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FEASIBILITY OF PRODUCING JET FUEL FROM GPGP BY-PRODUCTS

Quarterly Technical Progress Report
for the Period February 17, 1988 through May 16, 1988

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EXECUTIVE SUMMARY

Research into the feasibility of producing jet fuel from the by-products of the Great Plains Gasification Plant continued. Samples of the Great Plains Gasification Plant phenolics stream which had been treated in the Hydrocarbon Research, Inc. (HRI) Dynaphen Process were characterized using gas chromatography and a flame ionization detector. The Dynaphen Process consists of a pressurized, high-temperature, non-catalytic hydrodealkylation of alkylphenols. In this process, the major reactor products are phenol and benzene. The results of the characterization of the Dynaphen samples performed at UNDEMRC were compared to the results of the characterization performed by HRI. In general, the results of the two characterizations were in good agreement.

In further first-stage reaction investigations, models for total heteroatom, nitrogen, and sulfur removal, aliphatic content; and aromatic content-to-aliphatic content ratio were determined for the GPGP tar/oil stream using the results from a statistical experimental design. These models were used to construct plots from which predictions were made of "optimal" conditions at which to perform the first-stage processing. It was determined that temperatures of approximately 380° to 400°C and pressures of 2000 to 2800 psi should produce the desired results. Tests will be performed at these "optimal" conditions to verify the predictions.

1.0 INTRODUCTION

It is the goal of the national energy policy to foster an adequate supply of energy at reasonable cost. Domestic production supplies approximately 60% of the United States' petroleum requirements. However, domestic and world supplies have been and will continue to be unreliable. Continued dependence upon foreign suppliers of crude oil could seriously affect our nation's economy, as well as jeopardize our national security. As such, synthetic liquid fuels are an essential part of an energy scenario which provides the United States with a means to reduce reliance on imported oil.

The Department of Defense (DOD) is the largest single consumer of liquid fuels in the United States, accounting for 2.7% of the nation's petroleum demand. Approximately one-half of the DOD requirements of Grade JP-4 turbine fuel, or 240,000 barrels, are consumed daily by the Air Force for aircraft operations. A naphtha-based fuel, JP-4 is used primarily in the United States, while JP-8 is a kerosene-type fuel which is used abroad. Because of the need to assure adequate supplies of both types of turbine fuel at

acceptable costs, the Air Force has investigated the characteristics, cost, and yield of these fuels when produced from tar sands, shale oil, and heavy oils, and is seeking similar data for coal-derived liquids.

One producer of coal-derived liquids is the Great Plains Gasification Plant (GPGP) in Beulah, North Dakota. The plant, which is located near several Air Force bases along the northern tier, currently produces over 150 million cubic feet per day of high-Btu synthetic natural gas (SNG) from North Dakota lignite. In addition, the plant generates three liquid streams: naphtha, crude phenol, and tar/oil. The naphtha, accounting for about 730 barrels per day (BPD), may be directly marketable because of its low boiling point and high aromatic content. The other two streams, consisting of a nominal 880 BPD of phenols from the Phenosolvan unit and 3200 BPD of tar oil from the primary quench, are available as potential sources of aviation jet fuel for the Air Force. Aviation fuels produced for the Great Plains liquids could become an indigenous fuel supply for the northern tier bases. Minot Air Force Base at Minot, North Dakota, is remote from jet fuel supplies and would benefit from this development if the jet fuel produced at Great Plains can meet all specifications and be cost competitive with other supplies.

2.0 GOALS AND OBJECTIVES

The primary objective of this project is to assess the technical and economic feasibility of producing aviation turbine fuel from the by-product streams of GPGP. These streams, as well as fractions thereof, will be characterized and subsequently processed over a wide range of process conditions. The chemical and physical characteristics of the resulting turbine fuel products will be compared to petroleum-based fuels to determine their ability to meet military specification requirements.

A second objective is to assess the conversion of the by-product streams into a new, higher-density aviation fuel. Since no performance specifications currently exist for a high-density jet fuel, reaction intermediates and products will only be characterized to indicate the feasibility of producing such a fuel.

3.0 TASK 1 - FEEDSTOCK CHARACTERIZATION: ANALYSIS OF DYNAPHEN SAMPLES

The Dynaphen process was developed by Hydrocarbon Research, Inc. (HRI) for the thermal hydrodealkylation of cresylic acids (1). A pressurized, high-temperature, non-catalytic hydrodealkylation reactor is used to hydrodealkylate the alkylphenols derived from a variety of materials, notably coal liquids (Figure 1). Dealkylation of cresylic acids is the primary reaction which occurs in the Dynaphen reactor, although some dehydroxylation occurs as well. Unconverted alkylphenols are recycled to the Dynaphen reactor so that the major reactor products are phenol and benzene.

Analyses of the eight HRI samples, three feedstocks and five products treated in the Dynaphen Process, have been completed. The data for the samples that were received for analysis are presented in Tables 1 and 3 through 13. To properly evaluate these data, a computer code was completed to enable data manipulation. Retention times were used to match similar compounds, and response factors were calculated and used to convert area

Figure 1. Basic Dynaphen flow scheme

percents to weight percents. This program has general utility for most spectroscopic data reduction and significantly improves reduction of gas chromatograph (GC) data.

Table 1 presents the data for the samples as they were received and analyzed at UNDEMRC in comparison to values obtained by HRI. In general, the data are in fair agreement. Of the five samples containing isopropanol, two are essentially the same, while the others are plus or minus approximately 10%. The water content values for samples 237-50 and 237-51 indicated a larger difference, while the other six values are similar. The EMRC water content values were determined by Karl-Fischer titration. The isopropanol values were determined from the GC analysis. GC equipment used as well as conditions of the analyses are presented in Table 2.

