assembly and the service ring. This support is designed to remove the 1500°F and 1100°F expansion line loads generated during operation because of the support anchor to line temperature differences.

c. Service Lines

Nearly all of the fluid service lines were fabricated from 0.5-in. OD by 0.035-in. wall Type 304 stainless-steel tubing with 37° flared fittings for ease of assembly and disassembly. Because of small thermal expansion motion at the preburner and injector end (top) and the need for some flexibility during assembly to avoid tight fabrication tolerances, thermal expansion loops are provided in the cool lines.

Two hot service lines are required: the preburner H_2/CH_4 mixture inlet line (1100°F) and the main-burner, hot-gas inlet line (approximately 1500°F).

The 1100°F preburner inlet line is a three-loop, helically coiled, 8.5-in.-mean-diameter, 3/4-in. Schedule 40, Type 304 stainless-steel expansion line designed to limit thermal expansion loads to 200 lb. This line is attached between the service ring thermal standoff and preburner injector with standard 37° flared fittings for ease of assembly and disassembly. An insulated, welded thermal sleeve is used at the service ring penetration to avoid bulk heatup of the ring by the 1100°F gases.

The 1500°F main-burner, hot-gas inlet line from the preburner assembly to the injector main burner is a helical coil expansion loop made from Incoloy 800 material. The salient design features are that the line minimizes the fuel flow pressure drop, limits the thermal expansion load into the injector to 200 lb, and is flanged at the steam generator exit to facilitate assembly and disassembly of the preburner assembly. Because of its good high-temperature strength, corrosion (steam) resistance, and hydrogen compatibility, Incoloy 800 was selected as the line material of construction.

d. Gas Chromatographic Sample Line Assembly

The GC sample line assembly was designed to permit sampling the reactor gases near the injector face. The assembly consists of three components: (1) a 1/8-in.-OD sample tube line attached to the reactor tube, (2) a 7-in.-long N₂/hot-gas tube-to-tube heat exchanger to cool the sampled gas from about 2000°F to about 1000°F before exiting the reactor pressure vessel shell, and (3) a 1/4-in.-OD N₂ coolant line. Both lines contain expansion loops necessary to limit the thermal expansion stresses to allowable levels.

To evaluate the performance of the preburner assembly and injector main burner, the sample line assembly was employed during the preburner assembly evaluation tests and before coal flow during some hydrogasification tests.

V. PERFORMANCE TESTING

The AFHP program performance testing phase is subdivided into the following four sections:

Section A. INTRODUCTION--outlines the overall program test objectives and summarizes the testing performed.

Section B. PREBURNER CHARACTERIZATION TESTING--describes the specific preburner performance characterization/checkout test objectives and results.

Section C. REACTOR TESTING--presents the detailed coal-fed reactor test data, including reactor test conditions, coal and char properties, carbon conversions, material balances, reactor temperature profiles, product-gas composition, liquid product properties, and elemental (hydrogen, sulfur, nitrogen, and chlorine) conversions. Several preburner assembly modifications are also discussed.

Section D. REACTOR PERFORMANCE ANALYSIS--interprets the reactor test results.

A. INTRODUCTION

The major objectives of the test program were to

- Evaluate the operation and performance of the preburner and steam generator subsystems (preburner assembly).
- Determine baseline product slates under hydrogasification (low steam concentration) conditions at high reactor exit temperatures and long residence times.
- Determine the extent to which steam in the reactor reacts with char to produce CO_x and whether steam affects the hydrocracking of vapor-phase liquid hydrocarbons.
- Determine the effects on the product slate of temperature and injected reactor gas composition.
- Determine the effects on the reactor chemistry and product slate of CO_x generated in the preburner system by partial oxidation of CH_4 .

- Acquire credible material balances and obtain quantitative data on the coal elemental conversions and the slate of hydrocarbon products obtained under suitable AFHP reactor conditions.

Activation of the test system was completed in August 1984. Testing began on 28 September 1984 with the initiation of preburner performance characterization/checkout testing. The preburner assembly was designed to supply the desired hot-gas mixtures to the hot-gas/coal injector at approximately 1500°F. The processes occurring in this unit include $H_2/O_2/CH_4$ ignition, steam generation, and the partial oxidation of the CH_4 to CO. Since the preburner assembly was the new key test hardware component, its operability and performance were assessed before any coal-fed reactor tests were conducted. Five preburner tests encompassing 14 test conditions were successfully performed. The operability and performance of the preburner assembly were demonstrated over the range of test conditions planned for the subsequent coal-fed reactor tests.

The reactor testing started in mid-September 1984 and continued through late February 1985. Eleven coal-fed reactor tests encompassing 19 test conditions were conducted. Seven of these tests (12 test conditions) were performed in a long-residence-time (5 to 8 s) reactor, while four tests (7 test conditions) were in a short-residence-time (approximately 2-s) reactor. All reactor tests were carried out at 1000 psig using a Kentucky No. 9 hvAb coal pulverized to 90% <200 mesh size as feedstock. A key achievement was the significant steam/char/hydrocarbon reactions that occurred (up to 29.4% coal carbon conversion to CO_x) at high-temperature, long-residence-time, and high-steam-concentration conditions. The preburner and reactor tests are summarized in Table 2. The AFHP reactor test data are summarized in Table 3.

In general, the test hardware and PDU performed well and according to design, and all test program objectives were accomplished. The preburner assembly was capable of producing the required hot-gas mixtures and demonstrated successful $H_2/O_2/CH_4$ ignition, steam generation, and effective

TABLE 2
CHRONOLOGICAL SUMMARY OF PREBURNER AND REACTOR TESTS

Test	Date	Number of Test Conditions	Duration ^a (min)	Comments
PB-1A	08/28/84	1	22	<u>Preburner Test Achievements</u> • Reliable preburner and main burner ignition • Successful steam generation • High conversion of CH₄ to CO_x (90 to 98%) • Total preburner assembly heat loads near predicted values
PB-1B	08/30/84 (a.m.)	5	47	
PB-1B	08/30/84 (p.m.)	2	37	
PB-1C	09/05/84	3	68	
PB-2	09/07/84	3	84	
		14	258	TOTALS FOR 5 PREBURNER TESTS
R-1	09/19/84	1	92 (52)	System checkout at baseline conditions - two reactor temperatures (~15% H ₂ O) Preburner combustion chamber wall burn-through near injector (4-week test delay) High temperature and high steam (~45% H ₂ O) concentration; high conversion to CO _x (18.6%) Steam concentration effect (~30% H ₂ O) Temperature scan test (~45% H ₂ O) Second preburner combustion chamber wall burn-through near injector (4-week test delay) Checkout of preburner chamber heat fluxes Low gas-to-coal ratio test (~30% H ₂ O) Temperature scan test at high steam concentration (~45% H ₂ O); high conversion to CO _x (29.4%) TOTALS FOR 7 LONG-RESIDENCE-TIME COAL TESTS
R-2	09/24/84	1	70 (52)	
R-3A	09/28/84	-	8	
R-3	10/26/84	1	78 (52)	
R-4	11/07/84	1	72 (55)	
R-5	11/13/84	2	74 (58)	
R-6A	11/29/84	-	12	
R-6B	01/04/85	-	46	
R-6	01/05/85	1	66 (46)	
R-7	01/11/85	5	86 (70)	
		12	604 (385)	
R-8	02/01/85	2	60 (39)	Temperature scan test (~45% H ₂ O) Temperature scan test (~30% H ₂ O) Material balance test - High benzene production condition (~30% H ₂ O) Methane addition test (~30% H ₂ O) TOTALS FOR 4 SHORT-RESIDENCE-TIME COAL TESTS
R-9	02/11/85	3	65 (50)	
R-10	02/15/85	1	75 (57)	
R-11	02/22/85	1	81 (37)	
		7	281 (183)	
		19	885 (568)	TOTALS FOR ALL 11 COAL REACTOR TESTS

^aO₂ flow time to preburner. Values in parentheses are coal flow times

TABLE 3
SUMMARY OF AFHP REACTOR TEST DATA RANGE

Gas-to-coal ratio	0.15-0.27 lb·mole/lb
Hydrogen mole fraction	0.54-0.87
Steam mole fraction	0.13-0.46
Total pressure	1000 psig
Residence time	2.0-7.9 s
Reactor exit temperature	1773-2044°F
Total carbon conversion	53.4-68.4%
Carbon conversion to gases	35.0-68.4%
Carbon conversion to CH ₄	30.7-53.3%
Total carbon conversion to liquids	0.0-19.7%
Carbon conversion to BTX	0.0-11.3%
Carbon conversion to CO _x	3.5-29.4%

conversion of CH₄ to CO_x (primarily CO). The main injector and reactor were also successfully operated, providing reactor injected-gas temperatures up to approximately 2600°F and reactor exit temperatures up to approximately 2050°F. The average coal flow duration for the 11 reactor tests was about 52 min, with an average coal throughput of 803 lb. PDU test durations were limited to approximately 1 h by the capacity of the main char receiver as well as that of the preburner/injector/reactor cooling water reservoir. Operation of the PDU was smooth, and excellent carbon, hydrogen, and ash balances were obtained during the reactor tests. The sampling and chemical analyses performed to support the testing program are described in Appendix A.

Twice in the test program, during startup of reactor tests R-3 and R-6, problems arose with the preburner assembly as a result of preburner wall burn-through. The associated design and operational modifications made to resolve these problems are discussed in detail in Section V.C.9.

B. PREBURNER CHARACTERIZATION TESTING

The main objective of these tests was to evaluate the operability and performance of the preburner assembly. These tests also served as checkouts for the on-line GC system and provided experience in controlling critical system temperatures and flow rates. No coal was fed to the FHP reactor during these tests.

1. Test Planning

The operating conditions targeted for the preburner performance characterization/checkout tests are presented in Table 4. With the exception of the main injector exit temperature, which could be made to exceed 1900°F during the reactor tests by adding more O₂ to the main injector, the test conditions in Table 4 were intended to simulate the full range of operating conditions planned for the coal-fed reactor testing.

TABLE 4
TARGET TEST CONDITIONS FOR PREBURNER PERFORMANCE
CHARACTERIZATION/CHECKOUT TESTS^a

Test	Test Condition	H ₂ /CH ₄ /O ₂ Preburner				Steam Generator			Main Injector				
		Flow Rate (lb/h)			Exit Temperature ^b (°F)	Flow Rate (lb/h)		Exit Temperature ^b (°F)	O ₂ Flow Rate (lb/h)	Exit Temperature ^b (°F)	Exit Gas Composition (mole %)		
		H ₂	CH ₄	O ₂		H ₂ O	H ₂				H ₂	Steam	CO
PB-1	1	168	0	172	2500	0	154	1200	86	1600	89.9	10.1	0
PB-1	2	168	0	237	3000	0	154	1500	86	1900	87.3	12.7	0
PB-1	3	168	0	237	3000	0	250	1200	187	1900	87.2	12.8	0
PB-1	4	168	0	309	3500	0	250	1500	110	1900	87.1	12.9	0
PB-1	5	212	0	297	3045	543	138	1200	195	1900	70.1	29.9	0
PB-1	6	212	0	377	3500	543	138	1500	118	1900	70.0	30.0	0
PB-1	7	256	0	446	3500	1043	48	1500	126	1900	55.2	44.8	0
PB-2	8	172	80	440	3500	447	150	1500	138	1900	69.5	28.0	2.5
PB-2	9	172	140	531	3500	723	97	1500	138	1900	59.2	36.6	4.4
PB-2	10	128	269	659	3500	781	86	1500	138	1900	53.1	38.5	8.4

^a H₂/CH₄ inlet temperature = 1100°F; H₂O inlet temperature to steam generator = 200°F; inlet temperature of all other reactants = 70°F.

^b Calculated exit temperatures include estimated test hardware heat losses.

The purpose of test PB-1 (no CH_4 addition) was to provide information on the preburner and main injector H_2/O_2 ignition characteristics, system heat losses, and preburner assembly steam generation capability. This test was accomplished by successively increasing the $\text{H}_2/\text{CH}_4/\text{O}_2$ preburner exit temperature from approximately 2500°F to 3500°F at 1200°F and 1500°F steam generator exit temperatures, respectively. The main injector exit temperature was limited to a maximum of 1900°F, and sufficient spray quench water was injected at the reactor exit to cool the reactor products to approximately 850°F. Initial testing was performed without adding water to the steam generator. The sequence of tests was arranged for ease of transition to increasingly more severe test conditions. Sufficient time was planned at each test condition to verify steady-state conditions, as indicated by on-line GC analyses and steady flow rates and temperatures.

Test PB-2 involved adding CH_4 to the preburner. The calculated main-injector exit-gas composition, assuming 100% conversion of CH_4 to CO in the preburner assembly, is noted in Table 4. This test made it possible to define the percentage of CH_4 conversion and the corresponding gas compositions at various conditions of interest.

2. Test Results

The test conditions actually achieved while conducting the preburner performance characterization/checkout tests are presented in Table 5. Tests PB-1A and PB-1B were performed to define the system performance without hot-water injection for steam generation. The steam generation capability of the preburner assembly was then demonstrated during test PB-1C. The injected gas composition was measured by on-line GC at a point about 6 in. from the main injector face. As shown in Table 5, the measured injected gas composition values for both tests PB-1 and PB-2 were in close agreement with those calculated from the actual test conditions.

TABLE 5

ACTUAL TEST CONDITIONS FOR PREBURNER PERFORMANCE CHARACTERIZATION/CHECKOUT TESTS

Test	Test Condi- tion	H ₂ /CH ₄ /O ₂ Preburner				Steam Generator			Main Injector							
		Flow Rate (lb/h)			Exit Temper- ature ^a (°F)	Flow Rate (lb/h)		Exit Temper- ature (°F)	O ₂ Flow Rate (lb/h)	Exit Temper- ature (°F)	Exit Gas Composition ^b (mole %)					% CH ₄ Conver- sion to CO _x
		H ₂	CH ₄	O ₂		H ₂ O	H ₂				H ₂	Steam	CO	CO ₂	CH ₄	
PB-1A	1	166	0	177	2497	0	153	1268	68	1561						
PB-1B	2	169	0	182	2480	0	152	1264	0	1192						
PB-1B	3	169	0	182	2485	0	151	1268	65	1544						
PB-1B	4	167	0	236	2917	0	150	1506	66	1766						
PB-1B	5	166	0	229	2877	0	251	1152	67	1381						
PB-1B	6	166	0	229	2877	0	245	1169	156	1729						
PB-1B	7	170	0	306	3397	0	250	1429	0	1364						
PB-1B	8	168	0	301	3382	0	249	1411	100	1746						
PB-1C	9	212	0	291	2897	454	118	1333	129	1773	74.5 (72.9)	25.0 (27.1)				
PB-1C	10	207	0	340	3237	525	120	1440	115	1799	71.8 (70.1)	28.1 (29.9)				
PB-1C	11	238	0	395	3308	913	49	1414	122	1790	59.4 (57.3)	40.1 (42.7)				
PB-2	12	169	80	356	2940	434	147	1249	0	1192	75.8 (76.3)	21.5 (21.1)	2.15 (2.55)	0.2	0.3	90
PB-2	13	167	78	427	3415	443	150	1471	88	1737	73.2 (71.3)	24.1 (26.2)	2.16 (2.46)	0.04	0.05	98
PB-2	14	168	148	527	3365	694	92	1483	85	1737	63.4 (60.9)	31.1 (34.4)	4.50 (4.70)	0.7	0.2	96

^a Calculated (complete conversion of CH₄ to CO assumed for CH₄ addition tests).^b Values in parentheses are theoretical for test conditions. Tests with CH₄ addition assume complete conversion of CH₄ to CO.

During test PB-2, the capability of the $H_2/CH_4/O_2$ preburner to convert CH_4 to CO_x (primarily CO) was demonstrated. The composition of the commercial-grade CH_4 fed to the system during test PB-2 is given in Table 6. As expected, CH_4 conversion to CO_x increased as preburner exit temperature increased, from 90% at 3000°F to 98% at 3500°F. Because of the high conversion of CH_4 to CO_x in the preburner, the need for a separate gaseous CO feed system in subsequent coal reactor tests was eliminated.

TABLE 6
COMPOSITION OF COMMERCIAL-GRADE
 CH_4 FED TO PREBURNER ASSEMBLY

Component	Composition (mole %)
CH_4	93.7
C_2H_6	3.2
C_3 's	0.8
CO_2	0.7
N_2	1.6

Figures 12 and 13 present DAS-generated plots of selected system temperatures and flow rates as a function of time during test PB-1A. The preburner assembly exit temperature and system hydrogen and oxygen flow rates are shown in Figure 12. The initial temperature rise was caused by the heating of the preburner hydrogen flow in the facility hydrogen heater. An abrupt decrease in the preburner assembly exit temperature occurred when the ambient temperature steam generator hydrogen flow was initiated. The sudden increase in temperature observed when the preburner oxygen flow was started indicates H_2/O_2 ignition in the preburner. Oxygen flow to the preburner was turned on when the injection temperature of the preburner hydrogen (not shown in Figure 12) reached about 1200°F.

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Figure 12. Preburner Assembly Exit Temperature and Flow Rates as a Function of Time During Preburner Test PB-1A

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Figure 13. Selected System Temperatures as a Function of Time During Preburner Test PB-1A

Figure 13 presents selected system temperature plots. Note the abrupt increase in reactor gas temperatures with main burner ignition (start of main burner O_2 flow). Generally, system flow rates and critical temperatures were easily controlled at desired values, and control of critical system pressures was very good.

In summary, the preburner performance characterization testing was successful, and the following goals were achieved:

- Operability and performance were demonstrated, including
  - . Reliable preburner and main burner ignition
  - . Successful steam generation
  - . High conversion of CH_4 to CO_x (primarily CO)
  - . Total preburner assembly heat loads near predicted values
- System control and operating characteristics were defined, resulting in:
  - . Smooth, easily controllable operation over desired operating range
  - . Successful checkout of gas feed, product, and on-line GC systems.

C. REACTOR TESTING

The reactor testing phase of the program began on 19 September 1984, and was completed in late February 1985. The pertinent test conditions employed for the reactor testing are summarized in Table 7. This table gives, for each of the 11 reactor tests, the reactor configuration (noted by residence time), actual measured reactor exit temperature, nominal injected-gas hydrogen concentration, inlet gas-to-coal ratio, and whether CH_4 addition was used. A comment column is included in Table 7 to designate whether the test was a material balance or temperature scanning test.

TABLE 7
TEST MATRIX SUMMARY FOR REACTOR TESTS

Test	Reactor Residence Time	Reactor Exit Temperature (°F)	Hydrogen (mole %)	Methane Addition	Reactor Inlet Gas/Coal (lb mole/lb)	Comments
Facility Checkout at Baseline Conditions						
R-1	Long ^a	1845	87	No	0.2	Material balance
R-2	Long	1982	86	No	0.2	Material balance
Investigate Steam Enhancement						
R-3	Long	1951	54	No	0.2	Material balance
R-4	Long	1973	71	No	0.2	Material balance
R-5	Long	1773 and 1839	~58	No	0.2	Temperature scan (2)
R-6	Long	1945	72	No	0.15	Material balance
R-7	Long	1787 to 1997	~60	No	0.2	Temperature scan (5)
R-8	Short ^a	1775 to 1940	~57	No	0.2	Temperature scan (2)
R-9	Short	1776 to 2034	~70	No	0.2	Temperature scan (3)
R-10	Short	1810	71	No	0.2	Material balance
Investigate CH ₄ Addition						
R-11	Short	2044	62	Yes	0.2	Material balance

^aLong is approximately 5 to 8 s; short is approximately 2 s

Material balance tests were conducted at a single test condition, while temperature scanning tests involved two or more operating conditions during a single test. For the latter, changes during a given test involved varying the reactor exit temperature. This was accomplished by adjusting the main injector oxygen flow rate, thereby causing a change in the injected-gas temperature and hence a change in the reactor exit temperature. Variations in gas-to-coal ratio, residence time, etc., were generally relatively small during the temperature scanning tests. Steady-state operation was typically achieved in about 10 min, as determined by stable reactor exit gas temperatures and constant exit gas compositions (measured via on-line GC analysis). As shown in Section V.C.4, good material balances were achieved on both types of test. The scanning tests enabled multiple operating points to be investigated during a given test, thereby significantly expanding the range and quantity of AFHP data collected during the test program.

All of the reactor tests were conducted at 1000 psig and used finely pulverized Kentucky No. 9 hvAb coal as feedstock. The nominal coal flow rate was 1/2 ton/h, with an average feed gas-to-coal ratio of 0.20 mole of gas fed per lb of coal. These flow conditions resulted in hydrogasifier operations that included both low- and high-benzene coproduction. The reactor conditions spanned injected-gas temperatures from approximately 1900 to 2600°F, reactor exit temperatures from 1775 to 2050°F, and residence times from 2 to 8 s. In general, the hydrogen partial pressure was maintained high enough (>55%) to ensure liquid decomposition. Based on previous testing in the PDU,⁷ test durations of about 1 h yielded accurate and credible material balances. The range of operating conditions selected provided for the accomplishment of all program test objectives.

The objectives of the first two reactor tests were to check out and confirm the operability of the PDU coal feed system and to establish baseline hydrogasification carbon conversions at long residence times and high reactor exit temperatures--conditions that exceeded prior Rockwell FHP operating experience. For these initial tests, no CH₄ or hot water for steam generation was added to the preburner. The steam concentration of the injected gas was maintained at the minimum value of the system (13 to 15%). Only the steam generated from the addition of oxygen for heating the hydrogen to its required injected temperature was fed to the reactor. Results of these two tests provided baseline data for defining the effects of steam addition on subsequent reactor tests.

Reactor tests R-3 through R-10 were conducted to investigate steam enhancement effects on reactor performance. Specifically, the effects of steam concentration, reactor exit temperature, residence time, and gas-to-coal ratio were evaluated. Tests R-1 through R-7 were performed in the long-residence-time (5- to 8-s) reactor. Test R-3 was carried out at high-temperature and high-steam concentration conditions to provide an indication early in the test program of any steam/char/hydrocarbon reactivity, and indeed, significant steam-enhancement reactions were observed. Tests R-4 and R-5 were performed

to further define the effects of steam concentration and reactor exit-gas temperature on the steam/char/hydrocarbon reactions. The effect of gas-to-coal ratio was evaluated during test R-6. In this test, the gas-to-coal ratio was reduced by lowering the injected-gas flow rate while maintaining the coal flow rate at a nominal 1/2 ton/h. In test R-7, both the gas and coal flow rates were reduced to increase the residence time to ~8 s. Five different steady-state conditions were achieved during this test by scanning the reactor exit temperature (1787 to 1997°F) at high-steam concentration.

The reactor was changed to the short-residence-time (~2-s) configuration for tests R-8 through R-11. Residence time was reduced by decreasing the diameter of the reactor (see Figure 11), while maintaining the length at a nominal 20 ft. Tests R-8 and R-9 were conducted to investigate reactor temperature and steam concentration effects in the short-residence-time reactor. Test R-10 was performed as a material balance test at high C_6H_6 coproduction conditions. The final test, R-11, was conducted to define the effects of CH_4 addition on reactor performance. Test conditions for the latter test were similar to those of the final operating parameters for test R-9, except for the addition of 22 mole % CH_4 to the hydrogen feed stream. This permitted a direct experimental comparison of the effects of CH_4 addition on reactor performance.

1. Test Conditions

Detailed test conditions for the 11 reactor tests are presented in Tables 8 and 9 for the long- and short-residence-time tests, respectively. The data provided include the reactor pressure, inlet-gas and reactor exit-gas temperatures, inlet gas composition, gas-to-coal ratio, system inlet flow rates, residence time, and test duration.

Reactor exit-gas temperature was varied from 1773 to 1997°F for the long-residence-time tests and from 1775 to 2044°F for the short-residence-time tests. Inlet gas temperature, gas-to-coal ratio, and steam concentration

TABLE 8
SUMMARY OF TEST CONDITIONS FOR LONG-RESIDENCE-TIME TESTS

Test Number	1	2	3	4	5		6	7				
Test Conditions	1	2	3	4	5A	5B	6	7A	7B	7C	7D	7E
Date	09/19/84	09/24/84	10/26/84	11/07/84	11/13/84	11/13/84	01/05/85	01/11/85	01/11/85	01/11/85	01/11/85	01/11/85
Reactor pressure (psig)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Inlet gas temperature (°F)	2014	2116	2296	2190	2035	1967	2202	1890	2041	2273	2518	2571
Inlet gas-to-coal (mole/lb)	0.22	0.21	0.22	0.20	0.22	0.22	0.15	0.25	0.24	0.24	0.24	0.25
Inlet gas composition (mole %)												
Steam	13.4	14.4	46.4	28.9	42.1	40.9	27.8	28.1	39.8	42.2	44.6	43.5
H ₂	86.6	85.6	53.6	71.1	57.9	59.1	72.2	61.9	60.2	57.8	55.4	56.5
System flow rates (lb/h)												
Coal	927	958	924	987	936	936	1025	587	587	587	587	587
Preburner H ₂	175	170	246	214	246	249	232	226	223	223	220	234
Preburner C ₂ H ₄	0	0	0	0	0	0	0	0	0	0	0	0
Preburner O ₂	303	305	398	345	403	403	222	220	227	226	225	227
Steam generator H ₂ O	0	0	938	428	884	877	338	595	595	600	595	588
Steam generator H ₂	226	232	51	141	62	65	48	0	0	0	0	0
Main injector O ₂	129	154	248	198	168	157	180	137	161	212	264	286
Reactor exit temperature (°F)	1845	1982	1951	1973	1839	1773	1945	1787	1863	1935	1974	1997
Residence time (s)	5.4	5.1	4.8	5.0	5.2	5.3	6.6	7.9	7.4	6.8	6.4	6.1
Test duration (min)	52	52	52	55	41	17	46	15	8	21	15	11

TABLE 9
SUMMARY OF TEST CONDITIONS FOR SHORT-RESIDENCE-TIME TESTS

Test Number	8		9			10	11
Test Conditions	8A	8B	9A	9B	9C	10	11
Date	02/01/85	02/01/85	02/11/85	02/11/85	02/11/85	02/15/85	02/22/85
Reactor pressure (psig)	1000	1000	1000	1000	1000	1000	1000
Inlet gas temperature (°F)	1940	2060	2054	2104	2219	2048	2224
Inlet gas-to-coal (moles/lb)	0.27	0.27	0.17	0.17	0.17	0.19	0.20
Inlet gas composition (mole %)							
Steam	42.4	43.7	29.1	29.6	30.4	28.6	27.9 ^a
H ₂	57.6	56.3	70.9	70.4	69.6	71.4	61.9
System flow rates (lb/h)							
Coal	749	749	1171	1171	1171	1047	1076
Preburner H ₂	298	298	288	286	288	289	135
Preburner CH ₄	0	0	0	0	0	0	342
Preburner O ₂	293	294	250	252	255	250	651
Steam generator H ₂ O	957	964	520	518	514	512	506
Steam generator H ₂	0	0	60	60	61	59	112
Main injector O ₂	222	260	226	240	268	216	207
Reactor exit temperature (°F)	1775	1940	1776	1877	2034	1810	2044
Residence time (s)	2.3	2.2	2.3	2.2	2.1	2.3	2.0
Test duration (min)	21	18	20	10	20	57	37

^aInlet gas also contains 7.3% CO, 1.8% CO₂, 1.0% CH₄, and 0.1% N₂

ranged from 1890 to 2571°F, 0.15 to 0.25 lb·mole/lb, and 13.4 to 46.4 mole %, respectively, for the long-residence-time tests. The corresponding ranges for the short-residence-time tests were 1940 to 2224°F, 0.17 to 0.27 lb·mole/lb, and 27.9 to 43.7 mole %, respectively. The injected gas was a mixture of steam and hydrogen for all tests except test R-11, which was specifically conducted to determine the effects of CH₄ addition on reactor performance. For this test, the gas injected into the reactor also contained products from the partial oxidation of the CH₄ fed to the preburner assembly (see footnote to Table 9). The duration of coal flow for the 11 reactor tests averaged about 53 min, with an average coal throughput of 803 lb.

The values reported in Tables 8 and 9 are average values for the steady-state portion of each test condition. Steady-state conditions were usually achieved rapidly either on the start of coal flow or on the change of test conditions during a temperature scanning test. The test durations correspond to the period during which coal was flowing at each test condition.

Inlet, or injected, reactor gas temperature was not measured during coal-flow tests because of the severe operating environment. Instead, it was calculated based on the test hardware inlet flow conditions and measured heat losses, taking into account partial combustion of the feed gases in the test hardware preburner and main burner. However, this parameter was measured about 6 in. from the coal/hot-gas injector face. Measured and calculated values of inlet-gas temperature were in good agreement during non-coal-flow conditions (i.e., before and after the coal-flow period). Reactor exit temperature is the average of two temperatures measured by sheathed thermocouples located in the flow stream about 6 in. from the exit of the 20-ft-long reactor.

Inlet-gas composition was calculated, based on the inlet flow conditions, again accounting for partial combustion of the feed gases before injection into the reactor. On-line GC verification of the composition of the injected gas was made for the CH_4 addition test, both before and after the coal-flow period.

The residence times of the gas and pulverized solids were essentially the same. Reported residence time is an average of the values calculated based on the temperature and composition of the reactor exit gas, and that of the gas/coal mixed temperature and the composition of the injected gas. Values from these two methods of calculation generally agree within 10 to 15%.

Detailed tabular AFHP data are given in Appendix B for each of the 19 test conditions.

During the coal-fed reactor tests, operation of the PDU was generally very smooth. The degree of control and stability of system flow rates, temperatures, and pressures is illustrated below using DAS-generated plots of key system parameters for selected tests.

Computerized DAS plots of system temperatures, pressures, and flows as a function of time are presented in Figures 14 through 17 for reactor test R-11. Reactor inlet temperature and preburner assembly H_2 , O_2 , and H_2O flow rates are shown in Figure 14. The reactor inlet and exit temperatures, and the preburner CH_4 and main burner O_2 flows are presented in Figure 15. The initial temperature rise appearing in Figure 14 is caused by the heating of the preburner H_2/CH_4 flow in the facility H_2/CH_4 heater. An abrupt decrease in temperature is noted when the H_2O flow to the steam generator is initiated. Before this time, the indicated steam generator water flow is not being injected into the test hardware. The sudden increase in temperature observed when the preburner oxygen flow was started indicates $H_2/CH_4/O_2$ ignition in the preburner. Oxygen flow to the preburner was turned on when the injection temperature of the H_2/CH_4 flow stream reached about 1250°F. A rapid rise in temperature also occurred on main burner ignition (i.e., the start of main burner O_2 flow). The main burner O_2 flow was adjusted slightly after coal flow had been initiated to achieve the desired reactor exit temperature.

The dynamic nature of the hot-gas/coal mixing can be seen from the fluctuations in the reactor inlet temperature. This parameter is measured by a T/C located in the flow stream 6 in. downstream from the injector face. Selected system temperatures and pressures are shown plotted versus time for test R-11 in Figures 16 and 17. Steady-state preburner H_2/CH_4 injection and preburner assembly exit temperatures were about 1140 and 1610°F, respectively. The reactor product stream was quenched to about 850°F at the reactor exit and further cooled to near ambient temperature in the light-oil condenser. In general, system flows, temperatures, and pressures were fairly steady during the coal-flow period.

Figure 14. Reactor Inlet Temperature and Preburner Assembly H₂, O₂, and H₂O Flow Rates as a Function of Time for Test R-11

Figure 15. Reactor Inlet and Exit Temperatures and Methane and Main Burner Oxygen Flow Rates as a Function of Time for Test R-11

Figure 16. Selected System Temperatures
as a Function of Time for Test R-11

Figure 17. Selected System Pressures
as a Function of Time for Test R-11

DAS-generated plots of selected system temperatures and flow rates as a function of time are shown in Figures 18 and 19 for test R-5. Procedures for system startup, operation, and control for this test were similar to those for test R-11. The reactor exit-gas temperature was decreased approximately 65°F for the last 17 min of this test by reducing of the main-burner oxygen flow rate. This change enabled two operating conditions to be evaluated in one reactor test. A similar procedure (i.e., adjustment of the main-burner oxygen flow rate) was employed on several other reactor tests when multiple test conditions were desired.

2. Coal and Char Properties

The solids feedstock to the reactor for all 11 tests was a Kentucky No. 9 hvAb coal pulverized to approximately 90% <200 mesh.

a. Chemical Analysis

Proximate and ultimate analyses of the coal fed to the reactor and the char collected in the main char receiver for each reactor test are presented in Appendix B. Average properties of the coal, including proximate and ultimate analyses, free-swelling index, and ash fusion temperature in a reducing atmosphere, are provided in Table 10. The quantity of coal fed and char collected for each reactor test is summarized in Table 11. Approximately 95% of the char was collected in the main char receiver vessel, while >99% was recovered in the main receiver and first cyclone. The carbon, hydrogen, ash, and moisture contents of the char collected from each test are summarized in Table 12.

The ultimate analyses of the coal and main receiver char from selected tests are compared in Table 13. In general, the carbon content of the char (~74 to 78 wt. %) is approximately the same as that of the parent coal (~74 wt. %). However, the hydrogen, sulfur, and nitrogen contents of the char are substantially lower, its chlorine content is slightly lower, and it is

Figure 18. Reactor Inlet Temperature and System Hydrogen and Oxygen Flow Rates as a Function of Time for Test R-5

Figure 19. Selected System Temperatures as a Function of Time for Test R-5

TABLE 10
PROPERTIES OF KENTUCKY NO. 9 HIGH-VOLATILE A BITUMINOUS COAL^a

Proximate analysis, as received ^b (Average for 11 tests)	Moisture (%)	1.95
	Ash (%)	8.27
	Volatile (%)	39.11
	Fixed carbon (%)	50.66
	Sulfur (%)	2.98
	Heating value (Btu/lb)	13,198
Ultimate analysis, dry basis ^b (Average for 11 tests)	Carbon (%)	74.38
	Hydrogen (%)	5.12
	Nitrogen (%)	1.50
	Chlorine (%)	0.17
	Sulfur (%)	3.04
	Ash (%)	8.44
	Oxygen (%)--by difference	7.35
Free swelling index ^b		5-1/2
Fusion temperature of ash (reducing) ^b	Initial deformation (°F)	2070
	Softening (H = W)(°F)	2185
	Softening (H = 1/2 W)(°F)	2300
	Fluid (°F)	2410

^aProvidence Mine No. 1

^bAnalysis by Commercial Testing & Engineering Company (Lombard, Illinois)

relatively free of oxygen. The ash content of the char (~20 wt. %) is more than twice that of the parent coal (8 wt. %), and thus the heating value of the char (~11,400 Btu/lb) is only about 85% of that of the coal.

b. Density

The true, bulk, and compacted densities of the coal and char from selected reactor tests are presented in Table 14. The true (solids) density of the chars is about 1.25 times that of the coal, whereas the bulk and compacted densities are only about 45% that of the coal. These differences indicate that the structure of the char is considerably more porous than that of the parent coal.

TABLE 11
SUMMARY OF COAL FED AND CHAR COLLECTED FOR REACTOR TESTS

Test	Coal Fed ^a	Char Collected ^a			
		Main Receiver	Cyclone 1	Cyclone 2	Total
R-1	795.5	319.3	23.7	3.2	346.2
R-2	824.1	307.6	15.5	0.6	323.7
R-3	795.5	266.9	13.7	1.4	282.0
R-4	901.1	318.4	17.6	1.0	337.0
R-5	897.4	362.3	14.6	3.7	380.6
R-6	781.0	311.3	10.5	0.4	322.2
R-7	675.1	241.1	7.6	0.9	249.6
R-8	489.1	192.9	8.3	1.4	202.6
R-9	973.5	381.7	46.3	3.2	431.2
R-10	981.8	396.8	40.4	2.3	439.5
R-11	654.5	255.6	13.2	2.1	270.9

^aDry basis

c. Sieve Analysis

Sieve analyses of several coal and char samples were performed to determine the particle-size distribution of the samples. The results are given in Table 15 and in Figures 20 and 21. The sieve analyses of the coal and main receiver char are compared in Figure 20. The mass median diameter of the coal particles is in the 50 to 60 μm range with about 90% <200 mesh. The main receiver char has a mass median diameter about twice that of the coal. Some agglomerates were observed in the main receiver char of several tests (see footnote to Table 15).

A typical comparison of the particle-size distribution of the main receiver char with that of the cyclone receiver chars is shown in Figure 21. In

TABLE 12
SUMMARY OF CARBON, HYDROGEN, ASH, AND MOISTURE CONTENT OF CHAR FOR REACTOR TESTS^a

Test	Main Receiver Char				Cyclone 1 Char				Cyclone 2 Char			
	Moisture Content (%)	Dry Basis			Moisture Content (%)	Dry Basis			Moisture Content (%)	Dry Basis		
		C (%)	H (%)	Ash (%)		C (%)	H (%)	Ash (%)		C (%)	H (%)	Ash (%)
R-1	1.74	74.91	1.44	20.80	16.80	62.02	1.24	33.20	35.04	72.98	2.65	19.98
R-2	2.65	75.64	0.98	21.11	24.32	71.26	0.93	23.02	39.20	70.60	1.80	22.80
R-3	7.82	72.88	1.00	22.68	34.66	83.41	0.95	13.83	53.31	81.59	2.21	13.32
R-4	2.04	74.72	0.92	21.52	19.96	76.31	0.88	20.48	36.21	80.98	1.14	15.82
R-5	6.02	75.61	1.25	20.82	28.70	81.53	1.68	14.38	17.36	90.07	2.94	4.90
R-6	4.50	75.86	0.90	20.56	32.50	80.22	1.04	15.98	63.60	91.20	1.80	5.87
R-7	23.45	73.37	0.93	22.84	49.00	81.52	1.11	14.22	53.80	83.16	2.42	10.58
R-8	13.70	73.96	1.38	21.28	38.20	85.76	1.90	10.51	30.00	90.28	2.84	4.91
R-9	3.50	75.57	1.44	19.74	6.52	79.55	1.34	16.77	20.80	82.25	1.50	13.90
R-10	4.72	75.56	1.52	19.61	10.10	80.42	1.71	15.51	33.60	89.24	2.79	5.74
R-11	28.20	74.86	0.86	21.00	47.40	85.88	1.14	10.36	36.30	89.64	2.16	6.11

^aBased on Rockwell analysis.

TABLE 13
COMPARISON OF COAL AND CHAR ANALYSES^a

Test	Coal Analysis ^b	Char Analysis				
		Test 2	Test 3	Test 7	Test 10	Test 11
Carbon (%)	74.38	76.67	74.79	73.71	78.39	76.15
Hydrogen (%)	5.12	0.71	0.47	0.52	1.25	0.70
Sulfur (%)	3.04	1.54	1.13	1.13	1.48	1.29
Nitrogen (%)	1.50	0.87	0.88	0.88	1.16	0.89
Chlorine (%)	0.17	0.10	0.10	0.18	0.13	0.19
Ash (%)	8.44	20.97	22.81	23.32	19.82	21.34
Oxygen (% diff)	7.35	-0.86	-0.18	0.26	-0.23	-0.56
Heating value (Btu/lb)	13,461	11,622	11,171	11,030	11,778	11,401

^aUltimate analysis, dry basis. Char is from main char receiver vessel.

^bAnalyses are by Chemical Testing & Engineering Company.

^cAverage for 11 tests

TABLE 14
TRUE, BULK, AND COMPACTED DENSITY OF COAL AND
CHARS FOR SELECTED REACTOR TESTS

Material	Density [lbm/ft ³ (g/ml)]		
	True	Bulk	Compacted
<u>Coal</u>			
Typical sample	82.4 (1.320)	31.7 (0.508)	42.2 (0.676)
<u>Main Char Receiver Char</u>			
Test R-3	106.5 (1.706)	14.2 (0.228)	18.8 (0.301)
Test R-11	103.4 (1.657)	13.2 (0.212)	18.0 (0.288)
<u>Cyclone 1 Char</u>			
Test R-3	101.3 (1.623)	12.7 (0.203)	16.5 (0.264)
<u>Cyclone 2 Char</u>			
Test R-3	100.0 (1.602)	16.0 (0.257)	20.7 (0.332)

TABLE 15
SIEVE ANALYSES OF COAL AND CHAR

U.S. Sieve Series Number	Sieve Opening (μm)	Cumulative Amount Passing Through Sieve (wt. %)						
		Coal			Char			
					Main Char	Receiver	Cyclone 1	Cyclone 2
		Initial Sample	Test R-3	Test R-11	Test R-3 ^a	Test R-11	Test R-3	Test R-3
400	37	11.8	11.9	13.3	18.8	13.6	14.8	8.0
325	44	19.1	37.1	24.8	24.0	17.7	26.4	15.6
200	74	86.8	89.9	90.1	45.2	36.8	54.8	33.1
100	149	98.6	99.0	98.7	70.4	67.2	90.7	43.9
50	297	99.6	99.5	99.5	84.6	85.8	99.0	55.2
30	595	100.0	99.7	99.7	93.4	94.5	99.7	63.7
16	1190	100.0	99.9	99.9	97.6	96.9	99.8	70.6

^aSample contained two large pieces (~1 in. in diameter) removed before sieving. Sample also contained large pieces (>16 mesh) that slowly broke down during sieving.

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Figure 20. Sieve Analyses of Coal and Main Receiver Char

Figure 21. Sieve Analyses of Chars from Reactor Tests R-3 and R-11

comparison with the main receiver char, cyclone 1 char is finer while the cyclone 2 char is coarser. This is presumably the result of agglomeration of the cyclone 2 char, probably caused by oils that are being condensed onto the solids at this point in the flow system.

3. Carbon Conversions

Experimental values of overall coal carbon conversion, carbon conversion to various gases (CH_4 , C_2H_6 , CO , and CO_2), C_6H_6 and C_7H_8 liquids, and non-BT (benzene-toluene) liquids are summarized in Tables 16 and 17 for the long- and short-residence-time reactor tests, respectively. These conversion data represent all 19 reactor test conditions investigated during the current program. The chemical analysis and sampling methods employed to characterize the reactor test system performance are described in Section II of Appendix A. The detailed computational analyses performed to define carbon conversions for each of the test conditions and to assess their reliability are presented in Section III of Appendix A. The calculational approach used in the data reduction is summarized below.

TABLE 16
SUMMARY OF CARBON CONVERSION FOR LONG-RESIDENCE-TIME REACTOR TESTS

Test Condition	Carbon Conversion (%)										
	Overall	Char	CH ₄	C ₂ H ₆	CO	CO ₂	Total Gases	C ₆ H ₆	C ₇ H ₈	Non-BT Liquids	Total Liquids
1	56.4	43.6	42.20	0.13	3.10	0.38	45.81	4.90	-	5.69	10.59
2	59.8	40.2	53.33	0.07	5.87	0.53	59.80	-	-	-	-
3	64.5	35.5	45.85	0.07	13.09	5.49	64.50	-	-	-	-
4	60.6	39.4	49.93	0.09	8.62	1.96	60.60	-	-	-	-
5A	60.1	39.9	44.40	0.10	4.60	1.90	51.00	4.50	-	4.60	9.10
5B	59.6	40.4	37.90	0.11	3.70	1.30	43.01	9.60	-	6.99	16.59
6	57.7	42.3	47.19	0.08	8.47	1.96	57.70	-	-	-	-
7A	58.7	41.3	40.00	0.07	3.70	1.40	45.17	5.00	-	8.53	13.53
7B	60.4	39.6	46.90	0.06	5.60	2.30	54.86	0.40	-	5.14	5.54
7C	63.8	36.2	44.40	0.05	12.60	4.90	61.95	-	-	1.85	1.85
7D	66.0	34.0	40.34	0.04	18.92	6.70	66.00	-	-	-	-
7E	68.4	31.6	38.98	0.03	22.19	7.20	68.40	-	-	-	-

TABLE 17
SUMMARY OF CARBON CONVERSION FOR SHORT-RESIDENCE-TIME REACTOR TESTS

Test Condition	Carbon Conversion (%)										
	Overall	Char	CH ₄	C ₂ H ₆	CO	CO ₂	Total Gases	C ₆ H ₆	C ₇ H ₈	Non-BT Liquids	Total Liquids
8A	57.8	42.2	32.90	0.13	4.00	1.10	38.13	11.20	0.06	8.41	19.67
8B	60.7	39.3	44.20	0.08	5.80	2.30	52.38	3.80	0.02	4.50	8.32
9A	53.4	46.6	30.70	0.18	3.40	0.74	35.02	9.90	0.08	8.40	18.38
9B	55.2	44.8	36.00	0.12	3.90	0.94	40.96	8.20	0.07	5.97	14.24
9C	58.1	41.9	46.40	0.13	7.00	1.70	55.23	0.60	-	2.27	2.87
10	55.4	44.6	33.60	0.15	3.40	0.80	37.95	9.80	0.07	7.58	17.45
11	59.6	40.4	45.50	0.14	8.10	3.40	57.14	0.40	-	2.06	2.46

Overall coal carbon conversion and carbon conversion to char were calculated by requiring an ash balance, with the overall char composition being that of the char from the main char receiver. The overall coal carbon conversion was taken as unity minus the "fraction converted" to char. Conversion to nonchar species was computed from

$$\eta_x = 100 \left[1 - \left(\frac{a_o}{a_c} \right) \left(\frac{x_c}{x_o} \right) \right] ,$$

where

η_x = conversion of carbon to nonchar components (%)

a_o = ash fraction of dry coal

a_c = ash fraction of dry char

x_o = fraction of carbon in dry coal

x_c = fraction of carbon in dry char.

Overall carbon conversions for the 11 reactor tests calculated, based on the carbon remaining in the char, were within approximately 1% (on the average) of the values reported in Tables 16 and 17. The ash tracer method has been employed by Rockwell to calculate overall carbon conversion on all previous coal FHP testing programs.

Carbon conversion to the various gas species was calculated using averaged test values of measured gas flow rate and composition in conjunction with the measured coal flow rate and composition. To substantiate the accuracy of the gas flow rate measurements, hydrogen flow checks were conducted in conjunction with most of the reactor tests. For these flow checks, steady test values of preburner and steam generator hydrogen flows were established, and inlet and exit flow rates were then measured normally (i.e., with NBS traceable, calibrated venturi meters). In general, the inlet- and outlet-gas flow checks were in good agreement.

Benzene (C_6H_6) and toluene (C_7H_8) conversions were based on the on-line GC analysis of the product stream upstream from the light-oil condenser. From the on-line GC, the ratios of C_6H_6 to CH_4 and C_7H_8 to CH_4 were determined. The use of these ratios together with the carbon conversion to CH_4 enabled the C_6H_6 conversions to be calculated.

The conversion to non-BT liquids was determined by difference (i.e., overall conversion minus conversion to gases plus BT). This approach has been shown to be justified in previous FHP coal and oil shale liquefaction test programs performed on the PDU.^{7,8,18} High liquid-collection efficiency is difficult to achieve during PDU testing when test durations are limited and carbon conversion to liquid products is relatively low.

Overall, the carbon conversion data are very consistent, and good carbon, hydrogen, and ash balances were attained. Overall carbon conversion, carbon conversion to gases, carbon conversion to liquids, and the effect of CH_4 addition on carbon conversion are discussed below.

a. Overall Carbon Conversion

Overall coal carbon conversion for the 11 reactor tests is plotted as a function of reactor exit temperature in Figure 22. The figure presents data from the long-residence-time tests (Figure 22a) and the short-residence-time tests (Figure 22b). Trend lines are shown for the various levels of inlet steam concentration (~15, 30, or 45% H_2O). Overall carbon conversion ranged from about 53 to 68%. Conversion increased with increasing reactor exit temperature, inlet steam concentration, and residence time. The steam concentration effect was most significant at the 45% level, in the long-residence-time reactor, and at high reactor exit temperatures. Slightly lower overall conversion was obtained at the low gas-to-coal ratio test conditions. The overall carbon conversion was not significantly affected by CH_4 addition.

a. Long-Residence-Time Tests

b. Short-Residence-Time Tests

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Figure 22. Overall Carbon Conversion versus Reactor Exit Temperature

b. Carbon Conversion to Gases

Total carbon conversion to gases (CH_4 , C_2H_6 , CO , and CO_2) for the 11 reactor tests is plotted versus reactor exit temperature in Figure 23. The carbon conversion to gases ranged from approximately 35 to 68% and increased with increasing reactor temperature, steam concentration, and residence time. As expected, the carbon conversion to gases increased more rapidly than overall conversion with either increasing reactor exit temperature or residence time. Neither low gas-to-coal ratio nor CH_4 addition significantly influenced the total carbon conversion to gases.

Carbon conversion to the major gas species (CH_4 , CO , and CO_2) is presented in Figures 24 and 25 for the short- and long-residence-time tests, respectively. Conversion to CH_4 , CO , and CO_2 ranged from about 31 to 53%, 3.1 to 22.2%, and 0.4 to 7.2%, respectively. In general, conversion to CO and CO_2 increased with increasing reactor temperature, steam concentration, and residence time. The effect of steam concentration on CO_x production was most significant at high temperatures in the long-residence-time reactor. Neither gas-to-coal ratio nor CH_4 addition significantly affected the distribution of gas species.

Carbon conversion to CH_4 , CO , and CO_2 increased steadily with increasing reactor exit temperature and steam concentration over the range of test conditions employed in the short-residence-time tests. For the long-residence-time reactor tests, however, the conversion to CH_4 was a more complex function of reactor exit temperature and steam concentration (Figure 25). At lower reactor exit temperatures ($<1875^\circ\text{F}$), conversion to CH_4 increased with increasing reactor temperature and steam concentration. Conversely, at high reactor temperatures, conversion to CH_4 decreased with increasing steam concentration. It is clear that the production of CO_x was obtained at the expense of CH_4 formation at the high-steam, high-temperature conditions employed in the long-residence-time reactor. As explained in

a. Long-Residence-Time Tests

b. Short-Residence-Time Tests

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Figure 23. Carbon Conversion to Gases versus Reactor Exit Temperature

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Figure 24. Carbon Conversion to Major Gas Species versus Reactor Exit Temperature for Short-Residence-Time Tests

Figure 25. Carbon Conversion to Major Gas Species versus Reactor Exit Temperature for Long-Residence-Time Tests

Section V.D, increased CO_x production at these more severe reactor conditions resulted from heterogeneous steam/char reactions as well as the effects of steam on liquid breakup.

c. Carbon Conversion to Liquids

Carbon conversion to C_6H_6 , non-BT light oil, and total liquids is plotted as a function of reactor exit temperature in Figures 26, 27, and 28, respectively. The carbon conversion to C_6H_6 (Figure 26) ranged from 0 to 11.2%. The production of C_6H_6 is primarily a function of the reactor exit temperature and to a lesser extent reactor residence time. The steam concentration, gas-to-coal ratio, and CH_4 addition had a negligible effect on the carbon conversion to C_6H_6 .

Similar to C_6H_6 production, non-BT light-oil production is primarily a function of reactor temperature and residence time (Figure 27). Carbon conversion to non-BT light oil ranged from about 0 to 8.5% and 2 to 8.5% in the long- and short-residence-time reactor tests, respectively. Again, gas-to-coal ratio, steam concentration, and CH_4 addition had a negligible effect on the non-BT light-oil production.

Carbon conversion to total liquids, i.e., C_6H_6 plus light oils, (Figure 28) ranged from 0 to approximately 20%. A reactor exit temperature of approximately 1975°F was required to eliminate the production of liquids in the long-residence-time reactor, while 2 to 3% liquids were still being produced in the short-residence-time reactor at ~2050°F.

The ratio of experimental to thermodynamic equilibrium pressure constants for several key reactions is presented in Table 18 for each of the reactor test conditions. The data from column 1 indicate that CO and CO_2 were in virtual equilibrium at nearly every test condition. This was not the case for CO and CH_4 , as evidenced in column 2. In fact, a large potential existed for further homogeneous CO production from CH_4 . Ratios much greater than

Figure 26. Carbon Conversion to Benzene versus Reactor Exit Temperature

Figure 27. Carbon Conversion to Non-BT Light Oil versus Reactor Exit Temperature

a. Long-Residence-Time Tests

b. Short-Residence-Time Tests

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Figure 28. Carbon Conversion to Total Liquids (Benzene plus Light Oils) versus Reactor Exit Temperature

TABLE 18
RATIO OF EXPERIMENTAL TO THERMODYNAMIC EQUILIBRIUM
PRESSURE CONSTANTS FOR SEVERAL KEY REACTIONS

Test Condition	$\frac{(\text{CO}_2)(\text{H}_2)}{(\text{CO})(\text{H}_2\text{O})}$	$\frac{(\text{CO})(\text{H}_2)^3}{(\text{CH}_4)(\text{H}_2\text{O})}$	$\frac{(\text{C}_2\text{H}_6)(\text{H}_2)}{(\text{CH}_4)^2}$
Long-Residence-Time Tests			
1	1.08	0.107	7.24
2	0.88	0.031	1.48
3	0.89	0.011	1.44
4	0.94	0.017	1.53
5A	0.80	0.010	3.08
5B	0.65	0.026	6.52
6	0.96	0.022	1.38
7A	0.82	0.031	4.14
7B	0.95	0.014	1.73
7C	1.00	0.019	1.40
7D	1.00	0.026	1.41
7E	1.04	0.031	0.94
Short-Residence-Time Tests			
8A	0.51	0.040	13.27
8B	0.86	0.006	2.45
9A	0.68	0.078	16.05
9B	0.82	0.024	4.93
9C	0.96	0.007	1.88
10	0.77	0.047	10.11
11	1.14	0.022	1.84

unity in column 3 correlate well with C_6H_6 and light-oil coproduction, indicating that hydrocracking reactions still occurred at these conditions.

d. Methane Addition Effects

One test (test R-11) was conducted to determine the potential effects of CH_4 addition on the reactor coal carbon conversions and product composition. For analysis purposes, operating conditions and coal carbon conversions for this test were compared with those from test R-9C (Table 19). Except for the CH_4 addition and subsequent production of CO_x in the preburner assembly

TABLE 19
COMPARISON OF TEST CONDITIONS/CONVERSIONS FOR
TESTS R-9C AND R-11 (CH₄ ADDITION)

Test	R-9C	R-11 ^a
Reactor pressure (psig)	1000	1000
Injected-gas temperature	2219	2224
Reactor exit temperature (°F)	2034	2044
Gas-to-coal ratio (lb·mole/lb)	0.17	0.20
Residence time (s)	2.1	2.0
Inlet-gas composition (mole %)		
H ₂	69.6	61.9
H ₂ O	30.4	27.9
CO	-	7.3
CO ₂	-	1.8
CH ₄	-	1.0
N ₂	-	0.1
Carbon conversion (%)		
CH ₄	46.40	45.50
C ₂ H ₆	0.13	0.14
C ₆ H ₆	0.60	0.40
CO	7.00	8.10
CO ₂	1.70	3.40
Non-BT liquids	2.27	2.06
Overall	58.20	59.60

^aCoal carbon conversion

during test R-11, conditions for the two tests were very similar. The observed levels of coal carbon conversion to the various products were essentially the same, while minor differences were believed to be within the range of experimental data scatter. The conclusion drawn from these data is that CH₄ addition did not significantly affect reactor coal carbon conversions or the product composition. This result is consistent with the various coal carbon conversion data plots shown above.

Coal carbon conversions for the CH₄ addition test were based on the difference in product flow rates measured before and after the initiations of coal flow. Commercial-grade CH₄ (Table 6) entered the system before and

after the coal-flow period. Carbon conversion data for the CH₄ addition test based on the carbon in the coal as well as the total system carbon (coal plus CH₄) are presented in Table 20.

TABLE 20
CARBON CONVERSIONS FOR CH₄ ADDITION TEST (R-11)

Basis	Carbon Conversion (%)									
	Overall	Char	CH ₄	C ₂ H ₆	C ₆ H ₆	CO	CO ₂	Non-BT Liquids	Total Gases	Total Liquids
Coal only	59.6	40.4	45.50	0.14	0.40	8.10	3.40	2.06	57.14	2.46
Coal plus CH ₄	69.4	30.6	37.09	0.11	0.30	23.54	6.80	1.56	67.54	1.86

4. Material Balances

The as-collected carbon, hydrogen, and ash balances for the reactor tests are summarized in Table 21. Averages of collected carbon, hydrogen, and ash recoveries were 98.2, 105.4, and 100.3%, respectively. These values are quite good given the size of the PDU system and the small amount of on-stream time available for each test.

The as-collected (measured) balances in Table 21 represent the portion of each component exiting the system relative to the quantity entering in the various feed streams. The method used to calculate these values is described in Appendix A. To substantiate the accuracy of the gas flow-rate measurements, hydrogen flow checks were conducted in conjunction with each reactor test. For these flow checks, steady test values of preburner and steam generator hydrogen flows were established, and inlet and exit flow rates were then measured using NBS traceable, calibrated venturi meters. The inlet- and outlet-gas flow checks were in good agreement for all tests. The carbon balance based on 100% ash recovery presented in Table 21 was calculated based on

TABLE 21
SUMMARY OF CARBON, HYDROGEN, AND ASH BALANCES
FOR REACTOR TESTS

Test	As-Collected Balances (%)			Carbon Based on 100% Ash Recovery
	Carbon	Hydrogen	Ash	
R-1	94.4	104.4	115.4	88.5
R-2	98.3	108.5	100.9	97.9
R-3	99.8	105.4	96.8	101.0
R-4	100.1	106.4	96.4	101.5
R-5	98.3	106.8	106.0	95.9
R-6	98.5	105.0	99.4	98.8
R-7	97.8	105.3	100.5	97.6
R-8	96.5	105.8	99.3	96.8
R-9	98.7	104.8	101.7	98.0
R-10	98.8	104.8	101.1	98.2
R-11	100.0	102.3	101.3	99.5
Average	98.2	105.4	100.3 ^a	98.5 ^a

^aBased on tests R-2 through R-11

the assumption that the unrecovered char composition was the same as that of the main receiver char. The average value for this parameter was 98.5%, which is considered excellent for this type of system.

The abnormally high ash balance on test R-1 has been attributed to residual oil shale char remaining in the system from previous oil shale FHP testing. The last test program completed in the PDU used an Eastern oil shale as feedstock. Eastern oil shale char typically contains about 5% carbon and 90% ash, whereas Kentucky No. 9 coal gasification chars contain approximately 75% carbon and 20% ash. Only about 0.6 gal of residual oil shale char would be required to account for the high ash balance on test R-1. This would also cause the carbon balance based on 100% ash recovery to be quite low for this test; that carbon balance is probably not very indicative of the actual carbon

accountability. However, the as-collected carbon balance for test R-1 is reasonably accurate because of the low carbon content (approximately 5%) of the residual oil shale char. This same logic applies to the collected hydrogen balance.

In general, tests in which non-BT hydrocarbon liquids were produced are those with the slightly lower carbon accountability (i.e., tests R-1, R-5, R-7, and R-8). Previous testing in the PDU has shown that the carbon not accounted for is lost in unrecovered liquids.^{7,8} Complete liquid recovery is difficult because of the small quantities produced relative to the large system size. However, the excellent carbon, hydrogen, and ash accountability obtained during the reactor tests lends credibility to the carbon conversion values.

5. Reactor Temperature Profiles

Several plots of the temperature along the length of the reactor are presented below as an aid to understanding the types of reactions occurring in the FHP reactor. Reactor wall temperature profiles for various long-residence-time reactor tests are shown in Figures 29 through 32. These temperatures were measured along the reactor length on the outside wall of the thin reactor tube. The exothermic nature of the CH_4 -forming hydrogasification reactions is evident in Figure 29 by the significant temperature rise (approximately 250°F) along the reactor length for the low steam concentration (approximately 15% H_2O) tests (tests R-1 and R-2). Note that the temperature rise occurs much faster at the high-temperature reactor conditions (test R-2).

The reactor wall temperature profiles at high inlet-steam concentrations (Figure 30) differ significantly from those at low steam concentrations. At the higher temperatures and inlet-steam concentrations, the reactor wall temperature profile is relatively flat. Under these conditions, the exothermic CH_4 -forming reactions are being counterbalanced by the endothermic CO_x formation reactions.

Figure 29. Reactor Wall Temperature Profiles for Baseline Hydrogasification Tests

Figure 30. Reactor Wall Temperature Profiles for Long-Residence-Time, High-Inlet-Steam-Concentration Tests

Figure 31. Comparison of Low- and High-Steam Concentration Reactor Wall Temperature Profiles for Long-Residence-Time Test Conditions

Figure 32. Effect of Inlet Steam Concentration on Reactor Wall Temperature Profile for Long-Residence-Time Test Conditions

The effect of inlet-steam concentration on the reactor wall temperature profile is shown in Figure 31. At similar inlet mix temperatures and gas-to-coal ratios but at higher inlet-steam concentrations (5B), the temperature rise along the reactor is less, the reactor exit temperature is lower, and the CO_x/CH_4 product ratio is higher. Figure 32 further illustrates the effect of inlet steam concentration on the reactor temperature profile. To obtain the same reactor exit temperature, the reactor inlet mix temperature must be increased as the inlet steam concentration is increased.

Reactor temperature profiles are presented in Figures 33 and 34 for the short-residence-time reactor tests. Reactor wall and inlet/exit insertion temperature measurements are also shown in these figures. The insertion thermocouples were located 6 in. from the injector face and/or exit of the reactor. Redundant T/Cs (two, 180° apart) were employed at the reactor exit. In general, because of heat losses, the reactor exit insertion T/Cs read approximately 70°F higher than the corresponding wall temperature. Temperature increased with increasing reactor length for all of the short-residence-time test conditions. This increase occurred because of the low CO_x production (only 4.1 to 11.5% carbon conversion) at these conditions. The magnitude of the temperature rise along the reactor decreased with increasing inlet steam concentration and decreasing reactor inlet mix temperature.

The reactor temperature profile for the CH_4 addition test (test R-11) is shown in Figure 35. A comparison with a non- CH_4 addition test (test 9C) at similar reactor operating conditions is also noted in this figure. The lower inlet mix temperature for the non- CH_4 addition test condition resulted from a slightly lower gas-to-coal ratio. When the coal flow was shut off, as shown in Figure 35 for test R-11, the reactor wall temperature profile decreased very gradually with reactor length as a result of system heat losses.

Figure 33. Reactor Temperature Profiles for Short-Residence-Time, 30% Inlet-Steam-Concentration Test Conditions

Figure 34. Reactor Temperature Profiles for Short-Residence-Time, High-Inlet-Steam-Concentration Test Conditions

Figure 35. Reactor Temperature Profile for CH₄ Addition Test

6. Product Gas Composition

The composition and flow rate of the gas exiting the H₂/CH₄/O₂ pre-burner, steam generator, main injector, and reactor are presented in detail in Appendix B for each reactor test condition.

a. Major Constituents

For the range of operating conditions employed during the AFHP reactor testing, approximately 35 to 68% of the coal carbon fed to the reactor was converted to gases (i.e., to CH₄, C₂H₆, CO, and CO₂). Removing the noncarbonaceous gases (i.e., H₂, H₂O, and N₂) and vapor phase BTX, the "separated" product-gas composition ranged from about 57 to 93% CH₄, 0.02 to 0.25% C₂H₆, 7 to 33% CO, and 0.8 to 10.5% CO₂.

The major species concentration of the "separated" product gas is plotted versus reactor exit temperature in Figure 36. The CH_4 concentration decreased with increasing reactor temperature, inlet-steam concentration, and residence time. Conversely, CO and CO_2 concentrations increased with increasing reactor temperature, steam concentration, and residence time. The gas-to-coal ratio had a negligible effect on the gas composition over the range studied (0.15 to 0.27). The effect of steam concentration on the CO_x and CH_4 concentrations is most significant at the long-residence-time and high-reactor-temperature conditions. The increase in CO_x at these conditions occurs at the expense of CH_4 production as well as from heterogeneous steam/char reactions.

b. Trace Species

Trace species analyses were performed to estimate the levels of H_2S , NH_3 , COS , HCN , and CS_2 contained in the product gas. Analyses for H_2S and NH_3 were determined experimentally during tests R-8 through R-10. Estimates of COS , HCN , and CS_2 concentrations were obtained using a thermochemical equilibrium computer code developed by NASA.

