378
10/30/79

DR. 259

FE-2038-25
Dist. Category UC-90d

COMMERCIAL SCALE EXPANDED BED HYDROPROCESSING OF SOLVENT REFINED COAL (SRC) EXTRACT

Interim
Technical Progress Report
on
Subtask I - Catalyst Screening

MASTER

Prepared By

Cities Service Company
Technology Assessment Department
P. O. Box 300
Tulsa, Oklahoma 74102

Principal Investigators

John D. Potts
Kenneth E. Hastings

In Cooperation With

Harold Unger
C-E Lummus Company

Date Published - August, 1978

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY
Under Contract No. EX-76-C-01-2038

ERRATA

Table of Contents

"Purpose - Contract Enxtenstion"
should be
"Purpose - Contract Extension"

Page 41 Misplaced

Bound page order is ...38, 41, 39, 40, 42...

Available from:

National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

Price: Printed copy: 5.25
Microfiche: $3.00

TABLE OF CONTENTS

TABLES (Continued)

TABLES (Continued)

FIGURES

APPENDIX TABLES - LIQUID PRODUCT YIELDS

APPENDIX TABLES (Continued)

ABSTRACT

The feasibility of utilizing an expanded bed reactor (LC-Fining Process) for upgrading SRC-I has been adequately demonstrated with respect to conversion of 850°F+ and desulfurization. The objective of this subtask was to determine the effectiveness of commercially available hydrotreating catalysts for improved denitrogenation. A goal was set of approximately 0.3 weight percent in the 390-850°F distillate fraction.

A catalyst screening study utilizing six commercial catalysts showed that a Shell 324 nickel-molybdenum 1/32 inch extrudate was superior to two other nickel-molybdenum catalysts, two cobalt-molybdenum catalysts, and a nickel-tungsten catalyst. The Shell 324 catalyst was run for 33 days of continuous operation and demonstrated conversion levels of 55-65 volume percent 850°F+ (based on feed) with a distillate product (390-850°F) containing approximately 0.3 weight percent nitrogen and 32 to 128 ppm sulfur. Catalyst activity was maintained by small temperature adjustments.

Proprietary LC-Fining expanded bed correlations for residuum processing of petroleum are applicable to coal liquids processing.

INTERIM
TECHNICAL PROGRESS REPORT
ON
SUBTASK I - CATALYST SCREENING

Introduction

Several years ago discussions were initiated between Cities Service Company and the Energy Research and Development Administration (ERDA), now a part of the Department of Energy. The use of an LC-Fining Process Unit was being considered for a commercial demonstration of expanded bed hydroprocessing of solvent refined coal (SRC-I) extract. The LC-Finer, located at the Lake Charles, Louisiana refinery of Cities Service, was originally designed to process 2500 Bbl/day of residuum at high temperature (750-850°F) and high pressure. The ultimate objective of the commercial demonstration run is to process 15,000 barrels of SRC-I from the SRC plant at Tacoma, Washington over a period of approximately one month.

Purpose - Original Contract

The original contract with ERDA consisted of two tasks. Task I involved PDU operation to determine the feasibility of operating an LC-Finer to process SRC-I and also to determine the optimum operating conditions for conversion and desulfurization. The Lummus Company, with laboratory process development units for LC-Fining located in New Brunswick, New Jersey, was chosen as the subcontractor for this project with Cities being the prime contractor. The choice of subcontractor was especially judicious as the Lummus Company is the exclusive worldwide licensor of the proprietary LC-Fining process and has an excellent perspective of the operating parameters. Task II is being performed coincidentially with the PDU operation of Task I. Task II is an engineering study of the Lake Charles operation to determine the scope and extent of the required commercial unit modifications as determined by the results from Task I. The as-yet unfunded Task III would be the actual commercial demonstration run made by processing 15,000 barrels of SRC-I in the Lake Charles LC-Finer.

Purpose - Contract Extension

The success of Task I in determining the feasibility of utilizing an LC-Finer for upgrading SRC-I stimulated further interest in this method of operation by DOE.[1] The goals were further modified by DOE to place a greater emphasis on nitrogen removal since conversion and desulfurization had been adequately demonstrated. Consequently, Task I was enlarged by a contract extension to investigate five additional subtasks:

1) Screen commercial catalysts for improved nitrogen removal to a level of approximately 0.3 weight percent in the 390-850°F distillate fraction;
2) Recycle unconverted bottoms and generate internal recycle solvent;
3) Test SRC from Western coal and also low severity extraction processing;
4) Determine effect of ash content in SRC on catalyst aging and make-up rate;
5) Use separate expanded bed demetallization reactor.

This interim report will encompass Subtask I only.

Objective (Subtask I)

The objective of this subtask was to determine the effectiveness of commercially available hydrotreating catalysts for improved denitrogenation of a solvent refined coal (SRC-I) extract in an expanded bed reactor (LC-Fining Process). A total of six commercially available catalysts were tested, i.e., two cobalt molybdenum, three nickel-molybdenum, and one nickel-tungsten. On the basis of the results of these screening tests, the best denitrogenation catalyst

(1) J. D. Potts, K. E. Hastings, E. D. Wysocki, "Commercial Scale Expanded Bed Hydroprocessing of Solvent Refined Coal (SRC) Extract", Interim Technical Progress Report, UC-90, Report No. FE-2038-17, November, 1977.

was selected for a subsequent 30-day aging run. This catalyst was found to be Shell 324 nickel-molybdenum 1/32-inch extrudate.

Equipment and Unit Operation

Six commercially available catalysts were chosen to be run for no longer than 12 days each. The selected process conditions were equivalent to those used in the 30-day catalyst aging run, LCF-26, using an American Cyanamid 1442B Co/Mo catalyst (namely: 810°F, $0.44SV_0$, 50/50 volume percent SRC/solvent ratio). Depending upon a predicted catalyst activity obtained from literature and catalyst manufacturer sources, a specific run could be initiated at a higher or lower temperature than a previous run on another catalyst, but ultimately each would be programmed to 810°F. The particulars for a given catalyst will be found in subsequent sections of this report.

The equipment used and the details of the process development unit (PDU) operation may be found in the Interim Technical Progress Report (FE-2038-17)[1] published in November, 1977.

Table I identifies the catalysts used in each specific run by a manufacturers designation and also a catalyst code designation which is pertinent to each catalyst. Also included in Table I is a summary of the experimental program for catalyst evaluation. In the written text of this report the catalysts will be identified by catalyst code designation as follows:

PDU-Run LCF	Catalyst Code Designation	Manufacturers Designation
29	Co/Mo-A	American Cyanamid 1442B
32	Co/Mo-B	American Cyanamid 1442B Modified for denitrogenation
30,35,36	Ni/Mo-A	Modified Shell 324
33	Ni/Mo-B	Ketjenfine 153S-0.8E
34	Ni/Mo-C	American Cyanamid MTG-S-1028
31	Ni/W-A	Shell 77-133

Charge Stock Preparation

Hydrogenated KC-Oil/LC-Finer PDU

In order to provide a foreign solvent with an enhanced hydrogen donor capability, it was planned to use a hydrogenated Koppers heavy residue creosote oil (KC-Oil) solvent in the five subtasks of the contract extension. It will be recalled that a light oil and a heavy oil product are obtained in both the solvent hydrogenation and also in the LC-Finer PDU using solvent/SRC feed blends. The heavy oil has a nominal IBP of 500°F. In order to produce a 400°F and a 500°F IBP hydrogenated KC-Oil solvent, the light oil would be cut to the desired IBP and blended back with the corresponding heavy oil fraction. This would provide hydrogenated solvent/SRC feed blends to study the effect of solvent boiling range at an IBP of 400°F and 500°F.

An attempt was made to hydrogenate the KC-Oil in a large expanded bed Lummus HDS unit with the unit having a capability of processing 10 gallons/hour. An equipment malfunction necessitated shutting the large unit down, and in the interim repair period subsequent hydrogenation of KC-Oil was to be done in the LC-Fining PDU (3-reactor mode)at a rate of 18 gallons/day (Run LC-27). Approximately 600 pounds of hydrogenated heavy oil was produced in the LC-Fining PDU operation. Unfortunately, 300 pounds of the hydrogenated KC-Oil from the LC-Fining PDU was contaminated with off-specification material. A decision was made to defer use of the remaining 300 pounds of hydrogenated oil from the LC-Finer and, instead, substitute hydrogenated KC-Oil from the Lummus HDS unit which had been repaired in the interim and was back on stream.

The light oil and heavy oil inspections from Run LCF-27 are presented in Table II together with the KC-Oil charge. An analysis of the Solvent Refined Coal (SRC-I) is also shown in Table II. The cobalt-molybdenum catalyst used for hydrotreating the solvent was a modified American Cyanamid 1442B. Table II shows that the hydrogenated KC-Oil had approximately 90 weight percent nitrogen and sulfur removal. The modified 1442B catalyst, therefore, became a candidate for the catalyst screening study.

Hydrogenated KC-Oil/Lummus HDS Unit

The hydrogenated KC-Oil solvent used for the catalyst screening study was prepared in the Lummus HDS unit. A heavy oil and a light oil are produced by a vacuum flash with the IBP of the heavy oil being approximately 500°F. In order to prepare the two different solvents for Run LCF-29 - a nominal 400°F and a 500°F IBP solvent - the heavy oil was used as-is and the light oil was distilled. The light oil was topped to 400°F minus and the 400°F plus material was added to the as-is heavy oil to produce the nominal 400°F IBP solvent. A second portion of the light oil was topped to 500°F minus and the 500°F plus material was added to the as-is heavy oil to produce the nominal 500°F IBP solvent.

Table III presents the inspection data for the two solvents - LCF-29 (S)/1-7 is the 400°F solvent and LCF-29 (S)/8-13 is the 500°F solvent. The nominal 500°F solvent represented by LCF-30S in Table III is a sample of the as-is heavy oil from the HDS unit (obtained from a blend of seven drums of heavy oil). Variations in the operation of the product recovery section of the HDS unit contribute to the relatively large amount of IBP-500°F fraction (11.8 volume percent) found in the nominally 500°F heavy oil (LCF-30S).

SRC/Hydrogenated KC-Oil Feed Blends

Table IV presents the feed blend properties obtained from blending the three solvents described previously with approximately 50% SRC. The feed blend for LCF-29/1-7 is lighter than LCF-29/8-13, has a lower viscosity and softening point, and a larger IBP-650°F distillate fraction - all of which reflect the addition of the 400-500°F light oil material from the light oil distillation into hydrogenated heavy oil solvent. The elemental analyses of the two feed blends are virtually identical.

The SRC/Hydrogenated KC-Oil (LCF-30S) feed blend designated as LCF-30 in Table IV was used for the subsequent catalyst screening tests (PDU Runs LCF-30 through LCF-34), and the catalyst aging tests (PDU Runs LCF-35 and LCF-36).

Results and Discussion

Comparative Catalyst Evaluation

In order to expedite the choice of a catalyst for testing in the subsequent subtasks, the initial catalyst comparisons were made essentially upon the basis of the analysis of the heavy oil fraction of the total liquid product and also upon the nitrogen content of this material. It was thus possible to obtain daily checks on the changes in the conversion of the SRC (850°F+) and also on the catalyst activity for denitrogenation in the heavy oil. This technique assumes that the heavy oil fraction is representative of the total liquid product since it accounts for approximately 90% by volume of the total liquid product based on feed.

Subsequently, specific periods within each run were chosen for a complete product analysis (gas, light oil, heavy oil) and yield data was calculated on the basis of the total feed blend (Reference: Tables in appendix A).

The denitrogenation activity is a function not only of the analytical levels of nitrogen in the feed and liquid products, but also of the absolute amounts of liquid product and fractions thereof. The percent denitrogenation is calculated on this basis.

Conversion is defined as the volume percent of 850°F+ material in the liquid feed blend converted to products boiling below 850°F. The conversions reported on a daily basis are calculated on the basis of heavy oil only.

Cobalt-Molybdenum Catalysts

Two cobalt-molybdenum catalysts were evaluated in the catalyst screening study. Co/Mo-A (American Cyanamid 1442B) was used for PDU Run LCF-29 which investigated the use of a hydrogenated KC-Oil solvent at an IBP of 400°F and 500°F. Co/Mo-B (American Cyanamid 1442B modified for denitrogenation) was used for PDU Run LCF-32.

A summary of the weight ratio conversion of 850°F+ material, gravity change, and the nitrogen, hydrogen contents of the heavy oil liquid product is presented in Table V. Table VI presents the yield of heavy oil liquid product fractions from PDU Run LCF-29 and the gravity for each fraction. A light oil product gravity is also shown. This type of data is representative of that obtained for the daily PDU checks on operability.

Table VII presents the heavy oil product analyses for Run LCF-32 and Table VIII presents a summary of the light and heavy oil recovered. Figure 1 shows a comparison of conversion and heavy oil nitrogen content between the two cobalt-molybdenum catalysts for Runs LCF-29 and LCF-32.

Following an initial high conversion of 77 weight percent of 850°F+ material in Run LCF-29, the conversion remained approximately constant at 65 weight percent from Period 5 through Period 12 (a change in solvent occurring at Period 7/8). The denitrogenation activity of the catalyst declined steadily from 61.3 to 39.5 percent with only a slight perturbation when the solvent was changed (400°F IBP to 500°F IBP prehydrogenated KC-Oil).

When compared to the base case catalyst (Co/Mo-A, LCF-29) the second cobalt-molybdenum catalyst (Co/Mo-B, LCF-32), presumably enhanced for increased denitrogenation, gave a lower conversion - 58 weight percent of 850°F+ material versus 65 weight percent. The denitrogenation activity of the two catalysts was comparable and both showed a declining trend with catalyst age. Run LCF-32 (Co/Mo-B catalyst) was terminated after five periods as no apparent advantage in conversion and denitrogenation was realized over the base case run, LCF-29 (Co/Mo-A catalyst).

