U.S. Department of Energy

Pittsburgh Energy Technology Center

Refining and End Use Study of Coal Liquids

Contract No. DE-AC22-93PC91029

Quarterly Report

July - September 1995

Section 1

Introduction and Summary

This report is Bechtel's eighth quarterly technical progress report and covers the period of July 1, 1995 through September 24, 1995.

1.1 Introduction

Bechtel, with Southwest Research Institute, Amoco Oil R&D, and the M.W. Kellogg Co. as subcontractors, initiated a study on November 1, 1993, for the U.S. Department of Energy's (DOE's) Pittsburgh Energy Technology Center (PETC) to determine the most cost effective and suitable combination of existing petroleum refinery processes needed to make specification transportation fuels or blending stocks, from direct and indirect coal liquefaction product liquids. This 47-month study, with an approved budget of $4.4 million dollars, is being performed under DOE Contract Number DE-AC22-93PC91029.

A key objective is to determine the most desirable ways of integrating coal liquefaction liquids into existing petroleum refineries to produce transportation fuels meeting current and future, e.g. year 2000, Clean Air Act Amendment (CAAA) standards. An integral part of the above objectives is to test the fuels or blends produced and compare them with established ASTM fuels. The comparison will include engine tests to ascertain compliance of the fuels produced with CAAA and other applicable fuel quality and performance standards.

The final part of the project includes a detailed economic evaluation of the cost of processing the coal liquids to their optimum products. The cost analyses is for the incremental processing cost; in other words, the feed is priced at zero dollars. The study reflects costs for operations using state of the art refinery technology; no capital costs for building new refineries is considered. Some modifications to the existing refinery may be required. Economy of scale dictates the minimum amount of feedstock that should be processed.

To enhance management of the study, the work has been divided into two parts, the Basic Program and Option 1.

The objectives of the Basic Program are to:

- Characterize the coal liquids
- Develop an optimized refinery configuration for processing indirect and direct coal liquids
- Develop a LP refinery model with the Process Industry Modeling System (PIMS) software.

The work has been divided into six tasks.

Task 1 - Development of a detailed project management plan for the Basic Program
Task 2 - Characterization of four coal liquid feeds supplied by DOE
Task 3 - Optimization of refinery processing configurations by linear programming

Task 4 - Pilot plant analysis of critical refinery process units to determine yield, product quality and cost assumptions. Petroleum cuts, neat coal liquids, and coal liquids/petroleum blends will be processed through the following process units: reforming, naphtha and distillate hydrotreating, catalytic cracking and hydrocracking.

Task 5 - Development of the project management plan for Option 1

Task 6 - Project management of the Basic Program and Option 1

The objectives of Option 1 are to:

- Confirm the validity of the optimization work of the Basic Program
- Produce large quantities of liquid transportation fuel blending stocks
- Conduct engine emission tests
- Determine the value and the processing costs of the coal liquids

This will be done by processing the coal liquids as determined by the optimization work, blending and characterizing the product liquids, and running engine emission tests of the blends. Option 1 has been divided into three tasks.

Task 1 - Based on the pilot plant and linear programming optimization work of the Basic Program, production runs of pilot plants (hydrotreating, reforming, catalytic cracking, and hydrocracking) will be conducted to produce sufficient quantities for blending and engine testing.

Task 2 - The pilot plant products will be blended, characterized, and engine tested

Task 3 - An economic analysis will be conducted to determine the costs of processing the coal liquids through the existing refinery

Table 1-1 shows which organization has the primary responsibility for each task.

1.2 Summary

The major efforts conducted during the third quarter of 1995 were in the areas of:

- IL catalytic cracking - Pilot plant tests showed that the indirect liquid (IL) wax was also an excellent catalytic cracker feed.
- IL wax hydrocracking - Pilot plant hydrocracking tests on the IL wax are in progress
- DL2 characterization and fractionation work is in progress.

