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EXPERIMENTAL PROGRAM FOR THE DEVELOPMENT OF PEAT GASIFICATION

Monthly Status Report

For the Period January 1 Through January 31, 1978

Submitted by

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ABSTRACT

In Task 4 (Lift-Line Reactor Studies) we conducted two peat hydrogasification tests at 215 psia and 1500°F (maximum temperature) using a synthesis gas and a steam-hydrogen mixture. The objectives of these tests were to determine the effects of the presence of steam and carbon oxides on the product yields during peat hydrogasification. In the test conducted with the synthesis gas, total carbon conversion was 59.8% of the feed carbon, and the yields of hydrocarbon gases and benzene were 21.3% and 5.3% of the feed carbon, respectively. The results from the other test are not yet complete and will be presented next month.

A test that had been conducted in December with a steam-hydrogen mixture at 115 psia was analyzed this month. The results show that 64.8% of the feed carbon was gasified, and the yields of hydrocarbon gases and benzene were 26.0% and 5.5% of the feed carbon, respectively.

At the project meeting with the Department of Energy (DOE) and Minnegasco in January, it was decided that we should attempt to achieve near-isothermal conditions during some of the hydrogasification tests in order to simulate conditions closer to those anticipated in the PEATGAS reactor.

In Task 5 (Steam-Oxygen Reactor Studies) we conducted four operations to prepare peat char and one test to gasify that char with steam and oxygen. The char gasification test was conducted at an average temperature of 1835°F near the bottom of the bed. The test was very successful at a superficial gas velocity of 0.83 ft/s; there was no sintering of ash in the reactor. Complete results from this test, which was conducted at about 380 psia, are not yet available and will be presented next month.

It was also decided at the project meeting that we should modify the char production equipment to allow char production in a reducing atmosphere of hydrogen plus carbon monoxide.

In Task 7 (Kinetic Studies and Modeling) we developed preliminary relationships for the yields of benzene and fuel oil and for hydrocarbon gas and total C_2^+ gas, based on the peat hydrogasification PDU data of tests conducted with hydrogen. Preliminary analyses of the tests conducted with a steam-hydrogen mixture and a synthesis gas show that total carbon conversion and hydrocarbon gas yields are higher than those expected on the basis of hydrogen partial pressure alone. This gasification characteristic of peat is also apparently different from that of coal. Therefore, more tests will have to be

conducted with the steam-hydrogen mixture and synthesis gas than had originally been anticipated.

As scheduled, we initiated Task 8 (Technical and Economic Evaluation) this month and started to evaluate comparative economics of slurry and lockhopper feed systems. At the January project meeting, tentative guidelines were discussed for evaluating the economics of producing 250 billion Btu per stream day of SNG from peat.

OPEN ITEMS

No critical technical or management problems occurred during January.

ACHIEVEMENT OF PROJECT OBJECTIVES

The overall objective of the program is to develop a process for the conversion of peat to substitute natural gas (SNG) and to evaluate its process economics.

All the laboratory-scale tests had been completed during an earlier report period, and a preferred reactor configuration for gasifying peat had been selected. The PDU tests now in progress will help establish the peat gasification process yields and process economics.

The following three major milestones were reached this month:

1. Hydrogasification tests with a synthesis gas were inititated, and a successful test was conducted. All previous tests were conducted with either hydrogen or steam-hydrogen mixtures; the commercial reactor concept incorporates peat hydrogasification with synthesis gas.

2. Sintér-free operation was achieved during peat char gasification in the fluidized-bed with steam and oxygen at 1835°F with a superficial gas velocity of 0.83 ft/s. The previous char gasification test, conducted at 1815°F, resulted in ash sintering when operated at a 0.48 ft/s gas velocity. In comparison, the commercial reactor concept incorporates char gasification in a sinter-free fluidized bed with steam and oxygen at 1850° to 1950°F.

3. Work was initiated on Task 8 for evaluating the process economics of converting peat to SNG. This work was related to evaluating alternative systems for feeding peat to a gasifier at 500 psig.

DETAILED MONTHLY TECHNICAL PROGRESS REPORT

Task 4. Lift-Line Reactor Studies

We conducted two hydrogasification tests: Runs LL-16 and LL-17. Run LL-16 was conducted with a synthesis gas (15 mole percent carbon monoxide, 19 mole percent carbon dioxide, 31 mole percent hydrogen, 34 mole percent steam, and 1 mole percent methane) at 215 psia and a maximum reactor temperature of 1512°F. Run LL-17 was conducted with a steam-hydrogen mixture (60 mole percent hydrogen) at a temperature and pressure similar to those of Run LL-16. The operating conditions and the results from these and two earlier tests (Runs LL-14 and LL-15) are shown in Table 1, the chemical analyses of the feeds and the residues from these tests are shown in Table 2, and the material balances for Runs LL-14 through LL-16 are shown in Table 3.