The H_2S and NH_3 concentrations in the product gas were determined at four different reactor operating conditions encompassing three tests. The results of these analyses are summarized in Table 22. Both H_2S and NH_3 concentrations (on a dry gas volume basis) ranged from about 3000 to 5000 ppm. The measured H_2S concentration was generally slightly greater than the NH_3 concentration. The corresponding sulfur and nitrogen conversions to H_2S and NH_3 are presented in Table 23 for each of these test conditions. A comparison of these conversion values with their respective overall elemental conversions indicates that, on the average, approximately 85% of the sulfur and 73% of the nitrogen converted were converted to H_2S and NH_3 , respectively.

a. Long-Residence-Time Tests

b. Short-Residence-Time Tests

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Figure 36. Major Species Concentration of "Separated" Product Gas

TABLE 22
EXPERIMENTAL H₂S AND NH₃
CONCENTRATIONS IN PRODUCT GAS

Test Condition	Concentration (ppm) ^a	
	H ₂ S	NH ₃
8A	2680	2770
9A	5080	3650
9C	5410	5230
10	4060	3570

^aDry-gas-volume basis

TABLE 23
SULFUR AND NITROGEN CONVERSIONS

Test Condition	Conversions (wt. %) ^a		Conversion (wt. %) ^b	
	Sulfur to H ₂ S	Nitrogen to NH ₃	Sulfur	Nitrogen
8A	51.7	43.3	84.8	76.0
9A	74.1	46.8	78.9	71.1
9C	79.6	67.7	78.9	71.1
10	65.6	50.0	79.1	67.5

^aBased on measured gas concentration and flow rate
^bOverall for entire test--based on ash tracer

Equilibrium estimates of the COS, HCN, and CS₂ concentrations in the product gas are given in Table 24 (on a wet-gas basis) for a range of reactor temperature and inlet-steam concentrations. The estimated equilibrium concentrations for COS and HCN ranged from approximately 6 to 15 ppm and 1 to 4 ppm, respectively, while that for CS₂ was roughly constant at 0.05 ppm.

7. Liquid Product Properties

The results of chemical analyses performed to characterize the light oil recovered from the light-oil condenser, the BTX stripped from the carbon adsorber bed, and the sour process water are presented below.

a. Light Oil

Table 25 summarizes the analyses performed on the light oil collected from tests R-8 through R-10, which were conducted in the short-residence-time

TABLE 24
ESTIMATED EQUILIBRIUM CONCENTRATIONS OF
COS, HCN, AND CS₂ IN PRODUCT GAS^a

Test	Temperature (°F)	% H ₂ O (inlet)	COS (exit ppm)	HCN (exit ppm)	CS ₂ (exit ppm)
R-2	1850	14.4	6.4	1.6	0.05
	1980	14.4	8.4	3.2	
	2000	14.4	8.7	3.5	
R-4	1850	28.9	12	1.3	0.05
	1980	28.9	14	2.1	
	2000	28.9	14	2.2	
R-3	1850	46.4	13	0.71	0.05
	1950	46.4	14	0.90	
	2000	46.4	15	0.98	

^aWet-gas basis

TABLE 25
SUMMARY OF LIGHT OIL CHEMICAL ANALYSES^a

Test	Oil Collected (lb)	Oil C ₆ H ₆ Content (wt. %)	Composition (wt. %)				Calorific Value (Btu/lb)
			Carbon	Hydrogen	Sulfur	Nitrogen	
R-8	12.9	39.2	93.7	6.02	0.14	0.10	27,180
R-9	42.6	46.0	92.7	6.69	0.36	0.25	24,423
R-10	64.1	45.0	93.1	6.47	0.35	0.09	26,063

^aMoisture- and char-free basis

reactor. Only in these tests were measurable quantities of light oil collected. Initially, the water and char contents of the light oils were determined so that the moisture- and char-free quantity of oil produced could be defined. These "cleaned" oil samples were then analyzed to define their benzene, carbon, hydrogen, sulfur, and nitrogen contents as well as their calorific values.

The C₆H₆ content of the light oil ranged from approximately 39 to 46%. Its water and char content ranged from approximately 27 to 70% and 0.2 to 1.4%, respectively, while the calorific value of the moisture- and char-free oils ranged from 24,423 to 27,180 Btu/lb. The average clean-oil carbon, hydrogen, sulfur, and nitrogen contents were 93.2, 6.4, 0.28, and 0.15%, respectively.

b. Stripped BTX

BTX samples were collected from 7 of the 11 reactor tests, and GC analyses were conducted to define the major constituents of each sample. In addition, the calorific value and carbon, hydrogen, sulfur, and nitrogen contents of the samples from tests R-5 and R-10 were determined. Results of these analyses are summarized in Table 26.

TABLE 26
SUMMARY OF BTX CHEMICAL ANALYSES^a

Test	BTX Collected (lb)	Major Constituents (wt. %)			Composition (wt. %)				Calorific Value (Btu/lb)
		C ₆ H ₆	C ₇ H ₈	Light Ends	Carbon	Hydrogen	Sulfur	Nitrogen	
R-1	17.9	96.4	1.06	2.51	--	--	--	--	--
R-5	13.2	98.8	0.75	0.40	91.4	7.98	0.60	0.01	29,773
R-7	1.3	97.0	2.04	0.97	--	--	--	--	--
R-8	5.8	98.2	1.06	0.71	--	--	--	--	--
R-9	9.5	98.2	0.94	0.85	--	--	--	--	--
R-10	20.4	98.3	0.70	1.02	91.7	7.70	0.50	0.03	28,881
R-11	4.7	94.5	1.56	3.95	--	--	--	--	--

^aMoisture- and char-free basis

The BTX collected was primarily composed of C₆H₆. On the average, the samples contained about 97% C₆H₆, 1.2% C₇H₈, and 1.5% unidentified light ends. No xylenes or thiophene were detected. Detection limits for these components were 0.2 and 0.5 wt. %, respectively. Average calorific value and carbon, hydrogen, sulfur, and nitrogen contents of the BTX were approximately 29,325 Btu/lb, 91.6%, 7.84%, 0.55%, and 0.02%, respectively. The C₆H₆ produced can be easily upgraded to high-purity, chemical-grade quality using existing catalytic process technology.

c. Process Water

Samples of process water from the light-oil decanter and the BTX steam stripping operation from test R-11 were analyzed for total organic carbon (TOC), C₆H₆, and C₆H₅OH content. Results of these analyses are summarized in Table 27. A total of 1.6% (7.67 lb) of the carbon fed to the reactor for this test was contained in the process water. The major portion of the carbon in the BTX recovery system water was in the form of C₆H₆ at a concentration slightly greater than its solubility in water (820 ppm).

TABLE 27
TOC, C₆H₆, AND C₆H₅OH CONTENT OF
PROCESS WATER FROM TEST R-11

Material	Content (ppm)		
	TOC	C ₆ H ₆ ^a	C ₆ H ₅ OH
Light-oil decanter water (3118 lb)	1560	161	0.005
BTX recovery system water (2582 lb)	1090	1070	0.011

^aSolubility in H₂O--820 ppm

Greater than 90% of the carbon in the light-oil decanter water was in the form of non-C₆H₆ light oil. The C₆H₅OH content of the process water was in the 0.005 to 0.011 ppm range.

8. Elemental Conversion

Elemental conversion is defined as unity minus the "fraction converted" to char. Overall hydrogen, sulfur, nitrogen, and chlorine elemental conversions are presented for the 11 reactor tests in Table 28. These conversions were calculated by requiring an ash balance, with the overall char composition being that of the char from the main char receiver. Conversion to nonchar species was computed by the following equation:

$$\eta_x = 100 \left[1 - \left(\frac{a_o}{a_c} \right) \left(\frac{X_c}{X_o} \right) \right] ,$$

where

- η_x = conversion of element to nonchar components (%)
- a_o = ash fraction of dry coal
- a_c = ash fraction of dry char
- X_o = fraction of element in dry coal
- X_c = fraction of element in dry char.

TABLE 28
HYDROGEN, SULFUR, NITROGEN, AND CHLORINE ELEMENTAL
CONVERSIONS FOR REACTOR TESTS

Test	Elemental Conversion (%)			
	Hydrogen	Sulfur	Nitrogen	Chlorine
R-1	90.8	80.6	75.8	44.6
R-2	94.4	80.1	76.8	93.3
R-3	96.6	86.6	77.3	79.7
R-4	95.8	82.8	80.5	71.7
R-5 ^a	93.4	81.8	62.0	64.5
R-6	96.7	81.2	77.9	67.6
R-7 ^a	96.4	86.4	78.6	64.0
R-8 ^a	90.8	84.8	76.0	66.2
R-9 ^a	89.7	78.9	71.1	66.9
R-10	89.7	79.1	67.5	69.1
R-11	94.7	83.6	76.8	54.1
Average	93.5	82.4	74.6	67.4

^aTemperature scanning tests

This is the same procedure by which overall carbon conversion is calculated. The average hydrogen, sulfur, nitrogen, and chlorine elemental conversions for the 11 reactor tests were 93.5, 82.4, 74.6, and 67.4%, respectively. Each of these average elemental conversions is higher than the average overall carbon conversion for the reactor tests. The elemental conversions are shown plotted as a function of reactor exit temperature for the seven material balance tests in Figure 37. In general, the elemental conversions increased slightly with increasing reactor exit temperature, and little effect of reactor residence time is evident. The wide range of data scatter for the chlorine conversion is the result of the poor accuracy for its determination at very low concentration levels (0.08 to 0.22 wt. %).

Figure 37. Hydrogen, Sulfur, Nitrogen, and Chlorine Elemental Conversions versus Reactor Exit Temperature

9. Preburner Assembly Modifications

As noted above, during the initial startup of two reactor tests (tests R-3 and R-6), burn-through of the inside wall of the preburner combustion chamber near its injector caused the initial attempt to conduct these tests to be terminated. Both incidents occurred before the start of coal flow at preburner operating conditions similar to or less severe than those successfully employed during previous tests. System shutdown was by an automatic "cut" sequence initiated by the DAS when low preburner coolant water flow was detected. The preburner combustion chamber pressure was higher than the coolant water system pressure. Consequently, the wall burn-through allowed combustion gases to pass through the opening in the inside chamber wall and into the coolant water passage. This gas flow restricted the flow of coolant water, resulting in the test "cut" sequence. The reasons for this problem and its resolution are discussed below.

The test hardware problem was attributed to high chamber wall heat fluxes near the preburner injector. Inadvertent use of "hard" coolant water also contributed to the first hardware failure (test R-3). Resolution of these problems involved increasing the cooling of the chamber wall near the injector and monitoring the water conditioning unit that supplied the "soft" water. Additional cooling was provided by decreasing the inside chamber wall thickness (0.030 in. instead of 0.075 in.), increasing the coolant water velocity (from ~16 to 60 ft/s), and reversing the coolant water flow direction in order to supply lower-temperature, higher-pressure water to the high heat flux region.

No definitive cause of the second preburner hardware incident (test R-6) was identified. However, primary suspects included contamination of the coolant water or hydrogen/oxygen reactant systems and liquid-metal embrittlement of the 0.030-in.-thick Incoloy 800 chamber wall. Although no evidence was found, system contamination could have disrupted the coolant water flow or created local high-temperature regions. After the first hardware incident, a 0.035-in.-diameter wire was brazed in a spiral pattern to the outside surface of the inner preburner combustion chamber wall near the injector in order to increase the coolant water velocity. A subsequent literature survey indicated that under certain conditions, the braze material employed (Easy-Flow 45) could cause liquid-metal embrittlement of the Incoloy 800 wall material.

To further enhance cooling of the preburner combustion chamber wall near the injector, the following changes were subsequently made: (1) the material of construction for the inside wall near the injector was changed to pure nickel, (2) a 0.035-in.-diameter pure-nickel wire was brazed (silver-copper eutectic with a 1450°F solidus temperature) in a spiral pattern along the outer coolant wall at a pitch sufficient to yield a water coolant velocity of 100 ft/s, and (3) the coolant water flow rate was increased by 20%. These changes greatly improved the heat transfer rate through the wall and significantly lowered its operating temperature. Additional measures were also taken to prevent contaminating the H_2/O_2 /coolant water systems. The program

testing was successfully completed following these hardware modifications. No evidence of erosion or overheating was noted when the chamber was inspected after completion of the test program.

D. REACTOR PERFORMANCE ANALYSIS

To understand the processes occurring during the FHP of coal requires careful interpretation of the reactor data. These analyses have led to correlation equations relating carbon conversion yields to reactor operating conditions. Equations that accurately predict reactor performance are necessary to select commercial-scale operating conditions that minimize overall plant capital and operating costs.

The three major operating parameters investigated during the current AFHP program were reactor exit temperature, residence time, and inlet steam concentration. As shown in Figure 22, an increase in reactor exit temperature, residence time, steam concentration, or gas-to-coal ratio caused an increase in total carbon conversion. This result is the effect of several processes operating in parallel. Higher reactor temperatures and inlet steam concentrations lead to increased heterogeneous steam/char and H_2 /char reaction rates and therefore higher overall carbon conversion.

Another reaction process involved is the deposition of vapor-phase liquids onto the surface of the char particles. This is most evident by comparing the two 30% steam tests at the long residence time in Figure 22. Reduction of the gas-to-coal ratio increased the partial pressure of the vapor-phase liquids and, as a consequence, increased the deposition reaction while decreasing the total carbon conversion. This effect has been noticed in past coal hydrogasification tests, and microphotographs of the char produced during the current test program showed surface nodules associated with the deposited liquids.

The distribution of the total carbon conversion between gases and liquids is depicted in Figures 23 and 28, respectively. As expected, the conversion to liquids decreased as temperature and/or residence time increased. As the liquids conversion decreased, the conversion to gases increased correspondingly as a result of the saturation, oxidation, and fragmentation of the liquids. One important result is the insensitivity of the liquids decomposition rate to changes in reactor inlet-gas composition. One would expect the reaction rate between the liquids and hydrogen to be significantly different from the reaction rate between the liquids and steam. Of course, a possible explanation for this observed result is that the rate-controlling step for liquids decomposition is entirely independent of the gas composition.

The general trend for carbon conversion to CH_4 and CO_x shows increased conversion as temperature and/or steam concentration is increased (Figures 24 and 25). The exception to this general trend is for the 45% steam condition at long residence time and high temperatures. Under these conditions, the CO_x continues to increase as temperature increases but the conversion to CH_4 first increases then decreases as the temperature rises. The only explanation for this trend is that steam is reacting with the liquid fragmentation products producing oxides rather than being hydrogenated to CH_4 . This homogeneous CO_x production is probably also occurring at other less severe operating conditions but at much lower reaction rates.

Another important aspect of reactor performance can be obtained by comparing the measured reactor exit compositions and partial equilibrium predictions. The main partial equilibrium equations are:

Presented in Table 18 for all AFHP test data conditions are the measured pressure equilibrium constants divided by the calculated constants based on thermodynamic properties. For most tests, CO_2 is in partial equilibrium with CO. However, there are some exceptions at test conditions exhibiting very low reactor exit temperatures. Since the main reaction for CO_2 production from CO is

the OH radical is probably in partial equilibrium with H atoms through the reversible reaction

The CO concentration at the reactor exit is much less than that based on partial equilibrium and the measured CH_4 concentration. Therefore, equilibrium is not restricting the homogeneous steam/hydrocarbon reactions.

The equilibrium between C_2H_6 and CH_4 is an indication of hydrocarbon fragmentation occurring at the reactor exit. Note that for all test conditions with BTX and/or oils production, the C_2H_6 concentration is much greater than the equilibrium value. This result is expected based on current detailed kinetic models for the decomposition of higher molecular weight hydrocarbons. These models predict that hydrocarbons decompose to CH_4 through the C_2 compounds. The slight super-equilibrium value for C_2H_6 for the cases for non-liquids production is probably caused by super-equilibrium H atom concentrations by the reversible reactions

This observation is consistent with the observed CO/ CO_2 equilibrium.

VI. CORRELATION OF AFHP/FHP TEST DATA

Flash hydropyrolysis tests on coal in short-residence-time reactors have been conducted at Rockwell International since 1975. These tests have been performed in both hydroliquefaction and hydrogasification experimental facilities ranging in nominal capacity from 1/4 ton/h of coal to 1 ton/h. A wide spectrum of data from these tests now exists.

In the past, these data have primarily been interpreted in the form of parametric graphical representations. An example is a plot of carbon conversion versus reactor exit temperature with either residence time, hydrogen pressure, or steam concentration as a parameter represented by a family of curves. Although such analyses are useful in depicting the effects of important test parameters on the performance of the reactor, they do not consider the net effects on performance of all significant parameters in a concise, tractable format. Therefore, the need to correlate all significant parameters to yield predictive correlations was recently recognized.

This section reports the currently most sophisticated method of correlating Rockwell AFHP/FHP data from advanced hydrogasification, hydrogasification, and hydroliquefaction tests. The method essentially involves defining a set of phenomenological reactions representing the processes occurring during AFHP/FHP and then applying a nonlinear multiple regression technique to the set of equations derived according to the kinetics of those reactions.

A. MODEL FORMULATION

In previous years, numerous researchers have devoted extensive effort to the understanding of coal decomposition and gasification. This research has produced numerous technical papers and reports that examine all aspects of coal conversion. As a result, many coal-particle chemistry models have been formulated that investigate coal conversion chemistry regimes from combustion to partial oxidation to hydrogasification and to hydroliquefaction. However, each formulation has only dealt with a specific coal chemistry regime. No

comprehensive formulation for coal chemistry has been shown able to handle all regimes of coal conversion or has been correlated to the extensive experimental data for those regimes.

The most comprehensive information currently available on the kinetics of the FHP of coal is given in the review papers by Anthony and Howard¹⁸ and by Gavalas.¹⁹ In the most common method of analysis, devolatilization kinetics are modeled in terms of multiple parallel reactions having a Gaussian distribution of activation energies. This description is adequate in quantifying overall AFHP/FHP kinetics but does not completely describe the kinetics of those reactions that eventually yield products such as light gases (CH_4 , CO , CO_2 , and $\text{C}_2\text{-C}_4$ hydrocarbons), BTX, and other liquids. Therefore, a need existed for modifying these kinetic schemes to include additional intermediate-step reactions yielding those products.

AFHP/FHP reactions can be postulated to any degree of complexity. However, when complicated chemical reactions are modeled by a set of essentially phenomenological reactions, it is prudent to keep the modeling scheme as simple as possible. Following this philosophy, it was decided to model reactions in an AFHP/FHP reactor by the generalized scheme shown in Figure 38. This scheme appears quite complicated but is essentially an extension of the model of Anthony et al.^{18, 21-23} with several reactions added. The overall scheme is similar to that used at Rockwell to analyze FHP hydroliquefaction and hydrogasification data.⁴ For these hydropyrolysis data, two different modeling techniques were used to determine the important parameters affecting carbon conversion: (1) the correlation of experimental data and (2) the detailed analysis of reactor performance (including particle heatup, devolatilization, volatile kinetics, and gas-phase dynamics). Under the current contract, the correlation model has been updated but not the detailed reactor performance model.

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Figure 38. AFHP/FHP Correlation Model

The salient features of the updated correlation model are as follows. Parent coal is assumed to devolatilize according to multiple parallel reactions to light hydrocarbon gases, vapor phase aromatic liquids (unsaturated hydrocarbon liquids), vapor phase partially saturated liquids, vapor phase BTX, CO_x , and char. All the parallel devolatilization reactions are assumed to have the same preexponential factor, but the activation energies are assumed to be distributed in a Gaussian mode. The aromatic liquids can be hydrogenated to partially saturated liquids, polymerized to char, and/or be oxidized to CO_x . The partially saturated liquids can be fragmented to light hydrocarbon gases and BTX. BTX species, in turn, can be hydrocracked further to light hydrocarbon gases and/or oxidized to CO_x . The char, too, can react heterogeneously with hydrogen and steam to form light gases.

1. Coal Devolatilization Kinetics

The devolatilization of the coal is assumed to follow the multiple parallel reaction scheme. The mass conservation equation for the j -th parallel reaction is

$$\frac{d}{dt} (\text{COAL})_j = -k_{vj} (\text{COAL})_j ,$$

where

$(\text{COAL})_j$ = fraction of nondevolatilized coal carbon for the j-th parallel reaction

t = time

k_{vj} = reaction rate for the j-th reaction
 $= \exp \left(b_j - \frac{E_j}{RT} \right)$

b_j = reaction coefficient for the j-th reaction
 $= \ln (1.67 \times 10^{13})$

E_j = activation energy for the j-th reaction
 $= \bar{E} + (j - \frac{n+1}{2})(\Delta E)$

R = gas constant

T = temperature

$\bar{E}$ = average activation energy for coal devolatilization (model parameter)

n = number of parallel reactions

$= 50$

$$\Delta E = \left(\frac{4\sigma_e}{n} \right)$$

σ_e = standard distribution for the devolatilization activation energy (model parameter)

The boundary equation for the preceding continuity equation is

$$(\text{COAL})_{j,t=0} = f_j ,$$

where

f_j = fraction of the initial coal carbon that is assigned to the j -th parallel reaction

$$= \frac{1}{\bar{f}} \left(\frac{\Delta E}{\sigma_e \sqrt{2\pi}} \right) \exp \left[- \frac{(E_j - \bar{E})^2}{2\sigma_e^2} \right]$$

$$\bar{f} = \sum_{j=1}^n \left\{ \left(\frac{\Delta E}{\sigma_e \sqrt{2\pi}} \right) \exp \left[- \frac{(E_j - \bar{E})^2}{2\sigma_e^2} \right] \right\}$$

2. Unsaturated Hydrocarbon Liquids Reactions

Past correlation of FHP data indicated that for certain reactor operating conditions the total carbon conversion decreased as residence time increased.⁴ This phenomenon was modeled by assuming that the highly unsaturated devolatilized liquids were thermally cracking, polymerizing, and/or depositing on the char particles after the vapor phase liquids had mixed with the injected gases. Since these reactions between the vapor phase liquids and the char particles were assumed to depend on the vapor phase liquid density after mixing with the injected gases and on the char density per unit reactor volume, the deposition rate was dependent on the injected gas-to-coal ratio.

Recent liquefaction tests⁷ have evaluated this dependence of total carbon conversion on the gas-to-coal ratio, and the results are shown in Figure 39. As indicated above in Figure 22, AFHP total carbon conversion to hydrocarbons was also found to depend on the gas-to-coal ratio. Although the reaction is probably occurring within the pore structure of the char particle, it is not a phenomenon associated with devolatilization. The devolatilization mechanism can, at most, only be dependent on the gas partial pressures and is independent of the amount of gas surrounding the coal particle.

Figure 39. Effect of Gas-to-Coal Ratio on Total Carbon Conversion for Hydroliquefaction Test Conditions⁷

The experimental data indicate that for a given reactor exit temperature and residence time, the carbon conversions to oils and BTX are not strong functions of total pressure and/or hydrogen concentration. This condition seems surprising since the saturation rate of the aromatic liquids should be a strong function of hydrogen partial pressure. This conflict can be explained by assuming that the decomposition of aromatic liquids is controlled by ring destabilization and that the saturation, oxidation, and deposition kinetic rates of the aromatic liquids control only the distribution of products from the ring destabilization/decomposition reactions.²⁰

To obtain closed-form carbon conversion equations for data correlation, it was assumed that all the different types of liquids decompose according to first-order kinetics. The mass conservation equation for the unsaturated hydrocarbon liquids is

$$\frac{d}{dt} (UHL) = (\alpha_{UHL}) \sum_{j=1}^n k_{vj} (COAL)_j - k_{UHL} (UHL) ,$$

where

(UHL) = fraction of coal carbon that is present as unsaturated hydrocarbon liquids

α_{UHL} = fraction of the devolatilization products that is unsaturated hydrocarbon liquids (model parameter)

k_{UHL} = total decomposition rate of the unsaturated hydrocarbon liquids

$$= \exp \left[b_{UHL} - \frac{E_{UHL}}{RT} \right]$$

b_{UHL} = unsaturated hydrocarbon liquids reaction coefficient (model parameter)

E_{UHL} = unsaturated hydrocarbon liquids activation energy (model parameter).

The product distribution of the unsaturated hydrocarbon liquids decomposition is defined as follows:

$$\lambda_{PSHL} = \gamma_s / (\gamma_s + \gamma_o + \gamma_d)$$

$$\lambda_{COX} = \gamma_o / (\gamma_s + \gamma_o + \gamma_d)$$

$$\lambda_{CHAR} = \gamma_d / (\gamma_s + \gamma_o + \gamma_d) ,$$

where

λ_{PSHL} = fraction of decomposition that produces partially saturated hydrocarbon liquids

λ_{COX} = fraction of decomposition that produces CO_x

λ_{CHAR} = fraction of decomposition that produces char

$$\gamma_s = P_{\text{H}_2}^{\phi_{\text{sH}_2\text{O}}} + \exp \left[b_s - \frac{E_s}{RT} \right] P_{\text{H}_2\text{O}}^{\phi_{\text{sH}_2\text{O}}}$$

$$\gamma_o = \exp \left[b_o - \frac{E_o}{RT} \right] P_{\text{H}_2\text{O}}^{\phi_{\text{oH}_2\text{O}}}$$

$$\gamma_d = \exp \left[b_d - \frac{E_d}{RT} \right] \left(\frac{\rho_{\text{GAS}}}{\text{gas/coal}} \right)^{\phi_d}$$

P_{H_2} = hydrogen partial pressure

$P_{\text{H}_2\text{O}}$ = steam partial pressure

ρ_{GAS} = gas density

In the preceding equations, all the b's, E's, and ϕ 's are model parameters.

3. Partially Saturated Hydrocarbon Liquids Kinetics

The partially saturated hydrocarbon liquids are assumed to fragment along saturated carbon-carbon bonds and produce light hydrocarbon gases and BTX. The mass conservation equation for the partial saturated hydrocarbon liquids is

$$\frac{d}{dt} (\text{PSHL}) = (\alpha_{\text{PSHL}}) \sum_{j=1}^n k_{v_j} (\text{COAL})_j + \lambda_{\text{PSHL}} k_{\text{UHL}} (\text{UHL}) - k_{\text{PSHL}} (\text{PSHL}) ,$$

where

(PSHL) = fraction of coal carbon that is present as partially saturated hydrocarbon liquids

α_{PSHL} = fraction of the devolatilization products that are partial saturated hydrocarbon liquids (model parameter)

k_{PSHL} = total fragmentation rate of the partially saturated liquids

$$= \exp \left[b_{PSHL} - \frac{E_{PSHL}}{RT} \right]$$

b_{PSHL} = partially saturated liquids reaction coefficient (model parameter)

E_{PSHL} = partially saturated liquids activation energy (model parameter)

The product distribution of the partially saturated hydrocarbon liquids fragmentation is

Fraction to BTX = β (model parameter)

Fraction to light hydrocarbon gases = $1 - \beta$.

4. BTX Kinetics

BTX is produced by the devolatilization of the coal and the fragmentation of partially saturated liquids and can decompose to light hydrocarbon gases and CO_x . The mass conservation equation for the BTX is

$$\frac{d}{dt} (BTX) = (\alpha_{BTX}) \sum_{j=1}^n k_{vj} (COAL)_j + \beta k_{PSHL} (PSHL) - k_{BTX} (BTX) ,$$

where

(BTX) = fraction of coal carbon that is present as BTX

α_{BTX} = fraction of the devolatilization products that is BTX (model parameter)

k_{BTX} = total decomposition rate of the BTX

$$= \exp \left[b_{BTX} - \frac{E_{BTX}}{RT} \right]$$

b_{BTX} = BTX reaction coefficient (model parameter)

E_{BTX} = BTX activation energy (model parameter)

The product distribution of the BTX decomposition is assumed to be

$$\epsilon_{\text{LHG}} = \gamma_s / (\gamma_s + \gamma_o)$$

$$\epsilon_{\text{COX}} = \gamma_o / (\gamma_s + \gamma_o)$$

where

ϵ_{LHG} = fraction to light hydrocarbon gases

ϵ_{COX} = fraction to CO_x

The γ 's in the preceding equations are defined above.

5. Char Kinetics

An important aspect of the advanced hydrogasification system is the promotion of steam/char reactions to increase overall carbon conversion and reduce hydrogen consumption in the reactor. Several different types of heterogeneous gas/char reactions were investigated during the development of the correlation model. These included reactions between hydrogen and steam with an activated char particle that deactivates and also the more standard gas/char kinetics. Statistical analyses of the results of this investigation indicated that the heterogeneous kinetics could be modeled by considering a single reaction between steam and char that produces CO_x . The mass conservation equation for the char was, therefore, written as

$$\begin{aligned} \frac{d}{dt} (\text{CHAR}) = & (\alpha_{\text{CHAR}}) \sum_{j=1}^n k_{v_j} (\text{COAL})_j \\ & + \lambda_{\text{CHAR}} k_{\text{UHL}} (\text{UHL}) - k_{\text{CHAR}} (\text{CHAR}) , \end{aligned}$$

where

(CHAR) = fraction of coal carbon that is present as char

α_{CHAR} = fraction of the devolatilization products that is char
(Note: $\alpha_{\text{CHAR}} = 1 - \alpha_{\text{UHL}} - \alpha_{\text{PSHL}} - \alpha_{\text{BTX}} - \alpha_{\text{LHG}} - \alpha_{\text{COX}}$)

k_{CHAR} = total heterogeneous reaction rate

$$= \exp \left[b_{\text{CHAR}} - \frac{E_{\text{CHAR}}}{RT} \right] P_{\text{H}_2\text{O}}^{\phi_{\text{CHAR}}}$$

b_{CHAR} = char/steam reaction coefficient (model parameter)

E_{CHAR} = char/steam activation energy (model parameter)

ϕ_{CHAR} = char/steam pressure exponent (model parameter)

6. Light Hydrocarbon Gases and CO_x Kinetics

The mass conservation equation for the light hydrocarbon gases is

$$\begin{aligned} \frac{d}{dt} (\text{LHG}) &= (\alpha_{\text{LHG}}) \sum_{j=1}^n k_{v_j} (\text{COAL})_j \\ &+ (1 - \beta) k_{\text{PSHL}} (\text{PSHL}) + \epsilon_{\text{LHG}} k_{\text{BTX}} (\text{BTX}) , \end{aligned}$$

where

(LHG) = fraction of coal carbon that is present as light hydrocarbon gases

α_{LHG} = fraction of the devolatilization products that are light hydrocarbon gases (model parameter).

The mass conservation equation for the CO_x is

$$\begin{aligned} \frac{d}{dt} (\text{COX}) &= (\alpha_{\text{COX}}) \sum_{j=1}^n k_{v_j} (\text{COAL})_j + \lambda_{\text{COX}} k_{\text{UHL}} (\text{UHL}) \\ &+ \epsilon_{\text{COX}} k_{\text{BTX}} (\text{BTX}) + k_{\text{CHAR}} (\text{CHAR}) , \end{aligned}$$

where

(COX) = fraction of coal carbon that is present as CO_x

^aCOX = fraction of the devolatilization products that are CO_x
(model parameter)

B. DATA CORRELATIONS

The mass conservation equations described in the preceding section are nonlinear differential equations that can only be solved using a complicated computer code. To obtain model correlation equations for evaluating experimental conversion data, certain simplifying assumptions must be invoked. The model correlation equations were derived based on the following assumptions:

- Constant temperature (evaluated based on measured reactor exit temperature)
- Constant hydrogen mole fraction (evaluated based on reactor inlet gas composition)
- Constant steam mole fraction (evaluated based on reactor inlet gas composition)
- Equal gas and particle residence times (obtained from experimental measurements).

These assumptions make the resulting mass conservation differential equations linear, and the system of equations was solved using Laplace transform techniques to obtain expressions for the total carbon conversion, carbon conversion to gases, BTX, and CO_x .

These model correlation equations contain several parameters that must be assigned values before the equations can be used to calculate carbon conversions. The parameter values were obtained by nonlinear, multivariate correlation of test data against the model equations. The Rockwell test data used in the correlation are presented in Table 29. The range of the Rockwell AFHP/FHP test data is summarized in Table 30.

TABLE 29

ROCKWELL DATA USED IN NONLINEAR MULTIPLE REGRESSION ANALYSIS
(Kentucky No. 9 hvAb Coal)
(Sheet 1 of 6)

Gas-to-Coal Ratio (moles/lb)	Inlet Mole Fractions		Pressure (psia)	Reactor Residence Time (s)	Temperatures (F)		Carbon Conversions (%)				Test
	Hydrogen	Steam			Mixed	Reactor Exit	Total	Gases	BTX	COx	
0.124	0.939	0.061	1015	0.155	1335	1290	38.2	-	-	-	LIQ 5
0.237	0.924	0.076	1015	0.126	1700	1700	54.2	21.5	-	-	LIQ 6
0.384	0.921	0.079	1015	0.119	1907	1950	61.5	29.7	-	-	LIQ 7
0.181	0.920	0.080	1015	0.274	1697	1690	59.6	28.9	-	-	LIQ 8
0.145	0.925	0.075	1015	0.063	1655	1720	56.0	18.7	-	-	LIQ 13
0.197	0.932	0.068	1515	0.098	1606	1770	59.7	28.2	-	-	LIQ 14
0.200	0.924	0.076	715	0.045	1701	1660	56.0	20.1	-	-	LIQ 15
0.220	0.933	0.067	1015	0.069	1607	1690	57.3	23.6	-	-	LIQ 16
0.145	0.927	0.073	1016	0.079	1604	1600	54.0	18.4	4.6	-	LIQ 20
0.227	0.930	0.070	1016	0.064	1739	1690	59.0	23.8	-	-	LIQ 21
0.184	0.932	0.068	517	0.057	1632	1630	57.0	22.2	2.7	-	LIQ 22
0.233	0.933	0.067	1018	0.063	1722	1640	60.0	21.3	-	-	LIQ 23
0.262	0.927	0.073	1017	0.061	1840	1770	63.8	27.7	-	-	LIQ 24
0.325	0.928	0.072	1016	0.121	1829	1918	63.0	23.0	9.7	-	LIQ 25
0.241	0.906	0.094	1015	0.128	1655	1721	61.5	23.5	7.5	-	LIQ 26
0.234	0.946	0.054	1016	0.134	1566	1609	57.1	20.9	5.4	-	LIQ 27
0.244	0.936	0.064	1014	0.126	1670	1765	58.7	25.4	7.2	-	LIQ 28
0.208	0.937	0.063	1512	0.212	1601	1721	57.6	27.5	8.7	-	LIQ 29
0.216	0.941	0.059	1013	0.136	1566	1627	54.6	24.1	5.3	-	LIQ 30
0.250	0.936	0.064	1511	0.209	1665	1938	62.8	-	8.5	-	LIQ 31
0.224	0.931	0.069	1011	0.127	1738	1835	62.2	27.4	8.6	-	LIQ 32
0.151	0.943	0.057	1014	0.367	1477	1568	48.2	20.6	4.0	-	LIQ 37
0.155	0.948	0.052	1015	0.390	1366	1405	46.2	15.2	1.9	-	LIQ 38
0.147	0.944	0.056	1013	0.359	1529	1661	51.3	24.0	5.4	-	LIQ 39
0.138	0.946	0.054	1019	0.555	1409	1586	48.1	23.4	4.7	-	LIQ 40
0.121	0.952	0.049	1013	0.587	1292	1431	43.2	16.5	2.1	-	LIQ 41
0.124	0.946	0.054	1016	0.523	1454	1687	51.8	26.0	7.2	-	LIQ 42
0.207	0.939	0.061	1023	0.023	1590	1620	49.5	15.4	2.2	-	LIQ 63
0.246	0.925	0.075	1010	0.020	1840	1790	51.0	19.9	5.4	-	LIQ 64
0.220	0.935	0.065	1014	0.021	1720	1660	52.4	14.0	3.1	-	LIQ 65
0.280	0.954	0.046	1006	0.058	1549	1309	45.2	12.5	-	2.3	LIQ 79-1
0.165	0.943	0.057	1005	0.061	1478	1482	45.1	-	-	-	LIQ 79-2
0.249	0.939	0.061	1004	0.059	1731	1615	55.4	20.3	-	3.5	LIQ 79-3
0.267	0.937	0.063	1012	0.055	1785	1741	55.1	24.0	-	4.2	LIQ 79-4

TABLE 29

ROCKWELL DATA USED IN NONLINEAR MULTIPLE REGRESSION ANALYSIS
(Kentucky No. 9 hvAb Coal)
(Sheet 2 of 6)

Gas-to-Coal Ratio (moles/lb)	Inlet Mole Fractions		Pressure (psia)	Reactor Residence Time (s)	Temperatures (F)		Carbon Conversions (%)				Test
	Hydrogen	Steam			Mixed	Reactor Exit	Total	Gases	BTX	COx	
0.223	0.937	0.063	514	0.040	1692	1551	52.9	15.1	-	2.7	LIQ 79-5
0.168	0.933	0.067	515	0.042	1579	1678	52.1	12.1	-	2.3	LIQ 79-6
0.286	0.938	0.062	1006	0.055	1678	1635	56.4	19.1	-	3.4	LIQ 79-7
0.254	0.941	0.059	1010	0.058	1680	1624	54.2	17.0	-	2.8	LIQ 79-8
0.299	0.926	0.074	511	0.047	1820	1746	54.5	18.1	-	3.1	LIQ 79-9
0.269	0.935	0.065	514	0.051	1698	1639	54.5	14.7	-	2.9	LIQ 79-10
0.300	0.946	0.054	1001	0.056	1638	1600	56.3	-	-	-	LIQ 79-11
0.291	0.945	0.055	1019	0.058	1671	1639	58.7	21.9	-	3.5	LIQ 79-12
0.241	0.931	0.069	511	0.055	1769	1701	55.4	17.5	-	3.3	LIQ 79-13
0.269	0.937	0.063	1005	0.058	1803	1775	58.1	28.2	-	4.1	LIQ 79-15
0.247	0.940	0.060	1006	0.059	1710	1643	55.2	20.9	-	3.7	LIQ 79-17
0.278	0.939	0.061	516	0.052	1716	1675	55.5	16.5	-	3.0	LIQ 79-18
0.381	0.940	0.060	515	0.048	1772	1708	60.4	24.4	-	4.0	LIQ 79-19
0.290	0.939	0.061	513	0.056	1709	1614	57.7	19.3	-	3.1	LIQ 79-20
0.235	0.942	0.058	1011	0.061	1692	1640	58.0	19.2	-	2.8	LIQ 79-21
0.216	0.945	0.055	1016	0.064	1724	1730	55.1	18.1	-	2.7	LIQ 79-23
0.217	0.951	0.049	1017	0.064	1700	1710	55.1	19.0	-	2.8	LIQ 79-24
0.355	0.938	0.062	1013	0.059	1811	1818	56.2	22.7	-	3.3	LIQ 79-27
0.296	0.938	0.062	1016	0.064	1766	1710	56.4	24.4	-	3.8	LIQ 79-28
0.282	0.943	0.057	1014	0.063	1686	1638	57.1	21.7	-	3.1	LIQ 79-29
0.428	0.932	0.068	515	0.048	1913	1781	56.2	26.5	-	4.9	LIQ 79-30
0.252	0.934	0.066	513	0.057	1736	1620	52.1	17.9	-	3.0	LIQ 79-31
0.278	0.947	0.053	1014	0.064	1633	1562	58.5	19.6	-	2.8	LIQ 79-32
0.296	0.943	0.057	1014	0.061	1709	1646	56.2	23.5	-	3.4	LIQ 79-33
0.285	0.945	0.055	1015	0.147	1684	1668	56.3	23.6	-	3.4	LIQ 79-34
0.311	0.940	0.060	1016	0.137	1799	1822	59.4	31.0	-	4.3	LIQ 79-35
0.268	0.949	0.051	1017	0.151	1617	1559	54.9	20.3	-	2.7	LIQ 79-37
0.329	0.940	0.060	516	0.123	1735	1653	56.3	22.4	-	3.7	LIQ 79-38
0.266	0.936	0.064	515	0.124	1792	1763	59.2	22.5	-	3.7	LIQ 79-39
0.286	0.943	0.057	1015	0.145	1729	1716	58.7	26.5	-	3.8	LIQ 79-40
0.313	0.950	0.050	515	0.130	1667	1572	54.8	20.8	-	3.2	LIQ 79-41
0.296	0.947	0.053	1015	0.149	1712	1683	58.5	27.3	-	3.8	LIQ 79-42
0.302	0.945	0.055	1016	0.152	1704	1665	58.4	24.7	-	3.7	LIQ 80-1
0.328	0.942	0.058	1014	0.139	1766	1745	60.5	29.0	-	4.1	LIQ 80-3

TABLE 29

ROCKWELL DATA USED IN NONLINEAR MULTIPLE REGRESSION ANALYSIS
(Kentucky No. 9 hvAb Coal)
(Sheet 3 of 6)

Gas-to-Coal Ratio (moles/lb)	Inlet Mole Fractions		Pressure (psia)	Reactor Residence Time (s)	Temperatures (F)		Carbon Conversions (%)				Test
	Hydrogen	Steam			Mixed	Reactor Exit	Total	Gases	BTX	COx	
0.303	0.943	0.057	516	0.123	1708	1641	58.2	19.8	-	3.3	LIQ 80-4
0.287	0.946	0.054	1014	0.143	1705	1694	59.1	27.2	-	3.9	LIQ 80-6
0.306	0.903	0.097	1014	0.311	1728	1763	56.4	31.0	-	4.2	LIQ 81-3
0.288	0.923	0.077	1013	0.326	1542	1495	51.4	21.5	-	3.0	LIQ 81-4
0.267	0.894	0.106	1014	0.330	1651	1646	52.2	24.6	-	3.7	LIQ 81-6
0.297	0.894	0.106	516	0.290	1706	1588	52.4	22.4	-	3.8	LIQ 81-7
0.259	0.885	0.115	1014	0.326	1645	1650	53.9	24.2	-	3.4	LIQ 81-8
0.554	0.941	0.059	1014	0.288	1864	1892	59.9	39.6	-	4.6	LIQ 81-9
0.268	0.884	0.116	513	0.557	1685	1652	54.2	23.3	-	3.8	LIQ 81-10
0.263	0.896	0.104	1015	0.658	1603	1654	54.0	25.9	-	3.5	LIQ 81-11
0.271	0.917	0.083	1014	0.659	1502	1497	52.0	20.7	-	2.5	LIQ 81-12
0.278	0.887	0.113	1012	0.641	1702	1808	56.0	32.1	-	3.7	LIQ 81-13
0.633	0.952	0.048	1015	0.566	1849	1921	59.5	47.7	-	4.8	LIQ 81-14
0.283	0.887	0.113	1014	0.639	1705	1812	55.2	34.1	-	3.9	LIQ 81-15
0.193	0.817	0.183	1015	0.071	1695	1642	51.6	19.7	-	3.3	LIQ 81-16
0.200	0.875	0.125	1017	0.076	1543	1472	46.1	16.3	-	2.3	LIQ 81-17
0.165	0.751	0.249	1015	0.066	1774	1746	51.9	24.7	-	3.5	LIQ 81-18
0.156	0.757	0.243	1017	0.094	1689	1657	50.6	21.1	-	3.4	LIQ 81-19
0.193	0.795	0.205	1014	0.067	1831	1836	52.8	26.0	-	4.2	LIQ 81-20
0.150	0.701	0.299	1009	0.091	1793	1819	49.1	23.9	-	4.0	LIQ 81-22
0.157	0.786	0.214	1011	0.100	1593	1536	45.7	17.6	-	2.6	LIQ 81-23
0.106	0.548	0.452	1009	0.135	1686	1657	43.5	21.3	-	4.0	LIQ 81-24
0.246	0.886	0.114	1017	0.337	1621	1662	55.8	24.2	-	3.5	LIQ 81-25
0.115	0.644	0.356	1016	0.746	1609	1670	47.1	23.9	-	3.5	LIQ 81-26
0.124	0.648	0.352	1016	0.717	1690	1630	48.6	24.1	-	3.3	LIQ 81-27
0.374	0.919	0.081	510	0.018	1765	1646	51.6	15.8	-	2.9	LIQ 81-33
0.233	0.928	0.072	1504	1.640	1494	1816	62.9	50.6	-	3.9	FHP 300-006
0.257	0.938	0.062	1513	0.985	1603	1909	64.6	48.6	-	3.9	FHP 300-011
0.243	0.939	0.061	1510	3.480	1619	1908	67.3	62.6	-	4.9	FHP 300-012
0.204	0.948	0.052	1515	4.330	1547	1859	58.9	58.9	-	4.1	FHP 300-014
0.145	0.929	0.071	1514	5.730	1460	1680	43.5	35.6	-	2.7	FHP 300-015
0.223	0.942	0.058	1511	2.430	1558	1706	49.9	-	-	-	FHP 300-069
0.117	0.930	0.070	1511	2.570	1347	1366	40.1	-	-	-	FHP 300-070
0.215	0.876	0.061	1508	2.300	1660	1819	55.6	49.0	-	-	FHP 313-021

TABLE 29

ROCKWELL DATA USED IN NONLINEAR MULTIPLE REGRESSION ANALYSIS
(Kentucky No. 9 hvAb Coal)
(Sheet 4 of 6)

Gas-to-Coal Ratio (moles/lb)	Inlet Mole Fractions		Pressure (psia)	Reactor Residence Time (s)	Temperatures (F)		Carbon Conversions (%)				Test
	Hydrogen	Steam			Mixed	Reactor Exit	Total	Gases	BTX	COx	
0.202	0.955	0.045	1506	2.620	1575	1926	59.8	54.2	-	4.3	FHP 313-022
0.197	0.957	0.043	1509	2.390	1620	1772	56.8	45.7	-	3.4	FHP 313-023
0.161	0.954	0.046	1020	1.630	1262	1130	37.0	9.7	-	1.0	FHP 318-011
0.128	0.939	0.061	998	1.360	1411	1360	42.0	18.1	-	1.9	FHP 318-012
0.152	0.932	0.068	1008	1.310	1565	1540	47.7	24.5	-	2.9	FHP 318-013
0.186	0.925	0.075	1042	1.040	1673	1750	53.0	32.6	-	4.2	FHP 318-015
0.165	0.934	0.066	1014	1.150	1644	1630	50.9	29.8	-	3.5	FHP 318-016
0.154	0.931	0.069	1508	1.780	1574	1570	53.6	32.3	-	3.3	FHP 318-018
0.170	0.929	0.071	1529	1.500	1602	1775	55.2	43.5	-	3.8	FHP 318-019
0.171	0.931	0.069	1520	1.520	1585	1825	55.2	35.8	-	3.2	FHP 318-020
0.185	0.940	0.060	994	1.860	1556	1600	48.8	30.9	-	3.6	FHP 318-031
0.250	0.949	0.051	1000	1.920	1534	1500	47.6	27.7	-	3.2	FHP 318-032
0.210	0.935	0.065	1001	1.800	1667	1800	56.5	44.2	11.3	4.5	FHP 318-036
0.211	0.937	0.063	1000	1.780	1683	1830	56.7	44.4	11.4	4.5	FHP 318-037
0.193	0.937	0.063	996	1.830	1622	1700	53.4	34.6	12.2	4.2	FHP 318-038
0.239	0.937	0.063	1002	1.770	1720	1900	59.4	-	-	-	FHP 318-039
0.256	0.935	0.065	1000	1.740	1744	1900	61.5	45.3	-	4.5	FHP 318-040
0.219	0.936	0.064	1000	1.820	1686	1800	54.8	43.6	10.8	4.6	FHP 318-050
0.251	0.938	0.062	1000	1.810	1705	1800	54.5	38.8	13.8	3.8	FHP 318-054
0.214	0.866	0.134	1014	5.730	1531	1821	55.9	47.2	2.2	3.4	AFHP R-1-1
0.215	0.866	0.134	1015	5.750	1532	1787	57.7	45.0	5.0	3.5	AFHP R-1-2
0.215	0.865	0.135	1015	5.660	1542	1867	57.0	47.6	4.7	3.6	AFHP R-1-3
0.215	0.866	0.134	1014	5.700	1537	1824	57.4	46.1	4.9	3.5	AFHP R-1-4
0.215	0.866	0.134	1015	5.640	1536	1873	56.0	46.7	4.8	3.5	AFHP R-1-5
0.216	0.866	0.134	1015	5.640	1536	1844	54.6	43.7	5.3	3.4	AFHP R-1-6
0.210	0.863	0.137	1016	5.580	1552	1875	54.6	50.2	0.0	3.8	AFHP R-2-1
0.208	0.857	0.143	1015	5.470	1598	1982	59.5	59.5	0.0	5.5	AFHP R-2-2
0.208	0.855	0.145	1016	5.420	1614	2000	61.2	61.2	0.0	6.7	AFHP R-2-3
0.208	0.854	0.146	1015	5.420	1616	2004	61.8	61.8	0.0	6.7	AFHP R-2-4
0.208	0.852	0.148	1015	5.400	1631	2011	63.3	63.3	0.0	7.5	AFHP R-2-5
0.218	0.540	0.460	1014	5.040	1792	1948	63.1	62.1	0.0	17.8	AFHP R-3-1
0.215	0.533	0.467	1015	5.120	1792	1951	66.0	65.1	0.0	18.1	AFHP R-3-2
0.217	0.539	0.461	1015	5.040	1805	1955	65.3	64.6	0.0	19.0	AFHP R-3-3
0.213	0.531	0.469	1014	5.120	1810	1956	64.2	63.5	0.0	18.5	AFHP R-3-4

TABLE 29

ROCKWELL DATA USED IN NONLINEAR MULTIPLE REGRESSION ANALYSIS
(Kentucky No. 9 hvAb Coal)
(Sheet 5 of 6)

Gas-to-Coal Ratio (moles/lb)	Inlet Mole Fractions		Pressure (psia)	Reactor Residence Time (s)	Temperatures (F)		Carbon Conversions (%)				Test
	Hydrogen	Steam			Mixed	Reactor Exit	Total	Gases	BTX	COx	
0.216	0.535	0.465	1016	5.080	1795	1961	65.2	64.7	0.0	19.0	AFHP R-3-5
0.201	0.712	0.288	1014	5.360	1659	1969	60.7	60.7	0.0	10.5	AFHP R-4-1
0.202	0.711	0.289	1013	5.320	1663	1974	61.6	61.6	0.0	10.4	AFHP R-4-2
0.202	0.711	0.289	1013	5.300	1668	1979	60.8	60.8	0.0	10.7	AFHP R-4-3
0.203	0.711	0.289	1014	5.300	1669	1975	60.6	60.6	0.0	10.7	AFHP R-4-4
0.203	0.710	0.290	1013	5.240	1685	1985	59.2	59.2	0.0	10.5	AFHP R-4-5
0.214	0.577	0.423	1014	5.580	1576	1843	59.0	49.4	4.6	6.3	AFHP R-5-1
0.213	0.575	0.425	1013	5.560	1590	1858	59.8	51.3	4.1	6.6	AFHP R-5-2
0.217	0.579	0.421	1012	5.440	1598	1854	60.0	50.6	4.8	6.4	AFHP R-5-3
0.217	0.583	0.417	1013	5.460	1592	1862	59.7	51.0	4.4	6.5	AFHP R-5-4
0.218	0.591	0.409	1013	5.560	1544	1773	60.4	43.0	9.6	5.0	AFHP R-5-5
0.151	0.723	0.277	1012	7.020	1552	1933	55.2	50.8	0.0	9.3	AFHP R-6-1
0.151	0.717	0.283	1012	7.000	1576	1934	57.4	52.9	0.0	9.6	AFHP R-6-2
0.151	0.717	0.283	1012	6.980	1567	1938	58.6	54.2	0.0	9.8	AFHP R-6-3
0.151	0.720	0.280	1013	7.000	1566	1941	57.4	53.2	0.0	9.8	AFHP R-6-4
0.153	0.720	0.280	1012	6.920	1561	1945	60.1	56.1	0.0	10.2	AFHP R-6-5
0.154	0.724	0.276	1012	6.860	1568	1947	59.7	55.8	0.0	10.1	AFHP R-6-6
0.247	0.619	0.381	1017	7.920	1519	1778	58.4	45.2	5.0	5.1	AFHP R-7-1
0.245	0.601	0.399	1017	7.620	1633	1877	59.6	54.9	0.4	7.9	AFHP R-7-2
0.245	0.578	0.422	1016	7.080	1825	1935	64.5	62.3	0.0	17.4	AFHP R-7-3
0.244	0.577	0.423	1016	7.090	1828	1940	63.7	61.7	0.0	17.6	AFHP R-7-4
0.242	0.553	0.447	1017	6.740	2006	1974	66.6	66.0	0.0	25.6	AFHP R-7-5
0.254	0.568	0.432	1016	6.300	2038	1999	68.4	68.4	0.0	29.4	AFHP R-7-6
0.269	0.576	0.424	1012	2.420	1597	1766	51.3	31.8	8.8	4.6	AFHP R-8-1
0.267	0.577	0.423	1015	2.440	1597	1778	56.1	35.8	9.8	5.2	AFHP R-8-2
0.268	0.575	0.425	1014	2.450	1588	1762	60.1	38.1	11.3	5.1	AFHP R-8-3
0.270	0.561	0.439	1015	2.300	1671	1952	62.8	51.8	3.8	8.0	AFHP R-8-4
0.268	0.564	0.436	1015	2.310	1691	1952	64.0	52.9	3.8	8.1	AFHP R-8-5
0.172	0.709	0.291	1012	2.480	1488	1749	53.2	34.3	10.3	4.0	AFHP R-9-1
0.172	0.708	0.292	1013	2.450	1507	1787	53.4	35.7	9.7	4.2	AFHP R-9-2
0.171	0.703	0.297	1014	2.400	1537	1889	56.1	41.7	8.4	5.0	AFHP R-9-3
0.171	0.703	0.297	1013	2.420	1530	1863	54.7	39.9	8.3	4.7	AFHP R-9-4
0.173	0.697	0.303	1013	2.280	1609	2040	60.0	56.2	0.5	8.8	AFHP R-9-5
0.172	0.696	0.304	1013	2.280	1612	2037	58.3	54.4	0.6	8.5	AFHP R-9-6

TABLE 29
ROCKWELL DATA USED IN NONLINEAR MULTIPLE REGRESSION ANALYSIS
(Kentucky No. 9 hvAb Coal)
(Sheet 6 of 6)

Gas-to-Coal Ratio (moles/lb)	Inlet Mole Fractions		Pressure (psia)	Reactor Residence Time (s)	Temperatures (F)		Carbon Conversions (%)				Test
	Hydrogen	Steam			Mixed	Reactor Exit	Total	Gases	BTX	COx	
0.191	0.712	0.288	1013	2.420	1549	1841	55.9	39.3	9.5	4.4	AFHP R-10-1
0.191	0.714	0.286	1013	2.450	1532	1806	56.2	38.0	10.4	4.2	AFHP R-10-2
0.191	0.712	0.288	1014	2.420	1546	1849	53.9	37.7	9.2	4.2	AFHP R-10-3
0.192	0.713	0.287	1012	2.430	1532	1814	55.5	37.8	10.0	4.0	AFHP R-10-4
0.192	0.715	0.285	1011	2.440	1522	1796	54.7	36.6	10.1	4.0	AFHP R-10-5
0.194	0.715	0.285	1011	2.410	1527	1809	55.8	38.0	10.0	4.2	AFHP R-10-6
0.192	0.613	0.285	1012	2.150	1724	2044	57.5	53.7	0.4	9.8	AFHP R-11-1
0.192	0.610	0.289	1012	2.140	1735	2045	60.2	56.4	0.4	11.2	AFHP R-11-2
0.193	0.611	0.288	1012	2.140	1732	2047	61.2	57.4	0.4	11.7	AFHP R-11-3
0.194	0.614	0.285	1013	2.130	1724	2046	61.4	57.6	0.4	11.7	AFHP R-11-4

TABLE 30
RANGE OF ROCKWELL DATA BASE USED FOR AFHP/FHP REACTOR MODELING

Test Data Range				
Gas-to-coal ratio	0.1-0.6 lb.mole/lb			
Hydrogen mole fraction	0.53-0.96			
Steam mole fraction	0.04-0.47			
Total pressure	500-1500 psia			
Residence time	0.02-8 s			
Reactor exit temperature	1130-2050 °F			
Total carbon conversion	37-68%			
Carbon conversion to gases	10-68%			
Carbon conversion to BTX	0.0-13.8%			
Carbon conversion to CO _x	1.0-29.4%			
Number of Data Points				
Test Mode	Carbon Conversion			
	Total	Gases	BTX	CO _x
Hydroliquefaction	94	90	19	62
Hydrogasification	27	24	5	23
AFHP	59	59	59	59
Total	180	173	83	144

The overall percent of variation explained and the standard error of the various conversions for the correlation were determined as follows:

- Overall variation explained = 99.0%
- Overall standard error = 2.4% carbon conversion
- Standard error for total carbon conversion = 2.9%
- Standard error for carbon conversion to gases = 2.8%
- Standard error for carbon conversion to BTX = 1.5%
- Standard error for carbon conversion to CO_x = 0.9%

The above standard errors are within the expected uncertainty range of the measured carbon conversions. The model parameters together with their respective standard error obtained by the nonlinear regression analyses are presented in Table 31. The kinetic parameters for liquid decomposition and BTX hydrocracking indicate that these processes are kinetically controlled and that their activation energies are characteristic of hydrocarbon decomposition activation energies. A plot of calculated total carbon conversion versus experimental conversion is presented in Figure 40, while the calculated values of carbon conversion to gases, BTX, and CO_x are plotted in Figures 41 through 43.

The correlation equations can be used to calculate carbon conversions for presentation in graphical parametric forms. Shown in Figures 44 through 49 are calculated values of carbon conversion to hydrocarbon gases, CO_x , light/heavy oils, and BTX as functions of reactor exit temperature at total pressures of 500 and 1000 psia, residence times of 2 and 5 s, and reactor inlet-steam mole fractions of 0.05 and 0.45 for an inlet gas-to-coal ratio of 0.2 lb·mole/lb. For low steam concentrations, the total carbon conversion continues to increase as pressure increases for temperatures where the saturation rate is important. Almost all of this increase is the result of lower deposition, and very little of the increase is caused by heterogenous hydrogenation of the char. For high steam concentrations, the total carbon conversion increases similarly but at higher reactor exit temperatures; a much more significant increase occurs because of the importance of steam/char reactions.

The effects of residence time on conversions at a total pressure of 1000 psia and reactor inlet steam mole fractions of 0.05 and 0.45 are shown in Figures 50 and 51. At low steam concentrations, the production of CO_x is almost constant, and increases in the reactor exit temperature cause the liquids to decompose at earlier residence times and with less carbon deposition.

TABLE 31
ESTIMATES OF MODEL CORRELATION PARAMETERS

Parameter	Estimated Value for Parameter	Standard Error of Parameter
$\bar{E}$	49.26	± 1.18
σ_e	16.70	± 2.12
a_{LHG}	0.144	± 0.017
a_{PSHL}	0.110	± 0.027
a_{BTX}	0.020	± 0.014
a_{UHL}	0.340	± 0.020
a_{COX}	0.038	± 0.003
β	0.385	± 0.036
b_{PSHL}	27.1	± 4.7
E_{PSHL}	56.0	± 10.6
b_{UHL}	7.18	± 1.03
E_{UHL}	16.3	± 2.4
b_{BTX}	23.0	± 2.6
E_{BTX}	63.0	± 6.7
b_{CHAR}	14.0	± 3.9
E_{CHAR}	56.3	± 10.8
ρ_{CHAR}	1.09	± 0.28
ρ_{SH_2}	3.67	± 0.57
b_s	7.30	± 5.42
E_s	-9.58	± 9.47
ρ_{SH_2O}	1.09	± 0.45
b_o	51.3	± 15.8
E_o	175.7	± 51.9
ρ_{OH_2O}	8.12	± 1.73
b_d	18.6	± 3.3
E_d	-15.4	± 5.3
ρ_d	1.79	± 0.23

^aUnits: Kinetic rate - s^{-1}
 Activation energy - kcal/mole
 Pressure - atm
 Density - moles/cm³
 Gas-to-coal ratio - moles/g

Figure 40. Comparison of Calculated Model Correlation and Observed Experimental Total Carbon Conversion

Figure 41. Comparison of Calculated Model Correlation and Observed Experimental Carbon Conversion to Gases

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Figure 42. Comparison of Calculated Model Correlation and Observed Experimental Carbon Conversion to BTX

4273-27

Figure 43. Comparison of Calculated Model Correlation and Observed Experimental Carbon Conversion to CO_x

Figure 44. Effect of Temperature and Steam Concentration on Carbon Conversion at a Total Pressure of 500 psia and 2.0 s Residence Time

4273-36

Figure 45. Effect of Temperature and Steam Concentration on Carbon Conversion at a Total Pressure of 1000 psia and 2.0 s Residence Time

Figure 46. Effect of Temperature and Steam Concentration on Carbon Conversion at a Total Pressure of 1500 psia and 2.0 s Residence Time

Figure 47. Effect of Temperature and Steam Concentration on Carbon Conversion at a Total Pressure of 500 psia and 5.0 s Residence Time

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Figure 48. Effect of Temperature and Steam Concentration on Carbon Conversion at a Total Pressure of 1000 psia and 5.0 s Residence Time

Figure 49. Effect of Temperature and Steam Concentration on Carbon Conversion at a Total Pressure of 1500 psia and 5.0 s Residence Time

4273-41

Figure 50. Effect of Residence Time and Reactor Exit Temperature on Carbon Conversion at Low Steam Concentration

4273-43

Figure 51. Effect of Residence Time and Reactor Exit Temperature on Carbon Conversion at High Steam Concentration

For high steam concentrations and low temperatures, the carbon conversions are very similar to the low steam concentration conversions. However, at high steam concentrations and high reactor exit temperatures, the effects are strikingly different. Large amounts of CO_x are produced at very early residence times during the liquids decomposition time interval. Because this increase in CO_x production does not increase the total carbon conversion, the CO_x is being produced at the expense of CH_4 . At longer residence times, CO_x production continues, and the total carbon conversion increases simultaneously, indicating that the oxides are being produced by the heterogeneous steam/char reactions.

VII. CONCLUSIONS AND RECOMMENDATIONS

The Task VIII studies described in this report led to the following conclusions:

- 1) The test hardware and coal hydrogasification PDU performed well and in accordance with the designs prepared in Tasks VI and VII.
- 2) The PDU was successfully activated and operated over the following range of test conditions:
  - a) Reactor exit temperature 1775 to 2050°F
  - b) Residence time 2 to 8 s
  - c) Inlet gas-to-coal ratios 0.15 to 0.27 lb-mole/lb
  - d) Inlet steam-to-hydrogen mole ratios 0.15 to 0.86
  - e) Hydrogen-feed-gas CH₄ concentration 0 and 22 mole %

Eleven coal-fed reactor tests (19 test conditions) were conducted using Kentucky No. 9 hvAb coal at a reactor pressure of 1000 psig. The average test duration was 52 min, with an average coal throughput of 803 lb. All program test objectives were achieved.

- 3) A significant data base was established to verify the reactor chemistry associated with the Rockwell Advanced Flash Hydro-pyrolysis (AFHP) concept for the production of SNG from coal.
- 4) Excellent carbon, hydrogen, and ash accountabilities were achieved during the reactor tests. As-collected carbon, hydrogen, and ash recoveries averaged 98.2%, 105.4%, and 100.3%, respectively.
- 5) Overall carbon conversion and total carbon conversion to gases (i.e., CH₄, C₂H₆, CO, and CO₂) ranged from 53.4 to 68.4% and 35.0 to 68.4%, respectively. Both increased with increasing temperature, residence time, inlet steam concentration, and/or gas-to-coal ratio. The gas produced was primarily composed of CH₄, with 30.7 to 53.3% of the carbon having been converted to CH₄. Carbon conversion to CO_x (primarily CO) ranged from 3.5 to 29.4%.

