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PIPELINE GAS FROM COAL—HYDROGENATION (IGT HYDROGASIFICATION PROCESS)

Quarterly Report No. 10 for October 1—December 31, 1978

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January 1980
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Work Performed Under Contract No. EX-76-C-01-2434

Institute of Gas Technology
IIT Center
Chicago, Illinois

U. S. DEPARTMENT OF ENERGY

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PIPELINE GAS FROM COAL — HYDROGENATION (IGT HYDROGASIFICATION PROCESS)

Project 70101 Quarterly Report No. 10

For the Period October 1 Through December 31, 1978

Prepared by
Institute of Gas Technology
IIT Center, 3424 S. State Street
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Date Published — January 1980

Prepared for the

UNITED STATES DEPARTMENT OF ENERGY

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY

The objective of this project is to perform the necessary pilot plant operations and related support studies to acquire data for a commercial/demonstration plant design based on the HYGAS® Process. To this end, tests are being conducted with Illinois bituminous coal to obtain data for optimizing the process. This quarterly covers the work done between October 1 and December 31, 1978.

Pilot Plant Operations

Tests 75 and 76 were completed during this reporting period. Test 77 was still in progress at the end of December.

Test 75 marked the return to high-pressure (900-psig) operation following successful low-pressure (500-psig) operation of the HYGAS reactor during Tests 71 through 74. The reactor was lighted on September 29. Char feed to the reactor began on September 30, and operations became self-sustained that same day.

The initial operating conditions for Test 75 were designed to explore different steam distributions between the fluidizing ring and the steam-oxygen distributor. These conditions were achieved before a leak at the Grayloc flange leading to the steam-oxygen gas distributor forced the early termination of the test.

Test 76 was conducted in late October and early November. Its objectives were to operate at high pressure (900 psig) and commercial/demonstration plant design steam-to-char and oxygen-to-char ratios. Nitrogen gas was used to maintain a 1.2 ft/s superficial velocity in the steam-oxygen gasifier when steam feed was reduced. Reactor operation was self-sustained by 1235 hours on October 29. Steam distribution variations between the fluidizing ring and the steam-oxygen distributor were explored further to discover solids-mixing characteristics in the steam-oxygen gasifier (SOG). The conditions required for this exploration had all been attained by 2100 hours, November 8. The reactor was operating under the conditions desired for the remainder of the test by 1600 hours, November 10. Several steady-state periods were slected for detailed study, and preliminary data from these periods are presented in this report. By 0305 hours on November 16, it became impossible to isolate a pinhole leak that had occurred in the spent-char slurry line, and therefore

Test 76 was terminated. The plant was then inspected and prepared for operation with run-of-mine (ROM) coal. The study of operations with ROM coal was initiated under the directive of the U.S. Department of Energy/Gas Research Institute (DOE/GRI) Operating Committee and is in keeping with the overall HYGAS project objective of generating operating data with many different types of coal.

The objective of Test 77 is to test the gasification behavior of Peabody No. 10 Mine caking bituminous, ROM coal at a 500-psig operating pressure, steam feed rates of 500 lb/hr, and 85% char conversion. Test 77 was initiated at 1245 hours on December 11, and pretreated char feed to the reactor began on December 16. Reactor operation became self-sustained at 2200 hours the same day.

Initial pretreater operation with ROM coal was sluggish; solids flow from the pretreater to the char cooler was poor. The pretreater was inspected, and the problem was solved by experimentally determining that ROM coal has a higher complete fluidization velocity than the washed coal from the same mine that had been used in previous tests. Increasing the superficial velocity in the char cooler and reducing the operating temperature in the pretreater reactor vessel significantly improved pretreater operation.

Results from Tests 71 and 74 have been tabulated and are presented in the Appendix along with pretreatment data from Tests 71 and 72. The results from Tests 71 and 74, which were designed to duplicate each other, show that this goal was achieved. Both tests were voluntarily terminated after successful operations resulted in a clinker-free steam-oxygen reactor. Carbon and char conversions from 70% to 80% were achieved in both tests.

Data Transfer

Additional data were supplied to Procon, Inc., to aid in its design of a commercial/demonstration HYGAS plant. Work continued on the cold-flow model of the upper stage of the HYGAS reactor, details of which are given in this report.

DOE Review of the HYGAS Project

From December 18 through December 22, an official six-member DOE Gasification Project Review Team and private industrial consultants conducted an in-depth review of the HYGAS program. This review involved all aspects of

the HYGAS program including contractual, organizational, and management areas, as well as operations and operating data.

INTRODUCTION

This quarterly report covers work done between October 1 and December 31, 1978, under DOE Contract No. EF-77-C-01-2434.

Tasks 1 through 6, which concerned demonstrating the feasibility of using lignite, bituminous, and subbituminous coal feedstocks in the HYGAS pilot plant, were completed between July 1, 1976, and June 30, 1977, and are reported in Project 9000 Interim Report No. 1 (DOE Report No. FE-2434-23). Tasks 7 through 9 were completed between July 1, 1977, and September 30, 1978. This work is reported in Project 9000 Quarterly Reports Nos. 5 through 9 (DOE Report Nos. FE-2434-20, -25, -29, -33, and -37). Task 10 was a change order clause.

Tasks 11 through 13, which involve continued pilot plant operations with Illinois No. 6 Seam, Peabody No. 10 Mine washed and ROM bituminous coal, commercial/demonstration plant design support, and operational support studies, are discussed in this report.

Task 11. Pilot Plant Experimental Operation

Test 75

Test 75 was a return to high-pressure operation after successful low-pressure (500-psig) operation in Tests 71 through 74. The reactor was lighted on September 29 at 1200 hours. Char feed to the reactor began at 1615 hours on September 30, and reactor operation became self-sustained at 2310 hours the same day. Two initial sets of conditions (6300 pounds of steam to the steam-oxygen distributor and 2700 pounds of steam to the fluidizing ring; 5800 pounds of steam to the steam-oxygen distributor and 3200 pounds of steam to the fluidizing ring) were achieved during Test 75 before a leak at the Grayloc flange leading to the steam-oxygen gas distributor forced an early termination of the test.

The coal mill was in operation during Test 75. On October 4, properly sized coal was dumped as fines through a torn screen on the SWECO fines screener. This additional load to the fines-handling system overloaded the screw conveyor system.

The weighbelt system measuring coal feed to the pretreater was routinely calibrated during Test 75. Pretreater operation began at 1500 hours, September 30. Early in the test, temperature excursions of over 900°F were indicated by a thermocouple close to the grid in the pretreater. This however, did not hinder the operation of the pretreater, and pretreated char was reliably delivered to the reactor slurry preparation area. Char feed to the reactor was interrupted during Test 75. On October 3, a leak developed in the low-pressure slurry piping system, and slurry flow had to be stopped to repair the leak. On October 5 at 0330 hours, a high slurry concentration plugged the high-pressure slurry pump, resulting in a loss of feed to the reactor; the slurry preparation section performed very well during this test.

Two steady-state periods were chosen from Test 75 for detailed analysis. Preliminary results are summarized in Table 1. Figure 1 is an overview plot of important variables in Test 75. During these periods, the reactor operated smoothly with no interruptions in char feed or in oxygen and steam flows. Solids flow throughout the reactor was smooth. Bed heights, bed densities, and temperatures were constant. Product gas analyses were constant, and the

Table 1. PRELIMINARY RESULTS FOR TEST 75
(Note: These Results Are Preliminary and Must Be Confirmed by Additional Studies.)

Steady-State Periods, date (hour)	10/2/78 (1200)-10/3/78 (0100)	10/3/78 (2200)-10/4/78 (0430)
Hours	13	6.5
% Char Conversion	72	91
Range	60-79	91
Char Feed, lb/hr	4295	4218
Net Char Feed,[a] lb/hr	3595	3518
Oxygen to Sparger, lb/hr	1006	960
Oxygen Net Char, lb/lb	0.29	0.29
Steam to Sparger, lb/hr	6312	5775
Steam to Fluidizing Ring, lb/hr	2663	3224
Total Steam/Net Char, lb/lb	2.63	2.69
Highest Average Steam-Oxygen Gasification Temperature, °F	1682	1689
Operating Pressure, psig	924	923
SOG Superficial Velocity,[b] ft/s	1.15	1.15
Total Product Gas		
pph	6109	5861
mol/hr	267	251
Product Gas Components, mol %		
H_2	31.53	31.52
H_2S	1.38	1.17
C_2H_6	0.02	0.31
CO_2	32.65	34.48
N_2	4.92	4.93
CH_4	18.34	17.26
CO	11.16	10.33
Superficial Velocity,[c] V_s, 2-ft diameter at distributor, ft/s	0.21	0.26
Jet Velocity,[d] ft/s	86.9	81.4
Jet Penetration,[d] in.	46.6	43.3
No. of Nozzles	6	6
Nozzle Diameter, in.	0.742	0.742
HTR[e] Bed Density, lb/ft^3	15	14
HTR Bed Height, ft	13	13
SOG Bed Density, lb/ft^3	12	11
SOG Bed Height, ft	16	17

[a] Net char feed rate = char feed − reactor overhead.

[b] Calculated at maximum steam-oxygen gasifier (SOG) gasification temperature.

[c] Calculated using the temperature of superheated steam.

[d] Calculated using the mixed temperatures of superheated steam and oxygen.

[e] High-temperature reactor.

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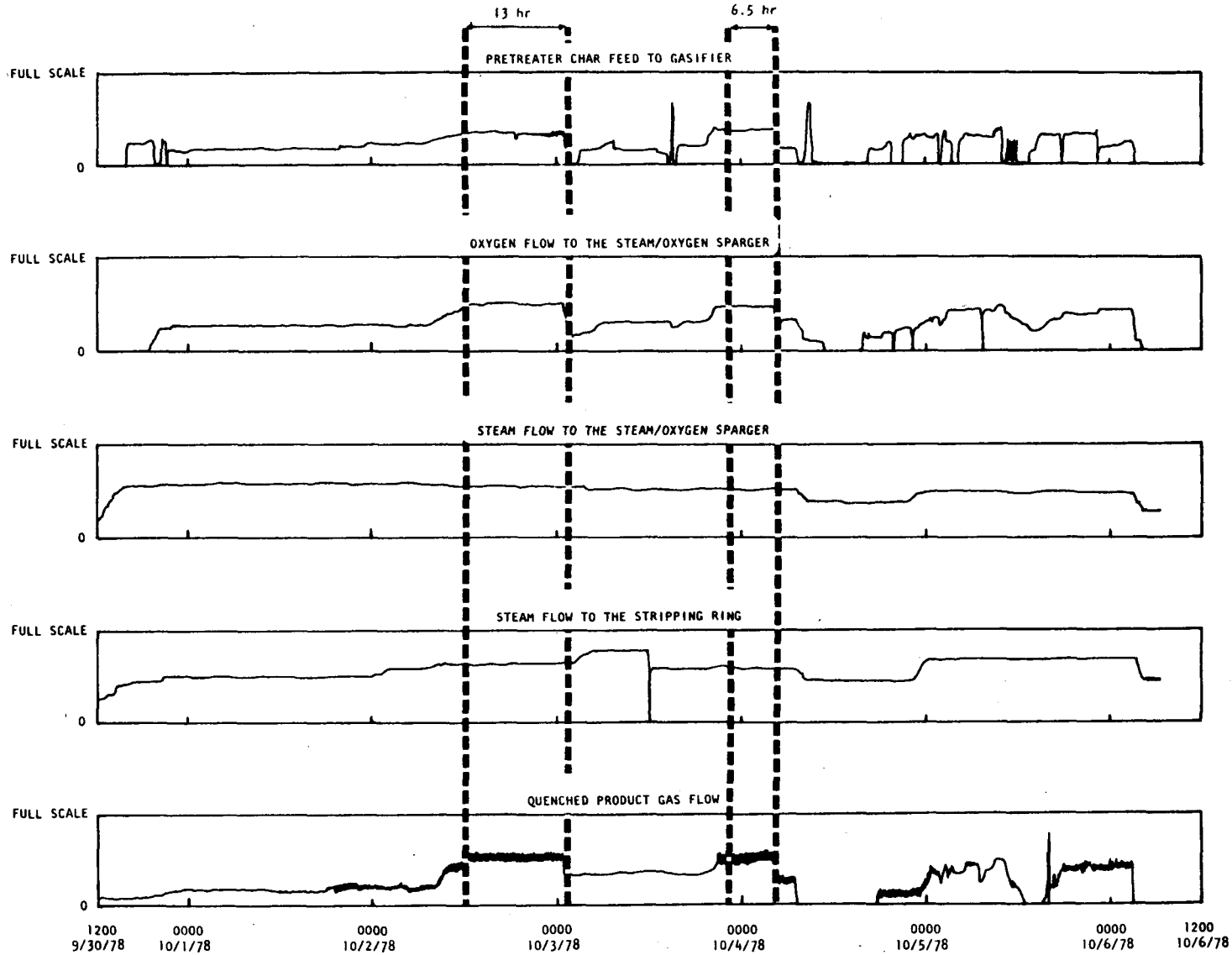

(Dashed lines indicate endpoints of steady-state operation.)

Figure 1. OVERVIEW OF TEST 75

product gas flow rate was steady. Test 75 was terminated after 124 hours of self-sustained operation because of an external leak at a Grayloc flange on the steam-oxygen line leading to the steam-oxygen gasifier distributor.

Downstream of the reactor, some level control problems occurred in the quench separator causing difficulties in oil-water separation. The purification system was put on-line at 0700 hours on October 2, and it operated well throughout the test. Foaming in the absorber tower was easily controlled by the addition of antifoam agents. The IGT fixed-bed methanation system was not put on-line during Test 75 because structural damage to the vessel and equipment, resulting from the June 22 fire in the liquid-phase methanation unit, was still being assessed. The oil-recovery unit and the solids cleanup section operated satisfactorily during the test. Operation of the low-pressure boiler was momentarily interrupted at 0725 hours on October 5 because of electrical malfunctions. The rest of the utilities performed well during the test.

The plant was inspected after Test 75. The coal mill was in good condition. Two of the screens in the SWECO fines screeners were replaced when an inspection revealed that they had holes. The pretreater was opened and inspected. A layer of coal tar, approximately 1-inch thick, had built up on the pretreater wall. A clinker was found at the base of the south side of the pretreater wall. This formation measured slightly more than 4 feet along the base of the wall, extending 1 foot out on the floor of the pretreater and tapering up along the wall to a height of about 1-1/2 feet. Many of the cap-and-guide rod assemblies were dislodged from their nozzles. An analysis indicated that condensation occurred at the start of pretreater operation and caused a high pressure differential across the grid and poor fluidization in the unit, resulting in clinker formations. Then the pretreater internal cooling coil bundles were pressure-tested. The northwest coil leaked and was removed and replaced. The pretreater venturi scrubber and quench tower had normal solids accumulations. The high-pressure slurry pumps were in good condition following Test 75.

The reactor was completely clean except for a 3-inch-diameter clinker found extending 12 inches up along the wall from its base at the coupling of the steam-oxygen gas distributor in the steam-oxygen gasifier. The clinker, which had been caused by an oxygen leak at the distributor coupling, extended

12 inches out along the main arm of the pipe distributor. Two nozzles on the distributor had loose coal in them. The refractory around the base of the line 340 spent-char standpipe was pitted. The quench section and the oil-recovery section were both clean after Test 75.

The torn SWECO screens were replaced in preparation for Test 76. The weigh table and the amplifier circuit card for the weighbelt systems measuring raw coal feed to the pretreater and pretreated char feed to the gasifier were replaced. The pretreater section was cleaned. The Grayloc flange at the base of the steam-oxygen gasifier had leaked during Test 75 and was inlaid and machined by Grayloc's technicians. The leaky wall-coupling of the steam-oxygen pipe distributor was rethreaded. The cyclone dipleg was cleaned, and one of the Grayloc flanges at the cyclone slurry pot was inlaid and machined. The rest of the Grayloc flanges on the reactor and quench systems were also inspected by Grayloc's technicians. The Grayloc flange on the oil lines from the prequench tower to the quench separator was repaired. Routine maintenance was performed on the rest of the plant, and all equipment was readied for the next test.

Test 76

Test 76 was designed to operate at high pressure (900 psig) and commercial/demonstration plant design steam-to-char and oxygen-to-char ratios. Superheated nitrogen was used to achieve a superficial velocity of 1.2 ft/s in the steam-oxygen gasifier. Initial pretest conditions (Table 2) were chosen to explore varied steam distributions between the fluidizing ring and the steam-oxygen distributor.

Table 2. TEST 76 PRETEST CONDITIONS

	Phase I		Phase II		
	Period 1	Period 2	Period 1	Period 2	Period 3
	lb/hr				
Steam to Distributor	5312	4874	5427	4783	4466
Nitrogen to Distributor	0	0	872	1365	1993
Steam to Fluidizing Ring	3674	4200	2815	2609	2405
Nitrogen to Fluidizing Ring	0	0	452	745	1074

Reactor light-off occurred on October 26, and oil circulation to the reactor was initiated at 2300 hours on October 28. Reactor pressure was reduced to fix a leak in the quench separator level float assembly. Reactor operations were self-sustained by 1235 hours on October 29. Solids flow through the reactor was sluggish in the early part of the test, but later became smooth. By November 1, the conditions set for Phase I, Periods 1 and 2, had been achieved (Table 2). Preliminary results from these two test periods are included in Table 3.

Smooth solids flow the the reactor was hampered by the coal mill wet-scrubber level control in the coal preparation section. By the morning of November 6, the conditions for Phase II, Periods 1 through 3, had been achieved (Tables 1 and 2). Nitrogen was added to maintain the superficial velocity, while steam feed to the steam-oxygen gasifier was reduced. Following a low-pressure boiler shutdown on November 6, the pilot plant city water supply was accidentally cut off by a city serviceman. The problem was quickly rectified, and char feed to the reactor was resumed within 30 minutes. At 1100 hours on November 7, leaks were found in the valve at the base of the feed slurry mix tank and the reactor pressure was reduced so that valve repairs could be made. The conditions desired for Test 76 were achieved at 1600 hours on November 10. Initial solids flow through the reactor was erratic, however, solids transfer problems were cleared up and the reactor operated smoothly. Several steady-state periods were achieved (Table 4). At 0305 hours on November 16, a pinhole leak was discovered in the spent-char slurry line immediately downstream from the flange at the spent-char slurry mix tank. This leak could not be isolated and, therefore, the test was terminated. Char conversions of over 80% were achieved at 1728°F in the steam-oxygen gasifier for a 22-hour period near the end of Test 76. Preliminary results from Test 76 are presented in Table 4. Figure 2 is an overview plot of important reactor variables during Test 76.

Pretreater operations for Test 76 began at 1356 hours on October 28. Operation of the pretreater was not smooth in the beginning of the test because of mechanical problems in the coal crushing and coal feeding sections. Plugging occurred in the 60-ton hopper rotary feeder, the fines screw feeder, and the discharge to the bucket elevator. Other problem areas included a torn screen in the SWECO fines screener, lockhopper high-level alarms, calibration of the weighbelts, a leaking duct to the coal mill furnace, and coal

Table 3. PRELIMINARY PRETEST RESULTS FOR TEST 76 (Note: These Results Are Preliminary and Must Be Confirmed by Additional Studies.)

	Phase I		Phase II		
	Period 1	Period 2	Period 1	Period 2	Period 3
Steady-State Periods, date (hr)	10/31/78 (0900)- 10/31/78 (2000)	11/1/78 (0700)- 11/1/78 (1400)	11/2/78 (0900)- 11/2/78 (1800)	11/5/78 (0600)- 11/5/78 (1900)	11/5/78 (2100)- 11/6/78 (0500)
Hours	11	7	9	13	8
Char Conversion					
% Conversion	87	87	92	63	53
Range	80-93	--	88-94	53-73	44-60
Char Feed, lb/hr	4008	3898	3792	4181	4467
Net Char Feed,[a] lb/hr	3308	3198	3092	3481	3767
O_2 to Distributor, lb/hr	991	992	994	901	896
O_2/Net Char, lb/lb	0.30	0.31	0.32	0.26	0.24
Steam to Distributor, lb/hr	5312	4874	5427	4783	4466
N_2 to Distributor, lb/hr	0	0	872	1365	1993
Steam to Fluidizing Ring, lb/hr	3674	4200	2815	2609	2405
N_2 to Fluidizing Ring, lb/hr	0	0	452	745	1074
Total Steam/Net Char, lb/lb	2.72	2.84	2.67	2.12	1.82
Highest Average SOG[b] Temperature, °F	1686	1682	1668	1683	1685
Operating Pressure, psig	920	924	930	928	933
SOG Superficial Velocity,[c] ft/s	1.15	1.16	1.13	1.10	1.10
Total Product Gas					
pph	6339	5777	6473	7367	8452
mol/hr	263.9	247.8	258.6	298.2	338.5
Composition, mol %					
H_2	30.63	31.38	24.89	22.61	20.47
H_2S	0.64	0.75	0.72	0.00	0.00
C_2H_6	0.39	0.38	0.22	0.02	0.09
CO_2	36.04	34.57	30.56	24.30	21.86
N_2	5.50	5.29	22.41	31.88	37.07
CH_4	16.92	17.59	13.64	13.44	12.67
CO	9.88	10.04	7.56	7.75	7.84
Superficial Velocity at Distributor,[d] ft/s	0.29	0.33	0.22	0.23	0.23
Jet Velocity,[e] ft/s	75.0	68.5	76.6	77.1	77.9
Jet Penetration,[e] in.	40.2	37.1	43.6	43.0	44.2
Number of Distributor Nozzles	6	6	6	6	6
Nozzle Inside Diameter, in.	0.742	0.742	0.742	0.742	0.742
HTR[f] Bed Density, lb/ft^3	11.5	11.5	11.8	12.3	13.7
HTR Bed Height, ft	13.7	12.6	13.3	13.0	12.1
SOG Bed Density, lb/ft^3	9.3	9.3	8.4	9.8	10.4
SOG Bed Height, ft	15.6	15.6	19.6	12.9	13.8

[a] Net char feed = char feed - overhead solids.

[b] SOG = steam-oxygen gasifier.

[c] Calculated at maximum average SOG temperature.

[d] Calculated using superheated steam temperature.

[e] Calculated using superheated steam and oxygen mixed temperature.

[f] HTR = high-temperature reactor.

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Table 4. PRELIMINARY RESULTS FOR TEST 76
(Note: These Results Are Preliminary and Must Be Confirmed by Additional Studies.)

Steady-State Periods, date (hr)	11/10/78 (1600)-11/11/78 (0400)	11/13/78 (0000)-11/14/18 (0400)	11/14/78 (1800)-11/15/78 (1600)
Hours	12	28	22
Char Conversion			
% Conversion	69	76	84
Range	60-83	57-91	68-91
Char Feed, lb/hr	4335	4605	2765
Net Char Feed,[a] lb/hr	3635	3905	2065
O_2 to Distributor, lb/hr	959	991	1008
O_2/Net Char, lb/lb	0.26	0.25	0.49
Steam to Distributor, lb/hr	4076	4033	4096
N_2 to Distributor, lb/hr	2635	2663	2648
Steam to Fluidizing Ring, lb/hr	2207	2174	2202
N_2 to Fluidizing Ring, lb/hr	1426	1436	1423
Total Steam/Net Char, lb/lb	1.73	1.59	3.05
Highest Average SOG[b] Temperature, °F	1715	1719	1728
Operating Pressure, psig	953	936	916
SOG Superficial Velocity,[c] ft/s	1.10	1.12	1.17
Total Product Gas			
pph	9513	9949	10,280
mol/hr	373	378	400
Composition, mol %			
H_2	18.38	17.18	18.27
H_2S	1.08	0.77	0.66
C_2H_6	0.23	0.26	0.26
CO_2	21.35	23.96	23.31
N_2	39.76	39.13	38.89
CH_4	11.31	11.72	11.07
CO	7.88	6.97	7.54
Superficial Velocity at Distributor,[d] ft/s	0.22	0.22	0.24
Jet Velocity,[e] ft/s	73.5	75.0	79.3
Jet Penetration,[e] in.	43.7	44.3	46.0
Number of Distributor Nozzles	6	6	6
Nozzle Inside Diameter, in.	0.742	0.742	0.742
HTR[f] Bed Density, lb/ft^3	11.2	N/A[g]	N/A
HTR Bed Height, ft	14.3	N/A	N/A
SOG Bed Density, lb/ft^3	8.9	10.1	10.3
SOG Bed Height, ft	16.2	19.5	19.5

[a] Net char feed = char feed − overhead solids.

[b] SOG = steam-oxygen gasifier.

[c] Calculated at maximum average SOG temperature.

[d] Calculated using superheated steam temperature.

[e] Calculated using superheated steam and oxygen mixed temperature.

[f] HTR = high-temperature reactor.

[g] N/A = not available.

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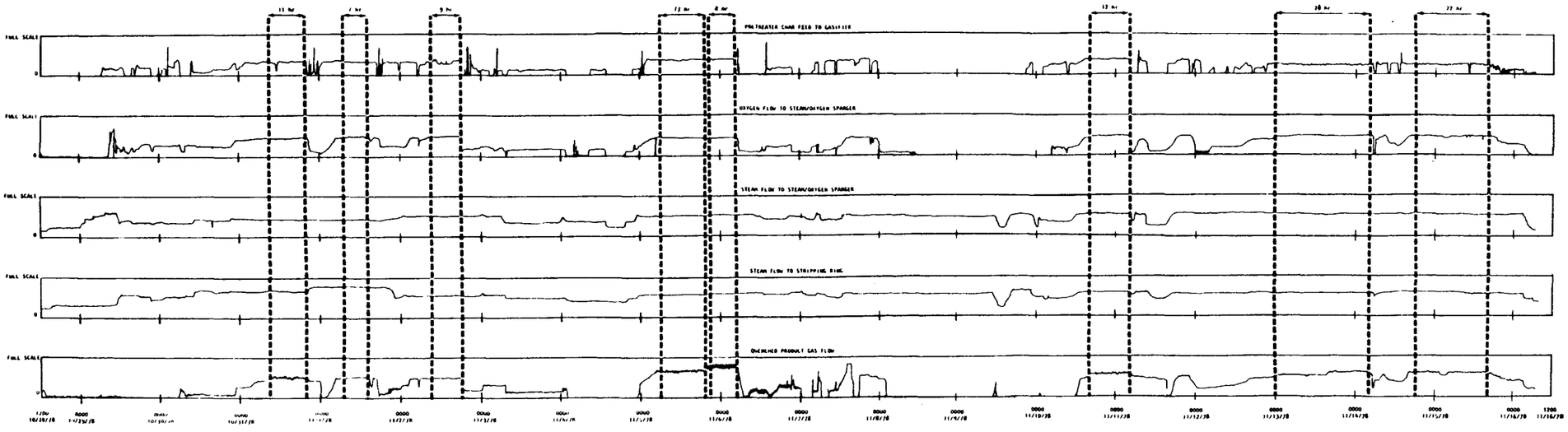

Note: Dashed lines indicate end points of steady-state operation.

Figure 2. OVERVIEW OF TEST 76

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mill wet-scrubber level control. These difficulties were overcome, and pretreated char was supplied to the reactor satisfactorily.

The slurry preparation section operated during Test 76 with a steady feed during most of the test. On November 2, the slurry mix tank level control malfunctioned and the slurry level rose, resulting in poor mixing and a plugged slurry piping system. On November 4, a leak in the low-pressure slurry loop forced the reactor to be placed on standby while the leak was repaired. This interrupted char feed to the reactor for 8 hours. On November 8, a leak in the valve at the bottom of the slurry mix tank forced the reactor to be put on standby again while the section was cleaned and the leak was repaired. Some initial difficulties with the quench separator level float occurred in the quench section downstream of the reactor. The level float was replaced while the reactor pressure was down for the repair of a leaking valve at the base of the feed slurry mix tank. The purification section operated satisfactorily during the test. In the effluent cleanup section, some difficulties were encountered with the Edens separator and the light-oil recovery system. Several shear pins on the Edens separator broke because of misalignment, and later in the test, a chain broke in the top skimmer. On November 7, the light-oil recovery unit developed a plug in the overhead line from the stripper to the separator. Toward the end of the test, a leak was found in the stripper tower and the unit was emptied and prepared for repairs. Despite these interruptions, the effluent cleanup section recovered oil and solids during the test.

During Test 76, the utilities generally operated well. On November 6, a short in the forced draft fan low-air shutdown switch shut down the low-pressure boiler. Electrical power was switched from the pilot plant turbine to Commonwealth Edison, and all the equipment in the coal preparation and pretreatment sections automatically shut down during the switchover. The problem was discovered, and the boiler was put back in operation after minimal delay. While the boiler was down, the steam-iron facility's boiler supplied steam to maintain the steam-tracing lines in the HYGAS pilot plant. The hydrogen plant was operated during the test start-up.

The IGT fixed-bed methanator was not activated during this test. The vessel walls were ultrasonically tested to determine possible erosion. Foundations for two of the effluent air cooler supports that had been damaged

during the fire were poured, and forms were constructed for the two other supports.

The coal preparation section was cleaned after Test 76. A hole in the coal mill cyclone was repaired. The secondary coal mill fan shroud had eroded and was repaired. Both primary and secondary fans were balanced before starting Test 77. Two torn SWECO fines screens were replaced, and the weighbelt was calibrated and inspected. The pretreater reactor had a small sintered coal formation on the grid. It was located along the side of the southwest wall about 8 inches high at the wall and extending out about 10 inches toward the center of the grid. The char transfer line from the pretreater to the char cooler was clear, and the cyclone diplegs and the equalizing line were clean. The char cooler was in good condition. In the pretreater quench section, the venturi scrubber had a normal buildup of tars. The quench tower gas outlet blind flange leaked and was temporarily patched during the test. New gaskets were installed in the flange before Test 77. Maintenance work is being performed on the char weighbelt because the weigh table is not level. The slurry preparation section was cleaned after Test 76. An inspection of the high-pressure char slurry feed pumps revealed that pump 3.08-05 was in good condition; whereas, two of the three discharge valve seats in pump 3.08-06 were broken. Routine maintenance is being performed on this section in preparation for tests with Peabody No. 10 Mine ROM coal.

The reactor was in good condition following Test 76; all sections were clear. There were some refractory chunks on the high-temperature reactor grid, and four of the grid nozzles were plugged with refractory material. A small, soft clinker formation was lying on the steam-oxygen sparger inlet pipe. This clinker originated at the coupling between the inner pipe and the sparger itself, where steam and oxygen leaked from the coupling threads below the normal steam-oxygen injection point. The clinker rose 16 inches up the reactor wall from the sparger coupling and was 3 inches wide at its base; a second fingerlike outgrowth rose 12 inches from the base on the interior side of the formation and measured 1-1/2 inches in diameter. The cyclone, its diplegs, and the solids slurry pot were in good condition. The cyclone was sent to Argonne National Laboratory for erosion inspection. The spent-char slurry tank was cleaned, and the leaking outlet piping that caused the termination of Test 76 was modified. The leak was an eroded hole at a point of

high turbulence. A block valve will be installed immediately adjacent to the outlet nozzle to eliminate any further possibility of run terminations caused by erosion in any portion of the spent-char slurry discharge piping.

Solids had accumulated in various quench system vessels, but did not pose any operating difficulties. Some Grayloc flanges in this section needed sealing surface service. In the purification section, the diglycolamine filter cartridge was replaced because a large amount of solids had accumulated in the unit. The oil stripping tower and separator were cleaned after Test 76. The leak that occurred on the stripping tower during the test was located adjacent to the water spray nozzle and is suspected to have been caused by water directly impinging on the wall. A belly-band patch was applied to the vessel to temporarily enable the system to continue operating through the end of the test. The eroded portion of the stripper vessel will be removed and replaced with a 1/2-inch-thick double-wall patch plate.

Test 77

In keeping with the directives of the DOE/GRI Operating Committee and with overall HYGAS project objectives, the pilot plant was prepared for operation with caking Illinois No. 6, ROM coal from the Peabody No. 10 Mine. The following is a typical analysis of ROM coal compared with washed coal:

Coal Feed	ROM	Washed
Proximate Analysis		
Moisture	2.6	3.2
Volatile Matter	35.4	39.9
Ash	16.8	9.6
Fixed Carbon	45.2	47.3
Total	100.0	100.0
Ultimate Analysis		
Ash	17.22	9.85
Carbon (Total)	61.9	69.09
Hydrogen	4.27	5.02
Sulfur	5.40	4.46
Nitrogen	1.02	1.30
Oxygen (Difference)	10.19	10.28
Total	100.00	100.00
Bulk Density, lb/ft^3	47.8	44.63

Once the reactor cyclone was returned from Argonne National Laboratory, the HYGAS reactor was cleaned and secured. Reactor light-off for Test 77 occurred at 1530 hours on December 8. The reactor was pressure-tested during

heat-up. On December 10 an instrument problem extinguished the start-up burner, and the reactor was depressurized to correct the difficulty. On December 11 at 1245 hours, the reactor was relighted and the pressure was brought up to 500 psig. Pretreated char feed was started on December 16, and the reactor became self-sustained at 2200 hours the same day.

Coal mill maintenance and repairs were completed during the early part of December. The primary and secondary fans were balanced, and the coal preparation section was put in operation. Freezing coal caused feeding problems in the coal mill feedhopper. These problems were temporarily solved by clearing the hoppers manually. On December 22, the coal mill was shut down when a hole developed in the lift-line. The hole was patched, and the coal mill was again operational. On December 25, cracks were found in the base of the secondary fan of the coal mill system and it was repaired. To prevent further problems with freezing coal in the feed hoppers, air heaters were installed to blow hot air into the system. This approach has allowed smoother operation at the mill.

Two of the internal cooling coils in the pretreater reactor were replaced prior to Test 77, and the pretreater was secured. Coal feed to the pretreater started at 1730 hours on December 14. Initial operation of the pretreater was sluggish; solids flow from the pretreater to the char cooler was poor. This section was shut down, opened, and cleared of all wet coal. The problem was traced to the higher fluidization velocity required by ROM coal, which has a higher bulk density than washed coal. The char cooler temperature gradient was then observed while the superficial velocity was varied to determine a superficial velocity which would yield good solids mixing. Increasing the superficial velocity in the char cooler and lowering the operating temperature in the pretreater reactor vessel significantly improved pretreater operation.

The quench, purification, and effluent cleanup sections and the utilities all operated satisfactorily. The hydrogen plant was put on standby, and the methanation section was not operated.

Test 77 was still in progress at the close of this reporting period.

Test Results

Final results from Tests 71 and 74 with washed Illinois No. 6 coal at 500-psig have been tabulated; the pretreatment data from Test 72 have also been completed. These data are presented in the Appendix. Figure A-62 is an overview of important operating variables during Test 74.

Tests 71 and 74 were designed to run under similar conditions, and the results show that they do indeed duplicate each other. Both tests were terminated voluntarily after successful operation, which left the steam-oxygen reactor absolutely clinker-free. Carbon and char conversions of approximately 80% were achieved in both tests.

Task 12. Demonstration Plant Support

One of the major activities under this task has been the transfer of data to Procon, Inc., for its design of a HYGAS demonstration plant. During the reporting period, the following data were supplied:

a. Material balance for washed coal

b. Documentation of slurry drying bed fines carry-over

c. A model of the 500-psi gasifier at different feed rates and bed heights

d. A cold-flow model.

Material Balance for Washed Coal

A revised material balance for the washed coal case was supplied to Procon. The computer printouts (Tables 5 and 6) are included for washed and ROM coal at the commercial design basis of a steam/carbon ratio of 1.0 and temperatures in the steam-oxygen gasifier and high-temperature reactor of 1850° and 1725°F, respectively.

The gasifier designed for washed coal operates slightly more efficiently than that designed for ROM coal, giving a higher direct methane yield and a higher total equivalent methane yield produced from the same number of moles of carbon in the feed. With ROM coal, a slightly longer residence time is required in the high-temperature reactor than in the steam-oxygen gasifier. The time, however, must be considered relative to the total mass of material in each bed. Because of its reduced ash content, washed coal requires a smaller gasifier: The steam-oxygen gasifier has a 12.5-foot diameter and is 37.2 feet high. The bed diameter is similar for ROM coal, although it is 42.9 feet high. Thus, the washed coal can operate in the gasifier designed

Table 5. MATERIAL BALANCE FOR COMMERCIAL DESIGN USING UNWASHED ILLINOIS BITUMINOUS COAL

INPUT ! FSVU= =0.9000 FCOS =0.0400 FN2 =0.1500 FHCN =0.0714

TYPE OF COAL = COMMENCIAL DESIGN USING ILLINOIS BITUMINOUS COAL (UNWASHED)

LOW TEMPERATURE REACTOR

SOLIDS FLOW RATE,MOLE/HR	FEED	CHAR PRODUCT	OIL PRODUCT	GAS FLOW RATE,MOLE/HR	FEED	PRODUCT
C	52.4813	41.0996	4.1905	CO	13.7623	12.6020
H(2)	21.5278	2.8439	2.3931	CO(2)	14.3993	16.8713
U	4.3750	0.0000	0.0000	H(2)	14.9699	17.7542
N(2)	0.4212	0.0842	0.0000	H(2)O	24.0408	24.5919
S	1.0667	0.1897	0.0000	CH(4)	7.6899	12.9491
ASH*	210.3000	210.3000	0.0000	C(2)H(6)	0.0000	0.2624
				C(6)H(6)	0.0000	0.0000
TEMPERATURE, DEGREE F	600.	1419.	1419.	NH(3)	0.0000	0.5247
				H(2)S	0.0830	0.9217
				N(2)	0.0000	0.0505
				TEMPERATURE, DEGREE F	1725.	1419.

ADDITIONAL PRODUCT GAS ! COS =0.0386 HCN =0.0481 ALSO BENZENE = 0.01393 TOLUENE = 0.58779 (MOLES)

HIGH TEMPERATURE REACTOR

SOLIDS FLOW RATE,MOLE/HR	FEED	PRODUCT	GAS FLOW RATE,MOLE/HR	FEED 1	FEED 2	PRODUCT
C	41.0996	31.1106	CO	11.4847	0.0000	13.7623
H(2)	2.8439	2.1527	CO(2)	11.7205	0.0000	14.3993
U	0.0006	0.0000	H(2)	16.7087	0.0000	14.9699
N(2)	0.0842	0.0842	H(2)O	31.6760	0.0000	24.0408
S	0.1897	0.1897	CH(4)	2.6573	0.0000	7.6899
ASH*	210.3000	210.3000	H(2)S	0.0830	0.0000	0.0830
			N(2)	0.0000	0.0000	0.0000
TEMPERATURE, DEGREE F	1419.	1725.	TEMPERATURE, DEGREE F	1850.	0.	1725.

SOLIDS RESIDENCE TIME = 41.1345 MINUTES (47.2603 MINUTES)

OXYGEN GASIFIER

SOLIDS FLOW RATE,MOLE/HR	FEED	PRODUCT	GAS FLOW RATE,MOLE/HR	FEED 1	FEED 2	PRODUCT
C	31.1106	5.2481	CO	0.0000	0.0000	11.4847
H(2)	2.1527	0.8317	CO(2)	0.0000	0.0000	11.7205
U	0.0000	0.0000	H(2)	0.0000	0.0000	16.7087
N(2)	0.0842	0.0842	H(2)O	0.0000	52.4813	31.6760
S	0.1897	0.1067	CH(4)	0.0000	0.0000	2.6573
ASH*	210.3000	210.3000	O(2)	7.0602	0.0000	0.0000
			H(2)S	0.0000	0.0000	0.0830
			N(2)	0.0000	0.0000	0.0000
TEMPERATURE, DEGREE F	1725.	1850.	TEMPERATURE, DEGREE F	370.	1000.	1850.