Table 1. OPERATING CONDITIONS AND RESULTS OF PEAT HYDROGASIFICATION TESTS IN THE PDU

Run No.	LL-14	LL-15	LL-16	LL-17
Test Duration, min	47	98	92	103
Steady-State Period, min	--	60	77	73
Operating Conditions				
Feed Gas, mol %	29% Nitrogen 71% Steam	45% Steam 55% Hydrogen	Syn Gas[h]	40% Steam 60% Hydrogen
Pressure,[a] psia	56	115	215	215
Temperature, °F				
Coil Inlet (0 ft)	1181	1019	1108	1095
1/4-Point (40 ft)	1419	1217	1332	1346
Mid-Point (80 ft)	1432	1354	1376	1409
3/4-Point (120 ft)	1500	1516	1512	1515
Coil Outlet (160 ft)	1382	1449	1443	1461
Gas Flow Rate, SCF/hr	212	570	737	827
Peat Feed Rate, lb/hr	15.7	4.6	7.8	6.8
Operating Results				
Gas Velocity,[b] ft/s	15.1	19.0	13.5	15.2
Residence Time,[c] s	10.6	8.4	11.8	10.5
Product Gas Flow Rate,[d] SCF/hr	138	310	412	516
Char Residue, lb/hr	6.61	1.47	2.80	2.18
Liquid Products, lb/hr				
Oil	0.21	0.15	0.28	0.41
Water	6.39	11.25	8.90	22.51
Total	6.60	11.40	9.[illegible]8	22.92
Product Gas Composition,[e] mol % (Dry)				
Carbon Monoxide	11.48	2.43	30.51	1.98
Carbon Dioxide	17.04	1.33	29.09	1.18
Nitrogen	43.02	1.30	--	0.13
Hydrogen	11.28	90.25	33.73	92.52
Methane	13.68	3.33	5.48	3.08
Ethane	1.12	0.99	0.81	0.82
Propane	--	--	--	--
Ethylene	1.76	0.17	0.14	0.07
Propylene	0.08	--	--	--
Benzene	0.50	0.20	0.24	0.22
Toluene	0.04	--	--	--
Total	100.00	100.00	100.00	100.00
Peat Component Conversions,[f] % of feed (daf)				
Carbon	52.5	64.8	59.8	NA
Hydrogen	88.4	89.8	89.9	NA
Oxygen	95.0	96.4	96.3	NA
Nitrogen	69.1	81.9	80.9	NA
Sulfur	37.3	81.6	74.1	NA
Product Yields, % of feed carbon				
Hydrocarbon Gases				
Methane	8.2	15.3	15.0	NA
Ethane	1.3	9.1	6.1	NA
Ethylene	2.1	1.6	1.1	NA
Total	11.6	26.0	22.2	
Carbon Oxides	17.0	17.2	15.5	NA
Oils				
Benzene	2.0	5.5	5.4	NA
Others[g]	21.9	16.1	16.7	NA
Total	23.9	21.6	22.1	

[a] Measured at reactor outlet.

[b] Gas velocity calculated at the average temperature and outlet pressure.

[c] Residence time calculated at the average gas velocity.

[d] On dry basis.

[e] Determined by mass-spectrometer analyses of samples taken during the test.

[f] Computed from the ultimate analysis of feed peat and residue char.

[g] Computed as the difference between total carbon conversion and carbon present in hydrocarbon gases (C_1 and C_2), carbon oxides, and benzene.

[h] Syn Gas Composition:

	mol %
Carbon Monoxide	15
Carbon Dioxide	19
Hydrogen	31
Methane	1
Steam	34

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Table 2. CHEMICAL AND SCREEN ANALYSES OF FEEDS AND RESIDUES OF PEAT HYDROGASIFICATION TESTS IN THE PDU

Run No.	LL-14		LL-15		LL-16	
Sample	Feed	Residue	Feed	Residue	Feed	Residue
Proximate Analysis, wt%						
Moisture	3.1	1.4	3.7	1.0	7.8	1.8
Volatile Matter	58.2	9.4	58.0	9.1	55.3	7.7
Fixed Carbon	22.6	50.5	22.7	44.4	22.1	48.9
Ash	16.1	38.7	15.6	45.5	14.8	41.6
Total	100.0	100.0	100.0	100.0	100.0	100.0
Ultimate Analysis (Dry), wt%						
Carbon	48.30	54.10	48.70	48.50	49.40	52.40
Hydrogen	5.01	1.37	5.11	1.47	5.01	1.34
Nitrogen	2.28	1.66	2.29	1.17	2.21	1.11
Oxygen	27.52	3.23	27.44	2.80	27.08	2.62
Sulfur	0.23	0.34	0.23	0.12	0.22	0.15
Ash	16.66	39.30	16.23	45.94	16.08	42.38
Total	100.00	100.00	100.00	100.00	100.00	100.00
Screen Analysis, U.S.S., wt%						
+10	--	0.9	--	--	--	--
−10+20	2.2	0.8	5.5	0.9	1.7	0.4
−20+30	21.7	2.9	23.1	2.0	21.5	3.3
−30+40	21.3	9.6	20.0	6.3	22.9	9.9
−40+50	19.8	14.1	17.7	8.9	18.9	14.1
−50+70	15.3	14.3	13.9	9.8	15.0	14.7
−70+100	12.1	15.1	11.8	10.4	11.8	15.2
−100+140	4.2	10.9	3.9	8.7	5.3	10.6
−140+170	1.0	4.2	0.9	4.3	0.8	5.2
−170+270	0.8	5.6	1.1	6.7	0.8	6.0
−270	1.6	21.6	2.1	42.0	1.3	20.6
Total	100.0	100.0	100.0	100.0	100.0	100.0
Average Particle Size, D_p, in.	0.0113	0.0044	0.0113	0.0031	0.0114	0.0044
Bulk Density, lb/ft^3	26.2	32.7	25.2	36.3	25.8	29.6