- 6) Carbon conversion to liquids (C_6H_6 and non- C_6H_6 light oils) was strongly dependent on reactor temperature and, to a lesser extent, on residence time. Liquids production decreased with increasing reactor temperature and residence time, while steam concentration and gas-to-coal ratio had a negligible effect on the carbon conversion to liquids. Values of total liquid carbon conversion ranged from about 20% at 1775°F and 2-s residence time to zero at >1975°F and residence times >5 s. Carbon conversion to C_6H_6 ranged from 11.2 to 0.0% over this same range of test conditions. The liquids produced had the following characteristics:
- a) On average, the BTX steam-stripped from the PDU activated carbon bed was 97% C_6H_6 , 1.2% C_7H_8 , and 1.5% unidentified light ends. Average calorific value and carbon, hydrogen, sulfur, and nitrogen contents of the BTX were 29,325 Btu/lb, 91.6%, 7.84%, 0.55%, and 0.02%, respectively. The BTX produced can be upgraded to high-purity chemical grade quality using existing commercial hydrotreating technology.
  - b) Light oil recovered from the PDU system contained between 39 and 46% C_6H_6 . Average calorific value and carbon, hydrogen, sulfur, and nitrogen contents for this oil were 25,890 Btu/lb, 93.2%, 6.4%, 0.28%, and 0.15%, respectively.
- 7) The AFHP test data carbon conversion trends were both self-consistent and consistent with previous Rockwell hydroliquefaction and hydrogasification FHP data.
- 8) Significant steam/char/hydrocarbon reactions occurred in the reactor at the more severe AFHP operating conditions to produce CO. The effect of steam addition was most significant at the high-steam-concentration level (~45 mole %), long residence times, and high reactor exit temperatures.
- 9) CH_4 addition (22 mole % CH_4 in the hydrogen feed stream), with subsequent partial oxidation of the CH_4 to CO in the preburner assembly, did not significantly affect the reactor coal conversions and/or product composition.
- 10) Several important aspects of reactor performance were noted by comparing measured reactor exit compositions with partial equilibrium predictions:
- a) For most test conditions, CO_2 was in partial equilibrium with CO. The exception was a few test conditions with low reactor exit temperatures.

- b) CO concentrations were much lower than those based on partial equilibrium and measured CH₄ concentrations. Therefore, equilibrium is not restricting homogeneous steam/hydrocarbon reactions, and a large potential exists for further homogeneous CO production from CH₄.
- 11) Simultaneous high CO_x and C₆H₆ production does not appear to be feasible with Kentucky No. 9 hvAb coal. High CO_x production is favored by high reactor exit temperatures, high steam concentrations, and long residence times. High C₆H₆ production is favored by shorter residence times and lower reactor temperatures.
  - 12) Average overall hydrogen (93.5%), sulfur (82.4%), nitrogen (74.6%), and chlorine (67.4%) elemental conversions for the 11 reactor tests were higher than the average overall carbon conversion (59.3%). The hydrogen, sulfur, nitrogen, and chlorine elemental conversions increased slightly with increasing reactor exit temperature, but other test variables had little effect.
  - 13) Based on average composition and heating value, the char produced would appear to be a good feedstock for an oxygasifier to generate makeup hydrogen or for other conventional combustion power generation equipment to provide overall process power requirements.
  - 14) Using the data obtained during this program, Rockwell has expanded and significantly improved its correlation model describing the processes occurring during coal FHP. The resulting correlation provides an excellent tool for subsequent evaluations to determine the economic potential of the Rockwell coal hydrogasification process.
  - 15) Results of a process economic study being performed with private-sector industrial consortium funding are key to the direction of future work on the Rockwell coal hydrogasification process. Two plant design options are currently being evaluated: (1) a high-carbon-conversion, high-CO_x production case with zero liquids production and (2) a moderate carbon conversion, low-CO_x production case with maximum C₆H₆ coproduction.

The successful completion of the Task VIII test program leads to the following specific recommendations for further study and investigation of the Rockwell flash hydrogasification reactor concept for the production of SNG from coal:

- 1) Additional AFHP/FHP reactor testing with Kentucky No. 9 hvAb coal to expand the data base and optimize test conditions for specific product yields. This testing should include (1) replicate testing at selected commercial design point(s); (2) further definition of temperature, residence time, steam concentration, and gas-to-coal ratio effects; and (3) operation at lower reactor pressure.
- 2) Reactor testing with alternate coals having properties significantly different than Kentucky No. 9 hvAb.
- 3) Experimental definition of trace species concentration levels in the reactor effluent streams. For example, C_6H_5OH in the process waste water; thiophene in the C_6H_6 ; or COS, HCN, or CS_2 in the product-gas stream.
- 4) Waste heat recovery quench (recuperator) hardware performance testing. Demonstration of successful operation of an efficient waste heat recovery device is an important factor in maintaining high overall process thermal efficiency.
- 5) Injector scaling should be demonstrated with the use of larger single- and multi-element injectors.
- 6) Continued expansion and improvement of the AFHP/FHP correlation model. Additional test data obtained should be employed to expand and improve the existing correlation model.
- 7) Experimental char combustion characterization testing to demonstrate the suitability of the char produced for oxy-gasification and/or other process power requirements.
- 8) Commercial plant process design and economic studies should be continued and further refined to optimize the various process plant configurations.

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APPENDIX A

DATA ANALYSIS PROCEDURES

This appendix presents the data analysis procedures employed in the Advancement of Flash Hydrogasification Program. Included is a definition of the test system instrumentation and measurements, an outline of PDU operating procedures, a description of the sampling and chemical analyses, and how this information was used to characterize the performance of the reactor test system.

I. TEST SYSTEM MEASUREMENTS

A. SYSTEM PLUMBING AND INSTRUMENTATION

A plumbing and instrumentation diagram of the hydrogasification process development unit (PDU) system is presented in Figure A-1. Table A-1 lists the parameters monitored/recorded by subsystem, keyed to Figure A-1. In addition to the test system instrumentation noted in Figure A-1, Table A-1 also contains the following preburner/injector/reactor assembly parameters, which were monitored during each test:

- Preburner assembly coolant-water temperature (seven locations)
- Preburner assembly exit pressure
- Redundant (two) preburner assembly exit-gas temperatures
- Injector hot-gas inlet line wall temperatures (three locations)
- Reactor pressure (measured on injector face)
- Reactor tube-wall temperature (nine locations)
- Redundant (two) reactor exit-gas temperatures
- Reactor inlet-gas temperature

Installation of new process systems or modifications to existing systems that were performed to conduct the test program are noted in Figure A-1 by "bold" system lines. The CO system was not required because of efficient conversion of CH_4 to CO in the preburner assembly; consequently, its installation was not completed.

TABLE A-1
INSTRUMENTATION LIST FOR COAL HYDROGASIFICATION PDU TESTING
(Page 1 of 5)

DAS Sequence Number	Measured Parameter	Parameter Acronym
Main Hydrogen System (to H ₂ /CH ₄ /O ₂ Preburner)		
119	Hydrogen supply pressure	PHS
138	Hydrogen heater supply pressure	PHHS
139	Hydrogen heater venturi upstream pressure	PHHV
210	Hydrogen heater venturi upstream temperature	THHV
169	Hydrogen heater venturi differential pressure 1	DPHHV-1
170	Hydrogen heater venturi differential pressure 2	DPHHV-2
164	H ₂ /CH ₄ heater inlet pressure	PHHI
187	H ₂ /CH ₄ heater exit gas temperature	THHO
134	H ₂ /CH ₄ injection pressure	PHI
186	H ₂ /CH ₄ injection temperature	THI
Steam Generator Hydrogen System		
154	Venturi meter upstream pressure	PSGHV
209	Venturi meter upstream temperature	TSGHV
150	Venturi meter differential pressure	DPSGHV
128	Injection pressure	PSGHI
Hydrogen/Methane Heater System		
143	Heater hydrogen burner supply pressure	PHBS
144	Heater burner main valve pressure 1	PBM-1
141	Heater hydrogen igniter supply pressure	PHIS
201	Heater stack-gas temperature	TBS
202	Heater burner igniter temperature	THHI
214	Heater outlet tube wall temperature	THHTO
216	Heater housing outside wall temperature	THHW

TABLE A-1
INSTRUMENTATION LIST FOR COAL HYDROGASIFICATION PDU TESTING
(Page 2 of 5)

DAS Sequence Number	Measured Parameter	Parameter Acronym
Methane System		
146	Supply pressure	PMS
219	Heat exchanger outlet temperature	TMHEO
124	Venturi meter upstream pressure	PMV
220	Venturi meter upstream temperature	TMV
123	Venturi meter differential pressure	DPMV
Carbon Monoxide System		
122	Supply pressure	PCOS
121	Venturi meter upstream pressure	PCOV
221	Venturi meter upstream temperature	TCOV
120	Venturi meter differential pressure	DPCOV
127	Injection pressure	PCOI
Oxygen System (Preburner)		
118	Supply pressure	POS
140	Venturi meter upstream pressure	POV-PB
211	Venturi meter upstream temperature	TOV-PB
165	Venturi meter differential pressure	DPOV-PB
148	Injection pressure	POI-PB
Oxygen System (Main Burner)		
156	Venturi meter upstream pressure	POV-MB
222	Venturi meter upstream temperature	TOV-MB
126	Venturi meter differential pressure	DPOV-MB
158	Injection pressure	POI-MB

TABLE A-1
INSTRUMENTATION LIST FOR COAL HYDROGASIFICATION PDU TESTING
(Page 3 of 5)

DAS Sequence Number	Measured Parameter	Parameter Acronym
Coal Feeder System		
159	Nitrogen supply pressure	PNS
129	Feeder top pressurizing supply pressure	PCFV-T
130	Feeder bottom pressurizing supply pressure	PCFV-B
132	Feeder tank pressure	PCF
Water System (Hardware Coolant/Quench)		
145	Tank pressure	PWT
179	Injector coolant water flow rate	FICW
206	Injector coolant water inlet temperature	TICWI
207	Injector coolant water outlet temperature	TICWO
142	Injector coolant water outlet pressure	PICWO
180	Preburner coolant water flow rate	FPBCW
160	Preburner coolant water inlet pressure	PPBCWI
228	Preburner coolant water inlet temperature	TPBCWI
229	Preburner coolant water outlet temperature	TPBCWO
125	Preburner coolant water outlet pressure	PPBCWO
178	Water spray quench flow rate	FQW
Hot Water (Steam) System		
157	Tank pressure	PSGWT
181	Water flow rate	FSGW
223	Water injection temperature	TSGWI
161	Water injection pressure	PSGWI
Reactor Pressure Vessel and Product Recovery Systems		
136	Reactor pressure (measured on pressure vessel wall)	PR-1
204	Reactor pressure vessel external wall temperature 1	TRSW-1

TABLE A-1
INSTRUMENTATION LIST FOR COAL HYDROGASIFICATION PDU TESTING
(Page 4 of 5)

DAS Sequence No.	Measured Parameter	Parameter Acronym
215	Reactor pressure vessel external wall temperature 2	TRSW-2
212	Quench vessel external wall temperature	TQSW-1
217	Quench vessel exit-gas temperature 1	TQO-1
225	Quench vessel exit-gas temperature 2	TQO-2
149	Quench vessel exit-gas pressure	PQO
213	Char receiver external wall temperature	TCRW-1
133	Char receiver exit-gas pressure	PCVO
198	Char receiver exit-gas temperature	TCVO
224	Cyclone 1 inlet-gas temperature	TCI-1
131	Cyclone 2 inlet-gas pressure	PCI-1
152	Condenser inlet-gas pressure	PLOCI
226	Condenser inlet-gas temperature	TLOCI
208	Condenser coolant water outlet temperature	TWLOCO
153	Condenser exit-gas pressure	PLOCO
218	Condenser exit-gas temperature	TLOCO
155	Flash drum pressure	PLOFD
175	Oil/water decanter tank weight	WTLO
151	BTX adsorber inlet pressure	PAVI
205	Product gas venturi meter upstream temperature	TPGV
147	Product gas venturi meter upstream pressure	PPGV
166	Product gas venturi meter differential pressure 1	DPPGV-1
167	Product gas venturi meter differential pressure 2	DPPGV-2
Preburner/Injector/Reactor Assembly		
230	Preburner coolant water temperature - Position 1	TPBCW-1
231	Preburner coolant water temperature - Position 2	TPBCW-2
232	Preburner coolant water temperature - Position 3	TPBCW-3
233	Preburner coolant water temperature - Position 4	TPBCW-4

TABLE A-1
INSTRUMENTATION LIST FOR COAL HYDROGASIFICATION PDU TESTING
(Page 5 of 5)

DAS Sequence Number	Measured Parameter	Parameter Acronym
234	Preburner coolant water temperature - Position 5	TPBCW-5
235	Preburner coolant water temperature - Position 6	TPBCW-6
236	Preburner coolant water temperature - Position 7	TPBCW-7
135	Preburner assembly exit pressure	PPB
196	Preburner assembly exit-gas temperature 1	TPBEG-1
197	Preburner assembly exit-gas temperature 2	TPBEG-2
239	Injector hot-gas inlet line temperature - Location 0	THGIL-0
237	Injector hot-gas inlet line temperature - Location 1	THGIL-1
238	Injector hot-gas inlet line temperature - Location 2	THGIL-2
137	Reactor pressure (measured on injector face)	PR-2
188	Reactor wall temperature - Location 1	TRW-1
189	Reactor wall temperature - Location 2	TRW-2
190	Reactor wall temperature - Location 3	TRW-3
191	Reactor wall temperature - Location 4	TRW-4
192	Reactor wall temperature - Location 5	TRW-5
193	Reactor wall temperature - Location 6	TRW-6
194	Reactor wall temperature - Location 7	TRW-7
195	Reactor wall temperature - Location 8	TRW-8
185	Reactor wall temperature - Location 9	TRW-9
200	Reactor gas temperature (reactor exit)	TR-1
203	Reactor gas temperature (reactor exit)	TR-2
199	Reactor gas temperature (reactor inlet)	TR-3

B. DATA ACQUISITION SYSTEM

The data acquisition system (DAS) employed consisted of a Hewlett-Packard (HP) 1000 Model F central computer processing unit, a 20-M byte hard disc, two

Figure A-1. Plumbing and Instrumentation Schematic of Hydrogasification PDU

magnetic tape drives, three HP Model 2250 measurement and control units (MCUs), a 400-line/min printer, a printing terminal, four cathode ray tube (CRT) terminals, and a TV display monitor.

One of the MCUs was capable of accepting up to 352 analog signal inputs. The testing used approximately 125 channels. All channels were scanned 5 times/s with the average value stored on disc and tape. The disc could store up to 3.6 h of data, and each reel of tape could hold about 8 h of data.

Data acquired during a test could be displayed in several forms. The typical configuration was as follows:

- Forty parameters in tabular form at a CRT terminal
- Four trend graphs at a CRT terminal
- Call-up of any parameter at a CRT terminal
- Twenty-four parameters in tabular form at the TV monitor.

All displays were concurrent and updated every 3 s. Values calculated from one or more measured parameters were also displayed.

Alarm levels (both low and high) could be set for up to 40 parameters (including calculated values). If an alarm level was exceeded, a message would appear on the printing terminal indicating the time, the parameter name, and whether it was a low or high alarm. If the parameter was one of the 40 in the tabular display, the displayed value would be in inverse video.

Up to 19 measured parameters could be monitored for test shutdown ("CUT") conditions. These parameters were scanned by a second MCU at a rate of once every 40 ms. If a CUT level was exceeded, an additional scan is made to verify the reading. If both scans were above the CUT level, a relay output from the MCU would initiate test shutdown. Some interlock checks were also controlled by this MCU.

Following a test, measured and calculated values could be retrieved from either disc or tape. Data could be printed out for any or all channels in tabular form as a function of time. Data plots could also be obtained for up to five channels plotted as a function of time or another chosen parameter.

The data acquisition equipment and PDU control consoles and test parameter display setup for conducting the tests are presented in Figures A-2 and A-3.

C. PDU OPERATING PROCEDURES

A brief outline of PDU operating procedures is presented in this section, with specific consideration given to system startup, shutdown, and safety circuitry.

The startup procedure for each test was generally handled as follows:

- The system was pressurized to the desired operating pressure with hydrogen (or the hydrogen/methane mixture) flowing through the system.
- When the above flows and system pressures stabilized, the desired injector and preburner coolant water flows were established.
- The gas-fired heater was started and adjusted until the hydrogen/methane feed gas mixture injection temperature reached approximately 1100°F.
- The ambient temperature hydrogen flow to the preburner was then established.
- Preburner oxygen flow was then started and adjusted until the preburner exit temperature reached approximately 1500°F. Shortly after the reactor exit gas temperature reached approximately 800°F, the water spray quench flow was started and adjusted, as necessary, for the remainder of the test to maintain the quenched temperature near 800°F.

a. TAPE DRIVES, DISC DRIVE, DIGITAL CLOCK, CENTRAL PROCESSING UNIT, PRINTING TERMINAL, AND CRT TERMINAL

b. LINE PRINTER/PLOTTER, MEASUREMENT AND CONTROL UNITS, AND TAPE DRIVE

Figure A-2. Data Acquisition System Equipment

Figure A-3. PDU Control Console, Test Parameter TV Monitor, Digital Voltmeters (DVMS), and Terminals for Test Parameter Observation by Engineering

- The preburner hot water (approximately 200°F) flow for the steam generator section of the preburner was started. Its flow was adjusted in conjunction with the preburner oxygen flow to keep the preburner exit temperature in the approximate 1000 to 1500°F range until the desired O₂ and steam flow rates were obtained.
- Oxygen flow to the main injector was started and adjusted until the temperature of the gas injected into the reactor reached approximately 2000°F, the maximum safe operating temperature of the reactor tube. The injected gas mixture was then sampled with the on-line GC.
- Coal flow was initiated after the injected gas mixture was sampled. (The test was then officially under way.)
- If an injected gas temperature greater than 2000°F was required to obtain a specific reactor temperature with coal flow, the procedure was modified as follows. After the coal was turned on, additional predetermined oxygen flow (referred to as boost O₂) was introduced through the main injector to bring the reactor temperature to the desired level.

- System flows (H_2 , CH_4 , O_2 , CO , coolant water, H_2O for steam generation, etc.) and temperatures (preburner inlet and outlet, reactor wall and exit, quench, etc.) were monitored continuously and adjusted, as required.

Shutdown of each test was conducted as follows:

- The O_2 flow and then the coal flow to the injector were terminated.
- The O_2 flow to the preburner and then the H_2O flow for steam generation were terminated.
- The ambient temperature H_2 flow to the preburner and the CO flow were terminated.
- The spray quench flow and then the gas-fired heater were terminated.
- The hydrogen and methane flows were terminated.
- Hardware coolant water flow was terminated.

The system shutdown sequence was accomplished in a relatively short time. As part of the system startup and shutdown operations, nitrogen purge gas systems were employed to properly purge the various feed systems and the reactor on-line GC sample probe.

Safety circuits were incorporated into the PDU to protect the test hardware and facility from damage. These "cut" circuits included:

- A high cut on the oxygen system flow rates
- A high cut on the preburner outlet temperature
- A low cut on hardware coolant water flow rates
- A low cut on the hydrogen/methane flow rates
- A high-temperature cut on the outlet temperature of the gas-fired heater hydrogen/methane stream
- A high-temperature cut on the reactor exit and wall temperatures.

In addition to these simple high and/or low cut circuits, interlock safety circuitry was used to ensure that O_2 system flows could be initiated only if the hydrogen/methane stream was flowing and its temperature was above that required to ensure autoignition. A stand Firex system was provided to protect the system components and instrumentation and control wiring.

II. SAMPLING AND CHEMICAL ANALYSES

A. SAMPLING

The sampling and chemical analyses performed were designed to yield quantitative data on the performance of the reactor system. Sampling and chemical analyses are summarized in Table A-2. The sample numbers listed in the left column of the table are shown as sample location points in the accompanying facility schematic, Figure A-4. Chemical analyses were performed on all gaseous, liquid, and solid feed and effluent product streams. These streams included the preburner exit gas and feed coal as well as all gases, liquids, and solids downstream from the reactor. The chemical analytical data were used to calculate detailed material balances together with coal carbon conversions and coal elemental conversions.

B. CHEMICAL ANALYSES

Discussions of the chemical analysis procedures performed on the various gas, liquid, and solid samples are described below.

1. Condensed Phase Sample Analysis

The following condensed phase samples were collected from the various sample points shown in Figure A-4:

TABLE A-2

ADVANCED FHP PROGRAM: SAMPLING AND CHEMICAL ANALYSES
(Sheet 1 of 3)

Sample	Frequency	Analysis
1. Coal - Kentucky No. 9 hvAb (90% <200 mesh)	Material when received Each test	Moisture, carbon, hydrogen, and ash by Rockwell--each test Ultimate and proximate analysis by CTE ^a --each test Sieve analysis on two selected tests by Rockwell Free swelling index on two selected tests by CTE One of each of the above plus true bulk, and compacted density and ash fusion temperature on sample of material when received at Rockwell
2. Main char receiver (V-240) char	Each test	Moisture, carbon, hydrogen, and ash by Rockwell--each test. Ultimate and proximate analysis by CTE--each test Sieve analysis, true, bulk, and compacted density on two selected tests by Rockwell
3. Cyclone chars 1 and 2	Each test	Moisture, carbon, hydrogen, and ash by Rockwell--each test, each cyclone Sieve analysis, true, bulk, and compacted density on one selected test by Rockwell--each cyclone

^aCTE--Commercial Testing & Engineering (Lombard, Illinois)

TABLE A-2

ADVANCED FHP PROGRAM: SAMPLING AND CHEMICAL ANALYSES
(Sheet 2 of 3)

Sample	Frequency	Analysis
4. Injected gas--in reactor just downstream from injector	On preburner tests-- 5-min intervals Before coal flow on two reactor tests-- 5-min intervals	Gas chromatographic (GC) analysis for H ₂ , O ₂ , N ₂ , CO, CO ₂ , CH ₄ , C ₂ H ₄ , and C ₂ H ₆ plus H ₂ O (by difference) Analysis performed on-line
5. Product gas--just upstream from condenser	Periodically during preburner tests Reactor tests at 5-min intervals	Light gases as in sample 4 above plus BT (benzene and toluene) during reactor tests Analysis performed on-line GC BT analysis was employed in calculation of carbon conversion to BT
6. Product gas--between pressure letdown valves (downstream from BTX adsorber)	Total of approximately 12 bottles during preburner tests Six or 7 bottles per test for each reactor test	Light gases as in sample 4 above--each test C ₃ and C ₄ hydrocarbons--selected tests Analysis performed on gas sample bottles
7. Light oil	Each test Light oil collected on only three tests	Moisture, carbon, hydrogen, nitrogen, sulfur, and ash--each test Benzene and calorific value--each test
8. Stripped BTX	Each test (BTX produced on 7 of 11 tests)	Benzene, toluene, xylene (BTX), and thiophene--each test Moisture, carbon, hydrogen, nitrogen, sulfur, and calorific value--selected tests

TABLE A-2
ADVANCED FHP PROGRAM: SAMPLING AND CHEMICAL ANALYSES
(Sheet 3 of 3)

Sample	Frequency	Analysis
9. Decanted light-oil water	Each test	Total organic carbon and benzene--selected test Phenols--selected test
10. Decanted BTX/water	Each test	Same as sample 9 above
11. Product-gas stream	<u>Three</u> selected tests	For NH ₃ and H ₂ S (for conversion of nitrogen and sulfur to NH ₃ /H ₂ S)

<u>Sample Location</u>	<u>Sample Point</u>	<u>Type of Sample</u>
1	Loading feeder	Coal feed
2	Main char receiver	Char
3	Cyclone 1	Char
3	Cyclone 2	Char
7	Light-oil decanter	Oil phase
9	Light-oil decanter	Aqueous phase
8	BTX decanter	BTX
10	BTX decanter	Aqueous phase

Representative samples from sample locations 1, 2, 3, 7, and 8 were analyzed routinely. The chemical analysis schemes for these samples are shown in Figures A-5 through A-9. Samples from locations 9 and 10, the aqueous phases from the light-oil/water decanter and the BTX decanter, were taken for each test; however, the analyses (shown in Figure A-10) were performed on one selected test only. The condensed process stream samples can be divided into three types for the purposes of chemical analysis:

- Solid Samples. These were the feed coal and the products from the main char receiver and from the two cyclone receivers. Most of the chemical analysis procedures were American Society for Testing and Materials (ASTM) methods or modifications of these methods to handle the special physical or chemical properties of the AFHP samples.
- Oil Samples. These were the oil phases from the light-oil/water decanter and the BTX decanter. A large portion of the light-oil samples were one- and two-ring aromatic hydrocarbons such as C_6H_6 , C_7H_8 , C_8H_{10} , and $C_{10}H_8$; while C_6H_6 was the bulk (>95%) of the BTX samples.
- Aqueous Phase Samples. These were the aqueous phases collected in the light-oil/water decanter and in the BTX decanter after steam-stripping the BTX adsorber bed. Chemical analyses were performed to determine whether significant amounts of hydrocarbons were either dissolved or dispersed in the aqueous phase.

The chemical analysis procedures used for the solid and liquid samples are presented below. The discussion gives the ASTM method numbers (where applicable) and briefly describes the techniques. Chemical analyses were performed on the solid samples after water was removed or until the water

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Figure A-5. Analysis of Coal Samples

4273-45

Figure A-6. Analysis of Main Char Receiver (V-240) Char Samples

4273-46

Figure A-7. Analysis of Cyclone Char Samples

4273-47

Figure. A-8. Analysis of Oil Phase from Light-Oil/Water Decanter

4273-48

Figure A-9. Analysis of BTX from BTX Decanter

4273-49

Figure A-10. Analysis of Aqueous Phases

content had been lowered to below 5%. The water content of the light oil was reduced by high-speed centrifuging before chemical analyses were performed. Analyses on the aqueous samples were conducted after any second phase had been removed.

a. Coal and Char Samples

(1) Determination of Moisture--ASTM D-3173

Moisture was determined by establishing the loss in weight of the sample at 107°C under rigidly controlled conditions of time, atmosphere, sample weight, and equipment. If the moisture content was over 5%, a large sample was dried in a forced-air oven at 15°F above room temperature. This sample was then used for the subsequent chemical analyses. The moisture analysis was reported to provide data for converting the analytical results to a dry basis.

(2) Determination of Carbon-Hydrogen--ASTM D-3178

The determination was made by burning a weighed quantity in a closed system and fixing the combustion products (H_2O and CO_2) in an absorption train after complete oxidation and purification from interfering substances.

(3) Determination of Ash--ASTM D-3174

Ash was determined by weighing the residue remaining after the coal was burned under rigidly controlled conditions of sample weight, temperature (750°C), and time.

(4) Sieve Analysis--ASTM D-197 ("Fineness Test of Pulverized Coal")

This analysis yields the size distribution of the pulverized coal by separating the particle sizes retained on 16-, 30-, 50-, 100-, 200-, 325-, and 400-mesh screens. As shown in Figures A-6 and A-7, the main char or cyclone char samples were analyzed before the sample was ground to pass a 20-mesh screen.

(5) True Density

This analysis was similar to that described in ASTM D-167 in the section "True Specific Gravity of Coke." Before analysis, the sample was ground to pass a 30-mesh screen. A 10-g portion of the sample that had been dried at 105°C was weighed in a specific gravity bottle (100-ml volumetric flask) with a sufficient quantity of distilled water to fill the bottle half full. The water was brought to a boil on a hot plate to displace all air from the surface of the coal (or char) particles. The bottle was cooled to room temperature and filled to the mark with distilled water. Through a series of weighings, the weight of dry sample and the volume of water it displaced were determined. True density equaled the weight per unit volume at room temperature (g/ml at 20°C).

(6) Bulk Density--ASTM D-2854 ("Apparent Density of Activated Carbon")

This procedure allowed the coal or char to free-fall into a 100-ml graduated cylinder until the sample was at the 100-ml mark. The density was calculated from the weight of sample and the apparent volume.

(7) Compacted Density--Adapted from ASTM D-3101

This analysis consisted of determining the bulk density and then tapping the graduated cylinder at a fixed frequency and amplitude with a blunt object until no further compaction occurred. The density was calculated from the weight of the sample and the compacted volume.

(8) Free Swelling Index--ASTM D-720

This small-scale test involved placing a 1-g sample into a cold crucible and then lowering the crucible at a specific rate into a furnace to bring the temperature to 820°C in a prescribed period. The crucible was cooled, and the resulting coke button was compared in size and shape to a set of standard profiles to yield information on the swelling properties of the coal.

(9) Fusibility of Coal--ASTM D-1857

This method involved observing the temperatures at which triangular pyramids (cones) prepared from coal ash attain and pass through certain stages of fusing and flow when heated at a specified rate in controlled reducing atmospheres.

(10) Ultimate Analysis of Coal--ASTM D-3176

Ultimate analysis as applied to coal included determining the carbon, hydrogen, sulfur, nitrogen, and ash content of the material and then calculating the oxygen content by difference. The sulfur determination was made by ASTM D-3177, and the nitrogen determination was made by ASTM D-3179.

(11) Proximate Analysis of Coal--ASTM D-3172

Proximate analysis as applied to coal consisted of determining moisture, volatile matter, ash, and fixed carbon. The volatile matter in coal was determined by ASTM D-3175. This latter procedure involved determining the percentage of gaseous products, exclusive of moisture, in the sample that was released under specific conditions of temperature. A 1-g sample in a covered platinum crucible was lowered into a furnace at 950°C for a prescribed period. The percentage loss was the volatile matter. The fixed carbon was obtained by subtracting the sum of the percentages of moisture, ash, and volatile matter from 100.

(12) Calorific Value--ASTM D-3286

Calorific value was determined by burning a weighed sample in oxygen in a calibrated isothermal-jacket bomb calorimeter. The calorimeter was standardized by burning benzoic acid. The calorific value was computed from temperature observations made before and after combustion and after allowing for heat contributed by other processes.

b. Light Oil and BTX Samples

(1) Determination of Weight of Dry Oil--ASTM D-95

In this analysis, a 20- to 50-g sample of the crude oil was distilled with 150 ml of C_8H_{10} . The water co-distilled with the C_8H_{10} was measured volumetrically. The weight of the dry oil was calculated from the weight percent of water. The BTX samples were analyzed for water by a Karl Fischer titration.

(2) Workup for Removal of Water and Solids (for oil phase only)

Approximately 100 ml of oil was centrifuged at 15,000 rpm for approximately 1 h. A center cut of the oil portion was then removed, leaving the solids and water as residue. This sample of "clean" oil was used for the subsequent chemical analyses shown in Figure A-8.

(3) Determination of Carbon and Hydrogen

This analysis was performed using a Coleman C&H semi-micro analyzer. A weighed sample was combusted in a stream of oxygen. The resulting H_2O and CO_2 were sequentially absorbed and weighed to determine the hydrogen and carbon contents, respectively.

(4) Determination of Sulfur--ASTM D-3177

This analysis, originally used for determining the total sulfur in coal and coke, was modified by instructions from Parr Instrument Co. for volatile samples. A 1-g sample was injected by syringe into a stainless-steel sample cup covered with "3M" sulfur-free type 810 magic transparent tape. The sample was then combusted in a Parr bomb, and the sulfur determined from the washings as a barium sulfate precipitate.

(5) Determination of Nitrogen

Nitrogen was determined by the Kjeldahl method. The sample was decomposed and the nitrogen fixed as ammonium sulfate by boiling with sulfuric acid. The nitrogen was then determined by boiling with sodium hydroxide, absorbing the liberated ammonia vapors in boric acid solution and titrating with a standard acid.

(6) Chromatographic Analysis of BTX

The BTX was analyzed by gas chromatography (GC). The following GC instrumentation and associated parameters were used for the analysis:

- Column 6 ft x 1/8 in. OD stainless steel
5% SP 1200/1.75% Bentone 34 on 80/100 Supelcoport
- Carrier He at 20 cm³/min
- Column temperature Isothermal, 80°C for 2 min
12°C/min up to 105°C
105°C for 10 min
- Calibration External standardization for C₆H₆, C₄H₄S,
C₇H₈, C₈H₁₀, and C₁₀H₈
- Compound identification Comparison of retention times with known compounds
- Sample preparation 1.0 ml sample to 50.0 ml with Freon TF
- Sample size 0.5 µl

The "light ends" were quantified by running isothermally at 105°C and injecting an undiluted sample.

(7) Benzene Content of Light Oil

Benzene was determined in the light oil by GC. The column, carrier, and column temperatures were the same as for the BTX (Item 6). Calibration was performed by internal standardization using P-C₈H₁₀ as the internal standard.

(8) Calorific Value--ASTM D-240

This method for determining the heat of combustion of liquid and hydrocarbon fuels was similar to the one used for the coal and char samples.

(9) Determination of Ash

Approximately 50 to 75 g of sample was transferred to a tared evaporating dish and weighed. The sample was evaporated to near dryness in a drying oven at 105°C under a nitrogen purge and then transferred to a muffle furnace where the temperature was increased slowly in 100°C increments to 750°C. The combustion was completed at 750°C to a constant weight of ash.

c. Aqueous Phase Samples

(1) Determination of Benzene

Benzene was determined by extracting a portion of the sample with pentane, followed by gas chromatography of the extract for C_6H_6 content. A C_6H_6 standard was prepared by dissolving a stock solution of C_6H_6 in methanol in water at levels comparable to the solubility of C_6H_6 in water. Quantification was made by comparing C_6H_6 peak heights of the samples to the standard.

(2) Determination of Total Organic Carbon

This analysis was performed on an Oceanography International Model 0524B total carbon analyzer. The instrument was standardized with a known carbon-containing primary standard, such as potassium acid phthalate. The samples were injected with a microliter syringe onto a hot nichrome wire in an oxygen atmosphere to combust carbon to CO_2 . The CO_2 was measured with a non-dispersive infrared detector.

(3) Determination of Phenols--EPA Method 420.3

This analysis was performed on a spectrophotometer based on the reaction of steam-distillable phenolic (C_6H_5OH) compounds with MBTH (3-methyl-2-benzothiazolinone hydrazone hydrochloride). The absorbance was measured at 490 nm. The concentration in the sample was expressed in terms of milligrams per liter of C_6H_5OH .

2. Gas Phase Sample Analysis

The following gas phase samples were collected from the various sample points shown in Figure A-4 and then analyzed:

<u>Sample Location</u>	<u>Sample Point</u>	<u>Type of Sample</u>
4	Just downstream from the injector	Hot gas from preburner analyzed on-line
5	Between cyclone 2 and condenser	Hot gas analyzed on-line
6	Just downstream from BTX adsorber	Gas sample bottles
11	Between cyclone 2 and condenser	Ammonia scrubbed into aqueous solution
11	Between cyclone 2 and condenser	Hydrogen sulfide scrubbed into aqueous solution

Because samples 4 and 5 were analyzed immediately on-line as they were "collected," the sample collection and analysis schemes are presented together below. Discussion of the ammonia and hydrogen sulfide samples is also combined, since these samples were obtained at the same sample point and through the same sampling system.

a. On-Line Gas Analysis

On-line GC sampling allows direct analysis for $\text{Ar}(\text{O}_2)$, H_2 , CO_2 , CH_4 , C_2H_4 , C_2H_6 , N_2 , CO , C_6H_6 , and $\text{C}_6\text{H}_5\text{CH}_3$ in the gas phase every 5 min. Sample valves were remotely actuated to sample either at sample point 4 (directly downstream from the injector face), or at sample point 5 (upstream from the condenser). A flow diagram of the GC and associated sampling systems is shown in Figure A-11, while the chromatographic columns and associated parameters are listed in Table A-3. The GC was located in a building adjacent to the test stand approximately 50 ft from either of the two sampling points.

Referring to Figure A-11, approximately 0.1% of the process stream was diverted through one of two Balston coalescing filters (1). An orifice (2) reduced the pressure to approximately 100 psi and a flow of approximately 50 standard liters/min. The sample flowed through a heated, 1/4-in. stainless-steel line (350°F) into the GC building and was then routed into a 140°C oven (No. 1) containing parallel coalescing filters under GC unit B. A main bypass line (7) equipped with a backpressure regulator (10) maintained line pressure below 120 psi. After leaving the set of coalescing filters, the gas sample entered oven No. 2 (140°C) under GC unit A, where a small portion was filtered and regulated down to 10 psi. The remainder of the gas exited through the second bypass line through valve 29.

The small 10-psi sample was split into three streams. The first entered GC unit A and was analyzed for H_2 only (see Table A-3, H_2 analyzer). The second stream entered unit A and was analyzed for Ar , CH_4 , CO_2 , C_2H_4 , C_2H_6 , N_2 , and CO . The third stream entered GC unit B and was analyzed for C_6H_6 and C_7H_8 .

TABLE A-3
GAS CHROMATOGRAPH TABLE

	GC Unit A		GC Unit B
Instrument	Daniels Ind. H-1000		Daniels Ind. H-1000
Measured output	Peak height		Peak height
Analysis frequency	5 min		5 min
	H ₂ analyzer	Light gas analyzer	C ₆ H ₆ -C ₇ H ₈ analyzer
Carrier gas	N ₂	He	He
Detector	Thermal conductivity	Thermal conductivity	Thermal conductivity
Automatic valve	Gas sampling with backflush	Gas sampling with backflush	Gas sampling with backflush
Columns used	Porapak T (backflush H ₂ O) Porapak Q: H ₂	Porapak T (backflush H ₂ O C ₃ , and up) Porapak Q: CO ₂ , C ₂ H ₄ , and C ₂ H ₆ Molecular sieve 5A: Ar, N ₂ , CO, and CH ₄	Carbowax 20M (backflush H ₂ O and heavies) ² TCEP: C ₆ H ₆ and C ₇ H ₈

b. On-Line Determination of H₂S and NH₃

As shown in Figure A-11, the sample line was tapped off before valve 29 and routed through aqueous scrubbers to determine H₂S and NH₃ concentrations. The single sample line was split into two parallel lines, one for each analysis. Each leg of the parallel split consisted of two 250-ml glass scrubbers, a front and back, and a wet-test meter. Sample gas was flowed at between 3 and 4 liters/min for the duration of the test. The H₂S scrubbers contained 150 ml of 0.1-N NaOH solution, while the NH₃ scrubber contained 150 ml of 0.1-N H₂SO₄. The H₂S and NH₃ scrubber solutions were refrigerated between sampling and analysis.

The NH_3 scrubber was analyzed by Kjeldahl distillation. A 100-ml aliquot was taken and introduced into the Kjeldahl flask. Excess 50% sodium hydroxide was added, and the mixture was distilled for 15 min into a receiver containing 50 ml of 0.1% boric acid with a mixed methyl red-methylene blue indicator. The receiver was back-titrated with 0.1-N HCl.

The H_2S scrubber was analyzed by a gravimetric BaSO_4 method. The sulfide was oxidized with bromine to sulfate, followed by precipitation of BaSO_4 with BaCl_2 solution.

The concentrations obtained for NH_3 and H_2S were corrected to standard temperature and pressure on a dry basis and were reported as parts per million in the dry sample stream.

c. Bottle Analyses

Gas samples taken downstream from the condenser and the pressure letdown valve were analyzed for all light-gas species determined by the on-line monitor as well as for the C_3 hydrocarbons that were in the vapor state at the process stream sampling point. The main difference between the on-line sample and the gas bottle sample was the absence of large amounts of water vapor in the gas bottles. Table A-4 lists the chromatographic columns, column arrangements, and other parameters used to carry out the gas bottle analyses.

The analysis was performed in two steps. The sample was first introduced onto column A to determine CO_2 , $\text{C}_2'\text{S}$, and $\text{C}_3'\text{S}$. A second sample was then introduced onto column B to determine N_2 , CH_4 , and CO .

TABLE A-4
GAS BOTTLE ANALYSES

Source	6 to 12 flow-through bottles, downstream from condenser
Instrument	Hewlett-Packard Model 5840
Detector	Dual thermal conductivity
Carrier gas	Helium
Sample preparation	Stainless-steel vacuum manifold with Wallace & Tiernan gauge (0 to 1500 mm Hg)
Sample introduction	Two 0.5 cm ³ loops on two 10-port gas sampling valves.
Columns	A 9-ft Porapak N: separates CO ₂ , C ₂ H ₄ , C ₂ H ₂ , C ₂ H ₆ , H ₂ O, C ₃ H ₆ (C ₃ H ₈), C ₄ , and C ₅ .
	B 11-ft molecular sieve 5Å: separates H ₂ , O ₂ (Ar), N ₂ , CH ₄ , and CO
Data acquisition	Integrated peaks measured against external standard (H ₂ by difference)

III. REACTOR TEST SYSTEM PERFORMANCE

This section describes the detailed methods by which system flow rates, conversions, process parameters, and material balances were determined. The raw test system data were used in conjunction with the detailed chemical analyses to define the performance of the AFHP reactor system.

A. FLOW-RATE MEASUREMENTS

1. Gas Flow Rates

Flow rates of reactant and product gases must be accurately determined to evaluate reactor performance. Accordingly, the flow rates of these gases were determined by using Herschel-type venturi meters calibrated to National Bureau

of Standards (NBS) traceable standards by an independent calibration laboratory. The flow rates were measured in the subsonic regime by determining the upstream pressure, the pressure drop across the venturi, and the upstream temperature, and then applying the following mass flow rate equation:

$$W = CYA_2 \left[\frac{2g_c(P_1 - P_2)\rho_1}{1 - B^4} \right]^{1/2},$$

where

W = mass flow rate (lb/s)

C = discharge coefficient

Y = expansion factor (see below)

A_2 = cross-sectional area of throat (ft²)

g_c = dimensional constant, 32.17 (lbm·ft/lbf·s²)

ρ_1 = density at upstream pressure and temperature (lb/ft³)

P_1, P_2 = pressure at upstream and downstream static pressure taps, respectively (lbf/ft²)

B = ratio of throat diameter to pipe diameter.

The expansion factor Y is given by:

$$Y = \left[r^{2/k} \left(\frac{k}{k-1} \right) \left(\frac{1 - r^{(k-1)/k}}{1 - r} \right) \left(\frac{1 - B^4}{1 - B^4 r^{2/k}} \right) \right]^{1/2}$$

where r is the pressure ratio, P_2/P_1 . The expansion factor Y allows for the change in gas density as it expands adiabatically from P_1 to P_2 . To determine Y required evaluating k , defined as the ratio of molar heat capacities (C_p/C_v). For the pure inlet gases, the k 's were known; for the mixed gases, a k_{mix} was calculated based on the measured composition of the gases. The values of ρ_1 were computed by taking into account the gas compressibility factor for the particular gas being metered.

The discharge coefficient was determined from calibration curves relating C to the Reynolds number (N_{Re}) at the venturi throat. These curves, generated by an independent laboratory, were traceable to NBS standards. An iterative approach was used to determine the discharge coefficient C by first assuming a value of unity. A corresponding gas flow and Reynolds number were calculated, from which a new value of C was determined by using the calibration curves. This process was repeated several times until it converged on a final value for C .

All nitrogen purge flow rates were measured by sonic orifices.

2. Coal Flow Rate

To obtain product conversions required knowing the flow rate of coal fed to the reactor. This latter determination was made gravimetrically by initially weighing the amount (M) of coal loaded into the coal feed tank and then weighing the remaining feedstock unloaded from this tank following a test. By recording the elapsed time (t) of coal flow, the average coal flow rate (W) could be calculated from

$$W_{\text{coal}} = \frac{M_{\text{coal in}} - M_{\text{coal out}}}{t_{\text{coal flow}}} \text{ (lb/s) } .$$

For steady-state operation in which the reactor and coal feed tank pressures were constant, this was also an accurate measure of the instantaneous coal flow rate.

3. Water Flow Rates

The flow rates of injector coolant water, preburner coolant water, quench water, and injected steam generator water were all measured by turbine flowmeters. The raw electrical signals generated by these meters were converted directly in the data acquisition system (DAS) to units of gallons per minute or pounds per hour. The meters were calibrated before the start of the test program.

B. CONVERSIONS

1. Overall Elemental

The calculation of overall coal elemental conversions (n_i) was based on an "ash tracer method." This approach is essentially an ash balance, in which it is assumed that the coal ash is inert and that all of the ash ends up in the char. By this reasoning:

$$\begin{aligned} n_i &= \text{overall fraction of element } i \\ &\quad \text{converted to nonchar components} \\ &= [1 - (\text{fraction of element } i \text{ in char})] \\ &= \left[1 - \frac{(M_{\text{char}})(X_i)_{\text{char}}}{(M_{\text{coal}})(X_i)_{\text{coal}}} \right] \\ &= \left[1 - \frac{(X_a)_{\text{coal}}(X_i)_{\text{char}}}{(X_a)_{\text{char}}(X_i)_{\text{coal}}} \right], \end{aligned}$$

where

M = mass (lb)

X_i = fraction of component i (carbon, hydrogen, sulfur, nitrogen, or chlorine) in coal fed or char produced

X_a = fraction of ash in coal fed or char produced.

2. Carbon to Various Products

Carbon conversion to each product is defined as the flow rate of carbon in that particular product exiting the reactor divided by the flow rate of the carbon contained within the feedstock (coal) fed to the reactor. The denominator of this ratio is the product of the feedstock flow rate and the mass fraction of carbon in the feedstock. Correspondingly, the numerator is equal to the mass flow rate of the particular product for which the conversion is being calculated times the mass fraction of carbon in that product. Thus, the mass flow rate of the individual products exiting the reactor required determination.

a. Gaseous Products

The gaseous product mass flow rate was determined by using a product gas venturi in conjunction with sampling and GC analysis of the product gas stream near the venturi meter. Carbon conversions for the gaseous species CH_4 , C_2H_6 , CO , and CO_2 were calculated as follows:

$$C_i = \frac{Y_i N (\text{mw}_i) X_{C_i}}{W_{\text{coal}} X_{C_{\text{coal}}}}$$

where

- C_i = fraction of carbon converted to component i
- Y_i = mole fraction of i^{th} component in product gas stream
- N = total molar product gas flow rate
- mw_i = molecular weight of i^{th} component
- X_{C_i} = mass fraction of carbon in i^{th} component
- W_{coal} = mass flow rate of coal fed to the reactor
- $X_{C_{\text{coal}}}$ = mass fraction of carbon in the coal feedstock as fed.

b. Benzene and Toluene

Benzene and C_7H_8 conversions were calculated based upon on-line GC analysis of the product gas stream upstream from the light-oil condenser. Note that this analysis was made before removal of the BT components from the product gas stream. From the on-line GC analysis, the ratios of C_6H_6 and C_7H_8 to CH_4 were determined. From these ratios and the product gas flow rate and composition at the product gas venturi, the C_6H_6 and C_7H_8 conversions were calculated as follows:

$$C_{\text{C}_6\text{H}_6} = \frac{(y_{\text{C}_6\text{H}_6} / y_{\text{CH}_4}) y_{\text{CH}_4} N (\text{mw}_{\text{C}_6\text{H}_6}) X_{\text{C}_{\text{C}_6\text{H}_6}}}{W_{\text{coal}} X_{C_{\text{coal}}}}$$

where

$$\begin{aligned}
 C_{C_6H_6} &= \text{fraction of carbon converted to } C_6H_6 \\
 (y_{C_6H_6} / y_{CH_4}) &= \text{molar ratio of } C_6H_6 \text{ to } CH \text{ from on-line GC} \\
 y_{CH_4} &= \text{mole fraction of } CH_4 \text{ in product gas stream} \\
 N &= \text{total molar product gas flow rate} \\
 mw_{C_6H_6} &= \text{molecular weight of } C_6H_6 \\
 x_{C_6H_6} &= \text{mass fraction of carbon in } C_6H_6.
 \end{aligned}$$

Substitution of C_7H_8 values for C_6H_6 values in the above equation results in the corresponding C_7H_8 conversion values.

c. Non-BT (Benzene-Toluene) Liquids

The coal carbon conversion to non-BT (benzene-toluene) liquids (C_l) was determined by difference (i.e., overall conversion minus conversion to gases plus BT). This approach has been shown to be justified in previous FHP coal and oil shale liquefaction test programs conducted on the PDU. High liquid collection efficiency in PDU testing has generally been difficult to attain for tests such as those conducted during this program in which test durations were limited and carbon conversion to liquids was relatively low.

3. Nitrogen to Ammonia and Sulfur to Hydrogen Sulfide

Conversions of nitrogen to NH_3 and sulfur to H_2S were determined for several tests. Concentrations of NH_3 and H_2S in the product gas stream were measured as described above (Section II.B). Similar to the calculation procedure for C_6H_6 and C_7H_8 carbon conversions, ratios of these components to CH_4 were used to relate the measured product gas stream NH_3 and

H₂S concentrations to nitrogen and sulfur conversions. Thus, the NH₃ and H₂S conversions were calculated as follows:

$$C_i = \frac{(y_i / y_{CH_4}) y_{CH_4} N (mw_i) X_i}{W_{coal} X_{i, coal}},$$

where

C_i = fraction of component i (N or S) converted to NH₃ or H₂S

(y_i / y_{CH_4}) = molar ratio of i (NH₃ or H₂S) to CH₄ at measurement location

y_{CH_4} = mole fraction of CH₄ in product gas stream

N = total molar product gas flow rate

mw_i = molecular weight of i (NH₃ or H₂S)

X_i = mass fraction of N in NH₃ or S in H₂S

W_{coal} = mass flow rate of coal

$X_{i, coal}$ = mass fraction i (N or S) in coal.

4. Methane Addition and Preburner Characterization Tests

In general, carbon conversions were based only on the carbon entering the reactor in the coal feedstock. However, during test R-11, carbon also entered the reactor with the CH₄ added to the inlet H₂ gas. Thus, a portion of the carbon in the product gas stream was from the CH₄ feed and not from the coal. The method of calculating the total coal carbon conversion to gaseous species for this test was therefore modified as follows:

$$C_{T, gas} = \frac{N \left[\sum_{i=1}^j Y_i (mw_i) X_{C, i} \right] - W_{CH_4} X_{C, CH_4}}{W_{coal} X_{C, coal}},$$

where

$C_{T \text{ gas}}$ = total coal carbon conversion to gaseous species

N = total molar product gas flow rate

Y_i = mole fraction of i^{th} component in product gas stream

mw_i = molecular weight of i^{th} component

X_{C_i} = mass fraction of carbon in i^{th} component

w_{CH_4} = mass flow rate of CH_4 feed stream

$X_{C_{CH_4}}$ = mass fraction of carbon in CH_4 feed stream.

The carbon entering the reactor with the CH_4 stream is assumed to remain in the gas phase and is subtracted from the total calculated flow of carbon in the product gas.

Coal carbon conversion to individual gas species was calculated by replacing the numerator in the preceding equation with the following:

$$\left\{ N \left[y_i (mw_i) X_{C_i} \right] \right\}_{\text{coal flow}} - \left\{ N \left[y_i (mw_i) X_{C_i} \right] \right\}_{\text{prior to coal flow}},$$

where the carbon in the product gas as the gas species before coal flow is subtracted from the total with coal flow. Flow measurements were taken before the start of coal flow to provide the data required to make these calculations. The CH_4 feed stream was flowing before coal flow.

During preburner operation with CH_4 feed and no coal flow, conversions to CO , CO_2 , etc., were calculated from exit-gas compositions using the following equation:

$$C_i = \frac{y_i n_i}{\sum_{i=1}^j y_i n_i},$$

where

C_i = conversion to i^{th} component

y_i = mole fraction of i^{th} component in product gas

n_i = subscript for carbon in molecular formula (e.g., $n = 2$ for C_2H_6).

C. PROCESS PARAMETERS

In addition to the calculation of system product conversions, several key process parameters were determined. The preburner exit gas temperature ($T_{\text{PB-EXIT}}$) was calculated by an enthalpy balance in which the total enthalpy of the incoming gas streams of hydrogen, oxygen, and CH_4 less heat losses to the preburner coolant water is equated to the total enthalpy of the exiting gas stream. Heat losses to the coolant water were calculated as the product of the coolant water flow rate, temperature rise, and heat capacity. The total enthalpy balance is given as:

$$(H_{\text{gas}})_{\text{in}} - \Delta H_{(H_2O)_{\text{coolant}}} = (H_{\text{gas}})_{\text{out}}$$

or

$$\sum_{i=1}^3 W_i H_i - \left[W_{(H_2O)_{\text{coolant}}} (TICWO - TICWI) C_p \right] = \sum_{j=1}^4 W_j H_j,$$

where

i = inlet stream nomenclature--H₂, O₂, CH₄

j = outlet stream nomenclature--H₂, H₂O(g), CO, CH₄

W = mass flow rate of respective streams

H = enthalpy of respective components

TICWO = temperature preburner coolant water out

TICWI = temperature preburner coolant water in.

The preburner exit gas temperature was calculated by an iterative method with the solution converging on the temperature that satisfied the enthalpy balance of the preceding equation.

In the steam generator section of the preburner assembly, liquid water was injected for steam generation; in addition, the capability for supplemental hydrogen injection existed. The steam generator exit gas temperature ($T_{SG-exit}$) was calculated by a similar enthalpy balance.

Finally, oxygen was injected into the main burner; the temperature of the hot gas exiting the main burner is referred to as the main burner exit- or injection-gas temperature ($T_{inj-gas}$). An enthalpy balance was also used to calculate the injection-gas temperature.

With $T_{inj-gas}$ calculated, a reactor mixed temperature (T_{mix}) could be determined, defined as the temperature at which the coal and hot injection gases reach thermal equilibrium, disregarding heats of reaction and thermal losses from the reactor.

Again, an enthalpy balance using an iterative solution technique enabled T_{mix} to be determined:

$$\Delta H_{coal} = - \Delta H_{inj-gas}$$

$$W_{\text{coal}} C_{p_{\text{coal}}} (T_{\text{mix}} - T_{\text{coal}_{\text{inj}}}) = H_{\text{mix-gas}} - H_{\text{inj-gas}}$$

$$W_{\text{coal}} C_{p_{\text{coal}}} (T_{\text{mix}} - T_{\text{coal}_{\text{inj}}}) = \sum_{i=1}^j W_i H_{i_{\text{mix-gas}}} - \sum_{i=1}^j W_i H_{i_{\text{inj-gas}}}$$

Another important process parameter used in reactor performance correlations is reactor residence time (t_{res}) given by:

$$t_{\text{res}} = \frac{V}{Q} = \frac{V\rho}{W},$$

where

V = reactor volume from injector face to quench plane

Q = volumetric flow rate of gas through reactor

ρ = density of products through reactor

W = mass flow rate of gas through reactor.

Assuming an ideal gas law in which

$$\rho = \frac{P(\text{mw})}{RT},$$

the equation for residence time becomes:

$$t_{\text{res}} = \frac{VP(\text{mw})}{RWT},$$

where

P = reactor pressure

mw = molecular weight of gas mixture

R = gas constant

T = temperature.

Three separate residence times were calculated, based on different temperatures, gas flow rates, and compositions, as given in Table A-5.

TABLE A-5
BASIS OF RESIDENCE TIME CALCULATIONS

Residence Time	Basis		
	Temperature	Flow Rate	Composition
$t_{inj-gas}$	$T_{inj-gas}$	Injected gas	Injected gas
t_{mix}	T_{mix}	Injected gas	Injected gas
t_{exit}	Measured reactor exit	Reactor exit gas	Reactor exit gas

D. MASS BALANCES

Ash, carbon, and hydrogen mass balances were performed on all tests to check overall system accountability. The simplest of these is the ash balance, in which the total ash collected in the char receivers is compared to the ash fed with the coal:

$$\eta_{ash} = \frac{\sum_i M_{char,i} X_{ash,i}}{M_{coal} X_{ash,coal}},$$

where

- η_{ash} = fraction of ash recovered
- M_{coal} = weight of total coal fed
- $X_{ash,coal}$ = weight fraction of ash in coal
- $M_{char,i}$ = weight of char in i^{th} vessel (e.g., char receiver, cyclone)
- $X_{ash,i}$ = weight fraction of ash in char from i^{th} vessel.

To obtain a carbon balance, the gas- and liquid-phase products must be considered in addition to char. The "as calculated" carbon balance was determined as follows:

$$\eta_c = C_{\text{total gas ave}} + C_{C_6H_6} + C_{C_7H_8} + C_1^* + \frac{\sum M_{\text{char } i} X_{C_i}}{M_{\text{coal}} X_{C_{\text{coal}}}},$$

where

η_c = fraction of carbon recovered

$C_{\text{total gas ave}}$ = average total measured carbon fraction to gases

$C_{C_6H_6}$ = average total measured carbon fraction to C_6H_6

$C_{C_7H_8}$ = average total measured carbon fraction to C_7H_8

C_1^* = fraction of carbon recovered as non-BT oil (1)

= $\frac{(\text{weight of non-BT oil recovered})(\text{carbon content of non-BT oil})}{M_{\text{coal}} X_{C_{\text{coal}}}}$

= $\frac{M_1 X_{C_1}}{M_{\text{coal}} X_{C_{\text{coal}}}}$

M_{coal} = weight of total coal fed

$X_{C_{\text{coal}}}$ = weight fraction of carbon in coal

$M_{\text{char } i}$ = weight of char in the i^{th} vessel (e.g., char receiver and cyclone)

X_{C_i} = weight fraction of carbon in char from the i^{th} vessel.

The hydrogen balance is more complex, since a portion of the inlet hydrogen gas is removed from the system in the form of condensed steam. This factor is accounted for by assuming all inlet oxygen (preburner, main burner,

and oxygen in the coal), less that exiting the reactor as CO and CO₂, is in the form of water. In this manner, the hydrogen in the condensed combustion steam can be calculated. The hydrogen in the product gas as H₂, CH₄, C₂H₆, etc., is determined by integrating the average flow rate of these gases over the duration of the test. Hydrogen present in the C₆H₆, C₇H₈, and "collected" char and light oil must also be accounted for in completing the balance. The overall "as-collected" hydrogen balance therefore becomes:

$$\eta_H = \frac{H_{\text{gas}} + H_{\text{char}} + H_{\text{PB}} + H_{\text{BT}} + H_{\text{oil}}}{\left(M_{\text{coal}} X_{H_{\text{coal}}} \right) + \left[W_{H_2_{\text{PB}}}^{\text{ave}} + W_{H_2_{\text{SG}}}^{\text{ave}} + \left(W_{CH_4}^{\text{ave}} X_{H_{CH_4}} \right) \right] \Delta t},$$

where

η_H = fraction of hydrogen recovered

H_{gas} = hydrogen in product gas stream = $\sum_i \left(W_{i_{\text{PG}}}^{\text{ave}} X_{H_i} \right) \Delta t$

H_{char} = hydrogen in collected char = $\sum_i \left(M_{\text{char}_i} X_{H_i} \right)$

H_{PB} = hydrogen consumed to produce H₂O

$$= \frac{2.02}{16.0} \left[M_{\text{coal}} X_{O_{\text{coal}}} + W_{O_2_{\text{PB}}}^{\text{ave}} + W_{O_2_{\text{SG}}}^{\text{ave}} - \sum_i \left(W_{i_{\text{PG}}}^{\text{ave}} X_{O_i} \right) \Delta t \right]$$

H_{BT} = hydrogen in BT produced

$$= M_{\text{coal}} \left[C_{C_6H_6} (X_H/X_C) C_{C_6H_6} + C_{C_7H_8} (X_H/X_C) C_{C_7H_8} \right]$$

H_{oil} = hydrogen in collected non-BT oil = $M_1 X_{H_1}$

and

$W_{i_{\text{PG}}}^{\text{ave}}$ = average mass flow rate of i^{th} component in product gas

X_{H_i} = weight fraction of hydrogen in i^{th} component

Δt = test duration
 $M_{\text{char } i}$ = weight of char collected in i^{th} vessel
 M_{coal} = weight of total coal fed
 $x_{\text{O coal}}$ = weight fraction of oxygen in coal
 $x_{\text{O } i}$ = weight fraction of oxygen in i^{th} component
 $(x_{\text{H}}/x_{\text{C}})_{\text{C}_6\text{H}_6}$ = ratio of hydrogen to carbon in C_6H_6
 $(x_{\text{H}}/x_{\text{C}})_{\text{C}_7\text{H}_8}$ = ratio of hydrogen to carbon in C_7H_8
 x_{H_1} = weight fraction of hydrogen in non-BT oil
 $x_{\text{H coal}}$ = weight fraction of hydrogen in coal
 $w_{\text{H}_2\text{PB ave}}$ = average mass flow rate of preburner hydrogen
 $w_{\text{H}_2\text{SG ave}}$ = average mass flow rate of steam generator hydrogen
 $w_{\text{CH}_4\text{ ave}}$ = average mass flow rate of CH_4
 $x_{\text{H CH}_4}$ = weight fraction of hydrogen in CH_4
 $w_{\text{O}_2\text{PB ave}}$ = average mass flow rate of O_2 to preburner
 $w_{\text{O}_2\text{MB ave}}$ = average mass flow rate of O_2 to main burner.

APPENDIX B
AFHP REACTOR TEST CONDITIONS AND PERFORMANCE DATA

This appendix presents the AFHP reactor test data in tabular form as follows:

- Table B-1 (13 pages) Ultimate analyses of the coal fed and main receiver (V-240)char produced for each of the eleven reactor tests. (Starting on Page B-5.)
- Table B-2 (38 pages) Summary of test conditions and performance of the AFHP reactor system for each of the 19 reactor test conditions. These data are representative of steady-state values for each respective test condition. (Starting on Page B-19.)
- Table B-3 (177 pages) Detailed test conditions and performance of the AFHP reactor system for each individual data point obtained during each of the 19 reactor test conditions. (Starting on Page B-57.)

I. COAL AND CHAR ANALYSES--TABLE B-1

Rockwell analyzed the coals and chars for carbon, hydrogen, ash, and moisture content. Commercial Testing and Engineering Company of Lombard, Illinois performed an ultimate analysis of each of these materials for each test. Rockwell and CTE analyses were combined to determine a composite analysis. These composite compositions were then used to calculate the system performance. In general, there was good agreement between the Rockwell- and CTE-determined C, H, and ash values. For two tests (R-2 and R-5), the composite char analysis resulted in a negative oxygen value (by difference). These char compositions were modified to zero oxygen by proportionally adjusting all elemental values.

II. AVERAGED REACTOR PERFORMANCE--TABLE B-2

Table B-2 contains the following information for each of the 19 reactor test conditions:

- Coal carbon conversions to various products
- Inlet streams flow rates and temperatures
- Heat losses and exit temperatures of the preburner, steam generator, main burner, and reactor
- Composition of the coal fed, char, and non-BT oil produced
- Residence time based on reactor gas inlet, outlet, and "mixed" conditions
- Exit mass flow rates, molar flow rates, and mole percents for the preburner, steam generator, main burner, and reactor.

The data contained in Table B-2 are representative of average steady-state values for each respective test condition. These values were determined based on an analysis of all program test data. In general, steady-state conditions were achieved rapidly after the start of a test (i.e., start of coal flow) or immediately after test conditions were changed during temperature scanning tests. Forty-eight of the 59 complete data points obtained during the reactor testing were used to define the steady-state reactor performance. The following 11 non-steady-state data points, obtained during system startup, were not included in the data averaging:

<u>Test Condition</u>	<u>Data Points</u>
1	1
2	1
3	1
5A	1
6	1, 2, 3 & 4
8A	1 & 2
11	1

To generate the information contained in Table B-2, a computer program was developed to calculate: (1) preburner, steam generator, and main burner exit temperatures, (2) the injected gas molar flow rate and "mixed" temperature (i.e., the temperature of the theoretical injected gas/coal mixture), (3) reactor heat losses, (4) reactor residence times, (5) the char composition and heating value, and (6) exit flow conditions based on all the input data. Although not presented explicitly in this table, the exit CO_2/CO molar ratios were provided as input data. Also, the non-BT light oil input composition was typical of that determined during the reactor testing. Char carbon and ash contents were calculated by requiring forced balances, with the other elemental concentrations proportionally adjusted based on the actual test char analysis such that the total mass percents summed to 100%. Exit gas H_2S and HCl values were determined assuming all sulfur and chlorine were converted to $\text{H}_2\text{S}/\text{HCl}$. The exit NH_3 values were calculated by assuming that NH_3 , N_2 , and H_2 were in equilibrium at the reactor exit conditions.

III. DETAILED REACTOR PERFORMANCE--TABLE B-3

The data contained in Table B-3 are representative of each of the 59 individual data points, and an additional data file page is included for every data point obtained during the test program. The presentation format is identical to that used in Table B-2, with an additional data file page included for every data point. Although the information is self-explanatory, the following should be noted: (1) the duration shown is the portion of test time which that data point specifically represents, (2) the residence time is the average of those based on the reactor "mixed" and outlet conditions, and (3) the average reactor temperature is the average of the exit and mixed temperatures. The AFHP data points given in Table B-3 were included in the AFHP/FHP data correlations presented above in Section VI.