SOLIDS RESIDENCE TIME = 14.7251 MINUTES (26.0568 MINUTES)

* FLOW RATE OF ASH IS IN LBS/HR

Table 6. MATERIAL BALANCE FOR COMMERCIAL DESIGN USING WASHED ILLINOIS BITUMINOUS COAL

INPUT : FSVOL =0.9000 FCOS =0.0400 FN2 =0.1500 FHCN =0.0714

TYPE OF COAL = COMMERCIAL DESIGN USING ILLINOIS BITUMINOUS COAL (WASHED) OCT. 13.78

LOW TEMPERATURE REACTOR

SOLIDS FLOW RATE,MOLE/HR	FEED	CHAR PRODUCT	OIL PRODUCT	GAS FLOW RATE,MOLE/HR	FEED	PRODUCT
C	52.4813	41.8954	4.1985	CO	13.7809	12.6817
H(2)	21.4413	2.8436	2.3931	CO(2)	14.3308	16.7493
O	4.3581	0.0000	0.0000	H(2)	14.9883	17.9321
N(2)	0.3243	0.0271	0.0000	H(2)O	23.9235	24.5055
S	0.8428	0.1662	0.0000	CH(4)	7.7441	13.0076
ASH*	102.9476	102.9476	0.0000	C(2)H(6)	0.0000	0.2624
				C(6)H(6)	0.0000	0.0012
TEMPERATURE, DEGREE F	600.	1439.	1439.	NH(3)	0.0000	0.4629
				H(2)S	0.0820	0.7275
				N(2)	0.0000	0.0446
				TEMPERATURE, DEGREE F	1725.	1439.

ADDITIONAL PRODUCT GAS : COS =0.0303 HCN =0.0424 ALSO BENZENE = 0.01309 TOLUENE = 0.58779 (MOLES)

HIGH TEMPERATURE REACTOR

SOLIDS FLOW RATE,MOLE/HR	FEED	PRODUCT	GAS FLOW RATE,MOLE/HR	FEED 1	FEED 2	PRODUCT
C	41.8954	30.6088	CO	11.1409	0.0000	13.7809
H(2)	2.8436	2.1180	CO(2)	11.6255	0.0000	14.3308
O	0.0000	0.0000	H(2)	16.4948	0.0000	14.9883
N(2)	0.0271	0.0271	H(2)O	31.9741	0.0000	23.9235
S	0.1662	0.1662	CH(4)	2.6028	0.0000	7.7441
ASH*	102.9476	102.9476	H(2)S	0.0820	0.0000	0.0820
			N(2)	0.0000	0.0000	0.0000
TEMPERATURE, DEGREE F	1439.	1725.	TEMPERATURE, DEGREE F	1850.	0.	1725.

SOLIDS RESIDENCE TIME = 45.4361 MINUTES (52.7311 MINUTES)

OXYGEN GASIFIER

SOLIDS FLOW RATE,MOLE/HR	FEED	PRODUCT	GAS FLOW RATE,MOLE/HR	FEED 1	FEED 2	PRODUCT
C	30.6888	5.2396	CO	0.0000	0.0000	11.1409
H(2)	2.1180	0.8429	CO(2)	0.0000	0.0000	11.6255
O	0.0000	0.0000	H(2)	0.0000	0.0000	16.4948
N(2)	0.0271	0.0271	H(2)O	0.0000	52.4813	31.9741
S	0.1662	0.8842	CH(4)	0.0000	0.0000	2.6028
ASH*	102.9476	102.9476	O(2)	6.9424	0.0000	0.0000
			H(2)S	0.0000	0.0000	0.0820
			N(2)	0.0000	0.0000	0.0000
TEMPERATURE, DEGREE F	1725.	1850.	TEMPERATURE, DEGREE F	370.	1000.	1850.

SOLIDS RESIDENCE TIME = 14.0952 MINUTES (24.0580 MINUTES)

* FLOW RATE OF ASH IS IN LBS/HR

for ROM coal but at slightly lower temperatures and improved conversions. The reverse case is not true without lower conversions or higher temperatures than desirable.

In a preliminary economic analysis, the washed coal required reduced steam, oxygen, and gasifier costs relative to ROM coal. The crux of the question is the cost of the coal. Comparing ROM with washed coal, it costs the same to mine a ton of rock, irrespective of its Btu value. The real cost of washed coal, therefore, is a function of the number of Btu's that are lost in the washing process. Even a 10% Btu loss tips the overall cost balance in favor of ROM coal. Btu losses in excess of 20% can be expected. This superficial analysis (much less detailed than Procon will prepare) indicated that ROM coal is probably the preferred alternative for commercial design.

Documentation of Slurry Drying Bed Fines Carry-Over

During this reporting period, it was formally documented that the fines carry-over from the slurry drying bed is 50% of the total amount of fines fed to the reactor.

The composition of the fines from the bottom of the cyclone in the HYGAS pilot plant closely approximates the composition of solids in the slurry drying bed. Therefore, elutriation is assumed to be a function of the size consist of the feed. According to published literature, the amount of elutriation should be directly proportional to the actual superficial gas velocity through the bed; however, the amount of elutriation is greater and is a stronger function of the velocity at elevated pressures.

Figure 3 presents the elutriation losses during steady-state periods of Tests 54, 61, 64, and 66 (all high-pressure tests) as a function of actual superficial velocity in the slurry drying bed in the pilot plant. Elutriation is expressed as a fraction of the −100 mesh material in the feed. Generally, a line that represents a conservative interpretation of the data passes through the point where 50% of the −100 mesh material is elutriated at a superficial gas velocity of 0.4 ft/s. A few data points show slightly greater elutriation, but more show significantly less, considering that the design basis for the quantity of fines present in the gasifier feed is conservative. The projected design point appears to be reasonable for the high-pressure case.

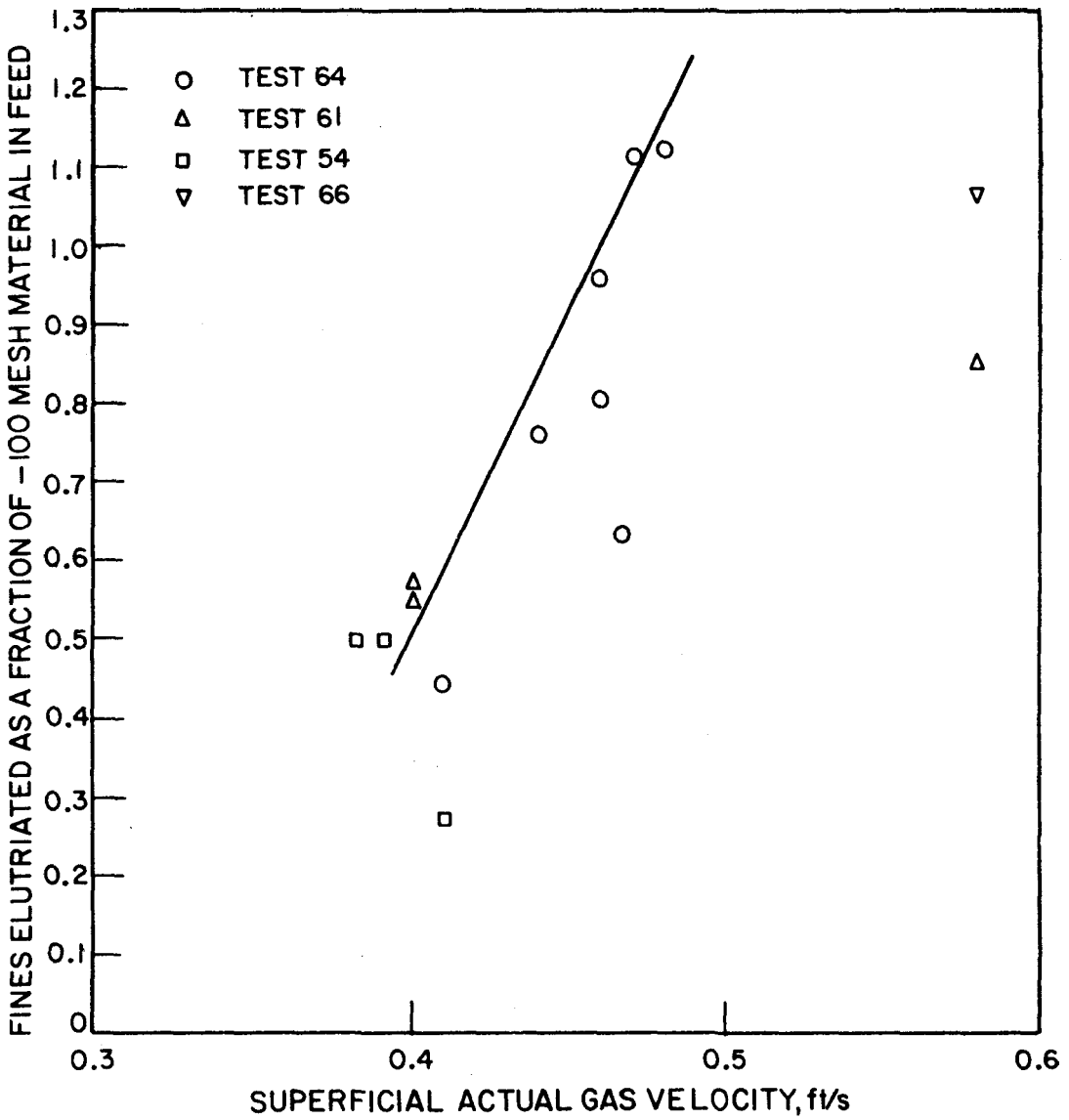


Figure 3. ELUTRIATION LOSSES DURING STEADY-STATE PERIODS OF HIGH PRESSURE TESTS AS A FUNCTION OF SUPERFICIAL VELOCITY IN THE SLURRY DRYING BED

Preliminary data from low-pressure operation indicate significantly reduced fines carry-over from the gasifier, thereby agreeing with laboratory results. Therefore, the design basis used here is conservative.

Model of the 500-psi Gasifier at Different Feed Rates and Bed Heights

The performance of the pilot plant indicated that a specific set of operating curves would be expected for a particular gasifier. Further reflection indicates that, with a fixed coal composition and gasifier configuration and with a fixed velocity in the SOG bed, the performance of the gasifier is dictated by the coal feed rate and the SOG temperature.

The curves are determined as follows:

a. The demonstration gasifier was sized at the base operating conditions of 1800°F in the SOG bed with a steam/carbon ratio of 1.234. The gasifier had internal dimensions of 15.37 feed ID by 28.24 feet high in the SOG and 23.42 feet ID by 38.82 feet high in the high-temperature reactor (HTR). Six such gasifiers are required to process 677.6 tons of dry, ROM, pretreated coal per hour into 27,535 moles of methane per hour (allowing 1.25% losses downstream).

b. To determine gasifier operation under other conditions, the following facts are important:

   1) The cross-sectional area of the gasifier is defined; therefore, the steam rate is approximately fixed.

   2) The heights of the individual beds are defined; therefore, the residence times are known functions of the coal feed rates and conversions.

   3) The temperature in the HTR must be adjusted by trial and error to give the proper conversion in the HTR to match the volume.

Figures 4 through 6 present the output for the base gasifier design when operating at full bed depth. The design point is 90% conversion at 1800°F with 100% of the design feed input. The cross parameter of design equivalent methane output is also 100%. Figure 3 shows that as the temperature is decreased at a constant coal feed rate, carbon conversion decreases and the fraction of design equivalent methane also decreases almost proportionately. If the coal feed rate is increased, carbon conversion decreases and the net total quantity of product increases, although not as much as the coal feed rate increases.

Figure 5 illustrates the changing steam/carbon ratio as the parameters are varied. The design point is a 1.23 steam/carbon ratio. As the temperature

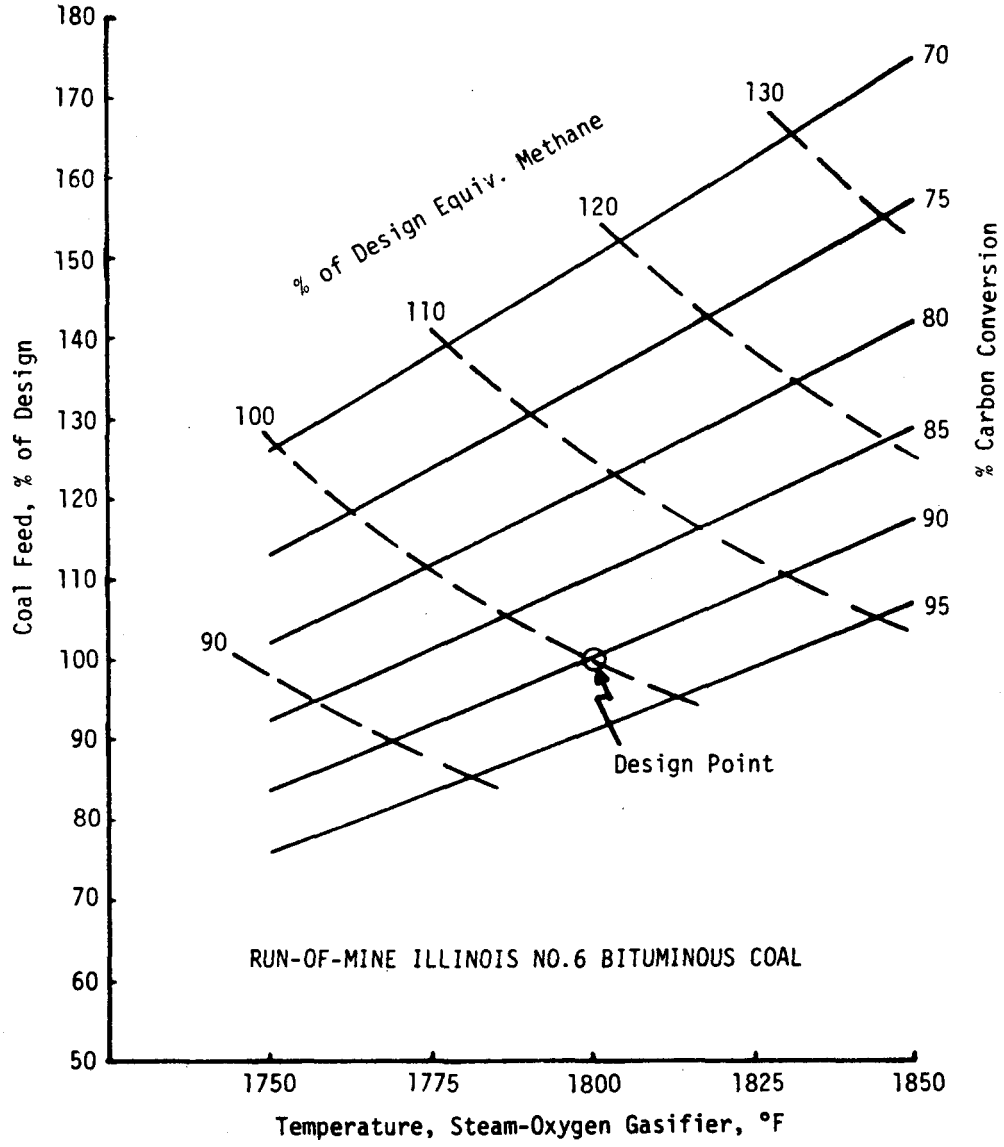


Figure 4. OPERATING CURVE RELATING COAL FEED, PERCENT OF DESIGN, AND TEMPERATURE IN THE STEAM/OXYGEN GASIFIER TO PERCENT OF DESIGN EQUIVALENT METHANE AND PERCENT CARBON CONVERSION

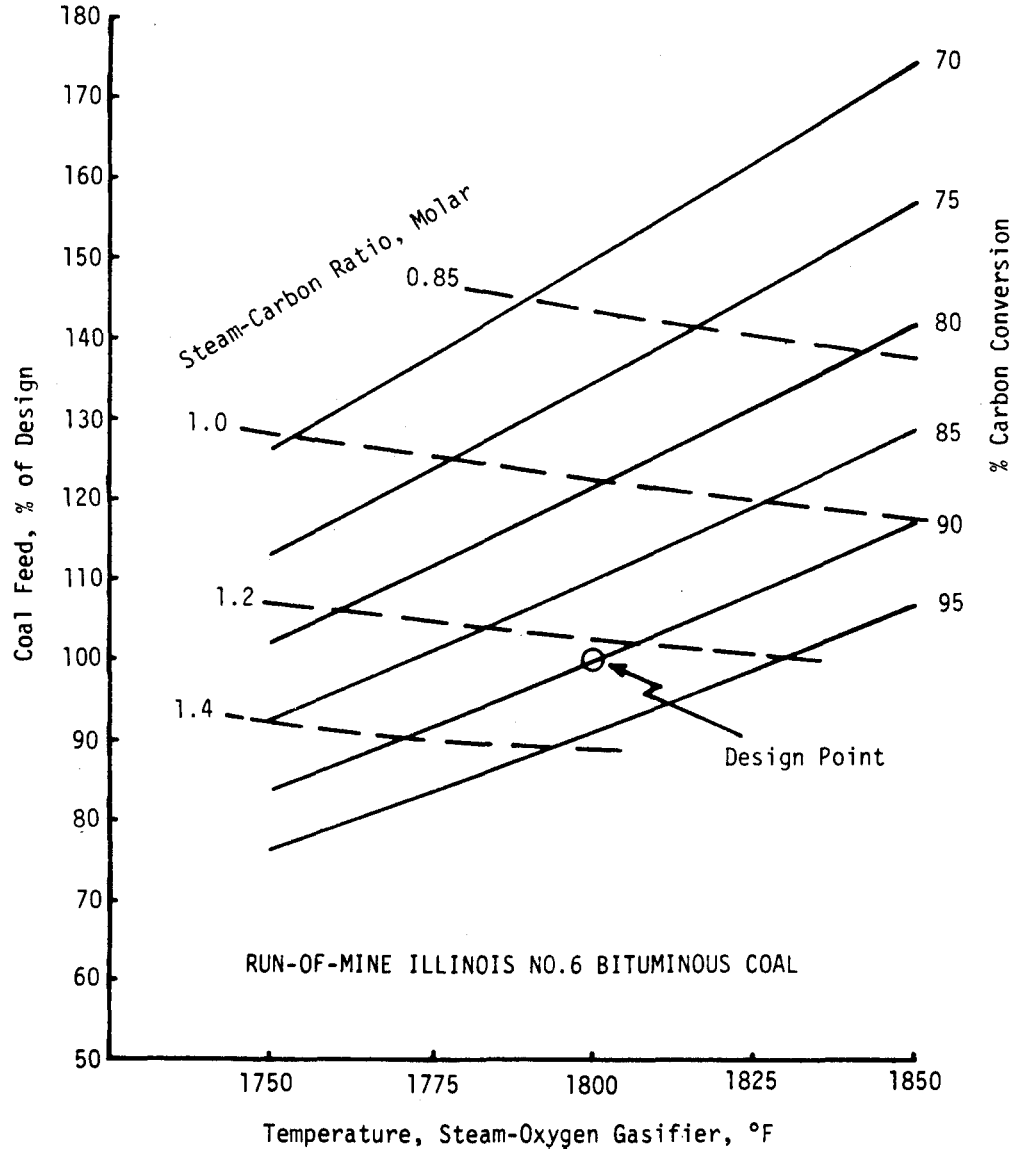


Figure 5. OPERATING CURVE RELATING COAL FEED, PERCENT OF DESIGN, AND TEMPERATURE IN THE STEAM-OXYGEN GASIFIER TO MOLAR STEAM/CARBON RATIO AND PERCENT CARBON CONVERSION

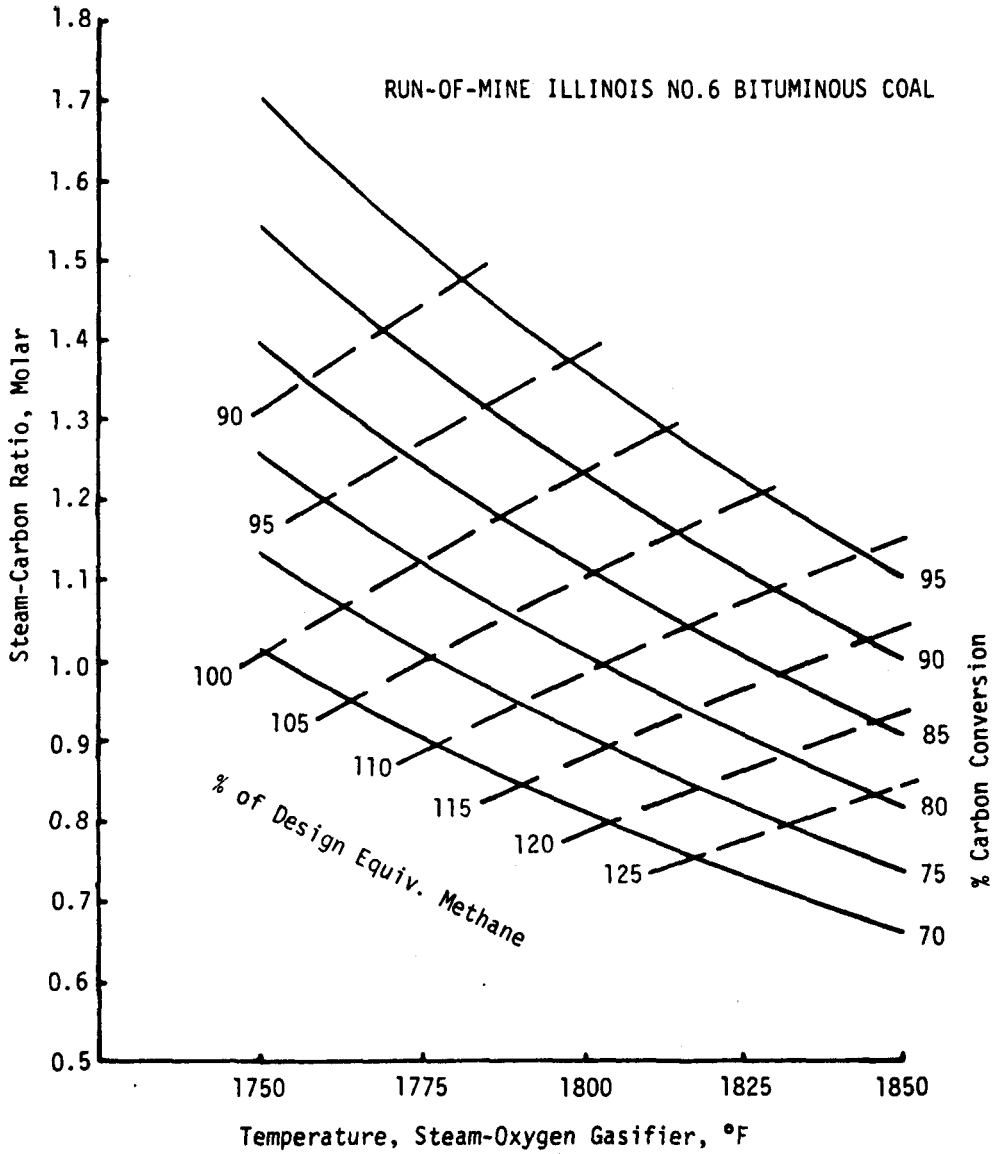


Figure 6. OPERATING CURVE RELATING MOLAR STEAM/CARBON RATIO AND TEMPERATURE IN THE STEAM-OXYGEN GASIFIER TO PERCENT OF DESIGN EQUIVALENT METHANE AND PERCENT CARBON CONVERSION

is decreased, at 100% of coal feed, the steam/carbon ratio increases slightly, because the velocity in the steam-oxygen gasifier is held constant and the oxygen requirement is decreased. Increasing the coal feed rate decreases the steam/carbon ratio.

Figure 6 illustrates that the data can be cross-plotted several ways to illustrate the effects of different variables.

It has been suggested that the demonstration plant design should include only those parameters that have been simultaneously achieved in the pilot plant. On initial examination, this implies that the gasifier should be operated at bed depths that are equal to those that can be run in the pilot plant. A second set of curves was developed for the same gasifier, but with a reduced bed depth, and is included in Figures 7 through 9. Figure 7 illustrates that, if the gasifier is run at the reduced bed depth with 100% of coal feed at 1800°F, the carbon conversion decreases to about 79% and the gasifier production is about 88% of design. Under these conditions, the steam/carbon ratio is still 1.23:1, as illustrated in Figures 8 and 9. If the reactor is operated at the suggested temperature of 1750°F and at a steam/carbon ratio of 1.5, about 77% of the coal is converted at 88% of the design coal feed rate to product 73% of the design product output. In assessing the oxygen demand, ROM coal requires slightly less oxygen in the same bed as washed coal. Because the suggested oxygen limitation is fixed on washed coal, an anticipated 100% of the design coal feed rate could be utilized at 1750°F and 70% conversion to yield about 78% of the design equivalent methane output.

If the gasifier is operated at full bed depth, it cannot quite conform to the suggested limitation on oxygen flow. In this mode, the gasifier requires 105% of the suggested oxygen flow at 1750°F and 90% conversion, with a steam/carbon ratio of 1.54. The design gasifier can operate at the conditions anticipated for commercial operation, producing 116% of design equivalent methane at 90% conversion and a temperature of 1850°F.

A similar set of curves were formulated for the washed, pretreated coal case so that the effect of this variable in the demonstration plant could be determined and the oxygen limitation defined. This set of curves should be indicative of Tests 71 through 74 in the pilot plant and could provide a rough check on the calculative approach. Figure 10 compares the predicted carbon conversions with those obtained experimentally in the pilot plant

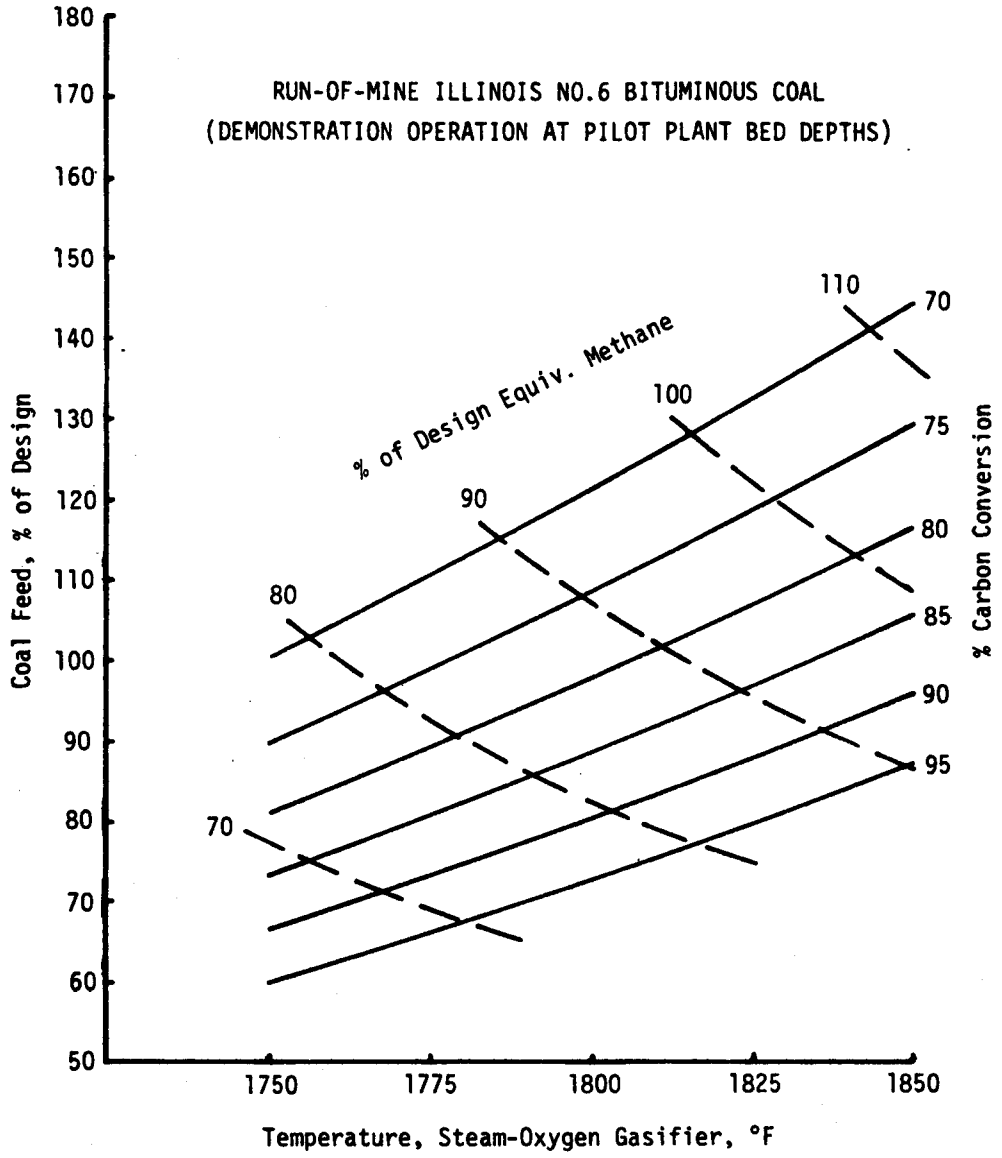


Figure 7. OPERATING CURVE RELATING PERCENT OF DESIGN COAL FEED AND TEMPERATURE IN THE STEAM-OXYGEN GASIFIER TO PERCENT OF DESIGN EQUIVALENT METHANE AND PERCENT CARBON CONVERSION

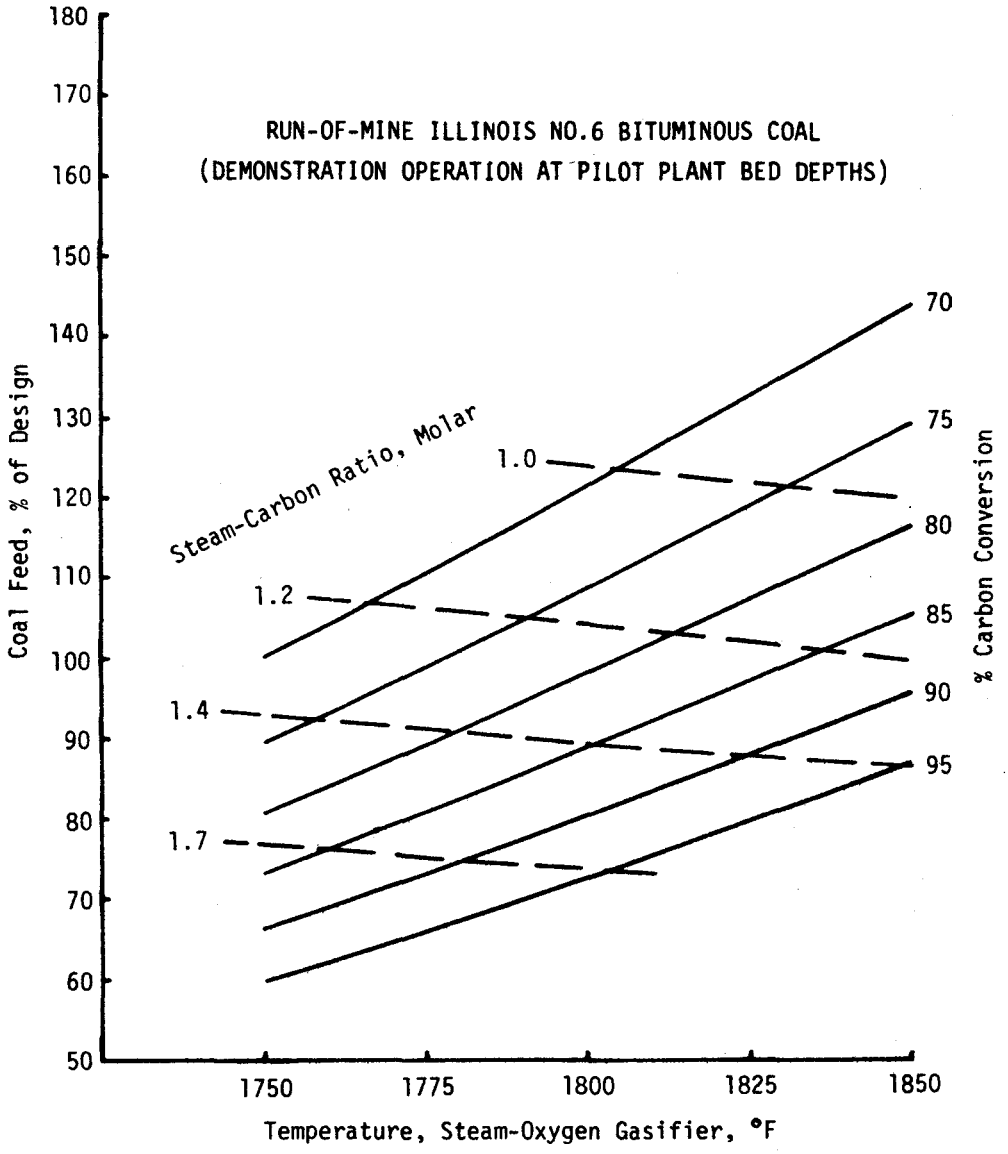


Figure 8. OPERATING CURVE RELATING PERCENT OF DESIGN, COAL FEED, AND TEMPERATURE IN THE STEAM-OXYGEN GASIFIER TO PERCENT CARBON CONVERSION AND MOLAR STEAM/CARBON RATIO

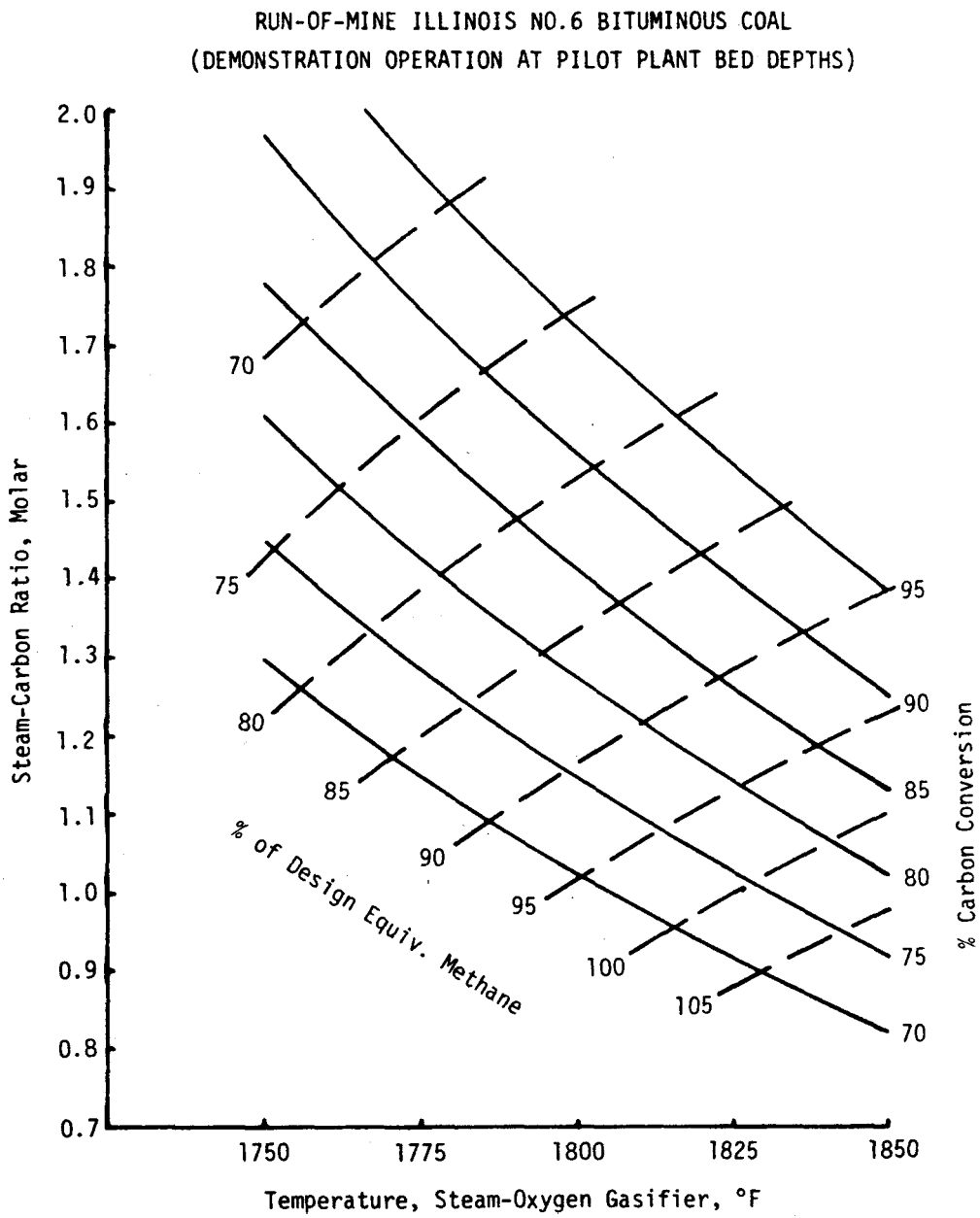


Figure 9. OPERATING CURVE RELATING MOLAR STEAM/CARBON RATIO AND TEMPERATURE IN THE STEAM-OXYGEN GASIFIER TO PERCENT DESIGN EQUIVALENT METHANE AND PERCENT CARBON CONVERSION

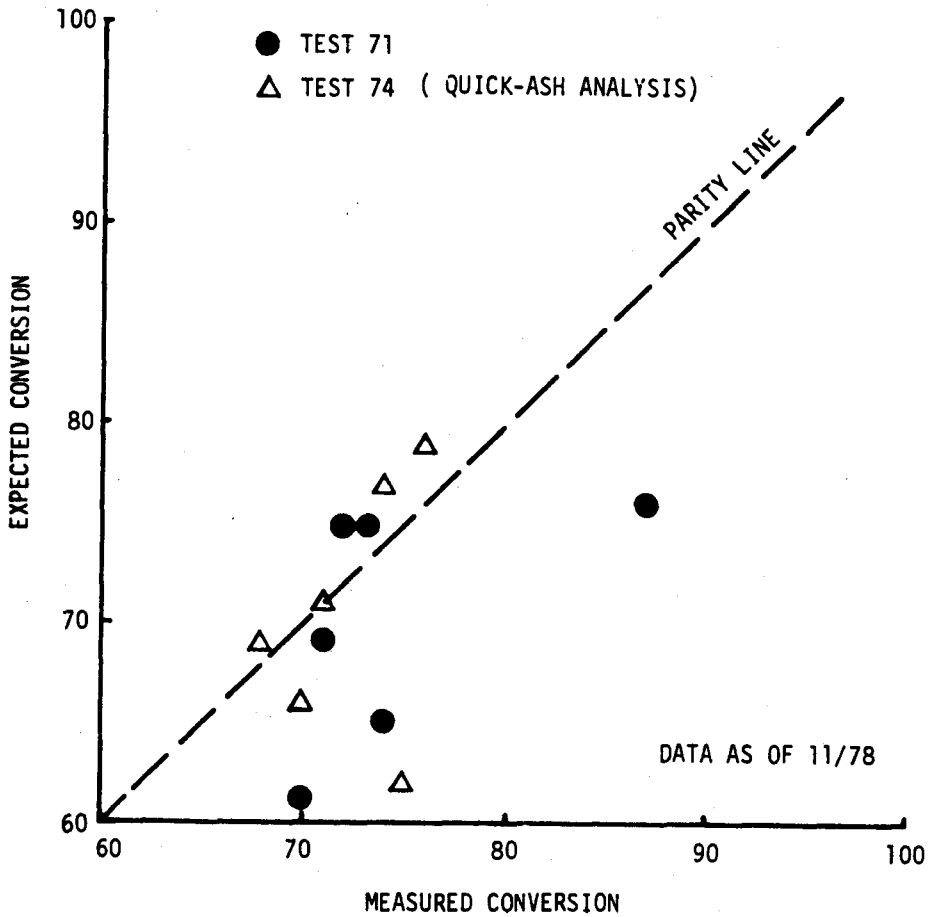


Figure 10. COMPARISON OF PILOT PLANT OPERATION TO DESIGN OPERATING CURVES

for these two tests. Generally, the agreement is good: For those points that show the greatest deviation from the parity line, the model is conservative.