Nickel-Molybdenum Catalysts

A nickel-molybdenum catalyst (Ni/Mo-A) proved to be the most active catalyst for both conversion and denitrogenation (Run LCF-30). After four 24-hour periods of operation, the Ni/Mo-A catalyst stabilized for an additional six periods at a conversion level of approximately 75 weight percent of 850°F+ material and a denitrogenation activity of approximately 75 percent. This behavior should be compared to the base case cobalt/molybdenum catalyst (Co/Mo-A, Run LCF-29) which stabilized at 65 weight percent conversion, but had a continually declining denitrogenation activity. Table IX presents the heavy oil product analyses for Run LCF-30 and Table X presents a summary of the light and heavy oil recovered.

Two other nickel-molybdenum catalysts were tested, neither of which proved to be either superior or equivalent to the Ni/Mo-A catalyst. Table XI presents the heavy oil product analyses for Run LCF-33 using a Ni/Mo-B catalyst and Table XII presents a summary of the light and heavy oil recovered. Table XIII presents the heavy oil product analyses for Run LCF-34 using a Ni/Mo-C catalyst and Table XIV presents a summary of the light and heavy oil recovered.

It will be noted from Table XI, LCF-33 (Ni/Mo-B catalyst), that during periods 9, 10 and 11, 12 the average reactor temperature was increased from 810 to 825°F, then from 825°F to 840°F. When the nitrogen content of the heavy oil product was normalized to 810°F (using proprietary LC-Fining correlations to be discussed in a subsequent section of this report), it was observed that the loss of denitrogenation activity continued during the high temperature periods. Thus, it may be concluded that the relatively constant nitrogen content of the heavy oil product at the higher temperatures (Table XI) merely reflected the temperature increase required to compensate for the loss in denitrogenation activity at a constant temperature.

Nickel-Tungsten Catalyst

A nickel-tungsten catalyst (LCF-31, Ni/W-A) was run and compared with the three nickel-molybdenum catalysts. The Ni/W-A catalyst was initially as active as the Ni/Mo-A catalyst, but did not show the stabilizing behavior of the Ni/Mo-A catalyst. Both the conversion and the denitrogenation activity continued to decline following Period 4 where the Ni/Mo-A catalyst began its stable performance. Table XV presents the heavy oil product analyses for Run LCF-31 and Table XVI presents a summary of the light and heavy oil recovered.

Summary - Catalyst Screening

Cities Service has developed proprietary correlations based on residuum processing in commercial expanded bed units. As stated previously, the catalyst screening runs were not initially made at the same operating temperature. Hence, the proprietary correlations were employed in order to relate the conversion of 850°F+ and nitrogen in the heavy oil fraction to a constant operating temperature of 780 or 810°F. Subsequent data obtained during the catalyst aging study (LCF-36) will substantiate this approach.

Figure 2 shows the catalyst screening comparisons with the data normalized to 810°F throughout a given run. It is apparent that the Shell 324 nickel-molybdenum 1/32-inch extrudate catalyst (Ni/Mo-A) is superior for conversion of 850°F+ material and for denitrogenation (lowest nitrogen level in the heavy oil). Within the constraints of the catalyst screening program, the Shell 324 catalyst was chosen for an immediate catalyst aging study and also for use in the remaining subtasks of this contract.

Appendix Tables I through VII present the liquid product yield and physical properties data by distillate fraction for the catalyst screening runs (LCF-29 through LCF-34). Table XVII summarizes the volume percent yield of each product fraction, based on total feed, together with elemental analyses for hydrogen, oxygen, and nitrogen. A general observation from Table XVII indicates that the nickel-molybdenum catalysts are superior to the cobalt-molybdenum catalysts for the upgrading of SRC. Several of the pertinent points of difference include the following:

a) Nickel-molybdenum catalysts provide a greater conversion of 850°F+ SRC as shown by the relative amounts of 850°F+ material remaining in the heavy oil product;

b) Nickel-molybdenum catalysts produce more IBP-390°F and 390-500°F fractions;

3) Nickel-molybdenum catalysts show a greater degree of hydrogenation, oxygen removal, and denitrogenation in all the heavy oil fractions;

d) On an equivalent activity basis, nickel-molybdenum would be chosen over nickel-tungsten catalysts due to the lower unit cost of the nickel-molybdenum catalysts.

This data substantiates the choice of a nickel-molybdenum catalyst for the future subtasks and,more specifically, the choice of the Shell 324 nickel-molybdenum species.

Catalyst Aging Runs

Run LCF-35 was the first attempt at a nominal 30-day catalyst aging study and was discontinued after 11 periods. Run LCF-36 was the second nominal 30-day catalyst aging run and was not terminated until completion of 33 periods. It will be recalled that a period is equivalent to a 24-hour operating day.

Tables XVIII and XIX present the heavy oil product analyses for Runs LCF-35 and LCF-36, respectively. Tables XX and XXI present a summary of the light and heavy oil recovered for the same runs. Appendix Tables VIII through XVII present the liquid product yield and physical properties data by distillate fraction for the two catalyst aging runs (LCF-35 and LCF-36).

Figure 3 shows a comparison of the 850°F+ conversion and the heavy oil nitrogen content between the catalyst screening run (LCF-30) and the two catalyst aging runs (LCF-35 and LCF-36) through the first eleven periods of operation. The data has been normalized to 780°F using proprietary LC-Fining correlations. This figure indicates that the catalysts have an "initial" high activity for conversion of 850°F+ material and for denitrogenation, but rapidly lose this "flush" or "initial" activity. It should be emphasized that after Period 4 Run LCF-36 was operating at a lined-out reactor temperature of 780°F rather than 810°F as in Runs LCF-30 and LCF-35. When the data was normalized to 780°F, the conversion for the three runs became virtually equivalent and reproducible between runs. However, the nitrogen content in the heavy oil is significantly lower for LCF-36 than for either LCF-30 or LCF-35.

A review of the start-up history of these three runs for the first five periods of operation shows the following:

Period	LCF-35	LCF-30	LCF-36
1	780	780	750
2	790	780	780
3	800	790	780
4	810	800	780
5	810	810	780

Run LCF-35 was brought up to the desired operating temperature of 810°F more rapidly than Run LCF-30. Run LCF-36 was held at a much lower temperature of 780°F for an extended period of time. Since conversion is postulated to be essentially a thermal phenomenom and denitrogenation is catalytic, it is reasonable to expect equivalent normalized conversions regardless of the thermal history (within limits), but somewhat different catalytic behavior depending on the start-up procedure. Many commercial catalytic processes behave substantially different when the start-up procedure is varied. Further investigation as to the effect of start-up procedure is strongly recommended.

After 27 periods of operation for Run LCF-36, the process development unit (1LCF) was shut down for the Christmas holidays. The run was restarted in January in a new process development unit (2LCF) with no adverse effects.

Figure 4 shows the conversion of 850°F+ for Run LCF-36. The upper curve shows the behavior of the conversion as the temperature was increased and represents the actual unit data. It should be noted that a conversion of 61-62 weight percent (based on the 850°F+ in the heavy oil) was maintained from Period 12 through Period 30 by adjusting the temperature only 20°F. The last two periods of Run LCF-36 were made at a temperature of 780°F. The lower curve is essentially a duplicate of the upper curve which was constructed from two widely separated sets of data. The continuity of the two curves during Periods 32 and 33 indicate that the normalizing correlation was valid and that no irreversible change in catalyst activity for conversion occurred when operating at a higher temperature.

Figure 5 shows the nitrogen content of the heavy oil product for Run LCF-36. The data for the nitrogen content behaved in a similar fashion to the conversion data with the exception of the nitrogen values for Periods 28 and 30. When Run LCF-36 was restarted in the new PDU, 2LCF, the nitrogen content of the heavy oil decreased from 0.51 to 0.43 weight percent. A possible explanation for this might be that during the unit shut-down and start-up, the catalyst had experienced a mild rejuvenation with respect to nitrogen activity at 800°F. A comparison of the unit data (not normalized) which is plotted in Figures 4 and 5 indicate that the response of conversion and denitrogenation is markedly different.

Sulfur Removal

The appendix tables show that in the vast majority of sulfur analyses, the level of sulfur is reported at <0.06 weight percent, indicating excellent desulfurization. The sulfur analyses were run according to the ASTM D-1552 test method. In order to confirm this excellent desulfurization, Dohrmann sulfur analyses were run on a random blend period, Run LCF-36/26B,27 (Appendix Table XV). The distillate portions of the total liquid product in the 390-850°F boiling range show sulfur contents from 32 to 128 ppm, confirming the claim of superior desulfurization.

Nitrogen Content of Distillate Fraction (390-850°F)

One of the most important criteria for upgrading solvent refined coal is to produce a distillate product with approximately 0.3 weight percent nitrogen. A data analysis of the distillate fraction of the TLP, or the 390-850°F portion (Table XXII), shows that the nitrogen content of this fraction is approximately 0.3 weight percent for once-through processing of SRC. The 850°F+ coal liquid feed (SRC-I) has a 2.1 weight percent nitrogen content. At the present time, nitrogen removal by two stage liquefaction - SRC-I production followed by expanded bed processing - is superior to that of one stage liquefaction as represented by SRC-II, Exxon Donor Solvent (EDS), and H-Coal.

In the once-through mode of operation (as contrasted to the recycle mode), the liquid product contains a substantial amount of foreign solvent. Additional runs are in progress to delineate the effects of the solvent and the SRC-I separately with respect to denitrogenation in each product fraction and also conversion to a specific product fraction.

Product Yield as a Percentage of Feed - Run LCF-36

Table XXIII presents the total product distribution as a function of the feed blend charge. The component yields are determined from a combination of the three product streams - gas, light oil, and heavy oil. The weight percent values reported for ammonia, hydrogen sulfide, and water are determined by difference between the nitrogen, sulfur, and oxygen values in the feed blend and product fraction streams. The product fraction analyses for nitrogen and oxygen are internally checked against the comparable analysis for the total liquid product.

No distinctive or definite trends are to be noted in either the product distribution or hydrogen consumption through Period 30B during which essentially constant catalytic activity was maintained by temperature adjustment. However, the check data at 780°F for Period 32B show a decreased activity when compared to Periods 5 and 11. This is reflected in a lower conversion of 850°F+, less C_5-500°F product fractions, and a lower hydrogen consumption. This change in activity is consistent with the data depicted in Figures 4 and 5 which was based on heavy oil analyses only.

When considering the hydrogen consumption of 2500-2800 SCF/BBL it must be kept in mind that this is based upon the feed blend charged. The feed blend is approximately 50 volume percent SRC and 50 volume percent prehydrogenated KC-Oil. Subsequent PDU runs will be made in other subtasks to attempt to define the role of solvent alone. This should provide a more representative value for hydrogen consumption which will be on the basis of SRC only (excluding foreign solvent).

Elemental Analysis of Liquid Product - Run LCF-36

Table XXIV presents the elemental analyses for hydrogen, oxygen, nitrogen, and sulfur for the selected blend periods of PDU Run LCF-36. Once again, no significant trends are observable with respect to catalyst age.

However, it may be observed that for a given blend period, small differences do occur for the product fractions. For instance, the oxygen analyses indicate a see-saw trend with both the 390-500°F and 650-850°F fractions representing low points. The nitrogen analyses, on the other hand, indicate that the 500-650°F fraction represents a low point.

Conclusions

In conclusion, it may be stated that:

1) A catalyst screening study disclosed a nickel-molybdenum catalyst (Shell 324 Ni/Mo) which was superior to two other nickel-molybdenum catalysts and a nickel-tungsten catalyst with respect to conversion and denitrogenation;

2) As expected, nickel-molybdenum catalysts were generically superior to cobalt-molybdenum catalysts for nitrogen removal;
3) Proprietary LC-Fining expanded bed correlations for residuum processing of petroleum are applicable to coal liquids processing;
4) A distillate product (390-850°F) was made containing approximately 0.3 weight percent nitrogen;
5) The distillate portions of the total liquid product in the 390-850°F boiling range show sulfur contents from 32 to 128 ppm.

TABLE I

LC-FINING PDU OPERATION
CATALYST SCREENING EXPERIMENTAL PROGRAM

PDU Run	Catalyst	Total Run Periods	Remarks
Catalyst Screening Tests			
LCF-29	Co/Mo-A American Cyanamid 1442B	1 thru 7	400°F IBP Solvent Feed Blend (53.6 wt.% SRC/46.4 wt.% 400°F IBP hydrogenated KC-Oil solvent)
LCF-29	Co/Mo-A American Cyanamid 1442B	8 thru 13	500°F IBP Solvent Feed Blend (53.1 wt.% SRC/46.9 500°F IBP hydrogenated KC-Oil solvent)
LCF-30	Ni/Mo-A Modified Shell 324	10	53 wt.% SRC/47 wt.% 500°F IBP hydrogenated KC-Oil solvent
LCF-31	Ni/W-A Shell 77-133	8	↓
LCF-32	Co/Mo-B American Cyanamid 1442B Modified for enhanced denitro.	5	↓
LCF-33	Ni/Mo-B Ketjenfine 153S-0.8E	12	↓
LCF-34	Ni/Mo-C American Cyanamid MTG-S-1028	5	↓
Catalyst Aging Tests			
LCF-35	Ni/Mo-A Modified Shell 324		↓
LCF-36	Ni/Mo-A Modified Shell 324		↓

TABLE II

LC-FINING PDU OPERATION
HYDROTREATING KOPPERS HEAVY RESIDUE CREOSOTE OIL (KC-OIL)