TABLE B-1
 ULTIMATE ANALYSES OF THE COAL FED AND MAIN RECEIVER (V-240)
 CHAR PRODUCED FOR EACH OF THE ELEVEN REACTOR TESTS

AFHP COAL AND CHAR ULTIMATE ANALYSIS
 TEST NUMBER: R-1

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.990	-	2.190	-	0.990	-
Carbon	73.228	73.960	72.920	74.553	73.228	73.960
Hydrogen	5.149	5.200	4.990	5.102	5.149	5.200
Nitrogen	-	-	1.500	1.534	1.519	1.534
Chlorine	-	-	0.160	0.164	0.162	0.164
Sulfur	-	-	3.010	3.077	3.047	3.077
Ash	8.079	8.160	8.120	8.302	8.079	8.160
Oxygen (diff)	-	-	7.110	7.268	7.826	7.905
Higher Heating Value (Btu/lb)			13161	13456	13322	13456

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	1.740	-	1.810	-	1.740	-
Carbon	73.607	74.910	74.870	76.250	73.607	74.910
Hydrogen	1.415	1.440	1.140	1.161	1.415	1.440
Nitrogen	-	-	0.900	0.917	0.901	0.917
Chlorine	-	-	0.220	0.224	0.220	0.224
Sulfur	-	-	1.450	1.477	1.451	1.477
Ash	20.438	20.800	20.220	20.593	20.438	20.800
Oxygen (diff)	-	-	-0.610	-0.622	0.228	0.232
Higher Heating Value (Btu/lb)			11474	11686	11482	11686

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-2

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.770	-	2.240	-	0.770	-
Carbon	72.984	73.550	72.570	74.233	72.984	73.550
Hydrogen	5.200	5.240	5.000	5.115	5.200	5.240
Nitrogen	-	-	1.470	1.504	1.492	1.504
Chlorine	-	-	0.160	0.164	0.163	0.164
Sulfur	-	-	3.030	3.099	3.075	3.099
Ash	8.186	8.250	8.210	8.398	8.186	8.250
Oxygen (diff)	-	-	7.320	7.487	8.130	8.193
Higher Heating Value (Btu/lb)			13167	13469	13365	13469

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	2.650	-	2.990	-	2.650	-
Carbon	73.636	75.640	74.380	76.673	73.636	75.640
Hydrogen	0.954	0.980	0.690	0.711	0.954	0.980
Nitrogen	-	-	0.840	0.866	0.843	0.866
Chlorine	-	-	0.100	0.103	0.100	0.103
Sulfur	-	-	1.490	1.536	1.495	1.536
Ash	20.551	21.110	20.340	20.967	20.551	21.110
Oxygen (diff)	-	-	-0.830	-0.856	-0.229	-0.235
Higher Heating Value (Btu/lb)			11275	11623	11315	11623

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-2 MODIFIED

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.770	-	2.240	-	0.770	-
Carbon	72.984	73.550	72.570	74.233	72.984	73.550
Hydrogen	5.200	5.240	5.000	5.115	5.200	5.240
Nitrogen	-	-	1.470	1.504	1.492	1.504
Chlorine	-	-	0.160	0.164	0.163	0.164
Sulfur	-	-	3.030	3.099	3.075	3.099
Ash	8.186	8.250	8.210	8.398	8.186	8.250
Oxygen (diff)	-	-	7.320	7.487	8.130	8.193
Higher Heating Value (Btu/lb)			13167	13469	13365	13469

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	2.650	-	2.990	-	2.650	-
Carbon	73.636	75.640	74.380	76.673	73.463	75.462
Hydrogen	0.954	0.980	0.690	0.711	0.952	0.978
Nitrogen	-	-	0.840	0.866	0.841	0.864
Chlorine	-	-	0.100	0.103	0.100	0.103
Sulfur	-	-	1.490	1.536	1.491	1.532
Ash	20.551	21.110	20.340	20.967	20.503	21.061
Oxygen (diff)	-	-	-0.830	-0.856	0.000	0.000
Higher Heating Value (Btu/lb)			11275	11623	11315	11623

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-3

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.930	-	2.160	-	0.930	-
Carbon	72.935	73.620	72.560	74.162	72.935	73.620
Hydrogen	5.201	5.250	5.020	5.131	5.201	5.250
Nitrogen	-	-	1.390	1.421	1.408	1.421
Chlorine	-	-	0.180	0.184	0.182	0.184
Sulfur	-	-	3.020	3.087	3.058	3.087
Ash	8.054	8.130	8.160	8.340	8.054	8.130
Oxygen (diff)	-	-	7.510	7.675	8.232	8.308
Higher Heating Value (Btu/lb)			13190	13481	13356	13481

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	7.820	-	1.470	-	7.820	-
Carbon	67.181	72.880	73.690	74.789	67.181	72.880
Hydrogen	0.922	1.000	0.460	0.467	0.922	1.000
Nitrogen	-	-	0.870	0.883	0.814	0.883
Chlorine	-	-	0.100	0.101	0.093	0.101
Sulfur	-	-	1.110	1.127	1.039	1.127
Ash	20.906	22.680	22.470	22.805	20.906	22.680
Oxygen (diff)	-	-	- .170	- .172	1.225	1.329
Higher Heating Value (Btu/lb)			11007	11171	10298	11171

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-4

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.430	-	1.840	-	0.430	-
Carbon	72.915	73.230	72.970	74.338	72.915	73.230
Hydrogen	4.988	5.010	4.970	5.063	4.988	5.010
Nitrogen	-	-	1.450	1.477	1.471	1.477
Chlorine	-	-	0.110	0.112	0.112	0.112
Sulfur	-	-	3.040	3.097	3.084	3.097
Ash	8.284	8.320	8.320	8.476	8.284	8.320
Oxygen (diff)	-	-	7.300	7.437	8.716	8.754
Higher Heating Value (Btu/lb)			13188	13435	13377	13435

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	2.040	-	3.460	-	2.040	-
Carbon	73.196	74.720	73.440	76.072	73.196	74.720
Hydrogen	0.901	0.920	0.520	0.539	0.901	0.920
Nitrogen	-	-	0.710	0.735	0.720	0.735
Chlorine	-	-	0.080	0.083	0.081	0.083
Sulfur	-	-	1.320	1.367	1.339	1.367
Ash	21.081	21.520	21.010	21.763	21.081	21.520
Oxygen (diff)	-	-	- .540	- .559	0.642	0.655
Higher Heating Value (Btu/lb)			11031	11426	11193	11426

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-5

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.780	-	1.760	-	0.780	-
Carbon	73.105	73.680	73.030	74.338	73.105	73.680
Hydrogen	5.140	5.180	5.080	5.171	5.140	5.180
Nitrogen	-	-	1.450	1.476	1.464	1.476
Chlorine	-	-	0.180	0.183	0.182	0.183
Sulfur	-	-	2.930	2.982	2.959	2.982
Ash	8.106	8.170	8.140	8.286	8.106	8.170
Oxygen (diff)	-	-	7.430	7.564	8.264	8.329
Higher Heating Value (Btu/lb)			13274	13512	13406	13512

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	6.020	-	3.410	-	6.020	-
Carbon	71.058	75.610	73.390	75.981	71.058	75.610
Hydrogen	1.175	1.250	0.820	0.849	1.175	1.250
Nitrogen	-	-	1.360	1.408	1.323	1.408
Chlorine	-	-	0.150	0.155	0.146	0.155
Sulfur	-	-	1.310	1.356	1.274	1.356
Ash	19.567	20.820	20.060	20.768	19.567	20.820
Oxygen (diff)	-	-	-5.00	-5.17	-5.63	-5.99
Higher Heating Value (Btu/lb)			11275	11673	10970	11673

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-5 MODIFIED

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.780	-	1.760	-	0.780	-
Carbon	73.105	73.680	73.030	74.338	73.105	73.680
Hydrogen	5.140	5.180	5.080	5.171	5.140	5.180
Nitrogen	-	-	1.450	1.476	1.464	1.476
Chlorine	-	-	0.180	0.183	0.182	0.183
Sulfur	-	-	2.930	2.982	2.959	2.982
Ash	8.106	8.170	8.140	8.286	8.106	8.170
Oxygen (diff)	-	-	7.430	7.564	8.264	8.329
Higher Heating Value (Btu/lb)			13274	13512	13406	13512

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	6.020	-	3.410	-	6.020	-
Carbon	71.058	75.610	73.390	75.981	70.634	75.159
Hydrogen	1.175	1.250	0.820	0.849	1.168	1.243
Nitrogen	-	-	1.360	1.408	1.316	1.400
Chlorine	-	-	0.150	0.155	0.145	0.154
Sulfur	-	-	1.310	1.356	1.267	1.348
Ash	19.567	20.820	20.060	20.768	19.450	20.696
Oxygen (diff)	-	-	-5.00	-5.17	0.000	0.000
Higher Heating Value (Btu/lb)			11275	11673	10970	11673

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-6

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.630	-	1.590	-	0.630	-
Carbon	73.315	73.780	73.200	74.383	73.315	73.780
Hydrogen	5.088	5.120	4.970	5.050	5.088	5.120
Nitrogen	-	-	1.470	1.494	1.485	1.494
Chlorine	-	-	0.180	0.183	0.182	0.183
Sulfur	-	-	3.010	3.059	3.040	3.059
Ash	8.407	8.460	8.470	8.607	8.407	8.460
Oxygen (diff)	-	-	7.110	7.224	7.853	7.904
Higher Heating Value (Btu/lb)			13248	13462	13377	13462

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	4.500	-	1.320	-	4.500	-
Carbon	72.446	75.860	76.300	77.321	72.446	75.860
Hydrogen	0.859	0.900	0.390	0.395	0.860	0.900
Nitrogen	-	-	0.780	0.790	0.754	0.790
Chlorine	-	-	0.140	0.142	0.136	0.142
Sulfur	-	-	1.360	1.378	1.316	1.378
Ash	19.635	20.560	20.390	20.663	19.635	20.560
Oxygen (diff)	-	-	-0.680	-0.689	0.353	0.370
Higher Heating Value (Btu/lb)			11416	11569	11048	11569

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-7

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.570	-	1.910	-	0.570	-
Carbon	72.793	73.210	72.890	74.309	72.793	73.210
Hydrogen	5.111	5.140	5.100	5.199	5.111	5.140
Nitrogen	-	-	1.450	1.478	1.470	1.478
Chlorine	-	-	0.180	0.184	0.183	0.184
Sulfur	-	-	2.930	2.987	2.970	2.987
Ash	8.243	8.290	8.240	8.400	8.243	8.290
Oxygen (diff)	-	-	7.300	7.443	8.660	8.711
Higher Heating Value (Btu/lb)			13256	13514	13437	13514

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	23.450	-	1.950	-	23.450	-
Carbon	56.165	73.370	72.270	73.707	56.165	73.370
Hydrogen	0.712	0.930	0.500	0.510	0.712	0.930
Nitrogen	-	-	0.860	0.877	0.671	0.877
Chlorine	-	-	0.180	0.184	0.141	0.184
Sulfur	-	-	1.110	1.132	0.867	1.132
Ash	17.484	22.840	22.870	23.325	17.484	22.840
Oxygen (diff)	-	-	0.260	0.265	0.510	0.667
Higher Heating Value (Btu/lb)			10815	11030	8444	11030

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-8

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.490	-	1.970	-	0.490	-
Carbon	73.279	73.640	73.050	74.518	73.279	73.640
Hydrogen	5.324	5.350	4.940	5.039	5.324	5.350
Nitrogen	-	-	1.570	1.602	1.594	1.602
Chlorine	-	-	0.180	0.184	0.183	0.184
Sulfur	-	-	2.910	2.968	2.953	2.968
Ash	8.628	8.670	8.560	8.732	8.628	8.670
Oxygen (diff)	-	-	6.820	6.957	7.549	7.586
Higher Heating Value (Btu/lb)			13181	13446	13380	13446

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	13.700	-	3.060	-	13.700	-
Carbon	63.827	73.960	72.450	74.737	63.827	73.960
Hydrogen	1.191	1.380	1.120	1.155	1.191	1.380
Nitrogen	-	-	0.930	0.959	0.828	0.959
Chlorine	-	-	0.160	0.165	0.142	0.165
Sulfur	-	-	1.100	1.135	0.980	1.135
Ash	18.365	21.280	21.140	21.807	18.365	21.280
Oxygen (diff)	-	-	0.040	0.042	0.967	1.121
Higher Heating Value (Btu/lb)			11123	11474	9902	11474

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-9

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	1.220	-	2.010	-	1.220	-
Carbon	72.860	73.760	72.640	74.130	72.860	73.760
Hydrogen	5.196	5.260	5.050	5.154	5.196	5.260
Nitrogen	-	-	1.470	1.500	1.482	1.500
Chlorine	-	-	0.180	0.184	0.182	0.184
Sulfur	-	-	2.960	3.021	2.984	3.021
Ash	8.327	8.430	8.370	8.542	8.327	8.430
Oxygen (diff)	-	-	7.320	7.469	7.749	7.845
Higher Heating Value (Btu/lb)			13168	13438	13274	13438

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	3.500	-	2.280	-	3.500	-
Carbon	72.925	75.570	74.270	76.003	72.925	75.570
Hydrogen	1.390	1.440	1.220	1.248	1.390	1.440
Nitrogen	-	-	1.000	1.023	0.987	1.023
Chlorine	-	-	0.140	0.143	0.138	0.143
Sulfur	-	-	1.470	1.504	1.451	1.504
Ash	19.049	19.740	19.630	20.088	19.049	19.740
Oxygen (diff)	-	-	-0.010	-0.009	0.560	0.580
Higher Heating Value (Btu/lb)			11550	11819	11406	11819

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-10

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.430	-	1.860	-	0.430	-
Carbon	73.164	73.480	73.070	74.455	73.164	73.480
Hydrogen	5.317	5.340	5.090	5.186	5.317	5.340
Nitrogen	-	-	1.500	1.528	1.521	1.528
Chlorine	-	-	0.180	0.183	0.182	0.183
Sulfur	-	-	2.980	3.036	3.023	3.036
Ash	8.463	8.500	8.330	8.488	8.463	8.500
Oxygen (diff)	-	-	6.990	7.124	7.900	7.933
Higher Heating Value (Btu/lb)			13147	13396	13339	13396

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	4.720	-	2.380	-	4.720	-
Carbon	71.994	75.560	74.570	76.388	71.994	75.560
Hydrogen	1.448	1.520	1.220	1.250	1.448	1.520
Nitrogen	-	-	1.130	1.158	1.103	1.158
Chlorine	-	-	0.130	0.133	0.127	0.133
Sulfur	-	-	1.440	1.475	1.405	1.475
Ash	18.684	19.610	19.350	19.822	18.684	19.610
Oxygen (diff)	-	-	-0.220	-0.226	0.519	0.544
Higher Heating Value (Btu/lb)			11498	11778	11222	11778

AFHP COAL AND CHAR ULTIMATE ANALYSIS
TEST NUMBER: R-11

COAL ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	0.450	-	1.930	-	0.450	-
Carbon	73.209	73.540	73.330	74.773	73.209	73.540
Hydrogen	5.316	5.340	5.010	5.109	5.316	5.340
Nitrogen	-	-	1.470	1.499	1.492	1.499
Chlorine	-	-	0.160	0.163	0.162	0.163
Sulfur	-	-	2.990	3.049	3.035	3.049
Ash	8.293	8.330	8.090	8.249	8.293	8.330
Oxygen (diff)	-	-	7.020	7.158	8.043	8.079
Higher Heating Value (Btu/lb)			13200	13460	13399	13460

V-240 CHAR ULTIMATE ANALYSIS (weight %)

	Rockwell		Commercial Testing		Composite	
	Received	Dry	Received	Dry	Received	Dry
Moisture	28.200	-	1.320	-	28.200	-
Carbon	53.749	74.860	75.140	76.145	53.749	74.860
Hydrogen	0.617	0.860	0.690	0.699	0.617	0.860
Nitrogen	-	-	0.880	0.892	0.640	0.892
Chlorine	-	-	0.190	0.193	0.139	0.193
Sulfur	-	-	1.270	1.287	0.924	1.287
Ash	15.078	21.000	21.060	21.342	15.078	21.000
Oxygen (diff)	-	-	-0.550	-0.558	0.653	0.908
Higher Heating Value (Btu/lb)			11251	11401	8186	11401

TABLE B-2

SUMMARY OF TEST CONDITIONS AND PERFORMANCE OF THE AFHP REACTOR SYSTEM
FOR EACH OF THE 19 REACTOR TEST CONDITIONS. THESE DATA ARE
REPRESENTATIVE OF STEADY-STATE VALUES FOR EACH
RESPECTIVE TEST CONDITION

AFHP TEST DATA EVALUATION
TEST CONDITION R-1

COAL CARBON CONVERSIONS:

Overall:	56.40 %				
Char:	43.60 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
42.20 %	0.13 %	4.90 %	0.00 %	3.48 %	5.69 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	303.00 lbs/hr	175.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	226.00 lbs/hr	
Main Burner:	Oxygen		
	129.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	927.00 lbs/hr	97.33 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
335611 Btu/hr	189458 Btu/hr	58340 Btu/hr	421841 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 78 F	Hydrogen & Natural Gas @ 1159 F
Steam Generator:	Water @ 200 F	Hydrogen @ 103 F
Main Burner:	Oxygen @ 84 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3331.3 F	1548.0 F	2029.7 F	1845.0 F
Reactor Mixed Temperature: 1545.9 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.215 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.91 seconds
Based on Reactor Outlet Conditions:	5.26 seconds
Based on Reactor Mixed Conditions:	6.09 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.990	0.000	0.000
Carbon	73.228	76.318	94.170
Hydrogen	5.149	1.467	5.460
Nitrogen	1.519	0.935	0.140
Sulfur	3.047	1.505	0.230
Chlorine	0.162	0.228	0.000
Oxygen	7.826	0.236	0.000
Ash	8.079	19.312	0.000

COAL HIGHER HEATING VALUE: 13322 Btu/lb

CHAR HIGHER HEATING VALUE: 11906 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	78.153	90.479	86.425	69.593
H2O	21.812	9.521	13.575	14.877
H	0.034	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.915
CO	0.000	0.000	0.000	0.874
CO2	0.000	0.000	0.000	0.107
CH4	0.000	0.000	0.000	11.904
H2S	0.000	0.000	0.000	0.347
HCl	0.000	0.000	0.000	0.009
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.018
Benzene	0.000	0.000	0.000	0.230
L/H Oils	0.000	0.000	0.000	0.115

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	67.853	179.971	171.908	139.430
H2O	18.937	18.938	27.001	29.806
H	0.030	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.837
CO	0.000	0.000	0.000	1.752
CO2	0.000	0.000	0.000	0.215
CH4	0.000	0.000	0.000	23.850
H2S	0.000	0.000	0.000	0.696
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.018
C2H6	0.000	0.000	0.000	0.037
Benzene	0.000	0.000	0.000	0.462
L/H Oils	0.000	0.000	0.000	0.230
Total	86.821	198.909	198.909	200.349

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	136.79	362.82	346.57	281.09
H2O	341.16	341.18	486.43	536.96
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.48
CO	0.00	0.00	0.00	49.07
CO2	0.00	0.00	0.00	9.46
CH4	0.00	0.00	0.00	382.63
H2S	0.00	0.00	0.00	23.72
HCl	0.00	0.00	0.00	0.63
NH3	0.00	0.00	0.00	0.31
C2H6	0.00	0.00	0.00	1.10
Benzene	0.00	0.00	0.00	36.05
L/H Oils	0.00	0.00	0.00	41.02
Char	0.00	0.00	0.00	387.81
Total	478.00	704.00	833.00	1857.33

AFHP TEST DATA EVALUATION
TEST CONDITION R-2

COAL CARBON CONVERSIONS:

Overall:	59.80 %				
Char:	40.20 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
53.33 %	0.07 %	0.00 %	0.00 %	6.40 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	305.00 lbs/hr	170.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	232.00 lbs/hr	
Main Burner:	Oxygen		
	154.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	958.00 lbs/hr	100.59 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
339260 Btu/hr	195266 Btu/hr	58088 Btu/hr	482440 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 66 F	Hydrogen & Natural Gas @ 1207 F
Steam Generator:	Water @ 200 F	Hydrogen @ 85 F
Main Burner:	Oxygen @ 67 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3430.1 F	1543.7 F	2120.5 F	1982.0 F
Reactor Mixed Temperature: 1603.0 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.208 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.72 seconds
Based on Reactor Outlet Conditions:	4.99 seconds
Based on Reactor Mixed Conditions:	5.91 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.770	0.000
Carbon	72.984	75.467
Hydrogen	5.200	0.978
Nitrogen	1.492	0.864
Sulfur	3.075	1.532
Chlorine	0.163	0.103
Oxygen	8.130	.000
Ash	8.186	21.056

COAL HIGHER HEATING VALUE: 13365 Btu/lb

CHAR HIGHER HEATING VALUE: 11624 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	77.351	90.440	85.613	65.141
H2O	22.599	9.560	14.387	15.017
H	0.047	0.000	0.000	0.000
OH	0.002	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.996
CO	0.000	0.000	0.000	1.716
CO2	0.000	0.000	0.000	0.153
CH4	0.000	0.000	0.000	15.573
H2S	0.000	0.000	0.000	0.372
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.010

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	65.243	180.342	170.716	129.857
H2O	19.062	19.063	28.689	29.935
H	0.040	0.000	0.000	0.000
OH	0.002	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.980
CO	0.000	0.000	0.000	3.420
CO2	0.000	0.000	0.000	0.305
CH4	0.000	0.000	0.000	31.044
H2S	0.000	0.000	0.000	0.741
HCl	0.000	0.000	0.000	0.033
NH3	0.000	0.000	0.000	0.013
C2H6	0.000	0.000	0.000	0.020
Total	84.346	199.405	199.405	199.349

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	131.53	363.57	344.16	261.79
H2O	343.40	343.43	516.84	539.30
H	0.04	0.00	0.00	0.00
OH	0.03	0.00	0.00	0.00
N2	0.00	0.00	0.00	111.49
CO	0.00	0.00	0.00	95.81
CO2	0.00	0.00	0.00	13.43
CH4	0.00	0.00	0.00	498.05
H2S	0.00	0.00	0.00	25.25
HCl	0.00	0.00	0.00	1.21
NH3	0.00	0.00	0.00	0.21
C2H6	0.00	0.00	0.00	0.61
Char	0.00	0.00	0.00	372.45
Total	475.00	707.00	861.00	1919.59

AFHP TEST DATA EVALUATION
TEST CONDITION R-3

COAL CARBON CONVERSIONS:

Overall:	64.50 %				
Char:	35.50 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.85 %	0.07 %	0.00 %	0.00 %	18.58 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	398.00 lbs/hr	246.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	938.00 lbs/hr	51.00 lbs/hr	
Main Burner:	Oxygen		
	248.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	924.00 lbs/hr	97.02 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
400830 Btu/hr	158602 Btu/hr	56980 Btu/hr	399772 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 65 F	Hydrogen & Natural Gas @ 1207 F
Steam Generator:	Water @ 226 F	Hydrogen @ 80 F
Main Burner:	Oxygen @ 65 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3283.5 F	1461.5 F	2303.4 F	1951.0 F
Reactor Mixed Temperature: 1795.6 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.216 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.41 seconds
Based on Reactor Outlet Conditions:	4.79 seconds
Based on Reactor Mixed Conditions:	5.40 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.930	0.000
Carbon	72.935	72.887
Hydrogen	5.201	1.000
Nitrogen	1.408	0.883
Sulfur	3.058	1.127
Chlorine	0.182	0.101
Oxygen	8.232	1.330
Ash	8.054	22.672

COAL HIGHER HEATING VALUE: 13356 Btu/lb

CHAR HIGHER HEATING VALUE: 11172 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.588	61.411	53.637	40.782
H2O	20.382	38.589	46.363	39.841
H	0.029	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.815
CO	0.000	0.000	0.000	3.487
CO2	0.000	0.000	0.000	1.464
CH4	0.000	0.000	0.000	12.217
H2S	0.000	0.000	0.000	0.364
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.009

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	97.131	122.445	106.945	85.876
H2O	24.875	76.942	92.443	83.894
H	0.036	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.821
CO	0.000	0.000	0.000	7.342
CO2	0.000	0.000	0.000	3.083
CH4	0.000	0.000	0.000	25.725
H2S	0.000	0.000	0.000	0.766
HCl	0.000	0.000	0.000	0.038
NH3	0.000	0.000	0.000	0.007
C2H6	0.000	0.000	0.000	0.020
Total	122.042	199.388	199.388	210.571

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	195.82	246.85	215.60	173.13
H2O	448.13	1386.15	1665.40	1511.38
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.04
CO	0.00	0.00	0.00	205.65
CO2	0.00	0.00	0.00	135.68
CH4	0.00	0.00	0.00	412.72
H2S	0.00	0.00	0.00	26.10
HCl	0.00	0.00	0.00	1.39
NH3	0.00	0.00	0.00	0.11
C2H6	0.00	0.00	0.00	0.59
Char	0.00	0.00	0.00	328.24
Total	644.00	1633.00	1881.00	2902.02

AFHP TEST DATA EVALUATION
TEST CONDITION R-4

COAL CARBON CONVERSIONS:

Overall:	60.60 %				
Char:	39.40 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
49.93 %	0.09 %	0.00 %	0.00 %	10.58 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	345.00 lbs/hr	214.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	428.00 lbs/hr	141.00 lbs/hr	
Main Burner:	Oxygen		
	198.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	987.00 lbs/hr	103.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
260704 Btu/hr	243948 Btu/hr	58274 Btu/hr	646153 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 50 F	Hydrogen & Natural Gas @ 1115 F
Steam Generator:	Water @ 202 F	Hydrogen @ 73 F
Main Burner:	Oxygen @ 50 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3293.5 F	1486.0 F	2195.5 F	1973.0 F
Reactor Mixed Temperature: 1669.7 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.202 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.58 seconds
Based on Reactor Outlet Conditions:	4.91 seconds
Based on Reactor Mixed Conditions:	5.70 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.430	0.000
Carbon	72.915	74.700
Hydrogen	4.988	0.920
Nitrogen	1.471	0.735
Sulfur	3.084	1.367
Chlorine	0.112	0.083
Oxygen	8.716	0.655
Ash	8.284	21.540

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11423 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.659	77.322	71.130	52.351
H2O	20.310	22.678	28.870	27.372
H	0.030	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.024
CO	0.000	0.000	0.000	2.539
CO2	0.000	0.000	0.000	0.580
CH4	0.000	0.000	0.000	14.718
H2S	0.000	0.000	0.000	0.387
HCl	0.000	0.000	0.000	0.011
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.013

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	84.572	154.528	142.152	106.410
H2O	21.562	45.321	57.696	55.636
H	0.032	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.113
CO	0.000	0.000	0.000	5.161
CO2	0.000	0.000	0.000	1.178
CH4	0.000	0.000	0.000	29.916
H2S	0.000	0.000	0.000	0.788
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.027
Total	106.167	199.849	199.849	203.262

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	170.50	311.53	286.58	214.52
H2O	388.45	816.47	1039.42	1002.30
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	115.23
CO	0.00	0.00	0.00	144.56
CO2	0.00	0.00	0.00	51.85
CH4	0.00	0.00	0.00	479.95
H2S	0.00	0.00	0.00	26.84
HCl	0.00	0.00	0.00	0.81
NH3	0.00	0.00	0.00	0.16
C2H6	0.00	0.00	0.00	0.81
Char	0.00	0.00	0.00	379.58
Total	559.00	1128.00	1326.00	2416.64

AFHP TEST DATA EVALUATION
TEST CONDITION R-5-A

COAL CARBON CONVERSIONS:

Overall:	60.10 %				
Char:	39.90 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.40 %	0.10 %	4.50 %	0.00 %	6.50 %	4.60 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	403.00 lbs/hr	246.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	884.00 lbs/hr	62.00 lbs/hr	
Main Burner:	Oxygen		
	168.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	936.00 lbs/hr	98.28 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
338131 Btu/hr	212198 Btu/hr	57910 Btu/hr	550119 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 49 F	Hydrogen & Natural Gas @ 1119 F
Steam Generator:	Water @ 228 F	Hydrogen @ 65 F
Main Burner:	Oxygen @ 44 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3296.1 F	1457.8 F	2027.4 F	1839.0 F
Reactor Mixed Temperature: 1582.5 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.216 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.83 seconds
Based on Reactor Outlet Conditions:	5.16 seconds
Based on Reactor Mixed Conditions:	5.88 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.780	0.000	0.000
Carbon	73.105	75.016	94.170
Hydrogen	5.140	1.241	5.460
Nitrogen	1.464	1.397	0.140
Sulfur	2.959	1.345	0.230
Chlorine	0.182	0.154	0.000
Oxygen	8.264	.000	0.000
Ash	8.106	20.847	0.000

COAL HIGHER HEATING VALUE: 13406 Btu/lb

CHAR HIGHER HEATING VALUE: 11651 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-5-A Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.330	63.211	58.009	41.607
H2O	20.638	36.789	41.991	41.668
H	0.031	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.863
CO	0.000	0.000	0.000	1.276
CO2	0.000	0.000	0.000	0.535
CH4	0.000	0.000	0.000	12.370
H2S	0.000	0.000	0.000	0.347
HCl	0.000	0.000	0.000	0.016
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.209
L/H Oils	0.000	0.000	0.000	0.092

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	96.817	127.589	117.089	85.077
H2O	25.187	74.258	84.758	85.201
H	0.037	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.810
CO	0.000	0.000	0.000	2.610
CO2	0.000	0.000	0.000	1.093
CH4	0.000	0.000	0.000	25.294
H2S	0.000	0.000	0.000	0.709
HCl	0.000	0.000	0.000	0.032
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.028
Benzene	0.000	0.000	0.000	0.427
L/H Oils	0.000	0.000	0.000	0.188
Total	122.043	201.847	201.847	204.478

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	195.18	257.22	236.05	171.51
H2O	453.76	1337.78	1526.95	1534.94
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	106.73
CO	0.00	0.00	0.00	73.10
CO2	0.00	0.00	0.00	48.12
CH4	0.00	0.00	0.00	405.80
H2S	0.00	0.00	0.00	24.15
HCl	0.00	0.00	0.00	1.18
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	0.86
Benzene	0.00	0.00	0.00	33.38
L/H Oils	0.00	0.00	0.00	33.42
Char	0.00	0.00	0.00	363.95
Total	649.00	1595.00	1763.00	2797.28

AFHP TEST DATA EVALUATION
TEST CONDITION R-5-B

COAL CARBON CONVERSIONS:

Overall:	59.60 %				
Char:	40.40 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
37.90 %	0.11 %	9.60 %	0.00 %	5.00 %	6.99 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	403.00 lbs/hr	249.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	877.00 lbs/hr	65.00 lbs/hr	
Main Burner:	Oxygen		
	157.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	936.00 lbs/hr	98.28 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
319000 Btu/hr	222983 Btu/hr	57212 Btu/hr	482686 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 51 F	Hydrogen & Natural Gas @ 1093 F
Steam Generator:	Water @ 227 F	Hydrogen @ 62 F
Main Burner:	Oxygen @ 46 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3270.9 F	1444.2 F	1972.2 F	1773.0 F
Reactor Mixed Temperature: 1543.9 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.218 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.88 seconds
Based on Reactor Outlet Conditions:	5.21 seconds
Based on Reactor Mixed Conditions:	5.92 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.780	0.000	0.000
Carbon	73.105	75.210	94.170
Hydrogen	5.140	1.244	5.460
Nitrogen	1.464	1.401	0.140
Sulfur	2.959	1.349	0.230
Chlorine	0.182	0.154	0.000
Oxygen	8.264	0.000	0.000
Ash	8.106	20.642	0.000

COAL HIGHER HEATING VALUE: 13406 Btu/lb

CHAR HIGHER HEATING VALUE: 11681 Btu/lb

AFHP TEST DATA EVALUATION

TEST CONDITION R-5-B

Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.581	63.867	59.067	44.583
H2O	20.390	36.133	40.933	40.924
H	0.028	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.825
CO	0.000	0.000	0.000	1.015
CO2	0.000	0.000	0.000	0.351
CH4	0.000	0.000	0.000	10.354
H2S	0.000	0.000	0.000	0.338
HCl	0.000	0.000	0.000	0.015
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.015
Benzene	0.000	0.000	0.000	0.437
L/H Oils	0.000	0.000	0.000	0.137

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	98.307	130.566	120.753	92.971
H2O	25.187	73.869	83.682	85.341
H	0.035	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.805
CO	0.000	0.000	0.000	2.116
CO2	0.000	0.000	0.000	0.733
CH4	0.000	0.000	0.000	21.591
H2S	0.000	0.000	0.000	0.706
HCl	0.000	0.000	0.000	0.032
NH3	0.000	0.000	0.000	0.011
C2H6	0.000	0.000	0.000	0.031
Benzene	0.000	0.000	0.000	0.911
L/H Oils	0.000	0.000	0.000	0.285
Total	123.530	204.435	204.435	208.533

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	198.19	263.22	243.44	187.43
H2O	453.76	1330.78	1507.56	1537.45
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	106.60
CO	0.00	0.00	0.00	59.27
CO2	0.00	0.00	0.00	32.24
CH4	0.00	0.00	0.00	346.39
H2S	0.00	0.00	0.00	24.04
HCl	0.00	0.00	0.00	1.17
NH3	0.00	0.00	0.00	0.19
C2H6	0.00	0.00	0.00	0.94
Benzene	0.00	0.00	0.00	71.20
L/H Oils	0.00	0.00	0.00	50.79
Char	0.00	0.00	0.00	367.56
Total	652.00	1594.00	1751.00	2785.28

AFHP TEST DATA EVALUATION
TEST CONDITION R-6

COAL CARBON CONVERSIONS:

Overall:	57.70 %				
Char:	42.30 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
47.19 %	0.08 %	0.00 %	0.00 %	10.43 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	222.00 lbs/hr	232.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	338.00 lbs/hr	48.00 lbs/hr	
Main Burner:	Oxygen		
	180.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1025.00 lbs/hr	107.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
289629 Btu/hr	167519 Btu/hr	59413 Btu/hr	408072 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 59 F	Hydrogen & Natural Gas @ 1126 F
Steam Generator:	Water @ 209 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 61 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2378.8 F	1375.9 F	2199.3 F	1936.0 F
Reactor Mixed Temperature: 1561.3 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.154 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.78 seconds
Based on Reactor Outlet Conditions:	6.20 seconds
Based on Reactor Mixed Conditions:	7.60 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.630	0.000
Carbon	73.315	75.857
Hydrogen	5.088	0.899
Nitrogen	1.485	0.790
Sulfur	3.040	1.378
Chlorine	0.182	0.142
Oxygen	7.853	0.370
Ash	8.407	20.564

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11569 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-6 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.942	79.298	72.161	49.406
H2O	12.057	20.702	27.839	25.370
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.611
CO	0.000	0.000	0.000	3.237
CO2	0.000	0.000	0.000	0.760
CH4	0.000	0.000	0.000	18.087
H2S	0.000	0.000	0.000	0.485
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.015

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	101.204	125.013	113.763	80.648
H2O	13.876	32.637	43.888	41.414
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.263
CO	0.000	0.000	0.000	5.285
CO2	0.000	0.000	0.000	1.241
CH4	0.000	0.000	0.000	29.524
H2S	0.000	0.000	0.000	0.792
HCl	0.000	0.000	0.000	0.036
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.025
Total	115.080	157.651	157.651	163.236

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	204.03	252.03	229.35	162.59
H2O	249.97	587.97	790.65	746.09
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	119.42
CO	0.00	0.00	0.00	148.03
CO2	0.00	0.00	0.00	54.61
CH4	0.00	0.00	0.00	473.66
H2S	0.00	0.00	0.00	26.98
HCl	0.00	0.00	0.00	1.31
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	0.75
Char	0.00	0.00	0.00	419.05
Total	454.00	840.00	1020.00	2152.63

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-A

COAL CARBON CONVERSIONS:

Overall:	58.70 %				
Char:	41.30 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
40.00 %	0.07 %	5.00 %	0.00 %	5.10 %	8.53 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	220.00 lbs/hr	226.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	595.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	137.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
307559 Btu/hr	143298 Btu/hr	52033 Btu/hr	338748 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 27 F	Hydrogen & Natural Gas @ 1133 F
Steam Generator:	Water @ 213 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 26 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2380.6 F	1224.5 F	1893.3 F	1787.0 F
Reactor Mixed Temperature: 1518.7 F			

PRESSURE: 1017.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.247 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	7.13 seconds
Based on Reactor Outlet Conditions:	7.34 seconds
Based on Reactor Mixed Conditions:	8.48 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.570	0.000	0.000
Carbon	72.793	75.424	94.170
Hydrogen	5.111	0.956	5.460
Nitrogen	1.470	0.902	0.140
Sulfur	2.970	1.163	0.230
Chlorine	0.183	0.189	0.000
Oxygen	8.660	0.686	0.000
Ash	8.243	20.680	0.000

COAL HIGHER HEATING VALUE: 13437 Btu/lb
CHAR HIGHER HEATING VALUE: 11339 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-A Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.734	67.768	61.868	48.687
H2O	12.266	32.232	38.132	38.121
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.644
CO	0.000	0.000	0.000	0.889
CO2	0.000	0.000	0.000	0.339
CH4	0.000	0.000	0.000	9.637
H2S	0.000	0.000	0.000	0.309
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.008
Benzene	0.000	0.000	0.000	0.201
L/H Oils	0.000	0.000	0.000	0.147

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	98.352	98.353	89.790	71.889
H2O	13.751	46.778	55.341	56.288
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.427
CO	0.000	0.000	0.000	1.313
CO2	0.000	0.000	0.000	0.501
CH4	0.000	0.000	0.000	14.230
H2S	0.000	0.000	0.000	0.456
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.012
Benzene	0.000	0.000	0.000	0.296
L/H Oils	0.000	0.000	0.000	0.217
Total	112.103	145.130	145.130	147.656

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	198.28	198.28	181.02	144.93
H2O	247.72	842.72	996.98	1014.05
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	67.98
CO	0.00	0.00	0.00	36.78
CO2	0.00	0.00	0.00	22.05
CH4	0.00	0.00	0.00	228.29
H2S	0.00	0.00	0.00	15.54
HCl	0.00	0.00	0.00	0.65
NH3	0.00	0.00	0.00	0.14
C2H6	0.00	0.00	0.00	0.37
Benzene	0.00	0.00	0.00	23.16
L/H Oils	0.00	0.00	0.00	38.70
Char	0.00	0.00	0.00	233.97
Total	446.00	1041.00	1178.00	1826.64

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-B

COAL CARBON CONVERSIONS:

Overall:	60.40 %				
Char:	39.60 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
46.90 %	0.06 %	0.40 %	0.00 %	7.90 %	5.14 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	227.00 lbs/hr	223.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	595.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	161.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
309610 Btu/hr	141188 Btu/hr	52022 Btu/hr	466389 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 27 F	Hydrogen & Natural Gas @ 1119 F
Steam Generator:	Water @ 213 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 27 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2428.3 F	1254.5 F	2042.6 F	1863.0 F
Reactor Mixed Temperature: 1633.1 F			

PRESSURE: 1017.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.245 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	6.77 seconds
Based on Reactor Outlet Conditions:	7.20 seconds
Based on Reactor Mixed Conditions:	8.10 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.570	0.000	0.000
Carbon	72.793	74.761	94.170
Hydrogen	5.111	0.947	5.460
Nitrogen	1.470	0.894	0.140
Sulfur	2.970	1.153	0.230
Chlorine	0.183	0.187	0.000
Oxygen	8.660	0.680	0.000
Ash	8.243	21.378	0.000

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 11239 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-B Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.173	67.130	60.124	45.418
H2O	12.826	32.870	39.876	39.080
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.670
CO	0.000	0.000	0.000	1.368
CO2	0.000	0.000	0.000	0.562
CH4	0.000	0.000	0.000	11.456
H2S	0.000	0.000	0.000	0.316
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.007
Benzene	0.000	0.000	0.000	0.016
L/H Oils	0.000	0.000	0.000	0.090

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	96.427	96.427	86.364	66.147
H2O	14.188	47.215	57.278	56.916
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.432
CO	0.000	0.000	0.000	1.992
CO2	0.000	0.000	0.000	0.819
CH4	0.000	0.000	0.000	16.685
H2S	0.000	0.000	0.000	0.461
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.011
Benzene	0.000	0.000	0.000	0.024
L/H Oils	0.000	0.000	0.000	0.131
Total	110.615	143.642	143.642	145.640

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	194.40	194.40	174.11	133.35
H2O	255.60	850.60	1031.89	1025.36
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	68.12
CO	0.00	0.00	0.00	55.79
CO2	0.00	0.00	0.00	36.03
CH4	0.00	0.00	0.00	267.67
H2S	0.00	0.00	0.00	15.70
HCl	0.00	0.00	0.00	0.67
NH3	0.00	0.00	0.00	0.11
C2H6	0.00	0.00	0.00	0.32
Benzene	0.00	0.00	0.00	1.85
L/H Oils	0.00	0.00	0.00	23.32
Char	0.00	0.00	0.00	226.33
Total	450.00	1045.00	1206.00	1854.63

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-C

COAL CARBON CONVERSIONS:

Overall:	63.90 %				
Char:	36.10 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.40 %	0.05 %	0.00 %	0.00 %	17.60 %	1.85 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	226.00 lbs/hr	223.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	600.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	212.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
304348 Btu/hr	146618 Btu/hr	53009 Btu/hr	442992 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 29 F	Hydrogen & Natural Gas @ 1125 F
Steam Generator:	Water @ 214 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 26 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2432.6 F	1247.1 F	2274.6 F	1935.0 F
Reactor Mixed Temperature: 1815.5 F			

PRESSURE: 1016.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.245 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	6.18 seconds
Based on Reactor Outlet Conditions:	6.74 seconds
Based on Reactor Mixed Conditions:	7.43 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.570	0.000	0.000
Carbon	72.793	73.243	94.170
Hydrogen	5.111	0.928	5.460
Nitrogen	1.470	0.876	0.140
Sulfur	2.970	1.130	0.230
Chlorine	0.183	0.183	0.000
Oxygen	8.660	0.666	0.000
Ash	8.243	22.975	0.000

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 11011 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-C Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.229	67.044	57.837	46.271
H2O	12.770	32.956	42.163	37.113
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.618
CO	0.000	0.000	0.000	2.991
CO2	0.000	0.000	0.000	1.163
CH4	0.000	0.000	0.000	10.479
H2S	0.000	0.000	0.000	0.311
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.006
L/H Oils	0.000	0.000	0.000	0.031

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	96.489	96.490	83.239	69.745
H2O	14.126	47.430	60.681	55.942
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.439
CO	0.000	0.000	0.000	4.508
CO2	0.000	0.000	0.000	1.753
CH4	0.000	0.000	0.000	15.795
H2S	0.000	0.000	0.000	0.469
HCl	0.000	0.000	0.000	0.019
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.009
L/H Oils	0.000	0.000	0.000	0.047
Total	110.615	143.920	143.920	150.732

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	194.52	194.52	167.81	140.61
H2O	254.48	854.48	1093.19	1007.81
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	68.33
CO	0.00	0.00	0.00	126.27
CO2	0.00	0.00	0.00	77.16
CH4	0.00	0.00	0.00	253.41
H2S	0.00	0.00	0.00	15.98
HCl	0.00	0.00	0.00	0.71
NH3	0.00	0.00	0.00	0.10
C2H6	0.00	0.00	0.00	0.27
L/H Oils	0.00	0.00	0.00	8.39
Char	0.00	0.00	0.00	210.61
Total	449.00	1049.00	1261.00	1909.63

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-D

COAL CARBON CONVERSIONS:

Overall:	66.00 %				
Char:	34.00 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
40.34 %	0.04 %	0.00 %	0.00 %	25.62 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	225.00 lbs/hr	220.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	595.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	264.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
302428 Btu/hr	147360 Btu/hr	54054 Btu/hr	502976 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 30 F	Hydrogen & Natural Gas @ 1122 F
Steam Generator:	Water @ 212 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 35 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2441.5 F	1247.2 F	2523.9 F	1974.0 F
Reactor Mixed Temperature: 2006.2 F			

PRESSURE: 1017.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.242 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.74 seconds
Based on Reactor Outlet Conditions:	6.52 seconds
Based on Reactor Mixed Conditions:	6.95 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.570	0.000
Carbon	72.793	72.218
Hydrogen	5.111	0.915
Nitrogen	1.470	0.863
Sulfur	2.970	1.114
Chlorine	0.183	0.181
Oxygen	8.660	0.657
Ash	8.243	24.053

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 10857 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-D Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.113	66.874	55.266	46.728
H2O	12.887	33.126	44.734	36.064
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.592
CO	0.000	0.000	0.000	4.377
CO2	0.000	0.000	0.000	1.560
CH4	0.000	0.000	0.000	9.349
H2S	0.000	0.000	0.000	0.309
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.005

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	95.064	95.064	78.563	71.732
H2O	14.063	47.090	63.591	55.362
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.444
CO	0.000	0.000	0.000	6.719
CO2	0.000	0.000	0.000	2.395
CH4	0.000	0.000	0.000	14.351
H2S	0.000	0.000	0.000	0.474
HCl	0.000	0.000	0.000	0.020
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.007
Total	109.127	142.154	142.154	153.509

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	191.65	191.65	158.38	144.61
H2O	253.35	848.35	1145.62	997.36
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	68.45
CO	0.00	0.00	0.00	188.20
CO2	0.00	0.00	0.00	105.42
CH4	0.00	0.00	0.00	230.23
H2S	0.00	0.00	0.00	16.15
HCl	0.00	0.00	0.00	0.73
NH3	0.00	0.00	0.00	0.09
C2H6	0.00	0.00	0.00	0.21
Char	0.00	0.00	0.00	201.17
Total	445.00	1040.00	1304.00	1952.63

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-E

COAL CARBON CONVERSIONS:

Overall:	68.40 %				
Char:	31.60 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
38.98 %	0.03 %	0.00 %	0.00 %	29.39 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	227.00 lbs/hr	234.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	588.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	286.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
305134 Btu/hr	148978 Btu/hr	54497 Btu/hr	467946 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 32 F	Hydrogen & Natural Gas @ 1102 F
Steam Generator:	Water @ 211 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 38 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2362.9 F	1243.4 F	2571.8 F	1997.0 F
Reactor Mixed Temperature: 2058.6 F			

PRESSURE: 1016.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.253 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.40 seconds
Based on Reactor Outlet Conditions:	6.11 seconds
Based on Reactor Mixed Conditions:	6.50 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.570	0.000
Carbon	72.793	70.922
Hydrogen	5.111	0.899
Nitrogen	1.470	0.848
Sulfur	2.970	1.094
Chlorine	0.183	0.177
Oxygen	8.660	0.645
Ash	8.243	25.415

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 10662 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-7-E Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.776	68.511	56.491	49.211
H2O	12.224	31.489	43.509	33.945
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.511
CO	0.000	0.000	0.000	4.878
CO2	0.000	0.000	0.000	1.578
CH4	0.000	0.000	0.000	8.562
H2S	0.000	0.000	0.000	0.296
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.003

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	101.883	101.883	84.008	79.703
H2O	14.188	46.827	64.702	54.978
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.448
CO	0.000	0.000	0.000	7.900
CO2	0.000	0.000	0.000	2.555
CH4	0.000	0.000	0.000	13.867
H2S	0.000	0.000	0.000	0.479
HCl	0.000	0.000	0.000	0.021
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.005
Total	116.072	148.710	148.710	161.962

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	205.40	205.40	169.36	160.68
H2O	255.60	843.60	1165.64	990.46
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	68.57
CO	0.00	0.00	0.00	221.30
CO2	0.00	0.00	0.00	112.45
CH4	0.00	0.00	0.00	222.47
H2S	0.00	0.00	0.00	16.32
HCl	0.00	0.00	0.00	0.76
NH3	0.00	0.00	0.00	0.10
C2H6	0.00	0.00	0.00	0.16
Char	0.00	0.00	0.00	190.39
Total	461.00	1049.00	1335.00	1983.64

AFHP TEST DATA EVALUATION
TEST CONDITION R-8-A

COAL CARBON CONVERSIONS:

Overall:	57.80 %				
Char:	42.20 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
32.90 %	0.13 %	11.20 %	0.06 %	5.10 %	8.41 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	293.00 lbs/hr	298.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	957.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	222.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	749.00 lbs/hr	78.64 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
311339 Btu/hr	221260 Btu/hr	49142 Btu/hr	146807 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 32 F	Hydrogen & Natural Gas @ 1169 F
Steam Generator:	Water @ 230 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 31 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2503.3 F	1150.8 F	1945.2 F	1775.0 F
Reactor Mixed Temperature: 1587.5 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.268 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.20 seconds
Based on Reactor Outlet Conditions:	2.30 seconds
Based on Reactor Mixed Conditions:	2.58 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.490	0.000	0.000
Carbon	73.279	74.439	94.170
Hydrogen	5.324	1.389	5.460
Nitrogen	1.594	0.966	0.140
Sulfur	2.953	1.143	0.230
Chlorine	0.183	0.166	0.000
Oxygen	7.549	1.129	0.000
Ash	8.628	20.769	0.000

COAL HIGHER HEATING VALUE: 13380 Btu/lb

CHAR HIGHER HEATING VALUE: 11548 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-8-A Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.610	64.450	57.544	47.546
H2O	12.389	35.550	42.456	41.670
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.511
CO	0.000	0.000	0.000	0.885
CO2	0.000	0.000	0.000	0.244
CH4	0.000	0.000	0.000	7.285
H2S	0.000	0.000	0.000	0.279
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.413
Toluene	0.000	0.000	0.000	0.002
L/H Oils	0.000	0.000	0.000	0.133

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	129.504	129.504	115.629	98.122
H2O	18.313	71.434	85.310	85.994
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.118
CO	0.000	0.000	0.000	1.827
CO2	0.000	0.000	0.000	0.503
CH4	0.000	0.000	0.000	15.034
H2S	0.000	0.000	0.000	0.575
HCl	0.000	0.000	0.000	0.024
NH3	0.000	0.000	0.000	0.011
C2H6	0.000	0.000	0.000	0.030
Benzene	0.000	0.000	0.000	0.853
Toluene	0.000	0.000	0.000	0.004
L/H Oils	0.000	0.000	0.000	0.275
Total	147.818	200.939	200.939	206.371

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	261.08	261.08	233.11	197.81
H2O	329.92	1286.92	1536.89	1549.22
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	87.35
CO	0.00	0.00	0.00	51.18
CO2	0.00	0.00	0.00	22.15
CH4	0.00	0.00	0.00	241.19
H2S	0.00	0.00	0.00	19.61
HCl	0.00	0.00	0.00	0.88
NH3	0.00	0.00	0.00	0.19
C2H6	0.00	0.00	0.00	0.89
Benzene	0.00	0.00	0.00	66.63
Toluene	0.00	0.00	0.00	0.36
L/H Oils	0.00	0.00	0.00	49.02
Char	0.00	0.00	0.00	311.15
Total	591.00	1548.00	1770.00	2597.64

AFHP TEST DATA EVALUATION
TEST CONDITION R-8-B

COAL CARBON CONVERSIONS:

Overall:	60.70 %				
Char:	39.30 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.20 %	0.08 %	3.80 %	0.02 %	8.10 %	4.50 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	294.00 lbs/hr	298.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	964.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	260.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	749.00 lbs/hr	78.64 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
313728 Btu/hr	220483 Btu/hr	48593 Btu/hr	160698 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 33 F	Hydrogen & Natural Gas @ 1161 F
Steam Generator:	Water @ 228 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 34 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2499.5 F	1141.2 F	2065.2 F	1940.0 F
Reactor Mixed Temperature: 1684.3 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.269 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.09 seconds
Based on Reactor Outlet Conditions:	2.16 seconds
Based on Reactor Mixed Conditions:	2.46 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.490	0.000	0.000
Carbon	73.279	73.316	94.170
Hydrogen	5.324	1.368	5.460
Nitrogen	1.594	0.951	0.140
Sulfur	2.953	1.125	0.230
Chlorine	0.183	0.163	0.000
Oxygen	7.549	1.111	0.000
Ash	8.628	21.965	0.000

COAL HIGHER HEATING VALUE: 13380 Btu/lb

CHAR HIGHER HEATING VALUE: 11374 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-8-B Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.568	64.294	56.222	43.838
H2O	12.431	35.706	43.778	42.439
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.528
CO	0.000	0.000	0.000	1.288
CO2	0.000	0.000	0.000	0.519
CH4	0.000	0.000	0.000	9.863
H2S	0.000	0.000	0.000	0.286
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.009
Benzene	0.000	0.000	0.000	0.141
Toluene	0.000	0.000	0.000	0.001
L/H Oils	0.000	0.000	0.000	0.072

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	129.441	129.442	113.191	89.769
H2O	18.376	71.885	88.136	86.905
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.129
CO	0.000	0.000	0.000	2.638
CO2	0.000	0.000	0.000	1.063
CH4	0.000	0.000	0.000	20.197
H2S	0.000	0.000	0.000	0.585
HCl	0.000	0.000	0.000	0.025
NH3	0.000	0.000	0.000	0.007
C2H6	0.000	0.000	0.000	0.018
Benzene	0.000	0.000	0.000	0.289
Toluene	0.000	0.000	0.000	0.001
L/H Oils	0.000	0.000	0.000	0.147
Total	147.818	201.327	201.327	204.775

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	260.95	260.95	228.19	180.97
H2O	331.05	1295.05	1587.81	1565.63
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	87.65
CO	0.00	0.00	0.00	73.90
CO2	0.00	0.00	0.00	46.79
CH4	0.00	0.00	0.00	324.03
H2S	0.00	0.00	0.00	19.93
HCl	0.00	0.00	0.00	0.91
NH3	0.00	0.00	0.00	0.12
C2H6	0.00	0.00	0.00	0.55
Benzene	0.00	0.00	0.00	22.61
Toluene	0.00	0.00	0.00	0.12
L/H Oils	0.00	0.00	0.00	26.23
Char	0.00	0.00	0.00	294.21
Total	592.00	1556.00	1816.00	2643.65

AFHP TEST DATA EVALUATION
TEST CONDITION R-9-A

COAL CARBON CONVERSIONS:

Overall:	53.40 %				
Char:	46.60 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
30.70 %	0.18 %	9.90 %	0.08 %	4.14 %	8.40 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	250.00 lbs/hr	288.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	520.00 lbs/hr	60.00 lbs/hr	
Main Burner:	Oxygen		
	226.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1171.00 lbs/hr	195.56 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
349933 Btu/hr	138275 Btu/hr	52418 Btu/hr	229503 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 46 F	Hydrogen & Natural Gas @ 1131 F
Steam Generator:	Water @ 211 F	Hydrogen @ 71 F
Main Burner:	Oxygen @ 48 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2255.9 F	1225.0 F	2058.6 F	1766.0 F
Reactor Mixed Temperature: 1497.0 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.172 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.09 seconds
Based on Reactor Outlet Conditions:	2.23 seconds
Based on Reactor Mixed Conditions:	2.69 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	1.220	0.000	0.000
Carbon	72.860	76.493	94.170
Hydrogen	5.196	1.457	5.460
Nitrogen	1.482	1.036	0.140
Sulfur	2.984	1.522	0.230
Chlorine	0.182	0.145	0.000
Oxygen	7.749	0.587	0.000
Ash	8.327	18.760	0.000

COAL HIGHER HEATING VALUE: 13274 Btu/lb

CHAR HIGHER HEATING VALUE: 11963 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-9-A Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	89.062	77.919	70.908	54.890
H2O	10.938	22.081	29.092	28.822
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.469
CO	0.000	0.000	0.000	1.132
CO2	0.000	0.000	0.000	0.248
CH4	0.000	0.000	0.000	10.233
H2S	0.000	0.000	0.000	0.393
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.010
C2H6	0.000	0.000	0.000	0.030
Benzene	0.000	0.000	0.000	0.550
Toluene	0.000	0.000	0.000	0.004
L/H Oils	0.000	0.000	0.000	0.200

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	127.231	156.993	142.868	116.974
H2O	15.626	44.490	58.615	61.420
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	7.393
CO	0.000	0.000	0.000	2.413
CO2	0.000	0.000	0.000	0.528
CH4	0.000	0.000	0.000	21.807
H2S	0.000	0.000	0.000	0.838
HCl	0.000	0.000	0.000	0.039
NH3	0.000	0.000	0.000	0.022
C2H6	0.000	0.000	0.000	0.064
Benzene	0.000	0.000	0.000	1.172
Toluene	0.000	0.000	0.000	0.008
L/H Oils	0.000	0.000	0.000	0.427
Total	142.857	201.483	201.483	213.105

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	256.50	316.50	288.02	235.82
H2O	281.50	801.50	1055.98	1106.51
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	207.11
CO	0.00	0.00	0.00	67.58
CO2	0.00	0.00	0.00	23.24
CH4	0.00	0.00	0.00	349.86
H2S	0.00	0.00	0.00	28.54
HCl	0.00	0.00	0.00	1.42
NH3	0.00	0.00	0.00	0.38
C2H6	0.00	0.00	0.00	1.92
Benzene	0.00	0.00	0.00	91.55
Toluene	0.00	0.00	0.00	0.75
L/H Oils	0.00	0.00	0.00	76.10
Char	0.00	0.00	0.00	519.77
Total	538.00	1118.00	1344.00	2710.56

AFHP TEST DATA EVALUATION
TEST CONDITION R-9-B

COAL CARBON CONVERSIONS:

Overall:	55.20 %				
Char:	44.80 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
36.00 %	0.12 %	8.20 %	0.07 %	4.84 %	5.97 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	252.00 lbs/hr	286.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	518.00 lbs/hr	60.00 lbs/hr	
Main Burner:	Oxygen		
	240.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1171.00 lbs/hr	195.56 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
352067 Btu/hr	139073 Btu/hr	50703 Btu/hr	204316 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 48 F	Hydrogen & Natural Gas @ 1123 F
Steam Generator:	Water @ 210 F	Hydrogen @ 70 F
Main Burner:	Oxygen @ 50 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2265.0 F	1228.0 F	2116.4 F	1877.0 F
Reactor Mixed Temperature: 1536.0 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.171 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.06 seconds
Based on Reactor Outlet Conditions:	2.16 seconds
Based on Reactor Mixed Conditions:	2.65 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	1.220	0.000	0.000
Carbon	72.860	75.921	94.170
Hydrogen	5.196	1.446	5.460
Nitrogen	1.482	1.028	0.140
Sulfur	2.984	1.511	0.230
Chlorine	0.182	0.144	0.000
Oxygen	7.749	0.582	0.000
Ash	8.327	19.368	0.000

COAL HIGHER HEATING VALUE: 13274 Btu/lb

CHAR HIGHER HEATING VALUE: 11874 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-9-B Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.897	77.790	70.304	52.184
H2O	11.103	22.210	29.696	29.399
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.529
CO	0.000	0.000	0.000	1.322
CO2	0.000	0.000	0.000	0.317
CH4	0.000	0.000	0.000	12.188
H2S	0.000	0.000	0.000	0.404
HCl	0.000	0.000	0.000	0.019
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.020
Benzene	0.000	0.000	0.000	0.463
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.145

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	126.114	155.876	140.876	109.490
H2O	15.751	44.504	59.504	61.683
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	7.405
CO	0.000	0.000	0.000	2.774
CO2	0.000	0.000	0.000	0.664
CH4	0.000	0.000	0.000	25.572
H2S	0.000	0.000	0.000	0.849
HCl	0.000	0.000	0.000	0.040
NH3	0.000	0.000	0.000	0.016
C2H6	0.000	0.000	0.000	0.043
Benzene	0.000	0.000	0.000	0.971
Toluene	0.000	0.000	0.000	0.007
L/H Oils	0.000	0.000	0.000	0.303
Total	141.865	200.380	200.380	209.816

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	254.25	314.25	284.01	220.73
H2O	283.75	801.75	1071.99	1111.25
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	207.44
CO	0.00	0.00	0.00	77.69
CO2	0.00	0.00	0.00	29.24
CH4	0.00	0.00	0.00	410.25
H2S	0.00	0.00	0.00	28.92
HCl	0.00	0.00	0.00	1.45
NH3	0.00	0.00	0.00	0.27
C2H6	0.00	0.00	0.00	1.28
Benzene	0.00	0.00	0.00	75.83
Toluene	0.00	0.00	0.00	0.65
L/H Oils	0.00	0.00	0.00	54.09
Char	0.00	0.00	0.00	503.46
Total	538.00	1116.00	1356.00	2722.56

AFHP TEST DATA EVALUATION
TEST CONDITION R-9-C

COAL CARBON CONVERSIONS:

Overall:	58.10 %				
Char:	41.90 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
46.40 %	0.13 %	0.60 %	0.00 %	8.70 %	2.27 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	255.00 lbs/hr	288.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	514.00 lbs/hr	61.00 lbs/hr	
Main Burner:	Oxygen		
	268.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1171.00 lbs/hr	195.56 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
354405 Btu/hr	139997 Btu/hr	54374 Btu/hr	191373 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 50 F	Hydrogen & Natural Gas @ 1122 F
Steam Generator:	Water @ 210 F	Hydrogen @ 71 F
Main Burner:	Oxygen @ 53 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2270.9 F	1238.5 F	2217.5 F	2034.0 F
Reactor Mixed Temperature: 1609.7 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.172 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	1.96 seconds
Based on Reactor Outlet Conditions:	2.03 seconds
Based on Reactor Mixed Conditions:	2.54 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	1.220	0.000	0.000
Carbon	72.860	74.917	94.170
Hydrogen	5.196	1.427	5.460
Nitrogen	1.482	1.014	0.140
Sulfur	2.984	1.491	0.230
Chlorine	0.182	0.142	0.000
Oxygen	7.749	0.575	0.000
Ash	8.327	20.434	0.000

COAL HIGHER HEATING VALUE: 13274 Btu/lb

CHAR HIGHER HEATING VALUE: 11717 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-9-C Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.843	77.947	69.640	48.456
H2O	11.157	22.053	30.360	28.740
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.547
CO	0.000	0.000	0.000	2.380
CO2	0.000	0.000	0.000	0.574
CH4	0.000	0.000	0.000	15.753
H2S	0.000	0.000	0.000	0.414
HCl	0.000	0.000	0.000	0.020
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.022
Benzene	0.000	0.000	0.000	0.034
L/H Oils	0.000	0.000	0.000	0.055

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	126.919	157.177	140.426	101.381
H2O	15.938	44.469	61.220	60.132
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	7.421
CO	0.000	0.000	0.000	4.979
CO2	0.000	0.000	0.000	1.201
CH4	0.000	0.000	0.000	32.959
H2S	0.000	0.000	0.000	0.866
HCl	0.000	0.000	0.000	0.041
NH3	0.000	0.000	0.000	0.010
C2H6	0.000	0.000	0.000	0.046
Benzene	0.000	0.000	0.000	0.071
L/H Oils	0.000	0.000	0.000	0.115
Total	142.857	201.646	201.646	209.224

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	255.87	316.87	283.10	204.38
H2O	287.13	801.13	1102.90	1083.30
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	207.90
CO	0.00	0.00	0.00	139.45
CO2	0.00	0.00	0.00	52.87
CH4	0.00	0.00	0.00	528.77
H2S	0.00	0.00	0.00	29.53
HCl	0.00	0.00	0.00	1.50
NH3	0.00	0.00	0.00	0.17
C2H6	0.00	0.00	0.00	1.39
Benzene	0.00	0.00	0.00	5.55
L/H Oils	0.00	0.00	0.00	20.57
Char	0.00	0.00	0.00	477.18
Total	543.00	1118.00	1386.00	2752.56

AFHP TEST DATA EVALUATION
TEST CONDITION R-10

COAL CARBON CONVERSIONS:

Overall:	55.40 %				
Char:	44.60 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
33.60 %	0.15 %	9.80 %	0.07 %	4.20 %	7.58 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	250.00 lbs/hr	289.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	512.00 lbs/hr	59.00 lbs/hr	
Main Burner:	Oxygen		
	216.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1047.00 lbs/hr	174.85 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
336447 Btu/hr	152988 Btu/hr	52143 Btu/hr	216682 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 70 F	Hydrogen & Natural Gas @ 1140 F
Steam Generator:	Water @ 225 F	Hydrogen @ 89 F
Main Burner:	Oxygen @ 71 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2272.9 F	1247.9 F	2046.3 F	1810.0 F
Reactor Mixed Temperature: 1532.0 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.192 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.10 seconds
Based on Reactor Outlet Conditions:	2.22 seconds
Based on Reactor Mixed Conditions:	2.65 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.430	0.000	0.000
Carbon	73.164	75.570	94.170
Hydrogen	5.317	1.520	5.460
Nitrogen	1.521	1.158	0.140
Sulfur	3.023	1.475	0.230
Chlorine	0.182	0.133	0.000
Oxygen	7.900	0.544	0.000
Ash	8.463	19.599	0.000

COAL HIGHER HEATING VALUE: 13339 Btu/lb

CHAR HIGHER HEATING VALUE: 11780 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-10 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	89.100	78.091	71.376	55.856
H2O	10.900	21.909	28.624	28.422
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.150
CO	0.000	0.000	0.000	1.042
CO2	0.000	0.000	0.000	0.234
CH4	0.000	0.000	0.000	10.212
H2S	0.000	0.000	0.000	0.369
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.023
Benzene	0.000	0.000	0.000	0.496
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.165