Introduction and Summary

Table 1-1 Project Task Primary Responsibility Chart

Task	Description	Bechtel	SwRI	Amoco	Kellogg
1	Project Management Plan (PMP) development	x			
2	Feed characterization		x		
3	Linear programming	x			
4	Pilot plant analysis -				
	Cat cracking of DL liquids				x
	Cat cracking of indirect wax			x	
	Hydrocracking of wax			x	
	Fractionation, reforming, hydrotreating, etc.		x		
5	Option 1 PMP development	x			
6	Project management	x			
Option 1 - Task 1	Pilot plant production -				
	Cat cracking of DL liquids and wax				x
	All other production work		x		
Option 1 - Task 2	Fuel blending, characterizing, engine testing		x		
Option 1 - Task 3	Economic analysis	x			

x = key participant

Section 2

SwRI Activities

Characterization and fractionation of the DL2 coal liquid is in progress and will be reported in the next quarterly report

Section 3

Bechtel Activities

3.1 Linear Programming Model - Task 3

A report on the design basis of the linear programming model for direct coal liquids is being developed.

Section 4

Amoco Activities

4.1 Indirect wax catalytic cracking

4.2 Summary

Blends of a high molecular weight synthetic Fischer-Tropsch wax from the LaPorte pilot unit, FCC-1509 (SwRI ID No.FL-2443), and a sample of Whiting catalytic cracker feed, FCC-1498 (FL 2312), were cracked in the AU-79L FCC pilot plant. Wax concentrations in the blends were 20 wt% and 40 wt%. Standard cracking conditions and catalyst, CCC-2194 (F9804), were used. The properties of the base gas oil and the FT wax are shown in Table 4-1. The test conditions are shown in Table 4-2 and the incremental product data for the wax are summarized in Tables 4-3 and 4-4.

The incremental product values shown in Table 4-4 were based on the price structure that had been used in earlier FT wax cracking tests. The product values reported here are somewhat different from the preliminary values that were reported earlier in the year, due to refinements in the test data. These differences do not alter the conclusion that LaPorte FT wax would make a valuable FCC feed yielding cracked products that are worth somewhat more than a dollar per barrel compared to those obtained from standard FCC feeds.

Incremental conversions for the wax were very high, averaging about 91 vol%. For this high conversion, coke yield was low at about 4 wt%. In spite of the high conversion, the FT wax produced about the same yield of C_2- gas as the standard cat feed. Most of the wax cracked to naphtha which had only slightly lower octanes than naphtha obtained from the standard cat feed. The wax also gave a large yield of valuable light olefins while cycle oil production was low.

The calculation procedures used to estimate incremental yields are outlined in Section 4.4.

4.3 Introduction

Coal can be converted to syngas, CO and H_2, which can be further converted to a distillate and wax via the well known Fischer-Tropsch reaction. The USA has vast quantities of coal which can be used to supplement our petroleum reserves by 1) directly liquefying the coal via high pressure hydrogenation reactions or 2) by indirectly liquefying the coal by first converting it to syngas and then liquefying the syngas via the Fischer-Tropsch reaction. The liquid products produced by either direct or indirect coal liquefaction would be blended with conventional petroleum feedstocks for upgrading in a modern refinery.

The impetus for this work is to determine how well blends of Fischer-Tropsch wax and conventional petroleum heavy vacuum gas oil crack in a modern FCC unit.

4.4 Experimental

FCC pilot plant runs were made with a feedstock containing both 20 wt% and 40 wt% purified Fischer-Tropsch wax (FL-2443) that were blended with a Whiting combined FCC feed (FL-2312). The catalyst was an equilibrium FCC catalyst from Conoco, Vektor 50, (F-9804; identified in Amoco runs as CCC-2194). The runs were made on pilot plant AU-79L. A process flow diagram is shown in Figure 1. The injector nozzle was increased from 0.02 inches to 0.04 inches in order to run without plugging AU-79 in an automated pilot plant with a 30 ft. riser that ranges in diameter from 1/4 to 1/2 inch. The test conditions, feed rates, and catalyst circulation rates are shown in Table 4-2.