Run LCF-27

LCF-27 Period	Solvent Refined Coal Charge	Koppers Hvy.Res. Creosote Oil Charge	Hydrogenated KC-Oil 1 Light Oil	Hydrogenated KC-Oil 1 Heavy Oil	Hydrogenated KC-Oil 2 Light Oil	Hydrogenated KC-Oil 2 Heavy Oil
Gravity, SP 60/60	1.230	1.1486	0.9881	1.0497	0.9535	1.0497
Gravity, °API		-8.3	11.7	3.3	16.9	3.3
Elemental Content, Wt%						
Carbon	86.17	91.48	85.47	90.15	90.19	90.88
Hydrogen	5.66	5.8	9.22	7.90	9.88	7.93
Oxygen	4.39	1.07				
Nitrogen	2.09	1.18	0.16	0.12	0.14(a)	0.11(a)
Sulfur	0.80	0.56	< 0.06	<0.06	<0.06	<0.06
Pour Point, °F	-	10	-	-	-	-
Softening Point, °F	353	-	-	-	-	-
Ash, Wt.%	0.15	0.02	0	0	0	0
Distillation, ASTM D-86			Vap.Temp.°F		Vap.Temp.°F	
IBP, Obs. Vol%	620	323	198		307	
5	850	488	207		354	
10	-	530	377		374	
20	-	575	400		397	
30	-	607	420		412	
40	-	633	440		425	
50	-	650	458		428	
60	-	674	485		455	
70	-	706	510		474	
80	-	752	555		503	
90	-	815	625		542	
95	-	845	-		571	
Final Temp., °F	850	850	658		587	
Distillate Recovered, Vol%	5.1	96.4	93.5		97.0	
Residue, Vol%	92.3	3.1	5.5		2.5	
Loss, Vol%	2.6	0.5	1.0		0.5	
Distillation Fraction & Residue(b)						
IBP-500°F, Vol%	-	6.2		17.7		16.7
Gravity, °API	-	0.3		17.4		17.0
Gravity, SP 60/60	-	1.0740		0.9503		0.9529
500-650°F, Vol%	-	44.2		46.6		51.8
Gravity, °API	-	-3.9		4.8		4.8
Gravity, Sp 60/60	-	1.1089		1.0382		1.0382
650-850°F, Vol%	-	46.0		31.0		26.5
Gravity, °API	-	-10.8		-4.4		-4.8
Gravity, Sp 60/60	-	1.1725		1.1135		1.1164
850°F+, Vol%	-	3.1		4.4		4.4
Gravity, °API	-	-20.2		-13.5		-12.0
Gravity, Sp 60/60	-	1.272		1.199		1.184

(a) Kjeldahl nitrogen values are 0.18 for light oil and 0.19 for heavy oil.
(b) Lummus standard 250 ml vacuum distillation

TABLE III

LUMMUS HDS OPERATION
FOREIGH SOLVENT PROPERTIES
HYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run No. (LCF-)	29(S)	29(S)	30S(e)
Period	1-7	8-13	
Gravity, Sp 60/60°F	1.080	1.103	1.1062
Pour Point, °F	<-10°	-7°	-5°
Viscosity, Kin. CS @ 100°F	11.76	15.72	17.87
Kin. CS @ 210°F	2.36	2.64	2.79
Elemental Content, Wt%			
Carbon	91.05	92.18	92.17
Hydrogen	7.33	6.73	6.70
Oxygen	0.48	0.67	0.59
Nitrogen	0.27	0.69	0.41
Sulfur	<0.06	0.15	0.09
Ash, Wt%	TR	TR	TR
Distillation, Vapor Temp, °F	(b)	(b)	(b)
IBP	369	323	337
5 Vol%	466	490	460
10	498	530	495
20	537	565	540
30	575	580	570
40	600	612	589
50	630	645	600
60	658	654	639
70	692	677	672
80	730	730	710
90	790	808	789
95	840	-	-
Final Temperature, °F	850	850	850
Distillate Recovered, Vol%	95.6	95.6	92.4
Residue, Vol%	4.6	4.9	6.5(c)
Loss (-), Gain (+), Vol%	+0.2	+0.5	-1.1
Distillate Fractions			
IBP-500°F, Vol%	9.7	(3.4)(a)	11.8
Gravity, Sp 60/60°F	0.9672	-(a)	1.0063
Sulfur, Wt%	TR	TR	<0.06
500-650°F, Vol%	47.7	49.9	49.8
Gravity, Sp 60/60°F	1.0497	1.0591	1.090
Sulfur, Wt%	<0.06	0.11	0.08
650-850°F, Vol%	38.2	41.8	30.8
Gravity, Sp 60/60°F	1.1243	1.1388	1.1527
Sulfur, Wt%	<0.06	0.16	0.10
850°F+ Residue, Vol%	4.6	4.9	6.5(c)
Gravity, Sp 60/60°F	1.234	1.232	-(d)
Sulfur, Wt%	<0.06	0.21	0.07

(a) Insufficient Sample
(b) Lummus Standard 250 ml Vacuum Distillation
(c) Based on assumed specific gravity of residue
(d) Residue was semi-solid and therefore unable to determine specific gravity by ASTM-D71-MODIFIED
(e) Hydrogenated KC-Oil used to prepare SRC/solvent feed blends for Run LCF-30 through LCF-36

TABLE IV

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

Run No. (SCF-)	29	29	30(a)
Period	(1-7)	(8-13)	
Composition			
Solvent, Wt% (ex drum)	46.4	46.9	47.0
SRC, Wt% (ex drum)	53.6	53.1	53.0
850°F+, Vol% (by distilln)	47.8	51.6	50.7
850°F+, Wt% (by distilln)	50.1	53.7	52.3
Gravity, °API	-11.9	-13.3	-14.1
, Sp 60/60°F	1.1836	1.1967	1.2048
Softening Point, °F	107	133	118
Viscosity, Kin. CS @ 350°F	9.73	16.67	10.88
, Kin. CS @ 400°F	5.03	9.84	5.95
Elemental Content, Wt%			
Carbon	88.76	88.85	89.37
Hydrogen	6.34	6.36	6.32
Oxygen	2.45	2.94	2.52
Nitrogen	1.19	1.29	1.23
Sulfur	0.43	0.44	0.41
Ash, Wt%	0.08	0.18	0.11
Distillation, Vapor Temp.,°F			
IBP	430	428	420
5 Vol%	515	534	500
10	556	568	549
20	610	615	610
30	654	665	653
40	705	740	720
50	810	850	826
Final Temperature, °F	850	850	850
Distillate Recovered, Vol%	54.3	49.8	52.0
Residue, Vol%	47.8	51.6	50.7
Loss (-), Gain (+), Vol%	+2.1	+1.4	+2.7
Distillate Fractions			
IBP-650°F, Vol%	29.6	27.5	30.0
Gravity, °API	4.7	2.0	2.9
, Sp 60/60°F	1.0389	1.0599	1.0528
Sulfur, Wt%	0.10	0.11	0.06
Nitrogen, Wt%	0.36	0.36	0.27
650-850°F, Vol%	24.6	22.2	22.0
Gravity, °API	-6.5	-7.0	-6.9
, Sp 60/60°F	1.1322	1.1366	1.1356
Sulfur, Wt%	0.22	0.21	0.14
Nitrogen, Wt%	0.76	0.66	0.64
850°F+, Vol%	47.8	51.6	50.7
Gravity, °API	-17.6	-17.8	-17.7
, Sp 60/60°F	1.2420	1.2440	1.2430
Sulfur, Wt%	0.65	0.63	0.67
Nitrogen, Wt%	2.28	2.03	2.00

(a) SRC/Hydrogenated KC-Oil feed blend used for Runs LCF-30 thru LCF-36

TABLE V

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-29 - Cobalt-Molybdenum Catalyst (Co/Mo-A)

Period LCF-29	Reactor Temperature °F	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+ (Feed-Prod / Feed)	Gravity Rise °API(d)
	Nominal Solvent BP - 400°F+				
1(a)	810	- (c)	-	-	-
2	↓	0.46 (61.3)	7.39	0.77	10.0
3	↓	0.48 (59.7)	7.53	0.70	13.2
4(b)	↓	-	-	-	-
5	↓	0.54 (54.6)	7.63	0.63	11.7
6	↓	0.55 (53.8)	7.51	0.65	12.0
7		0.59 (50.4)	7.54	0.65	11.7
	Nominal Solvent BP - 500°F+				
8	810	0.57 (55.8)	7.56	0.71	14.2
9	↓	0.61 (52.7)	7.47	0.67	13.1
10	↓	0.65 (49.6)	7.48	0.63	13.4
11	↓	0.60 (53.5)	7.51	0.67	13.4
12	↓	0.70 (45.7)	7.50	0.63	12.0
13	↓	0.78 (39.5)	7.20	0.59	11.6

(a) Initial product not representative, inadequate purge of start-up material
(b) Product not analyzed due to operational upset
(c) Numbers in parentheses refer to percent denitrogenation
(d) Gravity rise is the difference in the TLP gravity and the feed gravity

TABLE VI

LC-FINING PDU OPERATION
SUMMARY OF LIGHT & HEAVY OIL RECOVERED
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-29 - Cobalt-Molybdenum Catalyst (Co/Mo-A)

	Light Oil	Heavy Oil								
		Fractions								
Run LCF-29		IBP-500°F		500-650°F		650-850°F		850°F		Total
Period	°API	Vol%(a)	°API	Vol%(a)	°API	Vol%(a)	°API	Vol%(a)	°API	°API
	Nominal Solvent BP - 400°F									
1(b)	-	-	-	-	-	-	-	-	-	-
2	15.2	11.0	19.8	45.5	7.7	31.9	-2.5	10.8	-18.3	1.6
3	16.4	13.6	18.5	45.6	5.9	25.8	-3.0	14.3	-16.3	1.2
4(c)	-	-	-	-	-	-	-	-	-	-
5	14.5	11.4	18.2	44.7	5.7	25.7	-2.6	17.9	-14.5	-0.3
6	15.3	10.6	17.9	44.8	5.7	26.8	-2.3	16.9	-15.8	-0.2
7	15.3	7.9	16.3	38.5	6.4	33.4	-2.7	17.1	-16.7	-0.8
	Nominal Solvent BP - 500°F									
8	15.0	8.9	19.1	43.6	6.1	32.2	-2.6	15.0	-16.4	-0.1
9	14.2	11.1	18.0	42.3	5.4	27.5	-3.2	18.0	-16.4	-0.9
10	14.2	8.0	20.1	42.4	6.3	31.3	-2.7	19.1	-16.5	-0.6
11	14.1	8.0	20.3	41.6	6.5	33.7	-2.8	17.2	-16.7	-0.6
12	13.8	8.5	18.7	41.7	5.4	30.2	-3.4	19.5	-16.6	-1.8
13	13.4	9.2	17.0	43.4	4.4	25.6	-4.0	21.4	-16.5	-2.2

(a) Volume percent yield based on heavy oil recovered.
(b) Initial product not representative, inadequate purge of start-up material.
(c) Product not analyzed due to operational upset.

TABLE VII

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-32 - Cobalt-Molybdenum Catalyst (Co/Mo-B)

LCF-32 Period	Reactor Temperature °F	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+ (Feed-Prod / Feed)	Gravity Rise °API
1B (a)	780	0.58	7.84	0.43	-11.9(c)
2B	810	0.47	7.77	0.59	15.5
3	810	0.52	7.63	0.56	14.8
4	810	0.59	7.64	0.56	14.6
5 (b)	810	0.58	7.59	0.58	14.4

(a) Spot sample of heavy oil
(b) 12-hour period
(c) Calculated from the period data and the gravity of H.O. spot sample

TABLE VIII

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-32 - Cobalt-Molybdenum Catalyst (Co/Mo/B)

Run LCF-32	Light Oil	Heavy Oil Fractions								Heavy Oil
		IBP-500°F		500-650°F		650-850°F		850°F+		Total
Period	°API	Vol%(b)	°API	Vol%	°API	Vol%	°API	Vol%	°API	°API
1B (a)	-3.6	4.5	18.5	38.1	5.9	27.4	-1.6	30.2	-12.3	-2.1
2B	10.5	8.6	22.0	41.8	7.6	27.8	-1.3	21.8	-13.6	1.0
3	14.1	8.5	21.9	40.5	7.2	28.0	-1.5	23.0	-14.4	0.4
4	14.9	7.7	21.6	41.3	7.2	27.9	-1.7	23.1	-14.4	0.0
5	14.8	9.3	20.3	38.6	6.8	30.4	-1.7	21.9	-14.4	-0.4

(a) Spot sample of heavy oil

(b) Volume percent yield for fractions based on heavy oil recovered

TABLE IX

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-30 - Nickel-Molybdenum Catalyst (Ni/Mo-A)

LCF-30 Period	Reactor Temperature °F	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+ (Feed-Prod / Feed)	Gravity Rise °API
1B (a)	780	0.17	8.87	0.67	20.3
2	780	0.27	8.61	0.64	19.7
3B	790	0.32	8.46	0.68	18.6
4B	800	0.32	8.49	-	-
4B (a)	800	0.26	8.40	0.71	19.6(d)
5B	810	0.30(b)	-	0.77	20.1
5B (a)	↓	0.27	8.32	0.77	-
6B	↓	0.27	8.41	0.78	18.7
7	↓	0.33	8.23	0.71	18.6
8 (c)	↓	-	-	-	-
9 (a)	↓	0.32	8.14	0.75	19.6
10B	↓	0.34	8.11	0.77	18.4

(a) Spot sample of heavy oil
(b) Kjeldahl nitrogen analysis
(c) Unit upset during Period 7; reactor blowdown during Period 8; hence, no samples
(d) Calculated from the period data and the gravity of H.O. spot sample

TABLE X

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-30 - Nickel-Molybdenum Catalyst (Ni/Mo-A)

Run LCF-30	Light Oil	Heavy Oil								
		Fractions								
		IBP-500°F		500-650°F		650-850°F		850°F+		Total
Period	°API	Vol%(b)	°API	Vol%	°API	Vol%	°API	Vol%	°API	°API
1B	13.9	18.9	20.6	44.5	9.6	17.6	0.9	17.7	-10.4	6.0
2	19.3	12.9	22.0	42.1	10.2	24.2	1.4	19.5	-10.9	5.0
3B	(c)	11.1	23.0	46.6	10.2	24.8	0.6	17.0	-12.4	4.5
4B	19.5	-	-	-	-	-	-	-	-	-
4B(a)	-	12.0	22.9	47.9	9.9	24.0	0.6	15.4	-13.4	4.8
5B	19.4	14.0	22.0	48.4	9.5	24.9	-0.3	11.9	-15.0	5.1
5B(a)	-	11.6	22.4	48.9	9.8	26.9	-0.4	11.9	-15.5	4.7
6B	(d)	17.2	20.9	46.6	8.0	24.0	-1.3	11.5	-15.5	4.6
7	15.1	13.6	21.2	44.6	8.2	25.7	-1.2	14.8	-15.8	4.5
8 (e)	-	-	-	-	-	-	-	-	-	-
9 (a)	13.9	13.2	21.5	46.9	8.7	26.6	-1.3	12.8	-15.6	5.0
10B	17.2	13.4	21.8	45.8	8.8	28.2	-1.3	12.1	-15.8	3.7