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	127.727	156.993	143.493	117.209
H2O	15.626	44.046	57.546	59.642
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	6.611
CO	0.000	0.000	0.000	2.187
CO2	0.000	0.000	0.000	0.492
CH4	0.000	0.000	0.000	21.429
H2S	0.000	0.000	0.000	0.775
HCl	0.000	0.000	0.000	0.037
NH3	0.000	0.000	0.000	0.019
C2H6	0.000	0.000	0.000	0.048
Benzene	0.000	0.000	0.000	1.042
Toluene	0.000	0.000	0.000	0.006
L/H Oils	0.000	0.000	0.000	0.346
Total	143.353	201.039	201.039	209.841

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	257.50	316.50	289.28	236.29
H2O	281.50	793.50	1036.72	1074.47
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	185.18
CO	0.00	0.00	0.00	61.25
CO2	0.00	0.00	0.00	21.65
CH4	0.00	0.00	0.00	343.79
H2S	0.00	0.00	0.00	26.40
HCl	0.00	0.00	0.00	1.34
NH3	0.00	0.00	0.00	0.33
C2H6	0.00	0.00	0.00	1.44
Benzene	0.00	0.00	0.00	81.37
Toluene	0.00	0.00	0.00	0.59
L/H Oils	0.00	0.00	0.00	61.66
Char	0.00	0.00	0.00	452.09
Total	539.00	1110.00	1326.00	2547.85

AFHP TEST DATA EVALUATION
TEST CONDITION R-11

COAL CARBON CONVERSIONS:

Overall:	59.60 %				
Char:	40.40 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.50 %	0.14 %	0.40 %	0.00 %	11.50 %	2.06 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	651.00 lbs/hr	135.00 lbs/hr	342.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	506.00 lbs/hr	112.00 lbs/hr	
Main Burner:	Oxygen		
	207.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1076.00 lbs/hr	179.69 lbs/hr	

BURNER EXIT NATURAL GAS CARBON CONVERSIONS TO CARBON OXIDES:

Preburner: 90.0 %   Main Burner: 90.0 %

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
452452 Btu/hr	90842 Btu/hr	67268 Btu/hr	228327 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 60 F	Hydrogen & Natural Gas @ 1135 F
Steam Generator:	Water @ 224 F	Hydrogen @ 76 F
Main Burner:	Oxygen @ 59 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3023.4 F	1602.8 F	2302.6 F	2044.0 F
Reactor Mixed Temperature: 1729.7 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.193 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	1.85 seconds
Based on Reactor Outlet Conditions:	1.94 seconds
Based on Reactor Mixed Conditions:	2.33 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils	Natural Gas
Moisture	0.450	0.000	0.000	0.000
Carbon	73.209	74.867	94.170	72.490
Hydrogen	5.316	0.860	5.460	23.610
Nitrogen	1.492	0.892	0.140	2.590
Sulfur	3.035	1.287	0.230	0.000
Chlorine	0.162	0.193	0.000	0.000
Oxygen	8.043	0.907	0.000	1.310
Ash	8.293	20.992	0.000	0.000

COAL HIGHER HEATING VALUE: 13399 Btu/lb

CHAR HIGHER HEATING VALUE: 11402 Btu/lb

NATURAL GAS HIGHER HEATING VALUE: 22695 Btu/lb

AFHP TEST DATA EVALUATION
TEST CONDITION R-11 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	65.845	66.082	61.143	44.242
H2O	17.224	23.818	28.757	25.412
H	0.010	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.255	0.152	0.152	3.281
CO	14.143	8.442	7.145	9.292
CO2	0.856	0.511	1.808	2.671
CH4	1.667	0.995	0.995	14.613
H2S	0.000	0.000	0.000	0.388
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.021
Benzene	0.000	0.000	0.000	0.020
L/H Oils	0.000	0.000	0.000	0.044

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	81.550	137.112	126.865	96.591
H2O	21.332	49.420	59.667	55.480
H	0.012	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.316	0.316	0.316	7.163
CO	17.516	17.516	14.825	20.286
CO2	1.060	1.060	3.751	5.832
CH4	2.064	2.064	2.064	31.904
H2S	0.000	0.000	0.000	0.847
HCl	0.000	0.000	0.000	0.026
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.046
Benzene	0.000	0.000	0.000	0.044
L/H Oils	0.000	0.000	0.000	0.097
Total	123.852	207.488	207.488	218.325

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	164.41	276.42	255.76	194.73
H2O	384.31	890.32	1074.92	999.50
H	0.01	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	8.86	8.86	8.86	200.66
CO	490.64	490.64	415.27	568.23
CO2	46.65	46.65	165.07	256.68
CH4	33.11	33.11	33.11	511.85
H2S	0.00	0.00	0.00	28.85
HCl	0.00	0.00	0.00	0.95
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	1.38
Benzene	0.00	0.00	0.00	3.42
L/H Oils	0.00	0.00	0.00	17.23
Char	0.00	0.00	0.00	425.07
Total	1128.00	1746.00	1953.00	3208.69

TABLE B-3
DETAILED TEST CONDITIONS AND PERFORMANCE OF THE AFHP REACTOR SYSTEM
FOR EACH INDIVIDUAL DATA POINT OBTAINED DURING EACH OF THE
19 REACTOR TEST CONDITIONS

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-1
Data Point: 1

Test Date: 19 SEP 1984
Time Slice: 14:30:44
Duration (minutes): 8.5

Reactor Inlet Steam Mole Percent: 13.4
Reactor Inlet Hydrogen Mole Percent: 86.6
Reactor Exit Steam Mole Percent: 14.8
Reactor Exit Hydrogen Mole Percent: 69.4

Reactor Exit Temperature (deg F): 1821
Reactor Mixed Temperature (deg F): 1531
Average Reactor Temperature (deg F): 1676
Main Burner Exit Temperature (deg F): 2010

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 5.73
Reactor Inlet Gas to Coal (lb-moles/lb): 0.214

Carbon Conversion to Methane (%):	43.70
Carbon Conversion to Ethane (%):	0.05
Carbon Conversion to Benzene (%):	2.20
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	3.10
Carbon Conversion to Carbon Dioxide (%):	0.33
Carbon Conversion to L/H Oils (%):	6.48
Carbon Conversion to Carbon Oxides (%):	3.43
Carbon Conversion to BTX Liquids (%):	2.20
Carbon Conversion to Hydrocarbons (%):	52.43
Carbon Conversion to Hydrocarbon Gas (%):	43.75
Carbon Conversion to Gases (%):	47.18
Carbon Conversion to Liquids (%):	8.68
Total Carbon Conversion (%):	55.86

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 1

AFHP TEST DATA EVALUATION
TEST NUMBER R-1 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	55.86 %				
Char:	44.14 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
43.70 %	0.05 %	2.20 %	0.00 %	3.43 %	6.48 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	300.00 lbs/hr	175.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	226.00 lbs/hr	
Main Burner:	Oxygen		
	126.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	928.00 lbs/hr	97.44 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
333248 Btu/hr	184232 Btu/hr	59296 Btu/hr	477304 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 76 F	Hydrogen & Natural Gas @ 1156 F
Steam Generator:	Water @ 200 F	Hydrogen @ 104 F
Main Burner:	Oxygen @ 82 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3309.6 F	1539.6 F	2009.8 F	1821.0 F
Reactor Mixed Temperature: 1530.7 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.214 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.94 seconds
Based on Reactor Outlet Conditions:	5.33 seconds
Based on Reactor Mixed Conditions:	6.13 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.990	0.000	0.000
Carbon	73.228	76.498	94.170
Hydrogen	5.149	1.471	5.460
Nitrogen	1.519	0.936	0.140
Sulfur	3.047	1.508	0.230
Chlorine	0.162	0.229	0.000
Oxygen	7.826	0.237	0.000
Ash	8.079	19.121	0.000

COAL HIGHER HEATING VALUE: 13322 Btu/lb

CHAR HIGHER HEATING VALUE: 11934 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	78.371	90.573	86.614	69.376
H2O	21.596	9.427	13.386	14.755
H	0.032	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.921
CO	0.000	0.000	0.000	0.878
CO2	0.000	0.000	0.000	0.093
CH4	0.000	0.000	0.000	12.370
H2S	0.000	0.000	0.000	0.347
HCl	0.000	0.000	0.000	0.009
NH3	0.000	0.000	0.000	0.010
C2H6	0.000	0.000	0.000	0.007
Benzene	0.000	0.000	0.000	0.104
L/H Oils	0.000	0.000	0.000	0.131

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	68.041	180.158	172.283	138.659
H2O	18.750	18.751	26.626	29.490
H	0.028	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.838
CO	0.000	0.000	0.000	1.754
CO2	0.000	0.000	0.000	0.187
CH4	0.000	0.000	0.000	24.724
H2S	0.000	0.000	0.000	0.694
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.019
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.207
L/H Oils	0.000	0.000	0.000	0.262
Total	86.820	198.909	198.909	199.867

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	137.17	363.20	347.32	279.54
H2O	337.78	337.80	479.68	531.27
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.53
CO	0.00	0.00	0.00	49.13
CO2	0.00	0.00	0.00	8.22
CH4	0.00	0.00	0.00	396.65
H2S	0.00	0.00	0.00	23.65
HCl	0.00	0.00	0.00	0.62
NH3	0.00	0.00	0.00	0.33
C2H6	0.00	0.00	0.00	0.43
Benzene	0.00	0.00	0.00	16.20
L/H Oils	0.00	0.00	0.00	46.76
Char	0.00	0.00	0.00	392.11
Total	475.00	701.00	827.00	1852.44

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-1
Data Point: 2

Test Date: 19 SEP 1984
Time Slice: 14:35:44
Duration (minutes): 6.5

Reactor Inlet Steam Mole Percent: 13.4
Reactor Inlet Hydrogen Mole Percent: 86.6
Reactor Exit Steam Mole Percent: 14.7
Reactor Exit Hydrogen Mole Percent: 70.0

Reactor Exit Temperature (deg F): 1787
Reactor Mixed Temperature (deg F): 1532
Average Reactor Temperature (deg F): 1659.5
Main Burner Exit Temperature (deg F): 2010

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 5.75
Reactor Inlet Gas to Coal (lb-moles/lb): 0.215

Carbon Conversion to Methane (%):	41.40
Carbon Conversion to Ethane (%):	0.10
Carbon Conversion to Benzene (%):	5.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	3.10
Carbon Conversion to Carbon Dioxide (%):	0.36
Carbon Conversion to L/H Oils (%):	7.79
Carbon Conversion to Carbon Oxides (%):	3.46
Carbon Conversion to BTX Liquids (%):	5.00
Carbon Conversion to Hydrocarbons (%):	54.29
Carbon Conversion to Hydrocarbon Gas (%):	41.50
Carbon Conversion to Gases (%):	44.96
Carbon Conversion to Liquids (%):	12.79
Total Carbon Conversion (%):	57.75

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 2

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	57.75 %				
Char:	42.25 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
41.40 %	0.10 %	5.00 %	0.00 %	3.46 %	7.79 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	301.00 lbs/hr	175.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	227.00 lbs/hr	
Main Burner:	Oxygen		
	127.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	928.00 lbs/hr	97.44 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
326816 Btu/hr	196776 Btu/hr	58041 Btu/hr	489065 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 76 F	Hydrogen & Natural Gas @ 1154 F
Steam Generator:	Water @ 200 F	Hydrogen @ 104 F
Main Burner:	Oxygen @ 83 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3323.5 F	1535.6 F	2009.5 F	1787.0 F
Reactor Mixed Temperature: 1531.5 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.215 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.94 seconds
Based on Reactor Outlet Conditions:	5.38 seconds
Based on Reactor Mixed Conditions:	6.12 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.990	0.000	0.000
Carbon	73.228	75.850	94.170
Hydrogen	5.149	1.458	5.460
Nitrogen	1.519	0.929	0.140
Sulfur	3.047	1.496	0.230
Chlorine	0.162	0.227	0.000
Oxygen	7.826	0.235	0.000
Ash	8.079	19.806	0.000

COAL HIGHER HEATING VALUE: 13322 Btu/lb

CHAR HIGHER HEATING VALUE: 11833 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	78.298	90.565	86.585	69.976
H2O	21.668	9.435	13.415	14.715
H	0.033	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.911
CO	0.000	0.000	0.000	0.872
CO2	0.000	0.000	0.000	0.101
CH4	0.000	0.000	0.000	11.650
H2S	0.000	0.000	0.000	0.349
HCl	0.000	0.000	0.000	0.009
NH3	0.000	0.000	0.000	0.011
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.235
L/H Oils	0.000	0.000	0.000	0.157

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	67.978	180.592	172.654	140.686
H2O	18.812	18.813	26.751	29.583
H	0.029	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.843
CO	0.000	0.000	0.000	1.754
CO2	0.000	0.000	0.000	0.204
CH4	0.000	0.000	0.000	23.423
H2S	0.000	0.000	0.000	0.701
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.021
C2H6	0.000	0.000	0.000	0.028
Benzene	0.000	0.000	0.000	0.471
L/H Oils	0.000	0.000	0.000	0.315
Total	86.821	199.405	199.405	201.048

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	137.04	364.07	348.07	283.62
H2O	338.91	338.93	481.93	532.96
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.65
CO	0.00	0.00	0.00	49.13
CO2	0.00	0.00	0.00	8.96
CH4	0.00	0.00	0.00	375.78
H2S	0.00	0.00	0.00	23.90
HCl	0.00	0.00	0.00	0.66
NH3	0.00	0.00	0.00	0.36
C2H6	0.00	0.00	0.00	0.85
Benzene	0.00	0.00	0.00	36.83
L/H Oils	0.00	0.00	0.00	56.21
Char	0.00	0.00	0.00	378.53
Total	476.00	703.00	830.00	1855.44

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-1
Data Point: 3

Test Date: 19 SEP 1984
Time Slice: 14:43:44
Duration (minutes): 9.5

Reactor Inlet Steam Mole Percent: 13.5
Reactor Inlet Hydrogen Mole Percent: 86.5
Reactor Exit Steam Mole Percent: 14.8
Reactor Exit Hydrogen Mole Percent: 69.1

Reactor Exit Temperature (deg F): 1867
Reactor Mixed Temperature (deg F): 1542
Average Reactor Temperature (deg F): 1704.5
Main Burner Exit Temperature (deg F): 2024

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 5.66
Reactor Inlet Gas to Coal (lb-moles/lb): 0.215

Carbon Conversion to Methane (%):	43.90
Carbon Conversion to Ethane (%):	0.14
Carbon Conversion to Benzene (%):	4.70
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	3.20
Carbon Conversion to Carbon Dioxide (%):	0.39
Carbon Conversion to L/H Oils (%):	4.70
Carbon Conversion to Carbon Oxides (%):	3.59
Carbon Conversion to BTX Liquids (%):	4.70
Carbon Conversion to Hydrocarbons (%):	53.44
Carbon Conversion to Hydrocarbon Gas (%):	44.04
Carbon Conversion to Gases (%):	47.63
Carbon Conversion to Liquids (%):	9.40
Total Carbon Conversion (%):	57.03

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 3

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	57.03 %				
Char:	42.97 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
43.90 %	0.14 %	4.70 %	0.00 %	3.59 %	4.70 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	304.00 lbs/hr	175.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	227.00 lbs/hr	
Main Burner:	Oxygen		
	127.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	928.00 lbs/hr	97.44 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
335402 Btu/hr	188418 Btu/hr	58196 Btu/hr	406517 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 78 F	Hydrogen & Natural Gas @ 1162 F
Steam Generator:	Water @ 200 F	Hydrogen @ 104 F
Main Burner:	Oxygen @ 84 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3341.2 F	1551.3 F	2024.1 F	1867.0 F
Reactor Mixed Temperature: 1542.2 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.215 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.91 seconds
Based on Reactor Outlet Conditions:	5.22 seconds
Based on Reactor Mixed Conditions:	6.09 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.990	0.000	0.000
Carbon	73.228	76.102	94.170
Hydrogen	5.149	1.463	5.460
Nitrogen	1.519	0.932	0.140
Sulfur	3.047	1.501	0.230
Chlorine	0.162	0.228	0.000
Oxygen	7.826	0.236	0.000
Ash	8.079	19.539	0.000

COAL HIGHER HEATING VALUE: 13322 Btu/lb

CHAR HIGHER HEATING VALUE: 11872 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	78.080	90.471	86.491	69.127
H2O	21.884	9.529	13.509	14.827
H	0.035	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.920
CO	0.000	0.000	0.000	0.904
CO2	0.000	0.000	0.000	0.110
CH4	0.000	0.000	0.000	12.408
H2S	0.000	0.000	0.000	0.350
HCl	0.000	0.000	0.000	0.009
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.020
Benzene	0.000	0.000	0.000	0.221
L/H Oils	0.000	0.000	0.000	0.095

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	67.790	180.404	172.466	138.377
H2O	19.000	19.001	26.939	29.679
H	0.031	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.844
CO	0.000	0.000	0.000	1.810
CO2	0.000	0.000	0.000	0.221
CH4	0.000	0.000	0.000	24.837
H2S	0.000	0.000	0.000	0.700
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.017
C2H6	0.000	0.000	0.000	0.040
Benzene	0.000	0.000	0.000	0.443
L/H Oils	0.000	0.000	0.000	0.190
Total	86.821	199.405	199.405	200.176

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	136.66	363.69	347.69	278.97
H2O	342.29	342.31	485.31	534.69
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.67
CO	0.00	0.00	0.00	50.71
CO2	0.00	0.00	0.00	9.71
CH4	0.00	0.00	0.00	398.47
H2S	0.00	0.00	0.00	23.85
HCl	0.00	0.00	0.00	0.65
NH3	0.00	0.00	0.00	0.29
C2H6	0.00	0.00	0.00	1.19
Benzene	0.00	0.00	0.00	34.62
L/H Oils	0.00	0.00	0.00	33.92
Char	0.00	0.00	0.00	383.70
Total	479.00	706.00	833.00	1858.44

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-1
Data Point: 4

Test Date: 19 SEP 1984
Time Slice: 14:54:29
Duration (minutes): 10.0

Reactor Inlet Steam Mole Percent: 13.4
Reactor Inlet Hydrogen Mole Percent: 86.6
Reactor Exit Steam Mole Percent: 14.8
Reactor Exit Hydrogen Mole Percent: 69.6

Reactor Exit Temperature (deg F): 1824
Reactor Mixed Temperature (deg F): 1537
Average Reactor Temperature (deg F): 1680.5
Main Burner Exit Temperature (deg F): 2017

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 5.70
Reactor Inlet Gas to Coal (lb-moles/lb): 0.215

Carbon Conversion to Methane (%):	42.60
Carbon Conversion to Ethane (%):	0.10
Carbon Conversion to Benzene (%):	4.90
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	3.10
Carbon Conversion to Carbon Dioxide (%):	0.35
Carbon Conversion to L/H Oils (%):	6.36
Carbon Conversion to Carbon Oxides (%):	3.45
Carbon Conversion to BTX Liquids (%):	4.90
Carbon Conversion to Hydrocarbons (%):	53.96
Carbon Conversion to Hydrocarbon Gas (%):	42.70
Carbon Conversion to Gases (%):	46.15
Carbon Conversion to Liquids (%):	11.26
Total Carbon Conversion (%):	57.41

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 4

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	57.41 %				
Char:	42.59 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
42.60 %	0.10 %	4.90 %	0.00 %	3.45 %	6.36 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	302.00 lbs/hr	176.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	226.00 lbs/hr	
Main Burner:	Oxygen		
	127.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	928.00 lbs/hr	97.44 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
336003 Btu/hr	187031 Btu/hr	58217 Btu/hr	454527 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 77 F	Hydrogen & Natural Gas @ 1156 F
Steam Generator:	Water @ 200 F	Hydrogen @ 104 F
Main Burner:	Oxygen @ 83 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3310.8 F	1543.4 F	2016.7 F	1824.0 F
Reactor Mixed Temperature: 1536.8 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.215 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.92 seconds
Based on Reactor Outlet Conditions:	5.30 seconds
Based on Reactor Mixed Conditions:	6.10 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.990	0.000	0.000
Carbon	73.228	75.970	94.170
Hydrogen	5.149	1.460	5.460
Nitrogen	1.519	0.930	0.140
Sulfur	3.047	1.498	0.230
Chlorine	0.162	0.227	0.000
Oxygen	7.826	0.235	0.000
Ash	8.079	19.679	0.000

COAL HIGHER HEATING VALUE: 13322 Btu/lb

CHAR HIGHER HEATING VALUE: 11851 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	78.350	90.534	86.553	69.569
H2O	21.617	9.466	13.447	14.785
H	0.032	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.916
CO	0.000	0.000	0.000	0.874
CO2	0.000	0.000	0.000	0.099
CH4	0.000	0.000	0.000	12.016
H2S	0.000	0.000	0.000	0.349
HCl	0.000	0.000	0.000	0.009
NH3	0.000	0.000	0.000	0.010
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.230
L/H Oils	0.000	0.000	0.000	0.128

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	68.412	180.529	172.591	139.544
H2O	18.875	18.876	26.814	29.657
H	0.028	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.843
CO	0.000	0.000	0.000	1.754
CO2	0.000	0.000	0.000	0.198
CH4	0.000	0.000	0.000	24.102
H2S	0.000	0.000	0.000	0.701
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.019
C2H6	0.000	0.000	0.000	0.028
Benzene	0.000	0.000	0.000	0.462
L/H Oils	0.000	0.000	0.000	0.257
Total	87.316	199.405	199.405	200.583

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	137.92	363.95	347.94	281.32
H2O	340.04	340.05	483.06	534.28
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.66
CO	0.00	0.00	0.00	49.13
CO2	0.00	0.00	0.00	8.71
CH4	0.00	0.00	0.00	386.67
H2S	0.00	0.00	0.00	23.88
HCl	0.00	0.00	0.00	0.66
NH3	0.00	0.00	0.00	0.33
C2H6	0.00	0.00	0.00	0.85
Benzene	0.00	0.00	0.00	36.09
L/H Oils	0.00	0.00	0.00	45.90
Char	0.00	0.00	0.00	380.97
Total	478.00	704.00	831.00	1856.44

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-1
Data Point: 5

Test Date: 19 SEP 1984
Time Slice: 15:03:29
Duration (minutes): 9.5

Reactor Inlet Steam Mole Percent: 13.4
Reactor Inlet Hydrogen Mole Percent: 86.6
Reactor Exit Steam Mole Percent: 14.8
Reactor Exit Hydrogen Mole Percent: 69.5

Reactor Exit Temperature (deg F): 1873
Reactor Mixed Temperature (deg F): 1536
Average Reactor Temperature (deg F): 1704.5
Main Burner Exit Temperature (deg F): 2015

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 5.64
Reactor Inlet Gas to Coal (lb-moles/lb): 0.215

Carbon Conversion to Methane (%):	43.10
Carbon Conversion to Ethane (%):	0.14
Carbon Conversion to Benzene (%):	4.80
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	3.10
Carbon Conversion to Carbon Dioxide (%):	0.39
Carbon Conversion to L/H Oils (%):	4.47
Carbon Conversion to Carbon Oxides (%):	3.49
Carbon Conversion to BTX Liquids (%):	4.80
Carbon Conversion to Hydrocarbons (%):	52.51
Carbon Conversion to Hydrocarbon Gas (%):	43.24
Carbon Conversion to Gases (%):	46.73
Carbon Conversion to Liquids (%):	9.27
Total Carbon Conversion (%):	56.00

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 5

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	56.00 %				
Char:	44.00 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
43.10 %	0.14 %	4.80 %	0.00 %	3.49 %	4.47 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	303.00 lbs/hr	176.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	227.00 lbs/hr	
Main Burner:	Oxygen		
	127.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	928.00 lbs/hr	97.44 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
340560 Btu/hr	188416 Btu/hr	59116 Btu/hr	364572 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 79 F	Hydrogen & Natural Gas @ 1165 F
Steam Generator:	Water @ 200 F	Hydrogen @ 103 F
Main Burner:	Oxygen @ 85 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3319.6 F	1543.6 F	2015.3 F	1873.0 F
Reactor Mixed Temperature: 1536.5 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.215 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.91 seconds
Based on Reactor Outlet Conditions:	5.18 seconds
Based on Reactor Mixed Conditions:	6.09 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.990	0.000	0.000
Carbon	73.228	76.452	94.170
Hydrogen	5.149	1.470	5.460
Nitrogen	1.519	0.936	0.140
Sulfur	3.047	1.507	0.230
Chlorine	0.162	0.229	0.000
Oxygen	7.826	0.237	0.000
Ash	8.079	19.170	0.000

COAL HIGHER HEATING VALUE: 13322 Btu/lb

CHAR HIGHER HEATING VALUE: 11927 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 5 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	78.278	90.526	86.555	69.517
H2O	21.688	9.474	13.445	14.761
H	0.033	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.911
CO	0.000	0.000	0.000	0.873
CO2	0.000	0.000	0.000	0.110
CH4	0.000	0.000	0.000	12.131
H2S	0.000	0.000	0.000	0.346
HCl	0.000	0.000	0.000	0.009
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.020
Benzene	0.000	0.000	0.000	0.225
L/H Oils	0.000	0.000	0.000	0.090

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	68.349	180.963	173.025	139.740
H2O	18.937	18.938	26.876	29.672
H	0.029	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.841
CO	0.000	0.000	0.000	1.754
CO2	0.000	0.000	0.000	0.221
CH4	0.000	0.000	0.000	24.385
H2S	0.000	0.000	0.000	0.696
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.017
C2H6	0.000	0.000	0.000	0.040
Benzene	0.000	0.000	0.000	0.453
L/H Oils	0.000	0.000	0.000	0.181
Total	87.316	199.901	199.901	201.015

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	137.79	364.82	348.82	281.72
H2O	341.16	341.18	484.18	534.56
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.59
CO	0.00	0.00	0.00	49.13
CO2	0.00	0.00	0.00	9.71
CH4	0.00	0.00	0.00	391.21
H2S	0.00	0.00	0.00	23.71
HCl	0.00	0.00	0.00	0.63
NH3	0.00	0.00	0.00	0.29
C2H6	0.00	0.00	0.00	1.19
Benzene	0.00	0.00	0.00	35.36
L/H Oils	0.00	0.00	0.00	32.26
Char	0.00	0.00	0.00	391.10
Total	479.00	706.00	833.00	1858.44

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-1
Data Point: 6

Test Date: 19 SEP 1984
Time Slice: 15:13:44
Duration (minutes): 8.0

Reactor Inlet Steam Mole Percent: 13.4
Reactor Inlet Hydrogen Mole Percent: 86.6
Reactor Exit Steam Mole Percent: 14.7
Reactor Exit Hydrogen Mole Percent: 70.6

Reactor Exit Temperature (deg F): 1844
Reactor Mixed Temperature (deg F): 1536
Average Reactor Temperature (deg F): 1690
Main Burner Exit Temperature (deg F): 2014

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 5.64
Reactor Inlet Gas to Coal (lb-moles/lb): 0.216

Carbon Conversion to Methane (%):	40.10
Carbon Conversion to Ethane (%):	0.17
Carbon Conversion to Benzene (%):	5.30
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	3.00
Carbon Conversion to Carbon Dioxide (%):	0.43
Carbon Conversion to L/H Oils (%):	5.57
Carbon Conversion to Carbon Oxides (%):	3.43
Carbon Conversion to BTX Liquids (%):	5.30
Carbon Conversion to Hydrocarbons (%):	51.14
Carbon Conversion to Hydrocarbon Gas (%):	40.27
Carbon Conversion to Gases (%):	43.70
Carbon Conversion to Liquids (%):	10.87
Total Carbon Conversion (%):	54.57

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 6

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 6

COAL CARBON CONVERSIONS:

Overall:	54.57 %				
Char:	45.43 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
40.10 %	0.17 %	5.30 %	0.00 %	3.43 %	5.57 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	304.00 lbs/hr	176.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	228.00 lbs/hr	
Main Burner:	Oxygen		
	127.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	928.00 lbs/hr	97.44 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
336639 Btu/hr	189016 Btu/hr	57988 Btu/hr	352770 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 81 F	Hydrogen & Natural Gas @ 1157 F
Steam Generator:	Water @ 200 F	Hydrogen @ 101 F
Main Burner:	Oxygen @ 86 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3325.7 F	1542.4 F	2013.7 F	1844.0 F
Reactor Mixed Temperature: 1536.2 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.216 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.90 seconds
Based on Reactor Outlet Conditions:	5.20 seconds
Based on Reactor Mixed Conditions:	6.08 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.990	0.000	0.000
Carbon	73.228	76.916	94.170
Hydrogen	5.149	1.479	5.460
Nitrogen	1.519	0.942	0.140
Sulfur	3.047	1.517	0.230
Chlorine	0.162	0.230	0.000
Oxygen	7.826	0.238	0.000
Ash	8.079	18.679	0.000

COAL HIGHER HEATING VALUE: 13322 Btu/lb

CHAR HIGHER HEATING VALUE: 11999 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-1 - DATA POINT 6 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	78.206	90.518	86.557	70.559
H2O	21.760	9.482	13.443	14.667
H	0.034	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.891
CO	0.000	0.000	0.000	0.837
CO2	0.000	0.000	0.000	0.120
CH4	0.000	0.000	0.000	11.187
H2S	0.000	0.000	0.000	0.340
HCl	0.000	0.000	0.000	0.008
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.024
Benzene	0.000	0.000	0.000	0.246
L/H Oils	0.000	0.000	0.000	0.111

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	68.287	181.396	173.458	143.088
H2O	19.000	19.001	26.939	29.744
H	0.029	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.835
CO	0.000	0.000	0.000	1.697
CO2	0.000	0.000	0.000	0.243
CH4	0.000	0.000	0.000	22.687
H2S	0.000	0.000	0.000	0.689
HCl	0.000	0.000	0.000	0.016
NH3	0.000	0.000	0.000	0.019
C2H6	0.000	0.000	0.000	0.048
Benzene	0.000	0.000	0.000	0.500
L/H Oils	0.000	0.000	0.000	0.226
Total	87.317	200.397	200.397	202.793

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	137.67	365.69	349.69	288.47
H2O	342.29	342.31	485.31	535.85
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.44
CO	0.00	0.00	0.00	47.54
CO2	0.00	0.00	0.00	10.71
CH4	0.00	0.00	0.00	363.98
H2S	0.00	0.00	0.00	23.49
HCl	0.00	0.00	0.00	0.60
NH3	0.00	0.00	0.00	0.32
C2H6	0.00	0.00	0.00	1.45
Benzene	0.00	0.00	0.00	39.04
L/H Oils	0.00	0.00	0.00	40.19
Char	0.00	0.00	0.00	401.38
Total	480.00	708.00	835.00	1860.44

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-2
Data Point: 1

Test Date: 24 SEP 1984
Time Slice: 15:35:09
Duration (minutes): 11.0

Reactor Inlet Steam Mole Percent: 13.7
Reactor Inlet Hydrogen Mole Percent: 86.3
Reactor Exit Steam Mole Percent: 15.0
Reactor Exit Hydrogen Mole Percent: 68.2

Reactor Exit Temperature (deg F): 1875
Reactor Mixed Temperature (deg F): 1552
Average Reactor Temperature (deg F): 1713.5
Main Burner Exit Temperature (deg F): 2048

Reactor Pressure (psia): 1016
Reactor Residence Time (seconds): 5.58
Reactor Inlet Gas to Coal (lb-moles/lb): 0.210

Carbon Conversion to Methane (%):	46.30
Carbon Conversion to Ethane (%):	0.13
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	3.39
Carbon Conversion to Carbon Dioxide (%):	0.42
Carbon Conversion to L/H Oils (%):	4.40
Carbon Conversion to Carbon Oxides (%):	3.81
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	50.83
Carbon Conversion to Hydrocarbon Gas (%):	46.43
Carbon Conversion to Gases (%):	50.24
Carbon Conversion to Liquids (%):	4.40
Total Carbon Conversion (%):	54.64

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 7

AFHP TEST DATA EVALUATION
TEST NUMBER R-2 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	54.64 %				
Char:	45.36 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
46.30 %	0.13 %	0.00 %	0.00 %	3.81 %	4.40 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	297.00 lbs/hr	172.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	233.00 lbs/hr	
Main Burner:	Oxygen		
	143.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	958.00 lbs/hr	100.59 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
334550 Btu/hr	187927 Btu/hr	56855 Btu/hr	493114 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 63 F	Hydrogen & Natural Gas @ 1206 F
Steam Generator:	Water @ 200 F	Hydrogen @ 87 F
Main Burner:	Oxygen @ 63 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3354.3 F	1514.1 F	2048.1 F	1875.0 F
Reactor Mixed Temperature: 1552.5 F			

PRESSURE: 1016.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.210 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.83 seconds
Based on Reactor Outlet Conditions:	5.15 seconds
Based on Reactor Mixed Conditions:	6.02 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.770	0.000	0.000
Carbon	72.984	77.319	94.170
Hydrogen	5.200	1.002	5.460
Nitrogen	1.492	0.885	0.140
Sulfur	3.075	1.570	0.230
Chlorine	0.163	0.106	0.000
Oxygen	8.130	0.000	0.000
Ash	8.186	19.119	0.000

COAL HIGHER HEATING VALUE: 13365 Btu/lb

CHAR HIGHER HEATING VALUE: 11909 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-2 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	78.209	90.760	86.311	68.171
H2O	21.752	9.240	13.689	14.976
H	0.037	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.957
CO	0.000	0.000	0.000	0.975
CO2	0.000	0.000	0.000	0.121
CH4	0.000	0.000	0.000	13.314
H2S	0.000	0.000	0.000	0.353
HCl	0.000	0.000	0.000	0.016
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.019
L/H Oils	0.000	0.000	0.000	0.091

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	66.739	182.330	173.392	137.999
H2O	18.562	18.563	27.501	30.316
H	0.032	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.961
CO	0.000	0.000	0.000	1.973
CO2	0.000	0.000	0.000	0.244
CH4	0.000	0.000	0.000	26.952
H2S	0.000	0.000	0.000	0.716
HCl	0.000	0.000	0.000	0.032
NH3	0.000	0.000	0.000	0.017
C2H6	0.000	0.000	0.000	0.038
L/H Oils	0.000	0.000	0.000	0.183
Total	85.334	200.893	200.893	202.431

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	134.55	367.58	349.56	278.21
H2O	334.40	334.42	495.44	546.16
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	110.97
CO	0.00	0.00	0.00	55.28
CO2	0.00	0.00	0.00	10.76
CH4	0.00	0.00	0.00	432.39
H2S	0.00	0.00	0.00	24.39
HCl	0.00	0.00	0.00	1.16
NH3	0.00	0.00	0.00	0.29
C2H6	0.00	0.00	0.00	1.14
L/H Oils	0.00	0.00	0.00	32.67
Char	0.00	0.00	0.00	410.19
Total	469.00	702.00	845.00	1903.59

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-2
Data Point: 2

Test Date: 24 SEP 1984
Time Slice: 15:43:49
Duration (minutes): 12.4

Reactor Inlet Steam Mole Percent: 14.3
Reactor Inlet Hydrogen Mole Percent: 85.7
Reactor Exit Steam Mole Percent: 15.3
Reactor Exit Hydrogen Mole Percent: 64.9

Reactor Exit Temperature (deg F): 1982
Reactor Mixed Temperature (deg F): 1598
Average Reactor Temperature (deg F): 1790
Main Burner Exit Temperature (deg F): 2114

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 5.47
Reactor Inlet Gas to Coal (lb-moles/lb): 0.208

Carbon Conversion to Methane (%):	53.93
Carbon Conversion to Ethane (%):	0.08
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	4.98
Carbon Conversion to Carbon Dioxide (%):	0.47
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	5.45
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	54.01
Carbon Conversion to Hydrocarbon Gas (%):	54.01
Carbon Conversion to Gases (%):	59.46
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	59.46

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 8

AFHP TEST DATA EVALUATION

TEST NUMBER R-2 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	59.46 %				
Char:	40.54 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
53.93 %	0.08 %	0.00 %	0.00 %	5.45 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	301.00 lbs/hr	170.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	232.00 lbs/hr	
Main Burner:	Oxygen		
	155.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	958.00 lbs/hr	100.59 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
335133 Btu/hr	193728 Btu/hr	56738 Btu/hr	516599 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 66 F	Hydrogen & Natural Gas @ 1206 F
Steam Generator:	Water @ 200 F	Hydrogen @ 87 F
Main Burner:	Oxygen @ 67 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3404.8 F	1531.4 F	2113.9 F	1982.0 F
Reactor Mixed Temperature: 1598.2 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.208 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.74 seconds
Based on Reactor Outlet Conditions:	5.02 seconds
Based on Reactor Mixed Conditions:	5.92 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.770	0.000
Carbon	72.984	75.600
Hydrogen	5.200	0.980
Nitrogen	1.492	0.866
Sulfur	3.075	1.535
Chlorine	0.163	0.103
Oxygen	8.130	0.000
Ash	8.186	20.916

COAL HIGHER HEATING VALUE: 13365 Btu/lb

CHAR HIGHER HEATING VALUE: 11644 Btu/lb

AFHP TEST DATA EVALUATION
TEST NUMBER R-2 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	77.651	90.565	85.707	64.881
H2O	22.304	9.435	14.293	15.287
H	0.044	0.000	0.000	0.000
OH	0.002	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.005
CO	0.000	0.000	0.000	1.461
CO2	0.000	0.000	0.000	0.138
CH4	0.000	0.000	0.000	15.821
H2S	0.000	0.000	0.000	0.373
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.012

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	65.494	180.592	170.904	128.739
H2O	18.812	18.813	28.501	30.332
H	0.037	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.979
CO	0.000	0.000	0.000	2.899
CO2	0.000	0.000	0.000	0.274
CH4	0.000	0.000	0.000	31.393
H2S	0.000	0.000	0.000	0.739
HCl	0.000	0.000	0.000	0.033
NH3	0.000	0.000	0.000	0.012
C2H6	0.000	0.000	0.000	0.023
Total	84.345	199.405	199.405	198.424

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	132.04	364.07	344.54	259.54
H2O	338.90	338.93	513.46	546.45
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	111.46
CO	0.00	0.00	0.00	81.20
CO2	0.00	0.00	0.00	12.04
CH4	0.00	0.00	0.00	503.65
H2S	0.00	0.00	0.00	25.19
HCl	0.00	0.00	0.00	1.21
NH3	0.00	0.00	0.00	0.21
C2H6	0.00	0.00	0.00	0.70
Char	0.00	0.00	0.00	374.93
Total	471.00	703.00	858.00	1916.59

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-2
Data Point: 3

Test Date: 24 SEP 1984
Time Slice: 15:59:49
Duration (minutes): 12.3

Reactor Inlet Steam Mole Percent: 14.5
Reactor Inlet Hydrogen Mole Percent: 85.5
Reactor Exit Steam Mole Percent: 15.1
Reactor Exit Hydrogen Mole Percent: 64.6

Reactor Exit Temperature (deg F): 2000
Reactor Mixed Temperature (deg F): 1614
Average Reactor Temperature (deg F): 1807
Main Burner Exit Temperature (deg F): 2136

Reactor Pressure (psia): 1016
Reactor Residence Time (seconds): 5.42
Reactor Inlet Gas to Coal (lb-moles/lb): 0.208

Carbon Conversion to Methane (%):	54.46
Carbon Conversion to Ethane (%):	0.06
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	6.14
Carbon Conversion to Carbon Dioxide (%):	0.54
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	6.68
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	54.52
Carbon Conversion to Hydrocarbon Gas (%):	54.52
Carbon Conversion to Gases (%):	61.20
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	61.20

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 9

Notes:

Measures carbon conversions multiplied by 1.0595 to obtain agreement with ash tracer.

AFHP TEST DATA EVALUATION

TEST NUMBER R-2 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	61.20 %				
Char:	38.80 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
54.46 %	0.06 %	0.00 %	0.00 %	6.68 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	306.00 lbs/hr	170.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	232.00 lbs/hr	
Main Burner:	Oxygen		
	157.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	958.00 lbs/hr	100.59 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
338335 Btu/hr	194786 Btu/hr	59119 Btu/hr	488779 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 66 F	Hydrogen & Natural Gas @ 1205 F
Steam Generator:	Water @ 200 F	Hydrogen @ 86 F
Main Burner:	Oxygen @ 66 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3437.2 F	1548.5 F	2135.7 F	2000.0 F
Reactor Mixed Temperature: 1614.1 F			

PRESSURE: 1016.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.208 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.70 seconds
Based on Reactor Outlet Conditions:	4.97 seconds
Based on Reactor Mixed Conditions:	5.88 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.770	0.000
Carbon	72.984	74.898
Hydrogen	5.200	0.971
Nitrogen	1.492	0.858
Sulfur	3.075	1.521
Chlorine	0.163	0.102
Oxygen	8.130	0.000
Ash	8.186	21.651

COAL HIGHER HEATING VALUE: 13365 Btu/lb

CHAR HIGHER HEATING VALUE: 11536 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-2 - DATA POINT 3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	77.276	90.409	85.488	64.611
H2O	22.673	9.591	14.512	15.088
H	0.048	0.000	0.000	0.000
OH	0.002	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.003
CO	0.000	0.000	0.000	1.797
CO2	0.000	0.000	0.000	0.158
CH4	0.000	0.000	0.000	15.936
H2S	0.000	0.000	0.000	0.376
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.009

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	65.180	180.279	170.466	128.530
H2O	19.124	19.126	28.939	30.013
H	0.041	0.000	0.000	0.000
OH	0.002	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.984
CO	0.000	0.000	0.000	3.574
CO2	0.000	0.000	0.000	0.314
CH4	0.000	0.000	0.000	31.702
H2S	0.000	0.000	0.000	0.747
HCl	0.000	0.000	0.000	0.034
NH3	0.000	0.000	0.000	0.012
C2H6	0.000	0.000	0.000	0.017
Total	84.347	199.405	199.405	198.927

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	131.40	363.44	343.66	259.12
H2O	344.53	344.56	521.34	540.70
H	0.04	0.00	0.00	0.00
OH	0.03	0.00	0.00	0.00
N2	0.00	0.00	0.00	111.61
CO	0.00	0.00	0.00	100.11
CO2	0.00	0.00	0.00	13.83
CH4	0.00	0.00	0.00	508.60
H2S	0.00	0.00	0.00	25.46
HCl	0.00	0.00	0.00	1.23
NH3	0.00	0.00	0.00	0.20
C2H6	0.00	0.00	0.00	0.53
Char	0.00	0.00	0.00	362.21
Total	476.00	708.00	865.00	1923.59

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-2
Data Point: 4

Test Date: 24 SEP 1984
Time Slice: 16:08:29
Duration (minutes): 8.8

Reactor Inlet Steam Mole Percent: 14.6
Reactor Inlet Hydrogen Mole Percent: 85.4
Reactor Exit Steam Mole Percent: 15.2
Reactor Exit Hydrogen Mole Percent: 64.3

Reactor Exit Temperature (deg F): 2004
Reactor Mixed Temperature (deg F): 1616
Average Reactor Temperature (deg F): 1810
Main Burner Exit Temperature (deg F): 2139

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 5.42
Reactor Inlet Gas to Coal (lb-moles/lb): 0.208

Carbon Conversion to Methane (%):	55.09
Carbon Conversion to Ethane (%):	0.06
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	6.14
Carbon Conversion to Carbon Dioxide (%):	0.54
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	6.68
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	55.15
Carbon Conversion to Hydrocarbon Gas (%):	55.15
Carbon Conversion to Gases (%):	61.83
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	61.83

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 10

AFHP TEST DATA EVALUATION

TEST NUMBER R-2 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	61.83 %				
Char:	38.17 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
55.09 %	0.06 %	0.00 %	0.00 %	6.68 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	308.00 lbs/hr	169.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	233.00 lbs/hr	
Main Burner:	Oxygen		
	157.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	958.00 lbs/hr	100.59 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
342620 Btu/hr	195727 Btu/hr	58237 Btu/hr	501454 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 66 F	Hydrogen & Natural Gas @ 1209 F
Steam Generator:	Water @ 200 F	Hydrogen @ 84 F
Main Burner:	Oxygen @ 67 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3460.6 F	1551.4 F	2138.7 F	2004.0 F
Reactor Mixed Temperature: 1616.5 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.208 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.69 seconds
Based on Reactor Outlet Conditions:	4.97 seconds
Based on Reactor Mixed Conditions:	5.87 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.770	0.000
Carbon	72.984	74.631
Hydrogen	5.200	0.967
Nitrogen	1.492	0.854
Sulfur	3.075	1.515
Chlorine	0.163	0.102
Oxygen	8.130	0.000
Ash	8.186	21.930

COAL HIGHER HEATING VALUE: 13365 Btu/lb

CHAR HIGHER HEATING VALUE: 11495 Btu/lb

AFHP TEST DATA EVALUATION
TEST NUMBER R-2 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	76.990	90.346	85.425	64.301
H2O	22.956	9.654	14.575	15.176
H	0.052	0.000	0.000	0.000
OH	0.002	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.007
CO	0.000	0.000	0.000	1.800
CO2	0.000	0.000	0.000	0.158
CH4	0.000	0.000	0.000	16.148
H2S	0.000	0.000	0.000	0.378
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.009

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	64.558	180.154	170.341	127.697
H2O	19.249	19.251	29.064	30.138
H	0.044	0.000	0.000	0.000
OH	0.002	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.986
CO	0.000	0.000	0.000	3.574
CO2	0.000	0.000	0.000	0.314
CH4	0.000	0.000	0.000	32.069
H2S	0.000	0.000	0.000	0.750
HCl	0.000	0.000	0.000	0.034
NH3	0.000	0.000	0.000	0.012
C2H6	0.000	0.000	0.000	0.017
Total	83.852	199.405	199.405	198.591

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	130.15	363.19	343.41	257.44
H2O	346.78	346.81	523.59	542.95
H	0.04	0.00	0.00	0.00
OH	0.03	0.00	0.00	0.00
N2	0.00	0.00	0.00	111.66
CO	0.00	0.00	0.00	100.11
CO2	0.00	0.00	0.00	13.83
CH4	0.00	0.00	0.00	514.48
H2S	0.00	0.00	0.00	25.55
HCl	0.00	0.00	0.00	1.23
NH3	0.00	0.00	0.00	0.20
C2H6	0.00	0.00	0.00	0.53
Char	0.00	0.00	0.00	357.60
Total	477.00	710.00	867.00	1925.59

30 Aug 1985

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-2
Data Point: 5

Test Date: 24 SEP 1984
Time Slice: 16:17:29
Duration (minutes): 7.5

Reactor Inlet Steam Mole Percent: 14.8
Reactor Inlet Hydrogen Mole Percent: 85.2
Reactor Exit Steam Mole Percent: 15.1
Reactor Exit Hydrogen Mole Percent: 63.9

Reactor Exit Temperature (deg F): 2011
Reactor Mixed Temperature (deg F): 1631
Average Reactor Temperature (deg F): 1821
Main Burner Exit Temperature (deg F): 2160

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 5.40
Reactor Inlet Gas to Coal (lb-moles/lb): 0.208

Carbon Conversion to Methane (%):	55.73
Carbon Conversion to Ethane (%):	0.08
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	6.89
Carbon Conversion to Carbon Dioxide (%):	0.61
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	7.50
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	55.81
Carbon Conversion to Hydrocarbon Gas (%):	55.81
Carbon Conversion to Gases (%):	63.31
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	63.31

Graphics Plot Symbol: 1
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 11

AFHP TEST DATA EVALUATION

TEST NUMBER R-2 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	63.31 %					
Char:	36.69 %					
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils	
55.73 %	0.08 %	0.00 %	0.00 %	7.50 %	0.00 %	

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	312.00 lbs/hr	169.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	0.00 lbs/hr	232.00 lbs/hr	
Main Burner:	Oxygen		
	158.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	958.00 lbs/hr	100.59 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
343655 Btu/hr	198055 Btu/hr	58456 Btu/hr	511847 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 67 F	Hydrogen & Natural Gas @ 1209 F
Steam Generator:	Water @ 200 F	Hydrogen @ 83 F
Main Burner:	Oxygen @ 68 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3489.0 F	1568.7 F	2159.7 F	2011.0 F
Reactor Mixed Temperature: 1630.9 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.208 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.66 seconds
Based on Reactor Outlet Conditions:	4.96 seconds
Based on Reactor Mixed Conditions:	5.84 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.770	0.000
Carbon	72.984	73.977
Hydrogen	5.200	0.959
Nitrogen	1.492	0.847
Sulfur	3.075	1.502
Chlorine	0.163	0.101
Oxygen	8.130	- .000
Ash	8.186	22.615

COAL HIGHER HEATING VALUE: 13365 Btu/lb

CHAR HIGHER HEATING VALUE: 11394 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-2 - DATA POINT 5 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	76.688	90.196	85.231	63.908
H2O	23.253	9.804	14.769	15.098
H	0.057	0.000	0.000	0.000
OH	0.002	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.013
CO	0.000	0.000	0.000	2.023
CO2	0.000	0.000	0.000	0.179
CH4	0.000	0.000	0.000	16.363
H2S	0.000	0.000	0.000	0.381
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.012

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	64.306	179.408	169.533	126.704
H2O	19.499	19.501	29.376	29.933
H	0.048	0.000	0.000	0.000
OH	0.002	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.990
CO	0.000	0.000	0.000	4.011
CO2	0.000	0.000	0.000	0.355
CH4	0.000	0.000	0.000	32.441
H2S	0.000	0.000	0.000	0.756
HCl	0.000	0.000	0.000	0.034
NH3	0.000	0.000	0.000	0.012
C2H6	0.000	0.000	0.000	0.023
Total	83.854	198.909	198.909	198.259

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	129.64	361.69	341.78	255.44
H2O	351.28	351.31	529.22	539.25
H	0.05	0.00	0.00	0.00
OH	0.03	0.00	0.00	0.00
N2	0.00	0.00	0.00	111.79
CO	0.00	0.00	0.00	112.34
CO2	0.00	0.00	0.00	15.63
CH4	0.00	0.00	0.00	520.46
H2S	0.00	0.00	0.00	25.78
HCl	0.00	0.00	0.00	1.25
NH3	0.00	0.00	0.00	0.20
C2H6	0.00	0.00	0.00	0.70
Char	0.00	0.00	0.00	346.77
Total	481.00	713.00	871.00	1929.59

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-3
Data Point: 1

Test Date: 26 OCT 1984
Time Slice: 15:43:19
Duration (minutes): 16.3

Reactor Inlet Steam Mole Percent: 46.0
Reactor Inlet Hydrogen Mole Percent: 54.0
Reactor Exit Steam Mole Percent: 39.8
Reactor Exit Hydrogen Mole Percent: 41.7

Reactor Exit Temperature (deg F): 1948
Reactor Mixed Temperature (deg F): 1792
Average Reactor Temperature (deg F): 1870
Main Burner Exit Temperature (deg F): 2294

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 5.04
Reactor Inlet Gas to Coal (lb-moles/lb): 0.218

Carbon Conversion to Methane (%):	44.30
Carbon Conversion to Ethane (%):	0.06
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	12.50
Carbon Conversion to Carbon Dioxide (%):	5.26
Carbon Conversion to L/H Oils (%):	0.99
Carbon Conversion to Carbon Oxides (%):	17.76
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	45.35
Carbon Conversion to Hydrocarbon Gas (%):	44.36
Carbon Conversion to Gases (%):	62.12
Carbon Conversion to Liquids (%):	0.99
Total Carbon Conversion (%):	63.11

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 12

AFHP TEST DATA EVALUATION
TEST NUMBER R-3 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	63.11 %				
Char:	36.89 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.30 %	0.06 %	0.00 %	0.00 %	17.76 %	0.99 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	400.00 lbs/hr	250.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	939.00 lbs/hr	51.00 lbs/hr	
Main Burner:	Oxygen		
	247.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	924.00 lbs/hr	97.02 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
409977 Btu/hr	153492 Btu/hr	56469 Btu/hr	378937 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 60 F	Hydrogen & Natural Gas @ 1206 F
Steam Generator:	Water @ 226 F	Hydrogen @ 81 F
Main Burner:	Oxygen @ 61 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3256.6 F	1462.8 F	2294.4 F	1948.0 F
Reactor Mixed Temperature: 1792.0 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.218 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.38 seconds
Based on Reactor Outlet Conditions:	4.74 seconds
Based on Reactor Mixed Conditions:	5.35 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.930	0.000	0.000
Carbon	72.935	73.515	94.170
Hydrogen	5.201	1.009	5.460
Nitrogen	1.408	0.891	0.140
Sulfur	3.058	1.137	0.230
Chlorine	0.182	0.102	0.000
Oxygen	8.232	1.341	0.000
Ash	8.054	22.006	0.000

COAL HIGHER HEATING VALUE: 13356 Btu/lb

CHAR HIGHER HEATING VALUE: 11268 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-3 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.815	61.712	54.047	41.688
H2O	20.157	38.288	45.953	39.751
H	0.027	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.793
CO	0.000	0.000	0.000	3.296
CO2	0.000	0.000	0.000	1.387
CH4	0.000	0.000	0.000	11.680
H2S	0.000	0.000	0.000	0.358
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.008
L/H Oils	0.000	0.000	0.000	0.019

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	98.991	124.305	108.867	88.714
H2O	25.000	77.123	92.561	84.593
H	0.033	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.816
CO	0.000	0.000	0.000	7.013
CO2	0.000	0.000	0.000	2.951
CH4	0.000	0.000	0.000	24.856
H2S	0.000	0.000	0.000	0.761
HCl	0.000	0.000	0.000	0.038
NH3	0.000	0.000	0.000	0.007
C2H6	0.000	0.000	0.000	0.017
L/H Oils	0.000	0.000	0.000	0.040
Total	124.025	201.428	201.428	212.805

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	199.57	250.60	219.47	178.85
H2O	450.38	1389.40	1667.53	1523.98
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	106.91
CO	0.00	0.00	0.00	196.45
CO2	0.00	0.00	0.00	129.88
CH4	0.00	0.00	0.00	398.76
H2S	0.00	0.00	0.00	25.93
HCl	0.00	0.00	0.00	1.38
NH3	0.00	0.00	0.00	0.12
C2H6	0.00	0.00	0.00	0.51
L/H Oils	0.00	0.00	0.00	7.08
Char	0.00	0.00	0.00	338.17
Total	650.00	1640.00	1887.00	2908.02

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-3
Data Point: 2

Test Date: 26 OCT 1984
Time Slice: 15:53:19
Duration (minutes): 9.4

Reactor Inlet Steam Mole Percent: 46.7
Reactor Inlet Hydrogen Mole Percent: 53.3
Reactor Exit Steam Mole Percent: 40.4
Reactor Exit Hydrogen Mole Percent: 39.9

Reactor Exit Temperature (deg F): 1951
Reactor Mixed Temperature (deg F): 1792
Average Reactor Temperature (deg F): 1871.5
Main Burner Exit Temperature (deg F): 2300

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 5.12
Reactor Inlet Gas to Coal (lb-moles/lb): 0.215

Carbon Conversion to Methane (%):	46.90
Carbon Conversion to Ethane (%):	0.07
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	12.70
Carbon Conversion to Carbon Dioxide (%):	5.44
Carbon Conversion to L/H Oils (%):	0.86
Carbon Conversion to Carbon Oxides (%):	18.14
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	47.83
Carbon Conversion to Hydrocarbon Gas (%):	46.97
Carbon Conversion to Gases (%):	65.11
Carbon Conversion to Liquids (%):	0.86
Total Carbon Conversion (%):	65.97

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 13

AFHP TEST DATA EVALUATION

TEST NUMBER R-3 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	65.97 %				
Char:	34.03 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
46.90 %	0.07 %	0.00 %	0.00 %	18.14 %	0.86 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	399.00 lbs/hr	244.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	944.00 lbs/hr	51.00 lbs/hr	
Main Burner:	Oxygen		
	247.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	924.00 lbs/hr	97.02 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
399375 Btu/hr	161547 Btu/hr	56949 Btu/hr	430257 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 63 F	Hydrogen & Natural Gas @ 1206 F
Steam Generator:	Water @ 226 F	Hydrogen @ 81 F
Main Burner:	Oxygen @ 64 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3303.5 F	1459.2 F	2299.8 F	1951.0 F
Reactor Mixed Temperature: 1792.0 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.215 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.43 seconds
Based on Reactor Outlet Conditions:	4.82 seconds
Based on Reactor Mixed Conditions:	5.43 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.930	0.000	0.000
Carbon	72.935	72.180	94.170
Hydrogen	5.201	0.990	5.460
Nitrogen	1.408	0.875	0.140
Sulfur	3.058	1.116	0.230
Chlorine	0.182	0.100	0.000
Oxygen	8.232	1.316	0.000
Ash	8.054	23.422	0.000

COAL HIGHER HEATING VALUE: 13356 Btu/lb

CHAR HIGHER HEATING VALUE: 11064 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-3 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.367	61.084	53.315	39.860
H2O	20.601	38.916	46.685	40.435
H	0.031	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.830
CO	0.000	0.000	0.000	3.409
CO2	0.000	0.000	0.000	1.460
CH4	0.000	0.000	0.000	12.590
H2S	0.000	0.000	0.000	0.368
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.009
L/H Oils	0.000	0.000	0.000	0.017

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	96.075	121.391	105.953	83.314
H2O	24.937	77.338	92.776	84.516
H	0.038	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.825
CO	0.000	0.000	0.000	7.126
CO2	0.000	0.000	0.000	3.052
CH4	0.000	0.000	0.000	26.314
H2S	0.000	0.000	0.000	0.770
HCl	0.000	0.000	0.000	0.038
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.020
L/H Oils	0.000	0.000	0.000	0.035
Total	121.051	198.729	198.729	209.016

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	193.69	244.72	213.60	167.96
H2O	449.25	1393.28	1671.40	1522.58
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.15
CO	0.00	0.00	0.00	199.59
CO2	0.00	0.00	0.00	134.33
CH4	0.00	0.00	0.00	422.17
H2S	0.00	0.00	0.00	26.25
HCl	0.00	0.00	0.00	1.40
NH3	0.00	0.00	0.00	0.11
C2H6	0.00	0.00	0.00	0.59
L/H Oils	0.00	0.00	0.00	6.15
Char	0.00	0.00	0.00	317.73
Total	643.00	1638.00	1885.00	2906.02

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-3
Data Point: 3

Test Date: 26 OCT 1984
Time Slice: 16:01:59
Duration (minutes): 9.5

Reactor Inlet Steam Mole Percent: 46.1
Reactor Inlet Hydrogen Mole Percent: 53.9
Reactor Exit Steam Mole Percent: 39.3
Reactor Exit Hydrogen Mole Percent: 41.4

Reactor Exit Temperature (deg F): 1955
Reactor Mixed Temperature (deg F): 1805
Average Reactor Temperature (deg F): 1880
Main Burner Exit Temperature (deg F): 2314

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 5.04
Reactor Inlet Gas to Coal (lb-moles/lb): 0.217

Carbon Conversion to Methane (%):	45.50
Carbon Conversion to Ethane (%):	0.07
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	13.30
Carbon Conversion to Carbon Dioxide (%):	5.72
Carbon Conversion to L/H Oils (%):	0.71
Carbon Conversion to Carbon Oxides (%):	19.02
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	46.28
Carbon Conversion to Hydrocarbon Gas (%):	45.57
Carbon Conversion to Gases (%):	64.59
Carbon Conversion to Liquids (%):	0.71
Total Carbon Conversion (%):	65.30

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 14

AFHP TEST DATA EVALUATION

TEST NUMBER R-3 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	65.30 %				
Char:	34.70 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.50 %	0.07 %	0.00 %	0.00 %	19.02 %	0.71 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	400.00 lbs/hr	249.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	934.00 lbs/hr	51.00 lbs/hr	
Main Burner:	Oxygen		
	249.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	924.00 lbs/hr	97.02 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
397065 Btu/hr	165609 Btu/hr	56737 Btu/hr	392948 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 65 F	Hydrogen & Natural Gas @ 1215 F
Steam Generator:	Water @ 227 F	Hydrogen @ 80 F
Main Burner:	Oxygen @ 65 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3282.4 F	1474.0 F	2313.8 F	1955.0 F
Reactor Mixed Temperature: 1805.3 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.217 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.37 seconds
Based on Reactor Outlet Conditions:	4.74 seconds
Based on Reactor Mixed Conditions:	5.35 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.930	0.000	0.000
Carbon	72.935	72.508	94.170
Hydrogen	5.201	0.995	5.460
Nitrogen	1.408	0.878	0.140
Sulfur	3.058	1.121	0.230
Chlorine	0.182	0.100	0.000
Oxygen	8.232	1.322	0.000
Ash	8.054	23.075	0.000

COAL HIGHER HEATING VALUE: 13356 Btu/lb

CHAR HIGHER HEATING VALUE: 11114 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-3 - DATA POINT 3

Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.732	61.703	53.946	41.390
H2O	20.238	38.297	46.054	39.344
H	0.029	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.801
CO	0.000	0.000	0.000	3.516
CO2	0.000	0.000	0.000	1.512
CH4	0.000	0.000	0.000	12.030
H2S	0.000	0.000	0.000	0.362
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.009
L/H Oils	0.000	0.000	0.000	0.013

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	98.493	123.809	108.246	87.833
H2O	25.000	76.845	92.409	83.492
H	0.036	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.823
CO	0.000	0.000	0.000	7.462
CO2	0.000	0.000	0.000	3.209
CH4	0.000	0.000	0.000	25.529
H2S	0.000	0.000	0.000	0.768
HCl	0.000	0.000	0.000	0.038
NH3	0.000	0.000	0.000	0.007
C2H6	0.000	0.000	0.000	0.020
L/H Oils	0.000	0.000	0.000	0.029
Total	123.530	200.654	200.654	212.210

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	198.56	249.60	218.22	177.07
H2O	450.38	1384.40	1664.78	1504.14
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.09
CO	0.00	0.00	0.00	209.02
CO2	0.00	0.00	0.00	141.24
CH4	0.00	0.00	0.00	409.57
H2S	0.00	0.00	0.00	26.18
HCl	0.00	0.00	0.00	1.40
NH3	0.00	0.00	0.00	0.12
C2H6	0.00	0.00	0.00	0.59
L/H Oils	0.00	0.00	0.00	5.08
Char	0.00	0.00	0.00	322.52
Total	649.00	1634.00	1883.00	2904.02

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-3
Data Point: 4

Test Date: 26 OCT 1984
Time Slice: 16:12:09
Duration (minutes): 10.4

Reactor Inlet Steam Mole Percent: 46.9
Reactor Inlet Hydrogen Mole Percent: 53.1
Reactor Exit Steam Mole Percent: 40.3
Reactor Exit Hydrogen Mole Percent: 40.4

Reactor Exit Temperature (deg F): 1956
Reactor Mixed Temperature (deg F): 1810
Average Reactor Temperature (deg F): 1883
Main Burner Exit Temperature (deg F): 2327

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 5.12
Reactor Inlet Gas to Coal (lb-moles/lb): 0.213

Carbon Conversion to Methane (%):	45.00
Carbon Conversion to Ethane (%):	0.07
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	13.10
Carbon Conversion to Carbon Dioxide (%):	5.37
Carbon Conversion to L/H Oils (%):	0.68
Carbon Conversion to Carbon Oxides (%):	18.47
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	45.75
Carbon Conversion to Hydrocarbon Gas (%):	45.07
Carbon Conversion to Gases (%):	63.54
Carbon Conversion to Liquids (%):	0.68
Total Carbon Conversion (%):	64.22

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 15

AFHP TEST DATA EVALUATION
TEST NUMBER R-3 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	64.22 %				
Char:	35.78 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.00 %	0.07 %	0.00 %	0.00 %	18.47 %	0.68 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	401.00 lbs/hr	241.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	935.00 lbs/hr	52.00 lbs/hr	
Main Burner:	Oxygen		
	249.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	924.00 lbs/hr	97.02 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
406155 Btu/hr	151996 Btu/hr	57661 Btu/hr	407783 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 65 F	Hydrogen & Natural Gas @ 1208 F
Steam Generator:	Water @ 226 F	Hydrogen @ 79 F
Main Burner:	Oxygen @ 66 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3331.6 F	1476.9 F	2327.3 F	1956.0 F
Reactor Mixed Temperature: 1810.2 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.213 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.42 seconds
Based on Reactor Outlet Conditions:	4.82 seconds
Based on Reactor Mixed Conditions:	5.42 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.930	0.000	0.000
Carbon	72.935	73.017	94.170
Hydrogen	5.201	1.002	5.460
Nitrogen	1.408	0.885	0.140
Sulfur	3.058	1.129	0.230
Chlorine	0.182	0.101	0.000
Oxygen	8.232	1.331	0.000
Ash	8.054	22.535	0.000