4.4.1 Incremental yield calculations

Some unconventional feeds are difficult to crack in the FCC pilot plant in their pure state. For example, they might make too much gas or coke and tend to overload the pilot plant. Unconventional feeds may also be poorly represented by the feed technology in the FCC simulation model. These difficult feeds can still be cracked when blended with conventional gas oil and their product yields can be estimated if a few assumptions are more or less valid:

1. Pilot plant operating conditions, including catalyst properties, remain constant throughout the investigation.

2. The total volume of blended feed components equals the sum of their individual component volumes, i.e., there is no volume contraction or expansion when components are mixed. The same is true of the cracked products. This assumption is usually quite good if similar components such as gas oils, naphtha, or 430+ cycle oils are mixed with themselves. With dissimilar materials, for example mixing naphtha and the 430+ cycle oils, the no-volume-change assumption may be poor.

3. The cracking reactions of the gas oil and unconventional feed are largely independent of each other and the product yields of each feed component are approximately independent of the component's concentration in the total feed blend.

A system that can be used to calculate incremental yields based on these assumptions is outlined below. The particular equations that were used in this investigation are underlined with a dashed line.

4.4.2 Incremental Weight Yields

This is a simple weight balance and involves no assumptions in addition to having steady-state pilot plant operation.

$$W_I^P + W_{GO}^P = W_B^P \quad \text{or} \quad W_I^F\left(\frac{W_I^P}{W_I^F}\right) + W_{GO}^F\left(\frac{W_{GO}^P}{W_{GO}^F}\right) = W_B^F\left(\frac{W_B^P}{W_B^F}\right)$$

Definitions of the symbols are given in Section 4.4.6. Each term is divided by W_B^F and the equation is solved for the incremental weight fractional yield.

$$\left(\frac{W_I^P}{W_I^F}\right) = \left\{\left(\frac{W_P^W}{W_B^F}\right) - f_{GO}\left(\frac{W_{GO}^P}{W_{GO}^F}\right)\right\}\frac{1}{f1}$$

4.4.3 Specific gravity of the incremental products

A weight balance can be used to estimate the specific gravity of incremental products:

$$W_I^P + W_{GO}^P = W_B^P \text{ or } \rho_I^P V_I^P = \rho_B^P V_B^P - \rho_{GO}^P V_{GO}^P$$

$$\rho_I^P = \frac{\rho_B^P V_B^F\left(\frac{V_B^P}{V_B^F}\right) - \rho_{GO}^P V_{GO}^F\left(\frac{V_{GO}^P}{V_{GO}^F}\right)}{V_I^F\left(\frac{V_I^P}{V_I^F}\right)} = \frac{\rho_B^P\left(\frac{V_B^P}{V_B^F}\right) - \rho_B^P\left(\frac{V_B^P}{V_B^F}\right) - \rho_{GO}^P\left(\frac{V_{GO}^F}{V_B^F}\right)\left(\frac{V_{GO}^P}{V_{GO}^F}\right)}{\left(\frac{V_I^F}{V_B^F}\right)\left(\frac{V_I^P}{V_I^F}\right)}$$

An expression for calculating the specific gravity of a product can also be derived from its definition. If equations for weight and volume incremental yields (see next section) are substituted, the expression on the right side of the equation is obtained:

$$\rho_I^P = \frac{W_I^P}{V_I^P} = \left(\frac{W_I^P}{W_I^F}\right)\frac{W_I^F}{V_I^P} = \left(\frac{W_I^P}{W_I^F}\right)\frac{\rho_I^F V_I^F}{V_I^P} = \frac{\rho_I^F\left(\frac{W_B^P}{W_B^F}\right)}{\frac{V_I^P}{V_I^F}} = \frac{\left(\frac{W_B^P}{W_B^F}\right) - f_{GO}\left(\frac{W_{GO}^P}{W_{GO}^F}\right)}{\frac{1}{\rho_B^P}\left(\frac{W_B^P}{W_B^F}\right) - \frac{f_{GO}}{\rho_{GO}^P}\left(\frac{W_{GO}^P}{W_{GO}^F}\right)}$$

4.4.4 Incremental Volume Yields

A volume balance can be made on components using the assumption that no volume change occurs when the components are mixed. The volume balance gives:

