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TWO STAGE LIQUEFACTION

Integrated Quarterly Technical Progress Report—Parametric Study
for October 1, 1979—March 31, 1980

MASTER

By
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Bloomfield, New Jersey

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TWO STAGE LIQUEFACTION

INTEGRATED
QUARTERLY TECHNICAL PROGRESS REPORT
PARAMETRIC STUDY

PERIOD OCTOBER 1, 1979 - MARCH 31, 1980

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TABLE OF CONTENTS

	<u>Page No.</u>
1.0 Abstract	1
2.0 Introduction	3
2.1 Conclusions Derived from Prior Studies	4
2.2 Objectives	6
3.2 Task 1 LC-Fining Pilot Plant Procedures	8
3.0 Discussion of Results	11
3.1 Task 1 - Catalytic Expanded Bed Hydroprocessing Research	11
3.2 Task 2 - Two Stage Liquefaction PDU Exploratory Development	16
4.0 Work Forecast	20

FIGURES & TABLES

Figure 1	LC-Fining Pilot Plant - Schematic Flow Diagram	21
Figure 2	Conversion of 850°F+ - PDU Run 2LCF-22	22
Figure 3	Percent Denitrogenation - PDU Run 2LCF-22	22
Figure 4	Conversion of 850°F+ - PDU Run 2LCF-23	23
Figure 5	Percent Denitrogenation - PDU Run 2LCF-23	24
Figure 6	Conversion of 850°F+ - PDU Runs 2LCF-22, -23, -24	25
Figure 7	Conversion of 850°F+ - PDU Runs 2LCF-22, -23, -24	25
Figure 8	Percent Denitrogenation - PDU Runs 2LCF-22, -23, -24	26
Figure 9	Percent Denitrogenation - PDU Runs 2LCF-22, -23, -24	26
Figure 10	Chronology of TSL PDU Activity - January-March	27

Table of Contents (Cont'd.)

	<u>Page No.</u>
Table 1 Feed Properties - Run No. 2LCF-21	28
Table 2 Feed Properties - Run No. 2LCF-22	29
Table 3 Feed Properties - Run No. 2LCF-23	30
Table 4 Feed Properties - Run No. 2LCF-24	31
Table 5 Heavy Oil Product Analysis - PDU Run 2LCF-21	32
Table 6 Heavy Oil Product Analysis - PDU Run 2LCF-22	33
Table 7 Heavy Oil Product Analysis - PDU Run 2LCF-23	34
Table 8 Heavy Oil Product Analysis - PDU Run 2LCF-24	35
Table 9 Summary of Light & Heavy Oil Recovered-PDU Run 2LCF-24	36
Table 10 Summary of Light & Heavy Oil Recovered-PDU Run 2LCF-21	37
Table 11 Summary of Liquid Products Recovered - PDU Run 2LCF-22	38
Table 12 Summary of Light & Heavy Oil Recovered-PDU Run 2LCF-23	39
Table 13 Liquid Product Yields - PDU Run 2LCF-21	40
Table 14 Liquid Product Yields - PDU Run 2LCF-21	41
Table 15 Liquid Product Yields - PDU Run 2LCF-21	42
Table 16 Liquid Product Yields - PDU Run 2LCF-22	43
Table 17 Liquid Product Yields - PDU Run 2LCF-22	44
Table 18 Liquid Product Yields - PDU Run 2LCF-22	45
Table 19 Liquid Product Yields - PDU Run 2LCF-22	46
Table 20 Liquid Product Yields - PDU Run 2LCF-22	47
Table 21 Liquid Product Yields - PDU Run 2LCF-22	48
Table 22 Liquid Product Yields - PDU Run 2LCF-23	49
Table 23 Liquid Product Yields - PDU Run 2LCF-23	50
Table 24 Liquid Product Yields - PDU Run 2LCF-23	51

Table of Contents (Cont'd.)

	<u>Page No.</u>
Table 25 Liquid Product Yields - PDU Run 2LCF-23	52
Table 26 Liquid Product Yields - PDU Run 2LCF-23	53
Table 27 Liquid Product Yields - PDU Run 2LCF-24	54
Table 28 Liquid Product Yields - PDU Run 2LCF-24	55
Table 29 Liquid Product Yields - PDU Run 2LCF-24	56
Table 30 Liquid Product Yields - PDU Run 2LCF-24	57
Table 31 Liquid Product Yields - PDU Run 2LCF-24	58
Table 32 Liquid Product Yields - PDU Run 2LCF-24	59
Table 33 Liquid Product Yields - PDU Run 2LCF-24	60
Table 34 Yield Data - PDU Run 2LCF-21	61
Table 35 Yield Data - PDU Run 2LCF-22	62
Table 36 Yield Data - PDU Run 2LCF-23	63
Table 37 Yield Data - PDU Run 2LCF-24	64
Table 38 Catalyst Analyses - PDU Runs 2LCF-20, -21, -22	65
Table 39 Catalyst Analysis - PDU Run 2LCF-23	66
Table 40 Total Liquid Product Metals - PDU Run 2LCF-22	67
Table 41 Total Liquid Product Metals - PDU Run 2LCF-21	68
Table 42 Total Liquid Product Metals - PDU Run 2LCF-23	69
Table 43 Total Liquid Product Metals - PDU Run 2LCF-24	70
Table 44 Chronology - PDU Run 2LCF-21	71
Table 45 Chronology - PDU Run 2LCF-22	74
Table 46 Chronology - PDU Run 2LCF-23	79
Table 47 Chronology - PDU Run 2LCF-24	82
Table 48 Start-up Paste Solvent - Raw Koppers Creosote Oil	86
Table 49 Prehydrogenation of Raw Creosote Oil - 3LCF	87
Table 50 Elemental Analyses of Spent Catalyst - 3LCF	88

Table of Contents (Cont'd.)

	<u>Page No.</u>
Table 51 Short Contact Time Reaction Conditions & Analyses	89
Table 52 Indiana V Coal Analysis	91
References	92

1.0 ABSTRACT

This program combines a research study on Catalytic Expanded Bed Hydroprocessing of coal extracts (Task 1) and the operation of an integrated two-stage liquefaction process development unit (Task 2). The two tasks are to run co-currently. Parts of two subtasks were completed during this reporting period. Both reactors, the short contact time (SCT) first stage and the LC-Finer second stage, of the integrated PDU, were started up.

An eleven-day thermal baseline run was terminated because of operating difficulties at a maximum reaction temperature of 810°F. The results of this run show conclusively that coal extracts are highly refractory and that an active hydrogenation catalyst is needed to realize high conversion of extracts to distillate products.

Three runs of the parametric study, ranging from 22 to 30 days in on-stream time, were completed. The feed for these as well as all future runs in Task 1 was SRC-1 extract made in Wilsonville from Kentucky 9 coal, Pyro and Lafayette mines. The extract was deashed at Wilsonville by Kerr-McGee Critical Solvent Deashing (CSD). This is the first time an extract made from this coal and deashed by CSD has been a feed for LC-Fining. The solvent was pre-hydrogenated Koppers Creosote Oil with a boiling range of 500/850°F.

The first two of the runs suffered unusually severe catalyst activity decline. The activity decline during the third run agreed more closely with runs made under the earlier DOE Contract. The major difference between the first two runs and the third was in the hydrogen content of the Koppers oil - 8.4-8.7 percent in the first two runs compared to 7.1 percent in the third run.

The short contact time (SCT) and LC-Finer reactors of the integrated PDU were started up. The SCT started with a feed of 30 weight percent Illinois No. 6 and then switched to a paste feed with 36 percent Indiana V coal. The pasting solvent was raw Koppers oil. Conversions, as measured by a balance of insoluble organic matter, ranged from 90 to 94 percent at coal space rates of 143 to 244 pounds of coal per hour per cubic foot of reactor. The LC-Finer prehydrogenated sufficient Koppers oil to provide solvent for the rest of the Task 1 program. The SCT 500°F+ product will be feed for the LC-Finer, without deashing, until necessary modifications to the deasher are completed.

2.0 INTRODUCTION

Earlier investigation during the original and extended D.O.E. contracts demonstrated the ability of LC-Fining to process both Solvent Refined Coal (SRC-1) and Short-Contact Time (SCT) extracts. Cities Service Company, the developer of the LC-Fining process, was the prime contractor, while The Lummus Company was the subcontractor. All Process Development Unit (PDU) work was performed at the New Brunswick, New Jersey, laboratories of Lummus Engineering Development Center.

The successful processing of coal extracts suggested an integration of thermal hydroliquefaction and catalytic hydroprocessing. The reaction section starts with a SCT reactor operated at conditions to obtain high yields of extract, but with no emphasis on either desulfurization or paste solvent self-sufficiency. Hydrogen consumption is thereby minimized. The extract is deashed by the Lummus Antisolvent Deashing (ASDA) process and the deashed extract is hydrotreated in an LC-Fining unit. The LC-Fining operation produces most of the distillate product and some of the solvent for the coal paste feed to the SCT reactor. Most of the chemical hydrogen consumption takes place during LC-Fining, where reaction temperatures are 30-80°F lower than in the thermal SCT reaction. Consequently, light hydrocarbon gas make is lower, distillate yield is higher, and hydrogen consumption is lower than in single-stage liquefaction processes where reactions are at, or close to, the thermal liquefaction temperature of 850-860°F. This advanced Two-Stage Liquefaction process (TSL), therefore, holds promise to be a significant advance in the technology of direct coal hydroliquefaction.

The LC-Fining PDU program is now being continued under this contract, again sponsored by D.O.E., but with Lummus as the prime contractor. The objective of this work is to optimize the TSL process. The Catalytic Expanded Bed Hydroprocessing portion of the contract is being managed technically by Cities Service.

2.1 Conclusions Derived from Prior Studies

Four D.O.E. Interim Technical Progress Reports (FE-2038-17¹, FE-2038-25², FE-2038-34³, and FE-2038-42⁴) which describe in detail the results of the initial studies involved in expanded bed hydroprocessing of SRC-I, have been published and are available for distribution from NTIS.

From this previously reported work, the following conclusions are drawn⁴:

- a) Expanded bed LC-Finer processing for upgrading SRC-I is feasible at a conversion of 60 + weight percent 850°F+ and a denitrogenation of 70+ percent in the 850°F+ fraction (60+ percent in the TLP);
- b) Proprietary LC-Fining correlations for residuum processing of petroleum are applicable to coal liquids processing;
- c) Stable operation at 62 weight percent 850°F+ conversion has been achieved in once-through operation for up to 33 days using a Ni/Mo catalyst;
- d) Recycle processing of SRC-I coal extract in the LC-Finer produced an equilibrium recycle solvent containing 9 weight percent hydrogen after two recycle passes in the PDU;
- e) No "refractory" 850°F+ material was detected when recycling 500°F+ material;
- f) A 850°F+ conversion of approximately 87 weight percent (based on fresh SRC-I feed) was obtained during recycle processing;

- g) A distillate product (390-850°F) containing 0.3 weight percent nitrogen was routinely obtained during recycle processing at the above noted high conversion;
- h) In the recycle mode of processing coal extract in the LC-Finer, a catalyst addition rate of one pound of catalyst per ton of moisture free coal gave an 850°F+ conversion of 62 weight percent (based on fresh SRC-I feed) and a nitrogen content in the distillate fraction (390-850°F) of 0.36 weight percent. A similar correlation for once-through operation showed 48.5 weight percent 850°F+ conversion and 0.42 weight percent nitrogen in the distillate fraction.
- i) Short contact time coal extracts show a greater percentage denitrogenation in the total liquid product than SRC-1 coal extracts when processed by LC-Fining. Also, short contact time coal extracts show a lower C₁-C₄ gas yield.
- j) The 850°F+ conversion is a correlating parameter for comparing C₁-C₄ gas yield, C₅-500°F liquid yield, 500°F+ conversion, and 650°F+ conversion. Various combinations of the operating parameters of space velocity, total reactor pressure, and temperature achieve the same 850°F+ conversion. Thus, the product distribution can then be related to 850°F+ conversion with only minor variations between specific experimental runs. No difference in product distribution (at a given 850°F+ conversion) was noted for runs made with SRC-I/prehydrogenated KC-Oil at 70/30 and 50/50 nominal weight ratio feed blends.
- k) Higher pressure operation tends to decrease the catalyst deactivation rate for conversion.
- l) Non-deashed short contact time coal extracts show a higher 500°F+ and 650°F+ conversion than SRC-I coal extracts at a given 850°F+ conversion

in the LC-Finer. Deashed short contact time coal extracts very closely resemble SRC-I coal extract in liquid product distribution.

- m) The data obtained from higher pressure and higher space velocity operations in the LC-Finer correlate well with the previously reported data at $SV_{rel}=1.0$ and $P_{rel}=1.0$. The space velocity and pressure data presented in F E-2038-42 expanded the operability of LC-Fining to produce a product with a given 850°F+ conversion and level of nitrogen removal. Judicious selection of space velocity, pressure, and temperature allow the upgrading of coal extracts by LC-Fining to be more closely integrated with the operation of the coal liquefaction portion of TSL.

The current program combines a research study on the chemistry, mechanisms, and process conditions for the expanded bed upgrading of coal extracts with an exploratory development of a two-stage liquefaction process in which coal is converted to clean distillate products in an integrated process development unit (PDU) consisting of short-contact-time (SCT) coal extraction, Lummas Antisolvent Deashing (ASDA), and LC-Fining upgrading.

2.2 Objectives

Two major tasks are identified under this program. The first task entails the Expanded Bed Hydroprocessing Research, which is divided into subtasks covering effect of solvent boiling range, parametric study of process conditions, recycle operation, catalyst diffusional resistance, and catalyst screening and aging.

The second task involves the integrated two stage liquefaction PDU operations which are divided into five subtasks. The major objectives are outlined below:

Catalytic Expanded Bed Hydroprocessing Research

1. Identify the effect of process conditions on conversion and denitrogenation when hydroprocessing coal extract in an expanded bed.
2. Determine the effect of solvent boiling range on the performance of donor solvent.
3. Determine the effect of recycling either both solvent and unconverted coal extract or only the solvent on conversion and denitrification.
4. Measure the influence of diffusion on catalyst performance.
5. Screen catalyst candidates from fixed bed screening runs of other D.O.E. programs.
6. Determine catalyst deactivation rate for the best candidate from the catalyst screening program.

Two Stage Liquefaction PDU

1. Demonstrate in an integrated PDU, a two-stage liquefaction (TSL) process to prepare coal extract in the first stage followed by an expanded bed hydrotreatment (LC-Fining) second stage to produce liquid fuels from coal.
2. Obtain performance data using two selected boiling ranges for recycle solvent streams representative of equilibrium solvent conditions, and characterize the respective solvent efficiencies.
3. Determine the minimum hydrogen consumption required to meet product specifications, in particular to those for sulfur, ash, and nitrogen levels meeting current standards for use as fuel oil without requiring further treatment.
4. Develop correlations to quantitatively show the response of TSL end products to changes in the primary process variables: temperature, pressure, space velocity, and slurry concentrations.
5. Evaluate the performance of a scale-up LC-Fining PDU unit in conjunction with a Lummus Antisolvent Deashing unit on an integrated basis when processing SCT coal extracts.

Task 1 is a continuation of research programs started in 1976. Experimental work began in July, 1979 immediately after issuance of the contract. Simultaneously, construction was proceeding on the two-stage liquefaction PDU.

2.3 Task 1-LC-Fining Pilot Plant Procedures

The LC-Fining Pilot Plant consists of two expanded bed catalytic reactors in series, with provisions for liquid recycle for each reactor together with liquid feed, hydrogen supply, and product recovery facilities. (See Fig. 1)

Hydrogen from cylinders is compressed and fed on a once-through basis. The feedstock is metered by a positive displacement pump to the reactors. The hydrogen and the feed are preheated separately before combining and entering the first reactor. Reactor catalyst bed temperatures are maintained by means of

1) the recycle flow for each reactor and 2) external electric heaters to make up for heat losses.

The total effluent from the second reactor passes into a high-pressure, high-temperature separator. The liquid phase continues through a liquid level control valve to a low-pressure separator. The "heavy" oil product, (a nominal +400°F) from this separator is cooled and collected in a container on a weigh scale.

The gas and vapors from the high-pressure, high-temperature separator continue through a second condenser to a high pressure, low-temperature separator which collects the condensables, including water. This liquid passes through a liquid-level control valve to a decanter for separating and draining the water phase. The oil then enters the top of a stripper--a packed column. The gas which has gone through a pressure control valve is used as a stripping medium to remove any dissolved hydrogen sulfide and ammonia from the "light" oil (generally 150 to 650°F) which is collected in receivers as product.

The gas passes through a caustic scrubber to remove hydrogen sulfide before it is metered, sampled and vented.

Before each run, the reactors are charged with the designated Shell 324 extrudate catalysts, assembled, and pressure tested. The pilot plant is started up with a creosote oil, and reactor temperatures are raised to 750°F; the feed is then introduced gradually while startup oil rates are decreased to zero. Desired flowrates are established and held constant. The reactor catalyst bed temperatures are held at 750°F for 4 days with fresh catalyst and then raised to the desired temperature.

In the isothermal mode of operation, all recycle lines are controlled at the same temperature as the reactor, although there is a small temperature variation within the reactors. A second, non-isothermal, mode of operation is employed to reduce thermal cracking in the non-catalytic zones of the reactors. In this operation, the top zone of the reactors, about three feet of which are not in the expanded catalyst bed section, are left unheated and uninsulated. The outlet temperature of the recycle line for each reactor is limited to a maximum temperature of 650°F as is the outlet temperature of each transfer line.