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Table 3. MATERIAL BALANCES FOR PEAT HYDROGASIFICATION TESTS CONDUCTED IN THE PDU

Run No.	LL-14	LL-15	LL-16
		%	
Overall Material Balance	84	91	83
Ash Balance	101	94	101
Carbon Balance	89	89	93
Hydrogen Balance	79	91	71
Oxygen Balance	85	90	82

The objective of Run LL-16 was to determine the effect of the presence of carbon oxides and steam on the yields of peat hydrogasification. The results show that overall carbon conversion in this test was 59.8% of the feed carbon and that the yields of hydrocarbon gases, benzene, and fuel oil were 22.2%, 5.4%, and 16.7% of the feed carbon, respectively. The partial pressure of hydrogen in this test was 67 psia. The yields obtained in this test are only slightly lower than those obtained in Run LL-12, the lowest pressure test made with hydrogen, with a hydrogen partial pressure of 107 psia. In this test, the yields of hydrocarbon gases and benzene were 23.3% and 5.2%, respectively. Based on the kinetic model developed from the data on peat hydrogasification in hydrogen and experience with coal hydrogasification, much lower yields were anticipated in Run LL-16 because of lower hydrogen partial pressure. Therefore, more tests will have to be conducted to develop a better understanding of peat hydrogasification with synthesis gas.

The objective of Run LL-17 was to determine the effect of the presence of steam during hydrogasification of peat. The test was conducted with a steam-hydrogen mixture at 215 psia and a hydrogen partial pressure of 129 psia. The product yields from this test will be calculated next month when analyses of the residue char from this test become available.

The objective of Runs LL-14 and LL-15, which were conducted last month at total pressures of 56 and 115 psia, steam partial pressures of 40 and 63 psia, and hydrogen partial pressures of 0 and 52 psia, respectively, was to determine the effect of steam on peat hydrogasification. The results show that in Run LL-15 the total carbon conversion and hydrocarbon gas and benzene yields were 64.8%, 26.0%, and 5.5% of the feed carbon, compared to only 52.5%, 11.6%, and 2.0% of the feed carbon obtained in Run LL-14. A comparison of the results of Run LL-15 with those of LL-12 shows that although Run LL-15 was conducted with almost one-half the partial pressure of Run LL-12, total carbon conversion and hydrocarbon gas yields were higher from Run LL-15. This is contrary to what we would have expected based on coal hydrogasification experience and the kinetic model developed from the data obtained with only hydrogen. Therefore, more tests will have to be conducted to develop a better understanding of peat hydrogasification in the presence of steam.

The boiling-range analyses of the hydrocarbon liquids (excluding benzene) produced during Runs LL-11 through LL-13 are shown in Table 4. It shows that the test conducted at the higher hydrogen pressure (215 psia) yields fuel oil containing a higher fraction of the lighter hydrocarbon liquids (–400°F fraction). However, the effect of increasing hydrogen pressure from 215 to 515 psia is not significant.

Table 4. BOILING RANGE ANALYSIS OF OILS PRODUCED DURING PEAT HYDROGASIFICATION IN THE PDU

Run No.	LL-11	LL-12	LL-13
Operating Conditions			
Feed Gas	Hydrogen	Hydrogen	Hydrogen
Pressure, psia	215	107	515
Average Temperature, °F	1299	1284	1360
Specific Gravity	1.044		1.063
Boiling Fractions		wt %	
–400°F	25	9	24
400°-580°F	29	34	38
+580°F	46	57	38

At the project meeting held at IGT with DOE and Minnegasco in January, it was decided to modify the operating procedure and attempt to make a few tests with near-isothermal conditions and determine their effect on product yields.

Task 5. Steam-Oxygen Reactor Studies

The second peat-char gasification test, Run PSO-2, was conducted with steam and oxygen in the 6-inch diameter fluidized-bed reactor described in the December report. Char used in the test was prepared in Runs PC-8 through PC-11, which were conducted in the 10-inch-diameter fluidized-bed reactor in which peat was devolatilized in air at about 1000°F. The char was then screened to a –10+120 mesh size range before it was used in Run PSO-2. The test was very successful; there was no ash sintering at 1835°F, and the run was terminated voluntarily.

A summary of the key operating conditions and some preliminary results of this test are shown in Table 5. Detailed operating conditions and results of this test will be presented when analytical results of the solids are completed.

Table 5. PRELIMINARY RESULTS OF STEAM OXYGEN GASIFICATION OF MINNESOTA PEAT CHAR IN RUN PSO-2

Run No.	PSO-2
Steady-State Conditions	
Pressure, psig	368
Temperature (bottom bed), °F	
Average	1835
Maximum	1900
Bed Height, in.	34
Superficial Velocity, ft/s	0.83
Char Feed Rate, lb/hr	49
Gas Feed Rate, SCF/hr	
Nitrogen	2460
Oxygen	245
Steam	1000

Run PSO-2 lasted nearly 5 hours, during which time 230 pounds of peat char was fed at a rate of 49 lb/hr and at a pressure of 365 psig. Bed level was maintained at 34 inches. In order to prevent ash sintering, the fluidization velocity in this test was substantially higher (0.83 ft/s) than the 0.48 ft/s used in the first test (Run PSO-1), even though the ash sintering experienced in Run PSO-1 might have been initiated by spalled refractory pieces lodging on the feed gas distributor parts. The steady-state operating period was nearly 3.0 hours long. The test was terminated when the available peat char in the feed hopper was nearly depleted.