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$$V_I^P + V_{GO}^P = V_B^P \text{ or } V_I^F\left(\frac{V_I^P}{V_I^F}\right) + V_{GO}^F\left(\frac{V_{GO}^P}{V_{GO}^F}\right) = V_B^F\left(\frac{V_B^P}{V_B^F}\right)$$

$$\left(\frac{V_I^P}{V_I^F}\right) = \left\{\left(\frac{V_B^P}{V_B^F}\right) - \left(\frac{V_{GO}^F}{V_B^F}\right)\left(\frac{V_{GO}^P}{V_{GO}^F}\right)\right\} \div \left(\frac{V_I^F}{V_B^F}\right)$$

This equation is inconvenient as it involves volume fractions of the feed components. It can be converted to express the feed components in terms of weights:

$$\frac{W_I^F}{\rho_I^F}\left(\frac{V_I^P}{V_I^F}\right) + \frac{W_{GO}^F}{\rho_{GO}^F}\left(\frac{V_{GO}^P}{V_{GO}^F}\right) = \frac{W_B^F}{\rho_B^F}\left(\frac{V_B^P}{V_B^F}\right)$$

Each term is divided by W_B^F and the equation is solved for the unknown volumetric fractional yield:

$$\left(\frac{V_I^P}{V_I^F}\right) = \left\{\frac{1}{\rho_B^F}\left(\frac{V_B^P}{V_B^F}\right) - \frac{f_{GO}}{\rho_{GO}^F}\left(\frac{V_{GO}^P}{V_{GO}^F}\right)\right\}\frac{\rho_I^F}{\text{fi}}$$

This equation was used to calculate the C6-430 volume percent yield. The volumetric yield can also be derived in terms of the weight yields of the products:

$$V_I^P + V_{GO}^P = V_B^P \text{ or } V_I^F\left(\frac{V_I^P}{V_I^F}\right) = \frac{W_B^P}{\rho_B^P} - \frac{W_{GO}^P}{\rho_{GO}^P} = \frac{W_B^F}{\rho_B^P}\left(\frac{W_B^P}{W_B^F}\right) - \frac{W_{GO}^F}{\rho_{GO}^P}\left(\frac{W_{GO}^P}{W_{GO}^F}\right)$$

$$\left(\frac{V_I^P}{V_I^F}\right) = \frac{\frac{W_B^F}{\rho_B^P}\left(\frac{W_B^P}{W_B^F}\right) - \frac{W_{GO}^F}{\rho_{GO}^P}\left(\frac{W_{GO}^P}{W_{GO}^F}\right)}{\frac{W_I^F}{\rho_I^F}} = \left\{\frac{1}{\rho_B^P}\left(\frac{W_B^P}{W_B^F}\right) - \frac{f_{GO}}{\rho_{GO}^P}\left(\frac{W_{GO}^P}{W_{GO}^F}\right)\right\}\frac{\rho_I^F}{f_I}$$

A third approach is to derive an equation that uses the calculated specific gravity of the incremental product.

$$\frac{V_I^P}{V_I^F} = \frac{\dfrac{W_I^P}{\rho_I^P}}{\dfrac{W_I^F}{\rho_I^F}} = \left(\frac{W_I^P}{W_I^F}\right)\frac{\rho_I^F}{\rho_I^P}$$

These different methods of estimating volumetric yields of incremental products tend to give slightly different results possibly due to numerical roundoff and small measurement errors. Except for the C6-30 yield, this equation was used in the present investigation.