3.0 DISCUSSION OF RESULTS

3.1 Task 1 - Catalytic Expanded Bed Hydroprocessing Research

3.1.1. Thermal Baseline Run

PDU Run 2LCF-21 was performed to evaluate the extent of conversion and denitrogenation of SRC under thermal conditions only, in the absence of an active catalyst. The run processed a 70/30 volume percent SRC-I/500°F IBP KC-Oil blend over an inert 1/32 inch Shell catalyst support. The inert support was the extrudate base for the modified Shell 324 catalyst and had been calcined at 1100-1150°C. Feed blend properties for PDU Run 2LCF-21 are presented in Table 1.

The yield data for this run, shown on Table 34 indicates very little conversion of 850°F+ material - ranging from 8.7 to 17.4 weight percent. The normalized conversions averaged 12.5 volume percent. Under similar conditions with a Shell 325 Ni/Mo catalyst, the 850°F+ conversion would be approximately 40 volume percent. Gas make (C_2-C_4) are high for these low conversions. The results show that SRC-1 is extremely refractory. Unlike petroleum feeds, which are first thermally cracked and then hydrogenated, SRC-1 must first be hydrogenated before it is susceptible to thermal cracking. In the absence of an active hydrogenation catalyst, little conversion is effected and the yields are skewed toward light gases.

At the highest reaction temperature, 810°F, operability problems were experienced, probably due to coke formation. Conversion was the highest but hydrogen consumption was the lowest, 107 SCF/bbl. compared to 200-250 SCF/bbl. at 750°F and 780°F. The major effect of higher reaction temperature was to increase the cooking rate.

PDU Run 2LCF-21 established that the mechanism of SRC-1 conversion is predominately catalytic. In future analyses of SRC-1 (and SCT) extract, space velocities and kinetic models should be based on the volume or weight of catalyst charge.

Denitrogenation in PDU Run 2LCF-21 was near zero. The amount of nitrogen in the liquid product is approximately equal to that present in the feed blend. The negligible amount of NH_3 in the product gas reflects this behavior.

The thermal Baseline run was performed as part of Subtask 1.6, Catalyst Screening and Aging.

3.1.2. Parametric Study of Process Conditions

The purpose of this work in Subtask 1.3, is to identify the effect of process conditions on conversion and denitrogenation when processing coal extract in an expanded bed. The program, as originally outlined, was to investigate three temperatures, three pressures, and three space velocities in a set of six 21-day runs, as outlined below:

Run 1

Pressure, psig: 2400

Temperature, °F:	750	750	790	830	750
Space Velocity, V/HR-V:	0.44	0.73	0.73	0.73	0.44
Days of Operation:	4	4	5	4	4

Run 2

Pressure, psig: 2400

Temperature, °F:	750	790	790	790	750
Space Velocity, V/HR-V:	0.44	0.44	1.03	0.73	0.44
Days of Operation:	4	4	5	4	4

The other four runs were to follow the same sequence at two lower pressures, 2000 and 1600 psig. However, this program emphasized 750°F, the start-up temperature. In order to provide more data at higher conversions, a second three-run program was agreed upon with the approval of the DOE Program Manager, which has the following sequence of operating conditions:

Run 1

Pressure, psig:	2400									
Temperature, °F:	750	790	790	790	830	790	750	790	830	790
Space Velocity, V/HR-V:	0.44	0.44	1.03	0.73	0.73	0.44	0.73	0.73	0.44	0.44
Days of Operation:	4	4	4	4	4	4	4	4	4	4

The revised program retains all the features of the original, but with emphasis shifted to the higher temperatures. The catalyst age at the end of the 40-days would be about 1200 pounds of extract per pound of catalyst.

The feed for the Parametric Study and for the rest of Task 1 is SRC-1 extract made in Wilsonville runs 161 and 163. The coal for these runs was Kentucky 9 seam, Pyro and Lafayette Mines. No sodium carbonate addition was made for these SRC-1 runs and the extract was deashed by Kerr-McGee Critical Solvent Deashing (CSD). The solvent is Kopper's Creosote Oil (KC Oil) that was prehydrogenated to eight percent hydrogen in a separate LC-Fining unit in New Brunswick. The solvent boiling range is 500/850°F. Properties of extract, solvent, and the feed blend are listed in Tables 2, 3 and 4. The feed blend contains 70 volume percent extract.

Three PDU process parameter runs ranging from 22 to 30 days in length have been completed and analyzed for Subtask 1.3. PDU Runs 2LCF-22, -23, and -24 each operated under a variety of process conditions which were designed to measure the response in conversion and denitrogenation due to varying operating parameters. The feed blends consisted of a 70/30 volume % SRC/500°F IBP KC-Oil for all three runs. The SRC, obtained from the Wilsonville SRC facility, was produced from Kentucky 9 Pyro and Lafayette Mine Coals and was deashed using the Kerr-McGee Critical Solvent Deashing Process. These runs represent the first time this particular coal and the Kerr-McGee deasher have been used to provide an LC-Fining feedstock. The table below presents the major feed and operating parameters which were employed for these three PDU runs.

PDU Run	2LCF-22	2LCF-23	2LCF-24
SRC Source	SRC-1 Wilsonville Runs 161, 163 (Kentucky 9, Pyro and Lafayette) Kerr-McGee Deashed		
Solvent	KC-Oil 500-850°F		
Solvent Hydrogen, Wt. %	8.7	8.4	7.1
Feed Blend Ratio SRC/Solv. Vol. %	70/30		
Temperature, °F	750-830 Isothermal	750-830 Cooled Zones	750-830 Cooled Zones & Isothermal
Space Velocity, V/H/V	0.44-1.03	0.44-0.73	0.44-0.73
Pressure, psig	2400		
Run Length, Days	28	22	30
Final Catalyst Age, lb. 850°F+/lb. cat.	675	400	600

The raw 850°F+ conversion and denitrogenation data for PDU Runs 2LCF-22, -23, and -24 were normalized to a standard set of conditions and plotted against catalyst age (pounds of 850°F+ feed per pound of catalyst). The individual data points were adjusted to the conversion and denitrogenation which would have occurred at 790°F (isothermal operation) and 0.44 V/H/V (volume of 850°F+ per hour per volume of settled catalyst). Figures 6 and 8 represent these plots for percent 850°F+ conversion and percent denitrogenation, respectively.

Using linear regression, a straight line may be drawn through the normalized data points of each run to give an indication of catalyst activity versus catalyst age. Figures 7 and 9 show these lines with the run numbers labelled. It is observed that PDU Run 2LCF-22 had a large decline in conversion and denitrogenation. Denitrogenation in PDU Run 2LCF-23 also experienced a rapid decline. The rate of decrease in catalyst activity for these two runs was much larger than observed in any previous run of similar length, such as PDU Run 2LCF-17. In contrast, PDU Run 2LCF-24 achieved good catalyst activity maintenance.

Referring to the table of process run parameters, there are very few differences between PDU Run 2LCF-24 and PDU Runs 2LCF-22 and 23. Solvent hydrogen content is the only parameter which significantly differentiates PDU Run 2LCF-24. For PDU Runs 2LCF-22 and 2LCF-23, the Koppers Heavy Residue Creosote Oil was more severely prehydrogenated in order to raise the hydrogen content to that observed in the recycle solvent from PDU Run 2LCF-3. However, several investigators have reported that solvents can be over-hydrogenated with regard to the conversion of 850°F+ material. There appears to be an optimum level of hydrogen in the solvent above or below which conversion declines. How this has affected the catalyst activity in the LC-Finer remains to be

determined. Characterization work on the solvents to identify the types of constituents in the solvent should be beneficial. PDU Run 2LCF-24 employed the same solvent hydrogen level (7 wt.%) as had been used in runs prior to PDU Run 2LCF-20 with similarly good catalyst activity maintenance.

One area of concern with the Pyro and Lafayette extracts is the unusually high chloride concentration. Evidence of corrosion has been found in the feed lines to the first reactor.

For these three runs of the parametric study feed properties are shown in Tables 2 through 4; heavy oil product analyses are shown in Tables 6 through 8; summaries of light and heavy oil recovered are in Tables 10 through 12; liquid product yields are in Tables 16 through 33; yield data as a percentage of feed are shown in Tables 35 through 37; catalyst analyses are in Tables 38 and 39; and viscosity and product metals are shown in Tables 40 through 43. The chronologies of PDU Runs 2LCF-21 through -24 are in Tables 44 through 47. The raw conversion and denitrogenation data from PDU Runs 2LCF-22 and 2LCF-23 are shown in Figures 2 through 5.

3.2 Task 2 - Two Stage Liquefaction PDU Exploratory Development

Procurement of equipment and construction of the integrated PDU were initiated at the inception of the Contract. The first stage short contact time (SCT) extraction section is a new unit being constructed, which uses the coal feeder equipment and paste tanks which were formerly part of the clean Fuels from Coal (CFFC) HDS unit. The second stage LC-Finer (3LCF) is the former HDS unit of the CFFC process development unit. It has been modified to operate in the LC-Fining mode with internal recycle flow for each reactor.

3.2.1. LC-Fining

A shakedown run was made on the LC-Finer in January. Following this, Kopper's Creosote Oil (KC Oil) was prehydrogenated to approximately eight percent hydrogen for use as solvent in Task 1. Four weeks of running time were required to produce enough solvent for the entire Task 1 program. This effort extended from the first week of February to the end of March. Catalyst for this operation was American Cyanamid 1442A. The catalyst used for the second charge was from a new batch recently received from the manufacturer. It appeared softer than the standard 1442A used in the past. American Cyanamid confirmed that the catalyst had a higher attrition loss, 5 percent compared to 2.8 percent as measured by the standard test. The high attrition plugged the recycle lines. After three false starts with the second catalyst charge, the recycle lines were modified so as not to restrict the free flow of catalyst attrition lines. The LC-Finer was then operated at lower recycle rates to minimize catalyst attrition.

After the second stage (LCF-3) liquefaction unit had been in service for several days prehydrogenating KC-Oil to produce an 8+ wt.% hydrogen content solvent for Task 1 of the Two-Stage Liquefaction program, several high-pressure, let-down, control valve trim failures occurred involving tungsten carbide valve seat inserts popping out. The stem and seat design was the one employed satisfactorily during the CFFC program where the control valve operated below 250°F. A re-design of the seat insert was provided to the fabricator (based on the belief that a 1200°F+ melting point silver solder around the seat insert does not have adequate strength at 400/425°F to withstand a 1500 psig pressure drop across the control valve).

During a period when the 3LCF unit was idling to permit replacement of the tungsten carbide valve trims with stellite valve trims, the unit was on standby at an internal reactor maximum temperature of 350°F over a period of eight to ten hours. A temperature controller covering the lower middle quadrant of the second reactor tended to stick in the "heat" position for most of a two-hour period. Further, this same internal temperature point had been employed as a reference point to set an audible alarm to respond when any temperatures on the recorder exceeded 825°F. In this case, all recorder points were covered by the alarm with the exception of the point at which temperature excursions were occurring, where, through an omission, the relay covering that point had not been reset. Within several minutes of restarting liquid feed to the unit and prior to the expansion of the second reactor bed, an excessive exotherm of greater than 1200°F (off-scale) occurred in the second reactor, which occasioned a rupture and a small fire confined within the barricade. Personal injuries and building damage were prevented by the design of the unit and its barricade.

An improved high temperature alarm set-up on the controllers now permits testing the alarm set point for all recorded temperatures at any time without risking recurrence of the above incident.

The properties of the KC Oil feed are shown in Table 48. Operating conditions and product yields are shown in Table 49. Spent catalyst analyses are in Table 50.

3.2.2 Short Contact Time Extraction

The Short Contact Time (SCT) unit was put into operation during the third week of March, using 30 wt.% paste batches prepared with Illinois #6 coal and raw creosote oil for test runs. Several operating conditions

were tested which gave an average conversion of 92 to 94%. Preasphaltenes ranged from 10 to 12 wt.% in the liquid products.

A 36 wt.% Indiana V coal paste was prepared for a second series of runs with raw creosote oil as solvent. Operating conditions were:

1. 2400 psig and 840-850°F preheater outlet temperature.
2. Coal space rate of 261 lbs./hr./ft.³.
3. A gas rate to preheater of 10,000 SCF/ton coal with a hydrogen purity of 98 mole percent.

Operating conditions and analyses of solvent and liquid products are shown in Table 51. A chronology of Task 2 operations is shown in Figure 10. Analysis of Indiana V coal is shown in Table 52.

Two material balance periods were made and the results are being calculated. The unit was shut down to make several necessary modifications.

4.0 WORK FORECAST

4.1 Task 1

A modification to the work statement for Task 1 has been submitted. The three runs described below will investigate the most likely causes of the accelerated aging associated with PDU Runs 2LCF-22, -23, and -24.

1. A 25-day run with the SRC-1 which had been used in PDU Runs 2LCF-22, -23, and -24 except at controlled and constant reaction conditions to maintain a conversion range of 40-50 percent. NH_4OH will be added to neutralize excess chlorides in the SRC-1.

2. A 28-day run with Wilsonville SCR-1 made from Indiana V coal and deashed by Kerr-McGee CSD.

3. A six-week bench-scale program to investigate demetallization in a first reactor or guard chamber.

4.1 Task 2

Essential equipment repair and modification work on the Antisolvent De-asher (ASDA) will be complete during the second quarter of 1980. Until that time, SCT product will go directly to the LC-Finer without deashing. Pasting solvent will continue to be raw KC-Oil until solvent self-sufficiency is obtained from the liquid product made in the LC-Finer. When the deasher becomes operational, its first feed will be product from the LC-Finer.

Acknowledgement

All Tables and Graphs related to Expanded Bed Hydroprocessing Research have been provided by Cities Service Research and Development Company.

FIGURE 1

Task 1
LC-Fining Pilot Plant
Schematic Flow Diagram

FIGURE 2

FIGURE 3

FIGURE 6

CONVERSION OF 850°F⁺

PDU Runs 2LCF-22, -23, -24
70/30 Vol.% SRC/500°F IBP Solvent

FIGURE 7

CONVERSION OF 850°F⁺

PDU Runs 2LCF-22, -23, -24
70/30 Vol.% SRC/500°F IBP Solvent

FIGURE 8
PERCENT DENITROGENATION
 PDU Runs 2LCF-22, -23, -24
 70/30 Vol.% SRC/500°F IBP Solvent

FIGURE 9
PERCENT DENITROGENATION
 PDU Runs 2LCF-22, -23, -24
 70/30 Vol.% SRC/500°F IBP Solvent

TABLE I
(Update Table I, January, 1980 MPR)
LC-FINING PDU OPERATION
FEED PROPERTIES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run No. (2LCF-) Component	21 Solvent KC-23	21 SRC N-024	21 (1-4) Blend	21 (5-9) Blend	21 (10-11) Blend
Composition					
Solvent, Wt% (ex drum)	-	-	25.3	25.3	25.3
Description, IBP °F	500	-	500	500	500
SRC, Wt% (ex drum)	-	-	74.7	74.7	74.7
850°F+, Vol% (by distilln)	-	-	68.6	68.5	69.3
850°F+, Wt% (by distilln)	-	-	70.0	70.1	70.9
Gravity, °API					
, SP 60/60°F	0.9	-15.7	-14.6	-15.2	-14.5
Softening Point, °F	1.0687	1.2217	1.210	1.217	1.2090
Viscosity, Kin. CS @ 210°F	-4.0(a)	332	224	236	223
Kin. CS @ 310°F	32.77	-	-	-	-
Kin. CS @ 350°F	3.70	-	-	-	-
Kin. CS @ 400°F	-	-	526.5	606.2	374.6
	-	-	118.1	116.9	73.8
Elemental Content, Wt%					
Carbon	91.43	86.54	88.43	88.18	87.97
Hydrogen	8.04	5.88	6.42	6.40	6.48
Oxygen		4.65	3.54	3.50	
Nitrogen	0.26	2.10	1.56	1.52	1.53
Sulfur	<0.06	-	0.50	0.49	0.51
Ash, Wt%					
	Tr	-	0.12	0.13	0.11
Metals, ppm					
Vanadium		<50	6.3(c)	6.3	
Nickel		<5	2	2	
Iron		<5	210	230	
Titanium		526	190	190	
Sodium		<5	19	7.5	
Potassium		126	0.7	0.7	
Calcium		721	100	100	
Distillate Fractions					
IBP-650°F, Vol%	35.8		8.3	9.2	9.3
, Wt%	33.8		6.9	7.7	7.8
Gravity, °API	8.9		8.2	7.8	9.3
, SP 60/60°F	1.0078		1.0129	1.0158	1.0050
Carbon, Wt%	86.22		89.92	89.80	89.56
Hydrogen, Wt%	8.87		8.84	9.09	9.00
Nitrogen, Wt%	<0.20		<0.20	<0.20	<0.20
Sulfur, Wt%	<0.06		<0.06	<0.06	<0.06
650-850°F, Vol%	57.6	-(b)	25.2	24.5	23.6
, Wt%	59.1	-(b)	23.1	22.0	21.4
Gravity, °API	-2.3	-(b)	-3.9	-2.4	-2.0
, SP 60/60 °F	1.0951	-(b)	1.1087	1.0957	1.0927
Carbon, Wt%	91.42	87.90	91.40	91.33	90.72
Hydrogen, Wt%	7.70	7.10	7.31	7.14	7.48
Nitrogen, Wt%	0.26	1.26	0.59	0.53	0.51
Sulfur, Wt%	<0.06	0.50	0.24	0.15	0.17
850°F, Vol%	6.3	90.4	68.6	68.5	69.3
, Wt%	7.0	-	70.0	70.1	70.9
Gravity, °API	-12.1	-17.7	-16.9	-17.8	-17.1
, SP 60/60 °F	1.185	1.243	1.2351	1.245	1.2370
Carbon, Wt%	91.76	87.90	86.58	86.21	88.23
Hydrogen, Wt%	6.41	5.85	5.70	5.66	5.93
Nitrogen, Wt%	0.38	2.17	1.97	1.98	2.08
Sulfur, Wt%	<0.06	0.66	0.68	0.62	0.68