Table 6 presents complete operating data and results of the first steam-oxygen gasification test of Minnesota peat char (Run PSO-1), which was conducted last month. Chemical and screen analyses of the feed char and residue of this test are given in Table 7. Table 6 shows that in Run PSO-1, 57.8% of the carbon in the feed char was gasified and 41.8% of the steam fed was reacted.

In order to supply peat char for conducting further char gasification tests, additional runs were conducted in the 10-inch-diameter fluidized-bed reactor using dried peat. About 300 pounds of peat char was produced by devolatilizing the peat at temperatures of 1050° to 1150°F with nitrogen and air. About 900 pounds of dried peat (4% to 10% moisture) was prepared by drying the as-received peat in a gas-fired rotary dryer. The dried peat will be used for the production of additional char.

At the January project meeting, it was decided to modify the existing char production equipment to allow char production in a reducing atmosphere of hydrogen and carbon monoxide and to include steam if possible.

Table 6. OPERATING CONDITIONS AND RESULTS OF MINNESOTA PEAT CHAR STEAM-OXYGEN TESTS PERFORMED IN A 6-inch REACTOR

Run No.	PSO-1
Feed Material	Minnesota Peat Char
Feed Source, IGT char test no.	PC-1 through PC-7
Feed Sieve Size, U.S.S.	
Duration of Test, hr	3-3/4
Steady-State Operating Period, min	72
Operating Conditions	
Char Bed Height, in.	34
Reactor Pressure, psig	520
Reactor Temperature, °F	
Tube Wall, in. from tube bottom[a]	
8	945
12	1425
16	1500
18	--
22	1495
24	1505
30	--
34	--
38	1515
42	--
45	--
56	--
60	--
71[b]	--
75[b]	1375
Internal, in. from tube bottom	
12	1815
16	1740
25	1710
40[b]	1620
55[b]	1600
73[b]	1590
Feed Gas Distributor	
Number of Feed Ports	6
Diameter of Feed Ports, in.	5/32
Char Feed Rate,[d] lb/hr	80.8
Nitrogen Rate, SCF/hr	2090
Oxygen Rate, SCF/hr	300
Oxygen Concentration in Feed Gas, mol %	12.4
Oxygen/Char Ratio, SCF/lb	3.68
Steam Rate, lb/hr	45.2
Steam/Char Ratio, lb/lb	0.559
Purge Nitrogen (Shell), SCF/hr	210
Purge Nitrogen (Feed Screw), SCF/hr	103
Char Space Velocity, lb/cu ft-hr	126.5
Char Residence Time,[e] min	13.8
Steam Residence Time,[f] min	0.099
Superficial Feed Gas Velocity,[g] ft/s	0.48

Table 6, Cont. OPERATING CONDITIONS AND RESULTS OF MINNESOTA PEAT CHAR STEAM-OXYGEN TESTS PERFORMED IN A 6-inch REACTOR

Operating Results	
Product Gas Rate (Purge Nitrogen-Free),[h] SCF/hr	3270
Product Gas Yield (Nitrogen-Free), SCF/lb	14.51
Hydrogen Yield, SCF/lb	4.97
Carbon Monoxide Yield, SCF/lb	4.04
Carbon Dioxide Yield, SCF/lb	4.61
Hydrocarbon Yield, SCF/lb	0.889
Residue Char,[i] lb/hr	41.3
Bayonet Filter Fines, lb/hr	8.07
Sintered Ash (Total), lb	4.25
Condensed Water,[j] lb/hr	28.68
Net MAF Char Gasified, wt%	59.7
Carbon Gasified, wt%	57.8
Steam Reacted, lb/hr	20.6
Steam Reacted, % of steam fed	41.8
Steam Concentration in Product Gas, mol %	15.6
Overall Material Balance, %	99.9
Carbon Balance, %	99.7
Hydrogen Balance, %	94.8
Oxygen Balance, %	100.6
Product Gas Properties	
Gas Composition (Purge Nitrogen-Free), mol %	
Nitrogen	64.1
Carbon Monoxide	10.0
Carbon Dioxide	11.4
Hydrogen	12.3
Methane	2.2
Ethane	0.0
Argon	0.0
Hydrogen Sulfide	0.0
Total	100.0
Heating Value,[k] But/SCF	92.8
Specific Gravity (Air = 1.00)	0.915

[a] Bottom of char bed at 8 inches.

[b] Above the bed level.

[c] Eight inches above the bottom of the reactor tube.

[d] Based on weight of dry feed.

[e] (Char-feed bulk density) X (Char-bed volume)/Char feed rates.

[f] Char-bed volume/(CF/min of feed gases at reactor pressure and temperature).

[g] Based on feed gases — steam + oxygen + nitrogen. (CF/s feed gas at reactor pressure and temperature)/cross-sectional area of reactor.

[h] Calculated at 60°F and 30-in. Hg pressure.

[i] By ash balance.

[j] Based on weight of liquid recovered.