4.4.5 Octanes of the Incremental Naphtha

Octanes of the incremental naphtha can be calculated using an octane-barrels balance:

$$(ON_I)\left(V_I^{C5-430}\right) + (ON_{GO})\left(V_{GO}^{C5-430}\right) = (ON_B)\left(V_B^{C5-430}\right)$$

$$(ON_I)\left(V_I^F\right)\left(\frac{V_I^{C5-430}}{V_I^F}\right) + (ON_{GO})\left(V_{GO}^F\right)\left(\frac{V_{GO}^{C5-430}}{V_{GO}^F}\right) = (ON_B)\left(V_B^F\right)\left(\frac{V_B^{C5-430}}{V_B^F}\right)$$

Each term is divided by V_B^F, volumes are converted to weights, and the equation is solved for the octane:

$$ON_I = \frac{\dfrac{ON_B}{\rho_B^F}\left(\dfrac{V_B^{C5-430}}{V_B^F}\right) - \dfrac{f_{GO}ON_{GO}}{\rho_{GO}^F}\left(\dfrac{V_{GO}^{C5-430}}{V_{GO}^F}\right)}{\dfrac{f_I}{\rho_I^F}\left(\dfrac{V_I^{C5-430}}{V_I^F}\right)}$$

4.4.6 Incremental Conversion

This can be calculated direct form its definition:

$$V_I^{430+} = N^{430+} \text{ X } V_I^F\left(1 - X\right) \text{or } X = 1 - \left(\frac{V_I^{430+}}{V_I^F}\right)\frac{1}{N^{430+}}$$

4.4.7 Symbols

$f_{.} = \frac{W^{F}_{.}}{W^{F}_{B}}$ Weight fraction of base gas oil or incremental component in the feed

N^{430+} Volume fraction of feed boiling above 430^{of}

ON Octane number, RON or MON

V Volume of a feed or product component

W Weight of a feed or product component

$\left(\frac{Vp}{V_F}\right)$ Volume fraction yield of a product

$\left(\frac{V^{F}_{.}}{V^{F}_{B}}\right)$ Feed volume fraction of base gas oil or incremental component in the blend

$\frac{W^{p}_{.}}{W^{F}_{.}}$ Weight fraction yield of a product

$\rho_{.}$ Density of a feed or product component

Subscripts and superscripts:

I Incremental component

GO Base gas oil component

B Blend of incremental component and base gas oil

p Product

F Feed

4.5 Results and discussion

Fischer-Tropsch waxes are essentially n-paraffins with virtually no heteroatoms. Thus, they should readily crack in an FCC environment. Due to catalytic competitive adsorption effects, there are many synergistic effects on conversion and selectivity when processing petroleum and indirect liquefaction Fischer-Tropsch wax feedstock blends.

Process conditions were constant for the three runs (100% HVGO, 20% wax + 80% HVGO, 40% wax + 60% HVGO). As can be seen in Table 4-4, conversion is much higher for the wax feedstock compared with the gas oil feed (91% vs. 71.5%). With the wax, C_2- wt% yields are comparable, but the yields of valuable light olefins and isoparaffins are considerably higher compared with the HVGO. These olefins are valuable feedstocks for MTBE and other ether production. The olefins and isoparaffins can be alkylated to high octane stocks. C_5-430 naphtha volume yield is also higher, 76 vol% vs. 61 vol%. (R+M)/2 octane was about 1 octane number lower with the FT wax. This is not surprising, since the wax contains no aromatics. Cycle oil yields were almost three times higher with the HVGO (26.7% vs. 9.0 vol%). Thus, we can conclude that the purified LaPorte Fischer-Tropsch readily cracks to more valuable lighter product components, particularly gasoline boiling range material and C_3 to C_5 components. Coke makes were comparable with both feeds which was rather surprising since the HVGO contained more aromatics, a coke precursor.

Product values for the wax blends are in the $21.50 range vs. $19.50 for products from HVGO. Thus, we can conclude the cracking wax - HVGO blends can be quite profitable.

Some operability problems were encountered initially, when running with the wax blends. The feed injector nozzle tended to rapidly plug with a coke-like material. The I.D. of the nozzle was increased from 0.02 inches to 0.04 inches. No operability problems were encountered after this change.

4.6 Conclusions

1. Incremental conversions for the Fischer-Tropsch wax were very high, averaging about 91 vol% versus 71.5% for the HVGO.

2. Most of the wax cracked to naphtha, which had only slightly lower octanes than the naphtha obtained from the standard cat feed.