Further, individual data points could be affected by differences in the mechanical configuration assumed for the design model and that actually operated in the pilot plant.

Cold-Flow Model

A cold-flow model of the upper stage of the gasification reactor is being constructed. This stage of the system is the only section of the unit that is not a direct mechanical transfer of technology from the pilot plant reactor. The model is being constructed to determine the gas-solids behavior, on a large scale and at elevated pressure, in systems similar to the proposed demonstration plant design.

The procurement status of the various elements of this model is —

a. Compressor: received and set in place.

b. Instrumentation: received and partially installed.

c. Building Foundation: completed.

d. Building Structural Steel: nearly complete.

e. Vessels: all vessels have now been received and erected.

f. Cyclone: received and erected.

g. Pipeline Filters: received and installed.

h. Control Valves: received and installed.

Because of the poor weather during the last part of December, approximately 35% of the siding remains to be erected. Work on connecting the large 12-inch-diameter pipe to the solids receiver vessel is proceeding and is nearly completed.

Task 13. Operations Support Studies

Materials Testing

MPC corrosion/erosion coupons were tested during Tests 75 and 76, and are being tested during Test 77.

Engineering Services

The following engineering services were provided during this reporting period:

a. Bench-scale minimum pretreatment studies and analyses

b. Continued engineering and installation of the 400-ton char storage unit

c. Testing of a high-pressure and -temperature, continuous gas sampler for the first-stage reactor of the HYGAS unit

d. A process study on a fines waste-handling system for the pilot plant

e. A search for alternative means of weighing coal and char, and the purchase of an alternative system

f. Bench-scale unit tests to determine successful pretreatment conditions for ROM coal

g. Routine engineering and analytical duties.

FUTURE WORK

Test 77 operations were continuing at the close of this quarter. After Test 77 is terminated, the pilot plant will be inspected and any modifications thought necessary for optimizing plant operations will be made before Test 78 is started. The objective of Test 78 will be to explore the gasification behavior of ROM coal in the HYGAS pilot plant at a 500-psig operating pressure. A superficial velocity range from 1.2 to 1 ft/s will be covered, and steam feed without nitrogen dilution will be used. Installation of the 400-ton char storage unit will continue.

ACKNOWLEDGMENT

This program is jointly funded by the United States Department of Energy and the Gas Research Institute.

APPENDIX. Final Results From Tests 71 and 74 and Pretreatment Data for Test 72

The following data are presented in this Appendix:

- Key pretreater and reactor material and energy balances for Test 71 are given in Tables A-1 through A-10 and in Figures A-1 through A-32.
- Reactor material and energy balances for Test 74 are presented in Tables A-11 through A-14 and in Figures A-33 through A-60.
- Figure A-61 is an overview plot of important operation variables during Test 74.
- Complete pretreatment data for Test 72 are given in Tables A-15 through A-17 and in Figures A-63 through A-67.

Table A-1. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 71 FROM 4/20/78 (1700 Hours) TO 4/21/78 (0130 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	69.67	4.96	9.40	1.14	4.51		10.32	100
	Coal (Dry)	2329	166	314	38	151		345	3343
	Moisture		24	188					212
Streams to Pretreater	Air			701	2281		39		3021
	Steam		252	1999					2251
Nitrogen From Purges					53				53
Air From Purges				9	29				38
H_2O to Venturi Scrubber			1477	11,721					13,198
H_2O to Quench Tower			211	1673					1884
Nitrogen to Char Cooler					574				574
Cooling Water to Char Cooler			58	456					514
TOTAL INPUT		2329	2187	17,061	2976	151	39	345	25,088
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	70.40	3.50	7.48	1.37	4.42		12.83	100
	Char (Dry)	1824	91	193	37	116		333	2594
	Moisture		2	16					18
Slurry Waste From Quench	Wt % (Dry)	66.67	3.35	11.48	1.19	3.75		13.56	100
	Solids (Dry)	61	3	11	1	3		12	91
	Tars & Oils	40	4	4	0	1			49
	H_2O & Disc Materials	20	1693	13,435	0	13			15,161
Quench Tower Off-Gas	Total	200	380	3402	3151		39		7172
	Components:								
	H_2		0						0
	CO_2	126		337					463
	C_2H_6	11	3						14
	N_2				3151				3151
	CH_4	16	5						21
	CO	47		62					109
	O_2			51					51
	Ar						39		39
	H_2O		372	2952					3324
TOTAL OUTPUT		2145	2173	17,061	3189	133	39	345	25,085
Net (Output − Input)		−184	−13	0	213	−18	0	0	−3
% Balance (Output/Input)		92	99	100	107	86	100	100	100

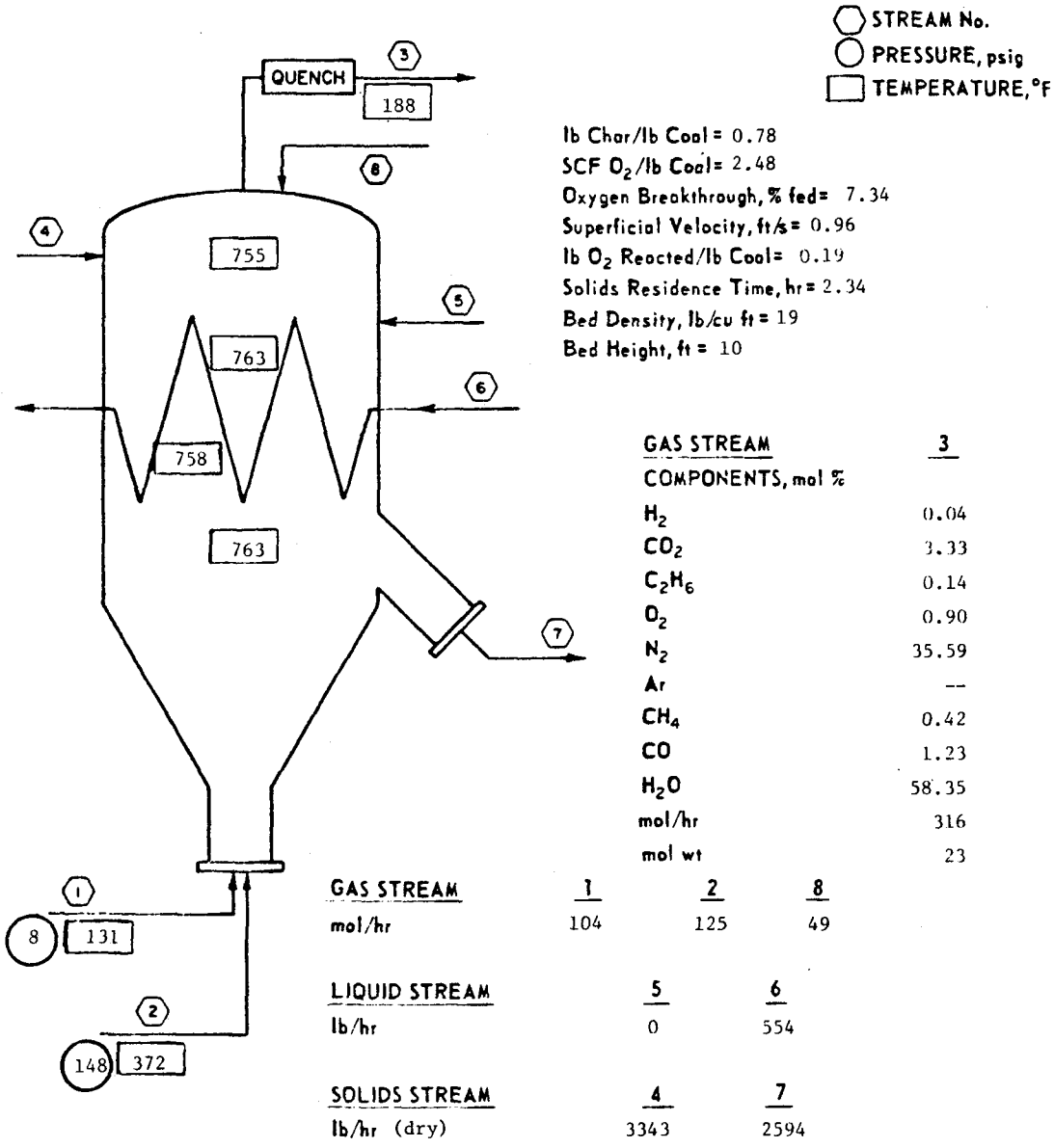
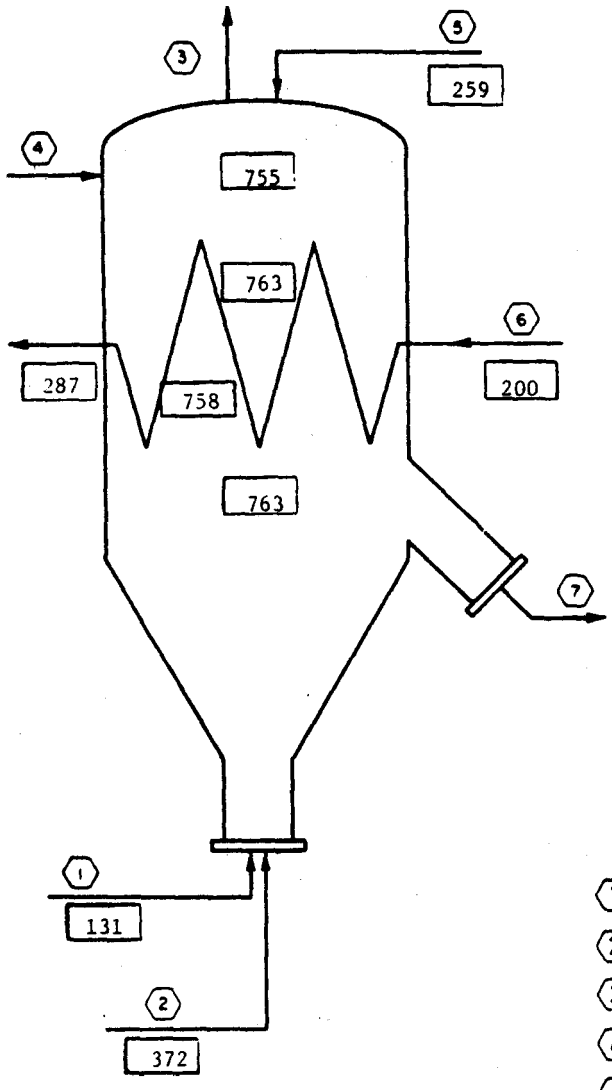


Figure A-1. PRETREATMENT DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/20/78 (1700 Hours) TO 4/21/78 (0130 Hours)



⬡ Stream No. ▭ Temperature, °F

Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1, 2, 4, 5, 6)	0.25
Heat of Combustion (Stream 4)	41.83
Steam Enthalpy (Streams 2 & 5)	3.13
Total	45.21
OUTPUT	
Sensible Heat (Streams 3 & 7)	3.09
Heat of Combustion (Streams 3 & 7)	33.76
Steam Enthalpy (Streams 3 & 6)	4.37
Total	41.22
% Balance 91	

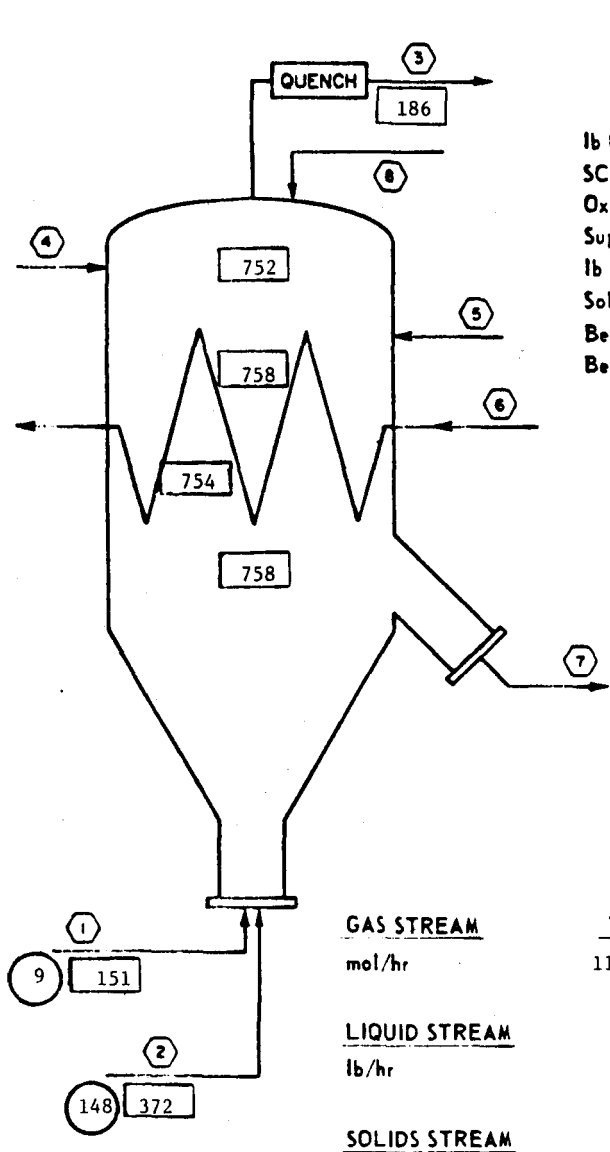
(1) Air to Pretreater
(2) Steam to Pretreater
(3) Pretreater Overhead
(4) Raw Coal to Pretreater
(5) Gas From Char Cooler
(6) Cooling Water to Cooling Coil in Pretreater
(7) Pretreated Char to Char Cooler

Figure A-2. PREHEATER HEAT BALANCE DATA SHEET FOR TEST 71 FOR STEADY PERIOD FROM 4/20/78 (1700 Hours) TO 4/21/78 (0130 Hours)

Table A-2. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 71 FROM 4/21/78 (1000 Hours) TO 4/22/78 (1130 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	69.19	5.01	9.83	1.29	4.48		10.20	100
	Coal (Dry)	2177	158	309	41	141		321	3147
	Moisture		20	162					182
Streams to Pretreater	Air			757	2464		42		3263
	Steam		214	1695					1909
Nitrogen From Purges					48				48
Air From Purges				9	29				38
H_2O to Venturi Scrubber			1440	11,427					12,867
H_2O to Quench Tower			201	1591					1792
Nitrogen to Char Cooler					576				576
Cooling Water to Char Cooler			64	505					569
TOTAL INPUT		2177	2097	16,455	3158	141	42	321	24,391
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	69.93	3.46	8.53	1.36	4.22		12.50	100
	Char (Dry)	1642	81	200	32	99		293	2347
	Moisture		3	27					30
Slurry Waste From Quench	Wt % (Dry)	65.36	3.30	12.32	1.21	4.11		13.70	100
	Solids (Dry)	131	7	25	2	8		28	201
	Tars & Oils	43	4	4	0	2			53
	H_2O & Disc Materials	19	1634	12,965	1	15			14,634
Quench Tower Off-Gas	Total	204	371	3234	3235		42		7086
	Components:								
	H_2		5						5
	CO_2	129		345					474
	C_2H_6	6	1						7
	N_2				3235				3235
	CH_4	30	10						40
	CO	39		52					91
	O_2			20					20
	Ar						42		42
	H_2O		355	2817					3172
TOTAL OUTPUT		2039	2100	16,455	3270	124	42	321	24,351
Net (Output − In)		−138	3	0	112	−17	0	0	−40
% Balance (Output/Input)		94	100	100	104	88	100	100	100



lb Char/lb Coal = 0.80
SCF O_2/lb Coal = 2.85
Oxygen Breakthrough, % fed = 2.69
Superficial Velocity, ft/s = 0.91
lb O_2 Reacted/lb Coal = 0.23
Solids Residence Time, hr = 2.10
Bed Density, lb/cu ft = 20
Bed Height, ft = 8

GAS STREAM	3
COMPONENTS, mol %	
H_2	0.84
CO_2	3.44
C_2H_6	0.08
O_2	0.63
N_2	36.91
Ar	--
CH_4	0.79
CO	1.04
H_2O	56.27
mol/hr	313
mol wt	23

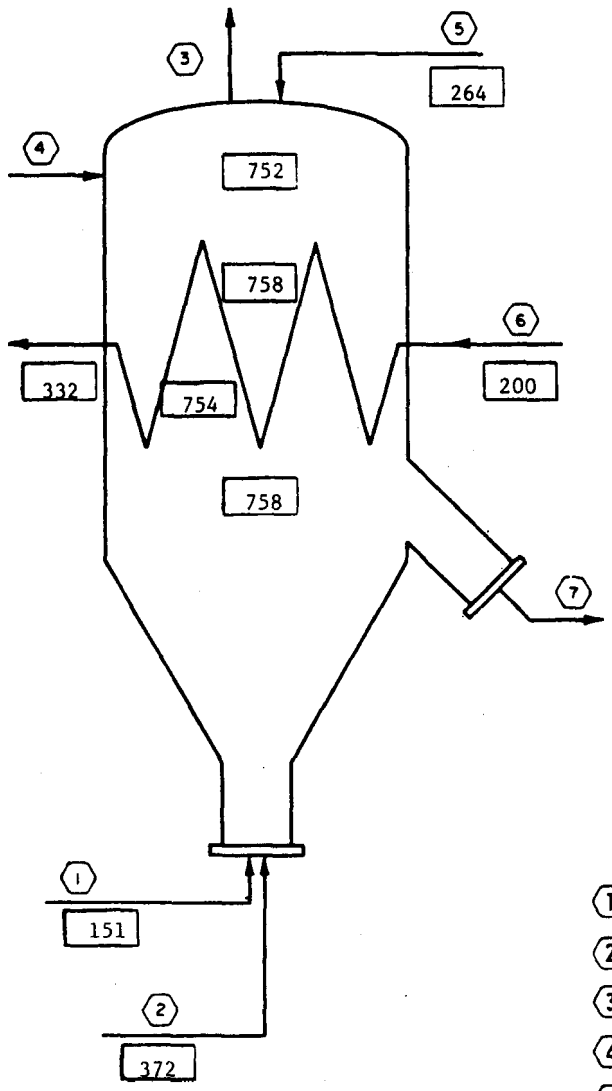
GAS STREAM	1	2	8
mol/hr	113	106	52

LIQUID STREAM	5	6
lb/hr	0	742

SOLIDS STREAM	4	7
lb/hr (dry)	3147	2347

(1) AIR TO PRETREATER
(2) STEAM TO PRETREATER
(3) PRETREATER OFF-GAS AFTER QUENCH
(4) RAW COAL TO PRETREATER
(5) DIRECT WATER QUENCH
(6) COOLING WATER TO COOLING COIL IN PRETREATER
(7) PRETREATER CHAR TO CHAR COOLER
(8) GAS FROM CHAR COOLER

Figure A-3. PRETREATMENT DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/21/78 (1000 Hours) TO 4/22/78 (1130 Hours)



Stream No. Temperature, °F

Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1, 2, 4, 5, 6)	0.30
Heat of Combustion (Stream 4)	39.30
Steam Enthalpy (Streams 2 & 5)	2.79
Total	42.39
OUTPUT	
Sensible Heat (Streams 3 & 7)	2.98
Heat of Combustion (Streams 3 & 7)	32.80
Steam Enthalpy (Streams 3 & 6)	4.13
Total	39.91
% Balance 94	

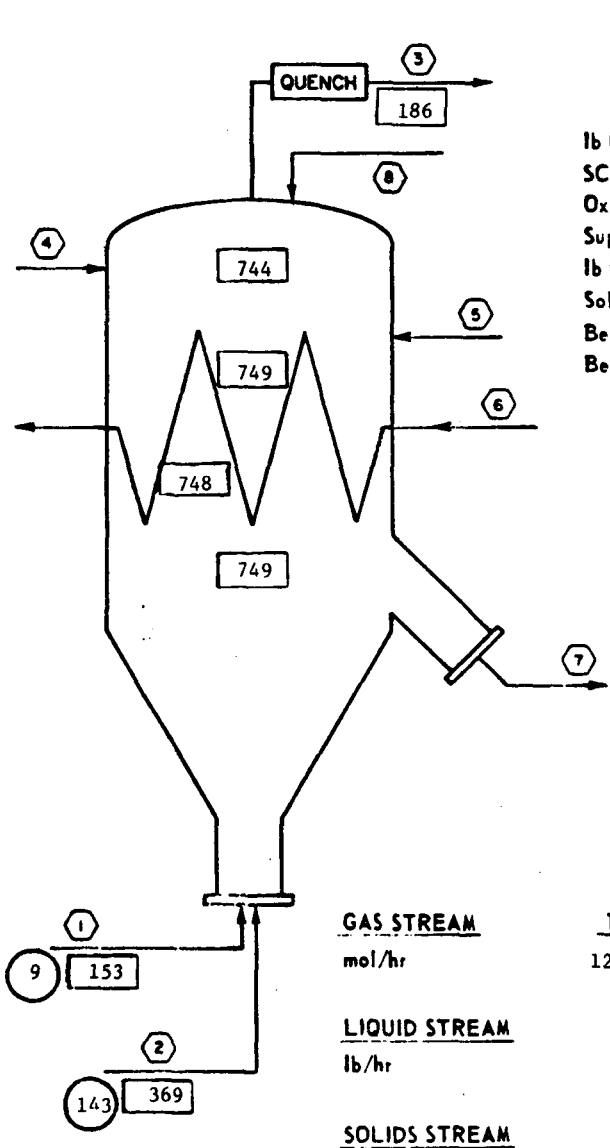
1. Air to Pretreater
2. Steam to Pretreater
3. Pretreater Overhead
4. Raw Coal to Pretreater
5. Gas From Char Cooler
6. Cooling Water to Cooling Coil in Pretreater
7. Pretreated Char to Char Cooler

Figure A-4. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 71 FOR STEADY PERIOD FROM 4/21/78 (1000 Hours) TO 4/22/78 (1130 Hours)

Table A-3. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 71 FROM 4/21/78 (1000 Hours) TO 4/21/78 (2000 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	69.05	4.98	9.84	1.26	4.55		10.32	100
	Coal (Dry)	2450	177	349	45	161		366	3548
	Moisture		24	193					217
Streams to Pretreater	Air			848	2763		47		3658
	Steam		196	1560					1756
Nitrogen From Purges					59				59
Air From Purges				9	29				38
H_2O to Venturi Scrubber			1426	11,313					12,739
H_2O to Quench Tower			201	1598					1799
Nitrogen to Char Cooler					562				562
Cooling Water to Char Cooler			76	601					677
TOTAL INPUT		2450	2100	16,471	3458	161	47	366	25,053
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	70.00	3.40	8.60	1.48	4.16		12.36	100
	Char (Dry)	1964	95	241	42	117		347	2806
	Moisture		4	35					39
Slurry Waste From Quench	Wt % (Dry)	65.87	3.29	12.10	1.15	4.07		13.52	100
	Solids (Dry)	94	5	17	2	6		19	143
	Tars & Oils	40	4	4	0	1			49
	H_2O & Disc Materials	21	1608	12,756	1	15			14,401
Quench Tower Off-Gas	Total	218	394	3418	3460		47		7537
	Components:								
	H_2		6						6
	CO_2	138		369					507
	C_2H_6	6	2						8
	N_2				3460				3460
	CH_4	32	11						43
	CO	42		56					98
	O_2			20					20
	Ar						47		47
	H_2O		375	2973					3348
TOTAL OUTPUT		2337	2110	16,471	3505	139	47	366	24,975
Net (Output − Input)		−113	10	0	47	−23	0	0	−78
% Balance (Output/Input)		95	101	100	101	80	100	100	100



lb Char/lb Coal = 0.82
SCF O_2/lb Coal = 2.83
Oxygen Breakthrough, % fed = 2.30
Superficial Velocity, ft/s = 0.93
lb O_2 Reacted/lb Coal = 0.23
Solids Residence Time, hr = 2.11
Bed Density, lb/cu ft = 19
Bed Height, ft = 9

GAS STREAM	3
COMPONENTS, mol %	
H_2	0.85
CO_2	3.47
C_2H_6	0.08
O_2	0.63
N_2	37.19
Ar	--
CH_4	0.79
CO	1.05
H_2O	55.94
mol/hr	332
mol wt	23

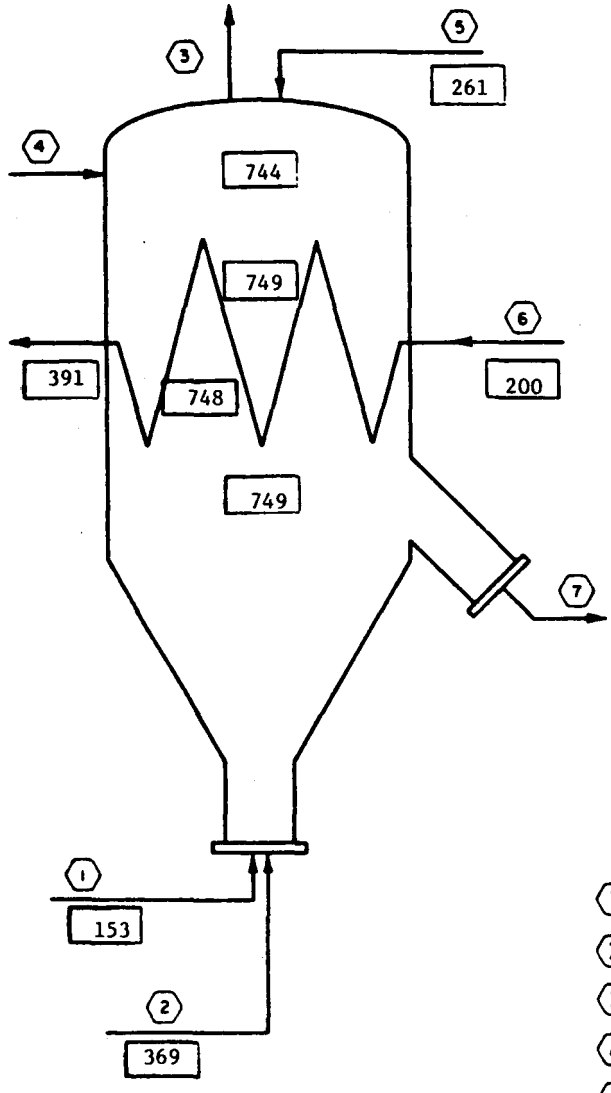
GAS STREAM	1	2	8
mol/hr	126	98	58

LIQUID STREAM	5	6
lb/hr	0	812

SOLIDS STREAM	4	7
lb/hr (dry)	3548	2806

(1) AIR TO PRETREATER
(2) STEAM TO PRETREATER
(3) PRETREATER OFF-GAS AFTER QUENCH
(4) RAW COAL TO PRETREATER
(5) DIRECT WATER QUENCH
(6) COOLING WATER TO COOLING COIL IN PRETREATER
(7) PRETREATER CHAR TO CHAR COOLER
(8) GAS FROM CHAR COOLER

Figure A-5. PRETREATMENT DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/21/78 (1000 Hours) TO 4/21/78 (2000 Hours)



Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1, 2, 4, 5, 6)	0.34
Heat of Combustion (Stream 4)	44.35
Steam Enthalpy (Streams 2 & 5)	2.73
Total	47.42
OUTPUT	
Sensible Heat (Streams 3 & 7)	3.21
Heat of Combustion (Streams 3 & 7)	36.97
Steam Enthalpy (Streams 3 & 6)	4.48
Total	44.66
% Balance 94	

1. Air to Pretreater
2. Steam to Pretreater
3. Pretreater Overhead
4. Raw Coal to Pretreater
5. Gas From Char Cooler
6. Cooling Water to Cooling Coil in Pretreater
7. Pretreated Char to Char Cooler

Figure A-6. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 71 FOR STEADY PERIOD FROM 4/21/78 (1000 Hours) TO 4/21/78 (2000 Hours)

Table A-4. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 71 FROM 4/21/78 (2000 Hours) TO 4/22/78 (1130 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	69.27	5.03	9.82	1.31	4.44		10.13	100
	Coal (Dry)	2001	145	284	38	128		293	2889
	Moisture		18	143					161
Streams to Pretreater	Air			697	2272		39		3008
	Steam		225	1783					2008
Nitrogen From Purges					41				41
Air From Purges				9	29				38
H_2O to Venturi Scrubber			1449	11,499					12,948
H_2O to Quench Tower			200	1588					1788
Nitrogen to Char Cooler					585				585
Cooling Water to Char Cooler			50	400					450
TOTAL INPUT		2001	2087	16,403	2965	128	39	293	23,916
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	69.49	3.43	8.60	1.34	4.27		12.87	100
	Char (Dry)	1427	70	177	28	88		264	2054
	Moisture		2	19					21
Slurry Waste From Quench	Wt % (Dry)	64.60	3.32	12.63	1.30	4.17		13.98	100
	Solids (Dry)	131	7	25	3	8		29	203
	Tars & Oils	44	4	4	0	2			54
	H_2O & Disc Materials	17	1645	13,052	0	16			14,729
Quench Tower Off-Gas	Total	194	360	3127	3077		39		6797
	Components:								
	H_2		5						5
	CO_2	123		328					451
	C_2H_6	6	1						7
	N_2				3077				3077
	CH_4	28	10						38
	CO	37		50					87
	O_2			21					21
	Ar						39		39
	H_2O		344	2728					3072
TOTAL OUTPUT		1813	2088	16,403	3108	114	39	293	23,858
Net (Output − Input)		−189	1	0	143	−14	0	0	−58
% Balance (Output/Input)		91	100	100	105	89	100	100	100

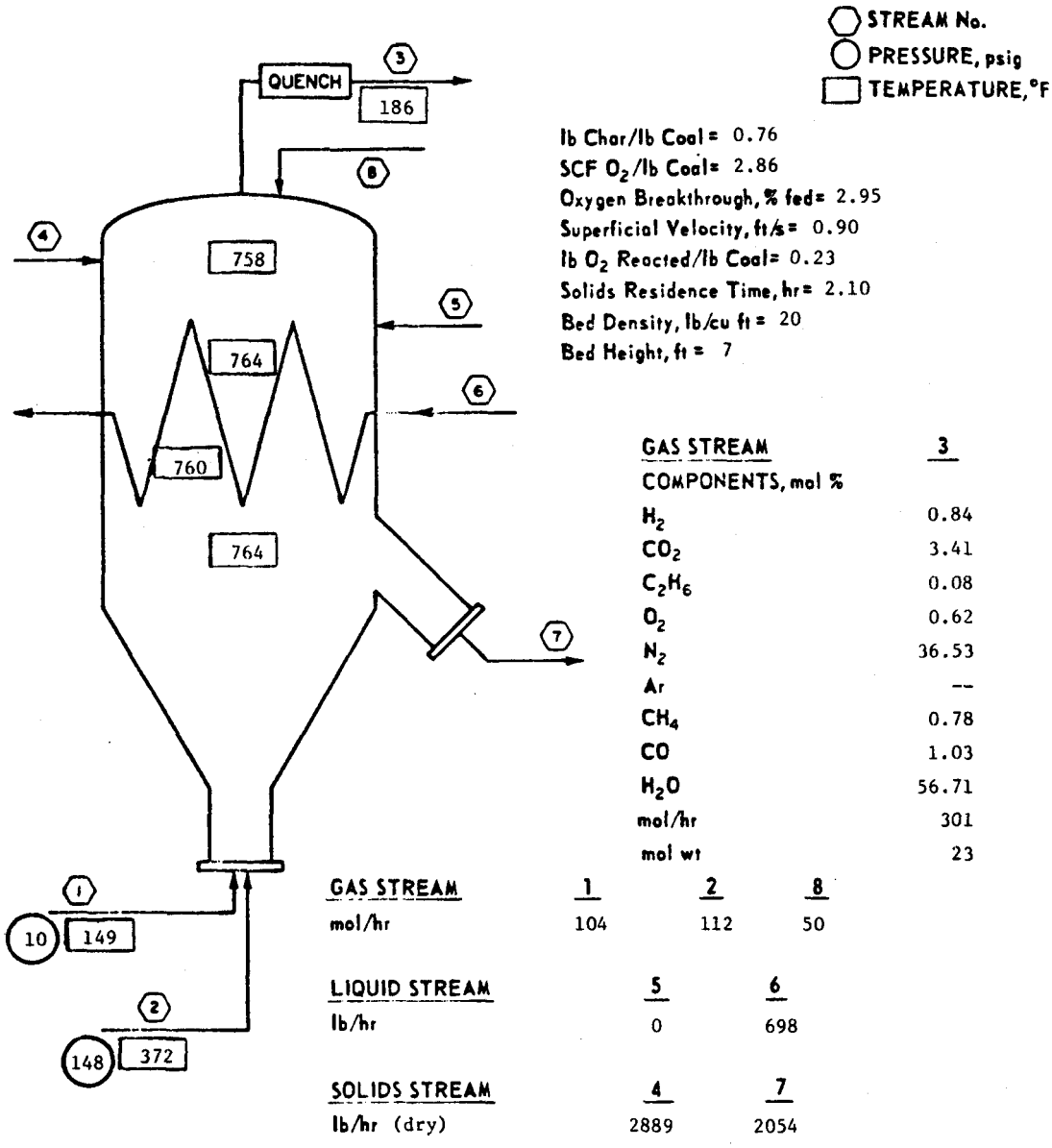
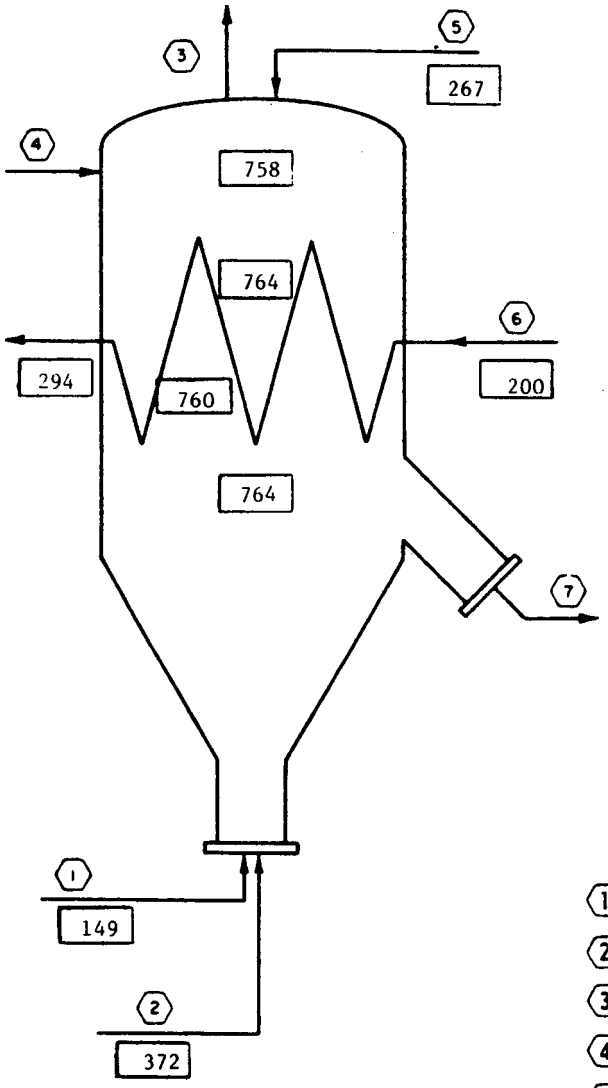


Figure A-7. PRETREATMENT DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/21/78 (1000 Hours) TO 4/22/78 (1130 Hours)



⬡ Stream No. ▭ Temperature, °F

Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1, 2, 4, 5, 6)	0.27
Heat of Combustion (Stream 4)	36.09
Steam Enthalpy (Streams 2 & 5)	2.78
Total	39.14
OUTPUT	
Sensible Heat (Streams 3 & 7)	2.82
Heat of Combustion (Streams 3 & 7)	29.09
Steam Enthalpy (Streams 3 & 6)	4.03
Total	35.94
% Balance 92	

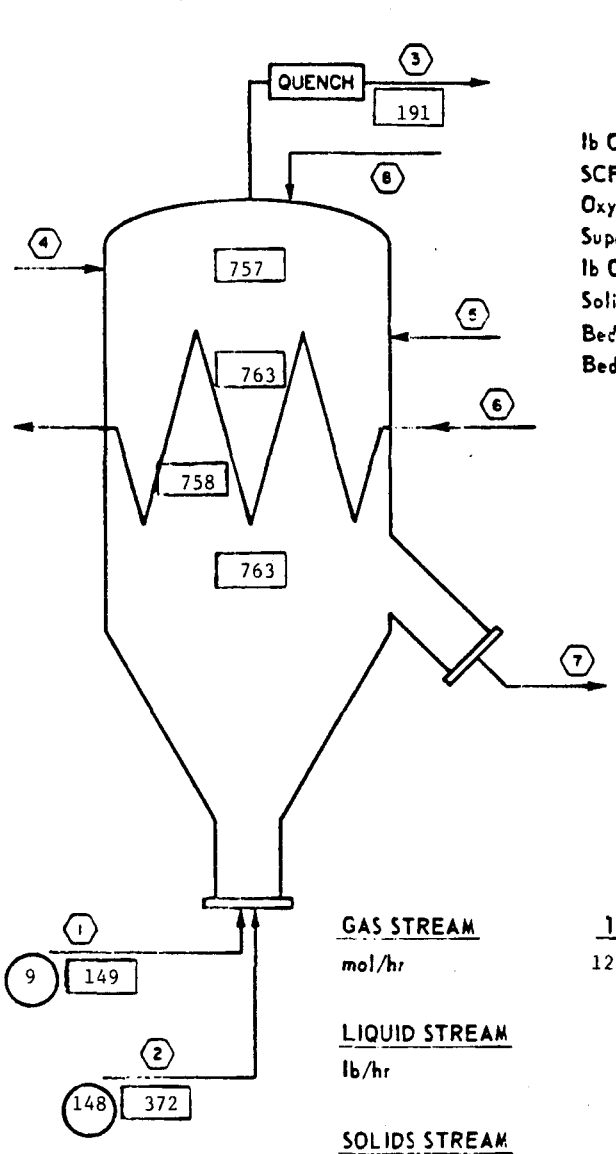
(1) Air to Pretreater
(2) Steam to Pretreater
(3) Pretreater Overhead
(4) Raw Coal to Pretreater
(5) Gas From Char Cooler
(6) Cooling Water to Cooling Coil in Pretreater
(7) Pretreated Char to Char Cooler