(a) Pour Point
(b) Insufficient Sample
(c) Revised

TABLE 2
(Update Table 11, May 1980 MPR)
LC-FINING PDU OPERATION
FEED PROPERTIES

SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run No. (2LCF-)	22	22	22	22	22	22	22	22
Component	Solvent	SRC	(1-4)	(5-8)	(10-13)	(14-18A)	(18B-23)	(24-28)
	KC-23	N-127	Blend	Blend	Blend	Blend	Blend	Blend
Composition								
Solvent, Wt% (ex drum)	-	-	24.6	24.6	24.6	24.6	24.6	24.6
Description, IBP °F	500	-	500	500	500	500	500	500
SRC, Wt% (ex drum)	-	-	75.4	75.4	75.4	75.4	75.4	75.4
850°F+, Vol% (by distilln)	-	-	69.9	69.5	68.2	72.2	70.9	71.4
850°F+, Wt% (by distilln)	-	-	71.2	70.9	70.0	73.4	72.4	73.0
Gravity, °API								
, SP 60/60°F	1.7	-16.3	-12.7	-14.0	-12.7	-13.8	-14.0	-13.3
Softening Point, °F	1.0623	1.2286	1.1909	1.2038	1.1915	1.2026	1.204	1.1968
Viscosity, Kin. CS @ 100°F	-10(a)	347	200	204	210	216	221	229
Kin. CS @ 210°F	29.44	-	-	-	-	-	-	-
Kin. CS @ 300°F	3.58	-	-	-	-	-	-	-
Kin. CS @ 350°F	-	-	1068.9	1548.8	1210.8	-	2182	-
	-	-	224.5	215.3	303.6	253.1	275.2	356.7
Elemental Content, Wt%								
Carbon	90.97	87.19	88.08	88.17	88.46	88.24	88.12	88.70
Hydrogen	8.72	6.23	6.71	6.86	6.75	6.43	6.44	6.57
Oxygen	-	-	2.29	-	-	-	2.99	-
Nitrogen	0.24	1.86	1.34	1.40	1.38	1.48	1.49	1.45
Sulfur	<0.06	0.90	0.77	0.70	0.65	0.72	0.71	0.68
Ash, Wt%								
	Tr	0.09	0.06	0.06	0.08	0.12	0.12	0.08
Metals, ppm								
Vanadium	-	-	4.7	-	-	-	4.4	-
Nickel	-	-	<2.0	-	-	-	2	-
Iron	-	-	170	-	-	-	240	-
Titanium	-	-	84	-	-	-	180	-
Sodium	-	-	8.0	-	-	-	15	-
Potassium	-	-	4.1	-	-	-	1.7	-
Calcium	-	-	6.3	-	-	-	8.1	-
Distillate Fractions								
IBP-500°F, Vol%	-	-	-	-	-	-	-	-
, Wt%	2.7	-	-	-	-	-	-	-
Gravity, °API	-	-	-	-	-	-	-	-
, SP 60/60°F	-	-	-	-	-	-	-	-
Carbon, Wt%	90.56	-	-	-	-	-	-	-
Hydrogen, Wt%	11.25	-	-	-	-	-	-	-
Nitrogen, Wt%	<0.13	-	-	-	-	-	-	-
Sulfur, Wt%	<0.06	-	-	-	-	-	-	-
500-650°F, Vol%	41.4	-	10.6(b)	10.6(b)	11.8(b)	17.0(b)	8.9(b)	9.4(b)
, Wt%	39.3	-	10.0	8.9	10.0	5.9	7.5	8.0
Gravity, °API	8.8	-	9.3	8.7	9.0	8.5	8.9	8.5
, SP 60/60°F	1.0086	-	1.0050	1.0093	1.0071	1.0107	1.0078	1.0107
Carbon, Wt%	89.43	-	88.91	88.08	88.89	89.34	89.23	89.52
Hydrogen, Wt%	9.68	-	9.22	9.76	9.20	9.31	9.13	9.25
Nitrogen, Wt%	<0.20	-	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Sulfur, Wt%	<0.06	-	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
650-850°F, Vol%	52.9	(c)(d)	21.6	22.3	21.7	22.8	22.1	20.8
, Wt%	54.5	7.3	19.8	20.2	20.0	20.7	20.1	19.1
Gravity, °API	-2.2	(d)	-2.1	-1.7	-2.3	-2.3	-2.3	-2.7
, SP 60/60 °F	1.0941	-	1.0935	1.0905	1.0955	1.0951	1.0948	1.0989
Carbon, Wt%	91.42	88.21	90.68	90.38	91.46	90.37	90.72	90.46
Hydrogen, Wt%	8.30	7.33	7.85	8.24	7.97	8.10	7.90	7.76
Nitrogen, Wt%	0.29	1.22	0.40	0.47	0.46	0.47	0.43	0.57
Sulfur, Wt%	<0.06	0.68	0.23	0.23	0.20	0.22	0.23	0.18
850°F+, Vol%	5.7	93.3	69.9	69.5	68.2	72.2	70.9	71.4
, Wt%	6.1	92.6	71.2	70.9	70.0	73.4	72.4	73.0
Gravity, °API	-6.9	-15.5	-15.0	-16.3	-15.8	-15.8	-16.5	-15.9
, SP 60/60 °F	1.1360	1.2202	1.2143	1.228	1.2277	1.2226	1.236	1.2235
Carbon, Wt%	93.04	87.93	86.84	87.78	88.07	87.50	88.02	87.57
Hydrogen, Wt%	6.88	6.14	5.71	5.98	6.06	6.12	5.89	5.98
Nitrogen, Wt%	0.29	1.91	1.75	1.74	1.86	1.90	1.79	1.96
Sulfur, Wt%	<0.06	0.88	0.94	0.89	0.87	0.90	0.89	0.80

(a) Pour Point

(c) IBP-850°F

(b) IBP-650°F

(d) Insufficient Sample.

TABLE 3
(Update Table I, March 1980 MPR)
LC-FINING PDU OPERATION
FEED PROPERTIES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run No. (2LCF-) Component	23 Solvent KC-23/17	23 Solvent KC-23/23	23 SRC N-127	23 (1-6) Blend	23 (7-12) Blend	23 (13-18) Blend	23 (18-22) Blend
Composition							
Solvent, Wt% (ex drum)	-	-	-	24.6	24.6	24.6	24.6
Description, IBP °F	500	500	-	500	500	500	500
SRC, Wt% (ex drum)	-	-	-	75.4	75.4	75.4	75.4
850°F+, Vol% (by distilln)	-	-	-	71.9	70.3	68.8	69.0
850°F+, Wt% (by distilln)	-	-	-	73.5	71.3	70.0	70.6
Gravity, °API	0.7	0.9	-16.3	-14.2	-14.5	-13.9	-13.3
, SP 60/60°F	1.0703	1.0687	1.2286	1.2060	1.2090	1.2030	1.1966
Softening Point, °F	-15(a)	-10(a)	347	223	218	203	226
Viscosity, Kin. CS @ 100°F	31.99	33.17	-	-	-	-	-
Kin. CS @ 210°F	3.55	3.78	-	-	-	-	-
Kin. CS @ 300°F	-	-	-	5377	2493	1553	3087
Kin. CS @ 350°F	-	-	-	485.8	302.6	208.6	426.3
Elemental Content, Wt%							
Carbon	91.11	91.04	87.62	89.14	88.52	88.49	88.27
Hydrogen	8.41	8.47	6.23	6.76	6.50	6.41	6.53
Oxygen	0.29	-	-	2.96	-	-	-
Nitrogen	0.22	0.21	1.86	1.52	1.43	1.45	1.42
Sulfur	<0.06	<0.06	0.90	0.63	0.69	0.74	0.69
Ash, Wt%	0.01	0.01	0.09	0.07	0.07	0.06	0.06
Metals, ppm							
Vanadium	-	-	-	4	-	-	-
Nickel	-	-	-	2	-	-	-
Iron	-	-	-	260	-	-	-
Titanium	-	-	-	160	-	-	-
Sodium	-	-	-	2	-	-	-
Potassium	-	-	-	1	-	-	-
Calcium	-	-	-	7.3	-	-	-
Distillate Fractions							
IBP-500°F, Vol%	(b)	(b)	-	-	-	-	-
, Wt%	3.7	3.9	-	-	-	-	-
Gravity, °API	(b)	(b)	-	-	-	-	-
, SP 60/60°F	(b)	(b)	-	-	-	-	-
Carbon, Wt%	(b)	(b)	-	-	-	-	-
Hydrogen, Wt%	(b)	(b)	-	-	-	-	-
Nitrogen, Wt%	(b)	(b)	-	-	-	-	-
Sulfur, Wt%	(b)	(b)	-	-	-	-	-
500-650°F, Vol%	37.1	36.6	-	7.2(c)	7.8(c)	10.4(c)	9.1(c)
, Wt%	35.0	34.5	-	6.1	6.5	8.7	7.7
Gravity, °API	8.8	7.5	-	6.5	8.4	8.1	8.7
, SP 60/60 °F	1.0086	1.0180	-	1.0254	1.0114	1.0136	1.0093
Carbon, Wt%	88.43	88.74	-	89.18	88.84	89.19	88.59
Hydrogen, Wt%	9.30	9.18	-	9.43	9.42	9.37	9.45
Nitrogen, Wt%	<0.20	<0.20	-	<0.20	<0.20	<0.20	<0.20
Sulfur, Wt%	<0.06	<0.06	-	<0.06	<0.06	<0.06	<0.06
650-850°F, Vol%	56.1	57.0	(b)(d)	22.4	24.2	21.0	23.7
, Wt%	57.4	58.8	7.3	20.4	22.1	17.5	21.6
Gravity, °API	-2.4	-3.2	(b)	-3.1	-3.1	-3.5	-1.9
, SP 60/60 °F	1.0957	1.1027	-	1.1020	1.1020	1.1057	1.0918
Carbon, Wt%	92.21	91.84	88.21	90.82	90.90	90.24	90.43
Hydrogen, Wt%	8.07	7.73	7.33	7.85	8.08	7.81	8.06
Nitrogen, Wt%	0.29	0.31	1.22	0.51	0.53	0.60	0.50
Sulfur, Wt%	<0.06	<0.06	0.68	0.23	0.24	0.27	0.23
850°F+, Vol%	6.6	5.8	93.3	71.9	70.3	68.8	69.0
, Wt%	7.2	6.4	92.6	73.5	71.3	70.0	70.6
Gravity, °API	-10.6	-12.9	-15.5	-16.6	-16.2	-16.0	-16.1
, SP 60/60 °F	1.1702	1.1926	1.2202	1.232	1.2270	1.2256	1.2257
Carbon, Wt%	93.22	92.45	87.93	88.18	87.90	87.97	87.47
Hydrogen, Wt%	6.65	6.52	6.14	6.13	6.17	6.13	6.05
Nitrogen, Wt%	0.38	0.36	1.91	1.79	1.86	1.82	1.83
Sulfur, Wt%	0.06	<0.06	0.88	0.87	0.89	0.97	0.93

(a) Pour Point
(c) IBP-650°F

(b) Insufficient Sample
(d) IBP-850°F

TABLE 4
(Update Table II, March 1980 MPR)

**LC-FINING PDU OPERATION
FEED PROPERTIES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL**

Run No. (2LCF-) Component	24 SRC N-127	24 Solvent KC-Blend/1	24 Solvent KC-Blend/2	24 (1-4) Blend	24 (5-9) Blend	24 (10-12) Blend	24 (13-16) Blend	24 (17-22) Blend	24 (23-28) Blend	24 (29-30) Blend
Composition										
Solvent, Wt% (ex drum)	-	-	-	24.2	24.2	24.2	24.2	24.2	24.2	24.2
Description, IBP °F	-	500	500	500	500	500	500	500	500	500
SRC, Wt% (ex drum)	-	-	-	75.8	75.8	75.8	75.8	75.8	75.8	75.8
850°F+, Vol% (by distilla)	-	-	-	70.4	69.0	70.0	70.9	73.2	72.2	71.8
850°F+, Wt% (by distilla)	-	-	-	71.2	70.6	71.4	72.0	74.4	73.4	72.8
Gravity, °API	-16.3	1.6	-1.4	-14.8	-13.5	-13.7	-14.3	-14.1	-14.1	-14.7
SP 60/60°F	1.2286	1.0631	1.0877	1.2122	1.1989	1.2010	1.2072	1.2056	1.2057	1.2050
Softening Point, °F	347	<-15(a)	<-15(a)	126	214	214	212	219	212	207
Viscosity, Kin. CS @ 100°F	-	22.37	15.16	-	-	-	-	-	-	-
Kin. CS @ 210°F	-	4.76	2.66	-	-	-	-	-	-	-
Kin. CS @ 300°F	-	-	-	1504	1408	1313	1666	2555	1611	1307
Kin. CS @ 350°F	-	-	-	449.9	202.6	187.8	223	352	282.9	189
Elemental Content, Wt%										
Carbon	87.62	92.24	91.54	88.81	88.69	88.49	88.86	88.50	88.36	87.82
Hydrogen	6.23	7.04	7.09	6.26	6.35	6.27	6.28	6.21	6.21	6.28
Oxygen	-	-	-	-	-	-	-	-	-	-
Nitrogen	1.86	0.26	0.26	1.49	1.48	1.47	1.44	1.49	1.47	1.48
Sulfur	0.90	0.13	0.17	0.73	0.70	0.73	0.76	0.75	0.76	0.60
Ash, Wt%	0.09	0.04	Tr	0.07	0.10	0.10	0.09	0.08	0.06	0.02
Metals, ppm										
Vanadium	-	-	-	3	4.1	-	-	-	-	-
Nickel	-	-	-	2	4.5	-	-	-	-	-
Iron	-	-	-	390	260	-	-	-	-	-
Titanium	-	-	-	170	180	-	-	-	-	-
Sodium	-	-	-	7	13	-	-	-	-	-
Potassium	-	-	-	3	8.8	-	-	-	-	-
Calcium	-	-	-	10	7.6	-	-	-	-	-
Distillate Fractions										
IBP-500°F, Vol%	-	26.4	6.9	-	-	-	-	-	-	-
Wt%	-	24.2	6.2	-	-	-	-	-	-	-
Gravity, °API	-	13.4	13.3	-	-	-	-	-	-	-
SP 60/60°F	-	0.9765	0.9772	-	-	-	-	-	-	-
Carbon, Wt%	-	82.15	81.47	-	-	-	-	-	-	-
Hydrogen, Wt%	-	7.92	8.09	-	-	-	-	-	-	-
Nitrogen, Wt%	-	<0.20	0.05	-	-	-	-	-	-	-
Sulfur, Wt%	-	<0.06	0.02	-	-	-	-	-	-	-
500-650°F, Vol%	-	36.5	44.0	14.3(b)	14.6(b)	12.8(b)	13.8(b)	11.8(b)	12.1(b)	12.7
Wt%	-	36.0	44.3	12.2	12.6	11.1	11.9	10.2	10.3	10.9
Gravity, °API	-	3.5	3.4	5.0	5.3	4.8	4.4	4.8	5.6	5.2
SP 60/60 °F	-	1.0481	1.0489	1.0366	1.0344	1.0382	1.0412	1.0382	1.0321	1.0351
Carbon, Wt%	-	90.95	86.95	89.44	89.44	89.58	89.21	89.48	89.71	89.01
Hydrogen, Wt%	-	7.57	7.67	7.94	8.03	7.82	7.73	7.70	7.71	7.90
Nitrogen, Wt%	-	<0.20	0.15	0.23	0.22	0.22	0.19	0.17	0.15	0.19
Sulfur, Wt%	-	0.07	0.13	0.12	0.11	0.12	0.13	0.14	0.11	0.09
650-850°F, Vol%	(c)(d)	32.2	43.0	17.8	17.9	18.7	17.3	16.4	17.5	17.4
Wt%	7.3	34.0	44.3	16.5	16.8	17.4	16.1	15.3	16.2	16.1
Gravity, °API	(d)	-5.5	-5.2	-5.8	-5.6	-4.8	-5.3	-5.1	-4.9	-4.8
SP 60/60 °F	-	1.1229	1.1205	1.1253	1.1243	1.1171	1.1215	1.1198	1.1177	1.1171
Carbon, Wt%	88.21	92.56	88.51	91.27	90.91	90.79	89.12	91.76	91.33	90.33
Hydrogen, Wt%	7.33	6.55	6.54	6.92	6.97	6.81	6.76	6.61	6.86	6.94
Nitrogen, Wt%	1.22	0.31	0.32	0.66	0.66	0.62	0.64	0.53	0.59	0.62
Sulfur, Wt%	0.68	0.25	0.26	0.39	0.39	0.42	0.43	0.39	0.36	0.39
850°F+, Vol%	93.3	4.4	4.6	70.4	69.0	70.0	70.9	73.2	72.2	71.8
Wt%	92.6	5.1	5.1	71.2	70.6	71.4	72.0	74.4	73.4	72.8
Gravity, °API	-15.5	-16.8	-13.8	-16.1	-16.3	-16.0	-16.1	-16.1	-16.1	-15.7
SP 60/60 °F	1.2202	1.2234	1.2025	1.2266	1.2279	1.2252	1.2259	1.2260	1.2257	1.2218
Carbon, Wt%	87.93	90.67	87.88	87.88	87.89	87.47	87.45	87.57	87.55	87.43
Hydrogen, Wt%	6.14	5.86	5.76	5.91	6.01	5.78	5.80	5.84	5.72	6.00
Nitrogen, Wt%	1.91	0.64	0.60	1.90	1.90	1.88	1.90	1.85	1.87	1.82
Sulfur, Wt%	0.88	0.39	0.16	0.85	0.90	0.94	0.94	0.86	0.92	0.96

(a) Pour Point
(c) IBP-850°F

(b) IBP-650°F
(d) Insufficient Sample

TABLE 5
(Update Table V, October, 1979 MPR)

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSIS
70/30 Vol % SRC/Solvent
PDU Run 2LCF-21 - Alpha Alumina (Inert) Shell Catalyst (a)

<u>2LCF-21 Period</u>	<u>Reactor Temperature °F</u>	<u>Total Pressure Psig</u>	<u>Space Velocity V/H/V (c)</u>	<u>Nitrogen Content Wt%</u>	<u>Hydrogen Content Wt%</u>	<u>Wt. Ratio of 850°F+ Feed-Prod Feed</u>	<u>Gravity Rise °API</u>
1 (b)	750	2100	0.43	1.55	6.11	0.07	2.3
2	750	2100	0.43	1.58	6.15		
3	750	2100	0.43	1.50	6.09	0.00	-0.6
4	750	2100	0.43	1.49	6.26		
5B (b)	780	2100	0.43	1.56	5.90	0.02	3.5
6	780	2100	0.43	1.56	5.81		
8 (b)	780	2100	0.43	1.58	5.95		
9B (b)	810	2100	0.43	1.74	5.66	0.03	3.4
10	810	2100	0.43	1.62	6.06		
11	810	2100	0.43	1.63	5.93	0.08	

(a) Shell carrier; calcined at 1130°C.