In the GC analysis, the samples were injected neat (0.02 microliters), and the flame ionization detector (FID) output was monitored. FID does not observe water and produces an output which is essentially proportional to the carbon-hydrogen content of each compound. Response factors are used to correct GC area % data to wt % data. For compound classes where response factors are similar, the wt % of a compound is similar to its area %. However, for compounds with widely different response factors (such as the GPGP crude phenol stream or samples mixed with isopropanol), area % and wt % may be far from equal. As shown in Table 1, the values for isopropanol are similar where HRI data are believed to be comprised of the mixed wt % values and the EMRC data were calculated using response factor data. The response factors used in the calculations have been verified to be within $\pm 5\%$ of other researchers' published data.

The direct application of response factors to calculate wt % assumes that all material injected into the GC leaves the column and is detected by the FID. In other words, the total effluent detected is believed to represent 100% of the sample. Compounds which are present in small concentrations in a sample or are reduced in concentration due to dilution may not be detected, thereby increasing the calculated concentration of the other detected compounds. Compounds such as some dihydroxybenzenes may be strongly adsorbed by the column and not detected. Errors due to the adsorption of multi-functional compounds will, during normalization, lead to increased area percents for measured species. However, this inherent error is thought to be at most only a few percent. For example, the total peaks present in the GC output are indicated in Table 1, as well as the number of peaks that are over 0.1 area%. The sum of the total peaks observed by FID is 100 area % while the sum of the peaks of over 0.1 area % is greater than 97%, indicating that the small peaks do not contain much material. In Tables 2 through 12, a period indicates that a peak was not observed, although it may have been present.

Table 2 presents a summary of the data for the HRI 5511, 237-61RC, and L-731 samples. The KF-water values were determined by Karl-Fischer analysis and calculated into the GC data to obtain as-received values. The latter two samples contained larger quantities of heavier material that do not appear on this table. Calculations were performed using the following equation:

$$100 * \text{kw}t\% / \text{Uwt}\% = \text{Amount left} \quad (1)$$

TABLE 3
SUMMARY OF GC/MS DATA FOR DYNAPHEN FEEDSTOCK SAMPLES^a

No.	Compound	SAMPLE		
		HRI 5511 (Crude Phenols)	L-731 (365°F+ cut of crude phenols)	237-61RC (74.9 wt% L-731; 15.1 wt % recycle; 10 wt % DI water)
1.	KF Water ^b	5.45	0.09	0.17
2.	Isopropanol	.	.	.
3.	Benzene	.	.	0.03
4.	Toluene	0.16	.	39.22
5.	C2-Benzene	0.08	.	1.69
6.	m,p-Xylene	0.12	.	2.22
7.	o-Xylene	0.07	0.01	0.14
8.	Aniline	0.13	0.28	0.21
9.	Phenol	44.55	25.38	2.14
10.	C3-Benzene	0.04	0.05	.
11.	Indane	0.02	.	.
12.	Indene	0.05	.	.
13.	o-Cresol	7.30	7.87	0.41
14.	m,p-Cresol	18.22	29.11	14.25
15.	Guaiacol	1.65	2.63	.
16.	C2-Phenol	0.30	0.44	.
17.	C2-Phenol	1.34	0.01	0.13
18.	C2-Phenol	0.98	2.42	.
19.	C2-Phenol	1.38	2.24	1.10
20.	C2-Phenol	2.36	3.82	.
21.	Naphthalene	0.26	0.38	7.22
22.	C1-Guaiacol	0.08	0.13	0.22
23.	Catechol	1.59	2.66	0.10
24.	C3-Phenol	0.16	0.20	0.01
25.	C3-Phenol	0.18	0.29	.
26.	Quinoline	0.03	0.07	1.49
27.	C1-Catechol	1.76	2.76	0.07
28.	C3-Phenol	0.17	0.19	0.19
29.	C3-Phenol	0.16	0.18	.
30.	2-Methylnaphthalene	0.22	0.20	1.43
31.	1-Methylnaphthalene	0.24	0.39	0.45
32.	C2-Catechol	0.87	1.35	0.03
33.	Biphenyl	0.05	0.07	2.21
34.	C2-Catechol	0.91	1.62	0.02
35.	Acenaphthene	0.03	0.05	0.94
36.	Dibenzofuran	0.06	0.10	1.25
37.	Naphthol	0.41	0.61	1.46
38.	Phenanthrene	0.08	0.11	2.75
39.	Fluoranthene	0.02	0.02	0.69
40.	Pyrene	0.02	0.03	0.53
	Total wt%	91.51	85.73	82.77
	# of GC Peaks	38	33	30