[k] High heating value calculated for saturated gas at 60°F, 30-in. Hg pressure.

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Table 7. CHEMICAL AND SCREEN ANALYSES OF FEEDS AND RESIDUES OF PEAT CHAR STEAM-OXYGEN GASIFICATION TESTS PERFORMED IN A 6-inch REACTOR

Run No.	PSO-1		
Sample	Feed	Residue	Filter Fines
Proximate Analysis, wt%			
Moisture	1.3	0.3	2.1
Volatile Matter	14.2	4.2	6.0
Fixed Carbon	47.0	30.9	44.2
Ash	37.5	64.6	47.7
Total	100.0	100.0	100.0
Ultimate Analysis (Dry), wt%			
Carbon	52.4	33.9	46.6
Hydrogen	1.88	0.37	0.96
Nitrogen	1.87	0.45	1.09
Oxygen	5.45	0.20	2.11
Sulfur	0.42	0.28	0.53
Ash	37.98	64.80	48.71
Total	100.00	100.00	100.00
Screen Analysis, U.S.S., wt%			
+12	1.3	5.2	0.0
+20	11.8	16.2	0.3
+30	6.9	15.9	0.2
+40	17.9	16.8	0.7
+60	25.6	22.3	2.3
+80	14.0	8.1	2.9
+100	6.6	7.4	2.9
+200	12.7	5.2	24.7
+325	1.6	0.4	14.3
−325	1.6	2.5	51.7
Total	100.0	100.0	100.0
Bulk Density, lb/ft^3	29.5	31.7	30.3
Gross Heating Value, Btu/lb	8381	5156	7236

Task 7. Kinetic Studies and Modeling

We continued to develop a more detailed kinetic model for peat hydrogasification based on the PDU data (Task 4). This model will permit us to predict individual species within the groups of hydrocarbon gases, carbon oxides, and heavy hydrocarbons, which are predictable based on an earlier model developed using the laboratory-scale data from Task 3.

The PDU test results are adding considerable information to our understanding of the kinetics of peat hydrogasification by virtue of longer residence times, wider ranges of hydrogen partial pressure, and more detailed descriptions of the liquid products. Application of the kinetic model to PDU data requires consideration of the reactor-wall temperature profile along the length of the reactor and heat transfer to the gas-solids stream, as well as kinetics. Therefore, a computer program was developed to solve the system of simultaneous first-order differential equations to describe the nine gas species, eight solid components, temperature, and velocity as functions of length along the reactor.

In our attempt to individually estimate C_1 and C_2 components of the hydrocarbon gases, we found a reasonable correlation between the C_2 fraction and the source of hydrocarbon gases. The total hydrocarbon gases consisting of methane and ethane (including ethylene) are formed in initial volatilization by the reaction of heavy oils with hydrogen and of char with hydrogen. The base carbon that gives rise to the char is 48% of the carbon in this peat. Of the volatile carbon, only some of that which gives rise to carbon oxides may not be completely evolved in these experiments. Thus, the hydrocarbon gases that come from the char can be estimated by –

$$\xi_{char\ HC} = \xi_c - \xi_v^o + \xi_{CO_x}^o - \xi_{CO_x} \qquad (1)$$

where –

$\xi_{char\ HC}$ = fraction of feed carbon in char converted to hydrocarbon gases

ξ_c = total carbon conversion

ξ_v^o = total volatile carbon

$\xi_{CO_x}^o$ = volatile carbon that would yield carbon oxides

ξ_{CO_x} = conversion to carbon oxides.

A plot of $\xi_{char\ HC}/\xi_{HC}$ versus ξ_{C_2}/ξ_{HC}* is presented in Figure 1. The coiled-tube test data alone imply a relatively constant ethane fraction. The PDU runs (in which the fraction of exit gases that was hydrocarbons was 5 to 10 times that of the coiled-tube runs and therefore more accurate) present evidence of a trend that implies that the ethane production in the char-hydrogen reaction is much greater than in the volatile matter reactions.

Our analyses of the short-residence-time tests in the coiled-tube laboratory reactor (Task 3) indicate a lower limiting oil yield of 14%. The longer residence times available in the PDU runs indicate higher conversions of the oil-to-hydrocarbon gases, and, at similar temperatures, a lower limiting value of about 7% oil yield. Furthermore, at this minimum oil yield it is all benzene. Figure 2 shows a possible relationship between benzene yield and the yield of heavier oils. The curve, drawn tentatively and as yet not included in the kinetic model, implies three regimes of fuel oil conversion. Under mild conditions, about one-third of the initial oil goes primarily to hydrocarbon gases; under more severe conditions, one-third of the oil goes nearly equally to benzene and hydrocarbon gases; and under sufficiently severe conditions one-third goes mainly to hydrocarbon gases.

Using the kinetic model in its present form which is not yet finalized, a comparison of the calculated and measured product yields for Runs LL-9 through LL-13 has been made and is shown in Table 8. This comparison shows that the model can predict the experimental results fairly well.

All the tests shown in Table 8 were conducted with hydrogen alone. Recent tests with a steam-hydrogen mixture and a synthesis gas show that the model will have to be modified to incorporate gasification characteristics of peat in these environments. Based on our experience in coal gasification, we expected that the overall effect of the presence of steam and carbon oxides would only reduce the partial pressure of hydrogen. This, however, is not so for peat, as indicated by the few recent tests made with a synthesis gas and a steam-hydrogen mixture.