(b) Spot sample of heavy oil.

(c) Volume of coal extract per hour per volume of settled catalyst.

TABLE 6
(Update Table IV, December 1979 MPR)

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSIS
70/30 Vol % SRC/IBP Solvent
PDU Run 2LCF-22 - Ni/Mo Catalyst (Shell 324)

2LCF-22 Period	Reactor Temperature °F	Total Pressure Psig	Space Velocity V/H/V (a)	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+(b) Feed-Prod Feed	Gravity Rise °API
1B (c)	750	2400	0.44	0.54	9.30		16.4
2	750	2400	0.44	0.55	9.14	0.50	
3	750	2400	0.44	0.58	8.93		
4	750	2400	0.44	0.49	9.24	0.49	
5B (c)	790	2400	0.44	0.43	8.70		
6	790	2400	0.44	0.36	8.98	0.60	
7	790	2400	0.44	0.39	8.92		
8	790	2400	0.44	0.37	8.81	0.65	
10	790	2400	1.03	0.99	7.47	0.29	
11	790	2400	1.03	0.97	7.62		
12	790	2400	1.03	1.05	7.22	0.28	
13	790	2400	1.03	1.15	7.33		
14	790	2400	1.03	1.22	7.09	0.29	
15B(c)	790	2400	0.73	1.09	7.13		
16	790	2400	0.73	1.01	7.71	0.37	
17	790	2400	0.73	1.27	6.96		
18B	790	2400	0.73	1.25	6.70	0.22	
19	790	2400	0.73	1.20	6.88		
20B(c)	830	2400	0.73	1.16	6.46	0.32	
21	830	2400	0.73	1.26	6.60	0.29	
22(c)	810	2400	0.73	1.29	6.43		
23B	830	2400	0.73	1.32	6.33		
24B	830	2400	0.73	1.36	6.27	0.20	
25B(c)	790	2400	0.44	1.24	6.80		
26	790	2400	0.44	1.23	6.88	0.32	
27	790	2400	0.44	1.22	6.87		
28	790	2400	0.44	1.14	7.00	0.29	

- (a) Volume of coal extract per hour per volume of settled catalyst.
(b) Based on total liquid product.
(c) Spot sample of heavy oil.

TABLE 7

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSIS
70/30 Vol% SRC/500°F IBP Solvent
PDU Run 2LCF-23 - Ni/Mo Catalyst (Shell 324)

2LCF-23 Period	Reactor Temperature °F	Total Pressure Psig	Space Velocity V/H/V (a)	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+(b) Feed-Prod Feed	Gravity Rise °API
1(c)	750	2400	0.44	0.84	8.22		
2(c)	750	2400	0.44	0.98	7.87	0.24	7.3
3	750	2400	0.44	0.95	7.96		
4	750	2400	0.44	1.01	7.67	0.23	8.6
5B(c)	790	2400	0.44	0.56	8.47		
6	790	2400	0.44	0.53	8.39	0.58	17.2
8B(c)	790	2400	0.44	-	-		
9	790	2400	0.44	0.63	8.34		
10	790	2400	0.44	0.89	7.88	0.35	14.9
11B(c)	790	2400	0.73	1.06	7.59		
12	790	2400	0.73	1.13	7.39	0.26	8.9
13	790	2400	0.73	1.01	7.56		
14	790	2400	0.73	1.05	7.53	0.27	11.4
15B(c)	830	2400	0.44	0.83	7.64		
16	830	2400	0.44	0.86	7.46	0.42	15.2
17	830	2400	0.44	0.90	7.38		
18	830	2400	0.44	1.04	7.22	0.33	11.8
19B(c)	790	2400	0.44	1.10	7.16		
20	790	2400	0.44	1.11	7.16	0.24	8.9
21	790	2400	0.44	1.11	7.16		
22	790	2400	0.44	1.09	7.22	0.25	9.14

(a) Volume of coal extract per hour per volume of settled catalyst.

(b) Based on total liquid product.

(c) Spot sample of heavy oil.

TABLE 8
(Update Table III, March 1980 MPR)

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSIS
70/30 Vol % SRC/500°F IBP Solvent
PDU Run 2LCF-24 - Ni/Mo Catalyst (Shell 324)

2LCF-24 Period	Reactor Temperature °F (d)	Total Pressure Psig	Space Velocity V/H/V (a)	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+ (b) Feed-Prod Feed	Gravity Rise °API
1 (c)	750	2400	0.44	0.78	8.26		
2	750	2400	0.44	0.82	8.20	0.29	11.2
3	750	2400	0.44	0.90	7.83		
4	750	2400	0.44	0.88	7.78	0.24	9.6
5B (c)	790	2400	0.44	0.71	8.07		
6	790	2400	0.44	0.71	8.12	0.34	10.6
7	790	2400	0.44	0.70	8.08		
8B	790	2400	0.44	0.74	7.89	0.34	10.4
9	790	2400	0.44	0.78	7.87		
10B (c)	790	2400	0.73	0.96	7.45	0.31	9.9
11	790	2400	0.73	0.96	7.32		
12E (c)	790	2400	0.73	0.98	7.18	0.27	8.7
13	790	2400	0.73	0.95	7.28		
14E (c)	790	2400	0.73	0.97	7.28	0.31	10.6
15	790	2400	0.73	0.95	7.21		
16	790	2400	0.73	0.93	7.41	0.32	10.5
17	790	2400	0.73	1.01	7.29		
18	790	2400	0.73	1.04	7.29	0.32	9.3
20	830	2400	0.44	0.58	7.74	0.62	18.7
21	830	2400	0.44	0.81	7.28		
22	830	2400	0.44	0.81	7.16	0.50	15.5
23B (c)	750	2400	0.44	1.12	7.09		
24	750	2400	0.44	1.13	7.14	0.24	7.1
25B (c)	810	2400	0.44	0.80	7.39		
26	810	2400	0.44	0.89	7.34	0.52	15.7
27	810	2400	0.44	0.94	7.11	0.46	14.0
28B (c)	790	2400	0.44	1.27	6.85	0.32	12.6
29	790	2400	0.44	1.03	7.23		
30	790	2400	0.44	1.03	7.33	0.35	11.8

- (a) Volume of coal extract per hour per volume of settled catalyst.
 (b) Based on total liquid product.
 (c) Spot sample of heavy oil.
 (d) Periods 1-13 with cooled non-catalytic zones.

TABLE 9
(Update Table IV, March 1980 MPR)

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
70/30 Vol.% SRC/500°F IBP Solvent
PDU Run 2LCF-24 Ni/Mo Catalyst (Shell 324)

Light Oil			Light Plus Heavy Oil								
Period	Temp °F ^(a)	°API	Fractions								Total °API
			IBP-500°F		500-650°F		650-850°F		850°F+		
			Vol%	°API	Vol%	°API	Vol%	°API	Vol%	°API	
2	750	18.6	6.0	22.8	20.5	9.9	22.3	1.8	52.4	-11.1	-4.4
4	750	17.3			25.9(c)	10.1	21.3	2.5	54.5	-12.3	-6.2
6	790	20.4	7.0	23.9	25.8	11.6	23.0	2.7	45.4	-13.9	-3.7
8B	790	20.9	7.2	24.0	26.8	11.5	20.7	2.5	46.5	-14.3	-4.2
10B (b)	790	18.9	7.6	22.1	23.6	9.8	21.2	1.2	49.0	-14.6	-5.8
12B (b)	790	18.7	6.5	22.3	21.1	9.9	22.1	1.1	51.9	-14.5	-6.8
14B (b)	790	19.9	8.7	24.1	23.2	10.7	20.4	1.2	49.7	-14.5	-6.1
16	790	21.7	7.3	23.7	24.0	9.9	21.0	1.1	48.3	-16.6	-5.8
18	790	18.8	6.5	23.4	24.7	10.1	20.0	0.8	48.4	-19.6	-6.6
20	830	21.8	22.2	25.3	29.6	11.7	21.5	1.2	27.5	-16.9	1.8
22	830	21.3	17.2	24.5	26.6	10.2	20.8	-0.5	36.4	-17.6	-2.7
24	750	15.7	5.2	19.5	19.9	8.1	20.5	-0.6	55.9	-14.6	-8.5
26	810	21.4	15.6	25.0	27.0	11.7	22.1	1.2	36.2	-16.9	-1.9
27	810	21.4	13.7	23.4	28.5	11.2	19.8	0.4	39.0	-16.9	-3.3
28B (b)	790	18.8	15.6	21.3	17.0	10.2	18.8	-0.3	49.4	-15.9	-5.5
30	790	17.8	10.0	22.7	23.9	10.8	20.4	1.1	47.0	-15.3	-5.2

- (a) Periods 1-13 with cooled non-catalytic zones.
(b) Spot sample of heavy oil.
(c) IBP-650°F cut.

TABLE 10
(Update Table VII, October, 1979 MPR)

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
70/30 Vol.% SRC/Solvent

PDU Run 2LCF-21 - Alpha Alumina (Inert) Shell Catalyst (a)

Period	Temp °F	Light Oil °API	Heavy Oil						Total °API
			Fractions						
			IBP-650°F		650-850°F		850°F+		
			Vol%	°API	Vol%	°API	Vol%	°API	
1 (b)	750	10.6	8.2	3.0	29.0	-6.9	63.4	-17.5	-14.3
3	750	7.0			33.0(c)	-3.4	68.8	-18.1	-15.9
5B(b)	780	6.0			33.9(c)	-2.9	66.4	-19.6	-15.0
9B(b)	810	8.2	5.9	4.8	28.5	-5.6	65.2	-20.2	-14.5
11	810		11.1	6.0	28.6	-5.2	62.5	-19.4	-15.9

(a) Shell carrier; calcined at 1130°C.

(b) Spot sample of heavy oil.

(c) IBP-850°F cut.

TABLE 11
(Update Table VI, December 1979 MPR)

LC-FINING PDU OPERATION
SUMMARY OF LIQUID PRODUCTS RECOVERED
70/30 Vol.% SRC/500°F IBP Solvent
PDU Run 2LCF-22 - Ni/Mo Catalyst (Shell 324)

Period	Temp °F	Light Oil	Total Liquid Product								
		°API	Fractions								Total °API
			IBP-500°F		500-650°F		650-850°F		850°F+		
			Vol%	°API	Vol%	°API	Vol%	°API	Vol%	°API	
2	750	14.4			34.2(a)	18.2	28.2	4.2	37.1	-8.7	3.5
4	750	21.7	10.1	30.2	23.5	14.4	29.8	4.8	37.2	-9.3	2.4
6	790	25.6	15.5	33.3	24.3	13.9	31.4	3.6	28.7	-11.6	4.5
8	790	24.5	18.7	33.0	27.3	13.8	29.6	3.6	24.8	-12.9	5.6
10	790	15.8	6.5	27.0	17.9	12.0	27.8	1.9	49.3	-13.9	-5.4
12	790	15.8	6.3	26.4	17.9	12.4	27.8	1.7	49.4	-14.5	-5.8
14	790	14.9	7.0	26.3	19.4	12.7	26.0	1.4	49.0	-14.9	-5.8
16	790	20.7	10.8	26.1	21.5	13.1	23.6	0.5	45.3	-15.6	-4.4
18B	790	18.4	5.9	25.9	16.4	12.2	23.5	-0.7	55.5	-15.4	-8.1
20B(b)	830	20.5	12.6	25.6	18.4	10.4	23.0	-3.0	47.2	-18.6	-7.6
21	830	19.7	11.2	25.0	16.7	10.6	23.5	-2.7	49.4	-18.2	-7.9
24B	830	18.4	5.1	22.5	15.0	9.7	25.1	-3.1	55.7	-18.8	-10.9
26	790	19.0	9.8	23.1	20.2	11.4	23.6	-1.4	47.5	-18.2	-7.3
28	790	18.6	7.5	23.8	19.7	11.6	24.4	-1.9	50.1	-17.3	-8.2

(a) IBP-650°F cut.

(b) Spot Sample of Heavy Oil.

TABLE 12

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
70/30 Vol.% SRC/500°F IBP Solvent
PDU Run 2LCF-23 - Ni/Mo Catalyst (Shell 324)

Period	Temp °F	Light Oil	Heavy Oil								
		°API	Fractions								
			IBP-500°F		500-650°F		650-850°F		850°F+		Total
			Vol%	°API	Vol%	°API	Vol%	°API	Vol%	°API	°API
2(a)	750	7.6			15.2(b)	10.6	29.2	1.4	56.5	-12.4	-7.0
4	750	18.4			18.8(b)	13.3	24.9	1.8	57.5	-13.0	-6.7
6	790	21.5	11.2	26.9	26.1	13.1	33.2	1.5	30.0	-13.5	0.7
10	790	20.6	7.9	26.1	18.7	13.0	27.9	2.7	46.4	-13.8	-3.8
12	790	17.5	5.3	23.4	16.3	11.3	27.2	0.9	52.7	-14.7	-7.7
14	790	18.3	5.4	24.5	19.3	11.5	24.3	0.6	50.8	-14.2	-4.4
16	830	21.7	12.8	27.2	22.9	13.8	24.8	1.0	39.9	-16.3	-2.4
18	830	20.8	9.9	25.8	21.3	12.6	23.3	-0.3	46.1	-16.3	-4.9
20	790	18.5	5.1	23.5	17.8	12.3	25.2	0.8	52.9	-15.0	-6.9
22	790	18.0	5.3	23.8	17.2	12.5	25.8	1.0	51.8	-15.4	-6.6

(a) Spot sample of heavy oil.

(b) IBP-650°F cut.

TABLE 13
(Update Table VII, December 1979 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Alpha Alumina (Inert) Shell Catalyst (a)
Run 2LCF-21 (Period 4)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	0.21(b) 0.15(b)	2.23 1.80	7.08 6.41	25.92 24.98	62.64 64.27	98.08 97.61
Gravity, °API SP 60/60°F	(c) -	12.0 0.9861	3.9 1.0451	-4.2 1.1117	-18.7 1.254	-14.0 1.2043
Pour Point, °F Softening Point, °F	<-15 -	<-15 -	<-15 -	45 -	- 359	- 189
Viscosity, CST. @ 100°F CST. @ 210°F CST @ 300°F CST @ 350°F	(c) - - -	3.46 1.45 - -	12.80 2.33 - -	241.19 6.89 - -	- - - -	- - 447.4 98.7
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	0.8	0.0	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	72.0	93.6	-	-	-	-
Saturates	27.2	6.4	-	-	-	-
Elemental, Wt%						
Carbon	81.51	85.49	89.52	90.65	89.48	89.03
Hydrogen	9.27	9.54	8.75	7.44	5.79	6.47
Oxygen	6.63	4.30	1.28	1.39	3.10	2.65
Nitrogen	0.51	0.80	0.54	0.73	2.07	1.60
Sulfur	<0.06	<0.06	<0.06	0.21	0.50	0.43
Ash, Wt%					0.89	0.59

(a) Shell carrier; calcined at 1130°C.

(b) C₅+ in gas are 0.52 liquid volume % and 0.29 weight % on feed.

(c) Insufficient sample.

TABLE 14
(Update Table VIII, December 1979 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Alpha Alumina (Inert) Shell Catalyst (a)
Run 2LCF-21 (Period 6)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	0.59(b) 0.44(b)	3.38 2.72	6.73 6.09	25.90 25.14	58.83 60.93	95.43 95.32
Gravity, °API SP 60/60°F	(c) 0.9813	12.7 0.9813	4.9 1.0374	-4.4 1.1136	-19.6 1.2643	-15.1 1.2155
Pour Point, °F	<-15	<-15	<-15	40	-	-
Softening Point, °F	-	-	-	-	375	181
Viscosity, CST @ 100°F	2.34	3.57	11.48	249.7	-	-
CST @ 210°F	0.89	1.12	2.18	6.82	-	-
CST @ 300°F	-	-	-	-	-	379.0
CST @ 350°F	-	-	-	-	-	86.31
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	0.0	0.0				
Naphthenes	-	-				
Aromatics	69.4	97.1				
Saturates	30.6	2.9				
Elemental, Wt%						
Carbon	81.82	84.29	89.26	90.98	89.06	89.11
Hydrogen	9.59	9.60	8.78	7.37	5.48	6.11
Oxygen	8.09	4.88	1.29	1.30	2.41	2.13
Nitrogen	0.42	0.82	0.54	0.75	2.18	1.57
Sulfur	<0.06	0.06	<0.06	<0.06	0.42	0.35
Ash, Wt%					0.75	0.49

(a) Shell carrier; calcined at 1130°C.