^a on an isopropanol-free basis; data in wt%

^b Karl-Fischer water

TABLE 4
SUMMARY OF GC/MS DATA FOR DYNAPHEN PRODUCT SAMPLES^a

No.	Compound	Sample (Feedstock)				237-61 (L-731; recycle)
		237-45 (crude phenols)	237-46	237-50 (92 wt% L-731; 8% DI water)	237-51	
1.	KF-Water ^b	13.61	20.89	22.36	24.47	21.15
2.	Isopropanol	.	.	.	.	.
3.	Benzene	11.43	31.39	6.49	14.76	27.26
4.	Toluene	4.98	3.97	6.74	7.31	10.06
5.	C2-Benzene	0.36	0.09	0.78	0.42	0.28
6.	m,p-Xylene	0.52	0.09	1.02	0.53	0.32
7.	o-Xylene	0.08	.	0.22	0.08	0.05
8.	Aniline	.	0.15	0.27	.	0.27
9.	Phenol	54.61	35.29	35.73	37.87	28.21
10.	C3-Benzene	.	.	0.01	.	.
11.	Indane	0.17	0.08	0.29	0.22	0.14
12.	Indene	0.12	0.07	0.16	0.14	0.09
13.	o-Cresol	1.31	0.13	3.24	0.86	0.34
14.	m,p-Cresol	7.91	1.15	15.27	6.76	3.90
15.	Guaiacol	.	.	.	.	.
16.	C2-Phenol	.	.	0.10	.	.
17.	C2-Phenol	0.07	.	0.31	.	0.01
18.	C2-Phenol	0.11	.	0.38	.	0.04
19.	C2-Phenol	.	.	0.30	.	0.16
20.	C2-Phenol	0.50	.	1.34	0.29	.
21.	Naphthalene	1.54	2.95	1.26	2.64	3.82
22.	C1-Guaiacol	.	0.05	0.03	.	0.08
23.	Catechol	.	.	0.29	.	.
24.	C3-Phenol	.	.	0.03	.	.
25.	C3-Phenol	.	0.12	0.01	.	0.22
26.	Quinoline	.	.	0.04	.	.
27.	C1-Catechol	.	.	0.14	.	0.06
28.	C3-Phenol	.	.	.	.	.
29.	C3-Phenol	.	.	0.01	.	.
30.	2-Methylnaphthalene	0.19	0.18	0.17	0.23	0.34
31.	1-Methylnaphthalene	0.11	0.04	0.15	0.12	0.07
32.	C2-Catechol	.	.	0.02	.	.
33.	Biphenyl	0.22	0.83	0.12	0.30	0.52
34.	C2-Catechol	.	.	0.06	.	0.01
35.	Acenaphthene	0.13	0.12	0.10	0.20	0.13
36.	Dibenzofuran	0.33	0.53	0.18	0.45	0.41
37.	Naphthol	0.26	0.08	0.36	0.39	0.19
38.	Phenanthrene	0.26	0.49	0.16	0.60	0.57
39.	Fluoranthene	0.07	0.14	0.04	0.18	0.10
40.	Pyrene	0.06	0.10	0.03	0.15	0.07
Total wt%		98.93	98.96	98.23	98.97	98.85
# of GC Peaks		24	23	37	99	99

^a on an isopropanol-free basis; data in wt%
^b Karl-Fischer water

TABLE 5

ADJUSTED^a GC/MS DATA FOR DYNAPHEN PRODUCT SAMPLES (HRI 5511 FEED)^b

No.	Compound	Sample	
		237-45	237-46
1.	KF-Water ^c	10.71	15.85
2.	Isopropanol	.	.
3.	Benzene	8.99	23.81
4.	Toluene	3.92	3.01
5.	C2-Benzene	0.28	0.07
6.	m,p-Xylene	0.41	0.07
7.	o-Xylene	0.06	.
8.	Aniline	.	0.11
9.	Phenol	42.96	26.77
10.	C3-Benzene	.	.
11.	Indane	0.14	0.06
12.	Indene	0.09	0.06
13.	o-Cresol	1.03	0.10
14.	m,p-Cresol	6.22	0.88
15.	Guaiacol	.	.
16.	C2-Phenol	.	.
17.	C2-Phenol	0.05	.
18.	C2-Phenol	0.08	.
19.	C2-Phenol	.	.
20.	C2-Phenol	0.39	.
21.	Naphthalene	1.21	2.23
22.	C1-Guaiacol	.	0.04
23.	Catechol	.	.
24.	C3-Phenol	.	.
25.	C3-Phenol	.	0.09
26.	Quinoline	.	.
27.	C1-Catechol	.	.
28.	C3-Phenol	.	.
29.	C3-Phenol	.	.
30.	2-Methylnaphthalene	0.15	0.14
31.	1-Methylnaphthalene	0.08	0.03
32.	C2-Catechol	.	.
33.	Biphenyl	0.17	0.63
34.	C2-Catechol	.	.
35.	Acenaphthene	0.10	0.09
36.	Dibenzofuran	0.26	0.41
37.	Naphthol	0.20	0.06
38.	Phenanthrene	0.21	0.37
39.	Fluoranthene	0.05	0.11
40.	Pyrene	0.05	0.08
	Total wt%	77.83	75.07
	# of GC Peaks	24	23

^a Data adjusted to liquid total in HRI letter dated Jan. 6, 1988.^b on an isopropanol-free basis; data in wt %.^c KF-Water = Karl Fischer water.

TABLE 6
GC/MS ANALYSIS DATA FOR HRI 5511
(Feedstock - Crude Phenols)

No.	Compound	Rf	RT (min)	A%	wt%	AR (wt%)
1.	KF-Water	.	.	.	.	5.45
2.	Isopropanol	0.53	2.030	.	.	.
3.	Benzene	1.12	5.142	.	.	.
4.	Toluene	1.07	8.441	0.27	0.17	0.16
5.	C2-Benzene	1.02	11.596	0.12	0.08	0.08
6.	m,p-Xylene	1.01	11.847	0.19	0.13	0.12
7.	o-Xylene	1.02	12.590	0.12	0.08	0.07
8.	Aniline	0.75	15.486	0.15	0.13	0.13
9.	Phenol	0.56	15.784	39.85	47.12	44.55
10.	C3-Benzene	1.00	16.573	0.06	0.04	0.04
11.	Indane	1.00	16.940	0.04	0.03	0.02
12.	Indene	1.00	17.206	0.08	0.06	0.05
13.	o-Cresol	0.69	17.710	8.05	7.73	7.30
14.	m,p-Cresol	0.69	18.355	20.08	19.27	18.22
15.	Guaiacol	0.57	18.607	1.50	1.75	1.65
16.	C2-Phenol	0.75	19.056	0.36	0.23	0.30
17.	C2-Phenol	0.75	20.201	1.60	1.41	1.34
18.	C2-Phenol	0.75	20.238	1.18	1.04	0.98
19.	C2-Phenol	0.75	20.697	1.65	1.45	1.38
20.	C2-Phenol	0.75	20.777	2.83	2.50	2.36
21.	Naphthalene	0.90	21.049	0.38	0.28	0.26
22.	C1-Guaiacol	0.60	21.185	0.08	0.09	0.08
23.	Catechol	0.50	21.547	1.27	1.69	1.59
24.	C3-Phenol	0.86	22.343	0.22	0.17	0.16
25.	C3-Phenol	0.86	22.507	0.25	0.19	0.18
26.	Quinoline	0.56	22.595	0.02	0.03	0.03
27.	C1-Catechol	0.63	23.105	1.77	1.86	1.76
28.	C3-Phenol	0.86	23.226	0.23	0.18	0.17
29.	C3-Phenol	0.86	23.340	0.22	0.17	0.16
30.	2-Methylnaphthalene	1.00	23.919	0.35	0.23	0.22
31.	1-Methylnaphthalene	1.00	24.288	0.39	0.25	0.24
32.	C2-Catechol	0.76	23.305	1.05	0.92	0.87
33.	Biphenyl	0.92	25.903	0.07	0.05	0.05
34.	C2-Catechol	0.76	26.028	1.11	0.97	0.91
35.	Acenaphthene	0.90	28.285	0.05	0.04	0.03
36.	Dibenzofuran	0.90	28.969	0.09	0.07	0.06
37.	Naphthol	0.85	29.036	0.55	0.43	0.41
38.	Phenanthrene	0.94	34.300	0.13	0.09	0.08
39.	Fluoranthene	0.93	39.285	0.02	0.02	0.02
40.	Pyrene	0.93	40.159	0.03	0.02	0.02
Total				86.44	91.02	91.51
# of Peaks, wt counts				37	151.04	