More tests will have to be conducted with a steam-hydrogen mixture and a synthesis gas to develop a more complete understanding of peat hydrogasification in the presence of steam and carbon oxides.

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* Where ξ_{HC} and ξ_{C_2} are the yields (fractions of feed carbon) of total hydrocarbon gases and ethane plus ethylene, respectively.

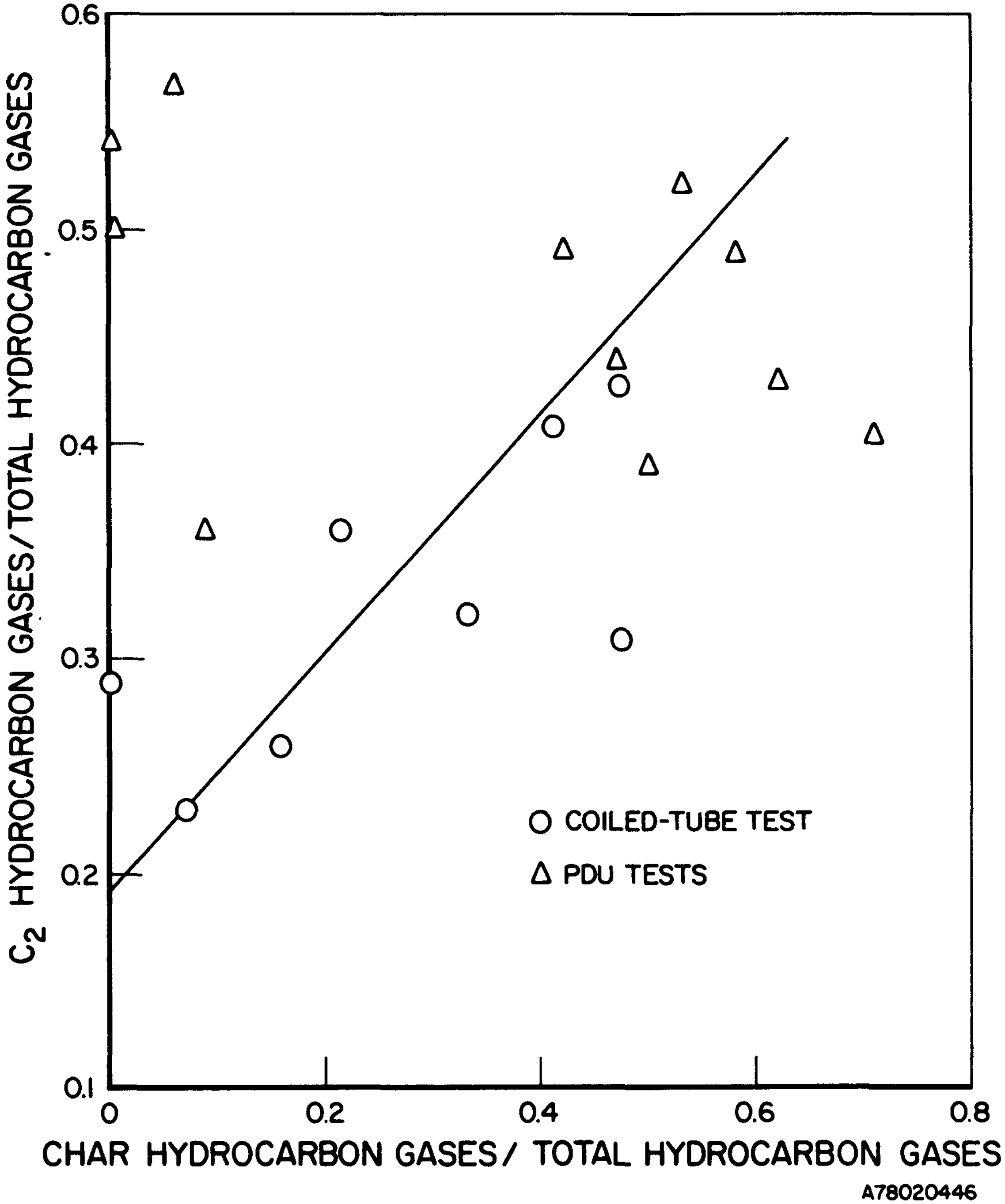

Figure 1. EFFECT OF THE FRACTION OF HYDROCARBON GASES PRODUCED FROM CHAR ON C_2 HYDROCARBON GAS YIELDS

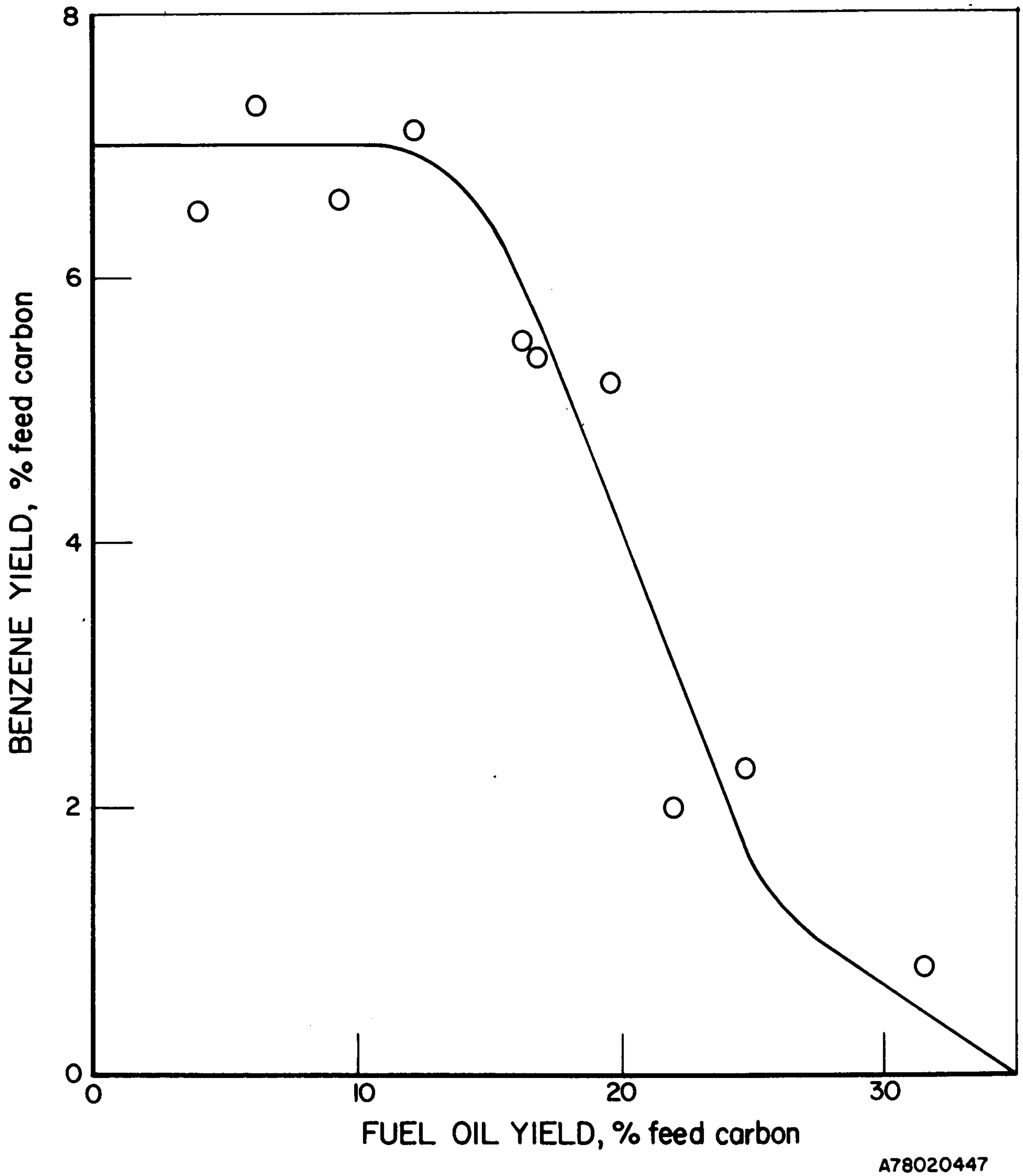

Figure 2. RELATIONSHIP BETWEEN BENZENE AND FUEL OIL YIELDS OBTAINED DURING PEAT HYDROGASIFICATION TESTS IN THE PDU

Table 8. COMPARISON OF EXPERIMENTAL CARBON CONVERSIONS AND PRODUCT YIELDS OBTAINED IN PEAT HYDROGASIFICATION PDU TESTS (WITH HYDROGEN ONLY) WITH THOSE CALCULATED BY THE KINETIC MODEL

Run No.	LL-9		LL-10		LL-11		LL-12		LL-13	
	Exptl*	Calcd**	Exptl	Calcd	Exptl	Calcd	Exptl	Calcd	Exptl	Calcd
Total Carbon Conversion, % feed carbon	57.8	59.8	58.0	59.7	53.6	59.8	62.1	56.1	66.6	67.5
Product Yields, % feed carbon										
Methane	20.6	20.8	16.9	15.7	22.0	22.8	13.3	14.1	22.8	19.4
Ethane	6.7	5.1	9.1	9.1	6.5	10.8	8.9	6.2	10.1	15.3
Carbon Monoxide	16.5	13.9	15.7	14.0	14.7	14.1	12.8	14.1	13.9	14.1
Benzene	7.3	7.9	6.6	7.9	6.4	7.9	5.2	7.9	7.1	7.9
Oils	13.8	14.0	15.9	20.2	10.4	11.4	24.7	21.0	18.4	18.0

* Experimental results.

** Calculated by the kinetic model for peat hydrogasification.

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Task 8. Technical and Economic Evaluation

As per the schedule, we initiated this task in January and started to evaluate two alternative methods of feeding peat to the high-pressure gasifier at 500 psig: slurry pumping and lockhoppers. The two feeding methods are being evaluated for 23,431 tons/day of dry peat. For the slurry feed system, peat will be dried to 10 weight percent moisture and then slurried in 70 weight percent light oil. For the lockhopper system, peat containing 25 weight percent moisture can be used. The results of this study will be presented next month.

At the January project meeting, tentative guidelines were established for evaluating the economics of producing 250 X 10^9 Btu/stream day of SNG from peat. The guidelines assume that milled peat, available at the plant, contains 50 weight percent moisture.