(a) Spot sample of heavy oil
(b) Volume percent yield for fractions based on heavy oil recovered
(c) No light oil recovered during Period 3
(d) Light oil not representative; contaminated with heavy oil
(e) Unit upset during Period 7; reactor blowdown during Period 8, hence, no samples

TABLE XI

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-33 - Nickel-Molybdenum Catalyst (Ni/Mo-B)

LCF-33 Period	Reactor Temperature °F	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+ (Feed-Prod / Feed)	Gravity Rise °API
1B (a)	780	0.30	8.66	0.49	17.9
2B (a)	810	0.26	8.20	0.69	19.7
3	810	0.30	8.34	0.65	19.1
4	810	0.33	8.24	0.65	18.5
5	810	0.33	8.24	0.64	18.4
6	810	0.39	8.00	0.56	17.2
7	810	0.42	8.02	0.57	18.0
8 (a)	810	0.40	7.94	0.57	17.1
9B (a)	825	0.37	7.83	0.65	17.2
10	825	0.44	7.77	0.64	17.2
11B(a)	840	0.44	7.36	0.66	15.0
12	840	0.41	7.60	0.75	17.2

(a) Spot samples of heavy oil

TABLE XII

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-33 - Nickel-Molybdenum Catalyst (Ni/Mo-B)

Run LCF-33	Light Oil	Heavy Oil Fractions								
		IBP-500°F		500-650°F		650-850°F		850°F+		Total
Period	°API	Vol%(b)	°API	Vol%	°API	Vol%	°API	Vol%	°API	°API
1B(a)	14.2	6.6	25.9	40.5	11.6	23.8	2.3	27.4	-9.9	3.3
2B(a)	19.3	14.2	22.5	46.2	10.4	22.6	-0.1	16.5	-14.0	4.8
3	19.8	11.7	24.4	47.4	10.5	22.2	-0.2	18.4	-14.2	4.3
4	19.4	14.8	22.8	43.0	9.7	23.7	-0.4	18.2	-14.3	3.8
5	20.0	10.9	24.5	45.4	10.2	24.2	1.0	19.2	-13.5	3.7
6	17.8	13.2	20.7	42.6	8.9	20.6	-1.1	23.0	-13.5	2.3
7	21.7	10.0	24.2	42.6	9.9	24.8	-0.3	22.3	-14.2	2.4
8 (a)	18.1	10.7	21.5	41.9	9.1	24.5	-0.7	22.6	-14.8	1.9
9B(a)	20.1	11.7	21.2	44.9	9.1	25.2	-1.7	18.0	-16.5	2.1
10	20.2	12.2	22.2	44.3	8.8	24.7	-1.9	18.3	-17.1	2.1
11B(a)	20.3	14.4	19.0	43.6	7.1	24.8	-3.2	17.1	-19.4	0.7
12	20.0	15.9	20.8	45.1	7.6	26.4	-3.2	12.3	-20.3	1.9

(a) Spot sample of heavy oil
(b) Volume percent yield for fractions based on heavy oil recovered

TABLE XIII

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-34 - Nickel-Molybdenum Catalyst (Ni/Mo-C)

LCF-34 Period	Reactor Temperature °F	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+ (Feed-Prod / Feed)	Gravity Rise °API
1 (a)	780	0.36	8.52	0.60	-
2B (a)	810	0.43	8.18	0.69	19.4
3	810	0.42	8.22	0.71	15.1
4	810	0.47	8.15	0.69	17.3
5	810	0.52	8.02	0.61	17.3

(a) Spot samples of heavy oil

TABLE XIV

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-34 - Nickel-Molybdenum Catalyst (Ni/Mo-C)

Run LCF-34	Light Oil	Heavy Oil								
		Fractions								
		IBP-500°F		500-650°F		650-850°F		850°F+		Total
Period	°API	Vol%(a)	°API	Vol%	°API	Vol%	°API	Vol%	°API	°API
1 (a)	-	8.2	23.9	41.2	9.8	28.6	1.3	21.3	-11.3	3.2
2B(a)	10.9	8.4	20.4	43.4	9.7	31.8	-0.4	16.4	-15.0	3.7
3	14.3	12.8	19.9	44.6	8.5	27.4	-1.2	15.1	-15.1	2.8
4	18.0	12.7	21.8	42.4	8.6	27.5	-0.8	16.0	-14.8	2.7
5	17.9	9.6	22.4	40.8	9.3	28.8	-0.7	20.5	-13.5	2.6

(a) Spot samples of heavy oil

TABLE XV

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-31 - Nickel-Tungsten Catalyst (Ni/W-A)

LCF-31 Period	Reactor Temperature °F	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+ (Feed-Prod / Feed)	Gravity Rise °API
1B	750	-	-	-	16.7
1B (a)	750	0.34	8.74	0.48	17.5(b)
2B (a)	790	0.21	8.58	0.65	20.4(b)
3	790	0.26	8.67	0.64	19.3
4B (a)	790	0.38	8.47	0.63	17.9
5B (a)	810	0.37	8.18	0.66	19.2(b)
6	810	0.40	8.13	0.70	17.4
7	810	0.45	7.98	0.67	16.9
8	810	0.50	7.94	0.58	16.8

(a) Spot sample of heavy oil
(b) Calculated from the period data and the gravity of H.O. spot sample

TABLE XVI

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-31 - Nickel-Tungsten Catalyst (Ni/W-A)

Run LCF-31	Light Oil	Heavy Oil Fractions								Heavy Oil
		IBP-500°F		500-650°F		650-850°F		850°F+		Total
Period	°API	Vol%(b)	°API	Vol%	°API	Vol%	°API	Vol%	°API	°API
1B	8.1	7.0	21.6	43.9	9.5	21.8	1.1	26.6	-10.9	2.4
1B(a)	-	7.1	22.9	43.4	10.2	20.7	2.2	27.8	-10.6	3.3
2B	17.1	-	-	-	-	-	-	-	-	-
2B(a)	-	11.3	22.9	47.6	10.9	21.8	1.7	18.3	-13.6	5.5
3	18.6	14.1	22.1	44.0	9.8	21.5	1.0	19.3	-12.9	4.6
4B(a)	(c)	9.2	21.5	45.5	9.9	24.7	1.0	19.7	-12.1	3.8
5B(a)	18.8	9.8	20.7	48.0	9.2	24.2	-0.5	17.6	-14.1	2.9
6	16.8	13.5	22.1	44.4	8.6	26.4	-3.0	15.3	-16.6	2.8
7	15.3	13.8	20.5	44.6	7.7	23.6	-1.1	17.6	-15.6	2.1
8	17.0	10.2	22.8	42.4	8.6	25.2	-0.8	21.9	-14.0	1.8

(a) Spot samples of heavy oil
(b) Volume percent yield for fractions based on heavy oil recovered
(c) No light oil recovered during Period 4

TABLE XVII

LIQUID PRODUCT FRACTION PROPERTIES
PROCESSING SRC-KOPPERS CREOSOTE

Fraction	IBP-390°F(1)	390-500°F	500-650°F	650-850°F	850°F+	TLP
Volume % on FF						
LCF-29/6 (Co/Mo-A)	14.3	12.2	31.6	24.1	20.0	102.2
29/12 (Co/Mo-A)	5.3	12.5	37.0	27.0	19.3	101.1
32/5 (Co/Mo-B)	6.2	12.1	35.5	29.5	17.2	100.5
30/7 (Ni/Mo-A)	12.5	17.2	38.7	22.1	14.3	104.8
33/6 (Ni/Mo-B)	13.3	16.0	33.9	25.0	16.4	104.6
34/5 (Ni/Mo-C)	9.5	13.3	39.2	25.4	15.7	102.9
31/6 (Ni/W-A)	10.6	13.6	37.2	26.2	14.0	101.6
Elemental, Wt%(2)						
Hydrogen						
LCF-29/6	10.89	9.49	8.20	7.23	6.20	7.48
29/12	10.70	9.72	7.99	7.04	5.93	7.34
32/5	-	9.92	8.42	7.36	6.10	7.72
30/7	11.44	10.00	8.86	7.34	6.13	8.10
33/6	11.50	10.35	9.04	7.75	6.25	8.19
34/5	11.55	10.02	8.81	7.72	6.19	8.18
31/6	11.40	9.99	8.99	7.66	5.95	8.03
Oxygen						
LCF-29/6	0.47	0.18	0.62	0.27	1.14	0.48
29/12	0.78	0.20	0.69	0.32	0.65	0.50
32/5	0.67	0.17	0.51	0.29	0.43	0.43
30/7	0.29	0.08	0.69	0.22	0.50	0.31
33/6	0.09	0.06	0.26	0.16	0.44	0.22
34/5	0.08	0.08	0.30	0.21	0.66	0.29
31/6	0.22	0.07	0.34	0.19	0.40	0.28
Nitrogen						
LCF-29/6	0.88	0.40	0.31	0.53	1.14	0.60
29/12	0.70	0.50	0.32	0.59	1.28	0.65
32/5	-	0.55	0.22	0.45	1.04	0.54
30/7	0.37	0.07	0.16	0.35	0.97	0.36
33/6	0.18	0.07	0.15	0.33	1.07	0.40
34/5	0.26	0.30	0.31	0.53	1.04	0.46
31/6	0.19	0.15	0.14	0.41	0.98	0.37

(1) Includes C_5+ in gas (2) Light and Heavy oil only

TABLE XVIII

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-35 - Modified Shell 324 Ni/Mo (Ni/Mo-A)

LCF-35 Period	Reactor Temperature °F	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+ $\left(\frac{\text{Feed-Prod}}{\text{Feed}}\right)$	Gravity Rise °API
1B (a)	780	0.22	8.80	0.63	18.5
2B (a)	790	0.26	8.52	0.66	18.4
3B (a)	800	0.30	8.55	0.71	18.4
4B (a)	810	0.27	8.50	0.74	18.7
5	810	0.33	8.13	0.72	18.0
7 (a)	810	0.36	8.12	0.70	18.1
8	810	0.35	8.19	-	-
9	810	0.44	8.02	0.69	18.9
10	810	0.44	8.19	-	-
11	810	0.45	8.03	0.66	16.3

(a) Spot samples of heavy oil

TABLE XIX

LC-FINING PDU OPERATION
HEAVY OIL PRODUCT ANALYSES
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-36 - Modified Shell 324 Ni/Mo (Ni/Mo-A)

LCF-36 Period	Reactor Temperature °F	Nitrogen Content Wt%	Hydrogen Content Wt%	Wt. Ratio of 850°F+ (Feed-Prod / Feed)	Gravity Rise °API
1B (a)	750	0.29	8.99	0.51	17.9
2B (a)	780	0.20	8.94	0.65	19.5
3	780	0.23	8.77	-	-
4	780	0.29	8.62	0.56	18.7
5	780	0.29	8.70	-	-
6	780	0.32	8.68	0.60	18.0
7B (a)	780	0.35	8.41	0.61	17.8
8B (a)	780	0.43	8.21	0.54	16.6
9	780	0.42	8.31	-	-
10	780	0.45	8.29	0.54	15.5
11	780	0.46	8.23	-	-
12A	780	0.47	8.20	-	-
12B (a)	790	0.43	8.16	0.63	17.4
13	790	0.41	8.14	0.62	17.1
14B (a)	790	0.45	8.09	0.58	15.9
16	790	0.46	8.13	0.63	16.6
17	790	0.48	8.08	-	-
18	790	0.51	8.04	0.58	16.0
19	790	0.51	7.99	-	-
20A	790	0.54	8.02	-	-
20B (a)	800	0.52	7.99	0.63	16.3
21	800	0.48	8.05	-	-
22	800	0.48	8.11	0.63	17.7
23B (a)	800	0.48	8.01	-	-
24	800	0.50	8.06	0.61	16.1
26A	800	0.50	8.23	-	-
26B	800	0.52	8.14	0.61	17.0
27	800	0.51	7.96	-	-
28B (a)(b)	800	0.43	8.12	0.65	16.4
30B (a)	800	0.43	8.07	0.59	14.7
31B (a)	780	0.61	7.92	-	-
32B (a)	780	0.58	7.75	0.42	12.5
33	780	0.67	7.69	0.48	12.9

(a) Spot samples of heavy oil
(b) Periods 28 through 33 - operation in new process development unit

TABLE XX

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-35 - Modified Shell 324 Ni/Mo (Ni/Mo-A)

Run LCF-35	Light Oil	Heavy Oil Fractions								Heavy Oil
		IBP-500°F		500-650°F		650-850°F		850°F+		Total
Period	°API	Vol%(a)	°API	Vol%	°API	Vol%	°API	Vol%	°API	°API
1B(b)	-	10.5	21.8	45.1	9.9	23.6	0.6	20.0	-11.6	4.4
2B(b)	19.1	10.7	23.6	43.4	10.4	27.7	0.7	18.0	-12.9	3.8
3B(b)	20.8	12.4	22.9	45.0	10.4	27.4	0.4	15.4	-14.1	4.4
4B(b)	21.3	11.4	22.5	45.3	10.2	29.4	-0.4	13.7	-15.4	4.0
5	21.2	12.9	21.0	45.3	9.1	27.2	-1.4	14.5	-16.3	3.2
7B(b)	-	11.7	22.2	44.4	8.9	27.2	-0.7	15.4	-15.8	3.2
9	18.3	10.5	22.4	45.7	8.7	27.5	-1.4	15.8	-16.2	2.4
11	22.9	10.5	21.8	42.4	8.3	29.2	-1.4	17.4	-15.9	1.7

TABLE XXI

LC-FINING PDU OPERATION
SUMMARY OF LIGHT AND HEAVY OIL RECOVERED
SRC-PREHYDROGENATED KOPPERS HEAVY RESIDUE CREOSOTE OIL

Run LCF-36 - Modified Shell 324 Ni/Mo (Ni/Mo-A)