Figure A-8. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 71 STEADY PERIOD FROM 4/21/78 (2000 Hours) TO 4/22/78 (1130 Hours)

Table A-5. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 71 FROM 4/26/78 (2230 Hours) TO 4/27/78 (0500 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	69.20	4.99	9.69	1.31	4.48		10.35	100
	Coal (Dry)	2994	216	419	57	193		448	4327
	Moisture		27	215					242
Streams to Pretreater	Air			860	2801		48		3709
	Steam		266	2107					2373
Nitrogen From Purges					65				65
Air From Purges				9	29				38
H_2O to Venturi Scrubber			1353	10,735					12,088
H_2O to Quench Tower			140	1112					1252
Nitrogen to Char Cooler					561				561
Cooling Water to Char Cooler			104	827					931
TOTAL INPUT		2994	2106	16,284	3913	193	48	448	25,586
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	69.80	3.60	8.02	1.43	4.26		12.89	100
	Char (Dry)	2181	112	250	45	133		403	3124
	Moisture		4	31					35
Slurry Waste From Quench	Wt % (Dry)	68.00	3.46	11.20	1.27	3.49		12.58	100
	Solids (Dry)	244	12	40	5	13		45	359
	Tars & Oils	69	7	7	1	2			86
	H_2O & Disc Materials	0	1536	12,186	1	0			13,723
Quench Tower Off-Gas	Total	198	441	3770	3132		48		7589
	Components:								
	H_2		5						5
	CO_2	125		334					459
	C_2H_6	6	1						7
	N_2				3132				3132
	CH_4	29	10						39
	CO	38		50					88
	O_2			13					13
	Ar						48		48
	H_2O		425	3373					3798
TOTAL OUTPUT		2692	2112	16,284	3184	148	48	448	24,916
Net (Output − Input)		−302	6	0	−329	−45	0	0	−670
% Balance (Output/Input)		90	100	100	81	77	100	100	97



lb Char/lb Coal = 0.78
SCF O_2/lb Coal = 2.35
Oxygen Breakthrough, % fed = 1.46
Superficial Velocity, ft/s = 1.09
lb O_2 Reacted/lb Coal = 0.2
Solids Residence Time, hr = 1.53
Bed Density, lb/cu ft = 22
Bed Height, ft = 7

GAS STREAM	3
COMPONENTS, mol %	
H_2	0.74
CO_2	3.04
C_2H_6	0.07
O_2	0.55
N_2	32.57
Ar	--
CH_4	0.69
CO	0.92
H_2O	61.42
mol/hr	343
mol wt	22

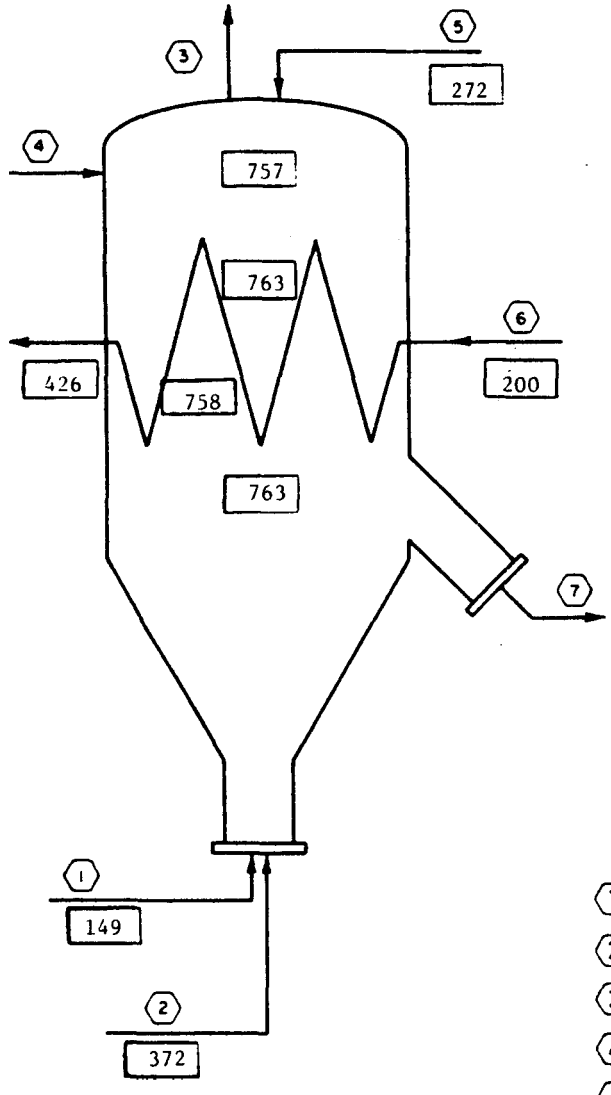
GAS STREAM	1	2	8
mol/hr	128	132	72

LIQUID STREAM	5	6
lb/hr	0	351

SOLIDS STREAM	4	7
lb/hr (dry)	4327	3124

(1) AIR TO PRETREATER
(2) STEAM TO PRETREATER
(3) PRETREATER OFF-GAS AFTER QUENCH
(4) RAW COAL TO PRETREATER
(5) DIRECT WATER QUENCH
(6) COOLING WATER TO COOLING COIL IN PRETREATER
(7) PRETREATER CHAR TO CHAR COOLER
(8) GAS FROM CHAR COOLER

Figure A-9. PRETREATMENT DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/26/78 (2230 Hours) TO 4/27/78 (0500 Hours)



Stream No. Temperature, °F

Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1, 2, 4, 5, 6)	0.35
Heat of Combustion (Stream 4)	54.15
Steam Enthalpy (Streams 2 & 5)	3.71
Total	58.21
OUTPUT	
Sensible Heat (Streams 3 & 7)	3.59
Heat of Combustion (Streams 3 & 7)	44.90
Steam Enthalpy (Streams 3 & 6)	4.41
Total	52.90
% Balance 91	

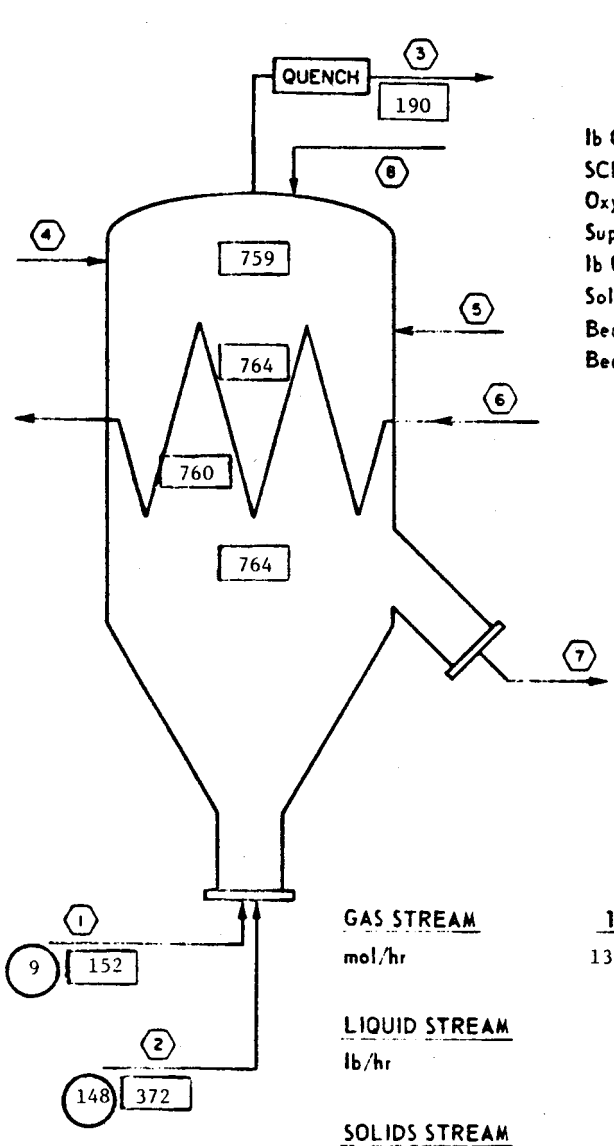
1. Air to Pretreater
2. Steam to Pretreater
3. Pretreater Overhead
4. Raw Coal to Pretreater
5. Gas From Char Cooler
6. Cooling Water to Cooling Coil in Pretreater
7. Pretreated Char to Char Cooler

Figure A-10. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 71 FOR STEADY PERIOD FROM 4/26/78 (2230 Hours) TO 4/27/78 (0500 Hours)

Table A-6. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 71 FROM 4/26/78 (1700 Hours) TO 4/27/78 (0500 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	69.03	4.99	9.78	1.32	4.51		10.37	100
	Coal (Dry)	2986	216	423	57	195		449	4326
	Moisture		27	217					244
Streams to Pretreater	Air			886	2884		49		3819
	Steam		253	2009					2262
Nitrogen From Purges					66				66
Air From Purges				9	29				38
H_2O to Venturi Scrubber			1353	10,740					12,093
H_2O to Quench Tower			147	1167					1314
Nitrogen to Char Cooler					550				550
Cooling Water to Char Cooler			95	755					850
TOTAL INPUT		2986	2091	16,206	3586	195	49	449	25,562
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	69.80	3.60	8.02	1.43	4.26		12.89	100
	Char (Dry)	2183	113	251	45	133		403	3128
	Moisture		4	31					35
Slurry Waste From Quench	Wt % (Dry)	67.90	3.47	11.18	1.27	3.57		12.61	100
	Solids (Dry)	245	13	40	5	13		46	362
	Tars & Oils	69	7	7	1	2			86
	H_2O & Disc Materials	41	1539	12,216	1	22			13,819
Quench Tower Off-Gas	Total	201	427	3661	3186		49		7524
	Components:								
	H_2		5						5
	CO_2	127		339					466
	C_2H_6	6	1						7
	N_2				3186				3186
	CH_4	29	10						39
	CO	39		51					90
	O_2			12					12
	Ar						49		49
	H_2O		411	3259					3670
TOTAL OUTPUT		2739	2103	16,206	3238	170	49	449	24,954
Net (Output − Input)		−247	12	0	−348	−25	0	0	−608
% Balance (Output/Input)		92	101	100	90	87	100	100	98



lb Char/lb Coal = 0.78
SCF O_2/lb Coal = 2.42
Oxygen Breakthrough, % fed = 1.37
Superficial Velocity, ft/s = 1.08
lb O_2 Reacted/lb Coal = 0.20
Solids Residence Time, hr = 1.43
Bed Density, lb/cu ft = 21
Bed Height, ft = 7

GAS STREAM	3
COMPONENTS, mol %	
H_2	0.77
CO_2	3.13
C_2H_6	0.07
O_2	0.57
N_2	33.60
Ar	--
CH_4	0.72
CO	0.95
H_2O	60.19
mol/hr	338
mol wt	22

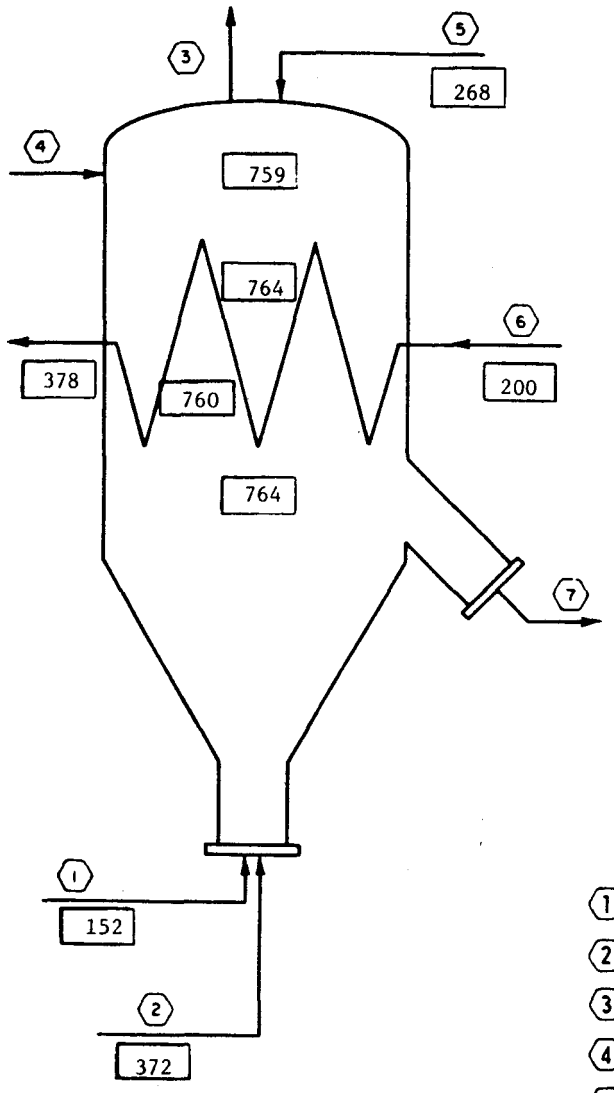
GAS STREAM	1	2	8
mol/hr	132	126	67

LIQUID STREAM	5	6
lb/hr	0	603

SOLIDS STREAM	4	7
lb/hr (dry)	4326	3128

(1) AIR TO PRETREATER
(2) STEAM TO PRETREATER
(3) PRETREATER OFF-GAS AFTER QUENCH
(4) RAW COAL TO PRETREATER
(5) DIRECT WATER QUENCH
(6) COOLING WATER TO COOLING COIL IN PRETREATER
(7) PRETREATER CHAR TO CHAR COOLER
(8) GAS FROM CHAR COOLER

Figure A-11. PRETREATMENT DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/26/78 (1700 Hours) TO 4/27/78 (0500 Hours)



⬡ Stream No. ▭ Temperature, °F

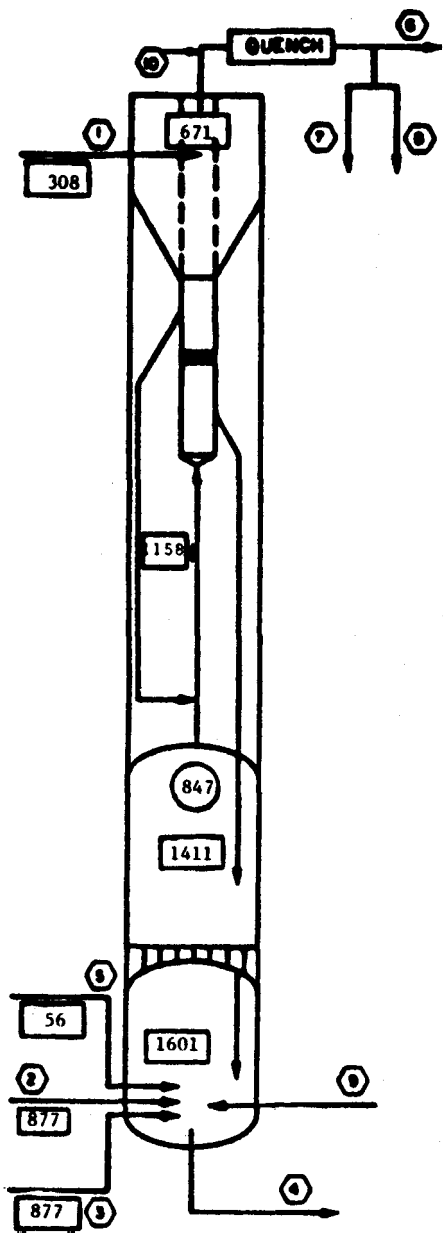
Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1, 2, 4, 5, 6)	0.37
Heat of Combustion (Stream 4)	53.99
Steam Enthalpy (Streams 2 & 5)	3.49
Total	57.85
OUTPUT	
Sensible Heat (Streams 3 & 7)	3.57
Heat of Combustion (Streams 3 & 7)	44.99
Steam Enthalpy (Streams 3 & 6)	4.56
Total	53.12
% Balance 92	

(1) Air to Pretreater
(2) Steam to Pretreater
(3) Pretreater Overhead
(4) Raw Coal to Pretreater
(5) Gas From Char Cooler
(6) Cooling Water to Cooling Coil in Pretreater
(7) Pretreated Char to Char Cooler

Figure A-12. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 71 FOR STEADY PERIOD FROM 4/26/78 (1700 Hours) TO 4/27/78 (0500 Hours)



MATERIAL BALANCE, %

C --
H --
O --
ASH --

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	38.17	33.62
CO_2	26.59	32.80
C_2H_6	0.29	0.39
N_2	10.27	9.58
H_2S	0.71	1.04
CH_4	15.11	14.62
CO	8.86	7.95
mol/hr (dry)	167	193

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.21	77.10	67.79
H	3.49	2.72	1.11
N	1.37	1.09	0.31
S	4.03	2.55	1.00
ASH	12.37	11.66	29.27
O	8.53	4.88	0.52
lb/hr (dry)	3889		

FEED MOISTURE, wt % 1.3

FEED SLURRY CONCN, wt % 30.76

LIQUID STREAMS

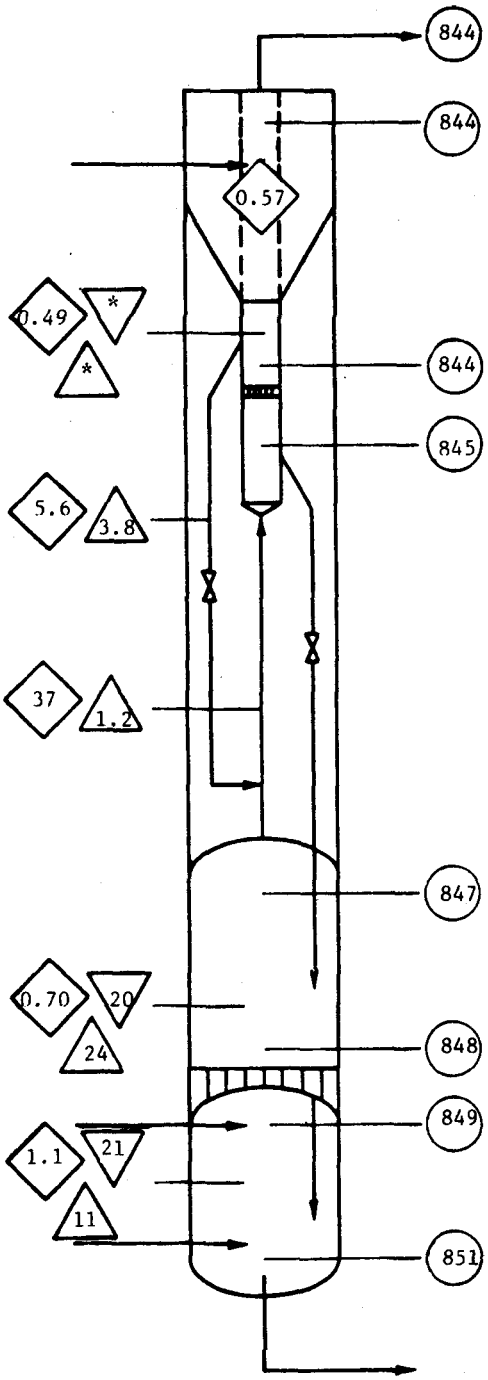
	7	8	1
	lb/hr		
H_2O	7159	--	--
LIGHT OIL	--	8802	8752

GAS FEED STREAMS

2	3	5	9
mol/hr			
411	58	25	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-13. HYGAS REACTOR DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/17/78 (1400 Hours) TO 4/17/78 (2100 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.32
lb STEAM/lb CARBON (net) = 3.50
lb OXYGEN/lb COAL FED = 0.20
lb STEAM/lb COAL FED = 2.2
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 93

BY ASH BALANCE

MAF† COAL GASIFIED, % = 66
CARBON GASIFIED, % = 59

METHANE YIELD, SCF/lb COAL FED = 2.8

EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 4.8

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 10
SOG = 25

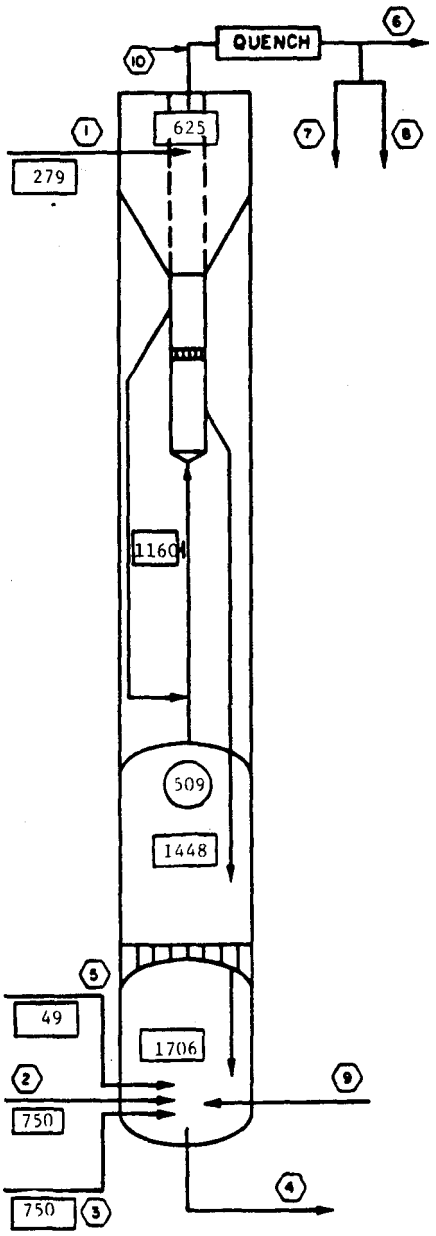
†MOISTURE ASH FREE.

Figure A-14. HYGAS REACTOR ENGINEERING DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/17/78 (1400 Hours) TO 4/17/78 (2100 Hours)

Table A-7. MATERIAL BALANCE SUMMARY FOR HYGAS GASIFIER FOR TEST 71 FROM 4/20/78 (2300 Hours) TO 4/23/78 (1000 Hours)

Basis = 1 hour. All units in pounds unless noted otherwise.

INPUT		C	H	O	N	S	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.20	3.43	8.43	1.40	4.14	12.40	100
	Coal (Dry)	2826	138	339	57	167	499	4026
	Moisture		6	53				59
Sparger	Oxygen			670				670
	Steam		463	3677				4140
Burner	Oxygen			0				0
	Steam		0	0				0
	Hydrogen		0					0
Stripping Ring	Steam		74	586				660
Nitrogen From Purges					527			527
Pump Seal Flush			56	444				500
Water to Cyclone Pot			430	3406				3836
Light-Oil In		7139	682					7821
TOTAL INPUT		9965	1849	9175	584	167	499	22,239
OUTPUT								
Reactor Overhead	Wt % (Dry)	76.81	2.92	4.79	1.19	2.92	11.38	100
	Dust (Dry)	760	29	47	12	29	112	989
Spent Char	Wt % (Dry)	59.09	0.87	0.44	0.28	1.23	38.09	100
	Char (Dry)	565	8	4	3	12	365	957
Product Gas After Quench	Total (Dry)	1135	255	1815	500	31		3736
	Components H_2		137					137
	CO_2	578		1541				2119
	C_2H_6	17	4					21
	H_2S		2			31		33
	N_2				500			500
	CH_4	334	112					446
	CO	206		274				480
Water Out + Dissolved Materials		17	844	7093	21	5		7980
Toluene Storage Tank Vent Gases		84	6	184	12	12		298
Stripper Vent Gas		22	4	32	21	1		80
Light-Oil Out		7198	687					7885
Estimated Oil Losses		--	--					--
TOTAL OUTPUT		9781	1833	9175	569	90	477	21,925
Net (Output — Input)		-184	-16	0	-15	-77	-22	-314
% Balance (Output/Input)		98	99	100	98	54	96	99



MATERIAL BALANCE, %

C	98
H	99
O	100
ASH	96

⬡ STREAM No.
○ PRESSURE, psig
□ TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	37.88	36.29
CO_2	26.55	28.43
C_2H_6	0.39	0.41
N_2	9.84	9.90
H_2S	0.53	0.70
CH_4	15.37	15.13
CO	9.44	9.13
mol/hr (dry)	181	192

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.20	76.81	59.09
H	3.43	2.92	0.87
N	1.40	1.19	0.28
S	4.14	2.92	1.23
ASH	12.40	11.38	38.09
O	8.43	4.79	0.44
lb/hr (dry)	4026	989	957

FEED MOISTURE, wt % 1.4

FEED SLURRY CONCN, wt % 34

LIQUID STREAMS

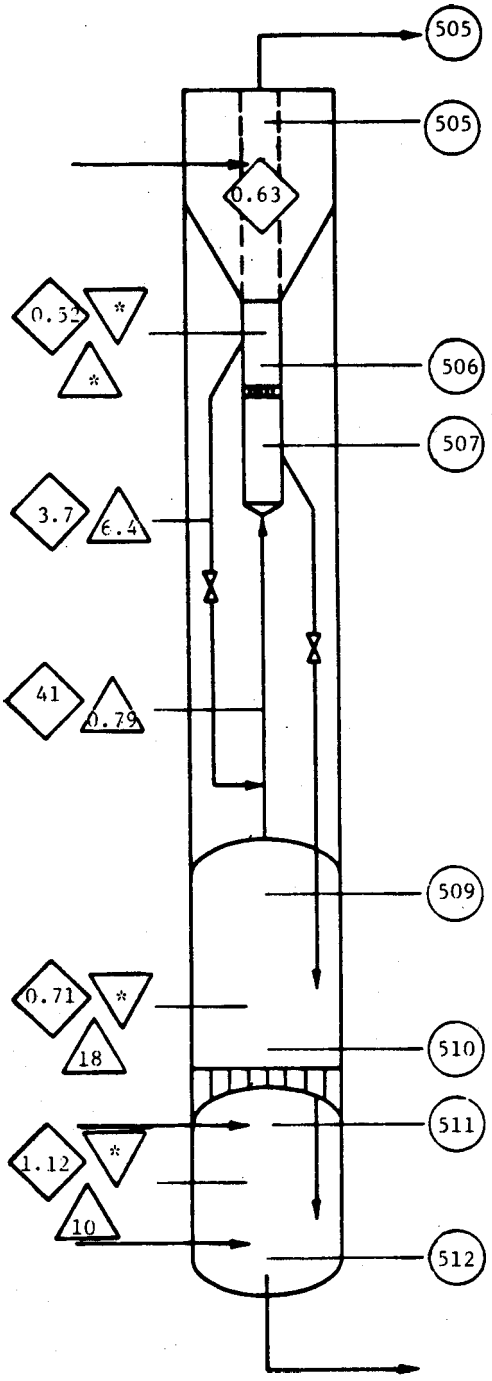
	7	8	1
	lb/hr		
H_2O	3644	--	--
LIGHT OIL	--	7885	7821

GAS FEED STREAMS

	2	3	5	9
	mol/hr			
	230	37	21	0

① FEED SLURRY
② HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
③ HIGH-PRESSURE STEAM TO STRIPPING RING
④ SPENT CHAR
⑤ HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
⑥ GASIFIER EFFLUENT AFTER QUENCH
⑦ WATER MADE
⑧ LIGHT OIL TO RECYCLE
⑨ GASES FROM EXTERNAL HEATER
⑩ REACTOR OVERHEAD

Figure A-15. HYGAS REACTOR DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/20/78 (2300 Hours) TO 4/23/78 (1000 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.32
lb STEAM/lb CARBON (net) = 2.32
lb OXYGEN/lb COAL FED = 0.17
lb STEAM/lb COAL FED = 1.19
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 90

BY ASH BALANCE

MAF† COAL GASIFIED, % = 77
CARBON GASIFIED, % = 73

METHANE YIELD, SCF/lb COAL FED = 2.74

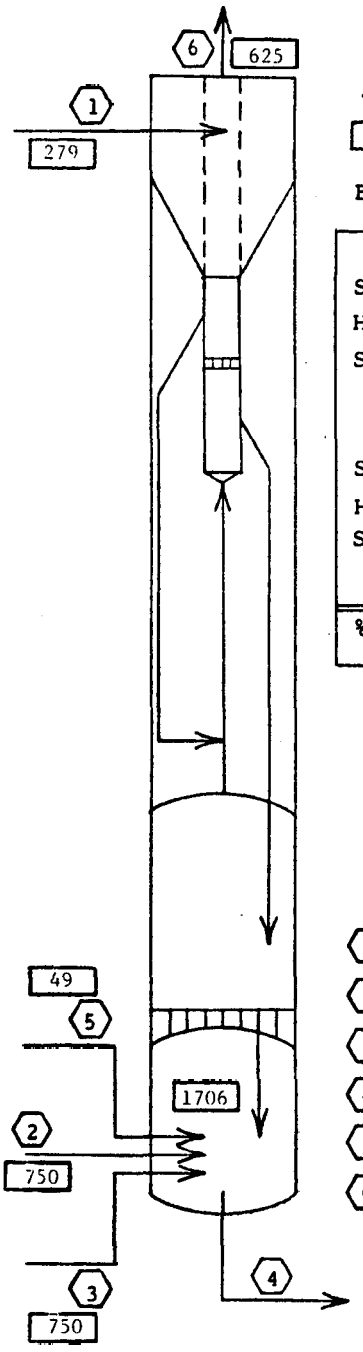
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 4.93

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 11
SOG = 18

†MOISTURE ASH FREE.

Figure A-16. HYGAS REACTOR ENGINEERING DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/20/78 (2300 Hours) TO 4/23/78 (1000 Hours)



Stream No.

Temperature, °F

Basis: 1 hour; Datum condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1 & 5)	1.0
Heat of Combustion* (Stream 1)	191.4
Steam Enthalpy (Streams 2 & 3)	6.4
Total	198.8
OUTPUT	
Sensible Heat (Streams 4 & 6)	5.0
Heat of Combustion* (Streams 4 & 6)	189.6
Steam Enthalpy + Light Oil Latent Heat (Stream 6)	5.8
Total	200.4
% Balance	101

1. Feed Slurry
2. High-Pressure Steam to Steam-Oxygen Sparger
3. High-Pressure Steam to Stripping Ring
4. Spent Char
5. High-Pressure Oxygen to Steam-Oxygen Sparger
6. Reactor Overhead

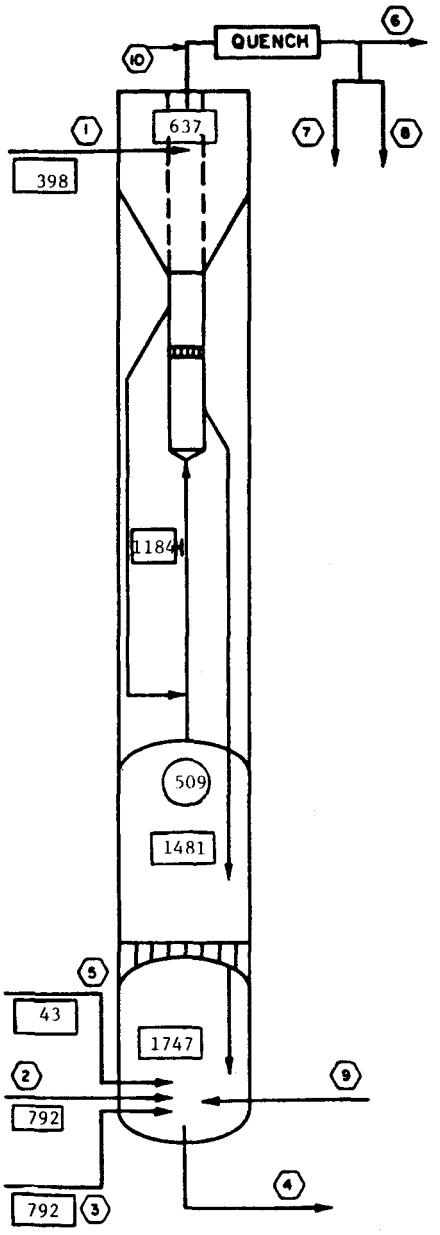
* High heating value.

Figure A-17. HYGAS REACTOR HEAT BALANCE DATA SHEET FOR TEST 71 FOR STEADY PERIOD FROM 4/20/78 (2300 Hours) TO 4/23/78 (1000 Hours)

Table A-8. MATERIAL BALANCE SUMMARY FOR HYGAS GASIFIER FOR TEST 71 FROM 4/20/78 (2300 Hours) TO 4/21/78 (1400 Hours)

Basis = 1 hour. All units in pounds unless noted otherwise.

INPUT		C	H	O	N	S	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.21	3.49	8.53	1.37	4.03	12.37	100
	Coal (Dry)	2810	140	341	55	161	495	4002
	Moisture		6	47				53
Sparger	Oxygen			639				639
	Steam		464	3679				4143
Burner	Oxygen			0				0
	Steam		0	0				0
	Hydrogen		0					0
Stripping Ring	Steam		75	592				667
Nitrogen From Purges					543			543
Pump Seal Flush			56	444				500
Water to Cyclone Pot			356	2824				3180
Light-Oil In		8213	784					8997
TOTAL INPUT		11,023	1881	8566	598	161	495	22,724
OUTPUT								
Reactor Overhead	Wt % (Dry)	76.31	2.83	5.27	1.14	2.96	11.49	100
	Dust (Dry)	652	24	45	10	25	98	854
Spent Char	Wt % (Dry)	59.66	0.88	0.69	0.29	1.13	37.35	100
	Char (Dry)	637	9	7	3	12	399	1067
Product Gas After Quench	Total (Dry)	1042	238	1685	489	39		3493
	Components H_2		130					130
	CO_2	541		1444				1985
	C_2H_6	12	3					15
	H_2S		2			39		41
	N_2				489			489
	CH_4	308	103					411
	CO	181		241				422
Water Out + Dissolved Materials		18	802	6716	10	10		7556
Toluene Storage Tank Vent Gases		34	2	74	5	5		120
Stripper Vent Gas		27	4	39	26	1		97
Light-Oil Out		8276	790					9066
Estimated Oil Losses		--	--					--
TOTAL OUTPUT		10,686	1869	8566	543	92	497	22,253
Net (Output — Input)		−337	−12	0	−55	−69	2	−471
% Balance (Output/Input)		97	99	100	91	57	100	98



MATERIAL BALANCE, %

C	97
H	99
O	100
ASH	100

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	38.17	37.28
CO_2	26.58	27.41
C_2H_6	0.29	0.30
N_2	10.28	10.50
H_2S	0.71	0.78
CH_4	15.11	14.98
CO	8.86	8.74
mol/hr (dry)	170	177

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.21	76.31	59.66
H	3.49	2.83	0.88
N	1.37	1.14	0.29
S	4.03	2.96	1.13
ASH	12.37	11.49	37.35
O	8.53	5.27	0.69
lb/hr (dry)	4002	854	1067

FEED MOISTURE, wt % 1.3

FEED SLURRY CONCN, wt % 30.8

LIQUID STREAMS

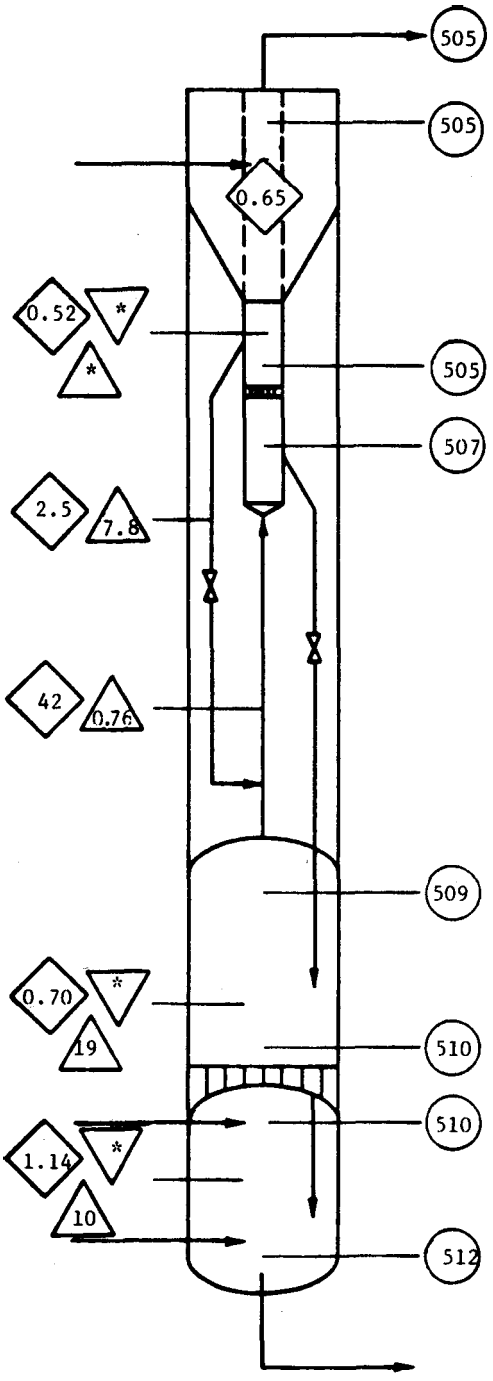
	7	8	1
	lb/hr		
H_2O	3876	--	--
LIGHT OIL	--	9066	8997

GAS FEED STREAMS

2	3	5	9
mol/hr			
230	37	20	0

1. FEED SLURRY
2. HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
3. HIGH-PRESSURE STEAM TO STRIPPING RING
4. SPENT CHAR
5. HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
6. GASIFIER EFFLUENT AFTER QUENCH
7. WATER MADE
8. LIGHT OIL TO RECYCLE
9. GASES FROM EXTERNAL HEATER
10. REACTOR OVERHEAD

Figure A-18. HYGAS REACTOR DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/20/78 (2300 Hours) TO 4/21/78 (1400 Hours)



PRESSURE, psig
DENSITY, lb/cu ft
VELOCITY, ft/s
MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.30
lb STEAM/lb CARBON (net) = 2.23
lb OXYGEN/lb COAL FED = 0.16
lb STEAM/lb COAL FED = 1.202
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 98

BY ASH BALANCE

MAF† COAL GASIFIED, % = 76
CARBON GASIFIED, % = 72

METHANE YIELD, SCF/lb COAL FED = 2.5

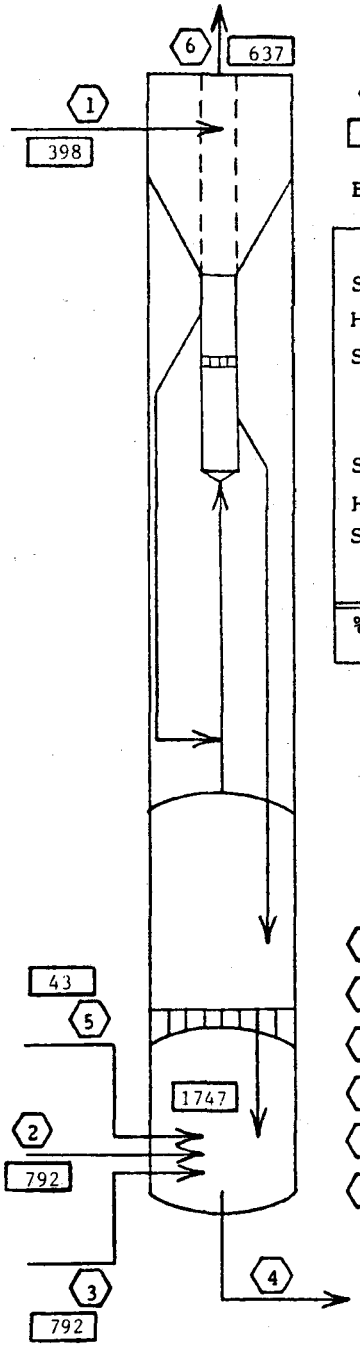
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 4.5

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 10
SOG = 19

†MOISTURE ASH FREE.