3. Yields of valuable C_3 to C_5 olefins were high with the wax feedstock while cycle oil production was low.

4. Operability with wax blends greater than 40% need to be demonstrated, Heat balance could be a problem with high concentrations of wax in the feedstock.

Amoco Activities

Table 4-1. Properties of the base gas oil and LaPorte FT wax.

	Base Gas Oil	LaPorte FT Wax
Feed, FCC-	1498	1509
API	26.1	26.14
S, wt.%	1.26	
N total, wt.%	0.0905	
RI @ 70 C	1.4801	
Rams Carbon, wt.%	0.28	
Boiling Point Distribution, Volume Percent Off		
430 F	6.25	0.00
450 F	7.50	
500 F	11.20	
550 F	17.23	
600 F	24.91	
650 F	34.89	
700 F	46.28	
750 F	57.91	
800 F	68.91	
850 F	78.65	
900 F	85.97	
950 F	91.84	
1000 F	95.25	
1100 F	97.04	
1200 F	98.84	

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Table 4-2. AU-79L test conditions

		Blend With LaPorte FT Wax	
Test No.	464-02	465-01	466-01
Feed, FCC-	1498	1499	1500
Percent Wax	0	20	40
Catalyst, CCC-	2194	2194	2194
Feed Rate, gm/min	14.4	14.3	14.4
Cat Circulation Rate, Gm/min	136	137	128
Cat-To-Oil	9.43	9.57	8.88
WHSV	45	44	47
Feed Temperature, F	394	393	394
Cracking Temperature, F	953	953	952

Table 4-3. Summary of yields for conventional FCC feed and LaPorte FT wax

	Conventional	Incremental Data For		
	FCC Feed	20% Wax	40% Wax	Average
Conversion, vol.% FF	71.5	90.1	91.9	91
H2S, wt.%	0.41	0	0	0
C2-, wt.%	1.72	1.73	1.52	1.63
Total C3, vol.%	4.86	7.46	7.09	7.28
Total C4, vol.%	9.18	15.55	15.46	15.51
Total C5, vol.%	8.66	17.79	17.58	17.69
C5-430, vol.%	51.37	61.16	63.70	62.43
RON, adj.	88.2	86.60	86.70	86.65
MON, adj.	79.6	78.80	79.20	79.00
(R+M)/2	83.9	82.70	82.90	82.80
430+ Cycle Oil, vol.%	26.68	9.93	8.13	9.03
Coke, wt.%	3.68	4.08	3.85	3.97

Table 4-4. Incremental yields and octane numbers for cracking FT Wax in gas oil.

AU-79L	FCC-1498	F-T Wax		Calculated Incremental Yields For LaPorte Fischer-Tropsch Wax			Normalized Incremental Yields For LaPorte Fischer-Tropsch Wax		
Test No.	464-02	465-01	466-01						
Wax, wt.%	0	20	40	20	40	Average	20	40	Average
Wt% yields									
H2S	0.41	0.31	0.14	0.00	0.00	0.00	0	0	0
H2	0.09	0.09	0.11	0.09	0.14	0.12	0.09	0.14	0.11
C1	0.63	0.65	0.62	0.73	0.61	0.67	0.73	0.60	0.67
C2=	0.54	0.53	0.51	0.49	0.47	0.48	0.49	0.46	0.48
C2	0.47	0.46	0.41	0.42	0.32	0.37	0.42	0.32	0.37
C3=	4.04	4.58	5.01	6.74	6.47	6.60	6.74	6.45	6.60
C3	0.82	0.80	0.75	0.72	0.65	0.68	0.72	0.64	0.68
IC4	3.17	3.39	3.47	4.27	3.92	4.10	4.27	3.91	4.09
NC4	0.69	0.71	0.75	0.79	0.84	0.82	0.79	0.84	0.81
Total C4 Paraffins	3.86	4.10	4.22	5.06	4.76	4.91	5.06	4.75	4.91
IC4=	1.32	1.64	1.98	2.92	2.97	2.95	2.92	2.96	2.94
1-C4=	1.27	1.47	1.67	2.27	2.27	2.27	2.27	2.26	2.27
CC4=	1.19	1.41	1.66	2.29	2.37	2.33	2.29	2.36	2.33
TC4=	1.55	1.84	2.14	3.00	3.03	3.01	3.00	3.02	3.01
Total C4 Olefins	5.33	6.36	7.45	10.48	10.63	10.56	10.49	10.61	10.55