(b) C₅+ in gas are 1.29 liquid volume % and 0.72 weight % on feed.

(c) Insufficient sample.

TABLE 15
(Update Table V, November 1979 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F Solvent
Alpha Alumina (Inert) Shell Catalyst (a)
Run 2LCF-21 (Period 11)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	0.70(b)	3.59	7.96	22.72	57.31	92.28
	0.67(b)	2.96	7.31	22.34	60.81	94.09
Gravity, °API	19.4	12.7	5.0	-4.1	-19.4	-14.9
SP 60/60°F	0.9377	0.9813	1.0366	1.1107	1.2627	1.2136
Pour Point, °F	<-15	<-15	(c)	45	-	-
Softening Point, °F	-	-	-	-	338	168
Viscosity, CST @ 100°F	1.71	3.29	10.71	175.7	-	-
CST @ 210°F	0.70	1.08	2.12	5.95	-	-
CST @ 300°F	-	-	-	-	-	277.5
CST @ 350°F	-	-	-	-	-	70.2
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	1.2	0.0	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	76.3	91.3	-	-	-	-
Saturates	22.5	8.7	-	-	-	-
Elemental, Wt%						
Carbon	82.58	85.64	90.35	91.20	89.99	89.81
Hydrogen	9.79	9.55	8.48	6.89	4.91	5.94
Oxygen	5.91	3.80	1.28	1.22	1.86	1.86
Nitrogen	0.46	0.54	0.55	0.70	2.13	1.69
Sulfur	<0.06	<0.06	<0.06	<0.06	0.40	0.34
Ash, Wt%					0.40	0.28

(a) Shell carrier; calcined at 1130°C.

(b) C₅+ in gas are 1.22 liquid volume % and 0.69 weight % on feed.

(c) Insufficient sample.

TABLE 16

(Update Table VIII, January 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-22 (Period 4)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	4.01(a) 2.83(a)	6.22 4.82	15.20 12.77	36.47 32.22	44.86 43.77	106.76 96.41
Gravity, °API SP 60/60°F	38.7 0.8314	22.0 0.9218	12.1 0.9854	4.9 1.0374	-9.7 1.162	-0.08 1.0754
Pour Point, °F Softening Point, °F	<-15 -	<-15 -	<-15 -	40 -	- 252	50 -
Viscosity, CST @ 100°F CST @ 210°F CST @ 300°F	1.00 0.65 -	2.43 0.96 -	9.64 2.23 -	119.5 6.11 -	- - -	- 37.56 7.47
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	1.0	1.0				
Naphthenes	-	-				
Aromatics	26.9	62.2				
Saturates	72.1	36.8				
Elemental, Wt%						
Carbon	84.37	88.28	88.22	90.60	90.22	87.73
Hydrogen	12.78	11.69	10.47	9.99	7.73	8.98
Oxygen	0.43	0.26	0.22	0.27	1.13	0.69
Nitrogen	0.30	0.20	<0.20	<0.20	1.01	0.51
Sulfur	<0.06	<0.06	<0.06	<0.06	0.19	<0.06
Ash, Wt%					0.13	0.04

(a) C₅+ in gas are 1.83 liquid volume % and 1.12 weight % on feed.

TABLE 17
(Update Table IX, January 1980 MPR)
LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-22 (Period 8)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	10.58(a) 7.16(a)	11.94 9.14	23.51 19.31	31.19 27.44	28.44 28.14	105.66 91.19
Gravity, °API	39.7	22.1	12.7	3.2	-12.6	4.7
SP 60/60°F	0.8265	0.9212	0.9813	1.0507	1.1905	1.0389
Pour Point, °F	<-20	<-20	<-20	35	-	-10
Softening Point, °F	-	-	-	-	226.5	-
Viscosity, CST @ 100°F	0.91	2.16	7.91	82.62	-	-
CST @ 210°F	0.51	0.89	1.95	5.39	-	5.60
CST @ 300°F	-	-	-	-	-	4.66
Hydrocarbon Type, Vol%						
Paraffins						
Olefins						
Naphthenes						
Aromatics						
Saturates						
Elemental, Wt%						
Carbon	84.96	88.56	89.33	91.08	91.51	87.16
Hydrogen	12.74	11.46	10.07	8.81	6.70	8.51
Oxygen	0.20	0.14	0.17	0.21	0.77	0.44
Nitrogen	<0.20	<0.20	<0.20	<0.20	0.84	0.30
Sulfur	<0.06	<0.06	<0.06	<0.06	0.17	<0.06
Ash, Wt%					0.04	0.02

(a) C₅+ in gas are 2.66 liquid volume % and 1.54 weight % on feed.

TABLE 18
(Update Table X, January 1980 MPR)
LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-22 (Period 12)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	3.96(a) 2.56(a)	6.11 4.76	13.09 11.34	28.12 25.94	50.82 51.43	102.10 96.03
Gravity, °API	34.4	20.5	10.5	1.8	-14.2	-5.3
SP 60/60°F	0.8529	0.9309	0.9965	1.0615	1.206	1.1208
Pour Point, °F	<-15	<-15	-30	35	-	-
Softening Point, °F	-	-	-	-	316.5	93
Viscosity, CST @ 100°F	1.17	2.36	10.71	114.54	-	-
CST @ 210°F	0.59	1.01	2.22	5.98	-	215.0
CST @ 300°F	-	-	-	-	-	21.05
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	0	0	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	31.7	74.1	-	-	-	-
Saturates	68.3	25.9	-	-	-	-
Elemental, Wt%						
Carbon	84.71	87.66	89.86	90.96	89.55	89.41
Hydrogen	12.69	10.91	10.23	8.49	6.51	7.73
Oxygen	1.14	0.55	0.28	0.41	2.03	1.36
Nitrogen	0.30	0.39	<0.20	0.20	1.53	0.96
Sulfur	<0.06	<0.06	<0.06	<0.06	0.49	0.28
Ash, Wt%					0.21	0.06

(a) C₅+ in gas are 1.36 liquid volume % and 0.81 weight % on feed.

TABLE 19
(Update Table IX, February 1980 MPR)
LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-22(Period 18B)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	3.48 (a) 2.66 (a)	5.65 4.43	9.45 8.22	23.27 21.79	57.46 58.38	99.31 95.48
Gravity, °API	27.0	18.3	9.3	-0.8	-15.8	-9.3
SP 60/60°F	0.8927	0.9446	1.0050	1.0826	1.2231	1.1575
Pour Point, °F	<-15	<-15	<-15	25	-	-
Softening Point, °F	-	-	-	-	337	135
Viscosity, CST @ 100°F	1.90	3.50	10.30	126.1	-	-
CST @ 210°F	0.75	1.18	2.30	5.97	-	2057
CST @ 300°F	-	-	-	-	-	64.9
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	6.3	6.2	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	46.8	68.4	-	-	-	-
Saturates	46.9	25.4	-	-	-	-
Elemental, Wt%						
Carbon	86.52	87.43	89.72	90.89	89.13	88.92
Hydrogen	11.97	10.63	9.69	7.99	6.01	7.13
Oxygen	1.99	0.91	0.44	0.70	2.13	1.84
Nitrogen	0.39	0.41	0.21	0.40	1.84	1.20
Sulfur	<0.06	<0.06	<0.06	0.11	0.53	0.36
Ash, Wt%					0.17	0.10

(a) C₅+ in gas are 1.40 liquid volume % and 0.81 weight % on feed.

TABLE 20
(Update Table X, February 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-22 (Period 24B)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	5.18 (a) 3.72 (a)	7.49 5.89	11.02 9.67	20.91 20.06	49.12 51.89	93.72 91.23
Gravity, °API	30.2	18.6	7.8	-3.2	-19.6	-10.0
SP 60/60°F	0.8751	0.9427	1.0158	1.1030	1.264	1.165
Pour Point, °F	<-30	<-30	-10	35	-	-
Softening Point, °F	-	-	-	-	359	112
Viscosity, CST @ 100°F	1.29	2.30	8.72	12.83	-	-
CST @ 210°F	0.61	0.91	1.94	5.66	-	817.9
CST @ 300°F	-	-	-	-	-	37.67
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	1.1	0.8	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	46.4	78.2	-	-	-	-
Saturates	52.5	21.0	-	-	-	-
Elemental, Wt%						
Carbon	82.86	87.74	90.34	91.25	90.24	90.44
Hydrogen	11.31	10.32	9.14	7.20	5.41	6.63
Oxygen	1.93	1.34	0.64	0.76	1.41	1.40
Nitrogen	0.58	0.45	0.27	0.51	1.95	1.27
Sulfur	<0.06	<0.06	<0.06	0.12	0.45	0.31
Ash, Wt%					0.14	0.07

(a) C₅+ in gas are 2.81 liquid volume % and 1.64 weight % on feed.

TABLE 21
(Update Table XI, February 1980 MPR)

**LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-22 (Period 28)**

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	4.59 (a) 3.13 (a)	7.89 6.20	12.65 10.99	25.00 23.69	47.38 49.40	97.51 93.41
Gravity, °API	30.1	18.9	10.2	-1.4	-18.1	-8.1
SP 60/60°F	0.8756	0.9408	0.9986	1.0880	1.248	1.1466
Pour Point, °F	<-15	<-15	<-15	30	-	-
Softening Point, °F	-	-	-	-	339	102
Viscosity, CST @ 100°F	1.29	2.49	7.96	115.6	-	-
CST @ 210°F	0.62	0.98	1.91	5.89	-	371.0
CST @ 300°F	-	-	-	-	-	25.6
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	0.9	0				
Naphthenes	-	-				
Aromatics	45.1	73.1				
Saturates	54.0	26.9				
Elemental, Wt%						
Carbon	84.62	87.32	89.62	91.25	90.77	90.05
Hydrogen	11.80	10.36	9.69	7.89	5.54	7.08
Oxygen	1.83	1.03	0.48	0.70	1.51	1.32
Nitrogen	0.47	0.42	0.23	0.43	1.87	1.20
Sulfur	<0.06	<0.06	<0.06	0.11	0.46	0.30
Ash, Wt%					0.14	0.07

(a) C₅+ in gas are 1.94 liquid volume % and 1.12 weight % on feed.

TABLE 22
(Update Table XII, February 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-23 (Period 4)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	1.31(a) 0.96(a)	3.36 2.61	12.43 10.70	27.01 24.61	58.31 57.69	102.42 96.57
Gravity, °API	31.6	20.0	9.9	2.0	-12.9	-7.0
SP 60/60°F	0.8676	0.9370	1.0007	1.0599	1.193	1.137
Pour Point, °F	<-15	<-15	<-15	30	-	-
Softening Point, °F	-	-	-	-	321	117
Viscosity, CST @ 100°F	1.39	2.32	11.20	169.11	-	-
CST @ 210°F	0.67	0.96	2.35	6.86	-	54.46
CST @ 300°F	-	-	-	-	-	19.6
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	8.5	10.3				
Naphthenes	-	-				
Aromatics	32.2	76.7				
Saturates	59.3	13.0				
Elemental, Wt%						
Carbon	86.03	88.06	90.01	90.49	89.81	89.92
Hydrogen	12.03	11.12	10.11	8.90	6.46	7.68
Oxygen	1.17	0.65	0.37	0.47	1.86	1.36
Nitrogen	0.27	0.28	<0.20	0.36	1.43	0.93
Sulfur	<0.06	<0.06	<0.06	<0.06	0.40	0.27
Ash, Wt%					0.10	0.05

(a) C₅+ in gas are 1.29 liquid volume % and 0.77 weight % on feed.

TABLE 23
(Update Table XIII, February 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-23 (Period 10)

<u>Fraction</u>	<u>Distillation Fractions</u>					<u>Total Liquid Product</u>
	<u>IBP-390°F</u>	<u>390-500°F</u>	<u>500-650°F</u>	<u>650-850°F</u>	<u>850°F+</u>	
Volume Percent and Weight Percent on Fresh Feed	3.62(a) 2.85(a)	7.53 5.78	16.09 13.47	27.75 24.81	48.14 47.95	103.13 94.86
Gravity, °API	33.9	21.1	11.6	2.6	-14.0	-4.3
SP 60/60°F	0.8555	0.9273	0.9888	1.0552	1.2042	1.1122
Pour Point, °F	<-15	<-15	<-15	25	-	-
Softening Point, °F	-	-	-	-	330	87
Viscosity, CST @ 100°F	1.16	2.24	9.51	101.8	-	-
CST @ 210°F	0.61	0.93	2.18	5.64	-	190.1
CST @ 300°F	-	-	-	-	-	16.05
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	3.0	2.5	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	33.0	68.8	-	-	-	-
Saturates	64.0	28.7	-	-	-	-
Elemental, Wt%						
Carbon	86.48	88.01	89.96	91.02	89.68	89.54
Hydrogen	12.64	11.16	10.28	8.66	6.59	8.11
Oxygen	1.09	0.31	0.22	0.27	1.85	0.93
Nitrogen	0.23	0.25	<0.20	<0.20	1.46	0.81
Sulfur	<0.06	<0.06	<0.06	<0.06	0.47	0.26
Ash, Wt%					0.19	0.06

(a) C₅+ in gas are 2.51 liquid volume % and 1.48 weight % on feed.

TABLE 24
(Update Table XIV, February 1980 MPR)

**LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-23 (Period 14)**

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	2.69(a) 1.86(a)	6.04 4.78	15.50 13.31	25.35 23.20	52.96 53.32	102.54 96.47
Gravity, °API SP 60/60°F	32.5 0.8628	20.0 0.9340	10.0 1.000	1.1 1.0671	-14.7 1.211	-6.5 1.1318
Pour Point, °F	<-15				-	-
Softening Point, °F	-	-	-	-	341	105
Viscosity, CST @ 100°F	1.16	2.44	9.84	71.16	-	-
CST @ 210°F	0.59	0.94	2.21	5.35	-	-
CST @ 300°F	-	-	-	-	-	35.61
CST @ 350°F	-	-	-	-	-	25.93
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	2.6	2.1				
Naphthenes	-	-				
Aromatics	36.5	69.8				
Saturates	60.9	28.1				
Elemental, Wt%						
Carbon	86.06	88.72	90.26	91.16	89.43	89.82
Hydrogen	12.22	10.86	9.97	8.38	6.39	7.67
Oxygen	1.31	0.58	0.32	0.49	2.17	1.41
Nitrogen	0.30	<0.20	<0.20	0.37	1.63	0.98
Sulfur	<0.06	<0.06	<0.06	0.07	0.56	0.33
Ash, Wt%					0.13	0.05

(a) C₅+ in gas are 1.50 liquid volume % and 0.90 weight % on feed.

TABLE 25

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-23 (Period 18)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and	6.35(a)	9.73	15.94	21.99	44.50	98.51
Weight Percent	3.90(a)	7.57	13.92	20.75	45.80	91.93
on Fresh Feed						
Gravity, °API	33.2	20.6	10.7	0.1	-16.6	-4.9
SP 60/60°F	0.8591	0.9303	0.9951	1.0752	1.232	1.1167
Pour Point, °F	<-15	<-15	<-15	30	-	-
Softening Point, °F	-	-	-	-	331	76
Viscosity, CST @ 100°F	1.13	2.16	7.75	78.32	-	-
CST @ 210°F	0.60	0.91	1.89	5.09	-	89.96
CST @ 300°F	-	-	-	-	-	11.45
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	3.4	3.0	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	41.0	69.6	-	-	-	-
Saturates	55.6	27.4	-	-	-	-
Elemental, Wt%						
Carbon	85.71	88.39	90.69	91.85	90.08	90.50
Hydrogen	11.70	10.68	9.80	8.13	5.88	7.62
Oxygen	0.81	0.38	0.28	0.43	1.72	1.04
Nitrogen	0.27	0.13	<0.20	0.22	1.64	0.88
Sulfur	<0.06	<0.06	<0.06	0.07	0.46	0.25
Ash, Wt%					0.11	0.05

(a) C₅+ in gas are 3.09 liquid volume % and 1.81 weight % on feed.

TABLE 26

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-23 (Period 22)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and	3.56(a)	5.90	14.10	24.09	51.95	99.60
Weight Percent on Fresh Feed	2.02(a)	4.60	12.99	22.31	52.83	94.75
Gravity, °API	31.3	20.3	10.8	0.6	-15.2	-7.2
SP 60/60°F	0.8692	0.9321	0.9944	1.0712	1.217	1.1383
Pour Point, °F	<-15	<-15	<-15	35	-	-
Softening Point, °F	-	-	-	-	340	137
Viscosity, CST @ 100°F	1.38	2.24	8.56	113.8	-	-
CST @ 210°F	0.63	1.01	2.07	6.12	-	-
CST @ 300°F	-	-	-	-	-	53.02
CST @ 350°F	-	-	-	-	-	22.15
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	2.6	1.9	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	40.4	67.0	-	-	-	-
Saturates	57.0	29.1	-	-	-	-
Elemental, Wt%						
Carbon	86.39	88.13	90.19	91.49	90.22	89.73
Hydrogen	11.96	10.76	10.10	8.56	6.26	7.60
Oxygen	1.24	0.64	0.34	0.54	2.06	1.46
Nitrogen	0.35	0.24	<0.20	0.28	1.73	1.07
Sulfur	<0.06	<0.06	<0.06	0.07	0.52	0.32
Ash, Wt%					0.15	0.07

(a) C₅+ in gas are 2.03 liquid volume % and 1.21 weight % on feed.