COAL HIGHER HEATING VALUE: 13356 Btu/lb

CHAR HIGHER HEATING VALUE: 11192 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-3 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.003	60.979	53.089	40.401
H2O	20.961	39.021	46.911	40.297
H	0.034	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.830
CO	0.000	0.000	0.000	3.522
CO2	0.000	0.000	0.000	1.444
CH4	0.000	0.000	0.000	12.097
H2S	0.000	0.000	0.000	0.366
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.009
L/H Oils	0.000	0.000	0.000	0.013

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	94.460	120.274	104.711	84.323
H2O	25.062	76.963	92.527	84.107
H	0.041	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.820
CO	0.000	0.000	0.000	7.350
CO2	0.000	0.000	0.000	3.013
CH4	0.000	0.000	0.000	25.248
H2S	0.000	0.000	0.000	0.765
HCl	0.000	0.000	0.000	0.038
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.020
L/H Oils	0.000	0.000	0.000	0.027
Total	119.565	197.237	197.237	208.718

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	190.43	242.47	211.10	170.00
H2O	451.50	1386.53	1666.90	1515.22
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.01
CO	0.00	0.00	0.00	205.88
CO2	0.00	0.00	0.00	132.60
CH4	0.00	0.00	0.00	405.07
H2S	0.00	0.00	0.00	26.06
HCl	0.00	0.00	0.00	1.39
NH3	0.00	0.00	0.00	0.11
C2H6	0.00	0.00	0.00	0.59
L/H Oils	0.00	0.00	0.00	4.87
Char	0.00	0.00	0.00	330.24
Total	642.00	1629.00	1878.00	2899.02

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-3
Data Point: 5

Test Date: 26 OCT 1984
Time Slice: 16:22:59
Duration (minutes): 6.6

Reactor Inlet Steam Mole Percent: 46.5
Reactor Inlet Hydrogen Mole Percent: 53.5
Reactor Exit Steam Mole Percent: 39.7
Reactor Exit Hydrogen Mole Percent: 40.9

Reactor Exit Temperature (deg F): 1961
Reactor Mixed Temperature (deg F): 1795
Average Reactor Temperature (deg F): 1878
Main Burner Exit Temperature (deg F): 2303

Reactor Pressure (psia): 1016
Reactor Residence Time (seconds): 5.08
Reactor Inlet Gas to Coal (lb-moles/lb): 0.216

Carbon Conversion to Methane (%):	45.60
Carbon Conversion to Ethane (%):	0.07
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	13.50
Carbon Conversion to Carbon Dioxide (%):	5.52
Carbon Conversion to L/H Oils (%):	0.48
Carbon Conversion to Carbon Oxides (%):	19.02
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	46.15
Carbon Conversion to Hydrocarbon Gas (%):	45.67
Carbon Conversion to Gases (%):	64.69
Carbon Conversion to Liquids (%):	0.48
Total Carbon Conversion (%):	65.17

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 16

AFHP TEST DATA EVALUATION
TEST NUMBER R-3 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	65.17 %				
Char:	34.83 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.60 %	0.07 %	0.00 %	0.00 %	19.02 %	0.48 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	399.00 lbs/hr	245.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	940.00 lbs/hr	52.00 lbs/hr	
Main Burner:	Oxygen		
	249.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	924.00 lbs/hr	97.02 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
399932 Btu/hr	154733 Btu/hr	56300 Btu/hr	356311 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 65 F	Hydrogen & Natural Gas @ 1196 F
Steam Generator:	Water @ 225 F	Hydrogen @ 78 F
Main Burner:	Oxygen @ 67 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3288.1 F	1457.3 F	2302.8 F	1961.0 F
Reactor Mixed Temperature: 1795.4 F			

PRESSURE: 1016.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.216 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.41 seconds
Based on Reactor Outlet Conditions:	4.76 seconds
Based on Reactor Mixed Conditions:	5.41 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.930	0.000	0.000
Carbon	72.935	72.571	94.170
Hydrogen	5.201	0.996	5.460
Nitrogen	1.408	0.879	0.140
Sulfur	3.058	1.122	0.230
Chlorine	0.182	0.101	0.000
Oxygen	8.232	1.323	0.000
Ash	8.054	23.008	0.000

COAL HIGHER HEATING VALUE: 13356 Btu/lb

CHAR HIGHER HEATING VALUE: 11124 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-3 - DATA POINT 5

Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.453	61.345	53.544	40.859
H2O	20.517	38.655	46.456	39.745
H	0.030	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.811
CO	0.000	0.000	0.000	3.589
CO2	0.000	0.000	0.000	1.468
CH4	0.000	0.000	0.000	12.124
H2S	0.000	0.000	0.000	0.364
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.009
L/H Oils	0.000	0.000	0.000	0.009

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	96.572	122.383	106.820	86.224
H2O	24.937	77.116	92.679	83.874
H	0.036	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.823
CO	0.000	0.000	0.000	7.575
CO2	0.000	0.000	0.000	3.097
CH4	0.000	0.000	0.000	25.585
H2S	0.000	0.000	0.000	0.768
HCl	0.000	0.000	0.000	0.038
NH3	0.000	0.000	0.000	0.007
C2H6	0.000	0.000	0.000	0.020
L/H Oils	0.000	0.000	0.000	0.019
Total	121.546	199.499	199.499	211.029

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	194.69	246.72	215.35	173.83
H2O	449.26	1389.28	1669.65	1511.02
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	107.09
CO	0.00	0.00	0.00	212.17
CO2	0.00	0.00	0.00	136.31
CH4	0.00	0.00	0.00	410.47
H2S	0.00	0.00	0.00	26.17
HCl	0.00	0.00	0.00	1.39
NH3	0.00	0.00	0.00	0.11
C2H6	0.00	0.00	0.00	0.59
L/H Oils	0.00	0.00	0.00	3.44
Char	0.00	0.00	0.00	323.45
Total	644.00	1636.00	1885.00	2906.02

28 Aug 1985

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-4
Data Point: 1

Test Date: 7 NOV 1984
Time Slice: 11:48:49
Duration (minutes): 19.1

Reactor Inlet Steam Mole Percent: 28.8
Reactor Inlet Hydrogen Mole Percent: 71.2
Reactor Exit Steam Mole Percent: 27.4
Reactor Exit Hydrogen Mole Percent: 52.2

Reactor Exit Temperature (deg F): 1969
Reactor Mixed Temperature (deg F): 1659
Average Reactor Temperature (deg F): 1814
Main Burner Exit Temperature (deg F): 2185

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 5.36
Reactor Inlet Gas to Coal (lb-moles/lb): 0.201

Carbon Conversion to Methane (%):	50.14
Carbon Conversion to Ethane (%):	0.09
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	8.52
Carbon Conversion to Carbon Dioxide (%):	1.96
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	10.48
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	50.23
Carbon Conversion to Hydrocarbon Gas (%):	50.23
Carbon Conversion to Gases (%):	60.71
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	60.71

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 17

AFHP TEST DATA EVALUATION
TEST NUMBER R-4 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	60.71 %				
Char:	39.29 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
50.14 %	0.09 %	0.00 %	0.00 %	10.48 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	338.00 lbs/hr	214.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	431.00 lbs/hr	138.00 lbs/hr	
Main Burner:	Oxygen		
	195.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	987.00 lbs/hr	103.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
256056 Btu/hr	249823 Btu/hr	57643 Btu/hr	642779 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 47 F	Hydrogen & Natural Gas @ 1152 F
Steam Generator:	Water @ 201 F	Hydrogen @ 73 F
Main Burner:	Oxygen @ 48 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3284.2 F	1480.8 F	2184.7 F	1969.0 F
Reactor Mixed Temperature: 1659.4 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.201 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.62 seconds
Based on Reactor Outlet Conditions:	4.95 seconds
Based on Reactor Mixed Conditions:	5.77 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.430	0.000
Carbon	72.915	74.656
Hydrogen	4.988	0.919
Nitrogen	1.471	0.734
Sulfur	3.084	1.366
Chlorine	0.112	0.083
Oxygen	8.716	0.654
Ash	8.284	21.588

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11416 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-4 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	80.072	77.308	71.169	52.159
H2O	19.898	22.692	28.831	27.380
H	0.029	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.039
CO	0.000	0.000	0.000	2.530
CO2	0.000	0.000	0.000	0.582
CH4	0.000	0.000	0.000	14.890
H2S	0.000	0.000	0.000	0.391
HCl	0.000	0.000	0.000	0.011
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.013

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	85.010	153.477	141.289	105.236
H2O	21.125	45.050	57.238	55.242
H	0.031	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.114
CO	0.000	0.000	0.000	5.105
CO2	0.000	0.000	0.000	1.174
CH4	0.000	0.000	0.000	30.042
H2S	0.000	0.000	0.000	0.788
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.027
Total	106.167	198.527	198.527	201.760

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	171.38	309.41	284.84	212.16
H2O	380.57	811.59	1031.16	995.20
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	115.24
CO	0.00	0.00	0.00	142.99
CO2	0.00	0.00	0.00	51.68
CH4	0.00	0.00	0.00	481.97
H2S	0.00	0.00	0.00	26.85
HCl	0.00	0.00	0.00	0.81
NH3	0.00	0.00	0.00	0.16
C2H6	0.00	0.00	0.00	0.81
Char	0.00	0.00	0.00	378.75
Total	552.00	1121.00	1316.00	2406.64

28 Aug 1985

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-4
Data Point: 2

Test Date: 7 NOV 1984
Time Slice: 11:56:59
Duration (minutes): 8.0

Reactor Inlet Steam Mole Percent: 28.9
Reactor Inlet Hydrogen Mole Percent: 71.1
Reactor Exit Steam Mole Percent: 27.6
Reactor Exit Hydrogen Mole Percent: 51.7

Reactor Exit Temperature (deg F): 1974
Reactor Mixed Temperature (deg F): 1663
Average Reactor Temperature (deg F): 1818.5
Main Burner Exit Temperature (deg F): 2187

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 5.32
Reactor Inlet Gas to Coal (lb-moles/lb): 0.202

Carbon Conversion to Methane (%):	51.12
Carbon Conversion to Ethane (%):	0.09
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	8.42
Carbon Conversion to Carbon Dioxide (%):	1.94
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	10.36
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	51.21
Carbon Conversion to Hydrocarbon Gas (%):	51.21
Carbon Conversion to Gases (%):	61.57
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	61.57

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 18

AFHP TEST DATA EVALUATION

TEST NUMBER R-4 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	61.57 %				
Char:	38.43 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
51.12 %	0.09 %	0.00 %	0.00 %	10.36 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	342.00 lbs/hr	215.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	433.00 lbs/hr	139.00 lbs/hr	
Main Burner:	Oxygen		
	197.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	987.00 lbs/hr	103.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
254210 Btu/hr	252004 Btu/hr	58202 Btu/hr	666751 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 50 F	Hydrogen & Natural Gas @ 1127 F
Steam Generator:	Water @ 203 F	Hydrogen @ 74 F
Main Burner:	Oxygen @ 49 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3282.8 F	1479.6 F	2186.7 F	1974.0 F
Reactor Mixed Temperature: 1663.0 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.202 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.59 seconds
Based on Reactor Outlet Conditions:	4.93 seconds
Based on Reactor Mixed Conditions:	5.72 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.430	0.000
Carbon	72.915	74.297
Hydrogen	4.988	0.915
Nitrogen	1.471	0.731
Sulfur	3.084	1.359
Chlorine	0.112	0.083
Oxygen	8.716	0.651
Ash	8.284	21.965

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11361 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-4 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.930	77.253	71.085	51.733
H2O	20.040	22.747	28.915	27.598
H	0.029	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.035
CO	0.000	0.000	0.000	2.495
CO2	0.000	0.000	0.000	0.575
CH4	0.000	0.000	0.000	15.145
H2S	0.000	0.000	0.000	0.391
HCl	0.000	0.000	0.000	0.011
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.013

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	85.256	154.219	141.906	104.626
H2O	21.375	45.411	57.724	55.815
H	0.031	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.116
CO	0.000	0.000	0.000	5.045
CO2	0.000	0.000	0.000	1.162
CH4	0.000	0.000	0.000	30.629
H2S	0.000	0.000	0.000	0.792
HCl	0.000	0.000	0.000	0.023
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.027
Total	106.663	199.630	199.630	202.244

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	171.88	310.91	286.08	210.93
H2O	385.08	818.09	1039.92	1005.53
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	115.30
CO	0.00	0.00	0.00	141.31
CO2	0.00	0.00	0.00	51.16
CH4	0.00	0.00	0.00	491.39
H2S	0.00	0.00	0.00	26.97
HCl	0.00	0.00	0.00	0.82
NH3	0.00	0.00	0.00	0.16
C2H6	0.00	0.00	0.00	0.81
Char	0.00	0.00	0.00	372.25
Total	557.00	1129.00	1326.00	2416.64

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-4
Data Point: 3

Test Date: 7 NOV 1984
Time Slice: 12:04:49
Duration (minutes): 7.9

Reactor Inlet Steam Mole Percent: 28.9
Reactor Inlet Hydrogen Mole Percent: 71.1
Reactor Exit Steam Mole Percent: 27.3
Reactor Exit Hydrogen Mole Percent: 52.3

Reactor Exit Temperature (deg F): 1979
Reactor Mixed Temperature (deg F): 1668
Average Reactor Temperature (deg F): 1823.5
Main Burner Exit Temperature (deg F): 2194

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 5.30
Reactor Inlet Gas to Coal (lb-moles/lb): 0.202

Carbon Conversion to Methane (%):	50.04
Carbon Conversion to Ethane (%):	0.08
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	8.72
Carbon Conversion to Carbon Dioxide (%):	2.00
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	10.72
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	50.12
Carbon Conversion to Hydrocarbon Gas (%):	50.12
Carbon Conversion to Gases (%):	60.84
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	60.84

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 19

AFHP TEST DATA EVALUATION
TEST NUMBER R-4 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	60.84 %				
Char:	39.16 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
50.04 %	0.08 %	0.00 %	0.00 %	10.72 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	345.00 lbs/hr	214.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	426.00 lbs/hr	141.00 lbs/hr	
Main Burner:	Oxygen		
	199.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	987.00 lbs/hr	103.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
255816 Btu/hr	248475 Btu/hr	59146 Btu/hr	628543 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 52 F	Hydrogen & Natural Gas @ 1097 F
Steam Generator:	Water @ 204 F	Hydrogen @ 74 F
Main Burner:	Oxygen @ 51 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3284.7 F	1480.6 F	2194.2 F	1979.0 F
Reactor Mixed Temperature: 1668.5 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.202 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.58 seconds
Based on Reactor Outlet Conditions:	4.89 seconds
Based on Reactor Mixed Conditions:	5.71 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.430	0.000
Carbon	72.915	74.602
Hydrogen	4.988	0.919
Nitrogen	1.471	0.734
Sulfur	3.084	1.365
Chlorine	0.112	0.083
Oxygen	8.716	0.654
Ash	8.284	21.644

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11408 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-4 - DATA POINT 3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.660	77.365	71.138	52.335
H2O	20.310	22.635	28.862	27.307
H	0.029	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.025
CO	0.000	0.000	0.000	2.571
CO2	0.000	0.000	0.000	0.590
CH4	0.000	0.000	0.000	14.756
H2S	0.000	0.000	0.000	0.388
HCl	0.000	0.000	0.000	0.011
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.012

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	84.572	154.528	142.090	106.338
H2O	21.562	45.210	57.648	55.484
H	0.031	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.114
CO	0.000	0.000	0.000	5.225
CO2	0.000	0.000	0.000	1.198
CH4	0.000	0.000	0.000	29.982
H2S	0.000	0.000	0.000	0.789
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.024
Total	106.167	199.738	199.738	203.186

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	170.50	311.53	286.45	214.38
H2O	388.45	814.47	1038.55	999.57
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	115.25
CO	0.00	0.00	0.00	146.35
CO2	0.00	0.00	0.00	52.74
CH4	0.00	0.00	0.00	481.01
H2S	0.00	0.00	0.00	26.87
HCl	0.00	0.00	0.00	0.81
NH3	0.00	0.00	0.00	0.16
C2H6	0.00	0.00	0.00	0.72
Char	0.00	0.00	0.00	377.77
Total	559.00	1126.00	1325.00	2415.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-4
Data Point: 4

Test Date: 7 NOV 1984
Time Slice: 12:12:49
Duration (minutes): 9.8

Reactor Inlet Steam Mole Percent: 28.9
Reactor Inlet Hydrogen Mole Percent: 71.1
Reactor Exit Steam Mole Percent: 27.3
Reactor Exit Hydrogen Mole Percent: 52.5

Reactor Exit Temperature (deg F): 1975
Reactor Mixed Temperature (deg F): 1669
Average Reactor Temperature (deg F): 1822
Main Burner Exit Temperature (deg F): 2194

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 5.30
Reactor Inlet Gas to Coal (lb-moles/lb): 0.203

Carbon Conversion to Methane (%):	49.75
Carbon Conversion to Ethane (%):	0.08
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	8.81
Carbon Conversion to Carbon Dioxide (%):	1.94
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	10.75
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	49.83
Carbon Conversion to Hydrocarbon Gas (%):	49.83
Carbon Conversion to Gases (%):	60.58
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	60.58

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 20

AFHP TEST DATA EVALUATION

TEST NUMBER R-4 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	60.58 %				
Char:	39.42 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
49.75 %	0.08 %	0.00 %	0.00 %	10.75 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	348.00 lbs/hr	214.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	423.00 lbs/hr	142.00 lbs/hr	
Main Burner:	Oxygen		
	200.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	987.00 lbs/hr	103.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
268863 Btu/hr	227618 Btu/hr	58047 Btu/hr	628448 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 52 F	Hydrogen & Natural Gas @ 1054 F
Steam Generator:	Water @ 203 F	Hydrogen @ 74 F
Main Burner:	Oxygen @ 52 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3256.2 F	1476.7 F	2193.8 F	1975.0 F
Reactor Mixed Temperature: 1668.9 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.203 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.57 seconds
Based on Reactor Outlet Conditions:	4.90 seconds
Based on Reactor Mixed Conditions:	5.70 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.430	0.000
Carbon	72.915	74.709
Hydrogen	4.988	0.920
Nitrogen	1.471	0.735
Sulfur	3.084	1.367
Chlorine	0.112	0.083
Oxygen	8.716	0.655
Ash	8.284	21.532

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11424 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-4   DATA POINT 4   Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.486	77.392	71.144	52.482
H2O	20.487	22.608	28.856	27.288
H	0.027	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.019
CO	0.000	0.000	0.000	2.591
CO2	0.000	0.000	0.000	0.571
CH4	0.000	0.000	0.000	14.634
H2S	0.000	0.000	0.000	0.387
HCl	0.000	0.000	0.000	0.011
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.012

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	84.386	154.836	142.336	106.904
H2O	21.750	45.231	57.731	55.585
H	0.028	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.113
CO	0.000	0.000	0.000	5.279
CO2	0.000	0.000	0.000	1.162
CH4	0.000	0.000	0.000	29.809
H2S	0.000	0.000	0.000	0.787
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.024
Total	106.165	200.067	200.067	203.695

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	170.12	312.15	286.95	215.52
H2O	391.83	814.85	1040.05	1001.38
H	0.03	0.00	0.00	0.00
OH	0.01	0.00	0.00	0.00
N2	0.00	0.00	0.00	115.23
CO	0.00	0.00	0.00	147.86
CO2	0.00	0.00	0.00	51.16
CH4	0.00	0.00	0.00	478.22
H2S	0.00	0.00	0.00	26.84
HCl	0.00	0.00	0.00	0.81
NH3	0.00	0.00	0.00	0.16
C2H6	0.00	0.00	0.00	0.72
Char	0.00	0.00	0.00	379.73
Total	562.00	1127.00	1327.00	2417.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-4
Data Point: 5

Test Date: 7 NOV 1984
Time Slice: 12:24:19
Duration (minutes): 10.2

Reactor Inlet Steam Mole Percent: 29.0
Reactor Inlet Hydrogen Mole Percent: 71.0
Reactor Exit Steam Mole Percent: 27.4
Reactor Exit Hydrogen Mole Percent: 52.9

Reactor Exit Temperature (deg F): 1985
Reactor Mixed Temperature (deg F): 1685
Average Reactor Temperature (deg F): 1835
Main Burner Exit Temperature (deg F): 2214

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 5.24
Reactor Inlet Gas to Coal (lb-moles/lb): 0.203

Carbon Conversion to Methane (%):	48.67
Carbon Conversion to Ethane (%):	0.09
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	8.52
Carbon Conversion to Carbon Dioxide (%):	1.95
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	10.47
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	48.76
Carbon Conversion to Hydrocarbon Gas (%):	48.76
Carbon Conversion to Gases (%):	59.23
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	59.23

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 21

AFHP TEST DATA EVALUATION

TEST NUMBER R-4 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	59.23 %				
Char:	40.77 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
48.67 %	0.09 %	0.00 %	0.00 %	10.47 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	351.00 lbs/hr	213.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	426.00 lbs/hr	144.00 lbs/hr	
Main Burner:	Oxygen		
	201.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	987.00 lbs/hr	103.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
270447 Btu/hr	238810 Btu/hr	59055 Btu/hr	622397 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 53 F	Hydrogen & Natural Gas @ 1109 F
Steam Generator:	Water @ 203 F	Hydrogen @ 73 F
Main Burner:	Oxygen @ 53 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3324.1 F	1498.0 F	2213.7 F	1985.0 F
Reactor Mixed Temperature: 1684.7 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.203 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.52 seconds
Based on Reactor Outlet Conditions:	4.84 seconds
Based on Reactor Mixed Conditions:	5.63 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.430	0.000
Carbon	72.915	75.245
Hydrogen	4.988	0.926
Nitrogen	1.471	0.740
Sulfur	3.084	1.377
Chlorine	0.112	0.084
Oxygen	8.716	0.660
Ash	8.284	20.968

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11506 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-4 - DATA POINT 5 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.206	77.290	71.032	52.853
H2O	20.759	22.710	28.968	27.425
H	0.034	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.007
CO	0.000	0.000	0.000	2.493
CO2	0.000	0.000	0.000	0.571
CH4	0.000	0.000	0.000	14.241
H2S	0.000	0.000	0.000	0.382
HCl	0.000	0.000	0.000	0.011
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.013

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	83.699	155.145	142.582	108.225
H2O	21.937	45.585	58.148	56.158
H	0.036	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.110
CO	0.000	0.000	0.000	5.105
CO2	0.000	0.000	0.000	1.168
CH4	0.000	0.000	0.000	29.161
H2S	0.000	0.000	0.000	0.782
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.027
Total	105.673	200.730	200.730	204.768

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	168.74	312.77	287.45	218.18
H2O	395.21	821.23	1047.55	1011.70
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	115.14
CO	0.00	0.00	0.00	142.99
CO2	0.00	0.00	0.00	51.42
CH4	0.00	0.00	0.00	467.84
H2S	0.00	0.00	0.00	26.65
HCl	0.00	0.00	0.00	0.80
NH3	0.00	0.00	0.00	0.16
C2H6	0.00	0.00	0.00	0.81
Char	0.00	0.00	0.00	389.94
Total	564.00	1134.00	1335.00	2425.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-5
Data Point: 1

Test Date: 13 NOV 1984
Time Slice: 15:58:00
Duration (minutes): 19.0

Reactor Inlet Steam Mole Percent: 42.3
Reactor Inlet Hydrogen Mole Percent: 57.7
Reactor Exit Steam Mole Percent: 41.9
Reactor Exit Hydrogen Mole Percent: 41.7

Reactor Exit Temperature (deg F): 1843
Reactor Mixed Temperature (deg F): 1576
Average Reactor Temperature (deg F): 1709.5
Main Burner Exit Temperature (deg F): 2022

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 5.58
Reactor Inlet Gas to Coal (lb-moles/lb): 0.214

Carbon Conversion to Methane (%):	43.00
Carbon Conversion to Ethane (%):	0.10
Carbon Conversion to Benzene (%):	4.60
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	4.40
Carbon Conversion to Carbon Dioxide (%):	1.86
Carbon Conversion to L/H Oils (%):	5.06
Carbon Conversion to Carbon Oxides (%):	6.26
Carbon Conversion to BTX Liquids (%):	4.60
Carbon Conversion to Hydrocarbons (%):	52.76
Carbon Conversion to Hydrocarbon Gas (%):	43.10
Carbon Conversion to Gases (%):	49.36
Carbon Conversion to Liquids (%):	9.66
Total Carbon Conversion (%):	59.02

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 22

AFHP TEST DATA EVALUATION

TEST NUMBER R-5 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	59.02 %				
Char:	40.98 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
43.00 %	0.10 %	4.60 %	0.00 %	6.26 %	5.06 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	399.00 lbs/hr	244.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	887.00 lbs/hr	60.00 lbs/hr	
Main Burner:	Oxygen		
	166.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	936.00 lbs/hr	98.28 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
325156 Btu/hr	223425 Btu/hr	58436 Btu/hr	500196 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 46 F	Hydrogen & Natural Gas @ 1133 F
Steam Generator:	Water @ 227 F	Hydrogen @ 67 F
Main Burner:	Oxygen @ 42 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3312.0 F	1454.9 F	2021.8 F	1843.0 F
Reactor Mixed Temperature: 1575.8 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.214 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.89 seconds
Based on Reactor Outlet Conditions:	5.19 seconds
Based on Reactor Mixed Conditions:	5.96 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.780	0.000	0.000
Carbon	73.105	75.430	94.170
Hydrogen	5.140	1.247	5.460
Nitrogen	1.464	1.405	0.140
Sulfur	2.959	1.353	0.230
Chlorine	0.182	0.155	0.000
Oxygen	8.264	-0.000	0.000
Ash	8.106	20.410	0.000

COAL HIGHER HEATING VALUE: 13406 Btu/lb

CHAR HIGHER HEATING VALUE: 11715 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-5 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.366	62.918	57.731	41.699
H2O	20.600	37.082	42.269	41.918
H	0.032	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.873
CO	0.000	0.000	0.000	1.234
CO2	0.000	0.000	0.000	0.522
CH4	0.000	0.000	0.000	12.057
H2S	0.000	0.000	0.000	0.347
HCl	0.000	0.000	0.000	0.016
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.215
L/H Oils	0.000	0.000	0.000	0.102

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	96.074	125.855	115.480	84.717
H2O	24.937	74.174	84.549	85.163
H	0.039	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.805
CO	0.000	0.000	0.000	2.507
CO2	0.000	0.000	0.000	1.060
CH4	0.000	0.000	0.000	24.497
H2S	0.000	0.000	0.000	0.704
HCl	0.000	0.000	0.000	0.032
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.028
Benzene	0.000	0.000	0.000	0.437
L/H Oils	0.000	0.000	0.000	0.206
Total	121.052	200.029	200.029	203.165

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	193.69	253.72	232.81	170.79
H2O	449.25	1336.28	1523.19	1534.25
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	106.59
CO	0.00	0.00	0.00	70.21
CO2	0.00	0.00	0.00	46.63
CH4	0.00	0.00	0.00	393.00
H2S	0.00	0.00	0.00	24.00
HCl	0.00	0.00	0.00	1.16
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	0.86
Benzene	0.00	0.00	0.00	34.12
L/H Oils	0.00	0.00	0.00	36.77
Char	0.00	0.00	0.00	371.75
Total	643.00	1590.00	1756.00	2790.28

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-5
Data Point: 2

Test Date: 13 NOV 1984
Time Slice: 16:06:00
Duration (minutes): 8.5

Reactor Inlet Steam Mole Percent: 42.5
Reactor Inlet Hydrogen Mole Percent: 57.5
Reactor Exit Steam Mole Percent: 42.2
Reactor Exit Hydrogen Mole Percent: 40.8

Reactor Exit Temperature (deg F): 1858
Reactor Mixed Temperature (deg F): 1590
Average Reactor Temperature (deg F): 1724
Main Burner Exit Temperature (deg F): 2042

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 5.56
Reactor Inlet Gas to Coal (lb-moles/lb): 0.213

Carbon Conversion to Methane (%):	44.60
Carbon Conversion to Ethane (%):	0.10
Carbon Conversion to Benzene (%):	4.10
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	4.60
Carbon Conversion to Carbon Dioxide (%):	1.96
Carbon Conversion to L/H Oils (%):	4.46
Carbon Conversion to Carbon Oxides (%):	6.56
Carbon Conversion to BTX Liquids (%):	4.10
Carbon Conversion to Hydrocarbons (%):	53.26
Carbon Conversion to Hydrocarbon Gas (%):	44.70
Carbon Conversion to Gases (%):	51.26
Carbon Conversion to Liquids (%):	8.56
Total Carbon Conversion (%):	59.82

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 23

AFHP TEST DATA EVALUATION
TEST NUMBER R-5 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	59.82 %				
Char:	40.18 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.60 %	0.10 %	4.10 %	0.00 %	6.56 %	4.46 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	403.00 lbs/hr	242.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	886.00 lbs/hr	61.00 lbs/hr	
Main Burner:	Oxygen		
	168.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	936.00 lbs/hr	98.28 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
336406 Btu/hr	213849 Btu/hr	58131 Btu/hr	532583 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 48 F	Hydrogen & Natural Gas @ 1130 F
Steam Generator:	Water @ 228 F	Hydrogen @ 66 F
Main Burner:	Oxygen @ 43 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3336.1 F	1467.5 F	2041.7 F	1858.0 F
Reactor Mixed Temperature: 1590.1 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.213 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.86 seconds
Based on Reactor Outlet Conditions:	5.18 seconds
Based on Reactor Mixed Conditions:	5.93 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.780	0.000	0.000
Carbon	73.105	75.125	94.170
Hydrogen	5.140	1.242	5.460
Nitrogen	1.464	1.399	0.140
Sulfur	2.959	1.347	0.230
Chlorine	0.182	0.154	0.000
Oxygen	8.264	0.000	0.000
Ash	8.106	20.732	0.000

COAL HIGHER HEATING VALUE: 13406 Btu/lb

CHAR HIGHER HEATING VALUE: 11668 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-5 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	78.985	62.718	57.454	40.846
H2O	20.978	37.282	42.546	42.182
H	0.035	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.885
CO	0.000	0.000	0.000	1.297
CO2	0.000	0.000	0.000	0.552
CH4	0.000	0.000	0.000	12.571
H2S	0.000	0.000	0.000	0.350
HCl	0.000	0.000	0.000	0.016
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.193
L/H Oils	0.000	0.000	0.000	0.090

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	94.831	125.109	114.609	82.554
H2O	25.187	74.369	84.869	85.255
H	0.042	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.809
CO	0.000	0.000	0.000	2.621
CO2	0.000	0.000	0.000	1.117
CH4	0.000	0.000	0.000	25.408
H2S	0.000	0.000	0.000	0.708
HCl	0.000	0.000	0.000	0.032
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.028
Benzene	0.000	0.000	0.000	0.389
L/H Oils	0.000	0.000	0.000	0.182
Total	120.061	199.478	199.478	202.111

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	191.18	252.22	231.05	166.43
H2O	453.75	1339.78	1528.95	1535.91
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	106.70
CO	0.00	0.00	0.00	73.40
CO2	0.00	0.00	0.00	49.14
CH4	0.00	0.00	0.00	407.63
H2S	0.00	0.00	0.00	24.12
HCl	0.00	0.00	0.00	1.17
NH3	0.00	0.00	0.00	0.14
C2H6	0.00	0.00	0.00	0.86
Benzene	0.00	0.00	0.00	30.41
L/H Oils	0.00	0.00	0.00	32.41
Char	0.00	0.00	0.00	365.97
Total	645.00	1592.00	1760.00	2794.28

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-5
Data Point: 3

Test Date: 13 NOV 1984
Time Slice: 16:15:00
Duration (minutes): 8.0

Reactor Inlet Steam Mole Percent: 42.1
Reactor Inlet Hydrogen Mole Percent: 57.9
Reactor Exit Steam Mole Percent: 41.8
Reactor Exit Hydrogen Mole Percent: 41.7

Reactor Exit Temperature (deg F): 1854
Reactor Mixed Temperature (deg F): 1598
Average Reactor Temperature (deg F): 1726
Main Burner Exit Temperature (deg F): 2046

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 5.44
Reactor Inlet Gas to Coal (lb-moles/lb): 0.217

Carbon Conversion to Methane (%):	44.10
Carbon Conversion to Ethane (%):	0.11
Carbon Conversion to Benzene (%):	4.80
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	4.50
Carbon Conversion to Carbon Dioxide (%):	1.86
Carbon Conversion to L/H Oils (%):	4.61
Carbon Conversion to Carbon Oxides (%):	6.36
Carbon Conversion to BTX Liquids (%):	4.80
Carbon Conversion to Hydrocarbons (%):	53.62
Carbon Conversion to Hydrocarbon Gas (%):	44.21
Carbon Conversion to Gases (%):	50.57
Carbon Conversion to Liquids (%):	9.41
Total Carbon Conversion (%):	59.98

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 24

AFHP TEST DATA EVALUATION

TEST NUMBER R-5 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	59.98 %				
Char:	40.02 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.10 %	0.11 %	4.80 %	0.00 %	6.36 %	4.61 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	409.00 lbs/hr	248.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	886.00 lbs/hr	62.00 lbs/hr	
Main Burner:	Oxygen		
	170.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	936.00 lbs/hr	98.28 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
338074 Btu/hr	212131 Btu/hr	58088 Btu/hr	547705 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 49 F	Hydrogen & Natural Gas @ 1113 F
Steam Generator:	Water @ 228 F	Hydrogen @ 65 F
Main Burner:	Oxygen @ 44 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3308.2 F	1474.0 F	2045.9 F	1854.0 F
Reactor Mixed Temperature: 1598.5 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.217 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.76 seconds
Based on Reactor Outlet Conditions:	5.09 seconds
Based on Reactor Mixed Conditions:	5.80 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.780	0.000	0.000
Carbon	73.105	75.063	94.170
Hydrogen	5.140	1.241	5.460
Nitrogen	1.464	1.398	0.140
Sulfur	2.959	1.346	0.230
Chlorine	0.182	0.154	0.000
Oxygen	8.264	0.000	0.000
Ash	8.106	20.797	0.000

COAL HIGHER HEATING VALUE: 13406 Btu/lb

CHAR HIGHER HEATING VALUE: 11658 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-5 - DATA POINT 3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.191	63.171	57.936	41.680
H2O	20.776	36.829	42.064	41.793
H	0.032	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.853
CO	0.000	0.000	0.000	1.247
CO2	0.000	0.000	0.000	0.515
CH4	0.000	0.000	0.000	12.219
H2S	0.000	0.000	0.000	0.344
HCl	0.000	0.000	0.000	0.016
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.015
Benzene	0.000	0.000	0.000	0.222
L/H Oils	0.000	0.000	0.000	0.091

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	97.433	128.206	117.581	85.695
H2O	25.562	74.744	85.369	85.926
H	0.039	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.810
CO	0.000	0.000	0.000	2.564
CO2	0.000	0.000	0.000	1.060
CH4	0.000	0.000	0.000	25.123
H2S	0.000	0.000	0.000	0.708
HCl	0.000	0.000	0.000	0.032
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.031
Benzene	0.000	0.000	0.000	0.456
L/H Oils	0.000	0.000	0.000	0.188
Total	123.036	202.950	202.950	205.601

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	196.43	258.46	237.04	172.76
H2O	460.51	1346.54	1537.96	1547.99
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	106.72
CO	0.00	0.00	0.00	71.81
CO2	0.00	0.00	0.00	46.63
CH4	0.00	0.00	0.00	403.06
H2S	0.00	0.00	0.00	24.14
HCl	0.00	0.00	0.00	1.17
NH3	0.00	0.00	0.00	0.14
C2H6	0.00	0.00	0.00	0.94
Benzene	0.00	0.00	0.00	35.60
L/H Oils	0.00	0.00	0.00	33.50
Char	0.00	0.00	0.00	364.82
Total	657.00	1605.00	1775.00	2809.28

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-5
Data Point: 4

Test Date: 13 NOV 1984
Time Slice: 16:22:01
Duration (minutes): 5.5

Reactor Inlet Steam Mole Percent: 41.7
Reactor Inlet Hydrogen Mole Percent: 58.3
Reactor Exit Steam Mole Percent: 41.4
Reactor Exit Hydrogen Mole Percent: 42.0

Reactor Exit Temperature (deg F): 1862
Reactor Mixed Temperature (deg F): 1592
Average Reactor Temperature (deg F): 1727
Main Burner Exit Temperature (deg F): 2038

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 5.46
Reactor Inlet Gas to Coal (lb-moles/lb): 0.217

Carbon Conversion to Methane (%):	44.40
Carbon Conversion to Ethane (%):	0.10
Carbon Conversion to Benzene (%):	4.40
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	4.60
Carbon Conversion to Carbon Dioxide (%):	1.89
Carbon Conversion to L/H Oils (%):	4.31
Carbon Conversion to Carbon Oxides (%):	6.49
Carbon Conversion to ETX Liquids (%):	4.40
Carbon Conversion to Hydrocarbons (%):	53.21
Carbon Conversion to Hydrocarbon Gas (%):	44.50
Carbon Conversion to Gases (%):	50.99
Carbon Conversion to Liquids (%):	8.71
Total Carbon Conversion (%):	59.70

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 25

AFHP TEST DATA EVALUATION
TEST NUMBER R-5 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	59.70 %				
Char:	40.30 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.40 %	0.10 %	4.40 %	0.00 %	6.49 %	4.31 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	405.00 lbs/hr	248.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	877.00 lbs/hr	63.00 lbs/hr	
Main Burner:	Oxygen		
	170.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	936.00 lbs/hr	98.28 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
340880 Btu/hr	209742 Btu/hr	57310 Btu/hr	517428 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 50 F	Hydrogen & Natural Gas @ 1112 F
Steam Generator:	Water @ 228 F	Hydrogen @ 64 F
Main Burner:	Oxygen @ 46 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3284.1 F	1463.7 F	2037.7 F	1862.0 F
Reactor Mixed Temperature: 1591.8 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.217 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.79 seconds
Based on Reactor Outlet Conditions:	5.08 seconds
Based on Reactor Mixed Conditions:	5.83 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.780	0.000	0.000
Carbon	73.105	75.172	94.170
Hydrogen	5.140	1.243	5.460
Nitrogen	1.464	1.400	0.140
Sulfur	2.959	1.348	0.230
Chlorine	0.182	0.154	0.000
Oxygen	8.264	0.000	0.000
Ash	8.106	20.683	0.000

COAL HIGHER HEATING VALUE: 13406 Btu/lb

CHAR HIGHER HEATING VALUE: 11675 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-5 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.396	63.540	58.305	42.000
H2O	20.573	36.460	41.695	41.381
H	0.029	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.852
CO	0.000	0.000	0.000	1.275
CO2	0.000	0.000	0.000	0.524
CH4	0.000	0.000	0.000	12.302
H2S	0.000	0.000	0.000	0.344
HCl	0.000	0.000	0.000	0.016
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.203
L/H Oils	0.000	0.000	0.000	0.085

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	97.685	128.952	118.327	86.357
H2O	25.312	73.994	84.619	85.085
H	0.036	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.808
CO	0.000	0.000	0.000	2.621
CO2	0.000	0.000	0.000	1.077
CH4	0.000	0.000	0.000	25.294
H2S	0.000	0.000	0.000	0.707
HCl	0.000	0.000	0.000	0.032
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.028
Benzene	0.000	0.000	0.000	0.418
L/H Oils	0.000	0.000	0.000	0.176
Total	123.034	202.946	202.946	205.612

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	196.93	259.97	238.55	174.10
H2O	456.01	1333.03	1524.45	1532.85
H	0.04	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	106.69
CO	0.00	0.00	0.00	73.40
CO2	0.00	0.00	0.00	47.39
CH4	0.00	0.00	0.00	405.80
H2S	0.00	0.00	0.00	24.10
HCl	0.00	0.00	0.00	1.17
NH3	0.00	0.00	0.00	0.14
C2H6	0.00	0.00	0.00	0.86
Benzene	0.00	0.00	0.00	32.63
L/H Oils	0.00	0.00	0.00	31.32
Char	0.00	0.00	0.00	366.84
Total	653.00	1593.00	1763.00	2797.28

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-5
Data Point: 5

Test Date: 13 NOV 1984
Time Slice: 16:38:01
Duration (minutes): 17.0

Reactor Inlet Steam Mole Percent: 40.9
Reactor Inlet Hydrogen Mole Percent: 59.1
Reactor Exit Steam Mole Percent: 40.9
Reactor Exit Hydrogen Mole Percent: 44.5

Reactor Exit Temperature (deg F): 1773
Reactor Mixed Temperature (deg F): 1544
Average Reactor Temperature (deg F): 1658.5
Main Burner Exit Temperature (deg F): 1972

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 5.56
Reactor Inlet Gas to Coal (lb-moles/lb): 0.218

Carbon Conversion to Methane (%):	37.90
Carbon Conversion to Ethane (%):	0.11
Carbon Conversion to Benzene (%):	9.60
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	3.70
Carbon Conversion to Carbon Dioxide (%):	1.28
Carbon Conversion to L/H Oils (%):	7.79
Carbon Conversion to Carbon Oxides (%):	4.98
Carbon Conversion to BTX Liquids (%):	9.60
Carbon Conversion to Hydrocarbons (%):	55.40
Carbon Conversion to Hydrocarbon Gas (%):	38.01
Carbon Conversion to Gases (%):	42.99
Carbon Conversion to Liquids (%):	17.39
Total Carbon Conversion (%):	60.38

Graphics Plot Symbol: 3
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 26

Notes:

Carbon conversion to methane might be low (see methane plot)

AFHP TEST DATA EVALUATION

TEST NUMBER R-5 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	60.38 %				
Char:	39.62 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
37.90 %	0.11 %	9.60 %	0.00 %	4.98 %	7.79 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	403.00 lbs/hr	249.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	877.00 lbs/hr	65.00 lbs/hr	
Main Burner:	Oxygen		
	157.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	936.00 lbs/hr	98.28 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
319000 Btu/hr	222983 Btu/hr	57212 Btu/hr	482314 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 51 F	Hydrogen & Natural Gas @ 1093 F
Steam Generator:	Water @ 227 F	Hydrogen @ 62 F
Main Burner:	Oxygen @ 46 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3270.9 F	1444.2 F	1972.2 F	1773.0 F
Reactor Mixed Temperature: 1543.9 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.218 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	4.88 seconds
Based on Reactor Outlet Conditions:	5.21 seconds
Based on Reactor Mixed Conditions:	5.92 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.780	0.000	0.000
Carbon	73.105	74.906	94.170
Hydrogen	5.140	1.239	5.460
Nitrogen	1.464	1.395	0.140
Sulfur	2.959	1.343	0.230
Chlorine	0.182	0.153	0.000
Oxygen	8.264	0.000	0.000
Ash	8.106	20.963	0.000

COAL HIGHER HEATING VALUE: 13406 Btu/lb

CHAR HIGHER HEATING VALUE: 11634 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-5 - DATA POINT 5 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	79.581	63.867	59.067	44.539
H2O	20.390	36.133	40.933	40.949
H	0.028	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.827
CO	0.000	0.000	0.000	1.011
CO2	0.000	0.000	0.000	0.350
CH4	0.000	0.000	0.000	10.358
H2S	0.000	0.000	0.000	0.340
HCl	0.000	0.000	0.000	0.016
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.015
Benzene	0.000	0.000	0.000	0.437
L/H Oils	0.000	0.000	0.000	0.152

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	98.307	130.566	120.753	92.840
H2O	25.187	73.869	83.682	85.356
H	0.035	0.000	0.000	0.000
OH	0.001	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.809
CO	0.000	0.000	0.000	2.108
CO2	0.000	0.000	0.000	0.729
CH4	0.000	0.000	0.000	21.591
H2S	0.000	0.000	0.000	0.708
HCl	0.000	0.000	0.000	0.032
NH3	0.000	0.000	0.000	0.011
C2H6	0.000	0.000	0.000	0.031
Benzene	0.000	0.000	0.000	0.911
L/H Oils	0.000	0.000	0.000	0.318
Total	123.530	204.435	204.435	208.444

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	198.19	263.22	243.44	187.16
H2O	453.76	1330.78	1507.56	1537.71
H	0.03	0.00	0.00	0.00
OH	0.02	0.00	0.00	0.00
N2	0.00	0.00	0.00	106.70
CO	0.00	0.00	0.00	59.04
CO2	0.00	0.00	0.00	32.09
CH4	0.00	0.00	0.00	346.39
H2S	0.00	0.00	0.00	24.13
HCl	0.00	0.00	0.00	1.18
NH3	0.00	0.00	0.00	0.19
C2H6	0.00	0.00	0.00	0.94
Benzene	0.00	0.00	0.00	71.20
L/H Oils	0.00	0.00	0.00	56.60
Char	0.00	0.00	0.00	361.93
Total	652.00	1594.00	1751.00	2785.28

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-5
Data Point: 1

Test Date: 5 JAN 1985
Time Slice: 12:55:59
Duration (minutes): 11.5

Reactor Inlet Steam Mole Percent: 27.7
Reactor Inlet Hydrogen Mole Percent: 72.3
Reactor Exit Steam Mole Percent: 25.4
Reactor Exit Hydrogen Mole Percent: 51.8

Reactor Exit Temperature (deg F): 1933
Reactor Mixed Temperature (deg F): 1552
Average Reactor Temperature (deg F): 1742.5
Main Burner Exit Temperature (deg F): 2198

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 7.02
Reactor Inlet Gas to Coal (lb-moles/lb): 0.151

Carbon Conversion to Methane (%):	41.40
Carbon Conversion to Ethane (%):	0.05
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	7.50
Carbon Conversion to Carbon Dioxide (%):	1.81
Carbon Conversion to L/H Oils (%):	4.49
Carbon Conversion to Carbon Oxides (%):	9.31
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	45.94
Carbon Conversion to Hydrocarbon Gas (%):	41.45
Carbon Conversion to Gases (%):	50.76
Carbon Conversion to Liquids (%):	4.49
Total Carbon Conversion (%):	55.25

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 27

AFHP TEST DATA EVALUATION

TEST NUMBER R-6 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	55.25 %					
Char:	44.75 %					
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils	
41.40 %	0.05 %	0.00 %	0.00 %	9.31 %	4.49 %	

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	222.00 lbs/hr	228.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	328.00 lbs/hr	47.00 lbs/hr	
Main Burner:	Oxygen		
	172.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1025.00 lbs/hr	107.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
290746 Btu/hr	167492 Btu/hr	60591 Btu/hr	278020 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 55 F	Hydrogen & Natural Gas @ 1134 F
Steam Generator:	Water @ 210 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 58 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2404.2 F	1400.1 F	2198.2 F	1933.0 F
Reactor Mixed Temperature: 1552.2 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.151 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.90 seconds
Based on Reactor Outlet Conditions:	6.24 seconds
Based on Reactor Mixed Conditions:	7.79 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.630	0.000	0.000
Carbon	73.315	76.720	94.170
Hydrogen	5.088	0.910	5.460
Nitrogen	1.485	0.799	0.140
Sulfur	3.040	1.394	0.230
Chlorine	0.182	0.144	0.000
Oxygen	7.853	0.374	0.000
Ash	8.407	19.659	0.000

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11700 Btu/lb

AFHP TEST DATA EVALUATION
 TEST NUMBER: R-6 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.731	79.250	72.297	51.815
H2O	12.269	20.750	27.703	25.369
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.622
CO	0.000	0.000	0.000	2.892
CO2	0.000	0.000	0.000	0.698
CH4	0.000	0.000	0.000	15.964
H2S	0.000	0.000	0.000	0.480
HCl	0.000	0.000	0.000	0.021
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.010
L/H Oils	0.000	0.000	0.000	0.124

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	99.219	122.533	111.783	84.071
H2O	13.876	32.082	42.833	41.162
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.254
CO	0.000	0.000	0.000	4.692
CO2	0.000	0.000	0.000	1.132
CH4	0.000	0.000	0.000	25.902
H2S	0.000	0.000	0.000	0.779
HCl	0.000	0.000	0.000	0.035
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.016
L/H Oils	0.000	0.000	0.000	0.201
Total	113.096	154.615	154.615	162.253

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	200.03	247.03	225.35	169.49
H2O	249.97	577.97	771.65	741.56
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	119.17
CO	0.00	0.00	0.00	131.44
CO2	0.00	0.00	0.00	49.84
CH4	0.00	0.00	0.00	415.55
H2S	0.00	0.00	0.00	26.54
HCl	0.00	0.00	0.00	1.27
NH3	0.00	0.00	0.00	0.16
C2H6	0.00	0.00	0.00	0.47
L/H Oils	0.00	0.00	0.00	35.83
Char	0.00	0.00	0.00	438.33
Total	450.00	825.00	997.00	2129.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-6
Data Point: 2

Test Date: 5 JAN 1985
Time Slice: 13:02:59
Duration (minutes): 8.2

Reactor Inlet Steam Mole Percent: 28.3
Reactor Inlet Hydrogen Mole Percent: 71.7
Reactor Exit Steam Mole Percent: 25.9
Reactor Exit Hydrogen Mole Percent: 50.2

Reactor Exit Temperature (deg F): 1934
Reactor Mixed Temperature (deg F): 1576
Average Reactor Temperature (deg F): 1755
Main Burner Exit Temperature (deg F): 2234

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 7.00
Reactor Inlet Gas to Coal (lb-moles/lb): 0.151

Carbon Conversion to Methane (%):	43.30
Carbon Conversion to Ethane (%):	0.07
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	7.70
Carbon Conversion to Carbon Dioxide (%):	1.86
Carbon Conversion to L/H Oils (%):	4.44
Carbon Conversion to Carbon Oxides (%):	9.56
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	47.81
Carbon Conversion to Hydrocarbon Gas (%):	43.37
Carbon Conversion to Gases (%):	52.93
Carbon Conversion to Liquids (%):	4.44
Total Carbon Conversion (%):	57.37

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 28

AFHP TEST DATA EVALUATION
TEST NUMBER R-6 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall: 57.37 %
Char: 42.63 %
Methane   Ethane   Benzene   Toluene   Carbon Oxides   L/H Oils
43.30 %   0.07 %   0.00 %   0.00 %   9.56 %   4.44 %

INLET FLOWRATES:

Preburner: Oxygen   Hydrogen   Natural Gas
223.00 lbs/hr   227.00 lbs/hr   0.00 lbs/hr
Steam Generator: Water   Hydrogen
332.00 lbs/hr   47.00 lbs/hr
Main Burner: Oxygen
180.00 lbs/hr
Reactor: Coal   Nitrogen
1025.00 lbs/hr   107.63 lbs/hr

HEAT LOSSES:

Preburner   Steam Generator   Main Burner   Reactor
296785 Btu/hr   163655 Btu/hr   63388 Btu/hr   369016 Btu/hr

PREHEAT TEMPERATURES:

Preburner: Oxygen @ 55 F   Hydrogen & Natural Gas @ 1137 F
Steam Generator: Water @ 208 F   Hydrogen @ 72 F
Main Burner: Oxygen @ 58 F

EXIT TEMPERATURES:

Preburner   Steam Generator   Main Burner   Reactor
2411.9 F   1400.5 F   2234.0 F   1934.0 F
Reactor Mixed Temperature: 1576.4 F

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.151 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions: 5.83 seconds
Based on Reactor Outlet Conditions: 6.29 seconds
Based on Reactor Mixed Conditions: 7.71 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.630	0.000	0.000
Carbon	73.315	75.977	94.170
Hydrogen	5.088	0.901	5.460
Nitrogen	1.485	0.791	0.140
Sulfur	3.040	1.380	0.230
Chlorine	0.182	0.142	0.000
Oxygen	7.853	0.371	0.000
Ash	8.407	20.437	0.000

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11587 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-6 - DATA POINT 2

Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.621	79.029	71.740	50.232
H2O	12.378	20.971	28.260	25.933
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.645
CO	0.000	0.000	0.000	2.991
CO2	0.000	0.000	0.000	0.723
CH4	0.000	0.000	0.000	16.822
H2S	0.000	0.000	0.000	0.489
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.014
L/H Oils	0.000	0.000	0.000	0.123

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	98.661	121.975	110.724	80.894
H2O	13.938	32.367	43.617	41.764
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.260
CO	0.000	0.000	0.000	4.817
CO2	0.000	0.000	0.000	1.164
CH4	0.000	0.000	0.000	27.091
H2S	0.000	0.000	0.000	0.788
HCl	0.000	0.000	0.000	0.036
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.022
L/H Oils	0.000	0.000	0.000	0.199
Total	112.600	154.341	154.341	161.043

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	198.90	245.90	223.22	163.08
H2O	251.10	583.10	785.78	752.40
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	119.34
CO	0.00	0.00	0.00	134.94
CO2	0.00	0.00	0.00	51.21
CH4	0.00	0.00	0.00	434.62
H2S	0.00	0.00	0.00	26.85
HCl	0.00	0.00	0.00	1.30
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	0.66
L/H Oils	0.00	0.00	0.00	35.43
Char	0.00	0.00	0.00	421.65
Total	450.00	829.00	1009.00	2141.62

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-6
Data Point: 3

Test Date: 5 JAN 1985
Time Slice: 13:12:59
Duration (minutes): 7.7

Reactor Inlet Steam Mole Percent: 28.3
Reactor Inlet Hydrogen Mole Percent: 71.7
Reactor Exit Steam Mole Percent: 25.9
Reactor Exit Hydrogen Mole Percent: 49.8

Reactor Exit Temperature (deg F): 1938
Reactor Mixed Temperature (deg F): 1567
Average Reactor Temperature (deg F): 1752.5
Main Burner Exit Temperature (deg F): 2218

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 6.98
Reactor Inlet Gas to Coal (lb-moles/lb): 0.151

Carbon Conversion to Methane (%):	44.40
Carbon Conversion to Ethane (%):	0.07
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	7.90
Carbon Conversion to Carbon Dioxide (%):	1.87
Carbon Conversion to L/H Oils (%):	4.32
Carbon Conversion to Carbon Oxides (%):	9.77
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	48.79
Carbon Conversion to Hydrocarbon Gas (%):	44.47
Carbon Conversion to Gases (%):	54.24
Carbon Conversion to Liquids (%):	4.32
Total Carbon Conversion (%):	58.56

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 29

AFHP TEST DATA EVALUATION
TEST NUMBER R-6 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	58.56 %				
Char:	41.44 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.40 %	0.07 %	0.00 %	0.00 %	9.77 %	4.32 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	222.00 lbs/hr	228.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	337.00 lbs/hr	47.00 lbs/hr	
Main Burner:	Oxygen		
	180.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1025.00 lbs/hr	107.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
293418 Btu/hr	165375 Btu/hr	58368 Btu/hr	364324 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 55 F	Hydrogen & Natural Gas @ 1126 F
Steam Generator:	Water @ 209 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 59 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2394.4 F	1382.3 F	2217.5 F	1938.0 F
Reactor Mixed Temperature: 1567.4 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.151 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.83 seconds
Based on Reactor Outlet Conditions:	6.26 seconds
Based on Reactor Mixed Conditions:	7.71 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.630	0.000	0.000
Carbon	73.315	75.534	94.170
Hydrogen	5.088	0.896	5.460
Nitrogen	1.485	0.787	0.140
Sulfur	3.040	1.372	0.230
Chlorine	0.182	0.141	0.000
Oxygen	7.853	0.368	0.000
Ash	8.407	20.901	0.000

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11519 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-6 - DATA POINT 3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.731	78.995	71.742	49.762
H2O	12.269	21.005	28.258	25.936
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.643
CO	0.000	0.000	0.000	3.064
CO2	0.000	0.000	0.000	0.725
CH4	0.000	0.000	0.000	17.218
H2S	0.000	0.000	0.000	0.491
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.014
L/H Oils	0.000	0.000	0.000	0.120

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	99.219	122.533	111.283	80.285
H2O	13.876	32.582	43.832	41.844
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.264
CO	0.000	0.000	0.000	4.943
CO2	0.000	0.000	0.000	1.170
CH4	0.000	0.000	0.000	27.779
H2S	0.000	0.000	0.000	0.793
HCl	0.000	0.000	0.000	0.036
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.022
L/H Oils	0.000	0.000	0.000	0.193
Total	113.096	155.115	155.115	161.337

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	200.03	247.03	224.35	161.85
H2O	249.97	586.97	789.65	753.84
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	119.44
CO	0.00	0.00	0.00	138.45
CO2	0.00	0.00	0.00	51.49
CH4	0.00	0.00	0.00	445.66
H2S	0.00	0.00	0.00	27.02
HCl	0.00	0.00	0.00	1.32
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	0.66
L/H Oils	0.00	0.00	0.00	34.47
Char	0.00	0.00	0.00	412.28
Total	450.00	834.00	1014.00	2146.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-6
Data Point: 4

Test Date: 5 JAN 1985
Time Slice: 13:18:00
Duration (minutes): 7.2

Reactor Inlet Steam Mole Percent: 28.0
Reactor Inlet Hydrogen Mole Percent: 72.0
Reactor Exit Steam Mole Percent: 25.6
Reactor Exit Hydrogen Mole Percent: 50.6

Reactor Exit Temperature (deg F): 1941
Reactor Mixed Temperature (deg F): 1566
Average Reactor Temperature (deg F): 1753.5
Main Burner Exit Temperature (deg F): 2218

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 7.00
Reactor Inlet Gas to Coal (lb-moles/lb): 0.151

Carbon Conversion to Methane (%):	43.30
Carbon Conversion to Ethane (%):	0.07
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	7.90
Carbon Conversion to Carbon Dioxide (%):	1.89
Carbon Conversion to L/H Oils (%):	4.19
Carbon Conversion to Carbon Oxides (%):	9.79
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	47.56
Carbon Conversion to Hydrocarbon Gas (%):	43.37
Carbon Conversion to Gases (%):	53.16
Carbon Conversion to Liquids (%):	4.19
Total Carbon Conversion (%):	57.35

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 30

AFHP TEST DATA EVALUATION

TEST NUMBER R-6 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	57.35 %				
Char:	42.65 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
43.30 %	0.07 %	0.00 %	0.00 %	9.79 %	4.19 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	221.00 lbs/hr	228.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	330.00 lbs/hr	47.00 lbs/hr	
Main Burner:	Oxygen		
	179.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1025.00 lbs/hr	107.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
291977 Btu/hr	164667 Btu/hr	60122 Btu/hr	326818 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 57 F	Hydrogen & Natural Gas @ 1123 F
Steam Generator:	Water @ 209 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 60 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2386.9 F	1386.0 F	2217.6 F	1941.0 F
Reactor Mixed Temperature: 1566.0 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.151 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.85 seconds
Based on Reactor Outlet Conditions:	6.25 seconds
Based on Reactor Mixed Conditions:	7.74 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.630	0.000	0.000
Carbon	73.315	75.985	94.170
Hydrogen	5.088	0.901	5.460
Nitrogen	1.485	0.791	0.140
Sulfur	3.040	1.380	0.230
Chlorine	0.182	0.142	0.000
Oxygen	7.853	0.371	0.000
Ash	8.407	20.429	0.000

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11588 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-6 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.786	79.234	72.003	50.611
H2O	12.214	20.766	27.997	25.556
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.636
CO	0.000	0.000	0.000	3.058
CO2	0.000	0.000	0.000	0.732
CH4	0.000	0.000	0.000	16.763
H2S	0.000	0.000	0.000	0.487
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.014
L/H Oils	0.000	0.000	0.000	0.116

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	99.282	122.596	111.408	81.794
H2O	13.813	32.131	43.319	41.303
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.260
CO	0.000	0.000	0.000	4.943
CO2	0.000	0.000	0.000	1.182
CH4	0.000	0.000	0.000	27.091
H2S	0.000	0.000	0.000	0.788
HCl	0.000	0.000	0.000	0.036
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.022
L/H Oils	0.000	0.000	0.000	0.188
Total	113.096	154.726	154.726	161.614

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	200.15	247.15	224.60	164.90
H2O	248.85	578.85	780.40	744.09
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	119.34
CO	0.00	0.00	0.00	138.45
CO2	0.00	0.00	0.00	52.04
CH4	0.00	0.00	0.00	434.62
H2S	0.00	0.00	0.00	26.85
HCl	0.00	0.00	0.00	1.30
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	0.66
L/H Oils	0.00	0.00	0.00	33.44
Char	0.00	0.00	0.00	421.80
Total	449.00	826.00	1005.00	2137.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-6
Data Point: 5

Test Date: 5 JAN 1985
Time Slice: 13:27:00
Duration (minutes): 7.4

Reactor Inlet Steam Mole Percent: 28.0
Reactor Inlet Hydrogen Mole Percent: 72.0
Reactor Exit Steam Mole Percent: 25.6
Reactor Exit Hydrogen Mole Percent: 49.6

Reactor Exit Temperature (deg F): 1945
Reactor Mixed Temperature (deg F): 1561
Average Reactor Temperature (deg F): 1753
Main Burner Exit Temperature (deg F): 2202

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 6.92
Reactor Inlet Gas to Coal (lb-moles/lb): 0.153

Carbon Conversion to Methane (%):	45.80
Carbon Conversion to Ethane (%):	0.07
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	8.30
Carbon Conversion to Carbon Dioxide (%):	1.95
Carbon Conversion to L/H Oils (%):	4.01
Carbon Conversion to Carbon Oxides (%):	10.25
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	49.88
Carbon Conversion to Hydrocarbon Gas (%):	45.87
Carbon Conversion to Gases (%):	56.12
Carbon Conversion to Liquids (%):	4.01
Total Carbon Conversion (%):	60.13

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 31

AFHP TEST DATA EVALUATION
TEST NUMBER R-6 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	60.13 %				
Char:	39.87 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.80 %	0.07 %	0.00 %	0.00 %	10.25 %	4.01 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	221.00 lbs/hr	231.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	339.00 lbs/hr	47.00 lbs/hr	
Main Burner:	Oxygen		
	180.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1025.00 lbs/hr	107.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
287691 Btu/hr	168411 Btu/hr	59425 Btu/hr	356266 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 58 F	Hydrogen & Natural Gas @ 1125 F
Steam Generator:	Water @ 209 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 61 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2378.3 F	1374.0 F	2201.8 F	1945.0 F
Reactor Mixed Temperature: 1560.8 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.153 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.81 seconds
Based on Reactor Outlet Conditions:	6.20 seconds
Based on Reactor Mixed Conditions:	7.65 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.630	0.000	0.000
Carbon	73.315	74.918	94.170
Hydrogen	5.088	0.889	5.460
Nitrogen	1.485	0.780	0.140
Sulfur	3.040	1.361	0.230
Chlorine	0.182	0.140	0.000
Oxygen	7.853	0.365	0.000
Ash	8.407	21.547	0.000

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11425 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-6 - DATA POINT 5 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.945	79.178	72.000	49.579
H2O	12.055	20.822	28.000	25.569
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.627
CO	0.000	0.000	0.000	3.196
CO2	0.000	0.000	0.000	0.751
CH4	0.000	0.000	0.000	17.635
H2S	0.000	0.000	0.000	0.492
HCl	0.000	0.000	0.000	0.023
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.013
L/H Oils	0.000	0.000	0.000	0.110

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	100.770	124.084	112.833	80.560
H2O	13.813	32.630	43.881	41.546
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.268
CO	0.000	0.000	0.000	5.193
CO2	0.000	0.000	0.000	1.220
CH4	0.000	0.000	0.000	28.655
H2S	0.000	0.000	0.000	0.800
HCl	0.000	0.000	0.000	0.037
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.022
L/H Oils	0.000	0.000	0.000	0.180
Total	114.584	156.714	156.714	162.488

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	203.15	250.15	227.47	162.41
H2O	248.85	587.85	790.53	748.47
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	119.56
CO	0.00	0.00	0.00	145.46
CO2	0.00	0.00	0.00	53.69
CH4	0.00	0.00	0.00	459.71
H2S	0.00	0.00	0.00	27.26
HCl	0.00	0.00	0.00	1.34
NH3	0.00	0.00	0.00	0.14
C2H6	0.00	0.00	0.00	0.66
L/H Oils	0.00	0.00	0.00	32.00
Char	0.00	0.00	0.00	399.93
Total	452.00	838.00	1018.00	2150.62