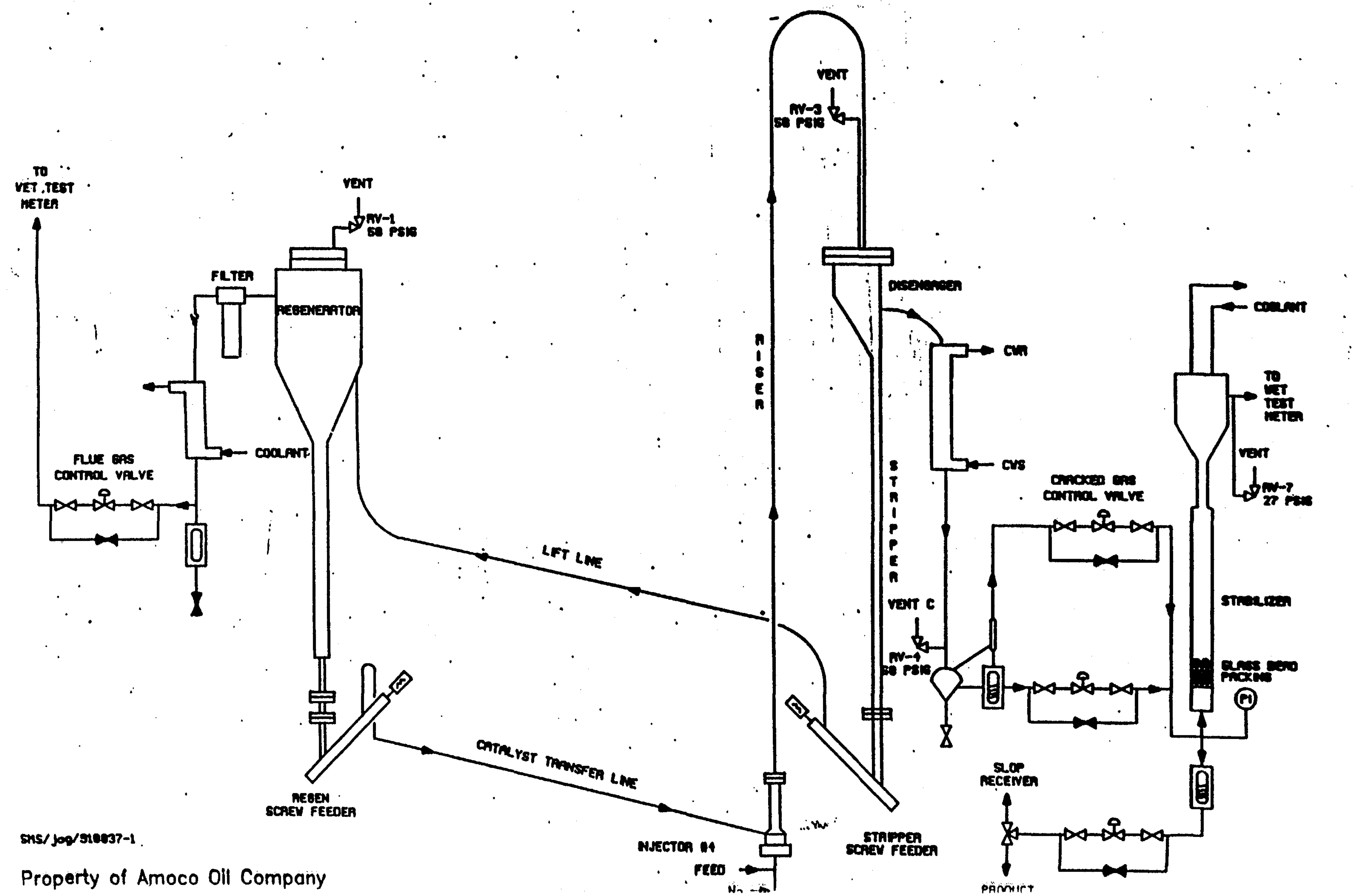
Table 4-4 (cont'd) Incremental yields and octane numbers for cracking FT Wax in gas oil.