KF-Water = Karl Fischer water; Rf = FID relative response factor; RT = GC retention time (min); A% = GC area percent; wt% = weight percent; AR = as received; wt counts = sum of A%/Rf.

TABLE 7
GC/MS ANALYSIS DATA FOR L-731
(Feedstock - 365°F+ cut of crude phenols)

No.	Compound	Rf	RT (min)	A%	wt%	AR (wt%)
1.	KF-Water	.	.	.	.	0.09
2.	Isopropanol	0.53	2.030	.	.	.
3.	Benzene	1.12	5.142	.	.	.
4.	Toluene	1.07	8.441	.	.	.
5.	C2-Benzene	1.02	11.596	.	.	.
6.	m,p-Xylene	1.02	11.847	.	.	.
7.	o-Xylene	1.02	12.590	0.01	0.01	0.01
8.	Aniline	0.75	15.486	0.30	0.28	0.28
9.	Phenol	0.56	15.784	20.18	25.40	25.38
10.	C3-Benzene	1.00	16.573	0.06	0.05	0.05
11.	Indane	1.00	16.940	.	.	.
12.	Indene	1.00	17.206	.	.	.
13.	o-Cresol	0.69	17.710	7.71	7.88	7.87
14.	m,p-Cresol	0.69	18.355	28.52	29.13	29.11
15.	Guaiacol	0.57	18.607	2.13	2.63	2.63
16.	C2-Phenol	0.75	19.056	0.47	0.44	0.44
17.	C2-Phenol	0.75	20.201	0.01	0.01	0.01
18.	C2-Phenol	0.75	20.238	2.58	2.42	2.42
19.	C2-Phenol	0.75	20.697	2.38	2.24	2.24
20.	C2-Phenol	0.75	20.777	4.06	3.82	3.82
21.	Naphthalene	0.90	21.049	0.48	0.38	0.38
22.	C1-Guaiacol	0.60	21.185	0.11	0.13	0.13
23.	Catechol	0.50	21.547	1.89	2.66	2.66
24.	C3-Phenol	0.86	22.343	0.25	0.20	0.20
25.	C3-Phenol	0.86	22.507	0.36	0.29	0.29
26.	Quinoline	0.56	22.595	0.05	0.07	0.07
27.	C1-Catechol	0.63	23.105	2.47	2.76	2.76
28.	C3-Phenol	0.86	23.226	0.24	0.19	0.19
29.	C3-Phenol	0.86	23.340	0.22	0.18	0.18
30.	2-Methylnaphthalene	1.00	23.919	0.28	0.20	0.20
31.	1-Methylnaphthalene	1.00	24.288	0.56	0.39	0.39
32.	C2-Catechol	0.76	25.305	1.45	1.35	1.35
33.	Biphenyl	0.92	25.903	0.09	0.07	0.07
34.	C2-Catechol	0.76	26.028	1.74	1.62	1.62
35.	Acenaphthene	0.90	28.285	0.07	0.05	0.05
36.	Dibenzofuran	0.90	28.969	0.13	0.10	0.10
37.	Naphthol	0.85	29.036	0.73	0.61	0.61
38.	Phenanthrene	0.94	34.300	0.15	0.11	0.11
39.	Fluoranthene	0.93	39.285	0.03	0.02	0.02
40.	Pyrene	0.93	40.159	0.04	0.03	0.03
Total				79.74	85.72	85.73
# of Peaks, wt counts				32	141.86	

KF-Water = Karl Fischer water; Rf = FID relative response factor; RT = GC retention time (min); A% = GC area percent; wt% = weight percent; AR = as received; wt counts = sum of A%/Rf;

TABLE 8

GC/MS ANALYSIS DATA FOR 237-61RC
(Feedstock - 74.9 wt% L-731, 15.1 wt% recycle, 10 wt% water)