Run LCF-36	Light Oil	Heavy Oil Fractions								
		IBP-500°F		500-650°F		650-850°F		850°F+		Total
Period	°API	Vol%	°API	Vol%	°API	Vol%	°API	Vol%	°API	°API
1B(a)	13.4	9.3	22.5	39.8	9.6	23.9	1.5	26.7	-9.4	3.5
2B(a)	17.1	8.6	25.5	43.5	11.8	28.4	2.1	18.9	-11.1	4.9
4	21.1	8.3	24.8	43.4	10.7	24.4	2.1	23.5	-10.9	4.1
6	21.0	7.8	24.3	46.6	10.0	24.6	0.8	21.1	-11.7	3.4
7B(a)	19.0	10.4	23.1	40.0	9.8	28.1	0.9	21.0	-12.1	3.1
8B(a)	20.0	7.7	23.7	40.0	9.3	26.7	0.3	24.4	-12.4	1.8
10	19.9	9.3	22.9	38.9	8.9	27.2	0.3	24.2	-12.4	1.7
12B(a)	19.9	10.1	22.2	42.3	9.0	27.3	0.0	19.5	-13.1	2.5
13	20.1	10.1	23.5	41.4	9.4	27.9	0.0	20.0	-13.3	2.5
14B(a)	14.4	8.9	22.3	40.0	8.7	28.5	-0.6	22.2	-13.9	1.4
16	17.3	9.5	23.8	41.6	9.1	29.0	-0.5	19.6	-13.9	2.2
18	19.7	9.1	22.8	42.2	8.3	27.0	-0.4	21.7	-14.2	1.2
20B(b)	19.5	7.9	22.5	42.6	9.0	29.9	-0.8	19.5	-14.6	1.4
22	20.9	10.6	21.4	43.2	8.2	26.2	-1.3	19.0	-15.0	2.7
24	19.4	10.9	21.8	41.8	3.2	27.0	-1.3	20.3	-14.4	1.4
26B	16.1	9.1	25.6	44.1	9.6	25.9	-0.2	20.6	-14.0	2.7
28B(a)(b)	17.1	8.4	20.9	40.0	8.0	33.8	-0.4	17.7	-16.2	0.7
30B(a)	17.0	-	-	43.0	8.4(c)	34.9	-1.4	21.2	-15.7	-0.9
32B	18.3	-	-	38.1	7.0(c)	32.0	-1.5	29.9	-13.9	-3.0
33	18.0	-	-	37.5	7.3(c)	35.4	-1.2	27.2	-14.3	-2.6

(a) Spot samples of heavy oil
(b) Periods 28 through 33 - Operation in new process development unit
(c) IBP-650°F cut

TABLE XXII

NITROGEN CONTENT - 390/850°F DISTILLATE FRACTION

PDU LCF-36 33-Day Catalyst Aging Run

Selected Blend Period	5	11	13	18/19	21/22	26B/27	30B	32B
Temperature	780	780	790	790	800	800	800	780
Conversion, Vol% 850°F+	50.5	55.4	61.8	57.4	64.7	66.6	61.0	44.2
Yield, Wt% of 390/850°F								
390-500°F	17.7	15.3	16.9	14.3	15.8	14.2	14.5	11.9
500-650°F	47.8	43.7	48.0	49.1	49.1	51.1	51.5	42.3
650-850°F	34.5	41.0	35.1	36.6	35.1	34.7	34.0	45.8
Nitrogen, Wt%								
390-500°F	0.31	0.36	0.23	0.26	0.34	0.35	0.26	0.38
500-650°F	0.12	0.25	0.05	0.20	0.29	0.15	0.12	0.32
650-850°F	0.30	0.45	0.30	0.45	0.57	0.43	0.50	0.51
390-850°F	0.22	0.35	0.17	0.30	0.39	0.28	0.27	0.41

TABLE XXIII

YIELD DATA AS A PERCENTAGE OF FEED

Run PDU LCF-36

Feed Blend: SRC/Prehyd. KC-Oil @ 53.0 Wt% SRC/47.0 Wt% Solvent

Blend Period PDU LCF-36	5	11	13	18/19	21/22	26B/27(a)	30B	32B
Average Reactor Temp., °F	780	780	790	790	800	800	800	780
Space Velocity (X times SV_0)	0.37	0.39	0.37	0.34	0.37	0.37	0.45	0.45
Conversion, Vol.% 850°F+	50.5	55.4	61.8	57.4	64.7	66.6	61.0	44.2
Gravity Rise, °API	—	—	17.1	16.0	17.7	17.0	14.7	12.5
Yield - Weight % of Feed								
H_2O	2.09	2.16	2.21	2.20	1.84	1.79	2.82	2.93
H_2S	0.38	0.48	0.44	0.44	0.44	0.42	0.44	0.44
NH_3	1.18	1.10	1.09	1.02	1.07	0.90	0.92	0.76
CH_4	1.26	1.46	1.64	1.57	1.89	1.61	1.95	1.25
C_2H_6	1.20	1.33	1.46	1.41	1.73	1.52	1.75	1.09
C_3H_8	1.28	1.45	1.59	1.51	1.89	1.80	1.80	1.04
C_3H_6	0.06	0.08	0.09	0.06	0.09	0.13	0.13	0.08
$i\text{-}C_4H_{10}$	0.10	0.12	0.14	0.13	0.17	0.15	0.16	0.07
$n\text{-}C_4H_{10}$	1.18	1.50	1.76	1.61	1.94	1.87	1.79	1.06
C_4H_8	0.01	-	0.01	0.02	0.03	0.04	0.01	0.02
C_5-390°F	6.61	7.38	8.46	6.28	5.42	6.68	5.81	5.13
390-500°F	11.21	9.78	11.05	9.36	10.85	9.81	9.51	6.63
500-650°F	30.32	27.93	31.48	32.10	33.78	35.37	33.72	25.82
650-850°F	21.92	26.24	22.98	23.92	24.14	24.06	22.23	27.9
850°F+	24.47	22.56	19.21	21.63	18.19	17.16	20.12	28.34
Total	103.27	103.57	103.60	103.27	103.47	103.31	103.15	102.56
Yield - Volume % of Feed								
C_5-390°F	9.9	12.9	12.74	9.53	9.46	10.54	8.91	7.22
390-500°F	14.5	12.5	14.13	11.98	13.76	12.46	12.08	8.36
500-650°F	36.4	33.2	37.49	37.68	39.72	41.72	39.46	30.14
650-850°F	24.8	29.6	25.58	26.41	26.62	26.56	24.40	30.81
850°F+	25.1	22.7	19.35	21.59	17.90	16.94	19.76	28.27
Total	110.7	110.9	109.29	107.19	107.46	108.22	104.61	104.80
H_2 Consumption (SCF/BBL)	2591	2842	2858	2599	2759	2631	2501	2033

(a) Period 27 - Reactor System PDU-1LCF
Period 28 - Reactor System PDU-2LCF

TABLE XXIV

ELEMENTAL ANALYSIS OF LIQUID PRODUCT

Run PDU LCF-36

Feed Blend: SRC/Prehyd. KC-Oil @ 53.0 Wt% SRC/47.0 St% Solvent

Blend Period PDU LCF-36	5	11	13	18/19	21/22	26B/27(a)	30B	32B
Average Reactor Temp., °F	780	780	790	790	800	800	800	780
Space Velocity (X times SV_0)	0.37	0.39	0.37	0.34	0.37	0.37	0.45	0.45
Conversion, Vol.% 850°F+	50.5	55.4	61.8	57.4	64.7	66.6	61.0	44.2
Elemental Analysis, Wt. %								
Hydrogen								
IBP-390°F	12.07	12.06	11.62	11.12	11.39	11.87	11.65	11.46
390-500°F	11.05	10.73	10.34	9.96	10.40	10.40	10.27	10.38
500-650°F	9.84	9.25	9.30	8.90	8.88	9.10	8.75	8.72
650-850°F	8.55	8.24	8.00	8.09	7.85	7.64	7.52	7.78
850°F+	7.17	6.80	6.38	6.58	6.33	6.11	5.97	6.28
Total Liquid Product	8.90	8.40	8.41	8.22	8.06	8.17	7.88	7.80
Oxygen								
IBP-390°F	0.20	0.58	0.60	1.01	0.97	0.92	1.42	1.76
390-500°F	0.08	0.18	0.22	0.31	0.27	0.24	0.40	0.69
500-850°F	0.30	0.41	0.38	0.49	0.49	0.41	0.47	0.49
650-850°F	0.20	0.38	0.27	0.31	0.31	0.29	0.33	0.43
850°F+	0.91	1.01	0.79	0.86	0.83	0.82	0.97	1.13
Total Liquid Product	0.38	0.48	0.39	0.53	0.51	0.51	0.60	0.71
Nitrogen								
IBP-390°F	0.31	0.35	0.40	0.41	0.41	0.46	0.26	0.40
390-500°F	0.31	0.36	0.23	0.26	0.34	0.35	0.26	0.38
500-650°F	0.12	0.25	0.05	0.20	0.29	0.15	0.12	0.32
650-850°F	0.30	0.45	0.30	0.45	0.57	0.43	0.50	0.51
850°F+	0.91	0.99	0.93	1.26	1.31	1.41	1.21	1.40
Total Liquid Product	0.33	0.44	0.38	0.43	0.39	0.55	0.53	0.66
Sulfur (c)								
IBP-390°F	<0.06	<0.06	<0.06	<0.06	<0.06	0.0042(b)	<0.06	<0.06
390-500°F	<0.06	<0.06	<0.06	<0.06	<0.06	0.0032(b)	<0.06	<0.06
500-650°F	<0.06	<0.06	<0.06	<0.06	<0.06	0.0051(b)	<0.06	<0.06
650-850°F	<0.06	<0.06	<0.06	<0.06	<0.06	0.0128(b)	<0.06	<0.06
850°F+	<0.06	<0.06	<0.06	<0.06	0.08	0.09	<0.06	0.13
Total Liquid Product	<0.06	<0.06	<0.06	<0.06	<0.06	0.0132(b)	<0.06	<0.06
Ash, Wt.%								
850°F+	0.14	0.33	0.33	0.18	0.41	0.29	0.21	0.28
Total Liquid Product	0.01	0.06	Tr	0.03	0.06	0.06	0.01	0.07

(a) Period 27 - Reactor System PDU 1LCF
    Period 28 - Reactor System PDU 2LCF
(b) By Dohrman Sulfur Analysis
(c) By ASTM D-1552 Sulfur Analysis