TABLE 27
(Update Table III, April 1980 MPR)

**LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-24 (Period 4)**

<u>Fraction</u>	<u>Distillation Fractions</u>					<u>Total Liquid Product</u>
	<u>IBP-390°F</u>	<u>390-500°F</u>	<u>500-650°F</u>	<u>650-850°F</u>	<u>850°F+</u>	
Volume Percent and Weight Percent on Fresh Feed	1.19(a) 0.91(a)	6.36 4.96	16.74 14.40	22.22 20.01	56.43 55.39	102.94 95.67
Gravity, °API SP 60/60°F	31.1 0.8702	18.2 0.9452	8.5 1.0107	2.1 1.0591	-12.6 1.1899	-5.9 1.1265
Pour Point, °F Softening Point, °F	<-15 -	<-15 -	<-15 -	30 -	- 326	- 111
Viscosity, CST @ 100°F CST @ 210°F CST @ 300°F CST @ 350°F	1.78 0.77 - -	3.18 1.00 - -	8.81 2.06 - -	147.1 6.4 - -	- - - -	- - 39.7 15.5
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	1.7	1.7				
Naphthenes	-	-				
Aromatics	37.7	76.4				
Saturates	60.6	21.9				
Elemental, Wt%						
Carbon	85.99	89.40	90.30	90.61	89.83	89.83
Hydrogen	11.61	10.57	9.59	8.76	6.76	7.73
Oxygen	1.12	0.32	0.44	0.45	1.95	1.33
Nitrogen	0.26	<0.20	<0.20	0.27	1.44	0.89
Sulfur	<0.06	<0.06	<0.06	0.07	0.38	0.25
Ash, Wt%					0.11	0.06

(a) C₅+ in gas are 3.14 liquid volume % and 1.87 weight % on feed.

TABLE 28
(Update Table IV, April 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-24 (Period 9)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	2.98(a) 2.19(a)	8.88 6.92	20.00 16.93	22.96 20.55	46.23 46.61	101.05 93.20
Gravity, °API	33.3	20.1	10.1	2.4	-14.5	-3.5
SP 60/60°F	0.8602	0.9334	0.9993	1.0568	1.2089	1.1058
Pour Point, °F	<-15	<-15	<-15	10	-	-
Softening Point, °F	-	-	-	-	336	96
Viscosity, CST @ 100°F	1.04	2.28	8.25	102.3	-	-
CST @ 210°F	0.68	0.95	1.95	5.87	-	-
CST @ 300°F	-	-	-	-	-	15.55
CST @ 350°F	-	-	-	-	-	7.46
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	1.2	1.2	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	36.0	73.5	-	-	-	-
Saturates	62.8	25.3	-	-	-	-
Elemental, Wt%						
Carbon	85.55	89.22	90.32	91.22	89.42	89.98
Hydrogen	11.60	10.71	9.64	8.55	6.31	8.00
Oxygen	0.59	0.17	0.31	0.27	1.82	1.02
Nitrogen	<0.20	<0.20	<0.20	<0.20	1.44	0.72
Sulfur	<0.06	<0.06	<0.06	<0.06	0.42	0.22
Ash, Wt%					0.15	0.11

(a) C₅+ in gas are 4.26 liquid volume % and 2.54 weight % on feed.

TABLE 29
(Update Table V, April 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-24 (Period 13)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	3.21(a) 2.05(a)	7.07 5.51	17.46 15.33	20.58 19.14	52.86 53.10	101.18 95.13
Gravity, °API SP 60/60°F	32.8 0.8612	19.1 0.9396	8.7 1.0093	0.8 1.0695	-14.8 1.213	-6.8 1.1350
Pour Point, °F	<-15	<-15	<-15	40	-	-
Softening Point, °F	-	-	-	-	344	110
Viscosity, CST @ 100°F	1.14	2.21	8.99	112.74	-	-
CST @ 210°F	0.59	0.98	2.14	6.15	-	-
CST @ 300°F	-	-	-	-	-	34.34
CST @ 350°F	-	-	-	-	-	12.72
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	2.1	1.9	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	37.0	73.8	-	-	-	-
Saturates	60.9	24.3	-	-	-	-
Elemental, Wt%						
Carbon	85.59	88.73	89.55	91.36	89.94	89.50
Hydrogen	11.57	10.37	9.10	8.14	6.11	7.42
Oxygen	1.20	0.39	0.46	0.44	2.09	1.35
Nitrogen	0.30	<0.20	<0.20	0.29	1.76	0.96
Sulfur	<0.06	<0.06	<0.06	0.07	0.50	0.33
Ash, Wt%					0.20	0.08

(a) C₅+ in gas are 2.44 liquid volume % and 1.46 weight % on feed.

TABLE 30
(Update Table VI, April 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-24 (Period 18)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	2.36(a) 1.73(a)	8.21 6.51	15.05 13.08	22.58 20.68	51.57 52.43	99.77 94.43
Gravity, °API	30.9	18.2	8.8	1.6	-14.7	-8.1
SP 60/60°F	0.8713	0.9452	1.0086	1.0631	1.2119	1.1408
Pour Point, °F	<-15	<-15	<-15	20	-	-
Softening Point, °F	-	-	-	-	336	103
Viscosity, CST @ 100°F	1.24	2.37	7.90	76.84	-	-
CST @ 210°F	0.63	0.97	1.98	5.24	-	-
CST @ 300°F	-	-	-	-	-	33.21
CST @ 350°F	-	-	-	-	-	13.0
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	1.6	1.0				
Naphthenes	-	-				
Aromatics	40.1	78.1				
Saturates	58.3	20.9				
Elemental, Wt%						
Carbon	84.85	89.79	89.91	91.24	90.02	89.79
Hydrogen	11.54	10.23	9.23	8.32	6.16	7.37
Oxygen	1.35	0.46	0.46	0.43	1.86	1.25
Nitrogen	0.34	<0.20	<0.20	0.27	1.63	0.94
Sulfur	<0.06	<0.06	<0.06	0.05	0.43	0.28
Ash, Wt%					0.18	0.05

(a) C₅+ in gas are 2.69 liquid volume % and 1.61 weight % on feed.

TABLE 31
(Update Table VII, April 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-24 (Period 22)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and	8.33(a)	9.24	22.73	19.96	33.87	94.13
Weight Percent	6.11(a)	7.19	19.57	18.51	34.88	86.26
on Fresh Feed						
Gravity, °API	28.3	19.2	9.3	-0.8	-17.8	-2.3
SP 60/60°F	0.8855	0.9390	1.0050	1.0824	1.244	1.0951
Pour Point, °F	<-15	<-15	<-15	30	-	55
Softening Point, °F	-	-	-	-	328	-
Viscosity, CST @ 100°F	1.25	2.28	6.99	98.36	-	-
CST @ 210°F	0.64	0.96	1.89	5.83	-	18.92
CST @ 300°F	-	-	-	-	-	4.57
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	1.7	1.6				
Naphthenes	-	-				
Aromatics	57.4	80.8				
Saturates	40.9	17.6				
Elemental, Wt%						
Carbon	85.70	89.18	90.44	91.82	91.09	89.45
Hydrogen	11.43	10.21	9.07	7.80	5.66	7.58
Oxygen	0.70	0.25	0.35	0.29	1.22	0.65
Nitrogen	0.40	<0.20	<0.20	0.27	1.55	0.69
Sulfur	<0.06	<0.06	<0.06	<0.06	0.29	0.13
Ash, Wt%						0.03

(a) C₅+ in gas are 6.82 liquid volume % and 3.99 weight % on feed.

TABLE 32
(Update Table VIII, April 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-24 (Period 27)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	4.14(a) 2.95(a)	12.89 9.94	21.21 18.17	19.62 18.06	37.68 38.15	95.54 87.27
Gravity, °API	31.2	19.3	9.8	0.1	-16.7	-3.0
SP 60/60°F	0.8697	0.9383	1.0014	1.0754	1.233	1.1013
Pour Point, °F	<-15	<-15	<-15	37	-	65
Softening Point, °F	-	-	-	-	341	-
Viscosity, CST @ 100°F	1.22	2.16	6.88	95.41	-	-
CST @ 210°F	0.63	0.94	1.81	5.42	-	41.51
CST @ 300°F	-	-	-	-	-	7.16
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	1.7	1.4	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	46.4	75.7	-	-	-	-
Saturates	51.9	22.9	-	-	-	-
Elemental, Wt%						
Carbon	84.73	89.25	90.03	91.17	90.30	89.88
Hydrogen	11.36	10.38	8.89	7.88	5.69	7.48
Oxygen	1.17	0.39	0.42	0.41	1.58	0.93
Nitrogen	0.24	<0.20	<0.20	0.25	1.66	0.86
Sulfur	<0.06	<0.06	<0.06	0.07	0.43	0.23
Ash, Wt%					0.11	0.03

(a) C₅+ in gas are 7.84 liquid volume % and 4.57 weight % on feed.

TABLE 33
(Update Table IX, April 1980 MPR)

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
70/30 Volume % SRC/500°F IBP Solvent
Run 2LCF-24 (Period 30)

Fraction	Distillation Fractions					Total Liquid Product
	1BP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and Weight Percent on Fresh Feed	3.17(a) 2.28(a)	9.99 7.79	21.07 18.21	19.79 18.24	45.73 46.17	99.75 92.69
Gravity, °API	31.6	19.2	9.3	0.6	-15.2	-5.1
SR 60/60°F	0.8676	0.9390	1.0050	1.0712	1.217	1.1197
Pour Point, °F	<-15	<-15	<-15	55	-	-
Softening Point, °F	-	-	-	-	340	87
Viscosity, CST @ 100°F	1.21	2.26	8.42	124.67	-	-
CST @ 210°F	0.65	0.95	1.91	2.83	-	151.17
CST @ 300°F	-	-	-	-	-	24.97
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	1.2	0.9				
Naphthenes	-	-				
Aromatics	41.5	76.4				
Saturates	57.3	22.7				
Elemental, Wt%						
Carbon	84.73	88.12	89.78	91.07	89.79	89.40
Hydrogen	11.15	10.18	9.23	7.95	6.00	7.52
Oxygen	1.44	0.49	0.46	0.52	1.99	1.32
Nitrogen	0.34	0.33	<0.20	0.31	1.71	0.94
Sulfur	<0.06	<0.06	<0.06	0.07	0.44	0.29
Ash, Wt%					0.08	0.02

(a) C₅+ in gas are 4.57 liquid volume % and 2.72 weight % on feed.

TABLE 34

LC-FINING PDU OPERATION
YIELD DATA AS A PERCENTAGE OF FEED
Run PDU 2LCF-21
Alpha Alumina (Inert) Shell Catalyst (a)
70/30 Vol% SRC/500°F IBP Solvent

Blend Period PDU 2LCF-21	4	6	11
Feed Blend, psig	2400	2400	2400
Average Reactor Temp, °F	750	780	810
Space Velocity, V/H/V (b)	0.37	0.39	0.45
Conversion, Vol% 850°F+	8.7	14.1	17.3
Gravity Rise, °API	0.6	0.1	-0.4
Yield - Weight % of Feed			
H ₂ O	1.13	1.70	2.00
H ₂ S	0.09	0.16	0.20
NH ₃	0.0	0.02	0.02
CH ₄	0.49	0.90	1.25
C ₂ H ₆	0.27	0.55	0.76
C ₃ H ₈	0.22	0.49	0.61
C ₃ H ₆	0.05	0.06	0.07
i-C ₄ H ₁₀	0.02	0.04	0.05
n-C ₄ H ₁₀	0.13	0.27	0.34
C ₄ H ₈	0.01	0.03	0.03
C ₅ -390°F	0.44	1.16	1.36
390-500°F	1.80	2.72	2.96
500-650°F	6.41	6.09	7.31
650-850°F	24.98	25.14	22.34
850°F+	64.27	60.93	60.81
Total	100.30	100.26	100.11
Yield - Volume % of Feed			
C ₅ -390°F	0.72	1.88	1.92
390-500°F	2.23	3.38	3.59
500-650°F	7.08	6.73	7.69
650-850°F	25.92	25.90	22.72
850°F+	62.64	58.83	57.31
Total	98.59	96.72	93.50
H ₂ Consumption (SCF/BBL)	250	209	107

(a) Shell carrier; calcined at 1130°C

(b) Volume of coal extract per hour per volume of settled catalyst.

TABLE 35
LC-FINING PDU OPERATION
YIELD DATA AS A PERCENTAGE OF FEED
Run PDU 2LCF-22
70/30 Vol. % SRC/500°F IBP Solvent

Blend Period PDU 2LCF-22	4	8	12	18B	24B	28
Reactor Pressure, psig	2400	2400	2400	2400	2400	2400
Average Reactor Temp., °F	750	790	790	790	830	790
Space Velocity, V/H/V (a)	0.37	0.38	1.09	0.88	0.73	0.39
Conversion, Vol% 850°F+	35.8	59.1	29.6	19.0	31.2	33.7
Gravity Rise, °API	12.6	18.7	7.4	4.7	3.3	5.2
Yield - Weight % of Feed						
H ₂ O	1.80	1.94	1.83	1.84	1.93	1.85
H ₂ S	0.82	0.75	0.41	0.39	0.42	0.42
NH ₃	1.03	1.35	0.55	0.41	0.35	0.40
CH ₄	0.47	1.70	0.56	0.75	1.85	1.27
C ₂ H ₆	0.50	1.52	0.48	0.56	1.33	1.61
C ₃ H ₈	0.45	1.55	0.43	0.51	1.25	0.93
C ₃ H ₆	0.01	0.04	0.02	0.04	0.08	0.07
i-C ₄ H ₁₀	0.03	0.15	0.03	0.05	0.12	0.69
n-C ₄ H ₁₀	0.40	1.41	0.39	0.47	0.99	0.82
C ₄ H ₈	-	-	-	0.01	0.02	0.02
C ₅ -390°F	3.96	8.70	3.38	3.49	5.36	4.25
390-500°F	4.82	9.14	4.76	4.43	5.89	6.20
500-650°F	12.77	19.31	11.34	8.22	9.67	10.99
650-850°F	32.22	27.44	25.94	21.79	29.06	23.69
850°F+	43.77	28.14	51.43	58.38	51.89	49.40
Total	103.05	103.14	101.55	101.34	101.21	101.41
Yield - Volume % of Feed						
C ₅ -390°F	5.85	13.23	5.32	4.88	7.99	6.53
390-500°F	6.22	11.94	6.11	5.65	7.49	7.89
500-650°F	15.20	23.51	13.09	9.45	11.02	12.65
650-850°F	36.47	31.19	28.12	23.27	20.91	25.00
850°F+	44.86	28.44	50.82	57.46	49.12	47.38
Total	108.60	108.31	103.46	100.71	96.53	99.45
H ₂ Consumption (SCF/BBL)	2396	2509	1220	1068	965	1109

(a) Volume of coal extract per hour per volume of settled catalyst.

TABLE 36

LC-FINING PDU OPERATION
YIELD DATA AS A PERCENTAGE OF FEED
Run PDU 2LCF-23
70/30 Vol % SRC/500°F IBP KC-Oil

Blend Period PDU 2LCF-23	4	10	14	18	22
Reactor Pressure, psig	2400	2400	2400	2400	2400
Average Reactor Temp, °F	750	790	790	830	790
Space Velocity, V/H/V (a)	0.45	0.44	0.72	0.49	0.46
Conversion, Vol% 850°F+	18.9	31.5	23.0	35.5	24.7
Gravity Rise, °API	7.2	10.2	7.4	8.4	6.1
Yield - Weight % of Feed					
H ₂ O	1.79	2.33	1.83	2.48	2.25
H ₂ S	0.39	0.47	0.45	0.49	0.41
NH ₃	0.74	0.80	0.61	0.75	0.50
CH ₄	0.28	0.57	0.38	1.36	0.62
C ₂ H ₆	0.33	0.59	0.41	1.20	0.63
C ₃ H ₈	0.29	0.58	0.36	1.23	0.61
C ₃ H ₆	0.01	0.02	0.02	0.05	0.04
i-C ₄ H ₁₀	0.03	0.06	0.03	0.13	0.05
n-C ₄ H ₁₀	0.24	0.62	0.31	0.66	0.66
C ₄ H ₈	0.00	0.00	0.00	0.01	0.00
C ₅ -390°F	1.72	4.32	2.76	5.71	3.22
390-500°F	2.61	5.78	4.78	7.57	4.60
500-650°F	10.70	13.47	13.31	13.92	12.99
650-850°F	24.61	24.81	23.20	20.75	22.31
850°F+	57.69	47.95	53.32	45.80	52.83
Total	101.43	102.37	101.77	102.11	101.72
Yield - Volume % of Feed					
C ₅ -390°F	2.60	6.13	4.19	9.45	5.59
390-500°F	3.36	7.53	6.04	9.73	5.90
500-650°F	12.43	16.09	15.50	15.94	14.10
650-850°F	27.01	27.75	25.35	21.99	24.09
850°F+	58.31	48.14	52.96	44.50	51.95
Total	103.71	105.64	104.04	101.61	101.63
H ₂ Consumption (SCF/BBL)	1127	1886	1390	1671	1354

(a) Volume of coal extract per hour per volume of settled catalyst.