AU-79L	FCC-1498 F-T Wax			Calculated Incremental Yields For LaPorte Fischer-Tropsch Wax			Normalized Incremental Yields For LaPorte Fischer-Tropsch Wax		
Test No.	464-02	465-01	466-01						
Wax, wt.%	0	20	40	20	40	Average	20	40	Average
Wt% yields									
I-C5	3.45	3.97	4.32	6.05	5.63	5.84	6.05	5.61	5.83
Cyclo-C5	0.03	0.03	0.02	0.03	0.01	0.02	0.03	0.00	0.02
NC5	0.50	0.59	0.68	0.95	0.95	0.95	0.95	0.95	0.95
Total C5 Saturates	3.98	4.59	5.02	7.03	6.58	6.81	7.03	6.56	6.80
1-C5=	0.35	0.45	0.56	0.85	0.88	0.86	0.85	0.87	0.86
Cyclo-C5=	0.07	0.08	0.07	0.12	0.07	0.10	0.12	0.07	0.09
C&T-2-C5=	1.34	1.71	2.02	3.19	3.04	3.12	3.19	3.03	3.11
2M-2-C4=	1.60	2.02	2.48	3.70	3.80	3.75	3.70	3.79	3.75
2M-1-C4=	1.32	1.62	2.07	2.82	3.20	3.01	2.82	3.19	3.01
C5==	0.02	0.03	0.04	0.07	0.07	0.07	0.07	0.07	0.07
Total C5 Unsaturates	4.70	5.91	7.24	10.75	11.05	10.90	10.76	11.02	10.89
C6/430	42.71	42.81	44.09	43.21	46.16	44.69	43.24	46.05	44.65
C5/430	51.37	53.32	56.36	61.12	63.85	62.48	61.16	63.70	62.43
430+	28.78	25.05	20.69	10.13	8.56	9.34	10.14	8.54	9.34
Coke	3.68	3.76	3.75	4.08	3.86	3.97	4.08	3.85	3.96
Sum Of Components	100.04	100.00	100.01	99.93	100.23	100.08	100.00	100.00	100.00

Table 4-4 (cont'd) Incremental yields and octane numbers for cracking FT Wax in gas oil.

AU-79L	FCC-1498	F-T Wax		Calculated Incremental Yields For		
Test No.	464-02	465-01	466-01	LaPorte Fischer-Tropsch Wax		
Wax, wt.%	0	20	40	20	40	Average
Volumetric Data				Calculated Incremental Data		
C6-430 vol.% Yield	48.98	49.89	51.95	53.53	56.41	54.97
C5-430 vol.% Yield	61.10	64.58	69.07	74.01	78.23	76.12
430+ vol.% Yield	26.68	23.33	19.26	9.95	8.13	9.04
Adj. C5-430 API	56.0	59.5	61.8	59.4	61.7	60.5
C5-430 S.G.	0.7547	0.7408	0.7320	0.7413	0.7326	0.7369
430+ API	14.7	15.4	15.3	23.4	18.3	20.8
430+ S.G.	0.9679	0.9632	0.9639	0.9138	0.9444	0.9291
Adj. RON	88.2	87.8	87.5	91.8	89.8	90.8
Adj. MON	79.6	79.4	79.4	83.6	82.0	82.8
(R+M)/2	83.9	83.6	83.45	87.7	85.9	86.8
Conversion, vol.%	71.52	75.44	79.98	90.05	91.87	90.96
Value, $/Barrel	~$19.50			~$21.15	~$21.50	~21.35

Figure 4-1 Process Flow Diagram
AU-79L Pilot Plant



SMS/jog/910837-1

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Section 5

M.W. Kellogg Activities

There was no project activity for this reporting period.