FIGURE 1

CONVERSION AND NITROGEN IN HEAVY OIL

Catalyst: Co/Mo-A
Co/Mo-B

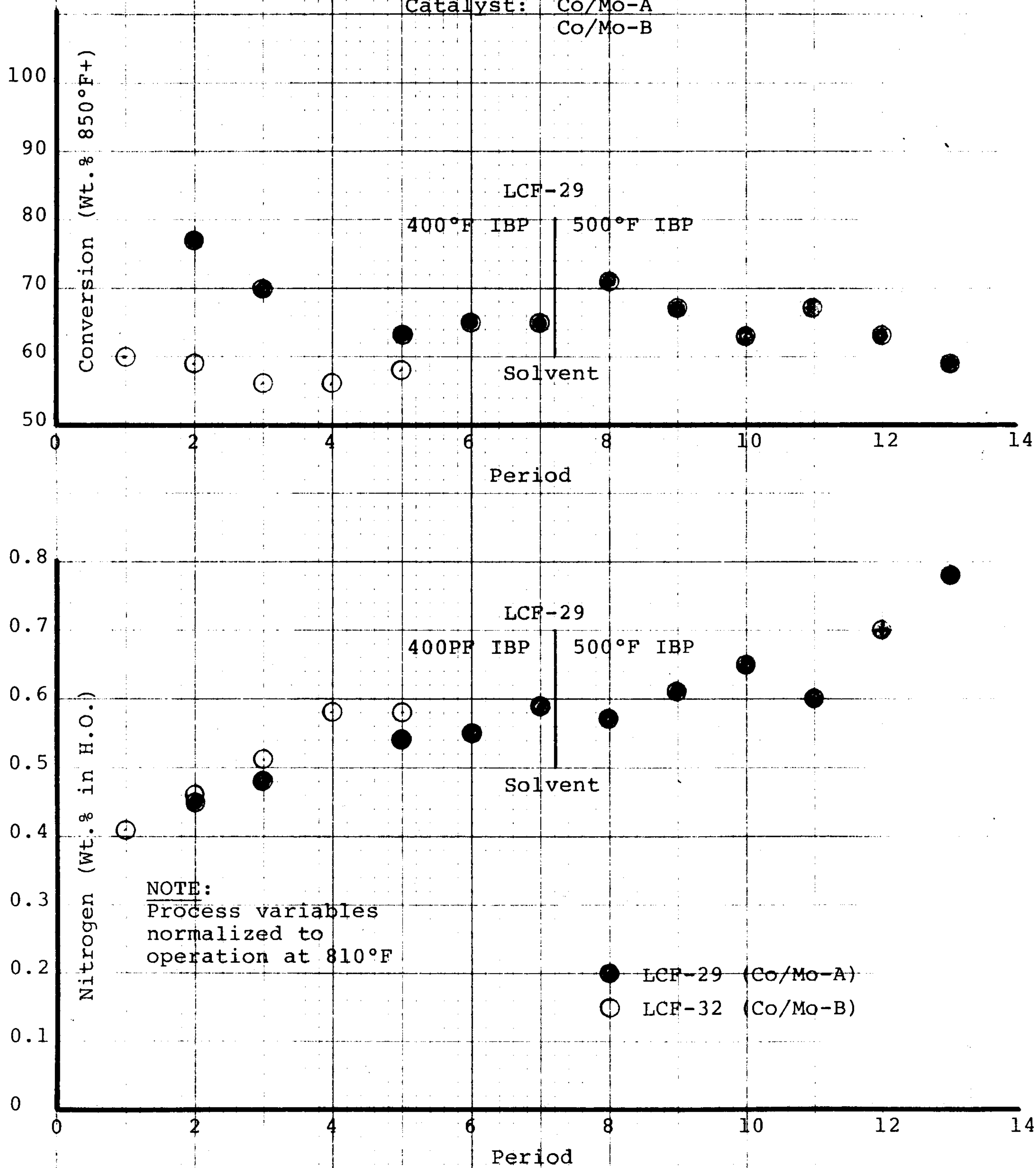


FIGURE 2

CONVERSION AND NITROGEN IN HEAVY OIL

Catalyst Screening

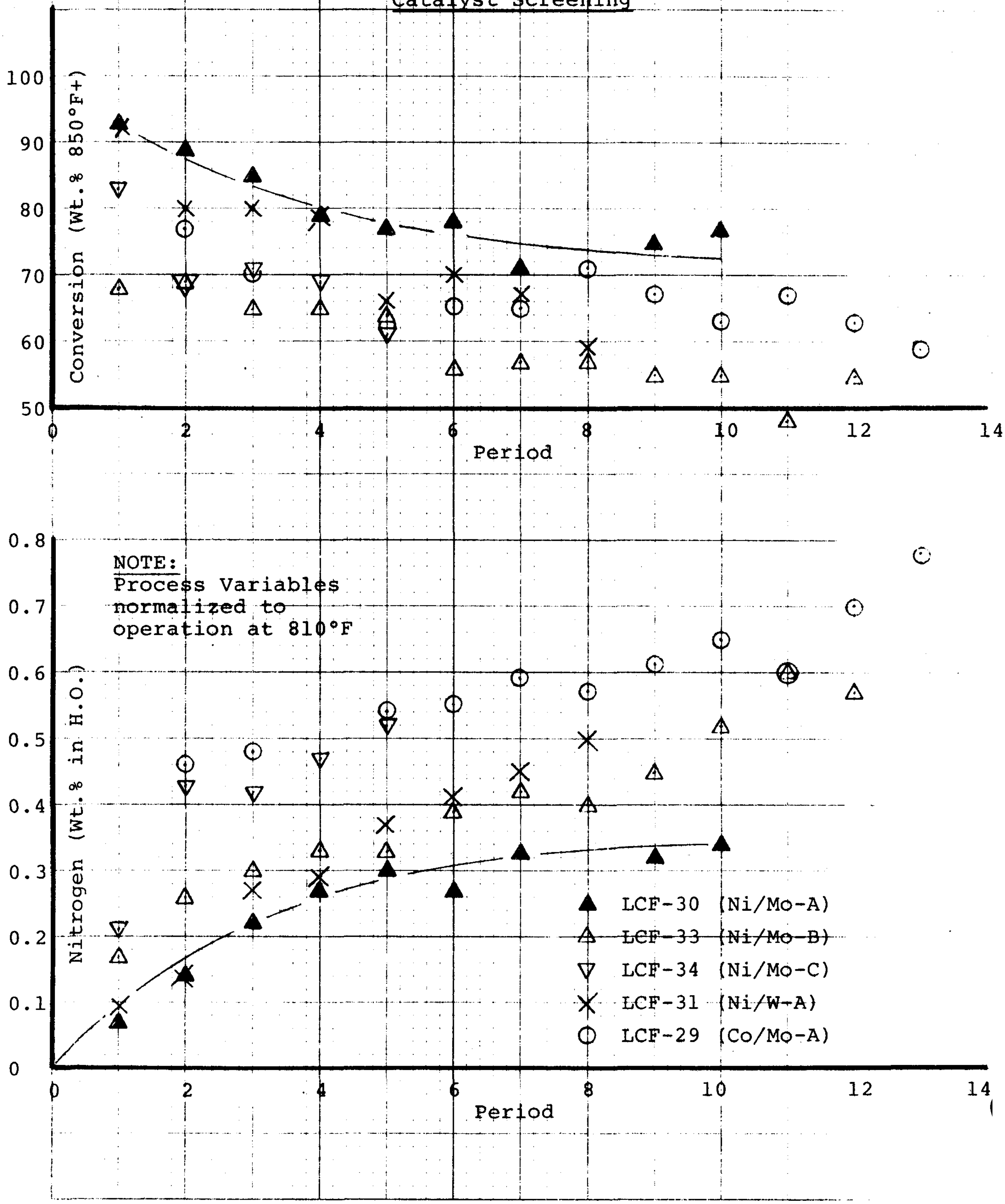


FIGURE 3

CONVERSION AND NITROGEN IN HEAVY OIL

Catalyst Aging
Ni/Mo-A Catalyst (Shell 324)

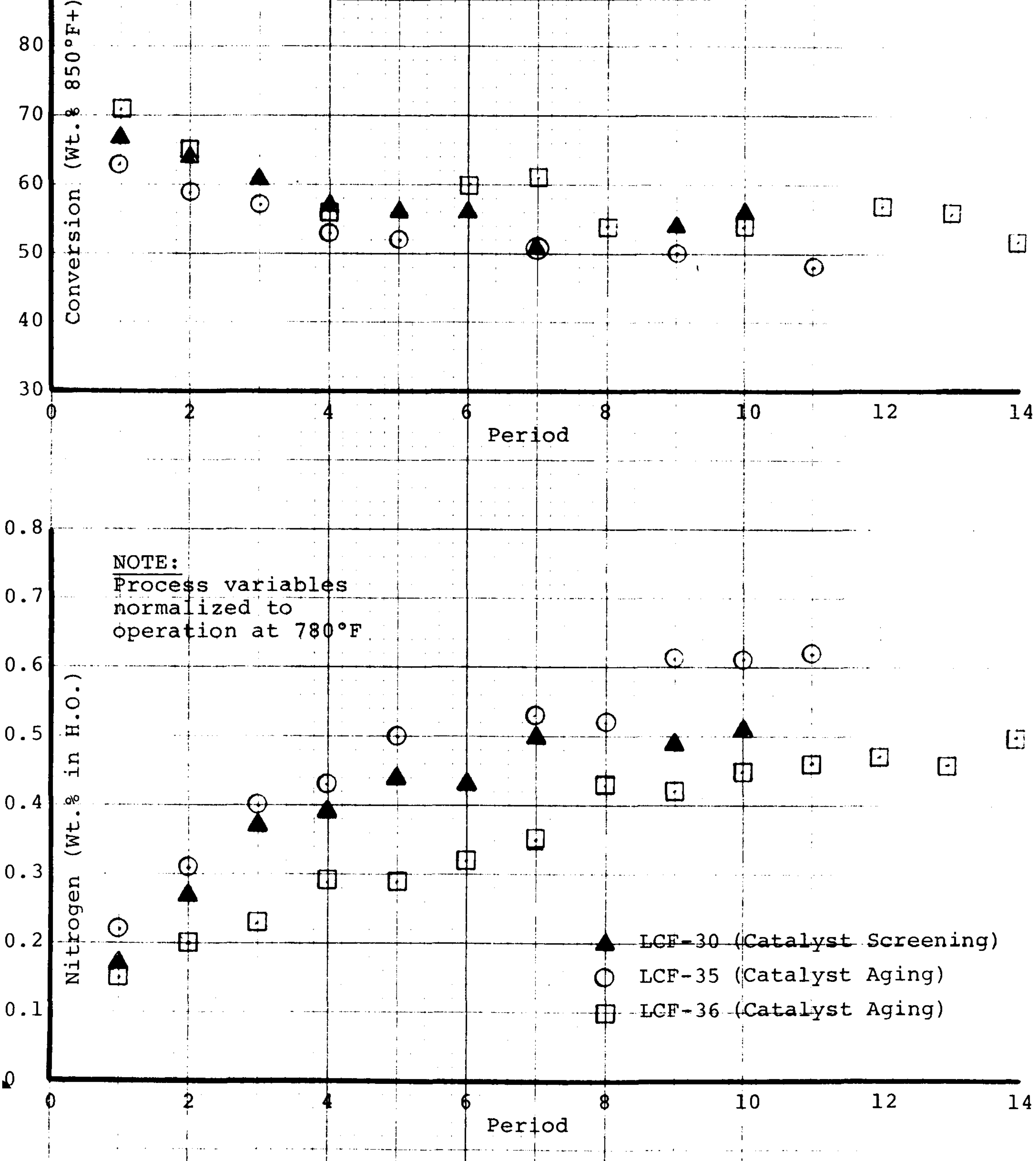
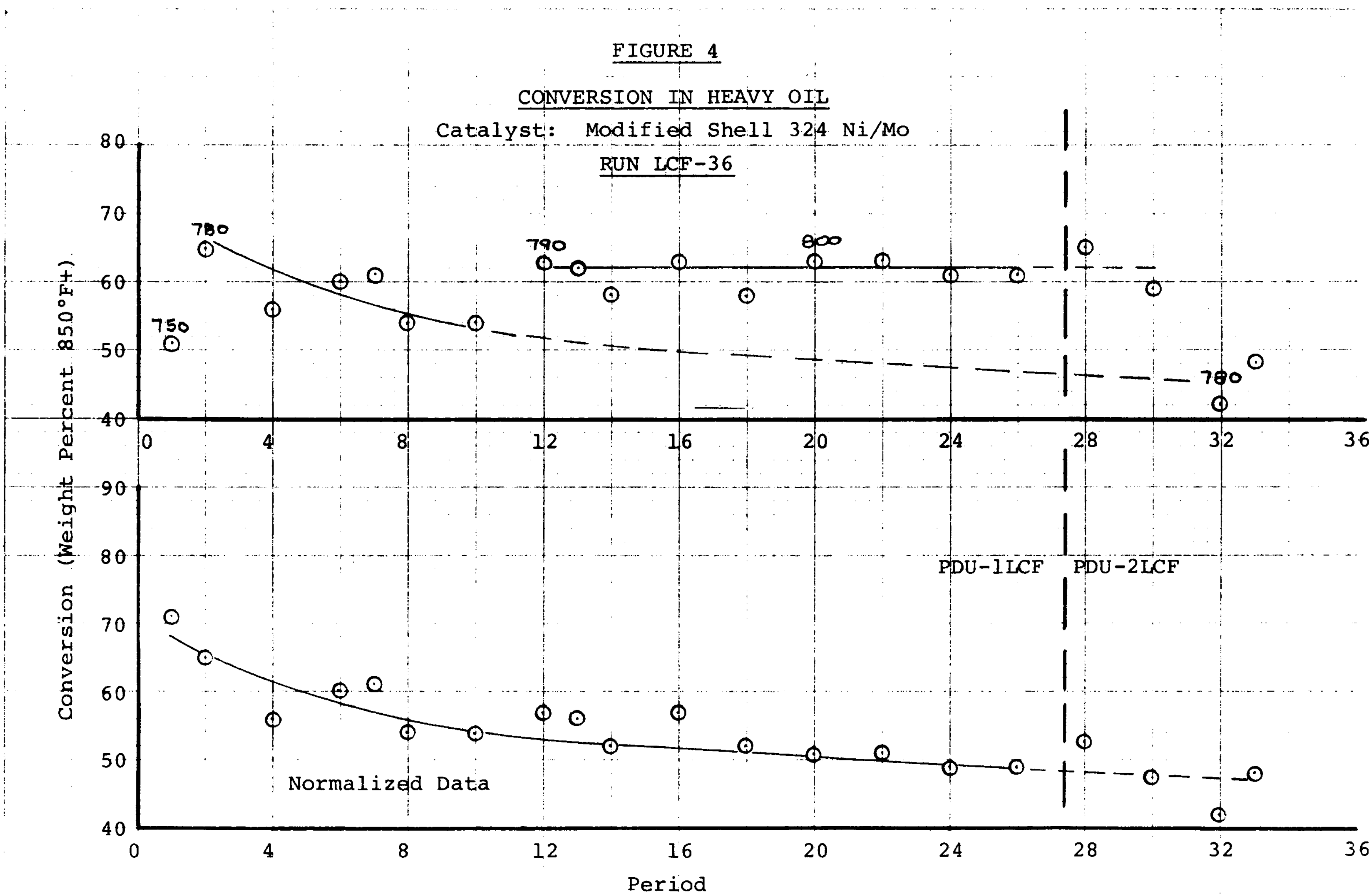


FIGURE 4

CONVERSION IN HEAVY OIL

Catalyst: Modified Shell 324 Ni/Mo

RUN LCF-36



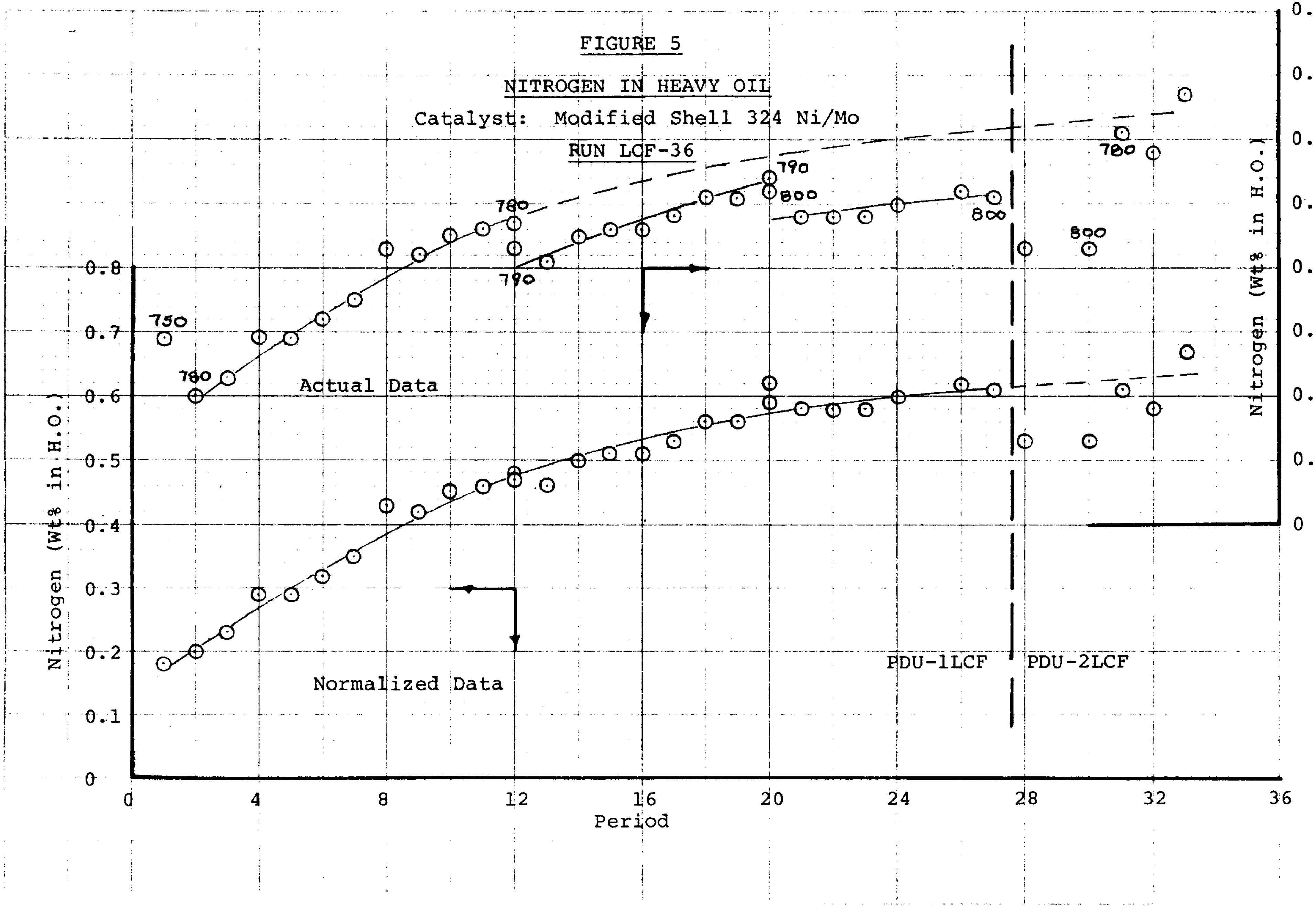


FIGURE 5
NITROGEN IN HEAVY OIL
Catalyst: Modified Shell 324 Ni/Mo
RUN LCF-36
Actual Data
Normalized Data
PDU-1LCF
PDU-2LCF
Nitrogen (Wt% in H.O.)
Period
750
780
790
800
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
4
8
12
16
20
24
28
32
36