No.	Compound	Rf	RT (min)	A%	wt%	AR (wt%)
1.	KF-Water	.	.	.	.	0.17
2.	Isopropanol	0.53	2.030	.	.	.
3.	Benzene	1.12	5.142	0.03	0.03	0.03
4.	Toluene	1.07	8.441	44.48	39.29	39.22
5.	C2-Benzene	1.02	11.596	1.83	1.69	1.69
6.	m,p-Xylene	1.02	11.847	2.40	2.23	2.22
7.	o-Xylene	1.02	12.590	0.15	0.14	0.14
8.	Aniline	0.75	15.486	0.17	0.21	0.21
9.	Phenol	0.56	15.784	1.27	2.15	2.14
10.	C3-Benzene	1.00	16.573	.	.	.
11.	Indane	1.00	16.940	.	.	.
12.	Indene	1.00	17.206	.	.	.
13.	o-Cresol	0.69	17.710	0.30	0.41	0.41
14.	m,p-Cresol	0.69	18.355	10.42	14.28	14.25
15.	Guaiacol	0.57	18.607	.	.	.
16.	C2-Phenol	0.75	19.056	.	.	.
17.	C2-Phenol	0.75	20.201	0.10	0.13	0.13
18.	C2-Phenol	0.75	20.238	.	.	.
19.	C2-Phenol	0.75	20.697	0.88	1.10	1.10
20.	C2-Phenol	0.75	20.777	.	.	.
21.	Naphthalene	0.90	21.049	6.88	7.23	7.22
22.	C1-Guaiacol	0.60	21.185	0.14	0.22	0.22
23.	Catechol	0.50	21.547	0.05	0.10	0.10
24.	C3-Phenol	0.86	22.343	0.01	0.01	0.01
25.	C3-Phenol	0.86	22.507	.	.	.
26.	Quinoline	0.56	22.595	0.89	1.50	1.49
27.	C1-Catechol	0.63	23.105	0.05	0.07	0.07
28.	C3-Phenol	0.86	23.226	0.18	0.19	0.19
29.	C3-Phenol	0.86	23.340	.	.	.
30.	2-Methylnaphthalene	1.00	23.919	1.51	1.43	1.43
31.	1-Methylnaphthalene	1.00	24.288	0.47	0.45	0.45
32.	C2-Catechol	0.76	25.305	0.02	0.03	0.03
33.	Biphenyl	0.92	25.903	2.15	2.21	2.21
34.	C2-Catechol	0.76	26.028	0.02	0.02	0.02
35.	Acenaphthene	0.90	28.285	0.90	0.94	0.94
36.	Dibenzofuran	0.90	28.969	1.19	1.25	1.25
37.	Naphthol	0.85	29.036	1.32	1.46	1.46
38.	Phenanthrene	0.94	34.300	2.74	2.75	2.75
39.	Fluoranthene	0.93	39.285	0.68	0.69	0.69
40.	Pyrene	0.93	40.159	0.52	0.53	0.53
	Total			81.74	82.74	82.77
	# of Peaks, wt counts			29	105.79	

KF-Water = Karl Fischer water; Rf = FID relative response factor; RT = GC retention time (min); A% = GC area percent; wt% = weight percent; AR = as received; wt counts = sum of A%/Rf;

TABLE 9
GC/MS ANALYSIS DATA FOR 237-45
(Dynaphen product from HRI-5511 feed)

No.	Compound	Rf	RT (min)	A%	wt%	AR (wt%)
1.	KF-Water	.	.	.	.	9.23
2.	Isopropanol	0.53	2.030	28.88	35.08	31.84
3.	Benzene	1.12	5.142	14.86	8.54	7.75
4.	Toluene	1.07	8.441	6.18	3.72	3.38
5.	C2-Benzene	1.02	11.596	0.42	0.27	0.24
6.	m,p-Xylene	1.02	11.847	0.62	0.39	0.35
7.	o-Xylene	1.02	12.590	0.09	0.06	0.05
8.	Aniline	0.75	15.486	.	.	.
9.	Phenol	0.56	15.784	35.48	40.79	37.03
10.	C3-Benzene	1.00	16.573	.	.	.
11.	Indane	1.00	16.940	0.20	0.13	0.12
12.	Indene	1.00	17.206	0.14	0.09	0.08
13.	o-Cresol	0.69	17.710	1.05	0.98	0.89
14.	m,p-Cresol	0.69	18.355	6.33	5.91	5.36
15.	Guaiacol	0.57	18.607	.	.	.
16.	C2-Phenol	0.75	19.056	.	.	.
17.	C2-Phenol	0.75	20.201	0.06	0.05	0.05
18.	C2-Phenol	0.75	20.238	0.09	0.08	0.07
19.	C2-Phenol	0.75	20.697	.	.	.
20.	C2-Phenol	0.75	20.777	0.43	0.37	0.34
21.	Naphthalene	0.90	21.049	1.61	1.15	1.04
22.	C1-Guaiacol	0.60	21.185	.	.	.
23.	Catechol	0.05	21.547	.	.	.
24.	C3-Phenol	0.86	22.343	.	.	.
25.	C3-Phenol	0.86	22.507	.	.	.
26.	Quinoline	0.56	22.595	.	.	.
27.	C1-Catechol	0.63	23.105	.	.	.
28.	C3-Phenol	0.86	23.226	.	.	.
29.	C3-Phenol	0.86	23.340	.	.	.
30.	2-Methylnaphthalene	1.00	23.919	0.22	0.14	0.13
31.	1-Methylnaphthalene	0.76	25.305	.	.	.
32.	C2-Catechol	0.76	25.305	.	.	.
33.	Biphenyl	0.92	25.903	0.23	0.16	0.15
34.	C2-Catechol	0.76	26.028	.	.	.
35.	Acenaphthene	0.90	28.285	0.13	0.10	0.09
36.	Dibenzofuran	0.90	28.969	0.35	0.25	0.22
37.	Naphthol	0.85	29.036	0.25	0.19	0.17
38.	Phenanthrene	0.94	34.300	0.28	0.19	0.18
39.	Fluoranthene	0.93	39.285	0.07	0.05	0.05
40.	Pyrene	0.93	40.159	0.06	0.04	0.04
Total				98.16	98.82	98.93
# of Peaks, wt counts				24	155.30	

KF-Water = Karl Fischer water; Rf = FID relative response factor; RT = GC retention time (min); A% = GC area percent; wt% = weight percent; AR = as received; wt counts = sum of A%/Rf;

TABLE 10
GC/MS ANALYSIS DATA FOR M237-46
(Same as 45)