Figure A-19. HYGAS REACTOR ENGINEERING DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/20/78 (2300 Hours) TO 4/21/78 (1400 Hours)



Stream No.

Temperature, °F

Basis: 1 hour; Datum condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1 & 5)	1.89
Heat of Combustion* (Stream 1)	210.36
Steam Enthalpy (Streams 2 & 3)	6.57
Total	218.82
OUTPUT	
Sensible Heat (Streams 4 & 6)	5.56
Heat of Combustion* (Streams 4 & 6)	208.42
Steam Enthalpy + Light Oil Latent Heat (Stream 6)	6.12
Total	220.10
% Balance	100

1. Feed Slurry
2. High-Pressure Steam to Steam-Oxygen Sparger
3. High-Pressure Steam to Stripping Ring
4. Spent Char
5. High-Pressure Oxygen to Steam-Oxygen Sparger
6. Reactor Overhead

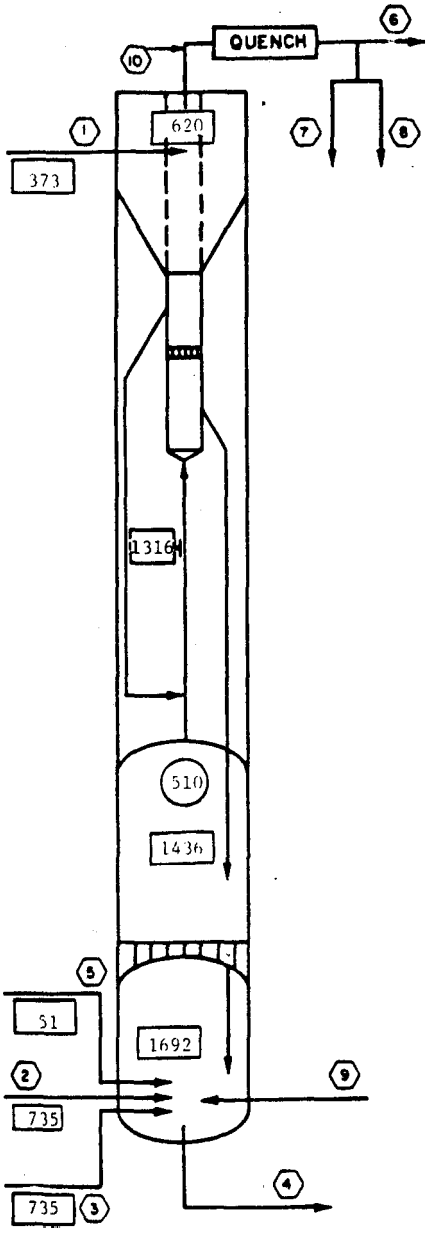
* High heating value.

Figure A-20. HYGAS REACTOR HEAT BALANCE DATA SHEET FOR TEST 71 FOR STEADY PERIOD FROM 4/20/78 (2300 Hours) TO 4/21/78 (1400 Hours)

Table A-9. MATERIAL BALANCE SUMMARY FOR HYGAS GASIFIER FOR TEST 71 FROM 4/21/78 (1700 Hours) TO 4/23/78 (1000 Hours)

Basis = 1 hour. All units in pounds unless noted otherwise.

INPUT		C	H	O	N	S	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.21	3.49	8.53	1.37	4.03	12.37	100
	Coal (Dry)	2836	141	345	55	163	500	4040
	Moisture		6	47				53
Sparger	Oxygen			682				682
	Steam		463	3678				4141
Burner	Oxygen			0				0
	Steam		0	0				0
	Hydrogen		0					0
Stripping Ring	Steam		73	583				656
Nitrogen From Purges					527			527
Pump Seal Flush			56	444				500
Water to Cyclone Pot			470	3725				4195
Light-Oil In		7032	672					7704
TOTAL INPUT		9868	1881	9504	582	163	500	22,498
OUTPUT								
Reactor Overhead	Wt % (Dry)	76.95	2.96	4.63	1.20	2.90	11.36	100
	Dust (Dry)	810	31	49	13	30	119	1052
Spent Char	Wt % (Dry)	59.60	0.89	0.34	0.30	1.27	37.60	100
	Char (Dry)	530	8	3	3	11	335	890
Product Gas After Quench	Total (Dry)	1172	261	1863	500	27		3823
	Components H_2		140					140
	CO_2	591		1574				2165
	C_2H_6	20	5					25
	H_2S		1			27		28
	N_2				500			500
	CH_4	345	115					460
	CO	216		289				505
Water Out + Dissolved Materials		33	865	7330	13	5		8246
Toluene Storage Tank Vent Gases		101	7	222	14	15		359
Stripper Vent Gas		25	4	37	25	1		92
Light-Oil Out		7092	677					7769
Estimated Oil Losses		--	--					--
TOTAL OUTPUT		9763	1853	9504	568	89	454	22,231
Net (Output — Input)		-105	-28	0	-14	-74	-46	-267
% Balance (Output/Input)		99	98	100	98	55	91	99



MATERIAL BALANCE, %

C	99
H	98
O	100
ASH	91

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	37.72	35.89
CO_2	26.53	28.73
C_2H_6	0.44	0.47
N_2	9.63	9.69
H_2S	0.45	0.66
CH_4	15.50	15.20
CO	9.73	9.36
mol/hr (dry)	185	198

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.21	76.95	59.60
H	3.49	2.96	0.89
N	1.37	1.20	0.30
S	4.03	2.90	1.27
ASH	12.37	11.36	37.60
O	8.53	4.63	0.34
lb/hr (dry)	4040	1052	890

FEED MOISTURE, wt % 1.3

FEED SLURRY CONCN, wt % 35

LIQUID STREAMS

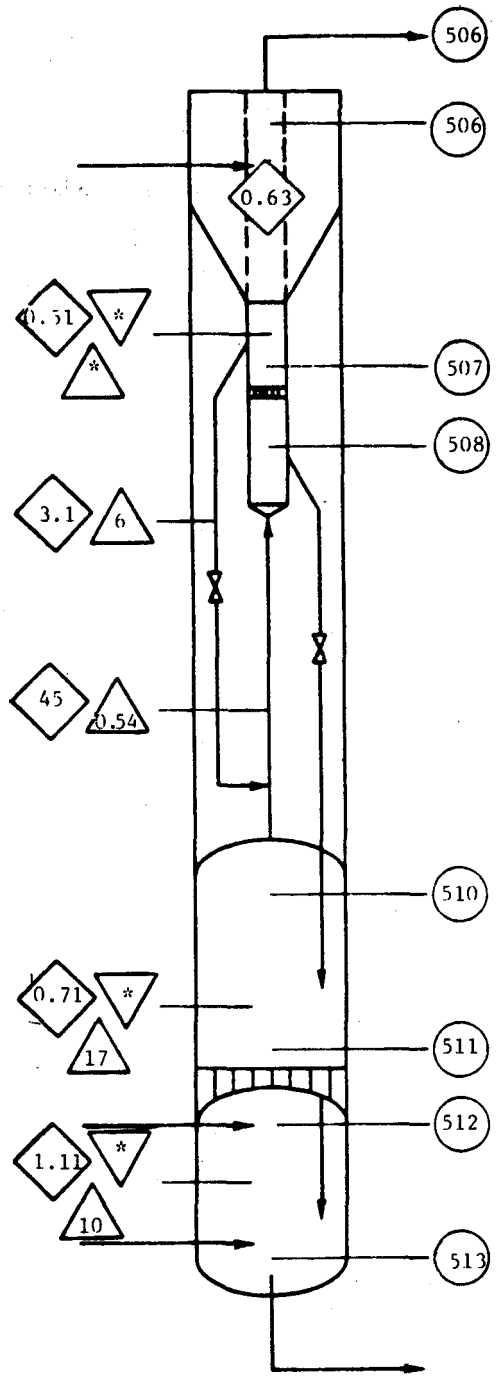
	7	8	1
	lb/hr		
H_2O	3551	--	--
LIGHT OIL	--	7769	7704

GAS FEED STREAMS

2	3	5	9
mol/hr			
230	36	21	0

1. FEED SLURRY
2. HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
3. HIGH-PRESSURE STEAM TO STRIPPING RING
4. SPENT CHAR
5. HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
6. GASIFIER EFFLUENT AFTER QUENCH
7. WATER MADE
8. LIGHT OIL TO RECYCLE
9. GASES FROM EXTERNAL HEATER
10. REACTOR OVERHEAD

Figure A-21. HYGAS REACTOR DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/21/78 (1700 Hours) TO 4/23/78 (1000 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.34
lb STEAM/lb CARBON (net) = 2.37
lb OXYGEN/lb COAL FED = 0.17
lb STEAM/lb COAL FED = 1.19
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 88

BY ASH BALANCE

MAF† COAL GASIFIED, % = 77
CARBON GASIFIED, % = 72

METHANE YIELD, SCF/lb COAL FED = 2.83

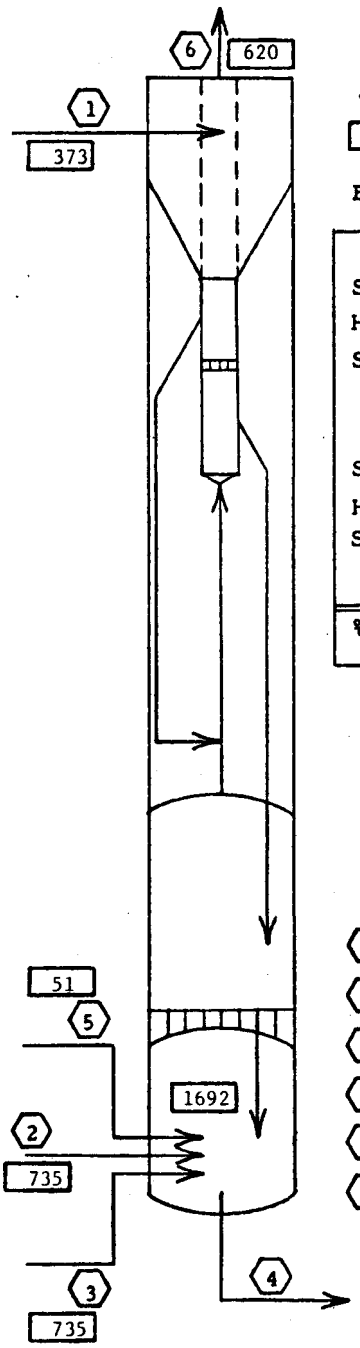
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 5.09

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 11
SOG = 18

†MOISTURE ASH FREE

Figure A-22. HYGAS REACTOR ENGINEERING DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/21/78 (1700 Hours) TO 4/23/78 (1000 Hours)



Stream No.

Temperature, °F

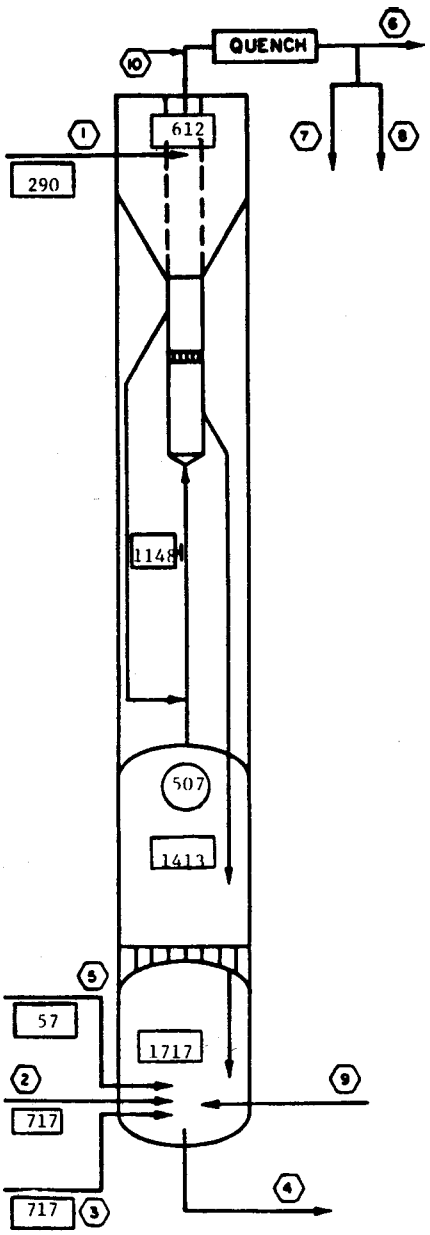
Basis: 1 hour; Datum condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1 & 5)	1.55
Heat of Combustion* (Stream 1)	189.14
Steam Enthalpy (Streams 2 & 3)	6.38
Total	197.07
OUTPUT	
Sensible Heat (Streams 4 & 6)	4.82
Heat of Combustion* (Streams 4 & 6)	188.22
Steam Enthalpy + Light Oil Latent Heat (Stream 6)	5.55
Total	198.59
% Balance	101

1. Feed Slurry
2. High-Pressure Steam to Steam-Oxygen Sparger
3. High-Pressure Steam to Stripping Ring
4. Spent Char
5. High-Pressure Oxygen to Steam-Oxygen Sparger
6. Reactor Overhead

* High heating value.

Figure A-23. HYGAS REACTOR HEAT BALANCE DATA SHEET FOR TEST 71 FOR STEADY PERIOD FROM 4/21/78 (2300 Hours) TO 4/23/78 (1000 Hours)



MATERIAL BALANCE, %

C
H
O
ASH

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	35.67	34.42
CO_2	27.42	29.23
C_2H_6	0.44	0.47
N_2	9.14	9.05
H_2S	0	0.11
CH_4	16.88	16.68
CO	10.45	10.04
mol/hr (dry)	187	196

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.21	77.04	60.28
H	3.49	2.69	0.94
N	1.37	1.13	0.32
S	4.03	2.64	1.69
ASH	12.37	12.04	36.63
O	8.53	4.41	0.14
lb/hr (dry)	4003		

FEED MOISTURE, wt % 1.3

FEED SLURRY CONCN, wt % 33.9

LIQUID STREAMS

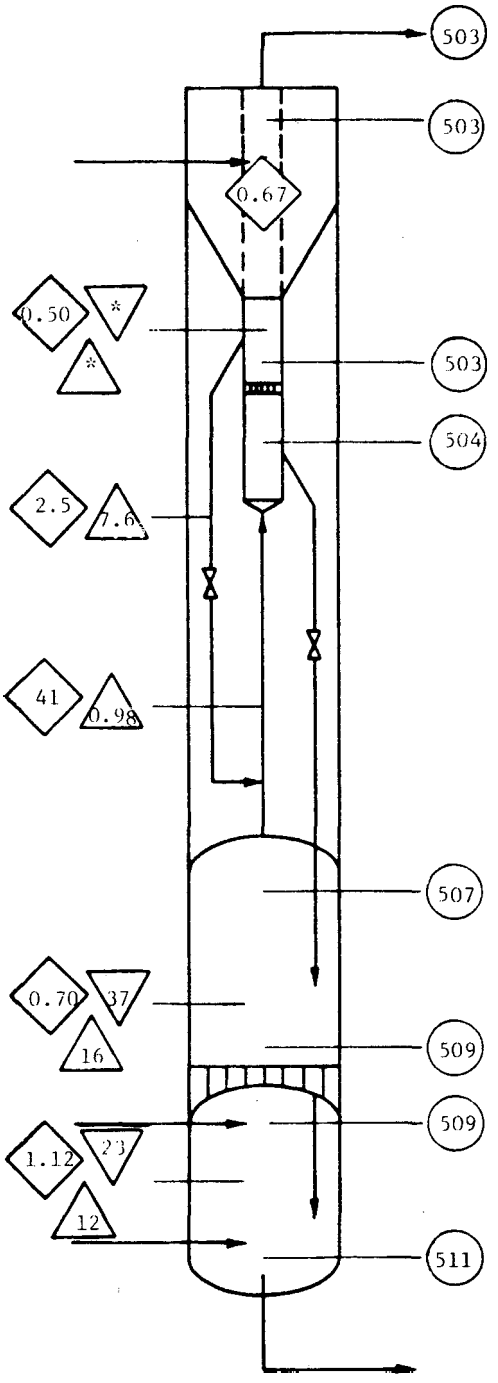
	7	8	1
	lb/hr		
H_2O	3464	--	--
LIGHT OIL	--	7866	7797

GAS FEED STREAMS

2	3	5	9
mol/hr			
226	35	23	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-24. HYGAS REACTOR DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/25/78 (2100 Hours) TO 4/26/78 (2100 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN / lb CARBON (net) = 0.34
lb STEAM / lb CARBON (net) = 2.16
lb OXYGEN / lb COAL FED = 0.19
lb STEAM / lb COAL FED = 1.17
lb COAL FED / 1000 SCF REACTOR PRODUCT GAS = 87

BY ASH BALANCE

MAF† COAL GASIFIED, % = 76
CARBON GASIFIED, % = 71

METHANE YIELD, SCF/lb COAL FED = 3.1

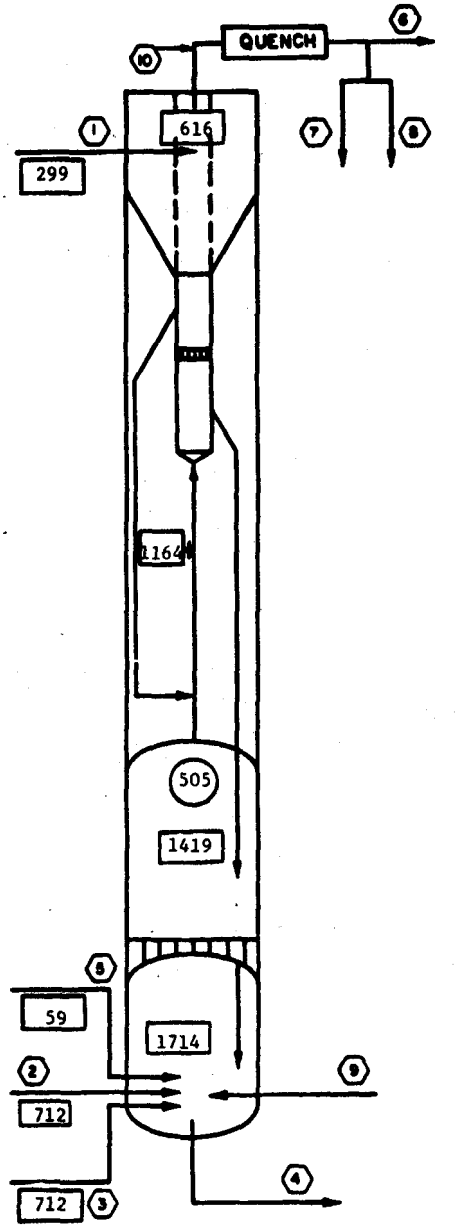
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 5.3

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 16
SOG = 17

†MOISTURE ASH FREE.

Figure A-25. HYGAS REACTOR ENGINEERING DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/25/78 (2100 Hours) TO 4/26/78 (2100 Hours)



MATERIAL BALANCE, %

C
H
O
ASH

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	35.67	34.13
CO_2	27.42	29.29
C_2H_6	0.44	0.47
N_2	9.14	9.32
H_2S	0	0.19
CH_4	16.88	16.57
CO	10.45	10.04
mol/hr (dry)	189	203

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.21	77.66	61.18
H	3.49	2.67	0.93
N	1.37	1.12	0.32
S	4.03	2.56	1.72
ASH	12.37	11.71	35.85
O	8.53	4.28	0
lb/hr (dry)	4006		

FEED MOISTURE, wt % 1.3

FEED SLURRY CONCN, wt % 34.3

LIQUID STREAMS

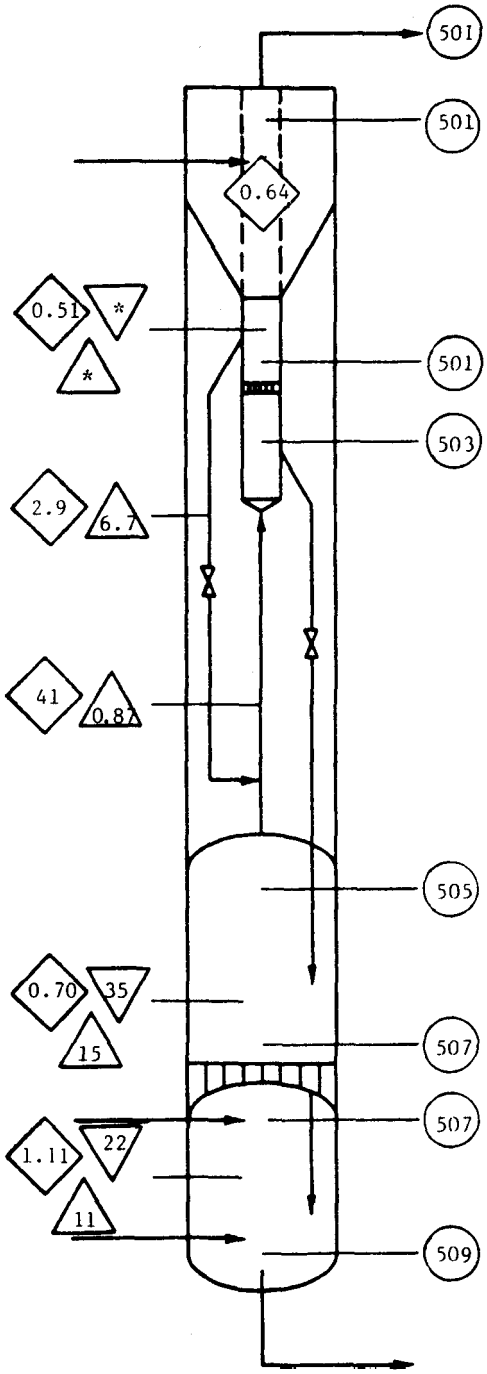
	7	8	1
	lb/hr		
H_2O	3400	--	--
LIGHT OIL	--	8975	8901

GAS FEED STREAMS

2	3	5	9
mol/hr			
225	35	23	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-26. HYGAS REACTOR DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/26/78 (0100 Hours) TO 4/26/78 (1600 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
• NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.33
lb STEAM/lb CARBON (net) = 2.10
lb OXYGEN/lb COAL FED = 0.19
lb STEAM/lb COAL FED = 1.17
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 85

BY ASH BALANCE

MAF† COAL GASIFIED, % = 75
CARBON GASIFIED, % = 70

METHANE YIELD, SCF/lb COAL FED = 3.2

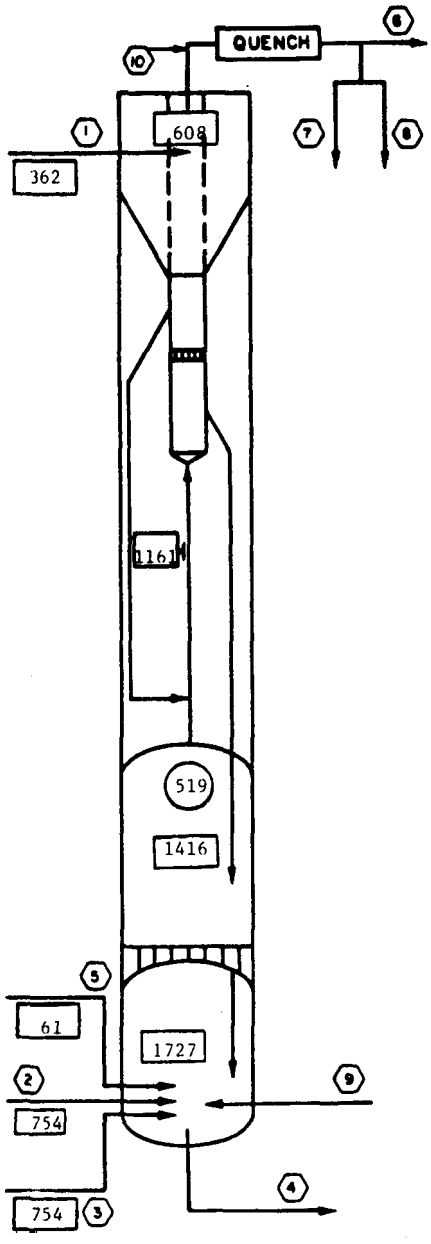
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 5.5

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 16
SOG = 17

†MOISTURE ASH FREE.

Figure A-27. HYGAS REACTOR ENGINEERING DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/26/78 (0100 Hours) TO 4/26/78 (1600 Hours)



MATERIAL BALANCE, %

C
H
O
ASH

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	34.25	34.21
CO_2	29.39	29.41
C_2H_6	0.48	0.48
N_2	9.10	9.14
H_2S	0.08	0.08
CH_4	17.32	17.26
CO	9.38	9.42
mol/hr (dry)	188	191

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.21	78.87	58.10
H	3.49	2.62	0.87
N	1.37	1.05	0.29
S	4.03	2.41	1.60
ASH	12.37	11.96	38.95
O	8.53	3.09	0.19
lb/hr (dry)	3942		

FEED MOISTURE, wt % 1.3

FEED SLURRY CONCN, wt % 31

LIQUID STREAMS

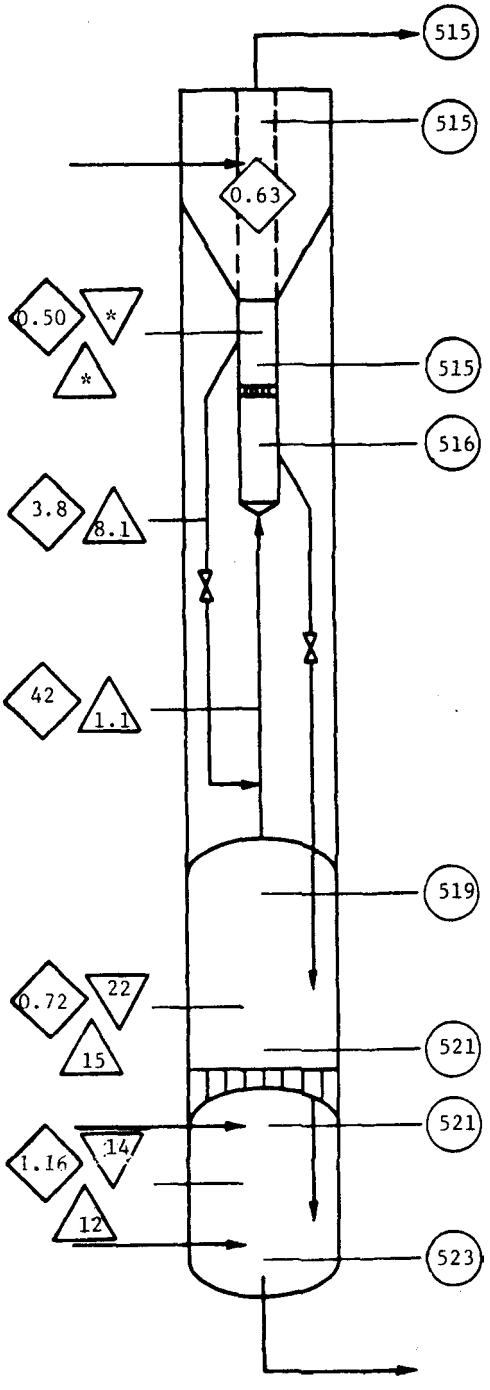
	7	8	1
	lb/hr		
H_2O	3877	--	--
LIGHT OIL	--	8882	8806

GAS FEED STREAMS

2	3	5	9
mol/hr			
242	34	23	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-28. HYGAS REACTOR DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/27/78 (1300 Hours) TO 4/28/78 (0200 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/ lb CARBON (net) = 0.32
lb STEAM/ lb CARBON (net) = 2.07
lb OXYGEN / lb COAL FED = 0.19
lb STEAM / lb COAL FED = 1.28
lb COAL FED / 1000 SCF REACTOR PRODUCT GAS = 125.4

BY ASH BALANCE

MAF† COAL GASIFIED, % = 78
CARBON GASIFIED, % = 74

METHANE YIELD, SCF/lb COAL FED = 2.3

EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 3.8

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 17
SOG = 16

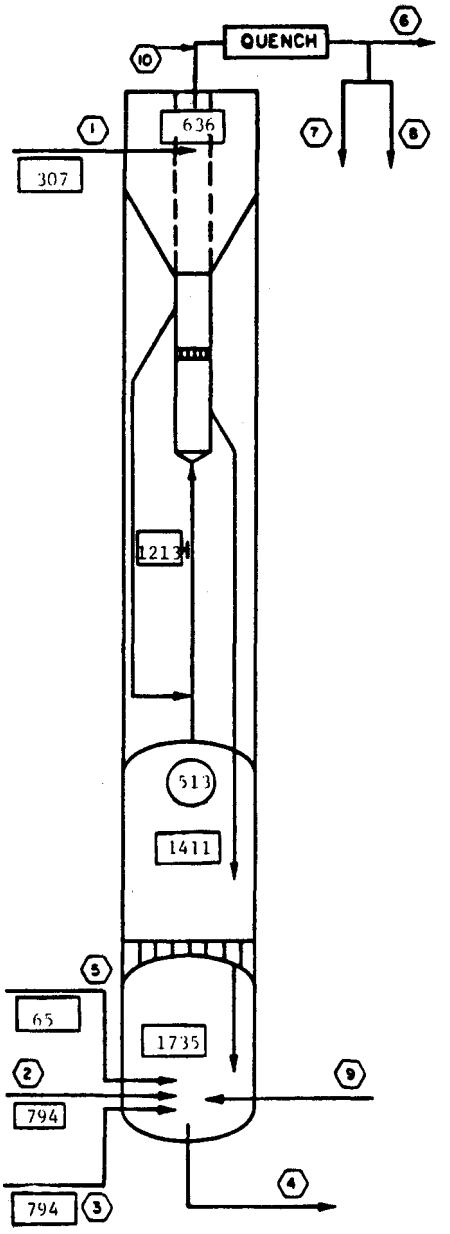
†MOISTURE ASH FREE.

Figure A-29. HYGAS REACTOR ENGINEERING DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/27/78 (1300 Hours) TO 4/28/78 (0200 Hours)

Table A-10. MATERIAL BALANCE SUMMARY FOR HYGAS GASIFIER FOR TEST 71 FROM 4/28/78 (0600 Hours) TO 4/28/78 (1200 Hours)

Basis = 1 hour. All units in pounds unless noted otherwise.

INPUT		C	H	O	N	S	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.21	3.49	8.53	1.37	4.03	12.37	100
	Coal (Dry)	2766	138	336	54	159	487	3940
	Moisture		6	46				52
Sparger	Oxygen			745				745
	Steam		450	3576				4026
Burner	Oxygen			0				0
	Steam		0	0				0
	Hydrogen		0					0
Stripping Ring	Steam		68	542				610
Nitrogen From Purges					486			486
Pump Seal Flush			56	444				500
Water to Cyclone Pot			313	2486				2800
Light-Oil In		13,539	1292					14,831
TOTAL INPUT		16,305	2323	8175	540	159	487	27,990
OUTPUT								
Reactor Overhead	Wt % (Dry)	79.50	2.62	3.69	1.13	2.31	10.75	100
	Dust (Dry)	838	28	39	12	24	113	1054
Spent Char	Wt % (Dry)	41.95	0.84	0.13	0.23	1.04	55.81	100
	Char (Dry)	290	6	1	2	7	387	693
Product Gas After Quench	Total (Dry)	1146	240	1884	417	0		3687
	Components H_2		126					126
	CO_2	614		1638				2252
	C_2H_6	17	4					21
	H_2S		0			0		0
	N_2				417			417
	CH_4	330	110					440
	CO	185		246				431
Water Out + Dissolved Materials		14	704	5971	22	6		6717
Toluene Storage Tank Vent Gases		117	11	244	26	13		411
Stripper Vent Gas		24	4	36	24	1		89
Light-Oil Out		13,597	1297					14,894
Estimated Oil Losses		--	--					--
TOTAL OUTPUT		16,026	2290	8175	503	51	500	27,545
Net (Output — Input)		-279	-33	0	-37	-108	13	-445
% Balance (Output/Input)		98	99	100	93	32	103	98



MATERIAL BALANCE, %

C	98
H	99
O	100
ASH	103

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	36.40	34.60
CO_2	29.68	31.71
C_2H_6	0.41	0.47
N_2	8.63	8.86
H_2S	0	0.23
CH_4	15.95	15.59
CO	8.93	8.54
mol/hr (dry)	168	188

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.21	79.50	41.95
H	3.49	2.62	0.84
N	1.37	1.13	0.23
S	4.03	2.31	1.04
ASH	12.37	10.75	55.81
O	8.53	3.69	0.13
lb/hr (dry)	3940	1054	693

FEED MOISTURE, wt % 1.3

FEED SLURRY CONCN, wt % 21

LIQUID STREAMS

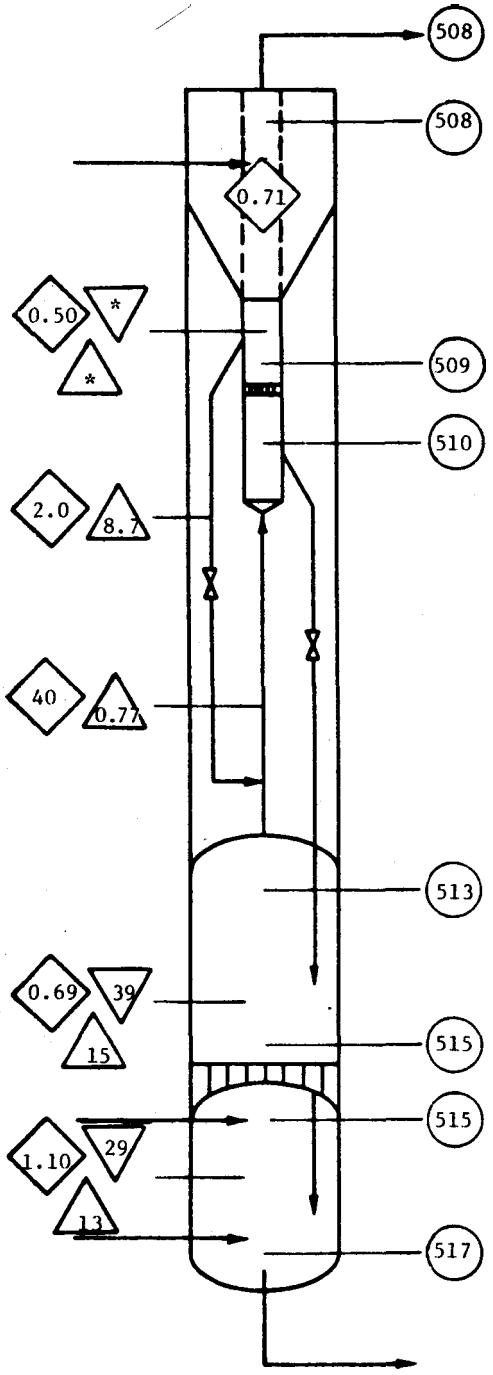
	7	8	1
	lb/hr		
H_2O	3417	--	--
LIGHT OIL	--	14,894	14,831

GAS FEED STREAMS

2	3	5	9
mol/hr			
224	34	23	0

1. FEED SLURRY
2. HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
3. HIGH-PRESSURE STEAM TO STRIPPING RING
4. SPENT CHAR
5. HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
6. GASIFIER EFFLUENT AFTER QUENCH
7. WATER MADE
8. LIGHT OIL TO RECYCLE
9. GASES FROM EXTERNAL HEATER
10. REACTOR OVERHEAD

Figure A-30. HYGAS REACTOR DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/28/78 (0600 Hours) TO 4/28/78 (1200 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.39
lb STEAM/lb CARBON (net) = 2.40
lb OXYGEN/lb COAL FED = 0.19
lb STEAM/lb COAL FED = 1.18
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 94

BY ASH BALANCE

MAF† COAL GASIFIED, % = 89
CARBON GASIFIED, % = 87

METHANE YIELD, SCF/lb COAL FED = 2.8

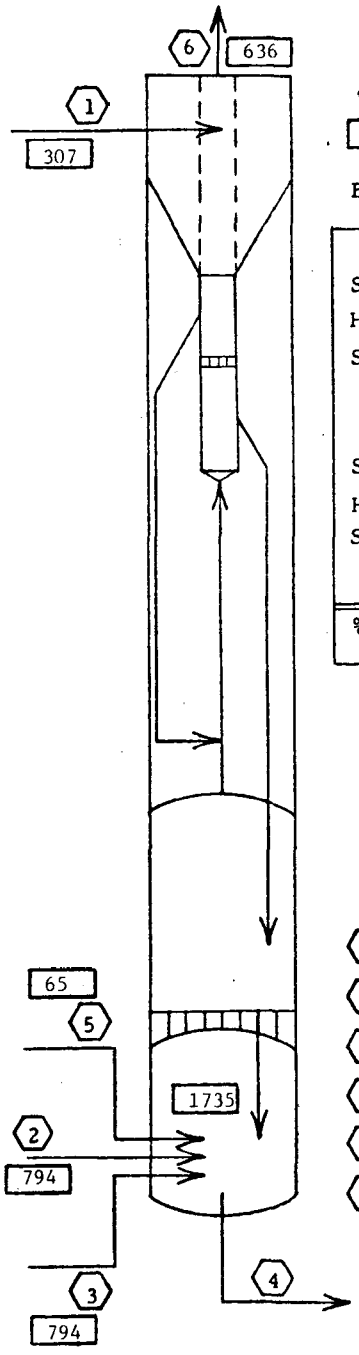
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 4.9

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 17
SOG = 16

†MOISTURE ASH FREE.

Figure A-31. HYGAS REACTOR ENGINEERING DATA FOR TEST 71 FOR STEADY PERIOD FROM 4/28/78 (0600 Hours) TO 4/28/78 (1200 Hours)



Stream No.