APPENDIX TABLES

APPENDIX

TABLE I

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-29 (Period 6)
(b)

Fraction	Distillation Fractions					
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	2.9 (c)	12.2	31.6	24.1	20.0	90.8 (d)
Weight Percent on Fresh Feed	2.2 (c)	10.0	27.8	22.3	20.5	82.8
Gravity, °API	29.4	15.1	4.9	-2.5	-14.9	-0.4
SP 60/60°F	0.8794	0.9652	1.0374	1.0967	1.214	1.0793
Pour Point, °F	<-23	<-23	<-20	+1.3	-	<-20
Softening Point, °F	-	-	-	-	200	-
Viscosity, CST @ 100°F	1.06	2.34	7.20	48.65	(a)	34.70
CST @ 150°F	-	-	-	-		8.57
CST @ 210°F	0.50	1.72	1.86	4.45		3.78
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	0	0	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	57.9	92.9	-	-	-	-
Saturates	42.1	7.1	-	-	-	-
Elemental, Wt%						
Carbon	87.08	89.45	90.71	92.21	92.35	90.60
Hydrogen	10.89	9.49	8.20	7.23	6.20	7.48
Oxygen	0.47	0.18	0.62	0.27	1.14	0.48
Nitrogen	0.88	0.40	0.31	0.53	1.14	0.60
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%	-	-	-	-	0.18	Trace

(a) Brookfield viscosity, Table XII, November, 1977 MPR.
(b) Data revised 4/28/78. Substitute for Table VI, November, 1977 MPR.
(c) C_5+ in gas are 11.4 liquid volume % and 6.9 weight % of feed.
(d) The total volume of fractions is higher than TLP because volume decreases on blending.

APPENDIX

TABLE II

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-29 (Period 12)
(b)

Distillation Fractions

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	2.7 (c)	12.5	37.0	27.0	19.3	98.5
Weight Percent on Fresh Feed	2.1 (c)	10.1	32.3	24.9	20.0	89.4
Gravity, °API	27.6	15.1	4.1	-3.6	-16.8	-1.2
SP 60/60°F	0.8891	0.9652	1.0435	1.1063	1.234	1.0861
Pour Point, °F	<-23	<-23	+15	+26	-	<-20
Softening Point, °F	-	-	-	-	233	-
Viscosity, CST @ 100°F	1.10	1.88	7.44	89.32	(a)	39.63
CST @ 150°F	-	-	-	-		-
CST @ 210°F	0.56	0.93	1.89	5.10		4.12
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	5.1	0	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	56.4	95.1	-	-	-	-
Saturates	38.5	4.9	-	-	-	-
Elemental, Wt%						
Carbon	86.12	89.90	91.02	92.15	91.87	90.30
Hydrogen	10.70	9.72	7.99	7.04	5.93	7.34
Oxygen	0.78	0.20	0.69	0.32	0.65	0.50
Nitrogen	0.70	0.50	0.32	0.59	1.28	0.65
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%	-	-	-	-	0.09	Trace

(a) Brookfield Viscosity, see Table XII, November, 1977 MPR
(b) Revised 4/28/78. Substitute for Table VII, November, 1977 MPR
(c) C_5+ in gas are 2.6 liquid volume % and 1.5 weight % of feed.

APPENDIX

TABLE III

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
SRC-KOPPERS CREOSOTE

Run LCF-30 (Period 7)
(b)

	Distillation Fractions					
Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	4.4 (c)	17.2	38.7	22.1	14.3	96.7
Weight Percent on Fresh Feed	3.1 (c)	13.3	33.2	20.5	14.1	84.2
Gravity, °API	32.0	17.8	6.9	-2.2	-16.0	3.2
SP 60/60°F	0.8654	0.9478	1.0224	1.0942	1.2250	1.0505
Pour Point, °F	<-23	<-23	<-23	+25	-	-18
Softening Point, °F	-	-	-	-	219	-
Viscosity, CST @ 100°F	1.04	2.16	7.56	88.03	(a)	15.72
CST @ 150°F	-	-	-	-		-
CST @ 210°F	0.56	0.96	1.89	5.60		2.73
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	-	1.8	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	52.3	85.7	-	-	-	-
Saturates	47.7	12.5	-	-	-	-
Elemental, Wt%						
Carbon	87.30	89.42	91.13	92.75	92.15	90.71
Hydrogen	11.44	10.00	8.86	7.34	6.13	8.10
Oxygen	0.29	0.08	0.69	0.22	0.50	0.31
Nitrogen	0.37	0.07	0.16	0.35	0.97	0.36
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%	-	-	-	-	0.16	Trace

(a) Brookfield Viscosity, see Table XII, November, 1977 MPR
(b) Revised 4/28/78. Substitute for Table IX, January, 1978 MPR
(c) C_5 and heavier in gas are 8.1 liq. vol.% and 4.7 wt.% on feed

APPENDIX

TABLE IV

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-31 (Period 6)
(b)

Fraction	Distillation Fractions IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	4.4 (c)	13.6	37.2	26.2	14.0	95.4
Weight Percent on Fresh Feed	3.1 (c)	10.7	31.5	23.8	14.3	83.4
Gravity, °API	32.2	18.1	7.6	-1.5	-16.5	2.9
SP 60/60°F	0.8644	0.9459	1.0173	1.0886	1.230	1.0528
Pour Point, °F	<-23	<-23	<-23	+25	-	-16
Softening Point, °F	-	-	-	-	2.7	-
Viscosity, CST @ 100°F	1.02	2.22	7.36	72.59	(a)	18.67
CST @ 150°F	-	-	-	-		-
CST @ 210°F	0.56	0.95	1.87	5.18		3.01
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	0	0	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	51.8	90.4	-	-	-	-
Saturates	48.2	9.6	-	-	-	-
Elemental, Wt%						
Carbon	86.16	89.05	91.22	92.13	92.25	89.92
Hydrogen	11.40	9.99	8.99	7.66	5.95	8.03
Oxygen	0.22	0.07	0.34	0.19	0.40	0.28
Nitrogen	0.19	0.15	0.14	0.41	0.98	0.37
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%	-	-	-	-	0.06	Trace

(a) Brookfield Viscosity, see Table XII, November, 1977 MPR
(b) Revised 4/28/78. Substitute for Table IX, November, 1977 MPR
(c) C_5+ in gas are 6.2 liquid volume % and 3.8 weight % of feed.

APPENDIX

TABLE V

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF
SRC-KOPPERS CREOSOTE

Run LCF-32 (Period 5)
(b)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and	3.6 (c)	12.1	35.5	29.5	17.2	97.9
Weight Percent on Fresh Feed	2.5 (c)	9.7	30.4	26.9	17.5	87.0
Gravity, °API	29.6	16.2	5.6	-2.3	-15.8	0.6
SP 60/60 °F	0.8783	0.9580	1.0321	1.0955	1.2230	1.0712
Pour Point, °F	<-23	<-23	<-23	+19	-	<-23
Softening Point, °F	-	-	-	-	227	-
Viscosity, CST @ 100°F	1.18	2.34	8.42	55.08	(a)	34.14
CST @ 150°F	-	-	-	-		-
CST @ 210°F	0.65	0.98	2.02	5.50		3.64
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	0	0	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	58.0	90.6	-	-	-	-
Saturates	42.0	9.4	-	-	-	-
Elemental, Wt%						
Carbon	86.50	89.72	91.29	91.61	92.61	90.02
Hydrogen	10.60	9.92	8.42	7.36	6.10	7.72
Oxygen	0.67	0.17	0.51	0.29	0.43	0.43
Nitrogen	0.74	0.55	0.22	0.45	1.04	0.54
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%	-	-	-	-	0.06	Trace

(a) Brookfield Viscosity, see Table XII November, 1977 MPR.
(b) Revised 4/28/78. Substitute for Table IV, December, 1977 MPR.
(c) C_5+ in gas are 2.6 liquid volume % and 1.5 weight % of feed.

APPENDIX

TABLE VI

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-33 (Period 6)
(b)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	930-500°F	500-650°F	650-850°F	850°F+	
Volume Percent and	5.4 (c)	16.0	33.9	25.0	16.4	96.7
Weight Percent	3.7 (c)	12.5	28.6	22.7	16.6	84.1
on Fresh Feed						
Gravity, °API	30.8	20.0	8.1	-1.1	-15.2	3.5
SP 60/60 °F	0.8718	0.9340	1.0136	1.0849	1.2170	1.0481
Pour Point, °F	<-23	<-23	<-23	+19	-	<-23
Softening Point, °F	-	-	-	-	223	-
Viscosity, CST @ 100°F	1.22	2.27	7.80	73.62	(a)	21.47
CST @ 150°F	-	-	-	-		-
CST @ 210°F	0.66	0.95	2.01	4.97		3.36
Hydrocarbon Type, Vol%						
Paraffins	-	-	-	-	-	-
Olefins	1.5	0	-	-	-	-
Naphthenes	-	-	-	-	-	-
Aromatics	51.6	82.1	-	-	-	-
Saturates	46.9	17.9	-	-	-	-
Elemental, Wt%						
Carbon	86.85	88.75	91.32	92.14	92.70	89.46
Hydrogen	11.50	10.35	9.04	7.75	6.25	8.19
Oxygen	0.09	0.06	0.26	0.16	0.44	0.22
Nitrogen	0.18	0.07	0.15	0.33	1.07	0.40
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%	-	-	-	-	Trace	0.03

(a) Brookfield Viscosity, see Table XII, November, 1977 MPR
(b) Revised 4/28/78. Substitute for Table XI, November, 1977 MPR.
(c) C_5+ in gas are 7.9 liquid volume % and 4.7 weight % of feed.

APPENDIX

TABLE VII

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-34 (Period 5)
(b)

Fraction	Distillation Fractions IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent (a) and	3.8 (c)	13.3	39.2	25.4	15.7	97.2 (a)
Weight Percent on Fresh Feed	2.9 (c)	11.2	32.7	22.5	15.7	84.9
Gravity, °API	32.6	17.9	7.1	-1.4	-15.2	2.9
SP 60/60°F	0.8623	0.9471	1.0209	1.0874	1.2170	1.0528
Pour Point, °F	<-23	<-23	<-20	25	-	<-15
Softening Point, °F	-	-	-	-	206	-
Viscosity, CST @ 100°F	1.05	2.29	8.69	97.8		23.07
CST @ 150°F	-	-	-	-		-
CST @ 210°F	0.57	0.96	2.12	6.33		3.61
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	2.3	0				
Naphthenes	-	-				
Aromatics	48.4	88.7				
Saturates	49.3	11.3				
Elemental, Wt%						
Carbon	86.95	89.39	90.43	92.35	92.76	91.69
Hydrogen	11.55	10.02	8.81	7.72	6.19	8.18
Oxygen	0.08	0.08	0.30	0.21	0.66	0.29
Nitrogen	0.26	0.30	0.31	0.53	1.04	0.46
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%					0.07	Trace

(a) The total volume of the fractions is higher than the TLP because the volume decreases when combined and blended.

(b) Revised 4/28/78. Substitute for Table X, January, 1978 MPR. C_5+ in gas are 5.7 liquid volume % and 3.4 weight % of feed.

APPENDIX

TABLE VIII

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-35 (Period 5)
(a)

Fraction	Distillation Fractions					Total Liquid
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Product
Volume Percent (a) and	5.7 (b)	16.1	35.0	25.0	13.3	95.1
Weight Percent on Fresh Feed	4.1 (b)	12.5	29.5	22.5	13.7	82.3
Gravity, °API	32.4	18.6	8.1	-0.7	-17.3	4.2
SP 60/60°F	0.8633	0.9427	1.0136	1.0821	1.239	1.0427
Pour Point, °F	<-23	<-23	<-23	27	-	<-16
Softening Point, °F	-	-	-	-	209	-
Viscosity, CST @ 100°F	1.06	2.28	7.11	65.07		16.32
CST @ 150°F	-	-	-	-		-
CST @ 210°F	0.58	0.98	1.85	4.70		3.14
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	1.9	0				
Naphthenes	-	-				
Aromatics	48.4	79.3				
Saturates	49.7	20.7				
Elemental, Wt%						
Carbon	86.59	88.21	91.22	92.64	93.85	90.90
Hydrogen	11.48	10.15	8.51	7.73	6.10	8.59
Oxygen	0.18	0.08	0.30	0.20	0.69	0.27
Nitrogen	0.22	0.21	0.22	0.30	0.89	0.33
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%					0.07	Trace

(a) Revised 4/28/78. Substitute for Table XI, January, 1978 MPR.
(b) C_5+ in gas are 10.9 liquid volume % and 6.6 weight % of feed.