No.	Compound	Rf	RT (min)	A%	wt%	AR (wt%)
1.	KF-Water	.	.	.	.	11.98
2.	Isopropanol	0.53	2.030	36.65	47.96	42.22
3.	Benzene	1.12	5.142	33.02	20.45	18.00
4.	Toluene	1.07	8.441	3.99	2.59	2.28
5.	C2-Benzene	1.02	11.596	0.09	0.06	0.05
6.	m,p-Xylene	1.02	11.847	0.09	0.06	0.05
7.	o-Xylene	1.02	12.590	.	.	.
8.	Aniline	0.75	15.486	0.11	0.10	0.09
9.	Phenol	0.56	15.486	0.11	0.10	0.09
10.	C3-Benzene	1.00	16.573	.	.	.
11.	Indane	1.00	16.940	0.07	0.05	0.04
12.	Indene	1.00	17.206	0.07	0.05	0.04
13.	o-Cresol	0.69	17.710	0.09	0.09	0.08
14.	m,p-Cresol	0.69	18.355	0.75	0.75	0.66
15.	Guaiacol	0.57	18.607	.	.	.
16.	C2-Phenol	0.75	19.056	.	.	.
17.	C2-Phenol	0.75	20.201	.	.	.
18.	C2-Phenol	0.75	20.238	.	.	.
19.	C2-Phenol	0.75	20.697	.	.	.
20.	C2-Phenol	0.75	20.777	.	.	.
21.	Naphthalene	0.90	21.049	2.49	1.92	1.69
22.	C1-Guaiacol	0.60	21.185	0.03	0.03	0.03
23.	Catechol	0.50	21.547	.	.	.
24.	C3-Phenol	0.86	22.343	.	.	.
25.	C3-Phenol	0.86	22.507	0.09	0.07	0.07
26.	Quincline	0.56	22.595	.	.	.
27.	C1-Catechol	0.63	23.105	.	.	.
28.	C3-Phenol	0.86	23.226	.	.	.
29.	C3-Phenol	0.86	23.340	.	.	.
30.	2-Methylnaphthalene	1.00	23.919	0.17	0.12	0.11
31.	1-Methylnaphthalene	1.00	24.288	0.04	0.03	0.02
32.	C2-Catechol	0.76	25.305	.	.	.
33.	Biphenyl	0.92	25.903	0.72	0.54	0.48
34.	C2-Catechol	0.76	26.028	.	.	.
35.	Acenaphthene	0.90	28.285	0.10	0.08	0.07
36.	Dibenzofuran	0.90	28.969	0.45	0.35	0.31
37.	Naphthol	0.85	29.036	0.06	0.05	0.05
38.	Phenanthrene	0.94	34.300	0.43	0.32	0.28
39.	Fluoranthene	0.93	39.285	0.13	0.09	0.08
40.	Pyrene	0.93	40.159	0.09	0.07	0.06
Total				98.30	98.82	98.96
# of Peaks, wt counts				23	144.19	

KF-Water = Karl Fischer water; Rf = FID relative response factor; RT = GC retention time (min); A% = GC area percent; wt% = weight percent; AR = as received; wt counts = sum of A%/Rf;

TABLE 11

GC/MS ANALYSIS DATA FOR 237-50
(Dynaphen product from 92 wt% L-731 and 8 wt% DI water)

No.	Compound	Rf	RT (min)	A%	wt%	AR (wt%)
1.	KF-Water	.	.	.	.	13.87
2.	Isopropanol	0.53	2.030	35.69	43.29	37.29
3.	Benzene	1.12	5.142	8.15	4.68	4.03
4.	Toluene	1.07	8.441	8.08	4.86	4.18
5.	C2-Benzene	1.02	11.596	0.89	0.56	0.48
6.	m,p-Xylene	1.02	11.847	1.17	0.74	0.63
7.	o-Xylene	1.02	12.590	0.25	0.16	0.14
8.	Aniline	0.75	15.486	0.23	0.19	0.17
9.	Phenol	0.56	15.784	22.42	25.74	22.17
10.	C3-Benzene	1.00	16.573	0.01	0.01	0.01
11.	Indane	1.00	16.940	0.32	0.21	0.18
12.	Indene	1.00	17.206	0.18	0.11	0.10
13.	o-Cresol	0.69	17.710	2.50	2.33	2.01
14.	m,p-Cresol	0.69	18.355	11.81	11.00	9.48
15.	Guaiacol	0.57	18.607	.	.	.
16.	C2-Phenol	0.75	19.056	0.08	0.07	0.06
17.	C2-Phenol	0.75	20.201	0.26	0.23	0.19
18.	C2-Phenol	0.75	20.238	0.32	0.28	0.24
19.	C2-Phenol	0.75	20.697	0.26	0.22	0.19
20.	C2-Phenol	0.75	20.777	1.13	0.97	0.83
21.	Naphthalene	0.90	21.049	1.27	0.91	0.78
22.	C1-Guaiacol	0.60	21.185	0.02	0.02	0.02
23.	Catechol	0.50	21.547	0.16	0.21	0.18
24.	C3-Phenol	0.86	22.343	0.03	0.02	0.02
25.	C3-Phenol	0.86	22.507	0.01	0.01	0.01
26.	Quinoline	0.56	22.595	0.02	0.03	0.02
27.	C1-Catechol	0.63	23.105	0.10	0.10	0.08
28.	C3-Phenol	0.86	23.226	.	.	.
29.	C3-Phenol	0.86	23.340	0.01	0.01	0.01
30.	2-Methylnaphthalene	1.00	23.919	0.19	0.12	0.11
31.	1-Methylnaphthalene	1.00	24.288	0.17	0.11	0.09
32.	C2-Catechol	0.76	25.305	0.02	0.01	0.01
33.	Biphenyl	0.92	25.903	0.12	0.08	0.07
34.	C2-Catechol	0.76	26.028	0.05	0.05	0.04
35.	Acenaphthene	0.90	28.285	0.10	0.07	0.06
36.	Dibenzofuran	0.90	28.969	0.18	0.13	0.11
37.	Naphthol	0.85	29.036	0.35	0.26	0.23
38.	Phenanthrene	0.94	34.300	0.17	0.11	0.10
39.	Fluoranthene	0.93	39.285	0.04	0.03	0.02
40.	Pyrene	0.93	40.159	0.03	0.02	0.02
Total				96.81	97.95	98.23
# of Peaks, wt counts				37	155.56	

KF-Water = Karl Fischer water; Rf = FID relative response factor; RT = GC retention time (min); A% = GC area percent; wt% = weight percent; AR = as received; wt counts = sum of A%/Rf;