Temperature, °F

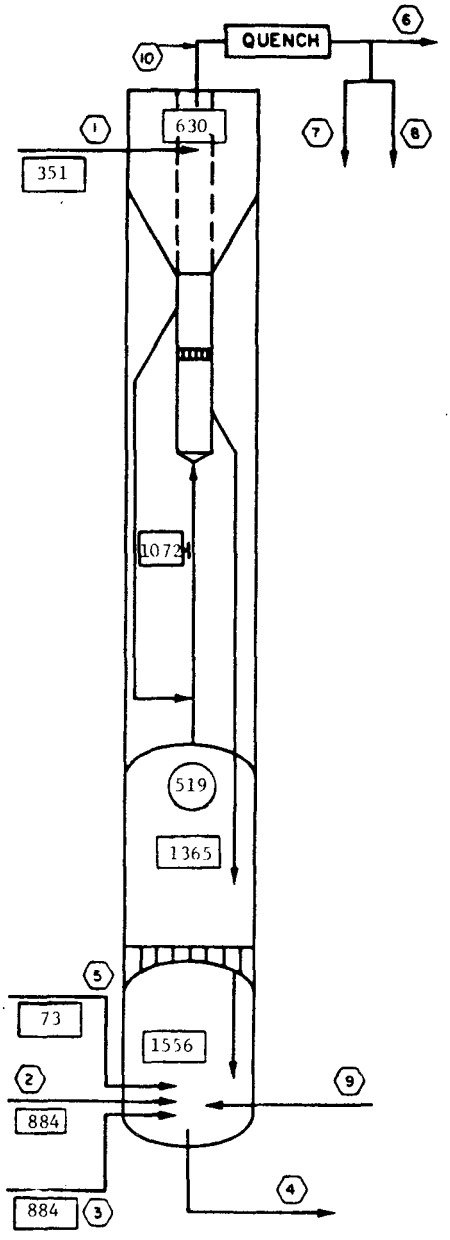
Basis: 1 hour; Datum condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1 & 5)	1.94
Heat of Combustion* (Stream 1)	319.64
Steam Enthalpy (Streams 2 & 3)	6.32
Total	327.90
OUTPUT	
Sensible Heat (Streams 4 & 6)	6.67
Heat of Combustion* (Streams 4 & 6)	314.12
Steam Enthalpy + Light Oil Latent Heat (Stream 6)	6.64
Total	327.43
% Balance	100

1. Feed Slurry
2. High-Pressure Steam to Steam-Oxygen Sparger
3. High-Pressure Steam to Stripping Ring
4. Spent Char
5. High-Pressure Oxygen to Steam-Oxygen Sparger
6. Reactor Overhead

* High heating value.

Figure A-32. HYGAS REACTOR HEAT BALANCE DATA SHEET FOR TEST 71 FOR STEADY PERIOD FROM 4/28/78 (0600 Hours) TO 4/28/78 (1200 Hours)



MATERIAL BALANCE, %

C --
H --
O --
ASH --

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	33.30	31.31
CO_2	29.64	32.34
C_2H_6	0.23	0.25
N_2	12.64	12.87
H_2S	1.94	1.87
CH_4	15.35	14.90
CO	6.90	6.45
mol/hr (dry)	100	107

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.73	76.05	66.15
H	3.73	2.73	1.09
N	1.50	1.18	0.37
S	3.70	2.61	0.84
ASH	11.33	12.03	30.24
O	9.01	5.39	1.31
lb/hr (dry)	2914	235	734

FEED MOISTURE, wt % 1.47
FEED SLURRY CONCN, wt % 34

LIQUID STREAMS

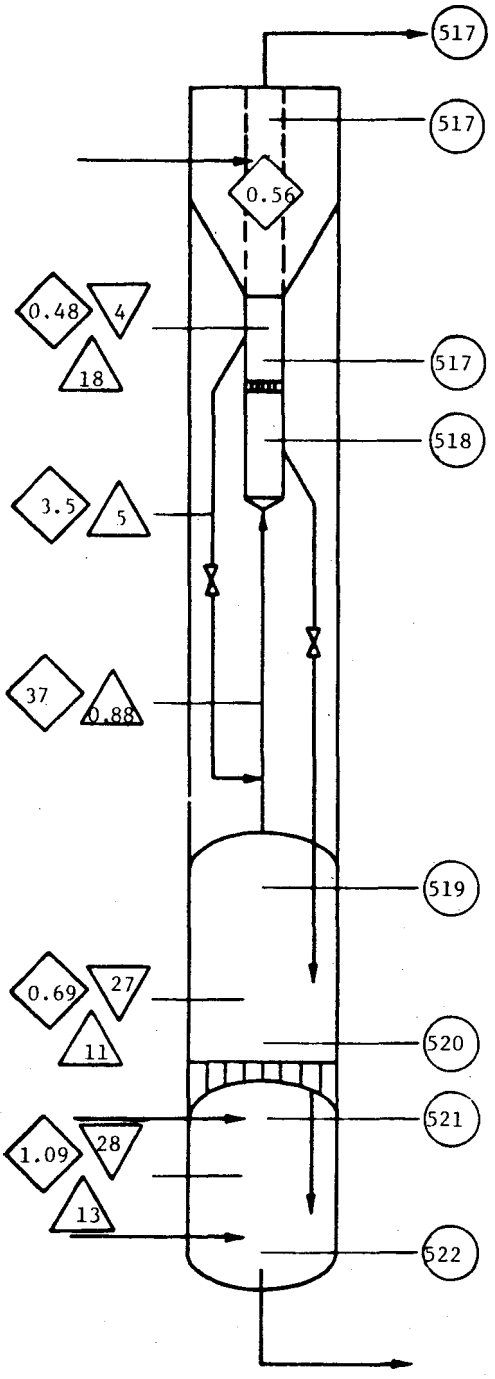
	7	8	1
	lb/hr		
H_2O	5062	--	--
LIGHT OIL	--	5850	5604

GAS FEED STREAMS

2	3	5	9
mol/hr			
208	84	15	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-33. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/10/78 (2000 Hours) TO 8/11/78 (0830 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
• NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and ocid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.26
lb STEAM/lb CARBON (net) = 2.79
lb OXYGEN/lb COAL FED = 0.17
lb STEAM/lb COAL FED = 1.80
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 136

BY ASH BALANCE

MAF† COAL GASIFIED, % = 71
CARBON GASIFIED, % = 65

METHANE YIELD, SCF/lb COAL FED = 2.08

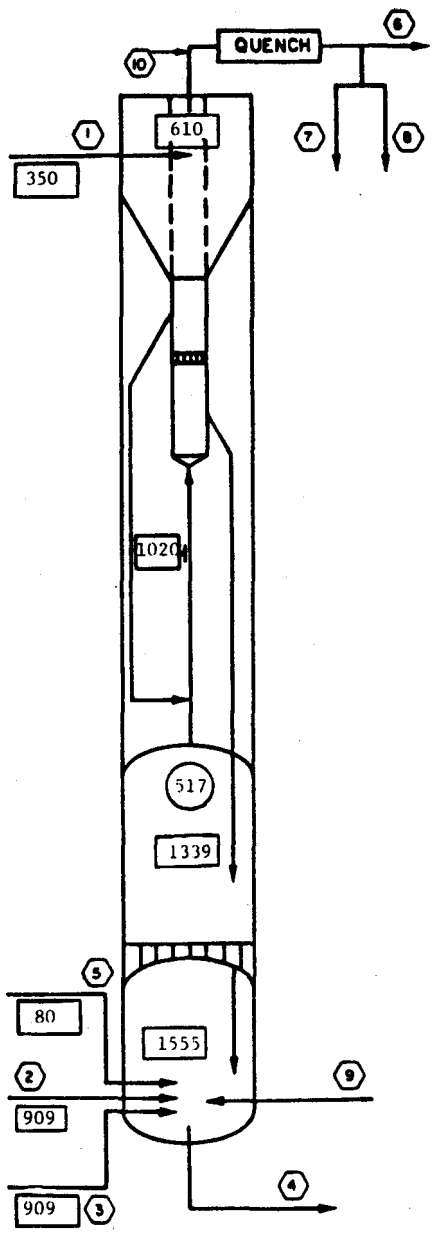
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 3.45

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 15
SOG = 16

†MOISTURE ASH FREE.

Figure A-34. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/10/78 (2000 Hours) TO 8/11/78 (0830 Hours)



MATERIAL BALANCE, %

C	--
H	--
O	--
ASH	--

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	30.74	30.66
CO_2	30.69	30.84
C_2H_6	0.32	0.32
N_2	11.78	11.78
H_2S	2.08	2.07
CH_4	17.91	17.85
CO	6.49	6.48
mol/hr (dry)	105	105

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.73	81.23	72.22
H	3.73	2.43	1.31
N	1.50	1.13	0.53
S	3.70	2.44	1.09
ASH	11.33	10.62	23.71
O	9.01	2.15	1.14
lb/hr (dry)	3531	166	1184

FEED MOISTURE, wt % 1.5

FEED SLURRY CONCN, wt % 35

LIQUID STREAMS

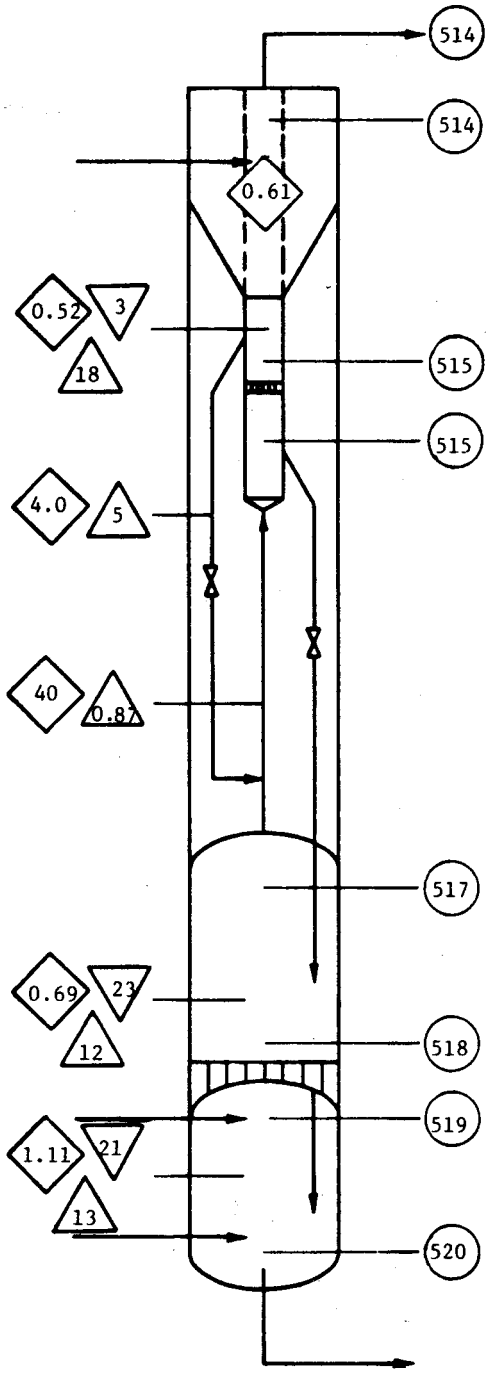
	7	8	1
	lb/hr		
H_2O	5004	--	--
LIGHT OIL	--	6691	6646

GAS FEED STREAMS

2	3	5	9
mol/hr			
184	110	16	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-35. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/11/78 (1300 Hours) TO 8/11/78 (2400 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
• NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.21
lb STEAM/lb CARBON (net) = 2.25
lb OXYGEN/lb COAL FED = 0.14
lb STEAM/lb COAL FED = 1.50
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 161

BY ASH BALANCE

MAF† COAL GASIFIED, % = 59
CARBON GASIFIED, % = 51

METHANE YIELD, SCF/lb COAL FED = 2.01

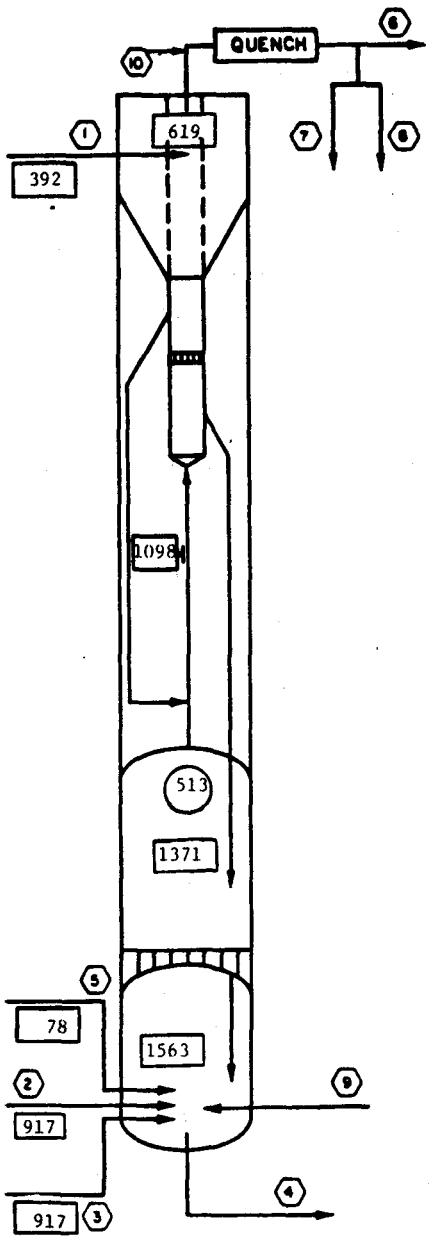
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 3.12

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 15
SOG = 16

†MOISTURE ASH FREE.

Figure A-36. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/11/78 (1300 Hours) TO 8/11/78 (2400 Hours)



MATERIAL BALANCE, %

C	--
H	--
O	--
ASH	--

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	33.24	30.63
CO_2	30.41	33.11
C_2H_6	0.22	0.25
N_2	13.09	14.03
H_2S	1.29	1.19
CH_4	14.69	14.09
CO	7.06	6.71
mol/hr (dry)	97	107

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.73	76.91	64.04
H	3.73	2.86	1.17
N	1.50	1.35	0.39
S	3.70	2.86	0.82
ASH	11.33	11.99	32.29
O	9.01	4.05	1.30
lb/hr (dry)	2988	270	632

FEED MOISTURE, wt % 1.5

FEED SLURRY CONCN, wt % 30

LIQUID STREAMS

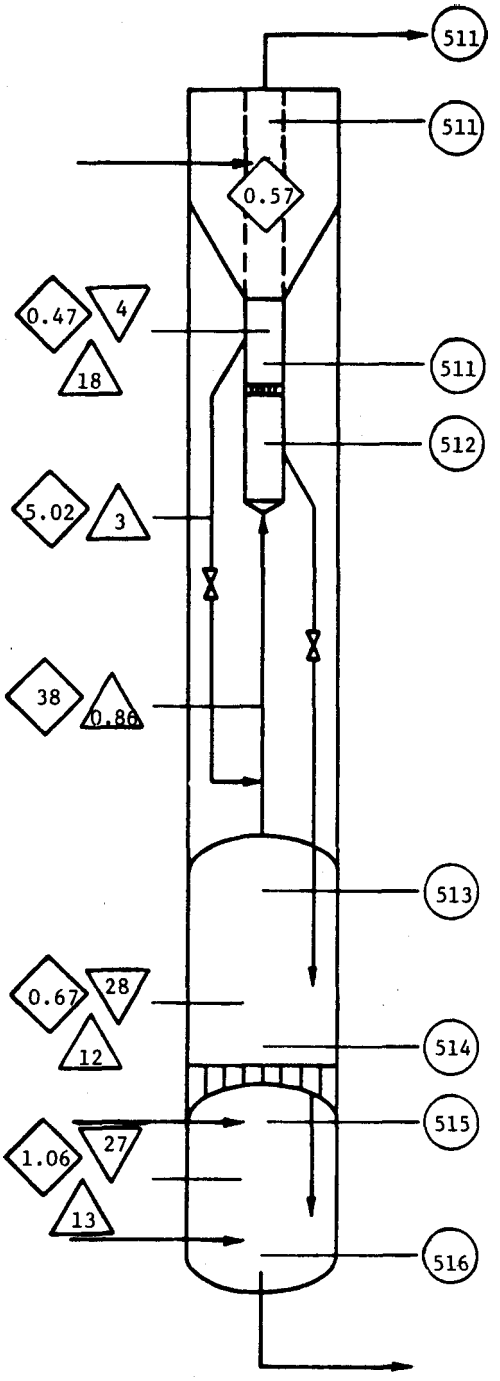
	7	8	1
	lb/hr		
H_2O	5054	--	--
LIGHT OIL	--	7058	7008

GAS FEED STREAMS

2	3	5	9
mol/hr			
139	138	16	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-37. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/12/78 (1700 Hours) TO 8/13/78 (1100 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.26
lb STEAM/lb CARBON (net) = 2.62
lb OXYGEN/lb COAL FED = 0.17
lb STEAM/lb COAL FED = 1.67
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 142

BY ASH BALANCE

MAF† COAL GASIFIED, % = 73
CARBON GASIFIED, % = 68

METHANE YIELD, SCF/lb COAL FED = 1.92

EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 3.25

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 15
SOG = 15

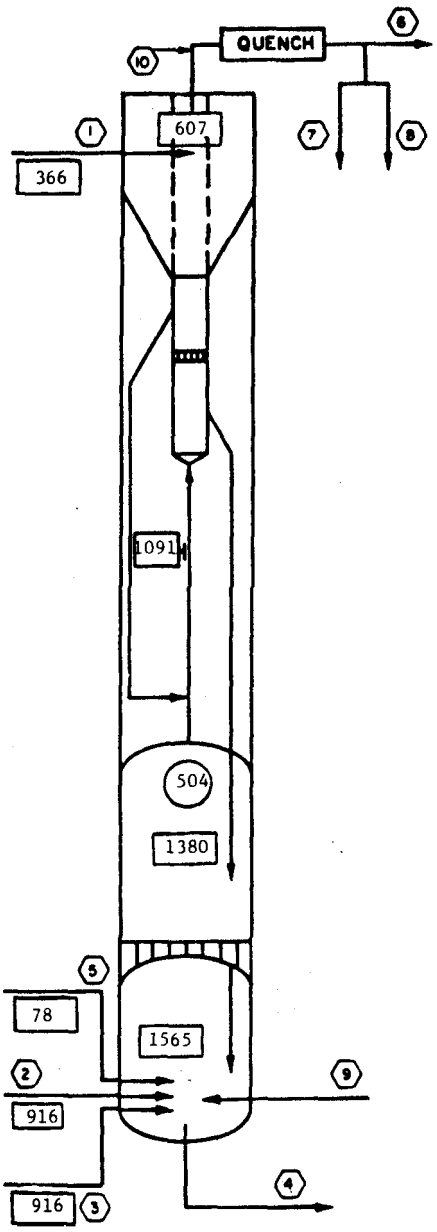
†MOISTURE ASH FREE.

Figure A-38. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/12/78 (1700 Hours) TO 8/13/78 (1100 Hours)

Table A-11. MATERIAL BALANCE SUMMARY FOR HYGAS GASIFIER TEST 74 FOR STEADY PERIOD FROM 8/14/78 (0300 Hours) TO 8/14/78 (1000 Hours)

Basis = 1 hour. All units in pounds unless noted otherwise.

INPUT		C	H	O	N	S	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.73	3.73	9.01	1.50	3.70	11.33	100
	Coal (Dry)	1748	92	223	37	91	280	2471
	Moisture		4	33				37
Sparger	Oxygen			503				503
	Steam		370	2938	0			3308
Burner	Oxygen			0				0
	Steam		0	0				0
	Hydrogen		0					0
Stripping Ring	Steam		225	1788	0			2013
Nitrogen From Purges					352			352
Pump Seal Flush			75	593				668
Cooling Water Spray			0	0				0
Water to Cyclone Pot			568	4511				5079
Light-Oil In		6042	578					6620
TOTAL INPUT		7790	1912	10,589	389	91	280	21,051
OUTPUT								
Reactor Overhead	Wt % (Dry)	75.23	2.77	4.41	1.27	2.84	13.49	100
	Dust (Dry)	146	5	9	2	6	26	194
Spent Char	Wt % (Dry)	63.32	1.11	0.98	0.38	0.81	33.40	100
	Char (Dry)	437	8	7	3	6	230	691
Product Gas After Quench	Total (Dry)	577	119	995	360	40		2091
	Components H_2		62					62
	CO_2	332		885				1217
	C_2H_6	5		1				6
	H_2S			3		40		43
	N_2				360			360
	CH_4	158	53					211
	CO	82		110				192
Water Out + Dissolved Materials		11	1195	9439	29	5		10,679
Toluene Storage Tank Vent Gases		51	3	114	10	3		181
Stripper Vent Gas		55	8	102	29	0		194
Light-Oil Out		6576	630					7025
Estimated Oil Losses								
TOTAL OUTPUT		7853	1968	10,666	433	60	256	21,235
Net (Output − Input)		63	56	77	44	−31	−24	184
% Balance (Output/Input)		101	103	101	111	66	91	101



MATERIAL BALANCE, %

C	101
H	103
O	101
ASH	91

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	33.25	31.47
CO_2	29.75	32.04
C_2H_6	0.24	0.21
N_2	13.82	13.49
H_2S	1.35	1.27
CH_4	14.19	14.02
CO	7.38	7.50
mol/hr (dry)	93	105

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.73	75.23	63.32
H	3.73	2.77	1.11
N	1.50	1.27	0.38
S	3.70	2.84	0.81
ASH	11.33	13.49	33.40
O	9.01	4.41	0.98
lb/hr (dry)	2470	194	691

FEED MOISTURE, wt % 1.5

FEED SLURRY CONCN, wt % 27

LIQUID STREAMS

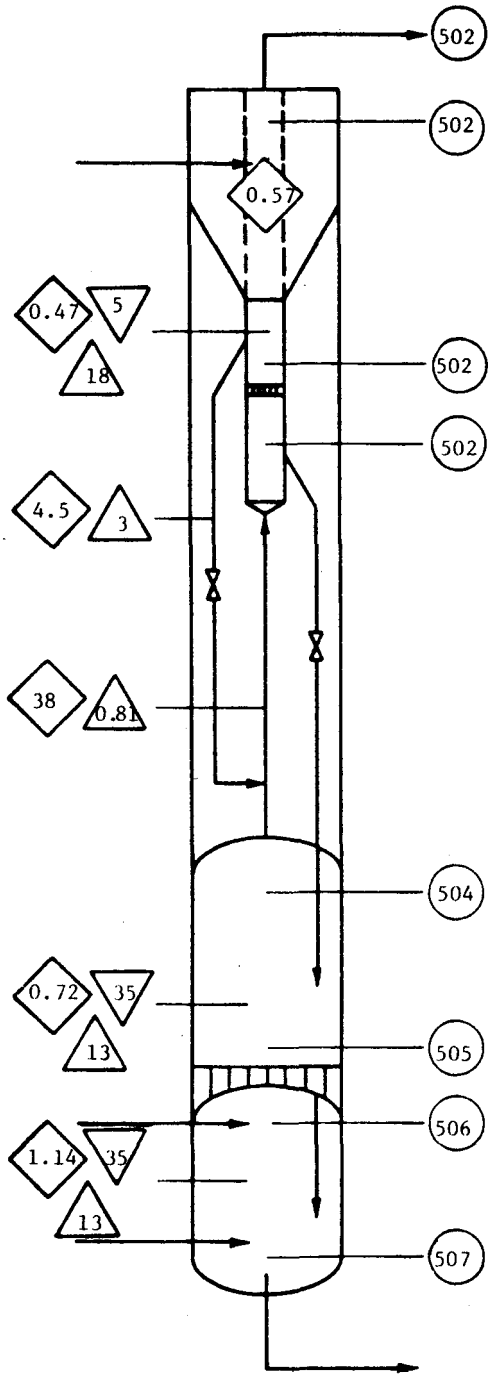
	7	8	1
	lb/hr		
H_2O	4932	--	--
LIGHT OIL	--	7205	6620

GAS FEED STREAMS

2	3	5	9
mol/hr			
184	112	16	0

1. FEED SLURRY
2. HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
3. HIGH-PRESSURE STEAM TO STRIPPING RING
4. SPENT CHAR
5. HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
6. GASIFIER EFFLUENT AFTER QUENCH
7. WATER MADE
8. LIGHT OIL TO RECYCLE
9. GASES FROM EXTERNAL HEATER
10. REACTOR OVERHEAD

Figure A-39. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/14/78 (0300 Hours) TO 8/14/78 (1000 Hours)



PRESSURE, psig
DENSITY, lb/cu ft
VELOCITY, ft/s
MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.31
lb STEAM/lb CARBON (net) = 3.32
lb OXYGEN/lb COAL FED = 0.20
lb STEAM/lb COAL FED = 2.15
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 116

BY ASH BALANCE

MAF† COAL GASIFIED, % = 75
CARBON GASIFIED, % = 70

METHANE YIELD, SCF/lb COAL FED = 2.27

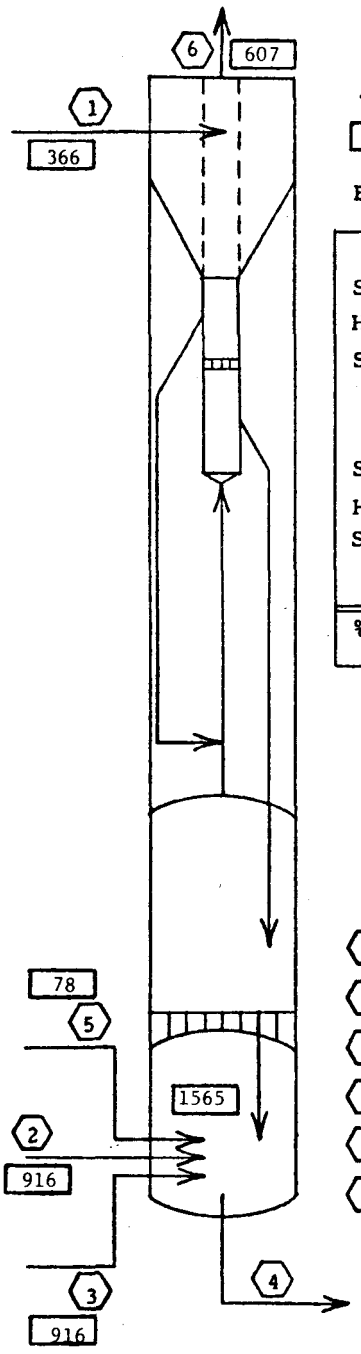
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 3.90

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 15
SOG = 17

†MOISTURE ASH FREE.

Figure A-40. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/14/78 (0300 Hours) TO 8/14/78 (1000 Hours)



Stream No.

Temperature, °F

Basis: 1 hour; Datum condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1 & 5)	8.267
Heat of Combustion* (Stream 1)	152.05
Steam Enthalpy (Streams 2 & 3)	2.524
Total	162.84
OUTPUT	
Sensible Heat (Streams 4 & 6)	3.032
Heat of Combustion* (Streams 4 & 6)	153.20
Steam Enthalpy + Light Oil Latent Heat (Stream 6)	5.615
Total	161.85
% Balance 99	

1. Feed Slurry
2. High-Pressure Steam to Steam-Oxygen Sparger
3. High-Pressure Steam to Stripping Ring
4. Spent Char
5. High-Pressure Oxygen to Steam-Oxygen Sparger
6. Reactor Overhead

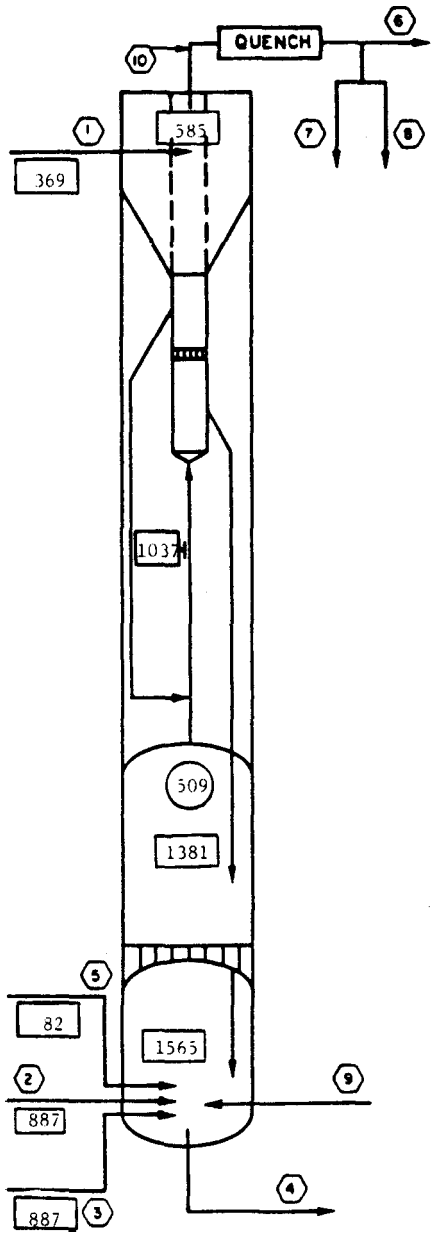
* High heating value.

Figure A-41. HYGAS REACTOR HEAT BALANCE DATA SHEET FOR TEST 74 FOR STEADY PERIOD FROM 8/14/78 (0300 Hours) TO 8/14/78 (1000 Hours)

Table A-12. MATERIAL BALANCE SUMMARY FOR HYGAS GASIFIER TEST 74 FOR STEADY PERIOD FROM 8/14/78 (1400 Hours) TO 8/15/78 (0900 Hours)

Basis = 1 hour. All units in pounds unless noted otherwise.

INPUT		C	H	O	N	S	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.73	3.73	9.01	1.50	3.70	11.33	100
	Coal (Dry)	2118	112	270	45	111	339	2995
	Moisture		5	40				45
Sparger	Oxygen			500				500
	Steam		466	3695	0			4161
Burner	Oxygen			0				0
	Steam		0	0				0
	Hydrogen		0					0
Stripping Ring	Steam		125	993	0			1118
Nitrogen From Purges					335			335
Pump Seal Flush			75	593				668
Cooling Water Spray			0	0				0
Water to Cyclone Pot			609	4834				5443
Light-Oil In		6715	643					7358
TOTAL INPUT		8833	2035	10,925	380	111	339	22,623
OUTPUT								
Reactor Overhead	Wt % (Dry)	78.08	2.65	4.11	1.30	2.69	11.16	100
	Dust (Dry)	197	7	10	3	7	28	252
Spent Char	Wt % (Dry)	68.01	1.15	1.19	0.46	0.95	28.24	100
	Char (Dry)	664	11	12	4	9	276	976
Product Gas After Quench	Total (Dry)	656	138	1087	352	52		2285
	Components H_2		69					69
	CO_2	359		958				1317
	C_2H_6	6	1					7
	H_2S		3			52		55
	N_2				352			352
	CH_4	194	65					259
	CO	97		129				226
Water Out + Dissolved Materials		11	1208	9539	26	4		10,788
Toluene Storage Tank Vent Gases		77	6	167	15	4		269
Stripper Vent Gas		40	4	71	21	0		136
Light-Oil Out		6821	653					7473
Estimated Oil Losses								
TOTAL OUTPUT		8466	2027	10,886	421	76	304	22,179
Net (Output — Input)		−367	−8	−39	41	−35	−35	−444
% Balance (Output/Input)		96	100	100	111	68	90	98



MATERIAL BALANCE, %

C	96
H	100
O	100
ASH	90

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	33.17	30.88
CO_2	29.15	32.41
C_2H_6	0.24	0.29
N_2	12.24	12.09
H_2S	1.58	1.55
CH_4	15.75	15.38
CO	7.86	7.40
mol/hr (dry)	103	114

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.73	78.08	68.01
H	3.73	2.65	1.15
N	1.50	1.30	0.46
S	3.70	2.69	0.95
ASH	11.33	11.16	28.24
O	9.01	4.11	1.19
lb/hr (dry)	2994	252	976

FEED MOISTURE, wt % 1.5

FEED SLURRY CONCN, wt % 29

LIQUID STREAMS

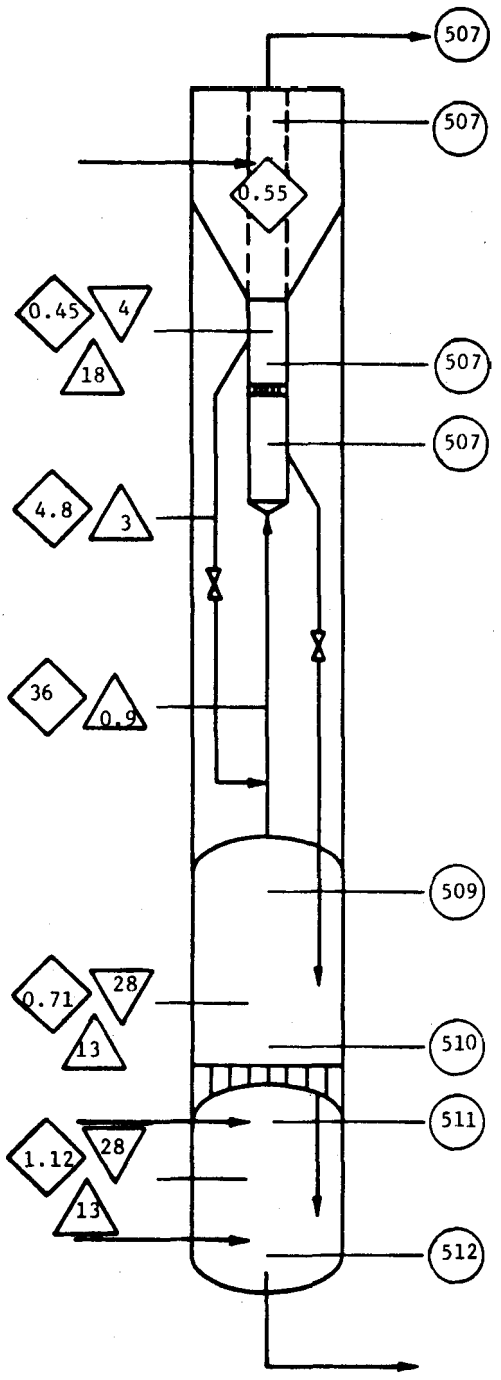
	7	8	1
	lb/hr		
H_2O	4677	--	--
LIGHT OIL	--	7473	7358

GAS FEED STREAMS

2	3	5	9
mol/hr			
231	62	16	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-42. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/14/78 (1400 Hours) TO 8/15/78 (0900 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
• NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.26
lb STEAM/lb CARBON (net) = 2.75
lb OXYGEN/lb COAL FED = 0.17
lb STEAM/lb COAL FED = 1.76
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 128

BY ASH BALANCE

MAF† COAL GASIFIED, % = 68
CARBON GASIFIED, % = 62

METHANE YIELD, SCF/lb COAL FED = 2.23

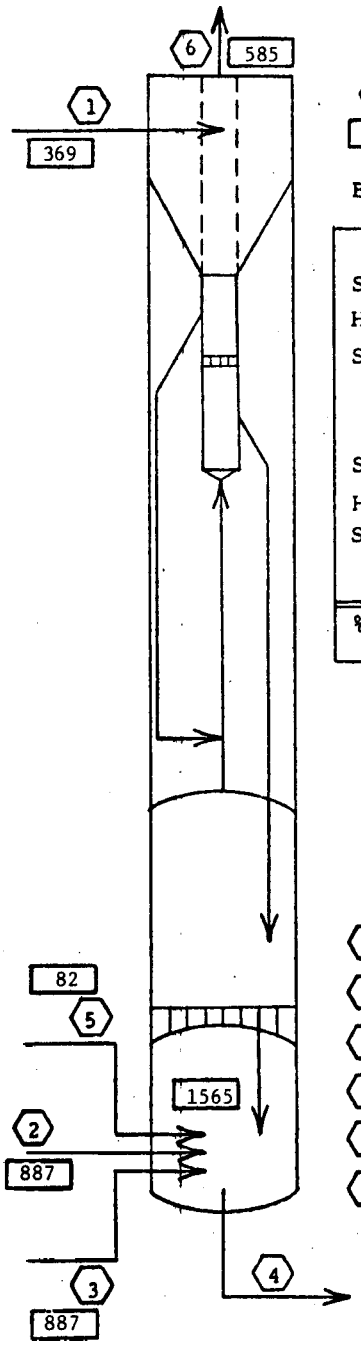
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 3.69

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 15
SOG = 17

†MOISTURE ASH FREE.

Figure A-43. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/14/78 (1400 Hours) TO 8/15/78 (0900 Hours)



Stream No.

Temperature, °F

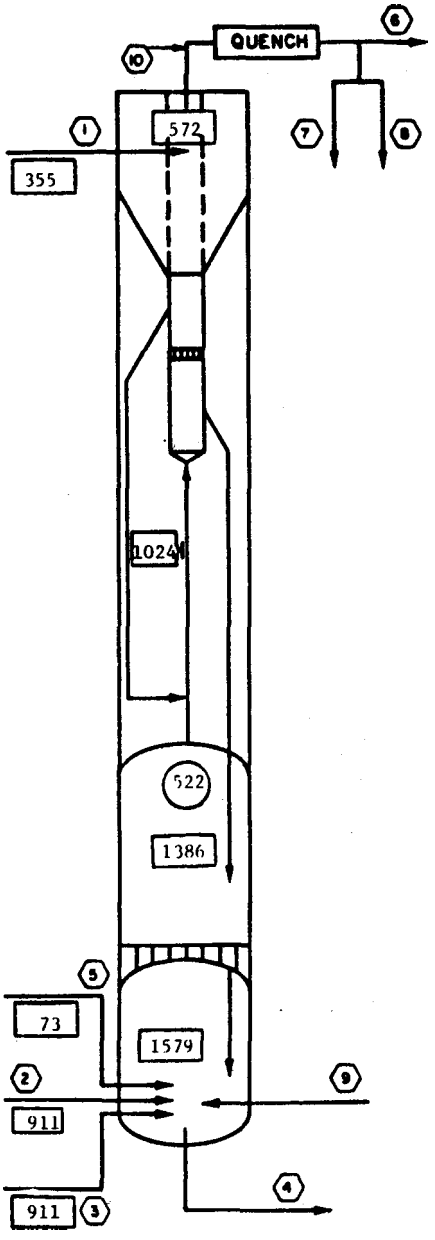
Basis: 1 hour; Datum condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1 & 5)	9.502
Heat of Combustion* (Stream 1)	172.00
Steam Enthalpy (Streams 2 & 3)	2.53
Total	184.03
OUTPUT	
Sensible Heat (Streams 4 & 6)	3.448
Heat of Combustion* (Streams 4 & 6)	163.95
Steam Enthalpy + Light Oil Latent Heat (Stream 6)	5.47
Total	172.87
% Balance 94	

1. Feed Slurry
2. High-Pressure Steam to Steam-Oxygen Sparger
3. High-Pressure Steam to Stripping Ring
4. Spent Char
5. High-Pressure Oxygen to Steam-Oxygen Sparger
6. Reactor Overhead

* High heating value.