PATENT STATUS

The work conducted during January 1978 is not considered patentable.

WORK SCHEDULE

A current milestone chart and the original program schedule are shown in Figure 3. However, in view of the recent findings in Task 4 relating to the hydrogasification characteristics of peat in the presence of steam and carbon oxides, additional tests will have to be conducted in the peat hydrogasification PDU to develop a more complete understanding of peat hydrogasification.

In addition the progress in Task 5 on peat char gasification with steam and oxygen is thwarted by the char production step. In the original proposal, char for this task was to be obtained from tests conducted in Task 6 (Fluidized-Bed Hydrogasification Tests). However, a decision was made in September 1977 not to initiate Task 6 on the basis that it would not be required for the preferred reactor configuration selected for peat gasification. Therefore, more effort is being expended per test in Task 5 than originally anticipated.

Reassessment of the project goals shows that the project will have to be extended in order to achieve all the objectives of the program and to meet the contractual obligations of submitting all the interim and final reports. A revised schedule and cost estimates are being prepared for approval of DOE and Minnegasco.

Approved W. W. Bodle
W. W. Bodle, Director
Process Analysis

Signed D V Punwani
D. V. Punwani, Assistant Director
Chemical Processing Research

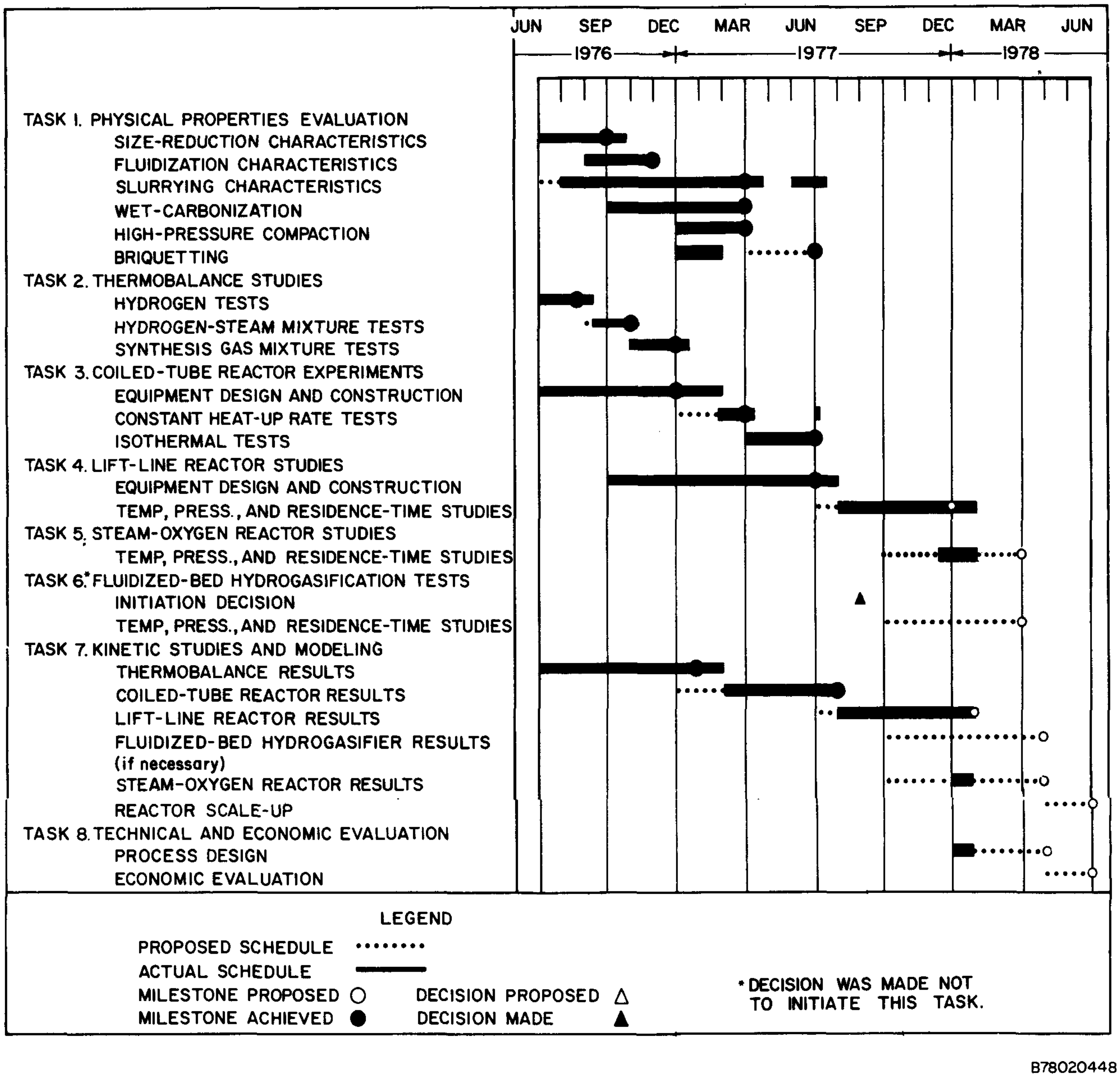

Figure 3. MILESTONE CHART FOR THE PEAT HYDROGASIFICATION PROGRAM

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