APPENDIX

TABLE IX

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-35 (Period 11)

(a)

Fraction	Distillation Fractions					Total Liquid Product
	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	
Volume Percent (a) and	5.0 (b)	14.1	38.1	22.7	19.2	99.1
Weight Percent on Fresh Feed	3.0 (b)	11.0	32.4	20.4	19.4	86.3
Gravity, °API	32.4	17.8	8.0	0.5	-14.8	3.2
SP 60/60°F	0.8633	0.9478	1.0143	1.0720	1.213	1.0505
Pour Point, °F	<-23	<-23	<-23	27	-	<-23
Softening Point, °F	-	-	-	-	212	-
Viscosity, CST @ 100°F	1.13	2.31	8.11	65.23		27.61
CST @ 150°F	-	-	-	-		-
CST @ 210°F	0.62	0.99	1.98	4.61		4.23
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	0.9	0				
Naphthenes	-	-				
Aromatics	45.1	88.5				
Saturates	54.0	11.5				
Elemental, Wt%						
Carbon	87.75	90.24	90.96	91.45	91.90	90.30
Hydrogen	11.51	10.12	8.69	7.52	6.26	8.03
Oxygen	0.65	0.19	0.38	0.26	0.80	0.47
Nitrogen	0.21	0.17	0.61	0.66	1.33	0.69
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%					0.08	0.04

(a) Revised 4/28/78. Substitute for Table XII, January, 1978 MPR
(b) C_5+ in gas are 6.4 liquid volume % and 3.8 weight % of feed.

APPENDIX

TABLE X

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-36 (Period 5)

(a)

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	4.0 (b)	14.5	36.4	24.8	25.1	104.8
Weight Percent on Fresh Feed	3.0 (b)	11.2	30.3	21.9	24.5	90.9
Gravity, °API	35.1	19.6	9.1	2.0	-10.9	3.9
SP 60/60 °F	0.8493	0.9365	1.0064	1.0599	1.173	1.0451
Pour Point, °F	<-23	<-23	<-23	+20	-	<-23
Softening Point, °F	-	-	-	-	185	
Viscosity, CST @ 100°F	1.05	2.28	8.08	56.42		32.86
CST @ 210°F	0.59	1.04	1.97	4.49		4.69
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	0	0				
Naphthenes	-	-				
Aromatics	37.3	70.6				
Saturates	62.7	29.4				
Elemental, Wt%						
Carbon	84.98	88.61	91.90	92.16	92.41	90.33 (a)
Hydrogen	12.07	11.05	9.84	8.55	7.17	8.90 (a)
Oxygen	0.20	0.08	0.30	0.20	0.91	0.38
Nitrogen	0.31	0.31	0.12	0.30	0.91	0.33 (a)
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%					0.14	0.01

(b) C_5+ in gas are 5.9 liquid volume % and 3.6 weight % on feed
(a) Revised 4-28-78. Substitute for Table IV, January, 1978 MPR

APPENDIX

TABLE XI

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-36 (Period 11)

(a)

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	4.4 (b)	12.5	33.2	29.6	22.7	102.4
Weight Percent on Fresh Feed	2.4 (b)	9.8	27.9	26.2	22.6	88.9
Gravity, °API	33.9	18.8	8.0	0.5	-12.6	3.3
SP 60/60 °F	0.8555	0.9415	1.0143	1.0720	1.190	1.0497
Pour Point, °F	<-23	<-23	<-23	26	-	<-23
Softening Point, °F	-	-	-	-	229	-
Viscosity, CST @ 100°F	1.10	2.25	8.10	82.37		50.36
CST @ 210°F	0.59	1.00	1.97	5.16		5.36
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	1.8	0.9				
Naphthenes	-	-				
Aromatics	36.4	73.9				
Saturates	61.8	25.2				
Elemental, Wt%						
Carbon	86.14	88.67	90.68	91.46	91.06	89.93
Hydrogen	12.06	10.73	9.25	8.24	6.80	8.40
Oxygen	0.58	0.18	0.41	0.28	1.01	0.48
Nitrogen	0.35	0.36	0.25	0.45	0.99	0.44 (a)
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%					0.33	0.06

(b) C_5+ in gas are 8.5 liquid volume % and 5.0 weight % on feed
(a) Revised 4-28-78. Substitute for Table V, January, 1978 MPR.

APPENDIX

TABLE XII

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-36 (Period 13)

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	4.11(a)	14.13	37.49	25.58	19.35	100.02
Weight Percent on Fresh Feed	3.24(a)	11.05	31.48	22.98	19.21	87.95
Gravity, °API	33.4	18.7	7.9	-1.2	-13.7	2.9
SP 60/60°F	0.8581	0.9421	1.0151	1.0863	1.201	1.0528
Pour Point, °F	<-20	<-20	<-16	40	-	<-15
Softening Point, °F	-	-	-	-	222	-
Viscosity, CST @ 100°F	1.06	2.36	8.13	106.82		31.16
CST @ 210°F	0.57	1.01	1.96	5.98		4.02
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	2.5	4.4				
Naphthenes	-	-				
Aromatics	41.6	82.4				
Saturates	55.9	13.2				
Elemental, Wt%						
Carbon	88.79	90.04	90.84	91.28	89.58	91.73
Hydrogen	11.62	10.34	9.30	8.00	6.38	8.41
Oxygen	0.60	0.22	0.38	0.27	0.79	0.39
Nitrogen	0.40	0.23	0.05	0.30	0.93	0.38
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%					0.33	TR

(a) C_5+ in gas are 8.63 liquid volume % and 5.22 weight % on feed

APPENDIX

TABLE XIII

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-36 (Periods 18/19)

(a)

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	5.11(b)	11.98	37.68	26.41	21.59	102.78
Weight Percent on Fresh Feed	3.61(b)	9.36	32.10	23.92	21.63	90.62
Gravity, °API	29.2	18.8	7.0	-1.2	-13.7	1.7
SP 60/60°F	0.8805	0.9415	1.0217	1.0859	1.201	1.0623
Pour Point, °F	<-20	<-20	<-16	35	-	<-23
Softening Point, °F	-	-	-	-	225	-
Viscosity, CST @ 100°F	1.23	2.44	8.10	116.99		38.76
CST @ 210°F	0.62	0.96	1.99	5.76		4.64
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	0.8	0				
Naphthenes	-	-				
Aromatics	51.1(a)	84.5				
Saturates	48.1	15.5				
Elemental, Wt%						
Carbon	88.77	87.18	89.91	90.51	91.35	90.44
Hydrogen	11.12	9.96	8.90	8.09	6.58	8.22
Oxygen	1.01	0.31	0.49	0.32	0.86	0.53
Nitrogen	0.41	0.26	0.20	0.45	1.26	0.43
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%					0.18	0.03

(b) C_5+ in gas are 4.42 liquid volume % and 2.68 weight % on feed

(a) Revised 4-28-78. Substitute for Table VI, January, 1978 MPR.

APPENDIX

TABLE XIV

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-36 (Periods 21/22)

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	2.77(a)	13.76	39.72	26.62	17.90	100.45
Weight Percent on Fresh Feed	1.42(a)	10.85	33.78	24.14	18.19	88.38
Gravity, °API	32.1	17.9	7.0	-1.6	-15.6	2.4
SP 60/60°F	0.8649	0.9471	1.0217	1.0897	1.221	1.0568
Pour Point, °F	<-20	<-20	<-16	35	-	<-23
Softening Point, °F	-	-	-	-	232	-
Viscosity, CST @ 100°F	1.12	2.65	7.93	101.93		28.24
CST @ 210°F	0.58	1.00	1.87	5.44		3.72
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	1.1	0.4				
Naphthenes	-	-				
Aromatics	46.2	82.7				
Saturates	52.7	16.9				
Elemental, Wt%						
Carbon	88.48	89.65	90.18	92.51	92.40	89.66
Hydrogen	11.39	10.40	8.88	7.85	6.33	8.06
Oxygen	0.97	0.27	0.49	0.31	0.83	0.51
Nitrogen	0.41	0.34	0.29	0.57	1.31	0.39
Sulfur	<0.06	<0.06	<0.06	<0.06	0.08	<0.06
Ash, Wt%					0.41	0.06

(a) C_5+ in gas are 6.69 liquid volume % and 4.00 weight % on feed

APPENDIX

TABLE XV

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-36 (Periods 26B/27)

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	4.69(a)	12.46	41.72	26.56	16.94	102.08
Weight Percent on Fresh Feed	3.19(a)	9.81	35.37	24.06	17.16	89.59
Gravity, °API	32.0	18.1	7.4	-1.5	-15.2	2.7
SP 60/60°F	0.8645	0.9459	1.0187	1.0884	1.217	1.0544
Pour Point, °F	<-16	<-16	<-16	40	-	<-23
Softening Point, °F	-	-	-	-	230	-
Viscosity, CST @ 100°F	1.08	2.25	8.00	111.97		27.09
CST @ 210°F	0.57	0.96	1.93	5.77		3.72
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	0.8	0.12				
Naphthenes	-	-				
Aromatics	44.8	81.7				
Saturates	54.4	17.1				
Elemental, Wt%						
Carbon	88.91	89.62	91.65	91.36	92.97	90.85
Hydrogen	11.87	10.40	9.10	7.64	6.11	8.17
Oxygen	0.92	0.24	0.41	0.29	0.82	0.51
Nitrogen	0.46	0.35	0.15	0.43	1.41	0.55
Sulfur (b)	0.0042	0.0032	0.0051	0.0128	0.09(c)	0.0132
Ash, Wt%					0.29	0.06

(a) C_5+ in gas are 5.85 liquid volume % and 3.49 weight % on feed
(b) By Dohrman sulfur analysis
(c) By ASTM D-1552 sulfur analysis

APPENDIX

TABLE XVI

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-36 (Period 30B)

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	4.51(a)	12.08	39.46	24.40	19.76	100.21
Weight Percent on Fresh Feed	3.17(a)	9.51	33.72	22.23	20.12	88.75
Gravity, °API	30.7	17.6	6.2	-2.3	-15.9	1.1
SP 60/60°F	0.8724	0.9490	1.0276	1.0955	1.224	1.0671
Pour Point, °F	<-20	<-20	<-18	25	-	-10
Softening Point, °F	-	-	-	-	238	-
Viscosity, CST @ 100°F	1.15	2.23	8.42	124.2		41.80
CST @ 210°F	0.60	0.93	2.00	6.05		4.66
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	2.7	0				
Naphthenes	-	-				
Aromatics	46.0	86.5				
Saturates	51.3	13.5				
Elemental, Wt%						
Carbon	85.53	89.65	91.17	91.99	91.47	90.27
Hydrogen	11.65	10.27	8.75	7.52	5.97	7.88
Oxygen	1.42	0.40	0.47	0.33	0.97	0.60
Nitrogen	0.26	0.26	0.12	0.50	1.21	0.53
Sulfur	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ash, Wt%					0.21	0.01

(a) C_5+ in gas are 4.40 liquid volume % and 2.64 weight % on feed

APPENDIX

TABLE XVII

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-36 (Period 32B)

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	4.24(a)	8.36	30.14	30.81	23.27	101.44
Weight Percent on Fresh Feed	2.75(a)	7.23	25.82	27.90	28.34	92.04
Gravity, °API	28.9	17.1	6.1	-1.25	-13.9	-1.6
SP 60/60°F	0.8822	0.9522	1.0283	1.0864	1.203	1.0893
Pour Point, °F	<-20	<-20	<-18	30	-	5
Softening Point, °F	-	-	-	-	245	-
Viscosity, CST @ 100°F	1.27	2.58	9.74	113.61		203.0
CST @ 210°F	0.63	1.03	2.14	5.68		8.35
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	3.8	0				
Naphthenes	-	-				
Aromatics	48.6	86.8				
Saturates	47.6	13.2				
Elemental, Wt%						
Carbon	86.14	89.38	90.15	91.62	91.03	90.57
Hydrogen	11.46	10.38	8.72	7.78	6.28	7.80
Oxygen	1.76	0.69	0.49	0.43	1.13	0.71
Nitrogen	0.40	0.38	0.32	0.51	1.40	0.66
Sulfur	<0.06	<0.06	<0.06	<0.06	0.13	<0.06
Ash, Wt%					0.28	0.07

(a) C_5+ in gas are 2.98 liquid volume % and 1.77 weight % on feed

APPENDIX

TABLE XVII

LIQUID PRODUCT YIELDS FROM THE PROCESSING OF SRC-KOPPERS CREOSOTE

Run LCF-36 (Period 32B)

Fraction	IBP-390°F	390-500°F	500-650°F	650-850°F	850°F+	Total Liquid Product
Volume Percent and	4.24(a)	8.36	30.14	30.81	23.27	101.44
Weight Percent on Fresh Feed	2.75(a)	7.23	25.82	27.90	28.34	92.04
Gravity, °API	28.9	17.1	6.1	-1.25	-13.9	-1.6
SP 60/60°F	0.8822	0.9522	1.0283	1.0864	1.203	1.0893
Pour Point, °F	<-20	<-20	<-18	30	-	5
Softening Point, °F	-	-	-	-	245	-
Viscosity, CST @ 100°F	1.27	2.58	9.74	113.61		203.0
CST @ 210°F	0.63	1.03	2.14	5.68		8.35
Hydrocarbon Type, Vol%						
Paraffins	-	-				
Olefins	3.8	0				
Naphthenes	-	-				
Aromatics	48.6	86.8				
Saturates	47.6	13.2				
Elemental, Wt%						
Carbon	86.14	89.38	90.15	91.62	91.03	90.57
Hydrogen	11.46	10.38	8.72	7.78	6.28	7.80
Oxygen	1.76	0.69	0.49	0.43	1.13	0.71
Nitrogen	0.40	0.38	0.32	0.51	1.40	0.66
Sulfur	<0.06	<0.06	<0.06	<0.06	0.13	<0.06
Ash, Wt%					0.28	0.07

(a) C_5+ in gas are 2.98 liquid volume % and 1.77 weight % on feed

*U.S. GOVERNMENT PRINTING OFFICE : 1979 0-620-097/2321