Figure A-44. HYGAS REACTOR HEAT BALANCE DATA SHEET FOR TEST 74 FOR STEADY PERIOD FROM 8/14/78 (1400 Hours) TO 8/15/78 (0900 Hours)



MATERIAL BALANCE, %

C	--
H	--
O	--
ASH	--

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	34.82	32.57
CO_2	28.14	31.12
C_2H_6	0.30	0.35
N_2	8.68	8.82
H_2S	1.59	1.62
CH_4	18.04	17.57
CO	8.43	7.96
mol/hr (dry)	113	124

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.88	79.62	70.76
H	3.51	2.67	1.25
N	1.50	1.18	0.57
S	3.66	2.63	1.44
ASH	11.53	10.20	24.37
O	8.92	3.70	1.61
lb/hr (dry)	4002	250	1162

FEED MOISTURE, wt % 1.95

FEED SLURRY CONCN, wt % 36

LIQUID STREAMS

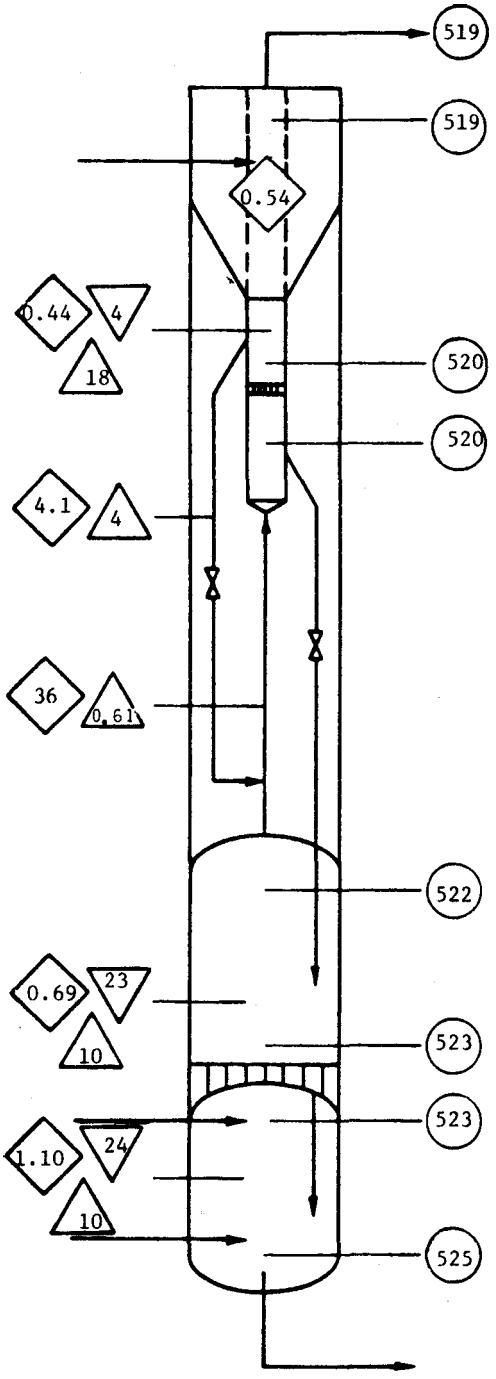
	7	8	1
	lb/hr		
H_2O	4663	--	--
LIGHT OIL	--	7211	7061

GAS FEED STREAMS

2	3	5	9
mol/hr			
231	62	16	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-45. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/16/78 (0000 Hours) TO 8/16/78 (1200 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.19
lb STEAM/lb CARBON (net) = 2.00
lb OXYGEN/lb COAL FED = 0.13
lb STEAM/lb COAL FED = 1.32
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 113

BY ASH BALANCE

MAF† COAL GASIFIED, % = 60
CARBON GASIFIED, % = 53

METHANE YIELD, SCF/lb COAL FED = 2.07

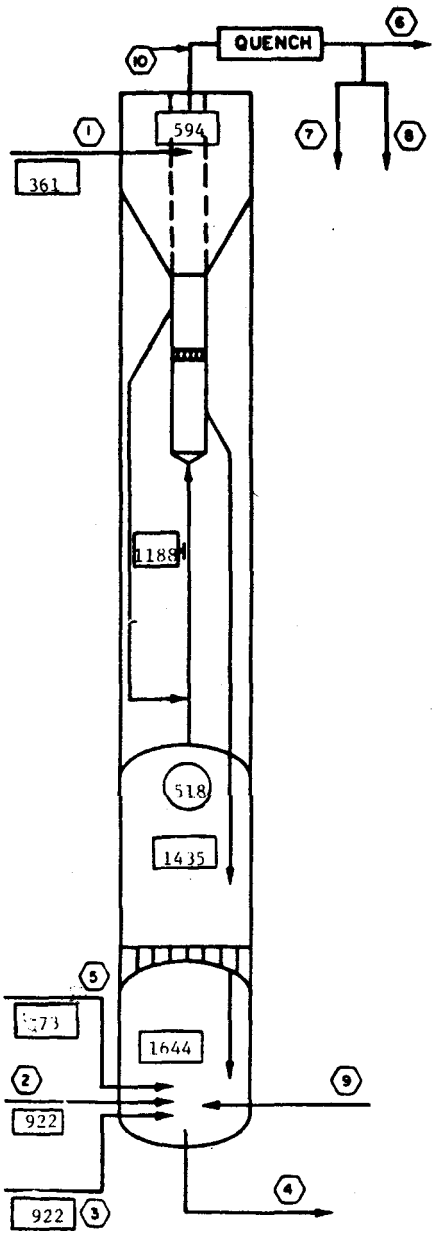
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 3.34

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 16
SOG = 22

†MOISTURE ASH FREE.

Figure A-46. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/16/78 (0000 Hours) TO 8/16/78 (1200 Hours)



MATERIAL BALANCE, %

C	--
H	--
O	--
ASH	--

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	35.24	33.42
CO_2	26.69	29.00
C_2H_6	0.33	0.34
N_2	7.52	8.00
H_2S	1.54	1.55
CH_4	17.60	17.25
CO	11.08	10.44
mol/hr (dry)	141	156

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.60	75.75	66.32
H	3.52	2.70	1.29
N	1.36	1.05	0.38
S	3.60	2.54	1.44
ASH	11.97	14.01	30.19
O	8.95	3.95	0.38
lb/hr (dry)	3945	280	1153

FEED MOISTURE, wt % 1.77

FEED SLURRY CONCN, wt % 37

LIQUID STREAMS

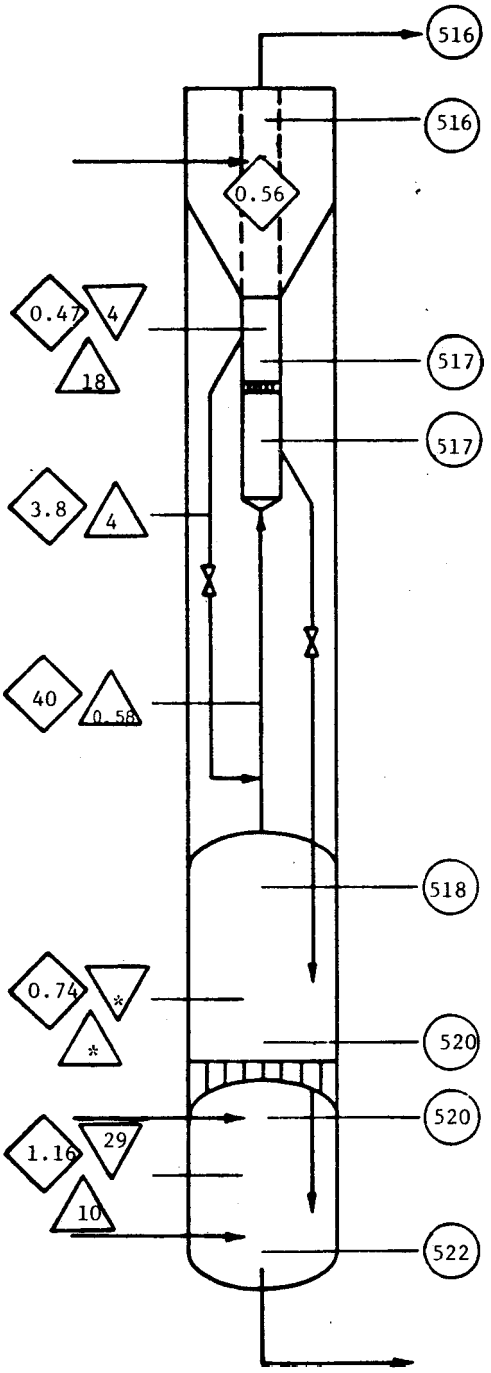
	7	8	1
	lb/hr		
H_2O	4149	--	--
LIGHT OIL	--	6899	6851

GAS FEED STREAMS

2	3	5	9
mol/hr			
232	62	20	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-47. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/17/78 (0000 Hours) TO 8/17/78 (0830 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
• NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.24
lb STEAM/lb CARBON (net) = 2.06
lb OXYGEN/lb COAL FED = 0.15
lb STEAM/lb COAL FED = 1.34
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 109

BY ASH BALANCE

MAF† COAL GASIFIED, % = 69
CARBON GASIFIED, % = 63

METHANE YIELD, SCF/lb COAL FED = 2.58

EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 4.32

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = *
SOG = 23

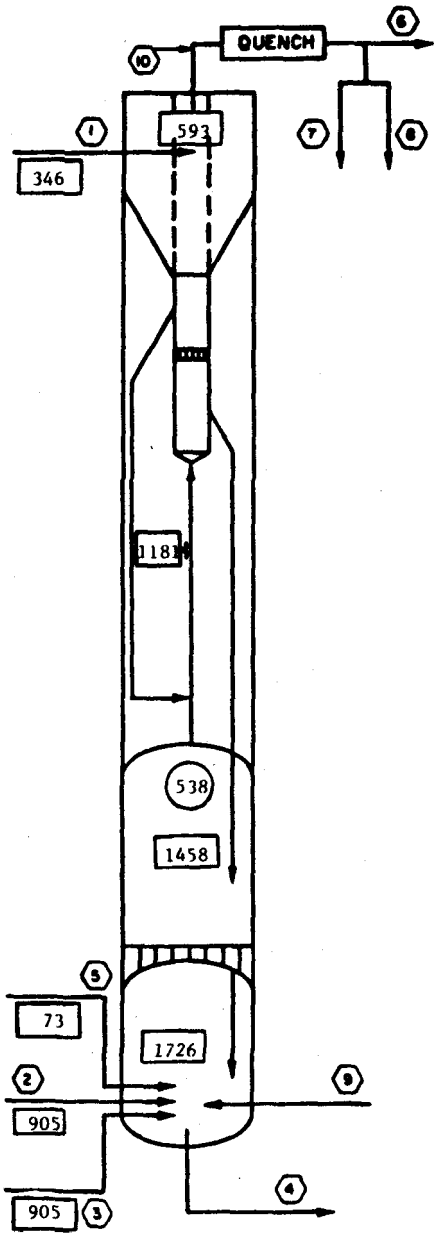
†MOISTURE ASH FREE

Figure A-48. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/17/78 (0000 Hours) TO 8/17/78 (0830 Hours)

Table A-13. MATERIAL BALANCE SUMMARY FOR HYGAS GASIFIER TEST 74 FOR STEADY PERIOD FROM 8/19/78 (1200 Hours) TO 8/20/78 (0900 Hours)

Basis = 1 hour. All units in pounds unless noted otherwise.

INPUT		C	H	O	N	S	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.88	3.51	8.92	1.50	3.66	11.53	100
	Coal (Dry)	2182	108	275	46	113	355	3079
	Moisture		7	54				61
Sparger	Oxygen			682				682
	Steam		469	3724	0			4193
Burner	Oxygen			0				0
	Steam	0	0					0
	Hydrogen		0					
Stripping Ring	Steam		126	1000	0			1126
Nitrogen From Purges					327			327
Pump Seal Flush			43	342				385
Cooling Water Spray			29	226				255
Water to Cyclone Pot			500	3968				4468
Light-Oil In		7345	702					8047
TOTAL INPUT		9527	1984	10,271	373	113	355	22,623
OUTPUT								
Reactor Overhead	Wt % (Dry)	75.86	2.73	4.17	1.06	2.65	13.54	100
	Dust (Dry)	329	12	18	5	11	59	434
Spent Char	Wt % (Dry)	62.39	1.07	1.00	0.28	1.40	33.86	100
	Char (Dry)	494	8	8	2	11	268	791
Product Gas After Quench	Total (Dry)	1066	209	1580	287	85		3167
	Components H_2		102					102
	CO_2	485		1292				1777
	C_2H_6	11	3					14
	H_2S		5			85		90
	N_2				287			287
	CH_4	294	99					393
	CO	216		288				504
Water Out + Dissolved Materials		7	1040	8200	33	3		9283
Toluene Storage Tank Vent Gases		89	7	197	8	0		301
Stripper Vent Gas		79	8	112	37	2		238
Light-Oil Out		7527	720					8247
Estimated Oil Losses								
TOTAL OUTPUT		9531	2004	10,115	372	112	327	22,461
Net (Output — Input)		4	20	−156	−1	−1	−28	−162
% Balance (Output/Input)		100	101	98	100	99	92	99



MATERIAL BALANCE, %

C	100
H	101
O	98
ASH	92

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	34.57	32.90
CO_2	27.47	30.36
C_2H_6	0.30	0.34
N_2	6.97	7.27
H_2S	1.80	1.66
CH_4	16.64	15.95
CO	12.25	11.53
mol/hr (dry)	147	163

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.88	75.86	62.39
H	3.51	2.73	1.07
N	1.50	1.06	0.28
S	3.66	2.65	1.40
ASH	11.53	13.54	33.86
O	8.92	4.17	1.00
lb/hr (dry)	3079	434	791

FEED MOISTURE, wt % 1.95

FEED SLURRY CONCN, wt % 28

LIQUID STREAMS

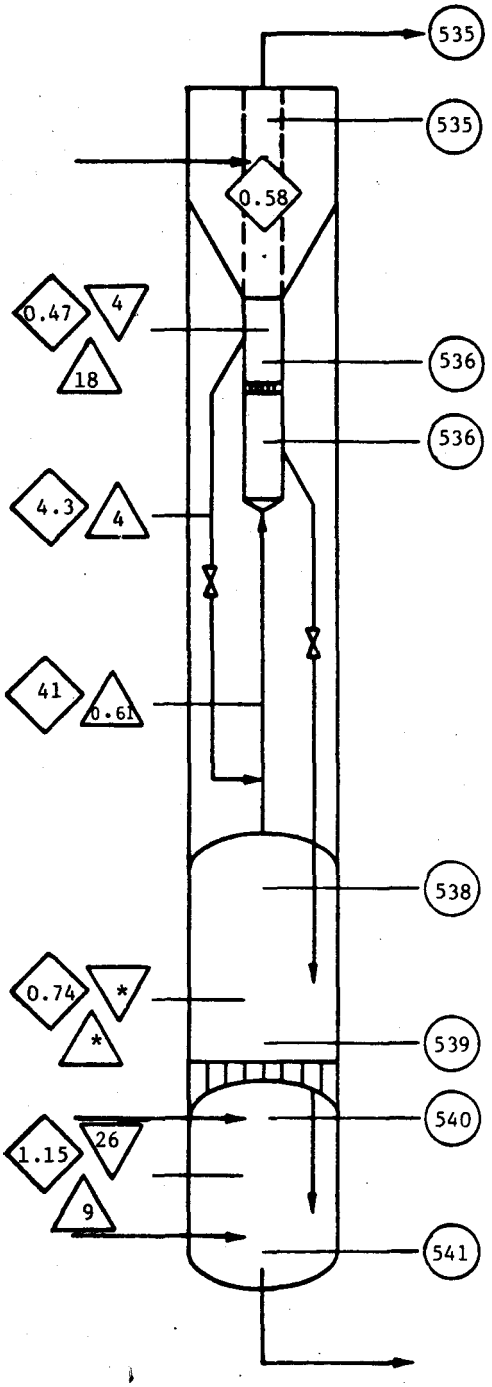
	7	8	1
	lb/hr		
H_2O	4430	--	--
LIGHT OIL	--	8247	8047

GAS FEED STREAMS

2	3	5	9
mol/hr			
233	62	21	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-49. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/19/78 (1200 Hours) TO 8/20/78 (0900 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.37
lb STEAM/lb CARBON (net) = 2.87
lb OXYGEN/lb COAL FED = 0.22
lb STEAM/lb COAL FED = 1.73
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 82

BY ASH BALANCE

MAF† COAL GASIFIED, % = 75
CARBON GASIFIED, % = 70

METHANE YIELD, SCF/lb COAL FED = 3.2

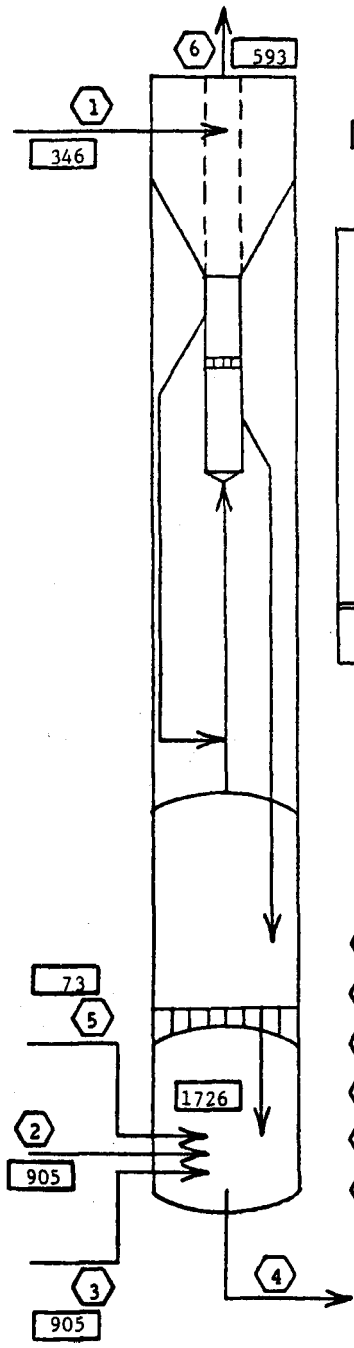
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 5.56

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = *
SOG = 21

†MOISTURE ASH FREE.

Figure A-50. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/19/78 (1200 Hours) TO 8/20/78 (0900 Hours)



Stream No.

Temperature, °F

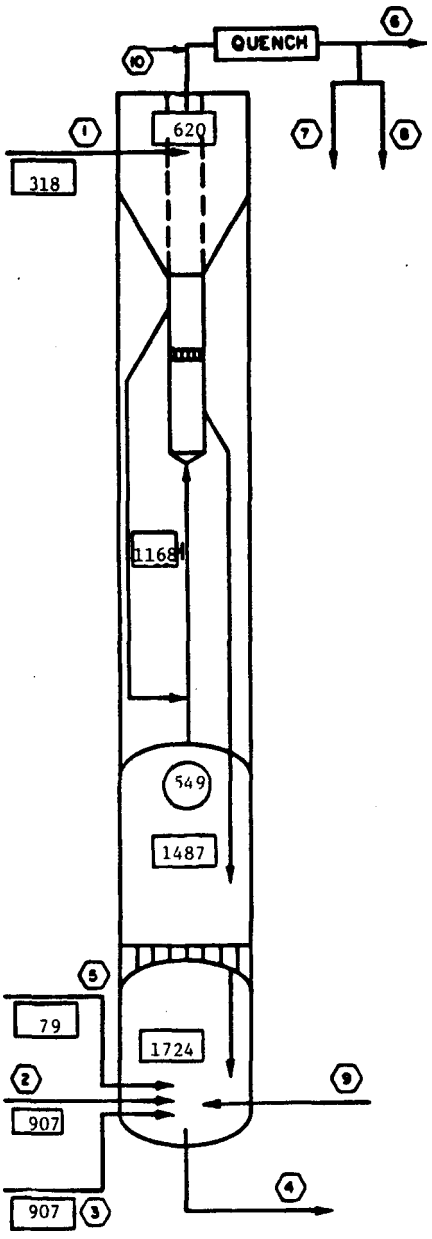
Basis: 1 hour; Datum condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1 & 5)	11.346
Heat of Combustion* (Stream 1)	185.35
Steam Enthalpy (Streams 2 & 3)	7.623
Total	204.32
OUTPUT	
Sensible Heat (Streams 4 & 6)	7.469
Heat of Combustion* (Streams 4 & 6)	184.84
Steam Enthalpy + Light Oil Latent Heat (Stream 6)	6.723
Total	199.03
% Balance 97	

1. Feed Slurry
2. High-Pressure Steam to Steam-Oxygen Sparger
3. High-Pressure Steam to Stripping Ring
4. Spent Char
5. High-Pressure Oxygen to Steam-Oxygen Sparger
6. Reactor Overhead

* High heating value.

Figure A-51. HYGAS REACTOR HEAT BALANCE DATA SHEET FOR TEST 74 FOR STEADY PERIOD FROM 8/19/78 (1200 Hours) TO 8/20/78 (0900 Hours)



MATERIAL BALANCE, %

C	--
H	--
O	--
ASH	--

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	34.12	32.46
CO_2	28.69	29.72
C_2H_6	0.28	0.28
N_2	6.08	8.01
H_2S	1.63	1.58
CH_4	15.46	14.86
CO	13.73	13.07
mol/hr (dry)	162	174

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.88	74.50	59.91
H	3.51	2.86	0.96
N	1.50	1.24	0.36
S	3.66	2.71	1.35
ASH	11.53	13.66	36.99
O	8.92	5.03	0.43
lb/hr (dry)	3429	382	746

FEED MOISTURE, wt % 2.0

FEED SLURRY CONCN, wt % 32

LIQUID STREAMS

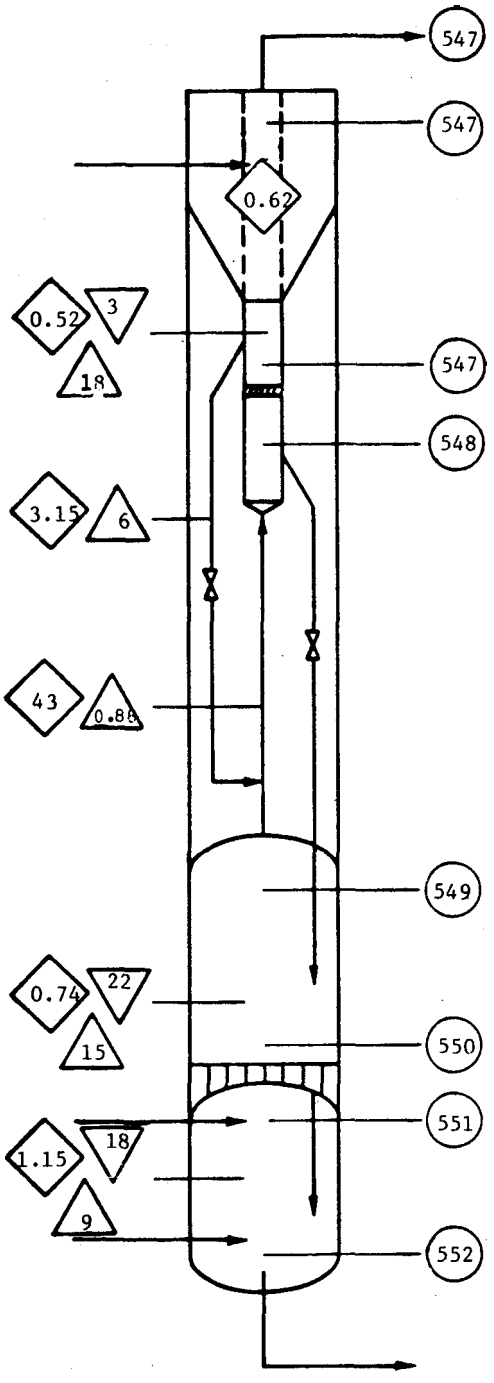
	7	8	1
	lb/hr		
H_2O	4870	--	--
LIGHT OIL	--	7600	7401

GAS FEED STREAMS

2	3	5	9
mol/hr			
212	84	22	0

1. FEED SLURRY
2. HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
3. HIGH-PRESSURE STEAM TO STRIPPING RING
4. SPENT CHAR
5. HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
6. GASIFIER EFFLUENT AFTER QUENCH
7. WATER MADE
8. LIGHT OIL TO RECYCLE
9. GASES FROM EXTERNAL HEATER
10. REACTOR OVERHEAD

Figure A-52. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/23/78 (1500 Hours) TO 8/25/78 (0700 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.33
lb STEAM/lb CARBON (net) = 2.49
lb OXYGEN/lb COAL FED = 0.21
lb STEAM/lb COAL FED = 1.56
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 86

BY ASH BALANCE

MAF† COAL GASIFIED, % = 78
CARBON GASIFIED, % = 74

METHANE YIELD, SCF/lb COAL FED = 2.86

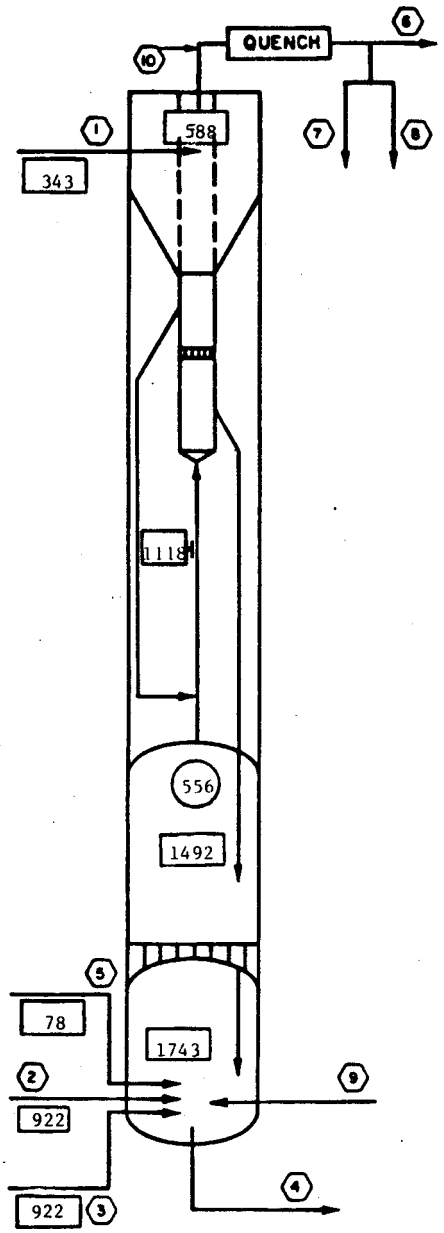
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 5.15

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 11
SOG = 16

†MOISTURE ASH FREE.

Figure A-53. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/23/78 (1500 Hours) TO 8/25/78 (0700 Hours)



MATERIAL BALANCE, %

C	--
H	--
O	--
ASH	--

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	33.70	31.91
CO_2	28.49	30.84
C_2H_6	0.35	0.39
N_2	5.85	6.27
H_2S	0.97	0.93
CH_4	16.34	16.03
CO	14.29	13.62
mol/hr (dry)	177	193

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	69.88	75.17	61.75
H	3.56	2.76	0.95
N	1.34	1.00	0.33
S	3.77	2.62	1.32
ASH	12.38	13.88	35.21
O	9.07	4.57	0.45
lb/hr (dry)	4036	342	1455

FEED MOISTURE, wt % 1.86

FEED SLURRY CONCN, wt % 30

LIQUID STREAMS

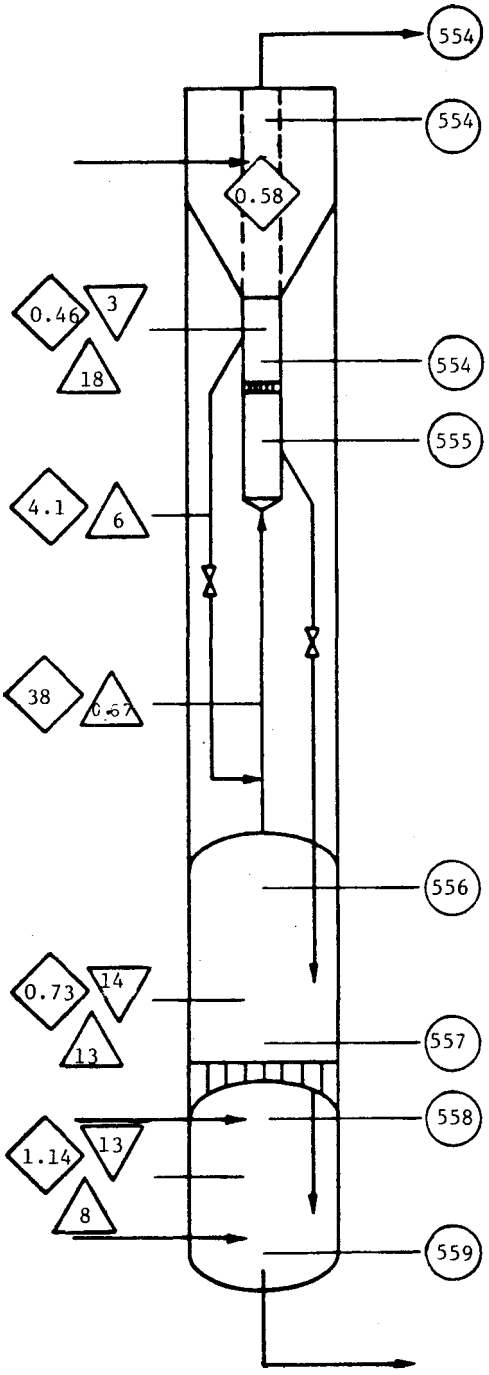
	7	8	1
	lb/hr		
H_2O	3932	--	--
LIGHT OIL	--	9543	9743

GAS FEED STREAMS

2	3	5	9
mol/hr			
211	84	23	0

1. FEED SLURRY
2. HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
3. HIGH-PRESSURE STEAM TO STRIPPING RING
4. SPENT CHAR
5. HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
6. GASIFIER EFFLUENT AFTER QUENCH
7. WATER MADE
8. LIGHT OIL TO RECYCLE
9. GASES FROM EXTERNAL HEATER
10. REACTOR OVERHEAD

Figure A-54. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/26/78 (0100 Hours) TO 8/27/78 (0300 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.28
lb STEAM/lb CARBON (net) = 2.07
lb OXYGEN/lb COAL FED = 0.18
lb STEAM/lb COAL FED = 1.31
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 89

BY ASH BALANCE

MAF† COAL GASIFIED, % = 74
CARBON GASIFIED, % = 69

METHANE YIELD, SCF/lb COAL FED = 2.91

EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 5.10

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 12
SOG = 18

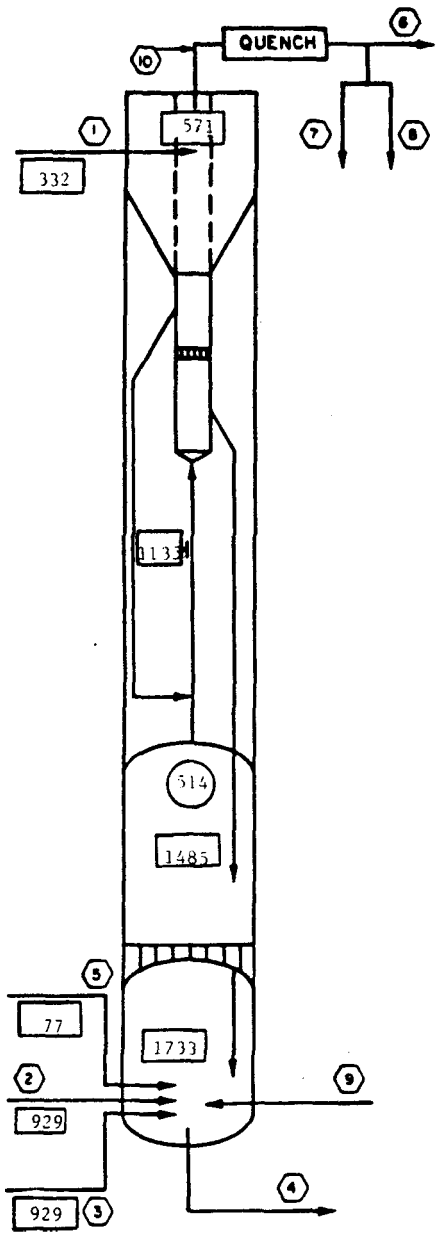
†MOISTURE ASH FREE.

Figure A-55. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/26/78 (0100 Hours) TO 8/27/78 (0300 Hours)

Table A-14. MATERIAL BALANCE SUMMARY FOR HYGAS GASIFIER TEST 74 FOR STEADY PERIOD FROM 8/27/78 (1800 Hours) TO 8/28/78 (1200 Hours)

Basis = 1 hour. All units in pounds unless noted otherwise.

INPUT		C	H	O	N	S	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.51	3.58	9.31	1.39	3.65	11.56	100
	Coal (Dry)	2365	120	312	47	122	388	3354
	Moisture		7	56				63
Sparger	Oxygen			736				736
	Steam		425	3376	0			3801
Burner	Oxygen			0				0
	Steam		0	0				0
	Hydrogen		0					0
Stripping Ring	Steam		168	1336	0			1504
Nitrogen From Purges					366			366
Pump Seal Flush			75	592				667
Cooling Water Spray			0	0				0
Water to Cyclone Pot			456	3621				4077
Light-Oil In		8418	805					9223
TOTAL INPUT		10,783	2056	10,029	413	122	388	23,791
OUTPUT								
Reactor Overhead	Wt % (Dry)	76.39	2.92	4.57	1.31	2.78	12.02	100
	Dust (Dry)	308	12	18	5	11	49	403
Spent Char	Wt % (Dry)	61.92	0.95	0.67	0.32	0.84	35.32	100
	Char (Dry)	574	9	6	3	8	327	927
Product Gas After Quench	Total (Dry)	1217	235	1954	270	64		3740
	Components H_2		120					120
	CO_2	586		1560				2146
	C_2H_6	13	3					16
	H_2S		4			64		68
	N_2				270			270
	CH_4	322	108					430
	CO			394				690
Water Out + Dissolved Materials		9	1013	8014	18	4		9058
Toluene Storage Tank Vent Gases		94	7	202	18	5		326
Stripper Vent Gas		50	6	86	22	4		168
Light-Oil Out		8601	823					9423
Estimated Oil Losses								
TOTAL OUTPUT		10,853	2105	10,280	336	96	376	24,045
Net (Output — Input)		70	49	251	−77	−26	−12	254
% Balance (Output/Input)		101	102	103	81	79	97	101



MATERIAL BALANCE, %

C	101
H	102
O	103
ASH	97

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	34.69	32.89
CO_2	28.33	30.69
C_2H_6	0.32	0.35
N_2	5.59	5.92
H_2S	1.16	1.22
CH_4	15.60	15.33
CO	14.31	13.60
mol/hr (dry)	172	187

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.51	76.39	61.92
H	3.58	2.92	0.95
N	1.39	1.31	0.32
S	3.65	2.78	0.84
ASH	11.56	12.02	35.32
O	9.31	4.57	0.67
lb/hr (dry)	3354	403	927

FEED MOISTURE, wt % 1.9

FEED SLURRY CONCN, wt % 29

LIQUID STREAMS

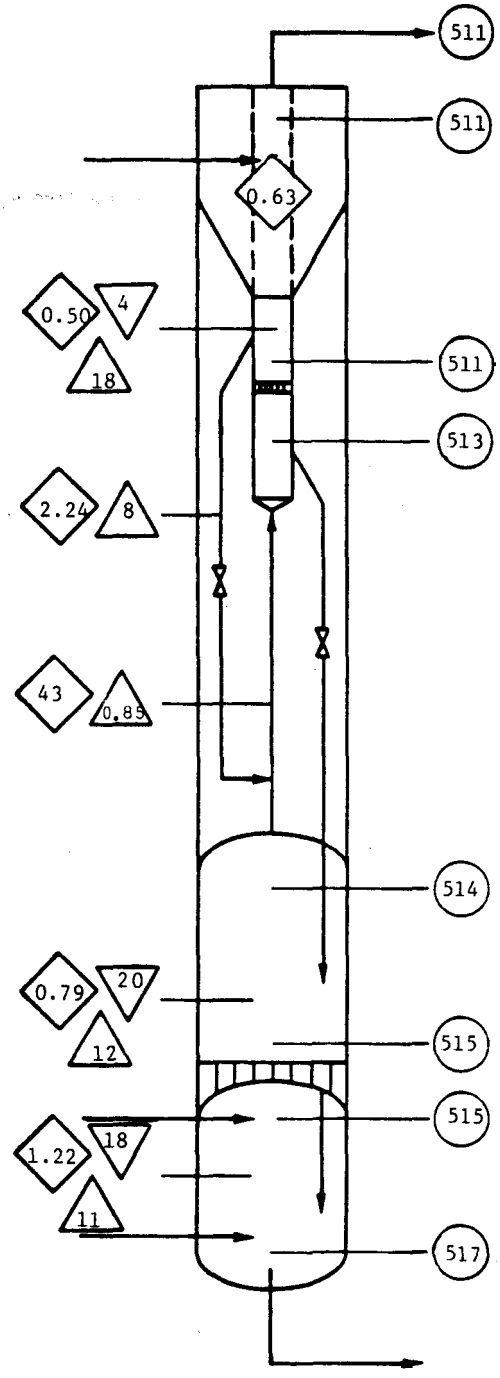
	7	8	1
	lb/hr		
H_2O	4314	--	--
LIGHT OIL	--	9423	9223

GAS FEED STREAMS

2	3	5	9
mol/hr			
211	84	23	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure A-56. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/27/78 (1800 Hours) TO 8/28/78 (1200 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN / lb CARBON (net) = 0.36
lb STEAM / lb CARBON (net) = 2.6
lb OXYGEN / lb COAL FED = 0.22
lb STEAM / lb COAL FED = 1.58
lb COAL FED / 1000 SCF REACTOR PRODUCT GAS = 76

BY ASH BALANCE

MAF† COAL GASIFIED, % = 76
CARBON GASIFIED, % = 71

METHANE YIELD, SCF/lb COAL FED = 3.24

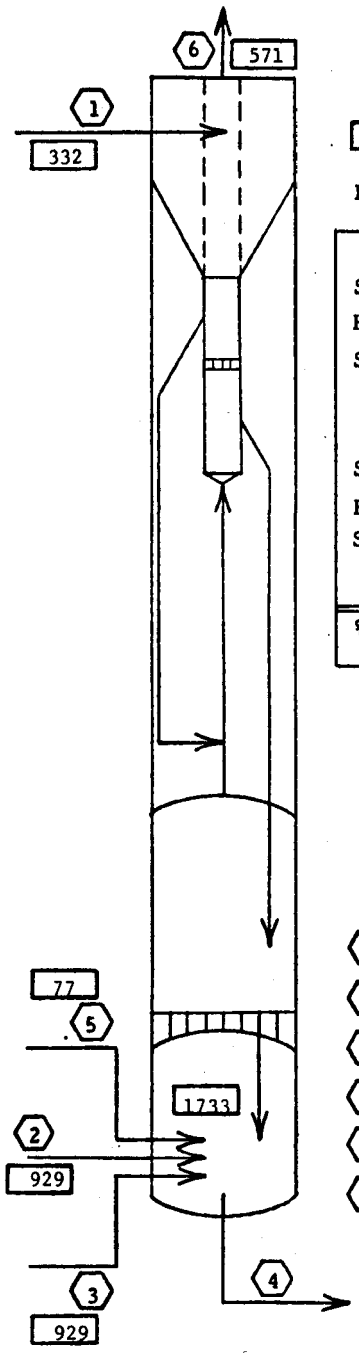
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 5.82

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 14
SOG = 15

†MOISTURE ASH FREE.

Figure A-57. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/27/78 (1800 Hours) TO 8/28/78 (1200 Hours)



Stream No.