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-6
Data Point: 6

Test Date: 5 JAN 1985
Time Slice: 13:33:00
Duration (minutes): 4.0

Reactor Inlet Steam Mole Percent: 27.6
Reactor Inlet Hydrogen Mole Percent: 72.4
Reactor Exit Steam Mole Percent: 25.3
Reactor Exit Hydrogen Mole Percent: 50.2

Reactor Exit Temperature (deg F): 1947
Reactor Mixed Temperature (deg F): 1568
Average Reactor Temperature (deg F): 1757.5
Main Burner Exit Temperature (deg F): 2209

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 6.86
Reactor Inlet Gas to Coal (lb-moles/lb): 0.154

Carbon Conversion to Methane (%):	45.60
Carbon Conversion to Ethane (%):	0.08
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	8.20
Carbon Conversion to Carbon Dioxide (%):	1.93
Carbon Conversion to L/H Oils (%):	3.94
Carbon Conversion to Carbon Oxides (%):	10.13
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	49.62
Carbon Conversion to Hydrocarbon Gas (%):	45.68
Carbon Conversion to Gases (%):	55.81
Carbon Conversion to Liquids (%):	3.94
Total Carbon Conversion (%):	59.75

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 32

AFHP TEST DATA EVALUATION
TEST NUMBER R-6 - DATA POINT 6

COAL CARBON CONVERSIONS:

Overall:	59.75 %				
Char:	40.25 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.60 %	0.08 %	0.00 %	0.00 %	10.13 %	3.94 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	222.00 lbs/hr	233.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	332.00 lbs/hr	48.00 lbs/hr	
Main Burner:	Oxygen		
	181.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1025.00 lbs/hr	107.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
293215 Btu/hr	165870 Btu/hr	59391 Btu/hr	363296 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 60 F	Hydrogen & Natural Gas @ 1127 F
Steam Generator:	Water @ 210 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 62 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2371.1 F	1382.2 F	2209.4 F	1947.0 F
Reactor Mixed Temperature: 1568.3 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.154 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.75 seconds
Based on Reactor Outlet Conditions:	6.15 seconds
Based on Reactor Mixed Conditions:	7.57 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.630	0.000	0.000
Carbon	73.315	75.070	94.170
Hydrogen	5.088	0.891	5.460
Nitrogen	1.485	0.782	0.140
Sulfur	3.040	1.364	0.230
Chlorine	0.182	0.141	0.000
Oxygen	7.853	0.366	0.000
Ash	8.407	21.387	0.000

COAL HIGHER HEATING VALUE: 13377 Btu/lb

CHAR HIGHER HEATING VALUE: 11449 Btu/lb

AFHP TEST DATA EVALUATION
TEST NUMBER R-6 - DATA POINT 6 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.994	79.530	72.362	50.162
H2O	12.006	20.470	27.638	25.283
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.608
CO	0.000	0.000	0.000	3.135
CO2	0.000	0.000	0.000	0.738
CH4	0.000	0.000	0.000	17.436
H2S	0.000	0.000	0.000	0.488
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.015
L/H Oils	0.000	0.000	0.000	0.108

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	101.700	125.509	114.196	82.077
H2O	13.876	32.304	43.617	41.369
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	4.267
CO	0.000	0.000	0.000	5.130
CO2	0.000	0.000	0.000	1.208
CH4	0.000	0.000	0.000	28.530
H2S	0.000	0.000	0.000	0.798
HCl	0.000	0.000	0.000	0.037
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.025
L/H Oils	0.000	0.000	0.000	0.176
Total	115.576	157.814	157.814	163.625

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	205.03	253.03	230.22	165.47
H2O	249.97	581.97	785.78	745.28
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	119.53
CO	0.00	0.00	0.00	143.70
CO2	0.00	0.00	0.00	53.14
CH4	0.00	0.00	0.00	457.71
H2S	0.00	0.00	0.00	27.20
HCl	0.00	0.00	0.00	1.34
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	0.75
L/H Oils	0.00	0.00	0.00	31.44
Char	0.00	0.00	0.00	402.92
Total	455.00	835.00	1016.00	2148.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-7
Data Point: 1

Test Date: 11 JAN 1985
Time Slice: 16:14:59
Duration (minutes): 15.0

Reactor Inlet Steam Mole Percent: 38.1
Reactor Inlet Hydrogen Mole Percent: 61.9
Reactor Exit Steam Mole Percent: 38.1
Reactor Exit Hydrogen Mole Percent: 48.7

Reactor Exit Temperature (deg F): 1778
Reactor Mixed Temperature (deg F): 1519
Average Reactor Temperature (deg F): 1648.5
Main Burner Exit Temperature (deg F): 1893

Reactor Pressure (psia): 1017
Reactor Residence Time (seconds): 7.92
Reactor Inlet Gas to Coal (lb-moles/lb): 0.247

Carbon Conversion to Methane (%):	40.00
Carbon Conversion to Ethane (%):	0.07
Carbon Conversion to Benzene (%):	5.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	3.70
Carbon Conversion to Carbon Dioxide (%):	1.41
Carbon Conversion to L/H Oils (%):	8.23
Carbon Conversion to Carbon Oxides (%):	5.11
Carbon Conversion to BTX Liquids (%):	5.00
Carbon Conversion to Hydrocarbons (%):	53.30
Carbon Conversion to Hydrocarbon Gas (%):	40.07
Carbon Conversion to Gases (%):	45.18
Carbon Conversion to Liquids (%):	13.23
Total Carbon Conversion (%):	58.41

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 33

AFHP TEST DATA EVALUATION
TEST NUMBER R-7 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	58.41 %				
Char:	41.59 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
40.00 %	0.07 %	5.00 %	0.00 %	5.11 %	8.23 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	220.00 lbs/hr	226.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	595.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	137.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
307559 Btu/hr	143298 Btu/hr	52033 Btu/hr	353329 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 27 F	Hydrogen & Natural Gas @ 1133 F
Steam Generator:	Water @ 213 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 26 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2380.6 F	1224.5 F	1893.3 F	1778.0 F
Reactor Mixed Temperature: 1518.7 F			

PRESSURE: 1017.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.247 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	7.13 seconds
Based on Reactor Outlet Conditions:	7.37 seconds
Based on Reactor Mixed Conditions:	8.48 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.570	0.000	0.000
Carbon	72.793	75.533	94.170
Hydrogen	5.111	0.957	5.460
Nitrogen	1.470	0.903	0.140
Sulfur	2.970	1.165	0.230
Chlorine	0.183	0.189	0.000
Oxygen	8.660	0.687	0.000
Ash	8.243	20.566	0.000

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 11355 Btu/lb

AFMP TEST DATA EVALUATION

TEST NUMBER R-7 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.734	67.768	61.868	48.702
H2O	12.266	32.232	38.132	38.112
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.643
CO	0.000	0.000	0.000	0.891
CO2	0.000	0.000	0.000	0.340
CH4	0.000	0.000	0.000	9.636
H2S	0.000	0.000	0.000	0.308
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.008
Benzene	0.000	0.000	0.000	0.201
L/H Oils	0.000	0.000	0.000	0.142

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	98.352	98.353	89.790	71.922
H2O	13.751	46.778	55.341	56.283
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.426
CO	0.000	0.000	0.000	1.316
CO2	0.000	0.000	0.000	0.502
CH4	0.000	0.000	0.000	14.230
H2S	0.000	0.000	0.000	0.456
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.012
Benzene	0.000	0.000	0.000	0.296
L/H Oils	0.000	0.000	0.000	0.210
Total	112.103	145.130	145.130	147.680

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	198.28	198.28	181.02	145.00
H2O	247.72	842.72	996.98	1013.96
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	67.97
CO	0.00	0.00	0.00	36.87
CO2	0.00	0.00	0.00	22.08
CH4	0.00	0.00	0.00	228.29
H2S	0.00	0.00	0.00	15.52
HCl	0.00	0.00	0.00	0.65
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	0.37
Benzene	0.00	0.00	0.00	23.16
L/H Oils	0.00	0.00	0.00	37.34
Char	0.00	0.00	0.00	235.28
Total	446.00	1041.00	1178.00	1826.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-7
Data Point: 2

Test Date: 11 JAN 1985
Time Slice: 16:24:59
Duration (minutes): 7.6

Reactor Inlet Steam Mole Percent: 39.9
Reactor Inlet Hydrogen Mole Percent: 60.1
Reactor Exit Steam Mole Percent: 39.1
Reactor Exit Hydrogen Mole Percent: 45.5

Reactor Exit Temperature (deg F): 1877
Reactor Mixed Temperature (deg F): 1633
Average Reactor Temperature (deg F): 1755
Main Burner Exit Temperature (deg F): 2043

Reactor Pressure (psia): 1017
Reactor Residence Time (seconds): 7.62
Reactor Inlet Gas to Coal (lb-moles/lb): 0.245

Carbon Conversion to Methane (%):	46.90
Carbon Conversion to Ethane (%):	0.06
Carbon Conversion to Benzene (%):	0.40
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	5.60
Carbon Conversion to Carbon Dioxide (%):	2.30
Carbon Conversion to L/H Oils (%):	4.36
Carbon Conversion to Carbon Oxides (%):	7.90
Carbon Conversion to BTX Liquids (%):	0.40
Carbon Conversion to Hydrocarbons (%):	51.72
Carbon Conversion to Hydrocarbon Gas (%):	46.96
Carbon Conversion to Gases (%):	54.86
Carbon Conversion to Liquids (%):	4.76
Total Carbon Conversion (%):	59.62

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 34

AFHP TEST DATA EVALUATION

TEST NUMBER R-7 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	59.62 %				
Char:	40.38 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
46.90 %	0.06 %	0.40 %	0.00 %	7.90 %	4.36 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	227.00 lbs/hr	223.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	595.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	161.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
309610 Btu/hr	141188 Btu/hr	52022 Btu/hr	445199 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 27 F	Hydrogen & Natural Gas @ 1119 F
Steam Generator:	Water @ 213 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 27 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2428.3 F	1254.5 F	2042.6 F	1877.0 F
Reactor Mixed Temperature: 1633.1 F			

PRESSURE: 1017.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.245 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	6.77 seconds
Based on Reactor Outlet Conditions:	7.15 seconds
Based on Reactor Mixed Conditions:	8.10 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.570	0.000	0.000
Carbon	72.793	75.070	94.170
Hydrogen	5.111	0.952	5.460
Nitrogen	1.470	0.897	0.140
Sulfur	2.970	1.158	0.230
Chlorine	0.183	0.188	0.000
Oxygen	8.660	0.682	0.000
Ash	8.243	21.052	0.000

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 11286 Btu/lb

AFHP TEST DATA EVALUATION
TEST NUMBER R-7 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.173	67.130	60.124	45.455
H2O	12.826	32.870	39.876	39.064
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.668
CO	0.000	0.000	0.000	1.367
CO2	0.000	0.000	0.000	0.562
CH4	0.000	0.000	0.000	11.452
H2S	0.000	0.000	0.000	0.315
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.007
Benzene	0.000	0.000	0.000	0.016
L/H Oils	0.000	0.000	0.000	0.076

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	96.427	96.427	86.364	66.225
H2O	14.188	47.215	57.278	56.915
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.431
CO	0.000	0.000	0.000	1.992
CO2	0.000	0.000	0.000	0.818
CH4	0.000	0.000	0.000	16.685
H2S	0.000	0.000	0.000	0.459
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.011
Benzene	0.000	0.000	0.000	0.024
L/H Oils	0.000	0.000	0.000	0.111
Total	110.615	143.642	143.642	145.694

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	194.40	194.40	174.11	133.51
H2O	255.60	850.60	1031.89	1025.34
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	68.09
CO	0.00	0.00	0.00	55.80
CO2	0.00	0.00	0.00	36.01
CH4	0.00	0.00	0.00	267.67
H2S	0.00	0.00	0.00	15.65
HCl	0.00	0.00	0.00	0.66
NH3	0.00	0.00	0.00	0.10
C2H6	0.00	0.00	0.00	0.32
Benzene	0.00	0.00	0.00	1.85
L/H Oils	0.00	0.00	0.00	19.78
Char	0.00	0.00	0.00	229.84
Total	450.00	1045.00	1206.00	1854.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-7
Data Point: 3

Test Date: 11 JAN 1985
Time Slice: 16:35:59
Duration (minutes): 13.4

Reactor Inlet Steam Mole Percent: 42.2
Reactor Inlet Hydrogen Mole Percent: 57.8
Reactor Exit Steam Mole Percent: 37.3
Reactor Exit Hydrogen Mole Percent: 46.0

Reactor Exit Temperature (deg F): 1935
Reactor Mixed Temperature (deg F): 1825
Average Reactor Temperature (deg F): 1380
Main Burner Exit Temperature (deg F): 2287

Reactor Pressure (psia): 1016
Reactor Residence Time (seconds): 7.08
Reactor Inlet Gas to Coal (lb-moles/lb): 0.245

Carbon Conversion to Methane (%):	44.90
Carbon Conversion to Ethane (%):	0.05
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	12.50
Carbon Conversion to Carbon Dioxide (%):	4.86
Carbon Conversion to L/H Oils (%):	2.18
Carbon Conversion to Carbon Oxides (%):	17.36
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	47.13
Carbon Conversion to Hydrocarbon Gas (%):	44.95
Carbon Conversion to Gases (%):	62.31
Carbon Conversion to Liquids (%):	2.18
Total Carbon Conversion (%):	64.49

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 35

AFHP TEST DATA EVALUATION
TEST NUMBER R-7 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	64.49 %				
Char:	35.51 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.90 %	0.05 %	0.00 %	0.00 %	17.36 %	2.18 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	229.00 lbs/hr	223.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	599.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	211.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
304118 Btu/hr	146620 Btu/hr	52461 Btu/hr	470456 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 29 F	Hydrogen & Natural Gas @ 1126 F
Steam Generator:	Water @ 214 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 30 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2453.7 F	1265.8 F	2286.7 F	1935.0 F
Reactor Mixed Temperature: 1824.8 F			

PRESSURE: 1016.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.245 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	6.16 seconds
Based on Reactor Outlet Conditions:	6.75 seconds
Based on Reactor Mixed Conditions:	7.40 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.570	0.000	0.000
Carbon	72.793	72.963	94.170
Hydrogen	5.111	0.925	5.460
Nitrogen	1.470	0.872	0.140
Sulfur	2.970	1.126	0.230
Chlorine	0.183	0.183	0.000
Oxygen	8.660	0.663	0.000
Ash	8.243	23.268	0.000

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 10969 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-7 - DATA POINT 3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.060	66.939	57.772	45.963
H2O	12.939	33.061	42.228	37.316
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.622
CO	0.000	0.000	0.000	2.957
CO2	0.000	0.000	0.000	1.150
CH4	0.000	0.000	0.000	10.621
H2S	0.000	0.000	0.000	0.313
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.006
L/H Oils	0.000	0.000	0.000	0.037

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	96.302	96.302	83.114	69.127
H2O	14.313	47.562	60.750	56.122
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.440
CO	0.000	0.000	0.000	4.447
CO2	0.000	0.000	0.000	1.729
CH4	0.000	0.000	0.000	15.973
H2S	0.000	0.000	0.000	0.470
HCl	0.000	0.000	0.000	0.020
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.009
L/H Oils	0.000	0.000	0.000	0.055
Total	110.615	143.864	143.864	150.398

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	194.14	194.14	167.56	139.36
H2O	257.85	856.86	1094.44	1011.07
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	68.36
CO	0.00	0.00	0.00	124.56
CO2	0.00	0.00	0.00	76.09
CH4	0.00	0.00	0.00	256.26
H2S	0.00	0.00	0.00	16.02
HCl	0.00	0.00	0.00	0.71
NH3	0.00	0.00	0.00	0.10
C2H6	0.00	0.00	0.00	0.27
L/H Oils	0.00	0.00	0.00	9.89
Char	0.00	0.00	0.00	207.96
Total	452.00	1051.00	1262.00	1910.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-7
Data Point: 4

Test Date: 11 JAN 1985
Time Slice: 16:41:59
Duration (minutes): 7.6

Reactor Inlet Steam Mole Percent: 42.3
Reactor Inlet Hydrogen Mole Percent: 57.7
Reactor Exit Steam Mole Percent: 37.2
Reactor Exit Hydrogen Mole Percent: 46.2

Reactor Exit Temperature (deg F): 1940
Reactor Mixed Temperature (deg F): 1828
Average Reactor Temperature (deg F): 1884
Main Burner Exit Temperature (deg F): 2292

Reactor Pressure (psia): 1016
Reactor Residence Time (seconds): 7.09
Reactor Inlet Gas to Coal (lb-moles/lb): 0.244

Carbon Conversion to Methane (%):	44.00
Carbon Conversion to Ethane (%):	0.05
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	12.70
Carbon Conversion to Carbon Dioxide (%):	4.94
Carbon Conversion to L/H Oils (%):	1.98
Carbon Conversion to Carbon Oxides (%):	17.64
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	46.03
Carbon Conversion to Hydrocarbon Gas (%):	44.05
Carbon Conversion to Gases (%):	61.69
Carbon Conversion to Liquids (%):	1.98
Total Carbon Conversion (%):	63.67

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 36

AFHP TEST DATA EVALUATION
TEST NUMBER R-7 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	63.67 %				
Char:	36.33 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.00 %	0.05 %	0.00 %	0.00 %	17.64 %	1.98 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	229.00 lbs/hr	222.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	595.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	211.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
304753 Btu/hr	146614 Btu/hr	53974 Btu/hr	449617 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 29 F	Hydrogen & Natural Gas @ 1123 F
Steam Generator:	Water @ 213 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 31 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2455.8 F	1268.3 F	2292.5 F	1940.0 F
Reactor Mixed Temperature: 1827.5 F			

PRESSURE: 1016.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.244 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	6.17 seconds
Based on Reactor Outlet Conditions:	6.75 seconds
Based on Reactor Mixed Conditions:	7.43 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.570	0.000	0.000
Carbon	72.793	73.349	94.170
Hydrogen	5.111	0.930	5.460
Nitrogen	1.470	0.877	0.140
Sulfur	2.970	1.132	0.230
Chlorine	0.183	0.184	0.000
Oxygen	8.660	0.667	0.000
Ash	8.243	22.862	0.000

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 11027 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-7 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.002	66.929	57.716	46.241
H2O	12.998	33.071	42.284	37.157
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.625
CO	0.000	0.000	0.000	3.010
CO2	0.000	0.000	0.000	1.171
CH4	0.000	0.000	0.000	10.429
H2S	0.000	0.000	0.000	0.312
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.006
L/H Oils	0.000	0.000	0.000	0.034

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	95.806	95.806	82.618	69.405
H2O	14.313	47.340	60.528	55.770
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.439
CO	0.000	0.000	0.000	4.518
CO2	0.000	0.000	0.000	1.757
CH4	0.000	0.000	0.000	15.653
H2S	0.000	0.000	0.000	0.468
HCl	0.000	0.000	0.000	0.019
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.009
L/H Oils	0.000	0.000	0.000	0.050
Total	110.119	143.146	143.146	150.095

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	193.14	193.14	166.56	139.92
H2O	257.85	852.86	1090.44	1004.72
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	68.32
CO	0.00	0.00	0.00	126.55
CO2	0.00	0.00	0.00	77.34
CH4	0.00	0.00	0.00	251.12
H2S	0.00	0.00	0.00	15.96
HCl	0.00	0.00	0.00	0.70
NH3	0.00	0.00	0.00	0.09
C2H6	0.00	0.00	0.00	0.27
L/H Oils	0.00	0.00	0.00	8.98
Char	0.00	0.00	0.00	211.64
Total	451.00	1046.00	1257.00	1905.64

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-7
Data Point: 5

Test Date: 11 JAN 1985
Time Slice: 16:54:59
Duration (minutes): 14.6

Reactor Inlet Steam Mole Percent: 44.7
Reactor Inlet Hydrogen Mole Percent: 55.3
Reactor Exit Steam Mole Percent: 36.1
Reactor Exit Hydrogen Mole Percent: 46.7

Reactor Exit Temperature (deg F): 1974
Reactor Mixed Temperature (deg F): 2006
Average Reactor Temperature (deg F): 1990
Main Burner Exit Temperature (deg F): 2524

Reactor Pressure (psia): 1017
Reactor Residence Time (seconds): 6.74
Reactor Inlet Gas to Coal (lb-moles/lb): 0.242

Carbon Conversion to Methane (%):	40.30
Carbon Conversion to Ethane (%):	0.04
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	18.90
Carbon Conversion to Carbon Dioxide (%):	6.74
Carbon Conversion to L/H Oils (%):	0.59
Carbon Conversion to Carbon Oxides (%):	25.64
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	40.93
Carbon Conversion to Hydrocarbon Gas (%):	40.34
Carbon Conversion to Gases (%):	65.98
Carbon Conversion to Liquids (%):	0.59
Total Carbon Conversion (%):	66.57

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Long_test_data
File Number: 37

AFHP TEST DATA EVALUATION
TEST NUMBER R-7 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	66.57 %				
Char:	33.43 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
40.30 %	0.04 %	0.00 %	0.00 %	25.64 %	0.59 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	225.00 lbs/hr	220.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	595.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	264.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
302428 Btu/hr	147360 Btu/hr	54054 Btu/hr	501139 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 30 F	Hydrogen & Natural Gas @ 1122 F
Steam Generator:	Water @ 212 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 35 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2441.5 F	1247.2 F	2523.9 F	1974.0 F
Reactor Mixed Temperature: 2006.2 F			

PRESSURE: 1017.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.242 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.74 seconds
Based on Reactor Outlet Conditions:	6.52 seconds
Based on Reactor Mixed Conditions:	6.95 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.570	0.000	0.000
Carbon	72.793	71.922	94.170
Hydrogen	5.111	0.912	5.460
Nitrogen	1.470	0.860	0.140
Sulfur	2.970	1.110	0.230
Chlorine	0.183	0.180	0.000
Oxygen	8.660	0.654	0.000
Ash	8.243	24.363	0.000

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 10812 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-7 - DATA POINT 5 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.113	66.874	55.266	46.720
H2O	12.887	33.126	44.734	36.064
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.593
CO	0.000	0.000	0.000	4.381
CO2	0.000	0.000	0.000	1.562
CH4	0.000	0.000	0.000	9.341
H2S	0.000	0.000	0.000	0.309
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.005
L/H Oils	0.000	0.000	0.000	0.010

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	95.064	95.064	78.563	71.710
H2O	14.063	47.090	63.591	55.354
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.444
CO	0.000	0.000	0.000	6.724
CO2	0.000	0.000	0.000	2.398
CH4	0.000	0.000	0.000	14.337
H2S	0.000	0.000	0.000	0.475
HCl	0.000	0.000	0.000	0.020
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.007
L/H Oils	0.000	0.000	0.000	0.015
Total	109.127	142.154	142.154	153.489

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	191.65	191.65	158.38	144.57
H2O	253.35	848.35	1145.62	997.22
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	68.48
CO	0.00	0.00	0.00	188.33
CO2	0.00	0.00	0.00	105.52
CH4	0.00	0.00	0.00	230.01
H2S	0.00	0.00	0.00	16.18
HCl	0.00	0.00	0.00	0.74
NH3	0.00	0.00	0.00	0.09
C2H6	0.00	0.00	0.00	0.21
L/H Oils	0.00	0.00	0.00	2.68
Char	0.00	0.00	0.00	198.61
Total	445.00	1040.00	1304.00	1952.63

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-7

Data Point: 6

Test Date: 11 JAN 1985

Time Slice: 17:10:59

Duration (minutes): 11.2

Reactor Inlet Steam Mole Percent: 43.2

Reactor Inlet Hydrogen Mole Percent: 56.8

Reactor Exit Steam Mole Percent: 33.7

Reactor Exit Hydrogen Mole Percent: 49.5

Reactor Exit Temperature (deg F): 1999

Reactor Mixed Temperature (deg F): 2038

Average Reactor Temperature (deg F): 2018.5

Main Burner Exit Temperature (deg F): 2543

Reactor Pressure (psia): 1016

Reactor Residence Time (seconds): 6.30

Reactor Inlet Gas to Coal (lb-moles/lb): 0.254

Carbon Conversion to Methane (%):	39.00
Carbon Conversion to Ethane (%):	0.03
Carbon Conversion to Benzene (%):	0.00
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	22.20
Carbon Conversion to Carbon Dioxide (%):	7.18
Carbon Conversion to L/H Oils (%):	0.00
Carbon Conversion to Carbon Oxides (%):	29.38
Carbon Conversion to BTX Liquids (%):	0.00
Carbon Conversion to Hydrocarbons (%):	39.03
Carbon Conversion to Hydrocarbon Gas (%):	39.03
Carbon Conversion to Gases (%):	68.41
Carbon Conversion to Liquids (%):	0.00
Total Carbon Conversion (%):	68.41

Graphics Plot Symbol: 2

Plot Symbol Scale: 1

Data File: Long_test_data

File Number: 38

AFHP TEST DATA EVALUATION

TEST NUMBER R-7 - DATA POINT 6

COAL CARBON CONVERSIONS:

Overall:	68.41 %				
Char:	31.59 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
39.00 %	0.03 %	0.00 %	0.00 %	29.38 %	0.00 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	223.00 lbs/hr	235.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	590.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	285.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	587.00 lbs/hr	61.63 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
305134 Btu/hr	148978 Btu/hr	54497 Btu/hr	426843 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 32 F	Hydrogen & Natural Gas @ 1102 F
Steam Generator:	Water @ 211 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 38 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2332.4 F	1219.1 F	2543.3 F	1999.0 F
Reactor Mixed Temperature: 2037.7 F			

PRESSURE: 1016.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.254 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	5.42 seconds
Based on Reactor Outlet Conditions:	6.09 seconds
Based on Reactor Mixed Conditions:	6.52 seconds

ULTIMATE ANALYSES (%)

	Coal	Char
Moisture	0.570	0.000
Carbon	72.793	70.916
Hydrogen	5.111	0.899
Nitrogen	1.470	0.848
Sulfur	2.970	1.094
Chlorine	0.183	0.178
Oxygen	8.660	0.645
Ash	8.243	25.421

COAL HIGHER HEATING VALUE: 13437 Btu/lb

CHAR HIGHER HEATING VALUE: 10661 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-7 - DATA POINT 6 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.043	68.732	56.803	49.516
H2O	11.957	31.268	43.197	33.699
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.506
CO	0.000	0.000	0.000	4.858
CO2	0.000	0.000	0.000	1.571
CH4	0.000	0.000	0.000	8.535
H2S	0.000	0.000	0.000	0.295
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.003

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	102.629	102.629	84.816	80.493
H2O	13.938	46.688	64.501	54.781
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	2.448
CO	0.000	0.000	0.000	7.898
CO2	0.000	0.000	0.000	2.554
CH4	0.000	0.000	0.000	13.874
H2S	0.000	0.000	0.000	0.479
HCl	0.000	0.000	0.000	0.021
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.005
Total	116.568	149.317	149.317	162.558

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	206.90	206.90	170.99	162.27
H2O	251.10	841.10	1162.01	986.90
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	68.57
CO	0.00	0.00	0.00	221.22
CO2	0.00	0.00	0.00	112.41
CH4	0.00	0.00	0.00	222.59
H2S	0.00	0.00	0.00	16.32
HCl	0.00	0.00	0.00	0.76
NH3	0.00	0.00	0.00	0.10
C2H6	0.00	0.00	0.00	0.16
Char	0.00	0.00	0.00	190.34
Total	458.00	1048.00	1333.00	1981.64

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-8
Data Point: 1

Test Date: 1 FEB 1985
Time Slice: 15:38:00
Duration (minutes): 8.5

Reactor Inlet Steam Mole Percent: 42.4
Reactor Inlet Hydrogen Mole Percent: 57.6
Reactor Exit Steam Mole Percent: 41.3
Reactor Exit Hydrogen Mole Percent: 49.5

Reactor Exit Temperature (deg F): 1766
Reactor Mixed Temperature (deg F): 1597
Average Reactor Temperature (deg F): 1681.5
Main Burner Exit Temperature (deg F): 1957

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 2.42
Reactor Inlet Gas to Coal (lb-moles/lb): 0.269

Carbon Conversion to Methane (%):	27.10
Carbon Conversion to Ethane (%):	0.11
Carbon Conversion to Benzene (%):	8.80
Carbon Conversion to Toluene (%):	0.04
Carbon Conversion to Carbon Monoxide (%):	3.60
Carbon Conversion to Carbon Dioxide (%):	0.99
Carbon Conversion to L/H Oils (%):	10.67
Carbon Conversion to Carbon Oxides (%):	4.59
Carbon Conversion to BTX Liquids (%):	8.84
Carbon Conversion to Hydrocarbons (%):	46.72
Carbon Conversion to Hydrocarbon Gas (%):	27.21
Carbon Conversion to Gases (%):	31.80
Carbon Conversion to Liquids (%):	19.51
Total Carbon Conversion (%):	51.31

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 1

AFHP TEST DATA EVALUATION
TEST NUMBER R-8 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	51.31 %				
Char:	48.69 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
27.10 %	0.11 %	8.80 %	0.04 %	4.59 %	10.67 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	296.00 lbs/hr	299.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	953.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	223.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	749.00 lbs/hr	78.64 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
313552 Btu/hr	220264 Btu/hr	47576 Btu/hr	86290 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 30 F	Hydrogen & Natural Gas @ 1163 F
Steam Generator:	Water @ 228 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 29 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2507.0 F	1160.2 F	1957.0 F	1766.0 F
Reactor Mixed Temperature: 1597.2 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.269 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.18 seconds
Based on Reactor Outlet Conditions:	2.28 seconds
Based on Reactor Mixed Conditions:	2.56 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.490	0.000	0.000
Carbon	73.279	76.559	94.170
Hydrogen	5.324	1.428	5.460
Nitrogen	1.594	0.993	0.140
Sulfur	2.953	1.175	0.230
Chlorine	0.183	0.171	0.000
Oxygen	7.549	1.160	0.000
Ash	8.628	18.513	0.000

COAL HIGHER HEATING VALUE: 13380 Btu/lb

CHAR HIGHER HEATING VALUE: 11877 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-8 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.525	64.515	57.588	49.479
H2O	12.474	35.485	42.412	41.317
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.485
CO	0.000	0.000	0.000	0.788
CO2	0.000	0.000	0.000	0.217
CH4	0.000	0.000	0.000	5.931
H2S	0.000	0.000	0.000	0.267
HCl	0.000	0.000	0.000	0.010
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.012
Benzene	0.000	0.000	0.000	0.321
Toluene	0.000	0.000	0.000	0.001
L/H Oils	0.000	0.000	0.000	0.167

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	129.812	129.813	115.875	103.316
H2O	18.501	71.400	85.338	86.273
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.101
CO	0.000	0.000	0.000	1.645
CO2	0.000	0.000	0.000	0.452
CH4	0.000	0.000	0.000	12.384
H2S	0.000	0.000	0.000	0.557
HCl	0.000	0.000	0.000	0.022
NH3	0.000	0.000	0.000	0.012
C2H6	0.000	0.000	0.000	0.025
Benzene	0.000	0.000	0.000	0.670
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.349
Total	148.314	201.213	201.213	208.809

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	261.70	261.70	233.60	208.29
H2O	333.30	1286.30	1537.40	1554.24
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	86.86
CO	0.00	0.00	0.00	46.08
CO2	0.00	0.00	0.00	19.91
CH4	0.00	0.00	0.00	198.67
H2S	0.00	0.00	0.00	19.00
HCl	0.00	0.00	0.00	0.80
NH3	0.00	0.00	0.00	0.21
C2H6	0.00	0.00	0.00	0.76
Benzene	0.00	0.00	0.00	52.35
Toluene	0.00	0.00	0.00	0.24
L/H Oils	0.00	0.00	0.00	62.19
Char	0.00	0.00	0.00	349.06
Total	595.00	1548.00	1771.00	2598.64

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-8
Data Point: 2

Test Date: 1 FEB 1985
Time Slice: 15:42:00
Duration (minutes): 7.0

Reactor Inlet Steam Mole Percent: 42.3
Reactor Inlet Hydrogen Mole Percent: 57.7
Reactor Exit Steam Mole Percent: 41.2
Reactor Exit Hydrogen Mole Percent: 48.5

Reactor Exit Temperature (deg F): 1778
Reactor Mixed Temperature (deg F): 1597
Average Reactor Temperature (deg F): 1687.5
Main Burner Exit Temperature (deg F): 1958

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 2.44
Reactor Inlet Gas to Coal (lb-moles/lb): 0.267

Carbon Conversion to Methane (%):	30.50
Carbon Conversion to Ethane (%):	0.13
Carbon Conversion to Benzene (%):	9.80
Carbon Conversion to Toluene (%):	0.05
Carbon Conversion to Carbon Monoxide (%):	4.10
Carbon Conversion to Carbon Dioxide (%):	1.10
Carbon Conversion to L/H Oils (%):	10.44
Carbon Conversion to Carbon Oxides (%):	5.20
Carbon Conversion to BTX Liquids (%):	9.85
Carbon Conversion to Hydrocarbons (%):	50.92
Carbon Conversion to Hydrocarbon Gas (%):	30.63
Carbon Conversion to Gases (%):	35.83
Carbon Conversion to Liquids (%):	20.29
Total Carbon Conversion (%):	56.12

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 2

AFHP TEST DATA EVALUATION

TEST NUMBER R-8 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	56.12 %				
Char:	43.88 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
30.50 %	0.13 %	9.80 %	0.05 %	5.20 %	10.44 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	296.00 lbs/hr	298.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	943.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	220.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	749.00 lbs/hr	78.64 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
307782 Btu/hr	225709 Btu/hr	48187 Btu/hr	112021 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 30 F	Hydrogen & Natural Gas @ 1162 F
Steam Generator:	Water @ 229 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 30 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2514.9 F	1169.3 F	1958.5 F	1778.0 F
Reactor Mixed Temperature: 1596.8 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.267 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.19 seconds
Based on Reactor Outlet Conditions:	2.30 seconds
Based on Reactor Mixed Conditions:	2.58 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.490	0.000	0.000
Carbon	73.279	75.036	94.170
Hydrogen	5.324	1.400	5.460
Nitrogen	1.594	0.973	0.140
Sulfur	2.953	1.152	0.230
Chlorine	0.183	0.167	0.000
Oxygen	7.549	1.137	0.000
Ash	8.628	20.134	0.000

COAL HIGHER HEATING VALUE: 13380 Btu/lb

CHAR HIGHER HEATING VALUE: 11641 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-8 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.483	64.606	57.736	48.511
H2O	12.516	35.394	42.264	41.250
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.507
CO	0.000	0.000	0.000	0.907
CO2	0.000	0.000	0.000	0.243
CH4	0.000	0.000	0.000	6.746
H2S	0.000	0.000	0.000	0.276
HCl	0.000	0.000	0.000	0.011
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.361
Toluene	0.000	0.000	0.000	0.002
L/H Oils	0.000	0.000	0.000	0.165

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	129.316	129.317	115.566	100.228
H2O	18.501	70.845	84.595	85.226
H	0.002	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.113
CO	0.000	0.000	0.000	1.874
CO2	0.000	0.000	0.000	0.503
CH4	0.000	0.000	0.000	13.937
H2S	0.000	0.000	0.000	0.570
HCl	0.000	0.000	0.000	0.024
NH3	0.000	0.000	0.000	0.011
C2H6	0.000	0.000	0.000	0.030
Benzene	0.000	0.000	0.000	0.746
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.341
Total	147.818	200.162	200.162	206.606

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	260.70	260.70	232.98	202.06
H2O	333.30	1276.30	1524.02	1535.38
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	87.22
CO	0.00	0.00	0.00	52.48
CO2	0.00	0.00	0.00	22.12
CH4	0.00	0.00	0.00	223.60
H2S	0.00	0.00	0.00	19.43
HCl	0.00	0.00	0.00	0.86
NH3	0.00	0.00	0.00	0.19
C2H6	0.00	0.00	0.00	0.89
Benzene	0.00	0.00	0.00	58.30
Toluene	0.00	0.00	0.00	0.30
L/H Oils	0.00	0.00	0.00	60.85
Char	0.00	0.00	0.00	320.96
Total	594.00	1537.00	1757.00	2584.64

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-8
Data Point: 3

Test Date: 1 FEB 1985
Time Slice: 15:50:00
Duration (minutes): 5.9

Reactor Inlet Steam Mole Percent: 42.5
Reactor Inlet Hydrogen Mole Percent: 57.5
Reactor Exit Steam Mole Percent: 41.7
Reactor Exit Hydrogen Mole Percent: 47.5

Reactor Exit Temperature (deg F): 1762
Reactor Mixed Temperature (deg F): 1588
Average Reactor Temperature (deg F): 1675
Main Burner Exit Temperature (deg F): 1945

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 2.45
Reactor Inlet Gas to Coal (lb-moles/lb): 0.268

Carbon Conversion to Methane (%):	32.90
Carbon Conversion to Ethane (%):	0.13
Carbon Conversion to Benzene (%):	11.20
Carbon Conversion to Toluene (%):	0.06
Carbon Conversion to Carbon Monoxide (%):	4.00
Carbon Conversion to Carbon Dioxide (%):	1.10
Carbon Conversion to L/H Oils (%):	10.74
Carbon Conversion to Carbon Oxides (%):	5.10
Carbon Conversion to BTX Liquids (%):	11.26
Carbon Conversion to Hydrocarbons (%):	55.03
Carbon Conversion to Hydrocarbon Gas (%):	33.03
Carbon Conversion to Gases (%):	38.13
Carbon Conversion to Liquids (%):	22.00
Total Carbon Conversion (%):	60.13

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 3

AFHP TEST DATA EVALUATION
TEST NUMBER R-8 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	60.13 %				
Char:	39.87 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
32.90 %	0.13 %	11.20 %	0.06 %	5.10 %	10.74 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	293.00 lbs/hr	298.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	957.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	222.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	749.00 lbs/hr	78.64 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
311339 Btu/hr	221260 Btu/hr	49142 Btu/hr	172621 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 32 F	Hydrogen & Natural Gas @ 1169 F
Steam Generator:	Water @ 230 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 31 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2503.3 F	1150.8 F	1945.2 F	1762.0 F
Reactor Mixed Temperature: 1587.5 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.268 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.20 seconds
Based on Reactor Outlet Conditions:	2.32 seconds
Based on Reactor Mixed Conditions:	2.58 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.490	0.000	0.000
Carbon	73.279	73.547	94.170
Hydrogen	5.324	1.372	5.460
Nitrogen	1.594	0.954	0.140
Sulfur	2.953	1.129	0.230
Chlorine	0.183	0.164	0.000
Oxygen	7.549	1.115	0.000
Ash	8.628	21.719	0.000

COAL HIGHER HEATING VALUE: 13380 Btu/lb

CHAR HIGHER HEATING VALUE: 11410 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-8 - DATA POINT 3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.610	64.450	57.544	47.455
H2O	12.389	35.550	42.456	41.710
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.515
CO	0.000	0.000	0.000	0.886
CO2	0.000	0.000	0.000	0.244
CH4	0.000	0.000	0.000	7.291
H2S	0.000	0.000	0.000	0.282
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.006
C2H6	0.000	0.000	0.000	0.014
Benzene	0.000	0.000	0.000	0.414
Toluene	0.000	0.000	0.000	0.002
L/H Oils	0.000	0.000	0.000	0.170

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	129.504	129.504	115.629	97.853
H2O	18.313	71.434	85.310	86.007
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.123
CO	0.000	0.000	0.000	1.828
CO2	0.000	0.000	0.000	0.503
CH4	0.000	0.000	0.000	15.034
H2S	0.000	0.000	0.000	0.581
HCl	0.000	0.000	0.000	0.025
NH3	0.000	0.000	0.000	0.012
C2H6	0.000	0.000	0.000	0.030
Benzene	0.000	0.000	0.000	0.853
Toluene	0.000	0.000	0.000	0.004
L/H Oils	0.000	0.000	0.000	0.351
Total	147.818	200.939	200.939	206.203

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	261.08	261.08	233.11	197.27
H2O	329.92	1286.92	1536.89	1549.45
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	87.50
CO	0.00	0.00	0.00	51.20
CO2	0.00	0.00	0.00	22.12
CH4	0.00	0.00	0.00	241.19
H2S	0.00	0.00	0.00	19.79
HCl	0.00	0.00	0.00	0.91
NH3	0.00	0.00	0.00	0.20
C2H6	0.00	0.00	0.00	0.89
Benzene	0.00	0.00	0.00	66.63
Toluene	0.00	0.00	0.00	0.36
L/H Oils	0.00	0.00	0.00	62.60
Char	0.00	0.00	0.00	297.54
Total	591.00	1548.00	1770.00	2597.64

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-8
Data Point: 4

Test Date: 1 FEB 1985
Time Slice: 15:58:00
Duration (minutes): 6.6

Reactor Inlet Steam Mole Percent: 43.9
Reactor Inlet Hydrogen Mole Percent: 56.1
Reactor Exit Steam Mole Percent: 42.6
Reactor Exit Hydrogen Mole Percent: 43.8

Reactor Exit Temperature (deg F): 1952
Reactor Mixed Temperature (deg F): 1671
Average Reactor Temperature (deg F): 1811.5
Main Burner Exit Temperature (deg F): 2047

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 2.30
Reactor Inlet Gas to Coal (lb-moles/lb): 0.270

Carbon Conversion to Methane (%):	43.70
Carbon Conversion to Ethane (%):	0.09
Carbon Conversion to Benzene (%):	3.80
Carbon Conversion to Toluene (%):	0.02
Carbon Conversion to Carbon Monoxide (%):	5.70
Carbon Conversion to Carbon Dioxide (%):	2.30
Carbon Conversion to L/H Oils (%):	7.23
Carbon Conversion to Carbon Oxides (%):	8.00
Carbon Conversion to BTX Liquids (%):	3.82
Carbon Conversion to Hydrocarbons (%):	54.84
Carbon Conversion to Hydrocarbon Gas (%):	43.79
Carbon Conversion to Gases (%):	51.79
Carbon Conversion to Liquids (%):	11.05
Total Carbon Conversion (%):	62.84

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 4

AFHP TEST DATA EVALUATION
TEST NUMBER R-8 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	62.84 %				
Char:	37.16 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
43.70 %	0.09 %	3.80 %	0.02 %	8.00 %	7.23 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	294.00 lbs/hr	298.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	976.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	259.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	749.00 lbs/hr	78.64 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
315808 Btu/hr	222615 Btu/hr	48397 Btu/hr	90104 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 32 F	Hydrogen & Natural Gas @ 1160 F
Steam Generator:	Water @ 229 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 33 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2496.9 F	1127.9 F	2046.8 F	1952.0 F
Reactor Mixed Temperature: 1670.9 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.270 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.10 seconds
Based on Reactor Outlet Conditions:	2.14 seconds
Based on Reactor Mixed Conditions:	2.47 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.490	0.000	0.000
Carbon	73.279	72.400	94.170
Hydrogen	5.324	1.351	5.460
Nitrogen	1.594	0.939	0.140
Sulfur	2.953	1.111	0.230
Chlorine	0.183	0.162	0.000
Oxygen	7.549	1.097	0.000
Ash	8.628	22.940	0.000

COAL HIGHER HEATING VALUE: 13380 Btu/lb

CHAR HIGHER HEATING VALUE: 11232 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-8 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.568	64.082	56.068	43.763
H2O	12.431	35.918	43.932	42.639
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.526
CO	0.000	0.000	0.000	1.268
CO2	0.000	0.000	0.000	0.512
CH4	0.000	0.000	0.000	9.722
H2S	0.000	0.000	0.000	0.287
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.010
Benzene	0.000	0.000	0.000	0.141
Toluene	0.000	0.000	0.000	0.001
L/H Oils	0.000	0.000	0.000	0.115

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	129.441	129.442	113.254	89.886
H2O	18.376	72.552	88.740	87.578
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.134
CO	0.000	0.000	0.000	2.605
CO2	0.000	0.000	0.000	1.051
CH4	0.000	0.000	0.000	19.969
H2S	0.000	0.000	0.000	0.589
HCl	0.000	0.000	0.000	0.026
NH3	0.000	0.000	0.000	0.007
C2H6	0.000	0.000	0.000	0.021
Benzene	0.000	0.000	0.000	0.289
Toluene	0.000	0.000	0.000	0.001
L/H Oils	0.000	0.000	0.000	0.236
Total	147.818	201.993	201.993	205.391

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	260.95	260.95	228.32	181.21
H2O	331.05	1307.05	1598.68	1577.74
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	87.79
CO	0.00	0.00	0.00	72.96
CO2	0.00	0.00	0.00	46.25
CH4	0.00	0.00	0.00	320.37
H2S	0.00	0.00	0.00	20.08
HCl	0.00	0.00	0.00	0.94
NH3	0.00	0.00	0.00	0.11
C2H6	0.00	0.00	0.00	0.62
Benzene	0.00	0.00	0.00	22.61
Toluene	0.00	0.00	0.00	0.12
L/H Oils	0.00	0.00	0.00	42.14
Char	0.00	0.00	0.00	281.71
Total	592.00	1568.00	1827.00	2654.64

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-8
Data Point: 5

Test Date: 1 FEB 1985
Time Slice: 16:02:00
Duration (minutes): 11.4

Reactor Inlet Steam Mole Percent: 43.6
Reactor Inlet Hydrogen Mole Percent: 56.4
Reactor Exit Steam Mole Percent: 42.3
Reactor Exit Hydrogen Mole Percent: 43.7

Reactor Exit Temperature (deg F): 1952
Reactor Mixed Temperature (deg F): 1691
Average Reactor Temperature (deg F): 1821.5
Main Burner Exit Temperature (deg F): 2075

Reactor Pressure (psia): 1015
Reactor Residence Time (seconds): 2.31
Reactor Inlet Gas to Coal (lb-moles/lb): 0.268

Carbon Conversion to Methane (%):	44.70
Carbon Conversion to Ethane (%):	0.08
Carbon Conversion to Benzene (%):	3.80
Carbon Conversion to Toluene (%):	0.03
Carbon Conversion to Carbon Monoxide (%):	5.80
Carbon Conversion to Carbon Dioxide (%):	2.33
Carbon Conversion to L/H Oils (%):	7.23
Carbon Conversion to Carbon Oxides (%):	8.13
Carbon Conversion to BTX Liquids (%):	3.83
Carbon Conversion to Hydrocarbons (%):	55.84
Carbon Conversion to Hydrocarbon Gas (%):	44.78
Carbon Conversion to Gases (%):	52.91
Carbon Conversion to Liquids (%):	11.06
Total Carbon Conversion (%):	63.97

Graphics Plot Symbol: 2
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 5

AFHP TEST DATA EVALUATION
TEST NUMBER R-8 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	63.97 %				
Char:	36.03 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
44.70 %	0.08 %	3.80 %	0.03 %	8.13 %	7.23 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	293.00 lbs/hr	298.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	953.00 lbs/hr	0.00 lbs/hr	
Main Burner:	Oxygen		
	260.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	749.00 lbs/hr	78.64 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
312523 Btu/hr	219248 Btu/hr	48706 Btu/hr	155988 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 33 F	Hydrogen & Natural Gas @ 1161 F
Steam Generator:	Water @ 228 F	Hydrogen @ 72 F
Main Burner:	Oxygen @ 34 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2495.5 F	1148.4 F	2074.7 F	1952.0 F
Reactor Mixed Temperature: 1690.7 F			

PRESSURE: 1015.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.268 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.09 seconds
Based on Reactor Outlet Conditions:	2.16 seconds
Based on Reactor Mixed Conditions:	2.46 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.490	0.000	0.000
Carbon	73.279	71.883	94.170
Hydrogen	5.324	1.341	5.460
Nitrogen	1.594	0.932	0.140
Sulfur	2.953	1.103	0.230
Chlorine	0.183	0.160	0.000
Oxygen	7.549	1.090	0.000
Ash	8.628	23.491	0.000

COAL HIGHER HEATING VALUE: 13380 Btu/lb

CHAR HIGHER HEATING VALUE: 11152 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-8 - DATA POINT 5 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	87.610	64.521	56.425	43.722
H2O	12.389	35.479	43.575	42.317
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	1.539
CO	0.000	0.000	0.000	1.301
CO2	0.000	0.000	0.000	0.522
CH4	0.000	0.000	0.000	10.024
H2S	0.000	0.000	0.000	0.291
HCl	0.000	0.000	0.000	0.013
NH3	0.000	0.000	0.000	0.003
C2H6	0.000	0.000	0.000	0.009
Benzene	0.000	0.000	0.000	0.142
Toluene	0.000	0.000	0.000	0.001
L/H Oils	0.000	0.000	0.000	0.116

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	129.504	129.504	113.254	89.097
H2O	18.313	71.212	87.463	86.234
H	0.001	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.137
CO	0.000	0.000	0.000	2.650
CO2	0.000	0.000	0.000	1.065
CH4	0.000	0.000	0.000	20.426
H2S	0.000	0.000	0.000	0.592
HCl	0.000	0.000	0.000	0.026
NH3	0.000	0.000	0.000	0.007
C2H6	0.000	0.000	0.000	0.018
Benzene	0.000	0.000	0.000	0.289
Toluene	0.000	0.000	0.000	0.002
L/H Oils	0.000	0.000	0.000	0.236
Total	147.818	200.717	200.717	203.780

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	261.08	261.08	228.32	179.62
H2O	329.92	1282.92	1575.68	1553.53
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	87.87
CO	0.00	0.00	0.00	74.24
CO2	0.00	0.00	0.00	46.86
CH4	0.00	0.00	0.00	327.70
H2S	0.00	0.00	0.00	20.18
HCl	0.00	0.00	0.00	0.96
NH3	0.00	0.00	0.00	0.11
C2H6	0.00	0.00	0.00	0.55
Benzene	0.00	0.00	0.00	22.61
Toluene	0.00	0.00	0.00	0.18
L/H Oils	0.00	0.00	0.00	42.14
Char	0.00	0.00	0.00	275.11
Total	591.00	1544.00	1804.00	2631.64

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-9
Data Point: 1

Test Date: 11 FEB 1985
Time Slice: 15:52:00
Duration (minutes): 15.7

Reactor Inlet Steam Mole Percent: 29.1
Reactor Inlet Hydrogen Mole Percent: 70.9
Reactor Exit Steam Mole Percent: 28.8
Reactor Exit Hydrogen Mole Percent: 55.1

Reactor Exit Temperature (deg F): 1749
Reactor Mixed Temperature (deg F): 1488
Average Reactor Temperature (deg F): 1618.5
Main Burner Exit Temperature (deg F): 2045

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 2.48
Reactor Inlet Gas to Coal (lb-moles/lb): 0.172

Carbon Conversion to Methane (%):	30.10
Carbon Conversion to Ethane (%):	0.20
Carbon Conversion to Benzene (%):	10.20
Carbon Conversion to Toluene (%):	0.08
Carbon Conversion to Carbon Monoxide (%):	3.30
Carbon Conversion to Carbon Dioxide (%):	0.71
Carbon Conversion to L/H Oils (%):	8.65
Carbon Conversion to Carbon Oxides (%):	4.01
Carbon Conversion to BTX Liquids (%):	10.28
Carbon Conversion to Hydrocarbons (%):	49.23
Carbon Conversion to Hydrocarbon Gas (%):	30.30
Carbon Conversion to Gases (%):	34.31
Carbon Conversion to Liquids (%):	18.93
Total Carbon Conversion (%):	53.24

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 6

AFHP TEST DATA EVALUATION

TEST NUMBER R-9 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	53.24 %				
Char:	46.76 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
30.10 %	0.20 %	10.20 %	0.08 %	4.01 %	8.65 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	248.00 lbs/hr	288.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	523.00 lbs/hr	60.00 lbs/hr	
Main Burner:	Oxygen		
	225.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1171.00 lbs/hr	195.56 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
349323 Btu/hr	137045 Btu/hr	52267 Btu/hr	232864 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 46 F	Hydrogen & Natural Gas @ 1130 F
Steam Generator:	Water @ 211 F	Hydrogen @ 71 F
Main Burner:	Oxygen @ 48 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2244.9 F	1214.5 F	2045.0 F	1749.0 F
Reactor Mixed Temperature: 1487.8 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.172 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.10 seconds
Based on Reactor Outlet Conditions:	2.25 seconds
Based on Reactor Mixed Conditions:	2.70 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	1.220	0.000	0.000
Carbon	72.860	76.542	94.170
Hydrogen	5.196	1.459	5.460
Nitrogen	1.482	1.036	0.140
Sulfur	2.984	1.523	0.230
Chlorine	0.182	0.145	0.000
Oxygen	7.749	0.587	0.000
Ash	8.327	18.708	0.000

COAL HIGHER HEATING VALUE: 13274 Btu/lb

CHAR HIGHER HEATING VALUE: 11971 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-9 - DATA POINT 1

Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	89.149	77.917	70.943	55.138
H2O	10.850	22.083	29.057	28.818
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.463
CO	0.000	0.000	0.000	1.098
CO2	0.000	0.000	0.000	0.236
CH4	0.000	0.000	0.000	10.017
H2S	0.000	0.000	0.000	0.392
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.011
C2H6	0.000	0.000	0.000	0.033
Benzene	0.000	0.000	0.000	0.566
Toluene	0.000	0.000	0.000	0.004
L/H Oils	0.000	0.000	0.000	0.206

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	127.356	157.118	143.055	117.695
H2O	15.501	44.531	58.594	61.515
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	7.392
CO	0.000	0.000	0.000	2.344
CO2	0.000	0.000	0.000	0.504
CH4	0.000	0.000	0.000	21.381
H2S	0.000	0.000	0.000	0.837
HCl	0.000	0.000	0.000	0.039
NH3	0.000	0.000	0.000	0.023
C2H6	0.000	0.000	0.000	0.071
Benzene	0.000	0.000	0.000	1.208
Toluene	0.000	0.000	0.000	0.008
L/H Oils	0.000	0.000	0.000	0.440
Total	142.857	201.650	201.650	213.456

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	256.75	316.75	288.40	237.27
H2O	279.25	802.25	1055.60	1108.21
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	207.08
CO	0.00	0.00	0.00	65.66
CO2	0.00	0.00	0.00	22.20
CH4	0.00	0.00	0.00	343.02
H2S	0.00	0.00	0.00	28.51
HCl	0.00	0.00	0.00	1.42
NH3	0.00	0.00	0.00	0.40
C2H6	0.00	0.00	0.00	2.14
Benzene	0.00	0.00	0.00	94.33
Toluene	0.00	0.00	0.00	0.75
L/H Oils	0.00	0.00	0.00	78.37
Char	0.00	0.00	0.00	521.22
Total	536.00	1119.00	1344.00	2710.56

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-9
Data Point: 2

Test Date: 11 FEB 1985
Time Slice: 15:59:00
Duration (minutes): 5.3

Reactor Inlet Steam Mole Percent: 29.2
Reactor Inlet Hydrogen Mole Percent: 70.8
Reactor Exit Steam Mole Percent: 29.0
Reactor Exit Hydrogen Mole Percent: 54.4

Reactor Exit Temperature (deg F): 1787
Reactor Mixed Temperature (deg F): 1507
Average Reactor Temperature (deg F): 1647
Main Burner Exit Temperature (deg F): 2075

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 2.45
Reactor Inlet Gas to Coal (lb-moles/lb): 0.172

Carbon Conversion to Methane (%):	31.40
Carbon Conversion to Ethane (%):	0.17
Carbon Conversion to Benzene (%):	9.60
Carbon Conversion to Toluene (%):	0.07
Carbon Conversion to Carbon Monoxide (%):	3.40
Carbon Conversion to Carbon Dioxide (%):	0.77
Carbon Conversion to L/H Oils (%):	7.95
Carbon Conversion to Carbon Oxides (%):	4.17
Carbon Conversion to BTX Liquids (%):	9.67
Carbon Conversion to Hydrocarbons (%):	49.19
Carbon Conversion to Hydrocarbon Gas (%):	31.57
Carbon Conversion to Gases (%):	35.74
Carbon Conversion to Liquids (%):	17.62
Total Carbon Conversion (%):	53.36

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 7

AFHP TEST DATA EVALUATION
TEST NUMBER R-9 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	53.36 %				
Char:	46.64 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
31.40 %	0.17 %	9.60 %	0.07 %	4.17 %	7.95 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	253.00 lbs/hr	287.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	518.00 lbs/hr	60.00 lbs/hr	
Main Burner:	Oxygen		
	227.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1171.00 lbs/hr	195.56 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
351741 Btu/hr	141919 Btu/hr	52865 Btu/hr	227831 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 47 F	Hydrogen & Natural Gas @ 1133 F
Steam Generator:	Water @ 211 F	Hydrogen @ 70 F
Main Burner:	Oxygen @ 48 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2275.7 F	1237.1 F	2074.9 F	1787.0 F
Reactor Mixed Temperature: 1507.4 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.172 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.08 seconds
Based on Reactor Outlet Conditions:	2.22 seconds
Based on Reactor Mixed Conditions:	2.68 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	1.220	0.000	0.000
Carbon	72.860	76.505	94.170
Hydrogen	5.196	1.458	5.460
Nitrogen	1.482	1.036	0.140
Sulfur	2.984	1.523	0.230
Chlorine	0.182	0.145	0.000
Oxygen	7.749	0.587	0.000
Ash	8.327	18.747	0.000

COAL HIGHER HEATING VALUE: 13274 Btu/lb

CHAR HIGHER HEATING VALUE: 11965 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-9 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.892	77.814	70.751	54.434
H2O	11.108	22.186	29.249	28.993
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.485
CO	0.000	0.000	0.000	1.138
CO2	0.000	0.000	0.000	0.258
CH4	0.000	0.000	0.000	10.512
H2S	0.000	0.000	0.000	0.395
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.010
C2H6	0.000	0.000	0.000	0.028
Benzene	0.000	0.000	0.000	0.536
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.190

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	126.548	156.310	142.122	115.503
H2O	15.813	44.566	58.754	61.519
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	7.394
CO	0.000	0.000	0.000	2.415
CO2	0.000	0.000	0.000	0.547
CH4	0.000	0.000	0.000	22.304
H2S	0.000	0.000	0.000	0.838
HCl	0.000	0.000	0.000	0.039
NH3	0.000	0.000	0.000	0.021
C2H6	0.000	0.000	0.000	0.060
Benzene	0.000	0.000	0.000	1.137
Toluene	0.000	0.000	0.000	0.007
L/H Oils	0.000	0.000	0.000	0.404
Total	142.361	200.876	200.876	212.188

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	255.12	315.12	286.52	232.86
H2O	284.88	802.88	1058.48	1108.29
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	207.13
CO	0.00	0.00	0.00	67.65
CO2	0.00	0.00	0.00	24.07
CH4	0.00	0.00	0.00	357.83
H2S	0.00	0.00	0.00	28.55
HCl	0.00	0.00	0.00	1.42
NH3	0.00	0.00	0.00	0.35
C2H6	0.00	0.00	0.00	1.82
Benzene	0.00	0.00	0.00	88.78
Toluene	0.00	0.00	0.00	0.65
L/H Oils	0.00	0.00	0.00	72.03
Char	0.00	0.00	0.00	520.13
Total	540.00	1118.00	1345.00	2711.56

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-9
Data Point: 3

Test Date: 11 FEB 1985
Time Slice: 16:05:00
Duration (minutes): 6.1

Reactor Inlet Steam Mole Percent: 29.7
Reactor Inlet Hydrogen Mole Percent: 70.3
Reactor Exit Steam Mole Percent: 29.4
Reactor Exit Hydrogen Mole Percent: 51.9

Reactor Exit Temperature (deg F): 1889
Reactor Mixed Temperature (deg F): 1537
Average Reactor Temperature (deg F): 1713
Main Burner Exit Temperature (deg F): 2117

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 2.40
Reactor Inlet Gas to Coal (lb-moles/lb): 0.171

Carbon Conversion to Methane (%):	36.60
Carbon Conversion to Ethane (%):	0.13
Carbon Conversion to Benzene (%):	8.30
Carbon Conversion to Toluene (%):	0.07
Carbon Conversion to Carbon Monoxide (%):	4.00
Carbon Conversion to Carbon Dioxide (%):	0.95
Carbon Conversion to L/H Oils (%):	6.06
Carbon Conversion to Carbon Oxides (%):	4.95
Carbon Conversion to BTX Liquids (%):	8.37
Carbon Conversion to Hydrocarbons (%):	51.16
Carbon Conversion to Hydrocarbon Gas (%):	36.73
Carbon Conversion to Gases (%):	41.68
Carbon Conversion to Liquids (%):	14.43
Total Carbon Conversion (%):	56.11

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 8

AFHP TEST DATA EVALUATION

TEST NUMBER R-9 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	56.11 %				
Char:	43.89 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
36.60 %	0.13 %	8.30 %	0.07 %	4.95 %	6.06 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	252.00 lbs/hr	286.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	518.00 lbs/hr	60.00 lbs/hr	
Main Burner:	Oxygen		
	240.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1171.00 lbs/hr	195.56 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
351053 Btu/hr	140667 Btu/hr	50950 Btu/hr	191460 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 48 F	Hydrogen & Natural Gas @ 1125 F
Steam Generator:	Water @ 211 F	Hydrogen @ 70 F
Main Burner:	Oxygen @ 50 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2267.7 F	1229.3 F	2117.4 F	1889.0 F
Reactor Mixed Temperature: 1536.7 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.171 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.06 seconds
Based on Reactor Outlet Conditions:	2.16 seconds
Based on Reactor Mixed Conditions:	2.65 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	1.220	0.000	0.000
Carbon	72.860	75.617	94.170
Hydrogen	5.196	1.441	5.460
Nitrogen	1.482	1.024	0.140
Sulfur	2.984	1.505	0.230
Chlorine	0.182	0.143	0.000
Oxygen	7.749	0.580	0.000
Ash	8.327	19.690	0.000

COAL HIGHER HEATING VALUE: 13274 Btu/lb

CHAR HIGHER HEATING VALUE: 11826 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-9 - DATA POINT 3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.897	77.790	70.304	51.897
H2O	11.103	22.210	29.696	29.403
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.537
CO	0.000	0.000	0.000	1.356
CO2	0.000	0.000	0.000	0.322
CH4	0.000	0.000	0.000	12.410
H2S	0.000	0.000	0.000	0.407
HCl	0.000	0.000	0.000	0.019
NH3	0.000	0.000	0.000	0.007
C2H6	0.000	0.000	0.000	0.022
Benzene	0.000	0.000	0.000	0.469
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.147

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	126.114	155.876	140.876	108.722
H2O	15.751	44.504	59.504	61.598
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	7.409
CO	0.000	0.000	0.000	2.841
CO2	0.000	0.000	0.000	0.675
CH4	0.000	0.000	0.000	25.998
H2S	0.000	0.000	0.000	0.853
HCl	0.000	0.000	0.000	0.040
NH3	0.000	0.000	0.000	0.015
C2H6	0.000	0.000	0.000	0.046
Benzene	0.000	0.000	0.000	0.983
Toluene	0.000	0.000	0.000	0.007
L/H Oils	0.000	0.000	0.000	0.308
Total	141.865	200.380	200.380	209.497

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	254.25	314.25	284.01	219.18
H2O	283.75	801.75	1071.99	1109.72
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	207.55
CO	0.00	0.00	0.00	79.59
CO2	0.00	0.00	0.00	29.70
CH4	0.00	0.00	0.00	417.09
H2S	0.00	0.00	0.00	29.08
HCl	0.00	0.00	0.00	1.46
NH3	0.00	0.00	0.00	0.26
C2H6	0.00	0.00	0.00	1.39
Benzene	0.00	0.00	0.00	76.76
Toluene	0.00	0.00	0.00	0.65
L/H Oils	0.00	0.00	0.00	54.90
Char	0.00	0.00	0.00	495.21
Total	538.00	1116.00	1356.00	2722.56

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-9
Data Point: 4

Test Date: 11 FEB 1985
Time Slice: 16:09:00
Duration (minutes): 3.4

Reactor Inlet Steam Mole Percent: 29.7
Reactor Inlet Hydrogen Mole Percent: 70.3
Reactor Exit Steam Mole Percent: 29.4
Reactor Exit Hydrogen Mole Percent: 52.5

Reactor Exit Temperature (deg F): 1863
Reactor Mixed Temperature (deg F): 1530
Average Reactor Temperature (deg F): 1696.5
Main Burner Exit Temperature (deg F): 2109

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 2.42
Reactor Inlet Gas to Coal (lb-moles/lb): 0.171