TABLE 37

LC-FINING PDU OPERATION
YIELD DATA AS A PERCENTAGE OF FEED

Run PDU 2LCF-24 70/30 Vol.% SRC/500°F IBP KC-Oil							
Blend Period PDU 2LCF-24	4	9	13	18	22	27	30
Reactor Pressure, psig	2400	2400	2400	2400	2400	2400	2400
Average Reactor Temp, °F	750(b)	790(b)	790(b)	790(c)	830(c)	810(c)	790(c)
Space Velocity, V/H/V (a)	0.46	0.46	0.73	0.86	0.54	0.54	0.51
Conversion, Vol% 850°F+	19.8	33.0	25.4	29.5	53.7	47.8	36.3
Gravity Rise, °API	8.9	10.0	7.5	6.0	11.8	11.1	9.6
Yield - Weight % of Feed							
H ₂ O	1.86	2.44	2.07	2.20	2.88	2.64	2.19
H ₂ S	0.52	0.52	0.47	0.51	0.67	0.59	0.35
NH ₃	0.77	0.97	0.63	0.72	1.07	0.87	0.75
CH ₄	0.36	0.75	0.57	0.74	2.50	2.07	1.08
C ₂ H ₆	0.37	0.71	0.54	0.60	1.89	1.65	0.86
C ₃ H ₈	0.30	0.70	0.49	0.54	1.95	1.55	0.74
C ₃ H ₆	0.01	0.01	0.01	0.03	0.07	0.07	0.05
i-C ₄ H ₁₀	0.04	0.07	0.05	0.06	0.20	0.17	0.08
n-C ₄ H ₁₀	0.30	0.66	0.43	0.49	1.81	1.52	0.69
C ₄ H ₈	0.00	0.01	0.01	0.01	0.04	0.02	0.02
C ₅ -390°F	2.78	4.73	3.50	3.34	10.10	7.52	5.00
390-500°F	4.96	6.92	5.51	6.51	7.19	9.94	7.79
500-650°F	14.40	16.93	15.33	13.08	19.57	18.17	18.21
650-850°F	20.01	20.55	19.14	20.68	18.51	18.06	18.24
850°F+	55.39	46.61	53.30	52.43	34.88	38.15	46.17
Total	102.01	102.58	101.85	101.94	103.33	102.99	102.22
Yield - Volume % of Feed							
C ₅ -390°F	4.34	7.24	5.65	5.06	15.15	11.97	7.74
390-500°F	6.36	8.88	7.07	8.21	9.24	12.89	9.99
500-650°F	16.74	20.00	17.46	15.05	22.73	21.21	21.07
650-850°F	22.22	22.96	20.58	22.58	19.96	19.62	19.79
850°F+	56.43	46.23	52.86	51.57	33.87	37.68	45.73
Total	106.09	105.31	103.62	102.47	100.95	103.37	104.32
H ₂ Consumption (SCF/BBL)	1666	2040	1479	1537	2646	2374	1762

(a) Volume of coal extract per hour per volume of settled catalyst.

(b) Maximum control temperature with cooled non-catalytic zones. The average catalytic temperatures were somewhat lower.

(c) Control temperature for isothermal operation.

TABLE 38
(Update Table XIII, January 1980 MPR)

CATALYST ANALYSES
PDU Runs 2LCF-20, -21, -22

	2LCF-20			2LCF-21			2LCF-22		
	Fresh(b) Catalyst	DC-30	DC-31	Fresh(c) Catalyst	DC-30	DC-31	Fresh(b) Catalyst	DC-30	DC-31
Carbon, Wt. %		8.99	10.23		18.88	24.39		11.52	11.58
Sulfur, Wt. %		5.97	5.98		0.12	0.14		8.06	6.95
Metals, PPM (a)									
Vanadium		1,200	500			70			
Nickel		21,000	21,000			200			
Iron		11,000	4,300			8,300			
Titanium		13,000	6,300			1,100			
Sodium		2,600	900			170			
Potassium		180	110			70			
Calcium		1,800	700			1,000			
Molybdenum		102,000	105,000						
Sieve Analysis, Wt. %									
Sieve No. 14	0.0	0.2	0.2	0(e)	0(d)	0(d)	0.2	0.5	0.1
16	0.2	0.1	0.1	0.3	0	0	0.2	4.2	0.3
18	24.3	21.7	15.2	0.2	0.2	0.6	24.3	29.6	19.8
20	67.2	67.1	70.6	12.5	0.5	5.0	67.2	61.3	72.6
25	7.7	10.3	13.6	63.0	0.3	7.8	7.7	4.3	6.8
40	0.5	0.5	0.3	23.9	97.8	84.6	0.5	0.1	0.1
Pan	0.2	0.5	0.0	0.1	1.2	2.0	0.2	0.0	0.0

- (a) Metal analyses are by Gulf.
 (b) Shell 324 Ni/Mo Catalyst. Lummus Sample No. C-069.
 (c) Shell carrier; calcined at 1130°C. CB 79-315. Lummus Sample No. C-078.
 (d) The reactor was drilled out.
 (e) Based on the bottom one-third of the original sample which contained more fines.

TABLE 39
(Update Table XII, April 1980 MPR)

CATALYST ANALYSIS (b)
PDU Run 2LCF-23

	2LCF-23		
	<u>Fresh Catalyst</u>	<u>DC-30</u>	<u>DC-31</u>
Carbon, Wt.%		6.98	10.77
Sulfur, Wt.%		6.85	6.85
Metals, ppm (a)			
Vanadium		380	110
Nickel		20,000	20,000
Iron		29,000	10,000
Titanium		9,300	4,300
Sodium		770	220
Potassium		220	66
Calcium		590	210
Molybdenum		104,000	102,000
Sieve Analysis, Wt.%			
Sieve No. 14	0.0	0.0	0.0
16	0.2	0.2	0.9
18	24.3	17.2	26.0
20	67.2	76.2	64.6
25	7.7	6.2	8.3
40	0.5	0.1	0.2
Pan	0.2	0.1	0.0

Catalyst analysis of PDU Run 2LCF-24 will appear in the next Quarterly Report.

(a) Metal analyses are by Gulf.

(b) Shell 324 Ni/Mo Catalyst. Lummus Sample No. N-069.

TABLE 40
(Update Table XV, February 1980 MPR)
850°F+ VISCOSITY AND
TOTAL LIQUID PRODUCT METALS
PDU Run 2LCF-22

LCF-Period	4		8		12		18B		24B		28	
Average Reactor Temp, °F	750		790		790		790		830		790	
Viscosity (a) 850°F+ Temperature, °F	450	500	450	500	500	550	500	550	500	550	450	500
AGS CPS at Shear Rate of												
0.2	-	-	-	-	-	-	-	-	-	-	4500	-
0.4	350	190	160	-	600	-	-	-	2150	1300	3400	600
0.8	300	165	135	-	400	250	775	725	1650	825	3000	600
1.5	180	100	88	34	240	140	410	380	1310	520	2550	550
3.0	110	76	55	29	185	85	310	235	-	400	2300	525
8.0	85	50	40	26.5	165	70	293	168	-	335	-	520
16.0	74.5	36.5	36.3	18.3	153	58	-	134	-	-	-	515
40.0	74	28	34.5	16.6	-	51	-	-	-	-	-	-
80.0	-	26.3	33.8	15.9	-	-	-	-	-	-	-	-
Spindle	18	18	18	18	18	18	18	18	18	18	34	34
Spindle Factor	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	0.28	0.28
Total Liquid Product												
Metals, PPM												
Vanadium	<2		1		4.6		4.6		3		3	
Nickel	4.5		0.9		2.7		3		3		3	
Iron	160		3		180		220		200		180	
Titanium	27		2		100		160		100		110	
Sodium	5.1		1		2		21		3		6.3	
Potassium	3.9		<0.1		1.6		2		2		1	
Calcium	4.7		0.6		9.3		7.9		6.2		4.8	

(a) Viscosity measured with Brookfield Viscometer.

TABLE 41

850°F+ VISCOSITY AND
TOTAL LIQUID PRODUCT METALS
PDU Run 21.CF-21

LCF-Period	4		6		11	
Average Reactor Temp, °F	750		780		810	
Viscosity (a) 850°F+ Temperature, °F	500	550	500	550	500	550
ABS CPS at Shear Rate of, Sec ⁻¹						
0.1	-	-	10000	-	7200	-
0.2	11200	-	7600	-	6500	-
0.4	5400	1000	4640	1100	3320	1300
0.8	3440	650	3740	755	2800	810
1.5	1850	412	3350	626	2250	526
3.0	1325	290	3175	440	1950	405
8.00	1100	250	-	411	1892	329.5
16.0	960	221.5	-	-	-	-
40.0	-	-	-	-	-	-
80.0	-	-	-	-	-	-
Spindle	34	18	34	18	34	18
Spindle Factor	0.28	1.32	0.28	1.32	0.28	1.32
Total Liquid Product						
Metals, PPM (b)						
Vanadium	7.8		6.4		7.5	
Nickel	7.3		4.4		5.0	
Iron	240		240		190	
Titanium	210		200		200	
Sodium	22		7.6		15	
Potassium	<2		<2		<2	
Calcium	100		100		100	

(a) Viscosity measured with Brookfield Viscometer.

(b) Metals analyzed by Gulf.

TABLE 42

(Update Table XIV, March 1980 MPR)

850°F+ VISCOSITY AND
TOTAL LIQUID PRODUCT METALS
PDU Run 2LCF-23

LCF-Period	4		10		14		18		22	
Average Reactor Temp, °F	750		790		790		830		790	
Viscosity (a) 850°F+ Temperature, °F	500	550	500	550	500	550	500	550	500	550
AGS CPS at Shear Rate of										
0.4	550	450	-	-	-	-	-	-	1000	-
0.8	375	300	400	700	475	450	600	550	625	500
1.5	220	170	280	330	320	240	360	280	440	260
3.0	180	110	230	205	270	150	280	160	375	175
8.0	158	80	213	130	250	108	255	110	348	135
16.0	146	66	209	90	240	93	238	91	-	121
40.0	-	62	-	82	-	84	-	89	-	-
80.0	-	-	-	-	-	-	-	-	-	-
Spindle	18	18	18	18	18	18	18	18	18	18
Spindle Factor	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Total Liquid Product										
Metals, PPM										
Vanadium	2		3		5.9		3.9		4	
Nickel	2		3		2		3		2	
Iron	130		140		120		140		170	
Titanium	140		140		120		110		150	
Sodium	3		2		3		3		2	
Potassium	<1		<1		1		<1		<1	
Calcium	5		5.7		6.6		4		3.6	

(a) Viscosity measured with Brookfield Viscometer.

TABLE 43
(Update Table X, April 1980 MPR)

850°F+ VISCOSITY AND
TOTAL LIQUID PRODUCT METALS
PDU Run 2LCF-24

LCF-Period	4		9		13		18		22	
Average Reactor Temp, °F	750		790		790		790		830	
Viscosity (a) 850°F+ Temperature, °F	500	550	500	550	500	550	500	550	500	550
AGS CPS at Shear Rate of										
0.4	-	-	-	-	-	-	-	-	-	-
0.8	375	325	700	575	800	500	600	425	600	-
1.5	280	180	500	290	590	260	410	220	370	210
3.0	220	115	420	195	505	180	370	150	285	120
8.0	200	95	388	173	475	155	335	130	250	95
16.0	193	83	-	136	-	143	-	115	236	83
40.0	-	87	-	-	-	-	-	-	-	78
80.0	-	-	-	-	-	-	-	-	-	-
Spindle	18	18	18	18	18	18	18	18	18	18
Spindle Factor	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Total Liquid Product										
Metals, PPM										
Vanadium	2		4		3		3		2.2	
Nickel	1		1		1		1		2	
Iron	120		140		180		210		170	
Titanium	150		190		210		190		100	
Sodium	4.8		7.7		4		3		3	
Potassium	0.5		0.5		0.4		1.0		0.9	
Calcium	4		5		5.9		5.4		5.3	

(a) Viscosity measured with Brookfield Viscometer.

TABLE 44

LC-FINING PILOT PLANT OPERATIONS

CHRONOLOGY

Run 2LCF-21

Inert Catalyst Support Test

September 25 to September 29, 1979

Load Reactors to Startup

The inert catalyst support material without the nickel-molybdenum metals loading was received from Shell Chemical Company and screened with 40 mesh screen after being dried (Lummus Catalyst NO. C-078). It was loaded into each of the two reactors which were subsequently assembled, pressure tested, wrapped and insulated. A feed blend of 70 weight percent solvent refined coal (Lummus Sample No. N024) with 30 weight percent prehydrogenated creosote oil (500°F+) was prepared.

September 29 to October 3, 1979

Period 1 to Period 4

Operating conditions were established at 2100 psig pressure, 750°F reactor temperatures, and 0.43 volumes of coal extract per hour per volume of settled catalyst. These conditions were maintained for the first four periods. Some operating difficulties in the product recovery system were encountered because the heavy oil product had a high melting point as a result of the low conversion of the feed. The reactors operated smoothly except for two short interruptions during the fourth period.

October 3 to October 6, 1979

Period 5A to Period 7, Shutdown

Reactor temperatures were raised to 780°F at a rate of 3°F per hour while other conditions were held constant. During Period 7 there were feed interruptions. Shortly before the end of the period, the PDU was shut down due to a feed setup in the transfer lines resulting from a plugged steam tracing line.

October 6 to October 9, 1979

Shutdown to Restartup

The plugged steam line was replaced. A damaged feed pump was also replaced. The transfer lines were cleaned, pressure tested, and insulated. The unit was started up and brought to operating conditions at a 780°F reactor temperature.

October 9 to October 11, 1979

Period 8 to Period 10, Shutdown

Following the completion of Period 8 (780°F reactor temperature), a spot product sample was taken and the reactor temperatures were raised to 810°F at the rate of 3°F per hour. Towards the latter part of Period 10, a leak developed in the recycle line of the first reactor and the PDU was shutdown.

October 11 to October 20, 1979

Shutdown to Second Catalyst Charge

During the shutdown, a pressure upset occurred and the second reactor became plugged as the result of the catalyst being lifted against the top screen. The catalyst had to be removed by drilling and a decision was made to replace the catalyst in both reactors with a fresh charge of the same catalyst.

All reactors and transfer lines were cleaned and flushed. The unit was reassembled, and pressure tested.

October 20 to October 26, 1979

Restartup to Shutdown

Two attempts to start up the unit resulted in plugged recycle and reactor outlet lines. Catalyst fines were found in the reactor outlet line. An inspection of the remaining fresh catalyst (essentially the bottom of the original lot) revealed a high amount of small broken pieces of the catalyst. The catalyst was removed from the reactors and rescreened through 31 by 8 mesh screen which is the size of the catalyst support and top screens. All lines and reactors were cleaned and flushed. The catalyst was washed and reloaded into the reactors. The unit was reassembled, pressure tested and insulated. The feed tanks were drained and a fresh feed blend was prepared.

October 26 to October 29, 1979

Restartup to Period 11, Shutdown

The PDU operation was restarted and after reactor temperatures reached 750°F they were raised 10°F per hour to 810°F and Period 10 was begun. A high pressure drop developed across the second reactor and an unsuccessful blowdown was attempted. The next day, during Period 11, two more unsuccessful attempts were made to blowdown the second reactor. During the course of the blowdowns, the recycle line for the second reactor was overheated. Since the conversion of the feed was low, the product in the line coked easily and plugged. The PDU was shut down. The catalyst in the second reactor was found to be lifted against the top screen, but was removed easily except for two inches at the top. The catalyst in the first reactor was found in its normal position and was removed easily.

TABLE 45

LC-FINING PILOT PLANT OPERATIONS

Chronology

PDU Run 2LCF-22

Parametric Study of Process Parameters

November 2 to November 8, 1979

Catalyst Loading to Startup

The Shell 324 nickel-molybdenum catalyst (Lummus Sample C-069) was loaded into each reactor. The reactors were assembled, pressure tested, wrapped, and insulated. The catalyst was presulfided and a feed blend of 70 Wt.% SRC (Wilsonville Runs 161 and 163, Lummus Sample No. N-127) /30 Wt.% prehydrogenated Koppers Heavy Residue creosote oil was prepared and the operations started.

November 9 to November 13, 1979

Period 1A to Period 4

The reactor conditions were set at 750°F temperature, 0.44 V/H/V space velocity (volumes of coal extract per hour per volume of settled catalyst) and 2400 psig pressure. Water was pumped periodically into the condenser between the high-temperature and low-temperature separators to prevent and clear any plugs of ammonium sulfide. During Periods 2 and 4 plugs were cleared which resulted in upsets in the second reactor recycle flow, but flows were quickly reestablished. The light oil lines and the top of the light oil stripper were cleared of plugs and the stripper was flushed while it was temporarily by-passed.

November 13 to November 17, 1979

Period 5A to Period 8

The reactor temperatures were raised to 790°F while other conditions were held the same. There was a feed interruption early in Period 7 which was quickly corrected. Otherwise, operations were smooth.

TABLE 45 (cont'd)

November 17 to November 18, 1979

Period 9A to Shutdown

The liquid hourly space rate was raised to 1.03 V/H/V. The liquid level controller for the high-pressure, high-temperature separator malfunctioned causing a loss of system pressure several times and the operation had to be shut down. During the shutdown a restriction developed in the transfer line between the two reactors.

November 18 to November 21, 1979

Maintenance to Holiday Shutdown

The liquid level control valves were checked and the trims were replaced. Also, the DP cell for the liquid level controller was replaced. The transfer line between the reactors was replaced and the bottom screen for the second reactor was cleaned. The feed tanks were drained for the Thanksgiving holiday shutdown.

November 26 to December 4, 1979

Preparations to Startup

The top of the first reactor was opened to correct the passage of any catalyst past the top screen. During this time, some catalyst was inadvertently blown out of the reactor. The remaining catalyst was removed, washed, dried and measured. The catalyst loss (about 22 vol.%) was made up with fresh catalyst. The top catalyst screen fitting was modified to contain a soft annular gasket to prevent catalyst escape. The unit was reassembled, pressure tested, wrapped and insulated.

The operations were resumed with feed, but leaks developed at the top of the reactors and the operations were shutdown. The top fitting for each reactor was replaced and operations were started again.