Temperature, °F

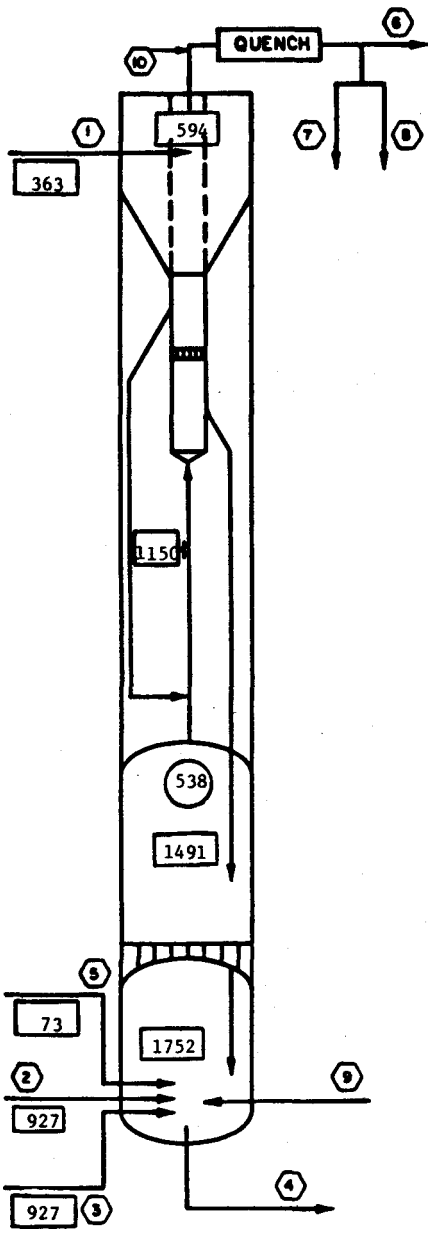
Basis: 1 hour; Datum condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1 & 5)	13.071
Heat of Combustion* (Stream 1)	210.10
Steam Enthalpy (Streams 2 & 3)	7.654
Total	230.83
OUTPUT	
Sensible Heat (Streams 4 & 6)	8.541
Heat of Combustion* (Streams 4 & 6)	209.84
Steam Enthalpy + Light Oil Latent Heat (Stream 6)	6.814
Total	225.20
% Balance	98

1. Feed Slurry
2. High-Pressure Steam to Steam-Oxygen Sparger
3. High-Pressure Steam to Stripping Ring
4. Spent Char
5. High-Pressure Oxygen to Steam-Oxygen Sparger
6. Reactor Overhead

* High heating value.

Figure A-58. HYGAS REACTOR HEAT BALANCE DATA SHEET FOR TEST 74 FOR STEADY PERIOD FROM 8/27/78 (1800 Hours) TO 8/28/78 (1200 Hours)



MATERIAL BALANCE, %

C	--
H	--
O	--
ASH	--

STREAM No.
PRESSURE, psig
TEMPERATURE, °F

GAS STREAMS

	6	10
mol % (dry)		
H_2	35.27	33.84
CO_2	26.96	29.03
C_2H_6	0.30	0.33
N_2	5.40	5.69
H_2S	1.14	1.14
CH_4	15.69	15.41
CO	15.23	14.56
mol/hr (dry)	179	196

SOLIDS STREAMS

	1	10	4
wt % (dry)			
C	70.01	74.31	58.75
H	3.41	2.81	0.95
N	1.37	1.27	0.27
S	3.63	2.67	1.46
ASH	11.94	14.31	38.07
O	9.63	4.63	0.51
lb/hr (dry)	3589	391	843

FEED MOISTURE, wt % 2.29

FEED SLURRY CONCN, wt % 28

LIQUID STREAMS

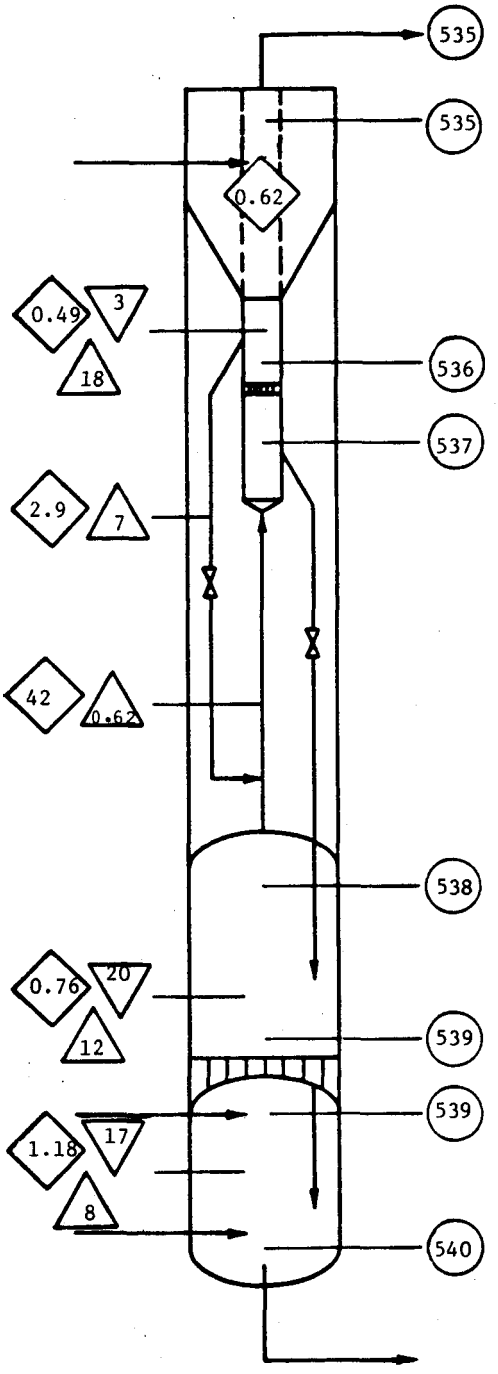
	7	8	1
	lb/hr		
H_2O	4201	--	--
LIGHT OIL	--	9468	9678

GAS FEED STREAMS

2	3	5	9
mol/hr			
211	84	23	0

1. FEED SLURRY
2. HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
3. HIGH-PRESSURE STEAM TO STRIPPING RING
4. SPENT CHAR
5. HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
6. GASIFIER EFFLUENT AFTER QUENCH
7. WATER MADE
8. LIGHT OIL TO RECYCLE
9. GASES FROM EXTERNAL HEATER
10. REACTOR OVERHEAD

Figure A-59. HYGAS REACTOR DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/28/78 (1900 Hours) TO 8/29/78 (0600 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.33
lb STEAM/lb CARBON (net) = 2.39
lb OXYGEN/lb COAL FED = 0.21
lb STEAM/lb COAL FED = 1.48
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 75

BY ASH BALANCE

MAF† COAL GASIFIED, % = 78
CARBON GASIFIED, % = 74

METHANE YIELD, SCF/lb COAL FED = 3.19

EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 5.82

BED HEIGHT, ft

SLURRY DRYER = 2
HTR = 14
SOG = 19

†MOISTURE ASH FREE.

Figure A-60. HYGAS REACTOR ENGINEERING DATA FOR TEST 74 FOR STEADY PERIOD FROM 8/28/78 (1900 Hours) TO 8/29/78 (0600 Hours)

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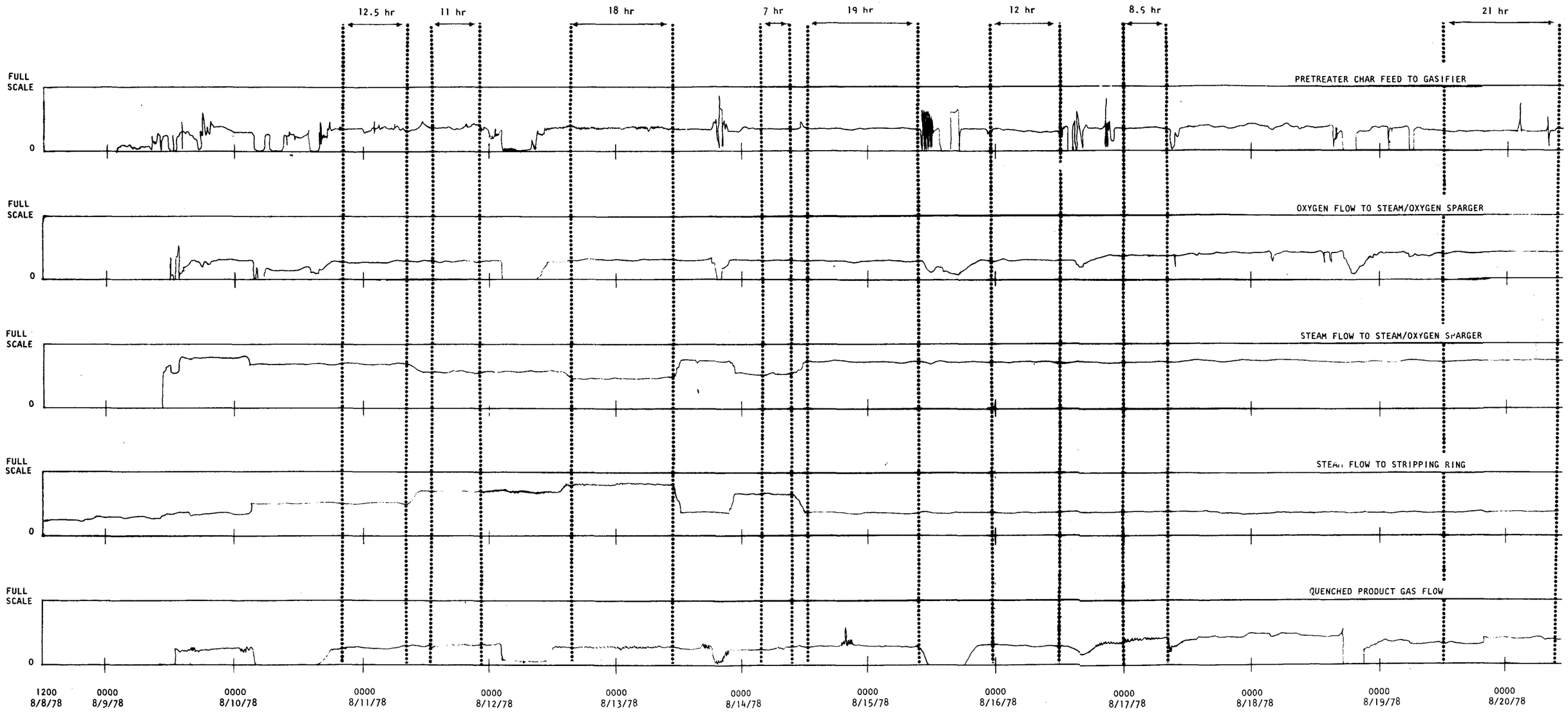

12.5 hr
11 hr
18 hr
7 hr
19 hr
12 hr
8.5 hr
21 hr
FULL SCALE
0
PRETREATER CHAR FEED TO GASIFIER
FULL SCALE
0
OXYGEN FLOW TO STEAM/OXYGEN SPARGER
FULL SCALE
0
STEAM FLOW TO STEAM/OXYGEN SPARGER
FULL SCALE
0
STEAM FLOW TO STRIPPING RING
FULL SCALE
0
QUENCHED PRODUCT GAS FLOW
1200 8/8/78
0000 8/9/78
0000 8/10/78
0000 8/11/78
0000 8/12/78
0000 8/13/78
0000 8/14/78
0000 8/15/78
0000 8/16/78
0000 8/17/78
0000 8/18/78
0000 8/19/78
0000 8/20/78

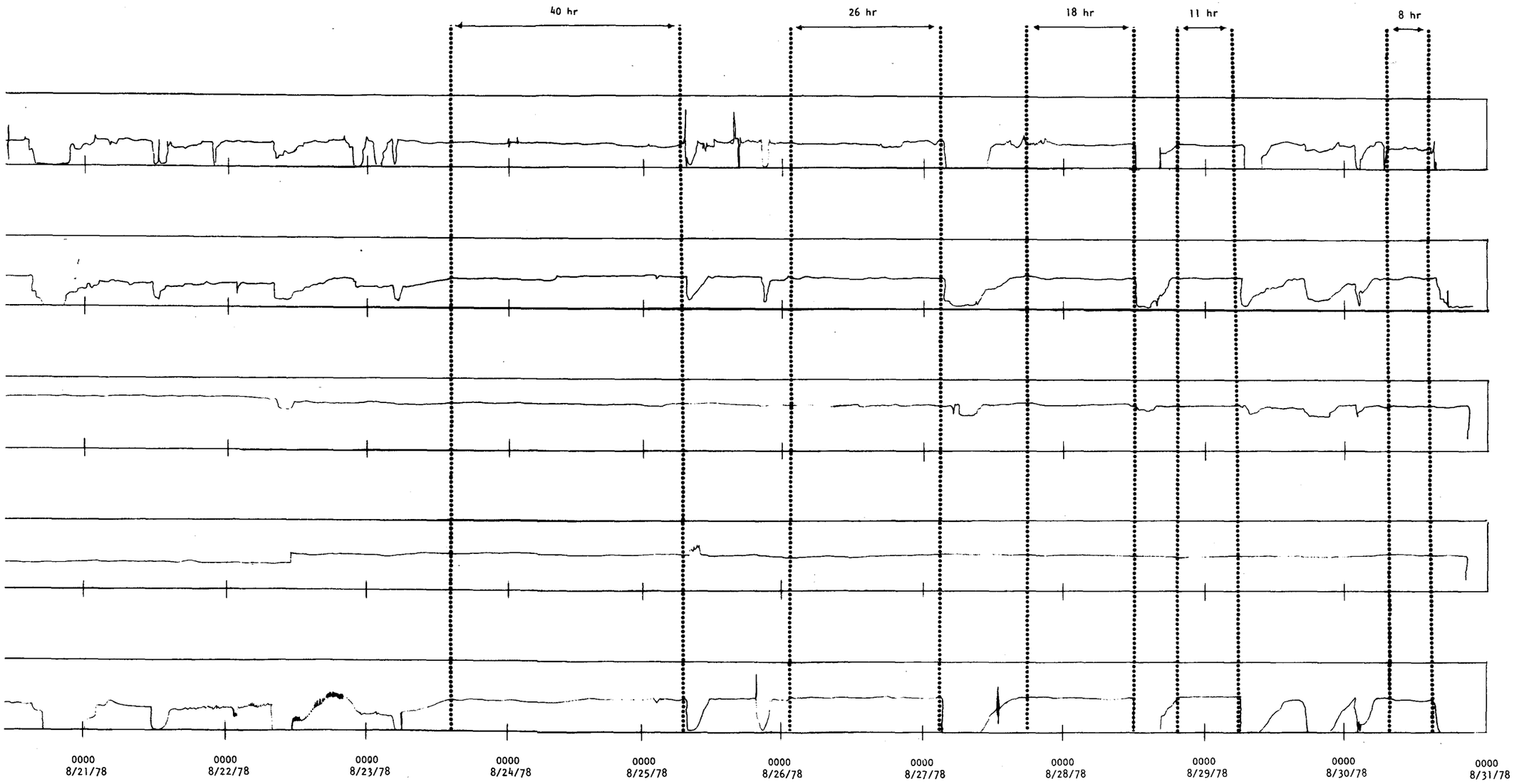
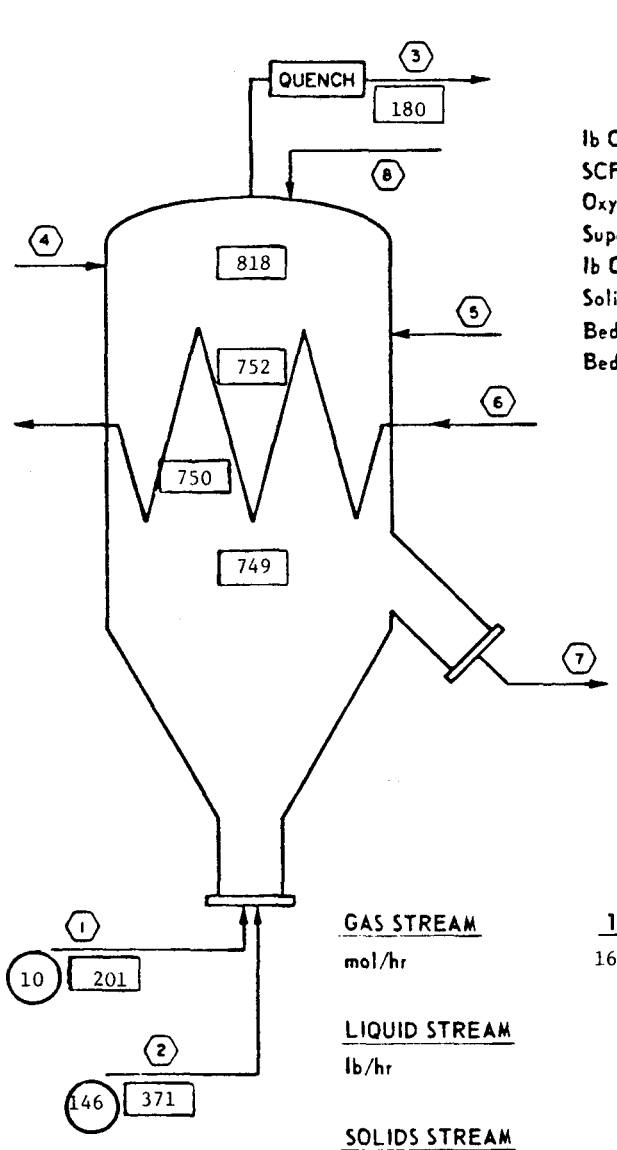


Figure A-61. OVERVIEW OF TEST 74

Table A-15. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 72 FROM 5/26/78 (0330 Hours) TO 5/26/78 (1530 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	69.10	5.04	10.02	1.21	4.53		10.08	100
	Coal (Dry)	2397	175	348	42	157		350	3469
	Moisture		24	190					214
Streams to Pretreater	Air			942	3068		53		4063
	Steam		185	1464					1649
Nitrogen From Purges					308				308
Air From Purges				9	29				38
H_2O to Venturi Scrubber			1329	10,545					11,874
H_2O to Quench Tower			280	2225					2505
Nitrogen to Char Cooler					447				447
Cooling Water to Char Cooler			58	456					514
TOTAL INPUT		2397	2051	16,179	3894	157	53	350	25,081
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	70.30	3.72	9.00	1.42	4.08		11.48	100
	Char (Dry)	2060	109	264	42	120		337	2932
	Moisture		7	56					63
Slurry Waste From Quench	Wt % (Dry)	64.65	2.77	14.02	1.40	3.59		13.57	100
	Solids (Dry)	63	3	14	1	4		13	98
	Tars & Oils	104	10	10	1	4			129
	H_2O & Disc Materials	11	1607	12,754	0	17			14,389
Quench Tower Off-Gas	Total	199	325	3081	3973		53		7631
	Components:								
	H_2		1						1
	CO_2	137		366					503
	C_2H_6	6	2						8
	N_2				3973				3973
	CH_4	12	4						16
	CO	44		58					102
	O_2			136					136
	Ar						53		53
	H_2O		318	2521					2839
TOTAL OUTPUT		2437	2061	16,179	4017	145	53	350	25,242
Net (Output − Input)		40	10	0	123	−12	0	0	161
% Balance (Output/Input)		102	101	100	103	92	100	100	101



lb Char/lb Coal = 0.86
SCF O_2/lb Coal = 3.22
Oxygen Breakthrough, % fed = 14.48
Superficial Velocity, ft/s = 0.96
lb O_2 Reacted/lb Coal = 0.23
Solids Residence Time, hr = 1.59
Bed Density, lb/cu ft = 15
Bed Height, ft = 9

GAS STREAM	3
COMPONENTS, mol %	
H_2	0.15
CO_2	3.55
C_2H_6	0.08
O_2	1.83
N_2	44.03
Ar	--
CH_4	0.30
CO	1.13
H_2O	48.93
mol/hr	322
mol wt	24

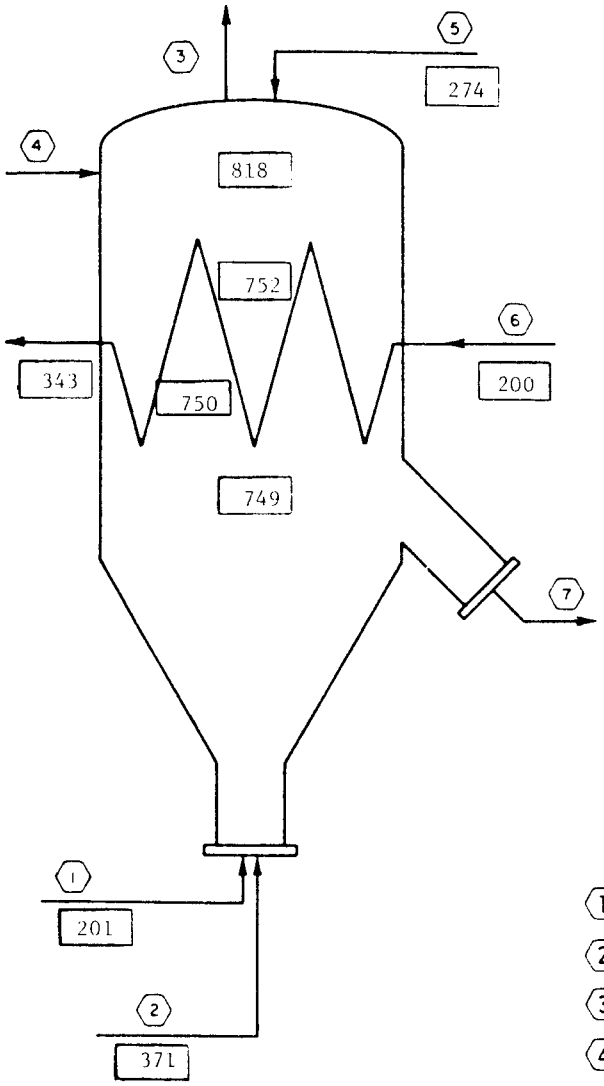
GAS STREAM	1	2	8
mol/hr	160	92	45

LIQUID STREAM	5	6
lb/hr	0	473

SOLIDS STREAM	4	7
lb/hr (dry)	3469	2932

(1) AIR TO PRETREATER
(2) STEAM TO PRETREATER
(3) PRETREATER OFF-GAS AFTER QUENCH
(4) RAW COAL TO PRETREATER
(5) DIRECT WATER QUENCH
(6) COOLING WATER TO COOLING COIL IN PRETREATER
(7) PRETREATER CHAR TO CHAR COOLER
(8) GAS FROM CHAR COOLER

Figure A-62. PRETREATMENT DATA FOR TEST 72 FOR STEADY PERIOD FROM 5/26/78 (0330 Hours) TO 5/26/78 (1530 Hours)



⬡ Stream No. ▭ Temperature, °F

Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1, 2, 4, 5, 6)	0.31
Heat of Combustion (Stream 4)	43.46
Steam Enthalpy (Streams 2 & 5)	2.44
Total	46.21
OUTPUT	
Sensible Heat (Streams 3 & 7)	3.21
Heat of Combustion (Streams 3 & 7)	39.14
Steam Enthalpy (Streams 3 & 6)	3.51
Total	45.86
% Balance 99	

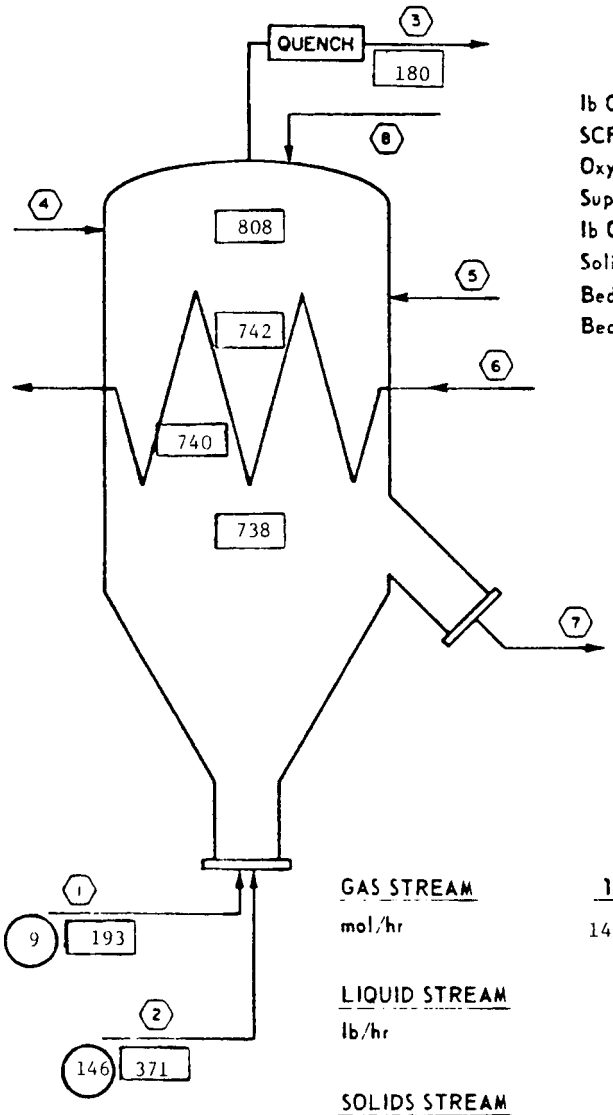
1. Air to Pretreater
2. Steam to Pretreater
3. Pretreater Overhead
4. Raw Coal to Pretreater
5. Gas From Char Cooler
6. Cooling Water to Cooling Coil in Pretreater
7. Pretreated Char to Char Cooler

Figure A-63. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 72 FOR STEADY PERIOD FROM 5/26/78 (0330 Hours) TO 5/26/78 (1530 Hours)

Table A-16. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 72 FROM 5/27/78 (1800 Hours) TO 5/28/78 (0130 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	68.27	4.91	9.74	1.34	4.69		11.05	100
	Coal (Dry)	2470	178	352	48	170		400	3618
	Moisture		22	174					196
Streams to Pretreater	Air			977	3182		55		4214
	Steam		197	1562					1759
Nitrogen From Purges					383				383
Air From Purges				9	29				38
H_2O to Venturi Scrubber			1308	10,380					11,688
H_2O to Quench Tower			309	2452					2761
Nitrogen to Char Cooler					411				411
Cooling Water to Char Cooler			28	226					254
TOTAL INPUT		2470	2042	16,132	4053	170	55	400	25,322
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	69.10	3.76	8.56	1.21	4.42		12.95	100
	Char (Dry)	2080	113	258	36	133		390	3010
	Moisture		3	27					30
Slurry Waste From Quench	Wt % (Dry)	64.27	2.58	14.44	1.41	3.74		13.58	100
	Solids (Dry)	47	2	11	1	3		10	74
	Tars & Oils	78	8	7	1	3			97
	H_2O & Disc Materials	19	1591	12,621	0	46			14,277
Quench Tower Off-Gas	Total	191	339	3208	4123		55		7916
	Components:								
	H_2		3						3
	CO_2	130		346					476
	C_2H_6	7	2						9
	N_2				4123				4123
	CH_4	12	4						16
	CO	42		56					98
	O_2			188					188
	Ar						55		55
	H_2O		330	2618					2948
TOTAL OUTPUT		2415	2056	16,132	4161	185	55	400	25,404
Net (Output − Input)		−55	14	0	108	15	0	0	82
% Balance (Output/Input)		98	101	100	103	106	100	100	100



lb Char/lb Coal = 0.84
SCF O_2/lb Coal = 3.20
Oxygen Breakthrough, % fed = 19.19
Superficial Velocity, ft/s = 1.0
lb O_2 Reacted/lb Coal = 0.22
Solids Residence Time, hr = 1.63
Bed Density, lb/cu ft = 17
Bed Height, ft = 8

GAS STREAM	3
COMPONENTS, mol %	
H_2	0.48
CO_2	3.22
C_2H_6	0.08
O_2	2.25
N_2	43.86
Ar	--
CH_4	0.31
CO	1.05
H_2O	48.75
mol/hr	336
mol wt	24

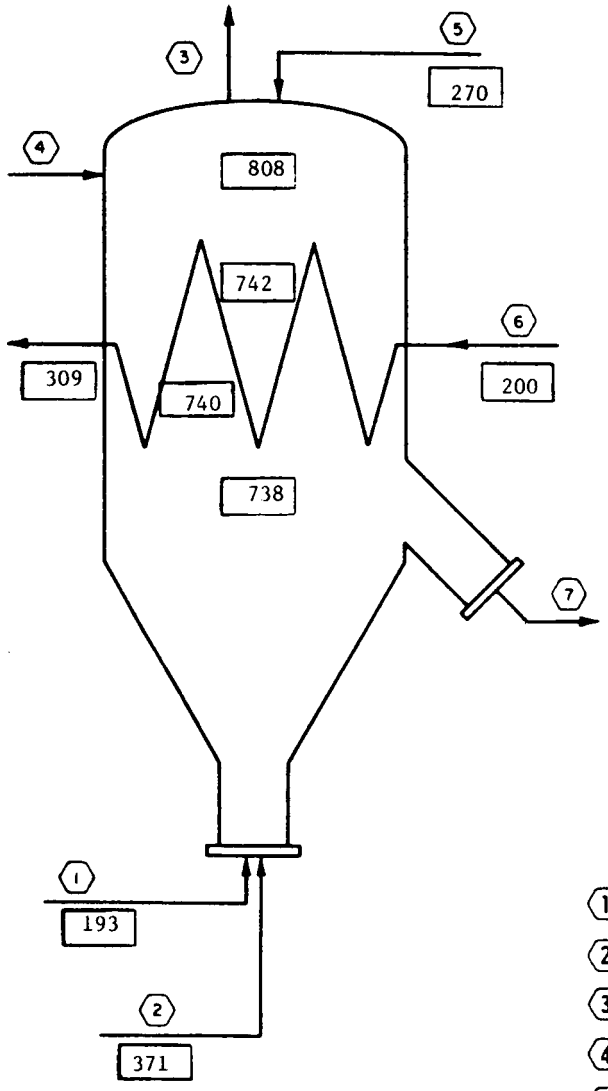
GAS STREAM	1	2	8
mol/hr	145	98	29

LIQUID STREAM	5	6
lb/hr	0	459

SOLIDS STREAM	4	7
lb/hr (dry)	3618	3010

(1) AIR TO PRETREATER
(2) STEAM TO PRETREATER
(3) PRETREATER OFF-GAS AFTER QUENCH
(4) RAW COAL TO PRETREATER
(5) DIRECT WATER QUENCH
(6) COOLING WATER TO COOLING COIL IN PRETREATER
(7) PRETREATER CHAR TO CHAR COOLER
(8) GAS FROM CHAR COOLER

Figure A-64. PRETREATMENT DATA FOR TEST 72 FOR STEADY PERIOD FROM 5/27/78 (1800 Hours) TO 5/28/78 (0130 Hours)



⬡ Stream No. ▭ Temperature, °F

Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1, 2, 4, 5, 6)	0.28
Heat of Combustion (Stream 4)	44.35
Steam Enthalpy (Streams 2 & 5)	2.29
Total	46.92
OUTPUT	
Sensible Heat (Streams 3 & 7)	3.24
Heat of Combustion (Streams 3 & 7)	39.47
Steam Enthalpy (Streams 3 & 6)	3.54
Total	46.25
% Balance 99	

(1) Air to Pretreater

(2) Steam to Pretreater

(3) Pretreater Overhead

(4) Raw Coal to Pretreater

(5) Gas From Char Cooler

(6) Cooling Water to Cooling Coil in Pretreater

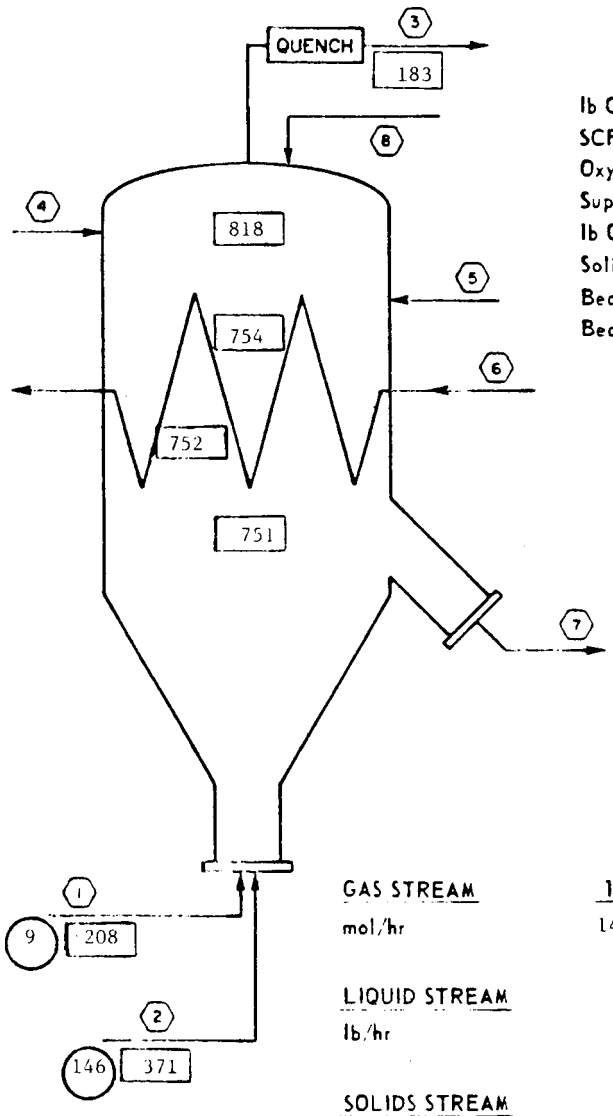
(7) Pretreated Char to Char Cooler

Figure A-65. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 72 FOR STEADY PERIOD FROM 5/27/78 (1800 Hours) TO 5/28/78 (0130 Hours)

Table A-17. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 72 FROM 5/29/78 (1300 Hours) TO 5/29/78 (2200 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	68.83	5.03	10.25	1.02	4.54		10.33	100
	Coal (Dry)	2712	198	405	40	179		407	3941
	Moisture		25	202					227
Streams to Pretreater	Air			988	3220		55		4263
	Steam		204	1619					1823
Nitrogen From Purges					441				441
Air From Purges				9	29				38
H_2O to Venturi Scrubber			1306	10,362					11,668
H_2O to Quench Tower			297	2358					2655
Nitrogen to Char Cooler					422				422
Cooling Water to Char Cooler			49	385					434
TOTAL INPUT		2712	2079	16,328	4152	179	55	407	25,912
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	69.10	3.76	8.56	1.21	4.42		12.95	100
	Char (Dry)	2058	112	255	36	132		386	2979
	Moisture		3	27					30
Slurry Waste From Quench	Wt % (Dry)	65.29	2.76	13.70	1.40	3.38		13.56	100
	Solids (Dry)	103	4	22	2	5		21	158
	Tars & Oils	117	12	10	1	4			144
	H_2O & Disc Materials	38	1568	12,446	0	18			14,071
Quench Tower Off-Gas	Total	204	380	3568	4168		55		8375
	Components:								
	H_2		3						3
	CO_2	137		366					503
	C_2H_6	7	2						9
	N_2				4168				4168
	CH_4	13	5						18
	CO	47		63					110
	O_2			202					202
	Ar						55		55
	H_2O		370	2937					3307
TOTAL OUTPUT		2520	2079	16,328	4207	159	55	407	25,755
Net (Output − Input)		−192	0	0	55	−20	0	0	−151
% Balance (Output/Input)		93	100	100	99	89	100	100	99



lb Char/lb Coal = 0.77
SCF O_2/lb Coal = 2.97
Oxygen Breakthrough, % fed = 20.44
Superficial Velocity, ft/s = 1.03
lb O_2 Reacted/lb Coal = 0.20
Solids Residence Time, hr = 1.56
Bed Density, lb/cu ft = 15
Bed Height, ft = 9

GAS STREAM	3
COMPONENTS, mol %	
H_2	0.44
CO_2	3.19
C_2H_6	0.08
O_2	2.24
N_2	41.47
Ar	--
CH_4	0.31
CO	1.09
H_2O	51.18
mol/hr	358
mol wt	23

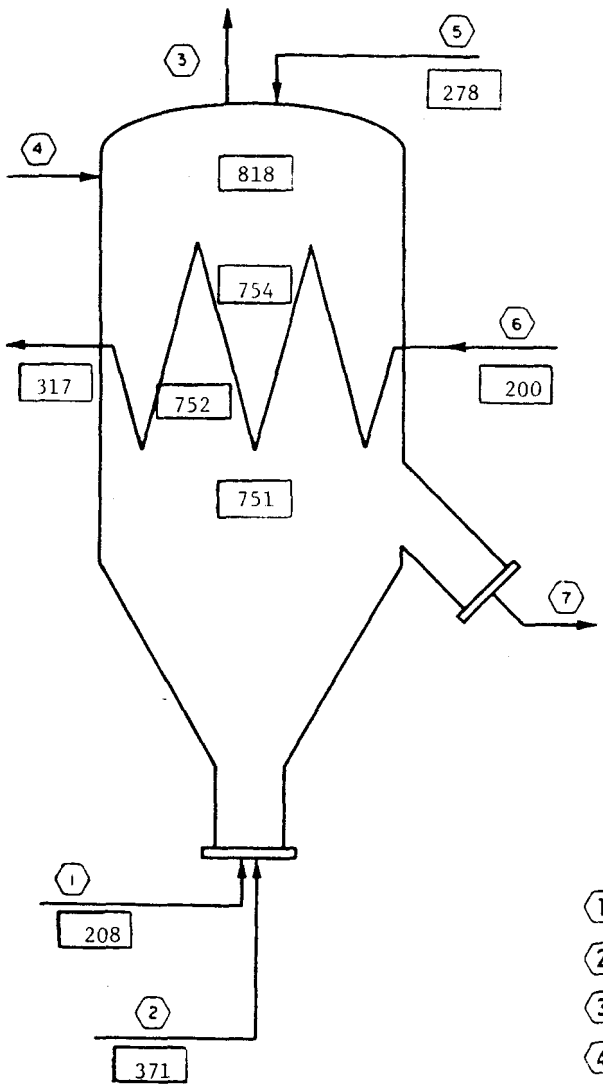
GAS STREAM	1	2	8
mol/hr	147	101	39

LIQUID STREAM	5	6
lb/hr	0	544

SOLIDS STREAM	4	7
lb/hr (dry)	3941	2979

(1) AIR TO PRETREATER
(2) STEAM TO PRETREATER
(3) PRETREATER OFF-GAS AFTER QUENCH
(4) RAW COAL TO PRETREATER
(5) DIRECT WATER QUENCH
(6) COOLING WATER TO COOLING COIL IN PRETREATER
(7) PRETREATER CHAR TO CHAR COOLER
(8) GAS FROM CHAR COOLER

Figure A-66. PRETREATMENT DATA FOR TEST 72 FOR STEADY PERIOD FROM 5/29/78 (1300 Hours) TO 5/29/78 (2200 Hours)



⬡ Stream No. ▭ Temperature, °F

Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.

INPUT	Btu X 10^6
Sensible Heat (Streams 1, 2, 4, 5, 6)	0.35
Heat of Combustion (Stream 4)	48.78
Steam Enthalpy (Streams 2 & 5)	2.55
Total	51.68
OUTPUT	
Sensible Heat (Streams 3 & 7)	3.50
Heat of Combustion (Streams 3 & 7)	40.88
Steam Enthalpy (Streams 3 & 6)	4.02
Total	48.40
% Balance	94

(1) Air to Pretreater
(2) Steam to Pretreater
(3) Pretreater Overhead
(4) Raw Coal to Pretreater
(5) Gas From Char Cooler
(6) Cooling Water to Cooling Coil in Pretreater
(7) Pretreated Char to Char Cooler

Figure A-67. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 72 FOR STEADY PERIOD FROM 5/29/78 (1300 Hours) TO 5/29/78 (2200 Hours)

pg