TABLE 12
GC/MS ANALYSIS DATA FOR 237-51
(Same as 50)

No.	Compound	Rf	RT (min)	A%	wt%	AR (wt%)
1.	KF-Water	.	.	.	.	13.37
2.	Isopropanol	0.53	2.030	42.43	51.84	44.91
3.	Benzene	1.12	5.142	16.09	9.30	8.06
4.	Toluene	1.07	8.441	7.62	4.61	3.99
5.	C2-Benzene	1.02	11.596	0.41	0.26	0.23
6.	m,p-Xylene	1.02	11.847	0.52	0.33	0.29
7.	o-Xylene	1.02	12.590	0.08	0.05	0.04
8.	Aniline	0.75	15.486	.	.	.
9.	Phenol	0.56	15.784	20.65	23.88	20.69
10.	C3-Benzene	1.00	16.573	.	.	.
11.	Indane	1.00	16.940	0.22	0.14	0.12
12.	Indene	1.00	17.206	0.14	0.09	0.08
13.	o-Cresol	0.69	17.710	0.58	0.54	0.47
14.	m,p-Cresol	0.69	18.355	4.54	4.26	3.69
15.	Guaiacol	0.57	18.607	.	.	.
16.	C2-Phenol	0.75	19.056	.	.	.
17.	C2-Phenol	0.75	20.201	.	.	.
18.	C2-Phenol	0.75	20.238	.	.	.
19.	C2-Phenol	0.75	20.697	.	.	.
20.	C2-Phenol	0.75	20.777	0.21	0.18	0.16
21.	Naphthalene	0.90	21.049	2.31	1.66	1.44
22.	C1-Guaiacol	0.60	21.185	.	.	.
23.	Catechol	0.50	21.547	.	.	.
24.	C3-Phenol	0.86	22.343	.	.	.
25.	C3-Phenol	0.86	22.507	.	.	.
26.	Quinoline	0.56	22.595	.	.	.
27.	C1-Catechol	0.63	23.105	.	.	.
28.	C3-Phenol	0.86	23.226	.	.	.
29.	C3-Phenol	0.86	23.340	.	.	.
30.	2-Methylnaphthalene	1.00	23.919	0.22	0.14	0.12
31.	1-Methylnaphthalene	1.00	24.288	0.12	0.08	0.07
32.	C2-Catechol	0.76	25.305	.	.	.
33.	Biphenyl	0.92	25.903	0.27	0.19	0.16
34.	C2-Catechol	0.76	26.028	.	.	.
35.	Acenaphthene	0.90	28.285	0.17	0.12	0.11
36.	Dibenzofuran	0.90	28.969	0.39	0.28	0.24
37.	Naphthol	0.85	29.036	0.33	0.25	0.22
38.	Phenanthrene	0.94	34.300	0.55	0.38	0.33
39.	Fluoranthene	0.93	39.285	0.16	0.11	0.10
40.	Pyrene	0.93	40.159	0.14	0.09	0.08
Total				98.17	98.81	98.97
# of Peaks, wt counts				22	154.44	

KF-Water = Karl Fischer water; Rf = FID relative response factor; RT = GC retention time (min); A% = GC area percent; wt% = weight percent; AR = as received; wt counts = sum of A%/Rf;

TABLE 13

GC/MS ANALYSIS DATA FOR 237-61
(Dynaphen product from 237-61RC feed)

No.	Compound	Rf	RT (min)	A%	wt%	AR (wt%)
1.	KF-Water	.	.	.	.	110.51
2.	Isopropanol	0.53	2.030	43.27	55.56	49.72
3.	Benzene	1.12	5.142	24.92	15.14	13.55
4.	Toluene	1.07	8.441	8.79	5.59	5.00
5.	C2-Benzene	1.02	11.596	0.23	0.16	0.14
6.	m,p-Xylene	1.02	11.847	0.26	0.18	0.16
7.	o-Xylene	1.02	12.590	0.04	0.03	0.02
8.	Aniline	0.75	15.486	0.17	0.15	0.13
9.	Phenol	0.56	15.784	12.89	15.66	14.02
10.	C3-Benzene	1.00	16.573	.	.	.
11.	Indane	1.00	16.940	0.11	0.08	0.07
12.	Indene	1.00	17.206	0.07	0.05	0.04
13.	o-Cresol	0.69	17.710	0.19	0.19	0.17
14.	m,p-Cresol	0.69	18.355	2.20	2.17	1.94
15.	Guaiacol	0.57	18.607	.	.	.
16.	C2-Phenol	0.75	19.056	.	.	.
17.	C2-Phenol	0.75	20.201	0.01	0.01	0.01
18.	C2-Phenol	0.75	20.238	0.02	0.02	0.02
19.	C2-Phenol	0.75	20.697	0.10	0.09	0.08
20.	C2-Phenol	0.75	20.777	.	.	.
21.	Naphthalene	0.90	21.049	2.80	2.12	1.90
22.	C1-Guaiacol	0.60	21.185	0.04	0.04	0.04
23.	Catechol	0.50	21.547	.	.	.
24.	C3-Phenol	0.86	22.343	.	.	.
25.	C3-Phenol	0.86	22.507	0.15	0.12	0.11
26.	Quinoline	0.56	22.595	.	.	.
27.	C1-Catechol	0.63	23.105	0.03	0.03	0.03
28.	C3-Phenol	0.86	23.226	.	.	.
29.	C3-Phenol	0.86	23.340	.	.	.
30.	2-Methylnaphthalene	1.00	23.919	0.28	0.19	0.17
31.	1-Methylnaphthalene	1.00	24.288	0.05	0.04	0.03
32.	C2-Catechol	0.76	25.305	.	.	.
33.	Biphenyl	0.92	25.903	0.39	0.29	0.26
34.	C2-Catechol	0.76	26.028	0.01	0.01	0.01
35.	Acenaphthene	0.90	28.285	0.10	0.07	0.06
36.	Dibenzofuran	0.90	28.969	0.30	0.23	0.20
37.	Naphthol	0.85	29.036	0.13	0.11	0.09
38.	Phenanthrene	0.94	34.300	0.44	0.32	0.28
39.	Fluoranthene	0.93	39.285	0.08	0.06	0.05
40.	Pyrene	0.93	40.159	0.05	0.04	0.04
Total				98.12	98.72	98.85
# of Peaks, wt counts				29	146.94	