TABLE 45 (cont'd)

December 4 to December 9, 1979

Period 10 to Period 14

The operating conditions were set at 790°F reactor temperature, 1.03 V/H/V liquid hourly space velocity, and 2400 psig pressure. During these periods, the pumping of water to the condenser between the two separators was changed from intermittent operation to continuous operation by recycling the water and using fresh water periodically. This prevented plugs and pressure upsets from ammonium sulfide deposits. Operations were smooth except during Period 14 when the feed flow was interrupted as a result of a plug in the feed tanks. Solvent was introduced temporarily while the condition was corrected and then feed was reintroduced.

December 9 to December 11, 1979

Period 15A to Period 16, Solvent Introduction

The liquid hourly space velocity was lowered to 0.73 V/H/V while other conditions were held the same. There were three feed interruptions during Period 15 which were corrected, but during Period 16 the feed pump malfunctioned and solvent was introduced to the unit.

December 11 to December 15, 1979

Maintenance to Feed Introduction

While the operation was maintained with solvent, the pump check valves and relief valves were replaced. The feed pump drive was found to be damaged and a spare pump was installed. The feed was then reintroduced in place of solvent.

December 15 to December 19, 1979

Period 16 (Restart) to Period 19

Operating conditions were established at 790°F reactor temperature, 0.73 V/H/V liquid hourly space velocity; and 2400 psig pressure. A feed interruption occurred near the start of Period 18 which was corrected. The remainder of the operations proceeded smoothly.

TABLE 45 (Cont'd)

December 19 to December 21, 1979

Period 20 to Period 21, Holiday Shutdown

The reactor temperatures were raised 3°F per hour to 830°F while other conditions were held the same. Operations were smooth and were shut down after Period 21 for the holidays. The feed blend was drained from the feed tanks for the Christmas holiday shutdown.

December 26 to December 28, 1979

Maintenance

Maintenance items were taken care of on the unit, including flowmeter calibrations.

January 2 to January 10, 1980

Preparations to Startup

The unit was pressure tested, wrapped and insulated. Some of the hydrogen flowmeters were recalibrated. Operations were started after several unsuccessful attempts due to overheated recycle lines which plugged and, also, a plugged transfer line.

January 11 to January 13, 1980

Period 22 to Period 24B

Operating conditions were established at 810°F reactor temperature, 0.73 V/H/V liquid hourly space velocity, and 2400 psig pressure for Period 22. During Period 23A the reactor temperatures were raised 10°F per hour to 830°F, and these conditions were maintained through Period 24B without any problems.

January 13 to January 17, 1980

Period 25A to Period 28

At the start of Period 25A, the reactor temperatures were lowered to 790°F and the liquid hourly space velocity was also lowered to 0.44 V/H/V while maintaining the pressure at 2400 psig pressure. The recycle flow for the second reactor stopped twice during Period 25A and solvent was pumped into the recycle line to reestablish flow.

TABLE 45 (cont'd)

The differential pressure increased across the second reactor during Period 25B. Unsuccessful attempts were made to decrease the differential pressure by "blowdowns" during the early parts of Periods 26 and 27.

January 17 to January 18, 1980

Shutdown to Catalyst Removal

The operation was shut down. The reactors were opened and catalyst was found in its normal settled position. The free-flowing catalyst was removed easily from each reactor.

TABLE 46

LC-FINING PILOT PLANT OPERATIONS

Chronology

PDU Run 2LCF-23

Parametric Study of Process Parameters

("Cool" Non-Catalytic Zones)

January 19 to January 23, 1980

Catalyst Loading to Startup

The Shell 324 nickel-molybdenum catalyst (Lummus Sample C-069) was loaded into each reactor. The reactors were assembled, pressure tested, wrapped, and insulated, except for part of the top of each reactor and the recycle line. The catalyst was presulfided. A feed blend of 70 Wt.% SRC (Wilsonville Runs 161 and 163, Lummus Sample No. N-127) and 30 Wt.% pre-hydrogenated creosote oil was prepared and operations started.

January 24 to January 31, 1980

Period 1 to Period 4

The reactor temperatures were set at 750°F maximum and the temperatures of the recycle line and transfer line outlets were set at 650°F. In this way the non-catalytic zones were held at "cooler" temperatures than with isothermal operation. The temperatures in the catalyst zones were at 750°F maximum temperature and the average temperature was somewhat less. The other operating conditions were set at a liquid hourly space velocity of 0.44 V/H/V (volumes of coal extract per hour per volume of settled catalyst) and 2400 psig pressure. During Period 2 the transfer line between the reactors plugged and the operation was shut down to replace the line. Operations were resumed and Period 2 was restarted. Water was pumped continuously to the inlet of the condenser between the two high-pressure separators in order to keep it clear. Most of the water was recycled and some fresh water was used. Operations proceeded satisfactorily.

TABLE 46 (cont'd)

January 31 to February 6, 1980

Period 5 to Period 10

The reactor temperatures were raised 3°F per hour to 790°F maximum. The recycle line and transfer line outlets were maintained at a 650°F temperature. Other conditions were also held the same. A feed interruption occurred during Period 6 and was corrected. Another feed interruption happened during Period 7. Solvent was introduced until the flow of feed in the pump suction line was established. Period 8A was then started and operating conditions were reestablished. A solvent block valve on the feed pump suction manifold was leaking solvent into the feed during Periods 7 and 8. An upstream block valve was closed to stop the solvent leakage. Another feed stoppage occurred during Period 10 because of an inadvertently closed pump suction valve. Also during Period 10, the water pump failed to maintain flow and a plug developed in the condenser between the high-pressure separators. The water flow was reestablished and the restriction was freed.

February 6 to February 10, 1980

Period 11A to Period 14

The liquid hourly space velocity was raised to 0.73 V/H/V while other conditions were held the same. Operations continued smoothly.

February 10 to February 14, 1980

Period 15A to Period 18

The reactor temperatures were raised 3°F per hour to 830°F maximum and the liquid hourly space velocity was decreased to 0.44 V/H/V while the pressure was maintained at 2400 psig. There were no operating difficulties.

February 14 to February 18, 1980

Period 19A to Period 22

The reactor temperatures were reduced to 790°F maximum while other conditions were held the same and operations proceeded satisfactorily.

TABLE 46 (cont'd)

February 18 to February 19, 1980

Shutdown to Catalyst Removal

The operation was shut down and the reactors opened. The catalyst was found in the normal settled position and the free-flowing catalyst was removed easily from each reactor.

TABLE 47

LC-Fining Pilot Plant Operations

Chronology
PDU-Run 2LCF-24

Parametric Study of Process Parameters
(Prehydrogenated Koppers Heavy Residue Creosote Oil Solvent: 7 Wt.% H₂)

February 21 to February 27, 1980

Catalyst Loading to Startup

The Shell 324 nickel-molybdenum catalyst (Lummus Sample C-069) was loaded into each reactor. The reactors were assembled, pressure tested, wrapped, and insulated except for a part of the top of each reactor and recycle line. The catalyst was presulfided. A feed blend of 70 Wt.% SRC (Wilsonville Runs 161 and 163, Lummus Sample No. N-127) and 30 Wt.% prehydrogenated creosote oil was prepared. The prehydrogenated creosote oil had a hydrogen content of 7.04 Wt.% compared to 8+ Wt.% used for Runs 2LCF-22 and 23.

February 27 to March 2, 1980

Period 1 to Period 4

The reactor temperatures were set at a 750° maximum and temperatures of the recycle line and transfer line outlets were set at 650°F. In this way the non-catalytic zones were held at "cooler" temperatures than with isothermal operation. The other operating conditions were set at a liquid hourly space velocity, of 0.44 V/H/V (volumes of coal extract per hour per volume of settled catalyst), and 2400 psig pressure. Water was pumped continuously to the inlet of the condenser between the two high-pressure separators in order to keep it clear. Most of the water was recycled. Toward the end of Period 3, the water pump was taken out of service for maintenance and returned early in Period 4. The feed pump experienced difficulty during Period 3 and the feed was switched to a spare pump while the pump check valves were replaced. During Period 4, the original feed pump was put back in service.

TABLE 47 (cont'd)

March 2 to March 4, 1980

Period 5A to Period 7, Solvent Introduction

The reactor temperatures were raised 3°F an hour to a 790°F maximum. Heavy oil product inadvertently passed into the light oil system during Period 5 and the stripper was by-passed. During Period 7 the utility boiler failed, and the steam pressure became too low to maintain the desired feed temperature. Sursol solvent was then introduced in place of the feed.

March 4 to March 7, 1980

Solvent Operation to Feed Reintroduction

While the steam pressure was low, a plug developed in the condenser between the two high-pressure separators which was ultimately cleared. Creosote oil was then fed to the unit in place of the Sursol solvent. The feed system was observed to be plugged and the lines had to be cleared or replaced. The pump check valves were also replaced before feed was reintroduced.

March 7 to March 9, 1980

Period 8A to Period 9

The reactor conditions were returned to 790°F maximum temperature, 0.44 V/H/V, and 2400 psig pressure. Operations were smooth except for a momentary power failure during Period 9 which led to a loss of recycle flow to the second reactor which was quickly corrected.

March 9 to March 13, 1980

Period 10A to Period 13

The feed and hydrogen rates were raised for operations at 0.73 V/H/V while the reactor temperatures and pressure were maintained at 790°F maximum and 2400 psig, respectively. During each of Periods 10B and 11 there was a recycle flow interruption to the second reactor which was corrected by pumping creosote oil into remote check valves in the recycle line. The feed line plugged during Period 12A as a result of a restricted steam

TABLE 47 (cont'd)

tracing line. Creosote oil was pumped to the reactors, by-passing the feed line, while the steam tracing was cleared. After three hours the feed was reintroduced and normal conditions reestablished with the start of Period 12B. Operations continued smoothly.

March 13 to March 21, 1980

Period 14A to Period 18

The reactors were operated isothermally starting with Period 14A. All three heating zones for each reactor were controlled at 790°F. The space velocity and reactor pressure were held at 0.73 V/H/V and 2400 psig, respectively. The recycle flow for the second reactor was briefly interrupted twice during Period 15 and corrected by pumping creosote oil into the recycle line for short times. This occurred also during Period 16A, but then the recycle line for the second reactor plugged and a rupture disc burst. The rupture disc was replaced and the plugged recycle line was cleared and flushed.

Operations were resumed beginning with Period 16B and the same conditions were maintained. There were minor difficulties with plugged lines in the product recovery section that were readily corrected. The reactor operations were smooth except for a momentary overheating of the middle zone of the first reactor during the early part of Period 18.

March 21 to March 25, 1980

Period 19A to Period 22

The reactor temperatures were raised 3°F per hour to 830°F and the feed and gas rates were lowered to correspond to 0.44 V/H/V. Near the end of Period 19A, the steam boiler failed again and steam pressure was lost. As a consequence, the feed to the unit was withdrawn and creosote oil introduced in its place. About 13 hours later, the steam pressure was regained and the feed was reintroduced. The reactor temperatures were raised 6°F per hour to 830°F and Period 20 was started. The pressure drop across the second reactor increased to 14 psi. Operations proceeded smoothly.

TABLE 47 (cont'd)

March 25 to March 27, 1980

Period 23A to Period 24

The reactor temperatures were lowered to 750°F while other conditions were maintained the same in order to attain a low conversion level. It was anticipated that this procedure would flush the reactors of any deleterious materials formed at the high conversion level of the previous periods. Attempts to blowdown the second reactor during Period 24 and several subsequent periods were unsuccessful.

March 27 to March 30, 1980

Period 25A to Period 27

The reactor temperatures were raised 3°F per hour to 810°F while other conditions were held the same. A feed interruption early in Period 26 was corrected.

March 30 to April 2, 1980

Period 28A to Period 30, Shutdown

The reactor conditions were held the same while the reactor temperatures were lowered to 790°F. Operations were shutdown after Period 30. The catalyst in the first reactor was found in its normal settled position and removed easily. The catalyst in the second reactor was found lifted against the top screen. Most of the catalyst came out by rapping on the reactor and the remaining portion at the top had to be rodded out. The catalyst from the second reactor had several agglomerates or clusters.

TABLE 48

FEED PROPERTY

START-UP PASTE SOLVENT

RAW KOPPERS CREOSOTE OIL

SPECIFIC GRAVITY @ 60/60°F		1.1960
ASH	wt. %	Trace
CARBON CONTENT	wt. %	91.70
HYDROGEN CONTENT	wt. %	5.34
SULFUR CONTENT	wt. %	0.62
NITROGEN CONTENT	wt. %	1.00

<u>FRACTIONAL</u>	<u>Wt. %</u>	<u>Vol. %</u>
IBP - 500°F	.72	0.7
500 - 650°F	6.08	7.0
650 - 850°F	66.11	68.3
850°F+	<u>27.09</u>	<u>24.0</u>
	100.00	100.0

PREHYDROGENATION OF RAW CREOSOTE OIL OPERATING CONDITIONS & YIELDS

—87—

TABLE 50

3LCFELEMENTAL ANALYSES OF SPENT CATALYST(FROM KOPPERS CREOSOTE)

DATES	2/14/80			3/13/80		
REACTORS	DC-31	DC-32	DC-33	DC-31	DC-32	DC-33
ELEMENTALS	(wt. %)*					
CARBON	13.43	14.18	6.30	9.53	8.81	8.06
HYDROGEN	1.03	1.05	.74	.90	.91	.88
NITROGEN	.89	.89	.79	.67	.66	.70
CARBON/ HYDROGEN	13.04	13.50	8.5	11.08	9.68	9.16

WASHING PROCEDURE: Spent catalyst first washed in toluene, then pyridine extracted.

* Based on total spent catalyst weight.

TABLE 51

SHORT CONTACT TIME REACTION CONDITIONS AND ANALYSES

Run No. (SCT-)	1-1	1-2	1-3	2-1
Period, month/day	3/19	3/19-3/20	3/20-3/23	3/28
<u>Process Conditions</u>				
Coal feed rate MT, lb./hr.	17.8	21.1	27.9	32.4
Coal content of paste, wt. % (nominal)	39	30	30	30
Gas feed, scf/ton MF coal	18,500	15,600	11,800	10,200
H ₂ purity, mol %	98	98	98	98
Coal space rate, lb./hr.-ft ³	143	170	225	244
Preheater outlet temperature, °F	840	850	850	850
Hydrogen Pressure-Preheater Inlet, psig	2,600	2,650	2,650	2,600
Hydrogen Pressure-Preheater Outlet, psig	2,500	2,500	2,500	2,500
Conversion (Based on I.O.M. Balance,) wt. %	91.8	94.6	--	89.6
<u>Elemental Analysis of Recycle</u>				
<u>Solvent, wt. % (1)</u>				
Carbon	91.70	91.70	91.70	91.70
Hydrogen	5.34	5.34	5.34	5.34
Nitrogen	1.00	1.00	1.00	1.00
Sulfur	0.62	0.62	0.62	0.62
Oxygen (By diff.)	1.34	1.34	1.34	1.34
Ash	nil	nil	nil	nil
<u>Elemental Analysis of Coal</u>				
<u>Paste Feed, wt. %</u>				
Carbon	84.09	84.09		
Hydrogen	5.19	5.19	(2)	(2)
Oxygen (By diff.)	3.81	3.81	N/A	N/A
Nitrogen	1.18	1.18		
Sulfur	1.65	1.65		
Ash	4.08	4.08		
<u>Distillate Fraction Analysis of</u>				
<u>Recycle Solvent, wt. %</u>				
IBP-500°F	0.72	0.72	0.72	0.72
500-650°F	6.08	6.08	6.08	6.08
650-850°F	66.11	66.11	66.11	66.11
850°F + Residue	27.09	27.09	27.09	27.09
<u>Elemental Analysis of Total</u>				
<u>Liquid Product, wt. % (3)</u>				
Carbon	88.04	86.13	85.98	82.17
Hydrogen	5.29	5.23	5.22	5.20
Nitrogen	1.22	1.12	1.14	3.39
Sulfur	1.08	1.05	0.98	1.12
Oxygen (By Diff.)	2.93	3.49	3.71(4)	4.06(4)
Ash	1.44	2.98	2.94	4.06

(1) Creosote Oil used as Paste Solvent

(2) Data not available

(3) Heavy Oil was used instead of total liquid product

(4) Analysis done by - Nuclear Products and Services, Union Carbide Corporation
Sterling Forest Lab., P.O. Bx. 324, Tuxedo, N. Y. 10987

(5) Illinois No. 6 used in Run SCT-1, Indiana V used thereafter.

TABLE 51

(Cont'd.)

SHORT CONTACT TIME REACTION CONDITIONS AND ANALYSES

Run No. (SCT-)	1-1	1-2	1-3	2-1
Period, month/day	3/19	3/19-3/20	3/20-3/23	3/28
<u>Solubles Analysis of Total Liquid Product, wt. % (1)</u>				
Oil	57.85	51.95	62.68	45.16
Asphaltene	26.22	33.28	21.94	35.06
Preasphaltene	11.85	10.04	—	12.23
Ash	1.44	2.98	2.97	4.18
I.O.M.	2.64	1.75	—	3.37
<u>Total Liquid Product Distribution, wt. % (1)</u>				
IBP-500°F	(2)	-(2)	—	—
500-650°F			5.34	7.93
650-850°F	N/A	N/A	54.17	44.86
850°F + Residue			40.49	47.21

(1) Heavy Oil was analyzed instead of total liquid product

(2) Data not available

TABLE 52

INDIANA V COAL

PROXIMATE ANALYSIS

Moisture Content	wt. % 2.63
Volatile Matter (Dry Basis)	wt. % 39.49
Ash Content (Dry Basis)	wt. % 10.65
Fixed Carbon (Dry Basis)	wt. % 49.50

ULTIMATE ANALYSIS (MF BASIS)

Carbon Content	wt. % 69.76
Hydrogen Content	wt. % 4.80
Sulfur Content	wt. % 3.41
Nitrogen Content	wt. % 1.38
Oxygen Content (By Diff.)	wt. % 10.00
Ash Content	wt. % 10.65

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