Carbon Conversion to Methane (%):	35.10
Carbon Conversion to Ethane (%):	0.11
Carbon Conversion to Benzene (%):	8.20
Carbon Conversion to Toluene (%):	0.07
Carbon Conversion to Carbon Monoxide (%):	3.80
Carbon Conversion to Carbon Dioxide (%):	0.93
Carbon Conversion to L/H Oils (%):	6.52
Carbon Conversion to Carbon Oxides (%):	4.73
Carbon Conversion to BTX Liquids (%):	8.27
Carbon Conversion to Hydrocarbons (%):	50.00
Carbon Conversion to Hydrocarbon Gas (%):	35.21
Carbon Conversion to Gases (%):	39.94
Carbon Conversion to Liquids (%):	14.79
Total Carbon Conversion (%):	54.73

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 9

AFHP TEST DATA EVALUATION

TEST NUMBER R-9 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	54.73 %				
Char:	45.27 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
35.10 %	0.11 %	8.20 %	0.07 %	4.73 %	6.52 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	251.00 lbs/hr	285.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	519.00 lbs/hr	60.00 lbs/hr	
Main Burner:	Oxygen		
	239.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1171.00 lbs/hr	195.56 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
353887 Btu/hr	136214 Btu/hr	50261 Btu/hr	199740 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 48 F	Hydrogen & Natural Gas @ 1120 F
Steam Generator:	Water @ 209 F	Hydrogen @ 70 F
Main Burner:	Oxygen @ 50 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2259.1 F	1221.5 F	2109.0 F	1863.0 F
Reactor Mixed Temperature: 1530.0 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.171 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.06 seconds
Based on Reactor Outlet Conditions:	2.18 seconds
Based on Reactor Mixed Conditions:	2.67 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	1.220	0.000	0.000
Carbon	72.860	76.073	94.170
Hydrogen	5.196	1.450	5.460
Nitrogen	1.482	1.030	0.140
Sulfur	2.984	1.514	0.230
Chlorine	0.182	0.144	0.000
Oxygen	7.749	0.584	0.000
Ash	8.327	19.205	0.000

COAL HIGHER HEATING VALUE: 13274 Btu/lb

CHAR HIGHER HEATING VALUE: 11898 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-9 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.903	77.745	70.274	52.507
H2O	11.097	22.255	29.726	29.407
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.528
CO	0.000	0.000	0.000	1.287
CO2	0.000	0.000	0.000	0.315
CH4	0.000	0.000	0.000	11.884
H2S	0.000	0.000	0.000	0.403
HCl	0.000	0.000	0.000	0.019
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.019
Benzene	0.000	0.000	0.000	0.463
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.158

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	125.681	155.443	140.505	110.156
H2O	15.688	44.497	59.435	61.694
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	7.403
CO	0.000	0.000	0.000	2.699
CO2	0.000	0.000	0.000	0.661
CH4	0.000	0.000	0.000	24.933
H2S	0.000	0.000	0.000	0.846
HCl	0.000	0.000	0.000	0.039
NH3	0.000	0.000	0.000	0.016
C2H6	0.000	0.000	0.000	0.039
Benzene	0.000	0.000	0.000	0.971
Toluene	0.000	0.000	0.000	0.007
L/H Oils	0.000	0.000	0.000	0.331
Total	141.369	199.940	199.940	209.795

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	253.37	313.37	283.26	222.08
H2O	282.63	801.63	1070.74	1111.43
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	207.37
CO	0.00	0.00	0.00	75.61
CO2	0.00	0.00	0.00	29.07
CH4	0.00	0.00	0.00	400.00
H2S	0.00	0.00	0.00	28.82
HCl	0.00	0.00	0.00	1.44
NH3	0.00	0.00	0.00	0.28
C2H6	0.00	0.00	0.00	1.17
Benzene	0.00	0.00	0.00	75.83
Toluene	0.00	0.00	0.00	0.65
L/H Oils	0.00	0.00	0.00	59.07
Char	0.00	0.00	0.00	507.72
Total	536.00	1115.00	1354.00	2720.56

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-9
Data Point: 5

Test Date: 11 FEB 1985
Time Slice: 16:24:00
Duration (minutes): 16.1

Reactor Inlet Steam Mole Percent: 30.3
Reactor Inlet Hydrogen Mole Percent: 69.7
Reactor Exit Steam Mole Percent: 28.7
Reactor Exit Hydrogen Mole Percent: 48.1

Reactor Exit Temperature (deg F): 2040
Reactor Mixed Temperature (deg F): 1609
Average Reactor Temperature (deg F): 1824.5
Main Burner Exit Temperature (deg F): 2216

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 2.28
Reactor Inlet Gas to Coal (lb-moles/lb): 0.173

Carbon Conversion to Methane (%):	47.30
Carbon Conversion to Ethane (%):	0.13
Carbon Conversion to Benzene (%):	0.50
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	7.10
Carbon Conversion to Carbon Dioxide (%):	1.70
Carbon Conversion to L/H Oils (%):	3.29
Carbon Conversion to Carbon Oxides (%):	8.80
Carbon Conversion to BTX Liquids (%):	0.50
Carbon Conversion to Hydrocarbons (%):	51.22
Carbon Conversion to Hydrocarbon Gas (%):	47.43
Carbon Conversion to Gases (%):	56.23
Carbon Conversion to Liquids (%):	3.79
Total Carbon Conversion (%):	60.02

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 10

AFHP TEST DATA EVALUATION
TEST NUMBER R-9 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	60.02 %				
Char:	39.98 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
47.30 %	0.13 %	0.50 %	0.00 %	8.80 %	3.29 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	255.00 lbs/hr	289.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	514.00 lbs/hr	61.00 lbs/hr	
Main Burner:	Oxygen		
	268.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1171.00 lbs/hr	195.56 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
354606 Btu/hr	139339 Btu/hr	54174 Btu/hr	195952 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 50 F	Hydrogen & Natural Gas @ 1122 F
Steam Generator:	Water @ 210 F	Hydrogen @ 71 F
Main Burner:	Oxygen @ 53 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2267.1 F	1238.5 F	2215.6 F	2040.0 F
Reactor Mixed Temperature: 1609.3 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.173 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	1.96 seconds
Based on Reactor Outlet Conditions:	2.03 seconds
Based on Reactor Mixed Conditions:	2.54 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	1.220	0.000	0.000
Carbon	72.860	74.188	94.170
Hydrogen	5.196	1.414	5.460
Nitrogen	1.482	1.004	0.140
Sulfur	2.984	1.476	0.230
Chlorine	0.182	0.140	0.000
Oxygen	7.749	0.569	0.000
Ash	8.327	21.208	0.000

COAL HIGHER HEATING VALUE: 13274 Btu/lb

CHAR HIGHER HEATING VALUE: 11603 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-9 - DATA POINT 5 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.882	78.001	69.714	48.101
H2O	11.118	21.999	30.286	28.719
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.552
CO	0.000	0.000	0.000	2.411
CO2	0.000	0.000	0.000	0.577
CH4	0.000	0.000	0.000	16.065
H2S	0.000	0.000	0.000	0.419
HCl	0.000	0.000	0.000	0.020
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.022
Benzene	0.000	0.000	0.000	0.028
L/H Oils	0.000	0.000	0.000	0.080

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	127.415	157.673	140.922	100.598
H2O	15.938	44.469	61.220	60.062
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	7.429
CO	0.000	0.000	0.000	5.043
CO2	0.000	0.000	0.000	1.208
CH4	0.000	0.000	0.000	33.599
H2S	0.000	0.000	0.000	0.876
HCl	0.000	0.000	0.000	0.042
NH3	0.000	0.000	0.000	0.010
C2H6	0.000	0.000	0.000	0.046
Benzene	0.000	0.000	0.000	0.059
L/H Oils	0.000	0.000	0.000	0.167
Total	143.353	202.142	202.142	209.139

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	256.87	317.87	284.10	202.80
H2O	287.13	801.13	1102.90	1082.05
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	208.11
CO	0.00	0.00	0.00	141.27
CO2	0.00	0.00	0.00	53.14
CH4	0.00	0.00	0.00	539.03
H2S	0.00	0.00	0.00	29.85
HCl	0.00	0.00	0.00	1.53
NH3	0.00	0.00	0.00	0.17
C2H6	0.00	0.00	0.00	1.39
Benzene	0.00	0.00	0.00	4.62
L/H Oils	0.00	0.00	0.00	29.81
Char	0.00	0.00	0.00	459.78
Total	544.00	1119.00	1387.00	2753.56

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-9
Data Point: 6

Test Date: 11 FEB 1985
Time Slice: 16:27:00
Duration (minutes): 3.7

Reactor Inlet Steam Mole Percent: 30.4
Reactor Inlet Hydrogen Mole Percent: 69.6
Reactor Exit Steam Mole Percent: 28.8
Reactor Exit Hydrogen Mole Percent: 48.6

Reactor Exit Temperature (deg F): 2037
Reactor Mixed Temperature (deg F): 1612
Average Reactor Temperature (deg F): 1824.5
Main Burner Exit Temperature (deg F): 2220

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 2.28
Reactor Inlet Gas to Coal (lb-moles/lb): 0.172

Carbon Conversion to Methane (%):	45.80
Carbon Conversion to Ethane (%):	0.13
Carbon Conversion to Benzene (%):	0.60
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	6.80
Carbon Conversion to Carbon Dioxide (%):	1.70
Carbon Conversion to L/H Oils (%):	3.31
Carbon Conversion to Carbon Oxides (%):	8.50
Carbon Conversion to BTX Liquids (%):	0.60
Carbon Conversion to Hydrocarbons (%):	49.84
Carbon Conversion to Hydrocarbon Gas (%):	45.93
Carbon Conversion to Gases (%):	54.43
Carbon Conversion to Liquids (%):	3.91
Total Carbon Conversion (%):	58.34

Graphics Plot Symbol: 5
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 11

AFHP TEST DATA EVALUATION
TEST NUMBER R-9 - DATA POINT 6

COAL CARBON CONVERSIONS:

Overall:	58.34 %				
Char:	41.66 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.80 %	0.13 %	0.60 %	0.00 %	8.50 %	3.31 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	255.00 lbs/hr	288.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	514.00 lbs/hr	61.00 lbs/hr	
Main Burner:	Oxygen		
	269.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1171.00 lbs/hr	195.56 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
353531 Btu/hr	142862 Btu/hr	55245 Btu/hr	176934 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 50 F	Hydrogen & Natural Gas @ 1124 F
Steam Generator:	Water @ 210 F	Hydrogen @ 70 F
Main Burner:	Oxygen @ 53 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2273.4 F	1238.4 F	2220.5 F	2037.0 F
Reactor Mixed Temperature: 1611.8 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.172 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	1.96 seconds
Based on Reactor Outlet Conditions:	2.03 seconds
Based on Reactor Mixed Conditions:	2.54 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	1.220	0.000	0.000
Carbon	72.860	74.828	94.170
Hydrogen	5.196	1.426	5.460
Nitrogen	1.482	1.013	0.140
Sulfur	2.984	1.489	0.230
Chlorine	0.182	0.142	0.000
Oxygen	7.749	0.574	0.000
Ash	8.327	20.528	0.000

COAL HIGHER HEATING VALUE: 13274 Btu/lb

CHAR HIGHER HEATING VALUE: 11703 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-9 - DATA POINT 6

Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.843	77.947	69.609	48.631
H2O	11.157	22.053	30.391	28.822
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.546
CO	0.000	0.000	0.000	2.308
CO2	0.000	0.000	0.000	0.577
CH4	0.000	0.000	0.000	15.542
H2S	0.000	0.000	0.000	0.414
HCl	0.000	0.000	0.000	0.020
NH3	0.000	0.000	0.000	0.005
C2H6	0.000	0.000	0.000	0.022
Benzene	0.000	0.000	0.000	0.034
L/H Oils	0.000	0.000	0.000	0.080

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	126.919	157.177	140.364	101.797
H2O	15.938	44.469	61.282	60.331
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	7.422
CO	0.000	0.000	0.000	4.830
CO2	0.000	0.000	0.000	1.208
CH4	0.000	0.000	0.000	32.533
H2S	0.000	0.000	0.000	0.867
HCl	0.000	0.000	0.000	0.041
NH3	0.000	0.000	0.000	0.010
C2H6	0.000	0.000	0.000	0.046
Benzene	0.000	0.000	0.000	0.071
L/H Oils	0.000	0.000	0.000	0.168
Total	142.857	201.646	201.646	209.325

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	255.87	316.87	282.97	205.22
H2O	287.13	801.13	1104.03	1086.89
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	207.92
CO	0.00	0.00	0.00	135.30
CO2	0.00	0.00	0.00	53.14
CH4	0.00	0.00	0.00	521.93
H2S	0.00	0.00	0.00	29.55
HCl	0.00	0.00	0.00	1.50
NH3	0.00	0.00	0.00	0.17
C2H6	0.00	0.00	0.00	1.39
Benzene	0.00	0.00	0.00	5.55
L/H Oils	0.00	0.00	0.00	29.99
Char	0.00	0.00	0.00	475.01
Total	543.00	1118.00	1387.00	2753.56

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-10
Data Point: 1

Test Date: 15 FEB 1985
Time Slice: 13:43:59
Duration (minutes): 14.0

Reactor Inlet Steam Mole Percent: 28.8
Reactor Inlet Hydrogen Mole Percent: 71.2
Reactor Exit Steam Mole Percent: 28.6
Reactor Exit Hydrogen Mole Percent: 55.2

Reactor Exit Temperature (deg F): 1841
Reactor Mixed Temperature (deg F): 1549
Average Reactor Temperature (deg F): 1695
Main Burner Exit Temperature (deg F): 2072

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 2.42
Reactor Inlet Gas to Coal (lb-moles/lb): 0.191

Carbon Conversion to Methane (%):	34.70
Carbon Conversion to Ethane (%):	0.14
Carbon Conversion to Benzene (%):	9.40
Carbon Conversion to Toluene (%):	0.06
Carbon Conversion to Carbon Monoxide (%):	3.60
Carbon Conversion to Carbon Dioxide (%):	0.83
Carbon Conversion to L/H Oils (%):	7.21
Carbon Conversion to Carbon Oxides (%):	4.43
Carbon Conversion to BTX Liquids (%):	9.46
Carbon Conversion to Hydrocarbons (%):	51.51
Carbon Conversion to Hydrocarbon Gas (%):	34.84
Carbon Conversion to Gases (%):	39.27
Carbon Conversion to Liquids (%):	16.67
Total Carbon Conversion (%):	55.94

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 12

AFHP TEST DATA EVALUATION

TEST NUMBER R-10 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	55.94 %				
Char:	44.06 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
34.70 %	0.14 %	9.40 %	0.06 %	4.43 %	7.21 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	248.00 lbs/hr	288.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	510.00 lbs/hr	58.00 lbs/hr	
Main Burner:	Oxygen		
	221.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1047.00 lbs/hr	174.85 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
333377 Btu/hr	152000 Btu/hr	50324 Btu/hr	209909 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 69 F	Hydrogen & Natural Gas @ 1145 F
Steam Generator:	Water @ 225 F	Hydrogen @ 89 F
Main Burner:	Oxygen @ 71 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2272.9 F	1250.3 F	2071.7 F	1841.0 F
Reactor Mixed Temperature: 1548.5 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.191 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.09 seconds
Based on Reactor Outlet Conditions:	2.21 seconds
Based on Reactor Mixed Conditions:	2.64 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.430	0.000	0.000
Carbon	73.164	75.389	94.170
Hydrogen	5.317	1.517	5.460
Nitrogen	1.521	1.155	0.140
Sulfur	3.023	1.472	0.230
Chlorine	0.182	0.133	0.000
Oxygen	7.900	0.543	0.000
Ash	8.463	19.792	0.000

COAL HIGHER HEATING VALUE: 13339 Btu/lb

CHAR HIGHER HEATING VALUE: 11751 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-10 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	89.149	78.088	71.179	55.220
H2O	10.850	21.912	28.821	28.570
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.174
CO	0.000	0.000	0.000	1.102
CO2	0.000	0.000	0.000	0.254
CH4	0.000	0.000	0.000	10.620
H2S	0.000	0.000	0.000	0.373
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.021
Benzene	0.000	0.000	0.000	0.479
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.158

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	127.356	156.126	142.313	115.071
H2O	15.501	43.810	57.623	59.536
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	6.614
CO	0.000	0.000	0.000	2.296
CO2	0.000	0.000	0.000	0.529
CH4	0.000	0.000	0.000	22.130
H2S	0.000	0.000	0.000	0.777
HCl	0.000	0.000	0.000	0.037
NH3	0.000	0.000	0.000	0.018
C2H6	0.000	0.000	0.000	0.045
Benzene	0.000	0.000	0.000	0.999
Toluene	0.000	0.000	0.000	0.005
L/H Oils	0.000	0.000	0.000	0.329
Total	142.857	199.936	199.936	208.387

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	256.75	314.75	286.90	231.98
H2O	279.25	789.25	1038.10	1072.56
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	185.27
CO	0.00	0.00	0.00	64.31
CO2	0.00	0.00	0.00	23.30
CH4	0.00	0.00	0.00	355.04
H2S	0.00	0.00	0.00	26.49
HCl	0.00	0.00	0.00	1.35
NH3	0.00	0.00	0.00	0.30
C2H6	0.00	0.00	0.00	1.34
Benzene	0.00	0.00	0.00	78.05
Toluene	0.00	0.00	0.00	0.50
L/H Oils	0.00	0.00	0.00	58.65
Char	0.00	0.00	0.00	447.69
Total	536.00	1104.00	1325.00	2546.85

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-10
Data Point: 2

Test Date: 15 FEB 1985
Time Slice: 13:51:59
Duration (minutes): 8.0

Reactor Inlet Steam Mole Percent: 28.6
Reactor Inlet Hydrogen Mole Percent: 71.4
Reactor Exit Steam Mole Percent: 28.4
Reactor Exit Hydrogen Mole Percent: 55.7

Reactor Exit Temperature (deg F): 1806
Reactor Mixed Temperature (deg F): 1532
Average Reactor Temperature (deg F): 1669
Main Burner Exit Temperature (deg F): 2048

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 2.45
Reactor Inlet Gas to Coal (lb-moles/lb): 0.191

Carbon Conversion to Methane (%):	33.70
Carbon Conversion to Ethane (%):	0.17
Carbon Conversion to Benzene (%):	10.30
Carbon Conversion to Toluene (%):	0.08
Carbon Conversion to Carbon Monoxide (%):	3.40
Carbon Conversion to Carbon Dioxide (%):	0.76
Carbon Conversion to L/H Oils (%):	7.83
Carbon Conversion to Carbon Oxides (%):	4.16
Carbon Conversion to BTX Liquids (%):	10.38
Carbon Conversion to Hydrocarbons (%):	52.08
Carbon Conversion to Hydrocarbon Gas (%):	33.87
Carbon Conversion to Gases (%):	38.03
Carbon Conversion to Liquids (%):	18.21
Total Carbon Conversion (%):	56.24

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 13

AFHP TEST DATA EVALUATION
TEST NUMBER R-10 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	56.24 %				
Char:	43.76 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
33.70 %	0.17 %	10.30 %	0.08 %	4.16 %	7.83 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	249.00 lbs/hr	289.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	510.00 lbs/hr	58.00 lbs/hr	
Main Burner:	Oxygen		
	215.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1047.00 lbs/hr	174.85 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
334236 Btu/hr	157061 Btu/hr	51372 Btu/hr	230185 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 69 F	Hydrogen & Natural Gas @ 1145 F
Steam Generator:	Water @ 226 F	Hydrogen @ 88 F
Main Burner:	Oxygen @ 70 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2273.9 F	1250.6 F	2047.8 F	1806.0 F
Reactor Mixed Temperature: 1532.0 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.191 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.11 seconds
Based on Reactor Outlet Conditions:	2.24 seconds
Based on Reactor Mixed Conditions:	2.66 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.430	0.000	0.000
Carbon	73.164	75.287	94.170
Hydrogen	5.317	1.515	5.460
Nitrogen	1.521	1.154	0.140
Sulfur	3.023	1.470	0.230
Chlorine	0.182	0.133	0.000
Oxygen	7.900	0.542	0.000
Ash	8.463	19.901	0.000

COAL HIGHER HEATING VALUE: 13339 Btu/lb

CHAR HIGHER HEATING VALUE: 11735 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-10 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	89.143	78.111	71.407	55.728
H2O	10.856	21.889	28.593	28.434
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.164
CO	0.000	0.000	0.000	1.037
CO2	0.000	0.000	0.000	0.232
CH4	0.000	0.000	0.000	10.281
H2S	0.000	0.000	0.000	0.372
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.026
Benzene	0.000	0.000	0.000	0.524
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.171

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	127.790	156.560	143.122	116.497
H2O	15.563	43.872	57.310	59.441
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	6.614
CO	0.000	0.000	0.000	2.168
CO2	0.000	0.000	0.000	0.485
CH4	0.000	0.000	0.000	21.493
H2S	0.000	0.000	0.000	0.778
HCl	0.000	0.000	0.000	0.037
NH3	0.000	0.000	0.000	0.019
C2H6	0.000	0.000	0.000	0.054
Benzene	0.000	0.000	0.000	1.095
Toluene	0.000	0.000	0.000	0.007
L/H Oils	0.000	0.000	0.000	0.357
Total	143.353	200.432	200.432	209.046

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	257.62	315.62	288.53	234.86
H2O	280.38	790.38	1032.47	1070.86
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	185.28
CO	0.00	0.00	0.00	60.74
CO2	0.00	0.00	0.00	21.33
CH4	0.00	0.00	0.00	344.81
H2S	0.00	0.00	0.00	26.53
HCl	0.00	0.00	0.00	1.35
NH3	0.00	0.00	0.00	0.33
C2H6	0.00	0.00	0.00	1.63
Benzene	0.00	0.00	0.00	85.52
Toluene	0.00	0.00	0.00	0.67
L/H Oils	0.00	0.00	0.00	63.69
Char	0.00	0.00	0.00	445.25
Total	538.00	1106.00	1321.00	2542.85

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-10
Data Point: 3

Test Date: 15 FEB 1985
Time Slice: 14:00:00
Duration (minutes): 8.0

Reactor Inlet Steam Mole Percent: 28.8
Reactor Inlet Hydrogen Mole Percent: 71.2
Reactor Exit Steam Mole Percent: 28.6
Reactor Exit Hydrogen Mole Percent: 55.8

Reactor Exit Temperature (deg F): 1849
Reactor Mixed Temperature (deg F): 1546
Average Reactor Temperature (deg F): 1697.5
Main Burner Exit Temperature (deg F): 2068

Reactor Pressure (psia): 1014
Reactor Residence Time (seconds): 2.42
Reactor Inlet Gas to Coal (lb-moles/lb): 0.191

Carbon Conversion to Methane (%):	33.40
Carbon Conversion to Ethane (%):	0.14
Carbon Conversion to Benzene (%):	9.10
Carbon Conversion to Toluene (%):	0.05
Carbon Conversion to Carbon Monoxide (%):	3.40
Carbon Conversion to Carbon Dioxide (%):	0.76
Carbon Conversion to L/H Oils (%):	7.04
Carbon Conversion to Carbon Oxides (%):	4.16
Carbon Conversion to BTX Liquids (%):	9.15
Carbon Conversion to Hydrocarbons (%):	49.73
Carbon Conversion to Hydrocarbon Gas (%):	33.54
Carbon Conversion to Gases (%):	37.70
Carbon Conversion to Liquids (%):	16.19
Total Carbon Conversion (%):	53.89

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 14

AFHP TEST DATA EVALUATION

TEST NUMBER R-10 ~ DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	53.89 %				
Char:	46.11 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
33.40 %	0.14 %	9.10 %	0.05 %	4.16 %	7.04 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	252.00 lbs/hr	288.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	510.00 lbs/hr	58.00 lbs/hr	
Main Burner:	Oxygen		
	217.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1047.00 lbs/hr	174.85 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
335870 Btu/hr	155689 Btu/hr	53172 Btu/hr	160415 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 71 F	Hydrogen & Natural Gas @ 1147 F
Steam Generator:	Water @ 225 F	Hydrogen @ 90 F
Main Burner:	Oxygen @ 72 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2293.8 F	1264.3 F	2067.8 F	1849.0 F
Reactor Mixed Temperature: 1545.7 F			

PRESSURE: 1014.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.191 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.10 seconds
Based on Reactor Outlet Conditions:	2.20 seconds
Based on Reactor Mixed Conditions:	2.65 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.430	0.000	0.000
Carbon	73.164	76.058	94.170
Hydrogen	5.317	1.530	5.460
Nitrogen	1.521	1.166	0.140
Sulfur	3.023	1.485	0.230
Chlorine	0.182	0.134	0.000
Oxygen	7.900	0.548	0.000
Ash	8.463	19.080	0.000

COAL HIGHER HEATING VALUE: 13339 Btu/lb

CHAR HIGHER HEATING VALUE: 11856 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-10 - DATA POINT 3 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.974	77.963	71.179	55.753
H2O	11.025	22.037	28.821	28.590
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.161
CO	0.000	0.000	0.000	1.038
CO2	0.000	0.000	0.000	0.232
CH4	0.000	0.000	0.000	10.193
H2S	0.000	0.000	0.000	0.367
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.008
C2H6	0.000	0.000	0.000	0.021
Benzene	0.000	0.000	0.000	0.463
Toluene	0.000	0.000	0.000	0.002
L/H Oils	0.000	0.000	0.000	0.154

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	127.106	155.876	142.313	116.510
H2O	15.751	44.060	57.623	59.746
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	6.605
CO	0.000	0.000	0.000	2.168
CO2	0.000	0.000	0.000	0.485
CH4	0.000	0.000	0.000	21.301
H2S	0.000	0.000	0.000	0.768
HCl	0.000	0.000	0.000	0.036
NH3	0.000	0.000	0.000	0.017
C2H6	0.000	0.000	0.000	0.045
Benzene	0.000	0.000	0.000	0.967
Toluene	0.000	0.000	0.000	0.005
L/H Oils	0.000	0.000	0.000	0.321
Total	142.857	199.936	199.936	208.974

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	256.25	314.25	286.90	234.88
H2O	283.75	793.75	1038.10	1076.34
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	185.04
CO	0.00	0.00	0.00	60.74
CO2	0.00	0.00	0.00	21.33
CH4	0.00	0.00	0.00	341.74
H2S	0.00	0.00	0.00	26.17
HCl	0.00	0.00	0.00	1.32
NH3	0.00	0.00	0.00	0.30
C2H6	0.00	0.00	0.00	1.34
Benzene	0.00	0.00	0.00	75.56
Toluene	0.00	0.00	0.00	0.42
L/H Oils	0.00	0.00	0.00	57.27
Char	0.00	0.00	0.00	464.40
Total	540.00	1108.00	1325.00	2546.85

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-10
Data Point: 4

Test Date: 15 FEB 1985
Time Slice: 14:08:00
Duration (minutes): 8.0

Reactor Inlet Steam Mole Percent: 28.7
Reactor Inlet Hydrogen Mole Percent: 71.3
Reactor Exit Steam Mole Percent: 28.6
Reactor Exit Hydrogen Mole Percent: 55.7

Reactor Exit Temperature (deg F): 1814
Reactor Mixed Temperature (deg F): 1532
Average Reactor Temperature (deg F): 1673
Main Burner Exit Temperature (deg F): 2046

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 2.43
Reactor Inlet Gas to Coal (lb-moles/lb): 0.192

Carbon Conversion to Methane (%):	33.60
Carbon Conversion to Ethane (%):	0.15
Carbon Conversion to Benzene (%):	9.90
Carbon Conversion to Toluene (%):	0.07
Carbon Conversion to Carbon Monoxide (%):	3.30
Carbon Conversion to Carbon Dioxide (%):	0.75
Carbon Conversion to L/H Oils (%):	7.71
Carbon Conversion to Carbon Oxides (%):	4.05
Carbon Conversion to BTX Liquids (%):	9.97
Carbon Conversion to Hydrocarbons (%):	51.43
Carbon Conversion to Hydrocarbon Gas (%):	33.75
Carbon Conversion to Gases (%):	37.80
Carbon Conversion to Liquids (%):	17.68
Total Carbon Conversion (%):	55.48

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 15

AFHP TEST DATA EVALUATION
TEST NUMBER R-10 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	55.48 %				
Char:	44.52 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
33.60 %	0.15 %	9.90 %	0.07 %	4.05 %	7.71 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	256.00 lbs/hr	289.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	515.00 lbs/hr	59.00 lbs/hr	
Main Burner:	Oxygen		
	212.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1047.00 lbs/hr	174.85 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
339302 Btu/hr	158284 Btu/hr	54497 Btu/hr	211732 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 71 F	Hydrogen & Natural Gas @ 1142 F
Steam Generator:	Water @ 226 F	Hydrogen @ 90 F
Main Burner:	Oxygen @ 72 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2304.0 F	1266.2 F	2045.7 F	1814.0 F
Reactor Mixed Temperature: 1532.1 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.192 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.10 seconds
Based on Reactor Outlet Conditions:	2.22 seconds
Based on Reactor Mixed Conditions:	2.64 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.430	0.000	0.000
Carbon	73.164	75.543	94.170
Hydrogen	5.317	1.520	5.460
Nitrogen	1.521	1.158	0.140
Sulfur	3.023	1.475	0.230
Chlorine	0.182	0.133	0.000
Oxygen	7.900	0.544	0.000
Ash	8.463	19.628	0.000

COAL HIGHER HEATING VALUE: 13339 Btu/lb

CHAR HIGHER HEATING VALUE: 11775 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-10 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	88.838	77.840	71.254	55.709
H2O	11.162	22.160	28.746	28.609
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.150
CO	0.000	0.000	0.000	1.003
CO2	0.000	0.000	0.000	0.228
CH4	0.000	0.000	0.000	10.210
H2S	0.000	0.000	0.000	0.369
HCl	0.000	0.000	0.000	0.018
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.023
Benzene	0.000	0.000	0.000	0.501
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.168

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	127.352	156.618	143.368	116.920
H2O	16.001	44.587	57.838	60.043
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	6.611
CO	0.000	0.000	0.000	2.105
CO2	0.000	0.000	0.000	0.478
CH4	0.000	0.000	0.000	21.429
H2S	0.000	0.000	0.000	0.775
HCl	0.000	0.000	0.000	0.037
NH3	0.000	0.000	0.000	0.019
C2H6	0.000	0.000	0.000	0.048
Benzene	0.000	0.000	0.000	1.052
Toluene	0.000	0.000	0.000	0.006
L/H Oils	0.000	0.000	0.000	0.352
Total	143.353	201.206	201.206	209.874

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	256.74	315.74	289.03	235.71
H2O	288.26	803.26	1041.97	1081.69
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	185.19
CO	0.00	0.00	0.00	58.95
CO2	0.00	0.00	0.00	21.05
CH4	0.00	0.00	0.00	343.79
H2S	0.00	0.00	0.00	26.41
HCl	0.00	0.00	0.00	1.34
NH3	0.00	0.00	0.00	0.32
C2H6	0.00	0.00	0.00	1.44
Benzene	0.00	0.00	0.00	82.20
Toluene	0.00	0.00	0.00	0.59
L/H Oils	0.00	0.00	0.00	62.72
Char	0.00	0.00	0.00	451.44
Total	545.00	1119.00	1331.00	2552.85

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-10
Data Point: 5

Test Date: 15 FEB 1985
Time Slice: 14:16:00
Duration (minutes): 7.5

Reactor Inlet Steam Mole Percent: 28.5
Reactor Inlet Hydrogen Mole Percent: 71.5
Reactor Exit Steam Mole Percent: 28.3
Reactor Exit Hydrogen Mole Percent: 56.5

Reactor Exit Temperature (deg F): 1796
Reactor Mixed Temperature (deg F): 1522
Average Reactor Temperature (deg F): 1659
Main Burner Exit Temperature (deg F): 2031

Reactor Pressure (psia): 1011
Reactor Residence Time (seconds): 2.44
Reactor Inlet Gas to Coal (lb-moles/lb): 0.192

Carbon Conversion to Methane (%):	32.40
Carbon Conversion to Ethane (%):	0.17
Carbon Conversion to Benzene (%):	10.00
Carbon Conversion to Toluene (%):	0.08
Carbon Conversion to Carbon Monoxide (%):	3.30
Carbon Conversion to Carbon Dioxide (%):	0.74
Carbon Conversion to L/H Oils (%):	8.01
Carbon Conversion to Carbon Oxides (%):	4.04
Carbon Conversion to BTX Liquids (%):	10.08
Carbon Conversion to Hydrocarbons (%):	50.66
Carbon Conversion to Hydrocarbon Gas (%):	32.57
Carbon Conversion to Gases (%):	36.61
Carbon Conversion to Liquids (%):	18.09
Total Carbon Conversion (%):	54.70

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 16

AFHP TEST DATA EVALUATION

TEST NUMBER R-10 - DATA POINT 5

COAL CARBON CONVERSIONS:

Overall:	54.70 %				
Char:	45.30 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
32.40 %	0.17 %	10.00 %	0.08 %	4.04 %	8.01 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	251.00 lbs/hr	290.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	511.00 lbs/hr	59.00 lbs/hr	
Main Burner:	Oxygen		
	213.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1047.00 lbs/hr	174.85 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
341088 Btu/hr	147066 Btu/hr	53569 Btu/hr	196094 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 71 F	Hydrogen & Natural Gas @ 1129 F
Steam Generator:	Water @ 223 F	Hydrogen @ 89 F
Main Burner:	Oxygen @ 71 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2261.1 F	1245.7 F	2031.1 F	1796.0 F
Reactor Mixed Temperature: 1521.7 F			

PRESSURE: 1011.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.192 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.11 seconds
Based on Reactor Outlet Conditions:	2.23 seconds
Based on Reactor Mixed Conditions:	2.65 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.430	0.000	0.000
Carbon	73.164	75.800	94.170
Hydrogen	5.317	1.525	5.460
Nitrogen	1.521	1.162	0.140
Sulfur	3.023	1.480	0.230
Chlorine	0.182	0.133	0.000
Oxygen	7.900	0.546	0.000
Ash	8.463	19.355	0.000

COAL HIGHER HEATING VALUE: 13339 Btu/lb

CHAR HIGHER HEATING VALUE: 11815 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-10 - DATA POINT 5 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	89.094	78.135	71.528	56.468
H2O	10.906	21.865	28.472	28.270
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.135
CO	0.000	0.000	0.000	0.999
CO2	0.000	0.000	0.000	0.224
CH4	0.000	0.000	0.000	9.805
H2S	0.000	0.000	0.000	0.366
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.010
C2H6	0.000	0.000	0.000	0.026
Benzene	0.000	0.000	0.000	0.504
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.173

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	128.161	157.427	144.114	119.008
H2O	15.688	44.053	57.366	59.581
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	6.607
CO	0.000	0.000	0.000	2.105
CO2	0.000	0.000	0.000	0.472
CH4	0.000	0.000	0.000	20.663
H2S	0.000	0.000	0.000	0.771
HCl	0.000	0.000	0.000	0.037
NH3	0.000	0.000	0.000	0.020
C2H6	0.000	0.000	0.000	0.054
Benzene	0.000	0.000	0.000	1.063
Toluene	0.000	0.000	0.000	0.007
L/H Oils	0.000	0.000	0.000	0.366
Total	143.849	201.480	201.480	210.753

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	258.37	317.37	290.53	239.92
H2O	282.63	793.63	1033.47	1073.37
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	185.08
CO	0.00	0.00	0.00	58.95
CO2	0.00	0.00	0.00	20.77
CH4	0.00	0.00	0.00	331.51
H2S	0.00	0.00	0.00	26.28
HCl	0.00	0.00	0.00	1.33
NH3	0.00	0.00	0.00	0.34
C2H6	0.00	0.00	0.00	1.63
Benzene	0.00	0.00	0.00	83.03
Toluene	0.00	0.00	0.00	0.67
L/H Oils	0.00	0.00	0.00	65.16
Char	0.00	0.00	0.00	457.80
Total	541.00	1111.00	1324.00	2545.85

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-10
Data Point: 6

Test Date: 15 FEB 1985
Time Slice: 14:25:00
Duration (minutes): 11.0

Reactor Inlet Steam Mole Percent: 28.5
Reactor Inlet Hydrogen Mole Percent: 71.5
Reactor Exit Steam Mole Percent: 28.4
Reactor Exit Hydrogen Mole Percent: 56.1

Reactor Exit Temperature (deg F): 1809
Reactor Mixed Temperature (deg F): 1527
Average Reactor Temperature (deg F): 1668
Main Burner Exit Temperature (deg F): 2034

Reactor Pressure (psia): 1011
Reactor Residence Time (seconds): 2.41
Reactor Inlet Gas to Coal (lb-moles/lb): 0.194

Carbon Conversion to Methane (%):	33.70
Carbon Conversion to Ethane (%):	0.14
Carbon Conversion to Benzene (%):	9.90
Carbon Conversion to Toluene (%):	0.06
Carbon Conversion to Carbon Monoxide (%):	3.40
Carbon Conversion to Carbon Dioxide (%):	0.75
Carbon Conversion to L/H Oils (%):	7.81
Carbon Conversion to Carbon Oxides (%):	4.15
Carbon Conversion to BTX Liquids (%):	9.96
Carbon Conversion to Hydrocarbons (%):	51.61
Carbon Conversion to Hydrocarbon Gas (%):	33.84
Carbon Conversion to Gases (%):	37.99
Carbon Conversion to Liquids (%):	17.77
Total Carbon Conversion (%):	55.76

Graphics Plot Symbol: 7
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 17

AFHP TEST DATA EVALUATION
TEST NUMBER R-10 - DATA POINT 6

COAL CARBON CONVERSIONS:

Overall:	55.76 %				
Char:	44.24 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
33.70 %	0.14 %	9.90 %	0.06 %	4.15 %	7.81 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	247.00 lbs/hr	292.00 lbs/hr	0.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	518.00 lbs/hr	60.00 lbs/hr	
Main Burner:	Oxygen		
	221.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1047.00 lbs/hr	174.85 lbs/hr	

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
337139 Btu/hr	149504 Btu/hr	51586 Btu/hr	206007 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 71 F	Hydrogen & Natural Gas @ 1132 F
Steam Generator:	Water @ 225 F	Hydrogen @ 89 F
Main Burner:	Oxygen @ 72 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2239.0 F	1223.4 F	2034.3 F	1809.0 F
Reactor Mixed Temperature: 1527.4 F			

PRESSURE: 1011.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.194 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	2.09 seconds
Based on Reactor Outlet Conditions:	2.20 seconds
Based on Reactor Mixed Conditions:	2.62 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils
Moisture	0.430	0.000	0.000
Carbon	73.164	75.450	94.170
Hydrogen	5.317	1.518	5.460
Nitrogen	1.521	1.156	0.140
Sulfur	3.023	1.473	0.230
Chlorine	0.182	0.133	0.000
Oxygen	7.900	0.543	0.000
Ash	8.463	19.727	0.000

COAL HIGHER HEATING VALUE: 13339 Btu/lb

CHAR HIGHER HEATING VALUE: 11761 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-10 - DATA POINT 6 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	89.341	78.269	71.477	56.051
H2O	10.659	21.731	28.523	28.366
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	3.118
CO	0.000	0.000	0.000	1.023
CO2	0.000	0.000	0.000	0.226
CH4	0.000	0.000	0.000	10.136
H2S	0.000	0.000	0.000	0.366
HCl	0.000	0.000	0.000	0.017
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.021
Benzene	0.000	0.000	0.000	0.496
Toluene	0.000	0.000	0.000	0.003
L/H Oils	0.000	0.000	0.000	0.168

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	129.403	159.165	145.352	118.850
H2O	15.438	44.191	58.004	60.146
H	0.000	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.000	0.000	0.000	6.612
CO	0.000	0.000	0.000	2.168
CO2	0.000	0.000	0.000	0.478
CH4	0.000	0.000	0.000	21.493
H2S	0.000	0.000	0.000	0.776
HCl	0.000	0.000	0.000	0.037
NH3	0.000	0.000	0.000	0.019
C2H6	0.000	0.000	0.000	0.045
Benzene	0.000	0.000	0.000	1.052
Toluene	0.000	0.000	0.000	0.005
L/H Oils	0.000	0.000	0.000	0.356
Total	144.841	203.356	203.356	212.038

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	260.88	320.88	293.03	239.60
H2O	278.12	796.12	1044.97	1083.56
H	0.00	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	0.00	0.00	0.00	185.22
CO	0.00	0.00	0.00	60.74
CO2	0.00	0.00	0.00	21.05
CH4	0.00	0.00	0.00	344.81
H2S	0.00	0.00	0.00	26.45
HCl	0.00	0.00	0.00	1.35
NH3	0.00	0.00	0.00	0.33
C2H6	0.00	0.00	0.00	1.34
Benzene	0.00	0.00	0.00	82.20
Toluene	0.00	0.00	0.00	0.50
L/H Oils	0.00	0.00	0.00	63.53
Char	0.00	0.00	0.00	449.16
Total	539.00	1117.00	1338.00	2559.85

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-11
Data Point: 1

Test Date: 22 FEB 1985
Time Slice: 14:09:59
Duration (minutes): 14.0

Reactor Inlet Steam Mole Percent: 28.5
Reactor Inlet Hydrogen Mole Percent: 61.3
Reactor Exit Steam Mole Percent: 25.9
Reactor Exit Hydrogen Mole Percent: 44.6

Reactor Exit Temperature (deg F): 2044
Reactor Mixed Temperature (deg F): 1724
Average Reactor Temperature (deg F): 1884
Main Burner Exit Temperature (deg F): 2298

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 2.15
Reactor Inlet Gas to Coal (lb-moles/lb): 0.192

Carbon Conversion to Methane (%):	43.80
Carbon Conversion to Ethane (%):	0.14
Carbon Conversion to Benzene (%):	0.40
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	7.01
Carbon Conversion to Carbon Dioxide (%):	2.76
Carbon Conversion to L/H Oils (%):	3.39
Carbon Conversion to Carbon Oxides (%):	9.77
Carbon Conversion to BTX Liquids (%):	0.40
Carbon Conversion to Hydrocarbons (%):	47.73
Carbon Conversion to Hydrocarbon Gas (%):	43.94
Carbon Conversion to Gases (%):	53.71
Carbon Conversion to Liquids (%):	3.79
Total Carbon Conversion (%):	57.50

Graphics Plot Symbol: 6
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 18

AFHP TEST DATA EVALUATION
TEST NUMBER R-11 - DATA POINT 1

COAL CARBON CONVERSIONS:

Overall:	57.50 %					
Char:	42.50 %					
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils	
43.80 %	0.14 %	0.40 %	0.00 %	9.77 %	3.39 %	

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	647.00 lbs/hr	135.00 lbs/hr	344.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	501.00 lbs/hr	110.00 lbs/hr	
Main Burner:	Oxygen		
	206.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1076.00 lbs/hr	179.69 lbs/hr	

BURNER EXIT NATURAL GAS CARBON CONVERSIONS TO CARBON OXIDES:

Preburner: 90.0 %   Main Burner: 90.0 %

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
452176 Btu/hr	89969 Btu/hr	68112 Btu/hr	224093 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 58 F	Hydrogen & Natural Gas @ 1145 F
Steam Generator:	Water @ 225 F	Hydrogen @ 75 F
Main Burner:	Oxygen @ 56 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
2996.8 F	1598.0 F	2298.0 F	2044.0 F
Reactor Mixed Temperature: 1724.3 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.192 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	1.86 seconds
Based on Reactor Outlet Conditions:	1.95 seconds
Based on Reactor Mixed Conditions:	2.35 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils	Natural Gas
Moisture	0.450	0.000	0.000	0.000
Carbon	73.209	75.652	94.170	72.490
Hydrogen	5.316	0.869	5.460	23.610
Nitrogen	1.492	0.901	0.140	2.590
Sulfur	3.035	1.301	0.230	0.000
Chlorine	0.162	0.195	0.000	0.000
Oxygen	8.043	0.918	0.000	1.310
Ash	8.293	20.164	0.000	0.000

COAL HIGHER HEATING VALUE: 13399 Btu/lb

CHAR HIGHER HEATING VALUE: 11522 Btu/lb

NATURAL GAS HIGHER HEATING VALUE: 22695 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-11 - DATA POINT 1 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	66.122	66.174	61.256	44.581
H2O	16.894	23.621	28.539	25.851
H	0.009	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.256	0.154	0.154	3.298
CO	14.196	8.535	7.220	8.966
CO2	0.850	0.511	1.827	2.596
CH4	1.672	1.005	1.005	14.192
H2S	0.000	0.000	0.000	0.386
HCl	0.000	0.000	0.000	0.011
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.021
Benzene	0.000	0.000	0.000	0.020
L/H Oils	0.000	0.000	0.000	0.073

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	82.113	136.682	126.524	96.754
H2O	20.980	48.790	58.948	56.102
H	0.011	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.318	0.318	0.318	7.157
CO	17.629	17.629	14.912	19.458
CO2	1.056	1.056	3.773	5.635
CH4	2.076	2.076	2.076	30.801
H2S	0.000	0.000	0.000	0.837
HCl	0.000	0.000	0.000	0.025
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.046
Benzene	0.000	0.000	0.000	0.044
L/H Oils	0.000	0.000	0.000	0.159
Total	124.184	206.551	206.551	217.027

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	165.54	275.55	255.07	195.06
H2O	377.96	878.97	1061.97	1010.71
H	0.01	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	8.91	8.91	8.91	200.50
CO	493.81	493.81	417.69	545.02
CO2	46.46	46.46	166.05	247.99
CH4	33.31	33.31	33.31	494.15
H2S	0.00	0.00	0.00	28.52
HCl	0.00	0.00	0.00	0.91
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	1.38
Benzene	0.00	0.00	0.00	3.42
L/H Oils	0.00	0.00	0.00	28.36
Char	0.00	0.00	0.00	442.53
Total	1126.00	1737.00	1943.00	3198.69

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-11
Data Point: 2

Test Date: 22 FEB 1985
Time Slice: 14:18:29
Duration (minutes): 8.0

Reactor Inlet Steam Mole Percent: 28.9
Reactor Inlet Hydrogen Mole Percent: 61.0
Reactor Exit Steam Mole Percent: 25.7
Reactor Exit Hydrogen Mole Percent: 44.1

Reactor Exit Temperature (deg F): 2045
Reactor Mixed Temperature (deg F): 1735
Average Reactor Temperature (deg F): 1890
Main Burner Exit Temperature (deg F): 2311

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 2.14
Reactor Inlet Gas to Coal (lb-moles/lb): 0.192

Carbon Conversion to Methane (%):	45.10
Carbon Conversion to Ethane (%):	0.14
Carbon Conversion to Benzene (%):	0.40
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	7.93
Carbon Conversion to Carbon Dioxide (%):	3.25
Carbon Conversion to L/H Oils (%):	3.39
Carbon Conversion to Carbon Oxides (%):	11.18
Carbon Conversion to BTX Liquids (%):	0.40
Carbon Conversion to Hydrocarbons (%):	49.03
Carbon Conversion to Hydrocarbon Gas (%):	45.24
Carbon Conversion to Gases (%):	56.42
Carbon Conversion to Liquids (%):	3.79
Total Carbon Conversion (%):	60.21

Graphics Plot Symbol: 6
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 19

AFHP TEST DATA EVALUATION

TEST NUMBER R-11 - DATA POINT 2

COAL CARBON CONVERSIONS:

Overall:	60.21 %				
Char:	39.79 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.10 %	0.14 %	0.40 %	0.00 %	11.18 %	3.39 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	652.00 lbs/hr	135.00 lbs/hr	341.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	506.00 lbs/hr	111.00 lbs/hr	
Main Burner:	Oxygen		
	207.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1076.00 lbs/hr	179.69 lbs/hr	

BURNER EXIT NATURAL GAS CARBON CONVERSIONS TO CARBON OXIDES:

Preburner:	90.0 %	Main Burner:	90.0 %

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
455771 Btu/hr	91603 Btu/hr	67198 Btu/hr	239079 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 60 F	Hydrogen & Natural Gas @ 1135 F
Steam Generator:	Water @ 224 F	Hydrogen @ 76 F
Main Burner:	Oxygen @ 58 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3032.2 F	1610.4 F	2311.3 F	2045.0 F
Reactor Mixed Temperature: 1734.9 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.192 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	1.85 seconds
Based on Reactor Outlet Conditions:	1.94 seconds
Based on Reactor Mixed Conditions:	2.33 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils	Natural Gas
Moisture	0.450	0.000	0.000	0.000
Carbon	73.209	74.627	94.170	72.490
Hydrogen	5.316	0.857	5.460	23.610
Nitrogen	1.492	0.889	0.140	2.590
Sulfur	3.035	1.283	0.230	0.000
Chlorine	0.162	0.192	0.000	0.000
Oxygen	8.043	0.905	0.000	1.310
Ash	8.293	21.246	0.000	0.000

COAL HIGHER HEATING VALUE: 13399 Btu/lb

CHAR HIGHER HEATING VALUE: 11366 Btu/lb

NATURAL GAS HIGHER HEATING VALUE: 22695 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-11 - DATA POINT 2 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	65.755	65.947	60.987	44.074
H2O	17.340	23.950	28.910	25.680
H	0.010	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.255	0.152	0.152	3.294
CO	14.117	8.442	7.147	9.227
CO2	0.858	0.513	1.808	2.660
CH4	1.664	0.995	0.995	14.545
H2S	0.000	0.000	0.000	0.390
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.021
Benzene	0.000	0.000	0.000	0.020
L/H Oils	0.000	0.000	0.000	0.073

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	81.330	136.396	126.137	95.863
H2O	21.448	49.535	59.794	55.856
H	0.013	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.315	0.315	0.315	7.164
CO	17.461	17.461	14.782	20.068
CO2	1.061	1.061	3.740	5.786
CH4	2.058	2.058	2.058	31.636
H2S	0.000	0.000	0.000	0.848
HCl	0.000	0.000	0.000	0.026
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.046
Benzene	0.000	0.000	0.000	0.044
L/H Oils	0.000	0.000	0.000	0.159
Total	123.686	206.826	206.826	217.505

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	163.96	274.97	254.29	193.26
H2O	386.39	892.39	1077.21	1006.27
H	0.01	0.00	0.00	0.00
OH	0.01	0.00	0.00	0.00
N2	8.83	8.83	8.83	200.68
CO	489.10	489.10	414.05	562.12
CO2	46.69	46.69	164.60	254.64
CH4	33.02	33.02	33.02	507.54
H2S	0.00	0.00	0.00	28.91
HCl	0.00	0.00	0.00	0.96
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	1.38
Benzene	0.00	0.00	0.00	3.42
L/H Oils	0.00	0.00	0.00	28.36
Char	0.00	0.00	0.00	420.00
Total	1128.00	1745.00	1952.00	3207.69

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-11
Data Point: 3

Test Date: 22 FEB 1985
Time Slice: 14:26:29
Duration (minutes): 8.3

Reactor Inlet Steam Mole Percent: 28.8
Reactor Inlet Hydrogen Mole Percent: 61.1
Reactor Exit Steam Mole Percent: 25.4
Reactor Exit Hydrogen Mole Percent: 44.1

Reactor Exit Temperature (deg F): 2047
Reactor Mixed Temperature (deg F): 1732
Average Reactor Temperature (deg F): 1889.5
Main Burner Exit Temperature (deg F): 2306

Reactor Pressure (psia): 1012
Reactor Residence Time (seconds): 2.14
Reactor Inlet Gas to Coal (lb-moles/lb): 0.193

Carbon Conversion to Methane (%):	45.63
Carbon Conversion to Ethane (%):	0.14
Carbon Conversion to Benzene (%):	0.40
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	8.32
Carbon Conversion to Carbon Dioxide (%):	3.34
Carbon Conversion to L/H Oils (%):	3.39
Carbon Conversion to Carbon Oxides (%):	11.66
Carbon Conversion to BTX Liquids (%):	0.40
Carbon Conversion to Hydrocarbons (%):	49.56
Carbon Conversion to Hydrocarbon Gas (%):	45.77
Carbon Conversion to Gases (%):	57.43
Carbon Conversion to Liquids (%):	3.79
Total Carbon Conversion (%):	61.22

Graphics Plot Symbol: 6
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 20

AFHP TEST DATA EVALUATION

TEST NUMBER R-11 - DATA POINT 3

COAL CARBON CONVERSIONS:

Overall:	61.22 %				
Char:	38.78 %				
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils
45.63 %	0.14 %	0.40 %	0.00 %	11.66 %	3.39 %

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	651.00 lbs/hr	135.00 lbs/hr	341.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	506.00 lbs/hr	112.00 lbs/hr	
Main Burner:	Oxygen		
	207.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1076.00 lbs/hr	179.69 lbs/hr	

BURNER EXIT NATURAL GAS CARBON CONVERSIONS TO CARBON OXIDES:

Preburner:	90.0 %	Main Burner:	90.0 %

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
449525 Btu/hr	91018 Btu/hr	67070 Btu/hr	224967 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 60 F	Hydrogen & Natural Gas @ 1132 F
Steam Generator:	Water @ 224 F	Hydrogen @ 76 F
Main Burner:	Oxygen @ 60 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3030.2 F	1606.2 F	2306.2 F	2047.0 F
Reactor Mixed Temperature: 1732.0 F			

PRESSURE: 1012.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.193 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	1.85 seconds
Based on Reactor Outlet Conditions:	1.94 seconds
Based on Reactor Mixed Conditions:	2.33 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils	Natural Gas
Moisture	0.450	0.000	0.000	0.000
Carbon	73.209	74.217	94.170	72.490
Hydrogen	5.316	0.853	5.460	23.610
Nitrogen	1.492	0.884	0.140	2.590
Sulfur	3.035	1.276	0.230	0.000
Chlorine	0.162	0.191	0.000	0.000
Oxygen	8.043	0.900	0.000	1.310
Ash	8.293	21.679	0.000	0.000

COAL HIGHER HEATING VALUE: 13399 Btu/lb

CHAR HIGHER HEATING VALUE: 11303 Btu/lb

NATURAL GAS HIGHER HEATING VALUE: 22695 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-11 - DATA POINT 3

Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	65.804	66.057	61.110	44.095
H2O	17.292	23.864	28.811	25.423
H	0.010	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.255	0.152	0.152	3.287
CO	14.119	8.424	7.130	9.323
CO2	0.856	0.510	1.804	2.681
CH4	1.664	0.993	0.993	14.670
H2S	0.000	0.000	0.000	0.391
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.021
Benzene	0.000	0.000	0.000	0.020
L/H Oils	0.000	0.000	0.000	0.073

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	81.390	136.951	126.695	96.134
H2O	21.388	49.475	59.731	55.427
H	0.013	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.315	0.315	0.315	7.167
CO	17.464	17.464	14.782	20.325
CO2	1.058	1.058	3.740	5.844
CH4	2.058	2.058	2.058	31.983
H2S	0.000	0.000	0.000	0.853
HCl	0.000	0.000	0.000	0.027
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.046
Benzene	0.000	0.000	0.000	0.044
L/H Oils	0.000	0.000	0.000	0.159
Total	123.686	207.322	207.322	218.017

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	164.08	276.09	255.42	193.81
H2O	385.31	891.31	1076.08	998.53
H	0.01	0.00	0.00	0.00
OH	0.01	0.00	0.00	0.00
N2	8.83	8.83	8.83	200.78
CO	489.17	489.17	414.05	569.32
CO2	46.57	46.57	164.60	257.19
CH4	33.02	33.02	33.02	513.12
H2S	0.00	0.00	0.00	29.06
HCl	0.00	0.00	0.00	0.98
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	1.38
Benzene	0.00	0.00	0.00	3.42
L/H Oils	0.00	0.00	0.00	28.36
Char	0.00	0.00	0.00	411.61
Total	1127.00	1745.00	1952.00	3207.69

ADVANCED FLASH HYDROGASIFICATION TEST RESULTS

AFHP Test Number: R-11
Data Point: 4

Test Date: 22 FEB 1985
Time Slice: 14:33:59
Duration (minutes): 6.4

Reactor Inlet Steam Mole Percent: 28.5
Reactor Inlet Hydrogen Mole Percent: 61.4
Reactor Exit Steam Mole Percent: 25.2
Reactor Exit Hydrogen Mole Percent: 44.4

Reactor Exit Temperature (deg F): 2046
Reactor Mixed Temperature (deg F): 1724
Average Reactor Temperature (deg F): 1885
Main Burner Exit Temperature (deg F): 2292

Reactor Pressure (psia): 1013
Reactor Residence Time (seconds): 2.13
Reactor Inlet Gas to Coal (lb-moles/lb): 0.194

Carbon Conversion to Methane (%):	45.82
Carbon Conversion to Ethane (%):	0.13
Carbon Conversion to Benzene (%):	0.40
Carbon Conversion to Toluene (%):	0.00
Carbon Conversion to Carbon Monoxide (%):	8.37
Carbon Conversion to Carbon Dioxide (%):	3.31
Carbon Conversion to L/H Oils (%):	3.39
Carbon Conversion to Carbon Oxides (%):	11.68
Carbon Conversion to BTX Liquids (%):	0.40
Carbon Conversion to Hydrocarbons (%):	49.74
Carbon Conversion to Hydrocarbon Gas (%):	45.95
Carbon Conversion to Gases (%):	57.63
Carbon Conversion to Liquids (%):	3.79
Total Carbon Conversion (%):	61.42

Graphics Plot Symbol: 6
Plot Symbol Scale: 1

Data File: Short_test_data
File Number: 21

AFHP TEST DATA EVALUATION
TEST NUMBER R-11 - DATA POINT 4

COAL CARBON CONVERSIONS:

Overall:	61.42 %					
Char:	38.58 %					
Methane	Ethane	Benzene	Toluene	Carbon Oxides	L/H Oils	
45.82 %	0.13 %	0.40 %	0.00 %	11.68 %	3.39 %	

INLET FLOWRATES:

Preburner:	Oxygen	Hydrogen	Natural Gas
	649.00 lbs/hr	136.00 lbs/hr	343.00 lbs/hr
Steam Generator:	Water	Hydrogen	
	506.00 lbs/hr	113.00 lbs/hr	
Main Burner:	Oxygen		
	208.00 lbs/hr		
Reactor:	Coal	Nitrogen	
	1076.00 lbs/hr	179.69 lbs/hr	

BURNER EXIT NATURAL GAS CARBON CONVERSIONS TO CARBON OXIDES:

Preburner: 90.0 %   Main Burner: 90.0 %

HEAT LOSSES:

Preburner	Steam Generator	Main Burner	Reactor
452098 Btu/hr	89664 Btu/hr	67611 Btu/hr	207301 Btu/hr

PREHEAT TEMPERATURES:

Preburner:	Oxygen @ 61 F	Hydrogen & Natural Gas @ 1138 F
Steam Generator:	Water @ 224 F	Hydrogen @ 77 F
Main Burner:	Oxygen @ 60 F	

EXIT TEMPERATURES:

Preburner	Steam Generator	Main Burner	Reactor
3002.9 F	1590.7 F	2291.8 F	2046.0 F
Reactor Mixed Temperature: 1723.7 F			

PRESSURE: 1013.0 psia

REACTOR INLET MOLAR FLOWRATE: 0.194 lb-moles/lb Coal

REACTOR RESIDENCE TIMES:

Based on Reactor Inlet Conditions:	1.85 seconds
Based on Reactor Outlet Conditions:	1.93 seconds
Based on Reactor Mixed Conditions:	2.33 seconds

ULTIMATE ANALYSES (%)

	Coal	Char	L/H Oils	Natural Gas
Moisture	0.450	0.000	0.000	0.000
Carbon	73.209	74.133	94.170	72.490
Hydrogen	5.316	0.852	5.460	23.610
Nitrogen	1.492	0.883	0.140	2.590
Sulfur	3.035	1.275	0.230	0.000
Chlorine	0.162	0.191	0.000	0.000
Oxygen	8.043	0.899	0.000	1.310
Ash	8.293	21.767	0.000	0.000

COAL HIGHER HEATING VALUE: 13399 Btu/lb

CHAR HIGHER HEATING VALUE: 11290 Btu/lb

NATURAL GAS HIGHER HEATING VALUE: 22695 Btu/lb

AFHP TEST DATA EVALUATION

TEST NUMBER R-11 - DATA POINT 4 Continued

EXIT MOLE PERCENTS

	Preburner	Steam Generator	Main Burner	Reactor
H2	66.118	66.324	61.390	44.380
H2O	16.993	23.603	28.536	25.190
H	0.009	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.255	0.152	0.152	3.270
CO	14.115	8.423	7.126	9.319
CO2	0.848	0.506	1.803	2.673
CH4	1.663	0.992	0.992	14.650
H2S	0.000	0.000	0.000	0.389
HCl	0.000	0.000	0.000	0.012
NH3	0.000	0.000	0.000	0.004
C2H6	0.000	0.000	0.000	0.019
Benzene	0.000	0.000	0.000	0.020
L/H Oils	0.000	0.000	0.000	0.073

EXIT MOLAR FLOWRATES (lb-moles/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	82.326	138.383	128.089	97.302
H2O	21.159	49.246	59.540	55.229
H	0.011	0.000	0.000	0.000
OH	0.000	0.000	0.000	0.000
N2	0.317	0.317	0.317	7.170
CO	17.575	17.575	14.869	20.431
CO2	1.055	1.055	3.762	5.860
CH4	2.070	2.070	2.070	32.120
H2S	0.000	0.000	0.000	0.853
HCl	0.000	0.000	0.000	0.027
NH3	0.000	0.000	0.000	0.009
C2H6	0.000	0.000	0.000	0.043
Benzene	0.000	0.000	0.000	0.044
L/H Oils	0.000	0.000	0.000	0.159
Total	124.514	208.646	208.646	219.247

EXIT MASS FLOWRATES (lbs/hr)

	Preburner	Steam Generator	Main Burner	Reactor
H2	165.97	278.98	258.23	196.16
H2O	381.18	887.18	1072.63	994.98
H	0.01	0.00	0.00	0.00
OH	0.00	0.00	0.00	0.00
N2	8.88	8.88	8.88	200.85
CO	492.29	492.29	416.48	572.28
CO2	46.45	46.45	165.56	257.90
CH4	33.21	33.21	33.21	515.31
H2S	0.00	0.00	0.00	29.09
HCl	0.00	0.00	0.00	0.99
NH3	0.00	0.00	0.00	0.15
C2H6	0.00	0.00	0.00	1.28
Benzene	0.00	0.00	0.00	3.42
L/H Oils	0.00	0.00	0.00	28.36
Char	0.00	0.00	0.00	409.95
Total	1128.00	1747.00	1955.00	3210.69

APPENDIX C
PUBLICATIONS RESULTING FROM AFHP PROGRAM

Following is a list of the technical publications that resulted from work performed on the Advancement of Flash Hydrogasification portion of DOE Contract DE-AC21-78ET10328.

1. Falk, A. Y., "Advancement of Flash Hydrogasification, Quarterly Technical Progress Report for January-March 1984," Report ET-10328-45, Rockwell International, Environmental & Energy Systems Division, Canoga Park, California (June 1984)
2. Falk, A. Y., "Advancement of Flash Hydrogasification, Quarterly Technical Progress Report for April-June 1984," Report ET-10328-46, Rockwell International, Rocketdyne Division, Canoga Park, California (August 1985)
3. Falk, A. Y., "Advancement of Flash Hydrogasification, Quarterly Technical Progress Report for July-September 1984," Report ET-10328-47, Rockwell International, Rocketdyne Division, Canoga Park, California (August 1985)
4. Falk, A. Y., "Advancement of Flash Hydrogasification, Quarterly Technical Progress Report for October-December 1984," Report ET-10328-48, Rockwell International, Rocketdyne Division, Canoga Park, California (August 1985)
5. Kahn, D. R., et al., "Advancement of Flash Hydrogasification," paper presented in "Proceedings of the Fifth Annual Gasification Projects Contractors Meeting," Report DOE/METC-85/6024, pp. 338-347 (June 1985)
6. Falk, A. Y., et al., "Topical Report, Advancement of Flash Hydrogasification, Task VIII - Performance Testing," ET-10328-49, Rockwell International, Rocketdyne Division, Canoga Park, California (June 1986)
7. Sprouse, K. M., "Topical Report, Modeling Bituminous Coal Devolatilization in the Electric Grid and Laminar Entrained Flow Research Reactors," Report ET-10328-50, Rockwell International, Rocketdyne Division, Canoga Park, California (April 1986)
8. Kahn, D. R., et al., "Final Technical Report, Advancement of Flash Hydrogasification," ET-10328-51, Rockwell International, Rocketdyne Division, Canoga Park, California (August 1986)