KR-Water = Karl Fischer water; Rf = FID relative response factor; RT = GC retention time (min); A% = GC area percent; wt% - weight percent; AR = as received; wt counts = sum of A%/Rf;

As was mentioned in the previous quarterly technical progress report (4), the results of the analysis of variance indicated that the total heteroatom content could be defined as a linear function of temperature and pressure of the first-stage reaction. This function is presented as Equation 2.

$$HC = 3.43 - 2.04 X1 - 0.67 X2 \quad (2)$$

where $X1 = (T - 360)/30$, $X2 = (P - 2000)/500$, and temperature (T) and pressure (P) are expressed in degrees C and psi, respectively. The equation was plotted as a function of temperature over the entire range of pressures included in the statistical matrix. This plot is shown in Figure 2. As the plot clearly shows, a total heteroatom content of zero is predicted to occur only at a temperature of 400°C at pressures of 2650 psi or greater.

Nitrogen content was determined by the statistical analysis to be a nonlinear function of temperature and pressure defined by Equation 3.

$$N = 0.000104 + (0.000041 X1) - (0.000661 X2) - (0.000722 X1X2) + (0.000655 X1^2) + (0.000602 X2^2) \quad (3)$$

where $X1$ and $X2$ are the same variables defined for Equation 2. Equation 3 was plotted as a function of temperature over the entire range of pressures included in the statistical matrix, as shown in Figure 3. It is difficult to determine optimal conditions for nitrogen removal from this plot; therefore, the portion of the plot which indicates that nitrogen contents of zero are possible was enlarged, and is shown in Figure 4. This plot predicts that any of the temperatures which were tested could result in a nitrogen content of zero if the proper pressure were selected. Generally, though, the "optimal" conditions appear to be between 360° and 380°C and 2275 and 2425 psi.

The statistical analysis indicated that sulfur content is temperature independent, following the nonlinear function given in Equation 4.

$$S = 0.000159 - 0.000150 X2 + 0.000427 X2^2 \quad (4)$$

where $X2$ is defined above. Equation 4 was plotted over the entire pressure range; the result is shown in Figure 5. The plot predicts that the lowest sulfur content, 0.00015%, can be expected to occur at a processing pressure of 2050 psi. At the "best" conditions for nitrogen removal (i.e., approximately 2300 psi), the sulfur content would be expected to still show nearly complete removal.

Equations describing the relationship of temperature and pressure with aliphatic content and aromatic-to-aliphatic ratio were also determined using the analysis of variance. The aliphatic content of the first-stage product was found to be a linear function of temperature and pressure defined by Equation 5.

$$ALI\ CON = 48.492 + 3.871 X1 + 2.409 X2 \quad (5)$$

Figure 2. Effect of temperature on total heteroatom content over the entire pressure range

Figure 3. Effect of temperature on nitrogen content over the entire pressure range

Figure 4. Detail of best nitrogen removal conditions

Figure 5. Effect of a change in pressure on sulfur content

where X1 and X2 are defined as for Equation 2. The aromatic-to-aliphatic ratio was defined as a linear function of temperature and pressure by Equation 6.

$$\text{ARO:ALI} = 1.082 - 0.176 X1 - 0.099 X2 \quad (6)$$

where, X1 and X2 are again defined as for Equation 2. Equations 5 and 6 were plotted over the ranges of temperature and pressure which were used in the testing, resulting in Figures 6 and 7, respectively. From Figure 6, it can be seen that the highest aliphatic content of the first-stage product is approximately 57%, occurring at 400°C and 2800 psi. These are, of course, the conditions at which the aromatic-to-aliphatic ratio is the lowest, as shown in Figure 7.

The correlations calculated by the statistical analyses indicated that Equations 2-6 fairly accurately predict their respective outcomes, and that the analyses of variance appear to be statistically valid.

A summary of the "optimal" first-stage conditions is presented in Table 14. As the table shows, the temperatures and pressures at which complete removal of nitrogen is predicted are not conducive to complete removal of sulfur. Likewise, the conditions at which the total heteroatom content is predicted to be zero are more severe than are necessary for the essentially complete removal of either nitrogen or sulfur. This indicates that virtually total oxygen removal from feedstocks with such a high initial oxygen concentration would require the most severe conditions.

Tests are currently being performed to ascertain whether or not the indicated conditions do indeed result in the production of the least amount of heteroatoms during the processing. The results of these tests will be presented in a future report.

TABLE 14
"OPTIMAL" FIRST-STAGE PROCESSING CONDITIONS
FOR GPGP TAR/OILS

<u>Parameter</u>	<u>Temperature (°C)</u>	<u>Pressure (psi)</u>
Heteroatom Content	400	2650
Nitrogen Content	360 - 380	2272 - 2425
Sulfur Content	---	2050
Aliphatic Content	400	2800
Aromatic:Aliphatic	400	2800

Figure 6. Effect of temperature on aliphatic content
over the entire range of pressures

Figure 7. Effect of temperature on the ratio of aromatic content
to aliphatic content over the entire pressure range

5.0 REFERENCES

1. Harris, E.C., "Production of Jet Fuels from Coal Derived Liquids, Volume V," September 1987-February 1988 Interim Report, Aero Propulsion Lab, Wright-Patterson AFB.
2. HRI Letter to C.L. Knudson regarding Dynaphen samples, 1/6/88.
3. "Feasibility of Producing Jet Fuel from GPGP By-Products," August-November 1987 Quarterly Technical Progress Report, UND Energy and Mineral Research Center.
4. "Feasibility of Producing Jet Fuel from GPGP By-Products," November 1987 - February 1988 Quarterly Technical Progress Report, UND Energy and Mineral Research Center.

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