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UPGRADING OF COAL LIQUIDS

INTERIM REPORT

HYDROTREATING AND FLUID CATALYTIC CRACKING OF EDS PROCESS DERIVED GAS OILS

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ABSTRACT

The objective of this work was to evaluate the applicability of commercial UOP hydrotreating and fluid catalytic cracking (FCC) processes to distillate liquids derived from the Exxon Donor Solvent (EDS) process. All feedstocks for these studies were derived from the 400-1000°F (204-538°C) fraction of the raw EDS product.

Five different feedstocks, ranging in hydrogen content from 7.41 to 11.95 wt-% were prepared by batch vacuum flash distillation or by catalytic hydrotreating in research pilot plants. Rerunning the raw feed to remove 18.7 wt-% bottoms failed to eliminate heptane insolubles. Therefore, a UOP black oil conversion catalyst, known to be effective in reducing heptane insolubles, was selected for hydrotreating the raw stock.

Results of fluid catalytic cracking in a research scale riser cracker unit showed that feed hydrogen content is a dominant factor in conversion and yield structure. Hydrotreating substantially improved the cracking characteristics of the EDS liquid product. As more hydrogen was added, conversion and gasoline yield increased and carbon deposition decreased. In the range of conditions investigated, gasoline Research octane numbers of 95-101 were obtained. Cycle oils containing 650°F$^-$ distillate as high as 85 vol-% were generated. The lighter portions of the cycle oil, boiling between 400-650°F, are valuable components of distillate fuels and heating oils.

Based on data obtained, it is concluded that with an appropriate degree of hydrotreatment the EDS process derived gas oil, or any other coal derived distillate of similar quality, can be readily processed into high quality gasolines by applying advanced commercial fluid catalytic cracking technology. The fluid catalytic cracker, in conjunction with a hydrotreater, shows potential to play a major role in future commercial refining of coal derived liquids.

1. INTRODUCTION

The objective of this program was to determine the applicability of commercial UOP conversion processes to coal distillate liquids generated by two DOE sponsored processes: H-Coal and Exxon Donor Solvent (EDS).

Four tasks were identified under this program. Each of these tasks covers coal liquids from both the H-Coal process and the EDS process. The first task involves two stage continuous hydrocracking of coal distillate liquids. The second task entails processing of distillates through continuous hydrotreating and fluid catalytic cracking units. The third task covers processing of coal derived naphthas through continuous hydrotreating-reforming bench scale units. The fourth task involves all data correlation.

Hydrotreating and fluid catalytic cracking of the H-Coal process derived distillate liquids were covered in Interim Report FE-2566-20. This report covers work under Task 2 on hydrotreating and fluid catalytic cracking of EDS process derived distillate liquids. Investigation was carried out on five distinct feedstocks. One was the original EDS oil. The second two were rerun EDS liquid products. The last two were hydrotreated EDS gas oils.

For reporting purposes, the experimental conditions employed in this work are expressed in terms of base conditions:

Temperature	T-T (base), °C
Pressure	P-P (base), psi
Space Velocity	LHSV/LHSV (base)
Catalyst Oil Weight Ratio	$\frac{\text{Catalyst/Oil}}{\text{Catalyst/Oil (base)}}$

The base conditions for hydrotreating represent conditions employed commercially for hydrotreating a typical Arabian vacuum gas oil. Similarly the base conditions for fluid catalytic cracking refer to those conditions used commercially for a typical Arabian gas oil.

2. EQUIPMENT

2.1. Hydrotreating

Hydrotreating of EDS gas oils was carried out in a bench scale continuous unit (UOP Research Plant 638H). A simplified flow diagram of a bench scale gas oil hydrotreating plant is shown in Figure 1. Hydrogen and gas oil feed are passed concurrently downflow over a fixed bed of a commercial black oil conversion catalyst. The catalyst is a composite of Group VI and Group VIII metals on a high surface area refractory support.

2.2. Fluid Catalytic Cracking

Fluid catalytic cracking of EDS derived distillate liquids (gas oils) was conducted in UOP Research Plant 593, a once-through Quick Quench (all riser) unit using equilibrium zeolitic and amorphous catalysts withdrawn from commercial FCC units. Figure 2 is a flow diagram of this small scale fluid catalytic cracker. It comprises a riser reactor, a catalyst regenerator-hopper system, a catalyst stripper-separator system, and a fractionator. The preheated fresh feed enters the unit at the mixing "Y" where it is mixed with the hot regenerated catalyst which flows down from the regenerator-hopper system through the catalyst transfer line. The catalyst and the vaporized feed travel rapidly through the riser reactor. The cracked oil vapors and the spent catalyst enter the stripper-separator system where the adsorbed hydrocarbons are stripped from the catalyst surface, and the oil vapors are separated from the catalyst. The stripped spent catalyst is charged to a catalyst receiver, and samples are taken to determine carbon content. The hydrocarbon vapors from the separator are sent to the fractionator for separation into gas, gasoline, and cycle oil. The spent catalyst is manually reloaded into the regenerator-hopper system, and is batch regenerated prior to the start of the next test.

3. CHARGE STOCKS

3.1. Gas Oil Hydrotreating

A single 55-gallon drum shipment of raw Exxon Donor Solvent (EDS) process liquid product was received on March 21, 1977. The contents were 50 gallons. This was assigned for work under Task 2. Inspections of this drum of material, identified as 3532-5, are listed in Table 1. They show very high values of steam jet gum, Conradson carbon, nitrogen content, and heptane insolubles. The distillation indicated that 15 vol-% boiled above 930°F.

This raw EDS liquid product was used to prepare two hydrogenated gas oils, as well as the two rerun feedstocks.

3.2. Fluid Catalytic Cracking

Fluid catalytic cracking studies were carried out on the raw EDS liquid product (3532-5), two rerun EDS liquid products (3532-10, 3532-27), and two hydrotreated gas oils (3532-12, 3532-15).

Some 13.4 gallons of the raw EDS liquid product 3532-5 was vacuum flashed to recover 81.3 wt-% as overhead, IBP to 526°C. Distillation information is shown in Table 2. This IBP to 526°C fraction was designated as rerun EDS liquid product 3532-10. Inspections are listed in Table 3. They show a very marked reduction in steam jet gum and Conradson carbon from the raw feed. The nitrogen content was also significantly reduced. However, the heptane insoluble content

remained high, 4.14 wt-%. These heptane insolubles are not "asphaltenes" in the conventional sense. Mass spectroscopy has identified them as distillable polycyclics containing up to four oxygen atoms per molecule.

Six and one-half gallons of the rerun EDS liquid product 3532-10 was vacuum flashed to strip the fuel oil fraction, and recover a 343°C$^+$ fraction. The objective was to provide a stock for cracking to fuel oil. Details of the distillation are shown in Table 4. The 343°C$^+$ fraction was designated as topped rerun EDS liquid product 3532-27. Inspections of this material are listed in Table 5. As expected, it is of poorer quality than the stock from which it was derived. The sulfur, oxygen, nitrogen contents and Conradson carbon values are higher and the hydrogen content is lower. Heptane insolubles, surprisingly, did not increase, possibly because of their volatility.

Two gas oils of increased hydrogen content were prepared by hydrotreating the raw EDS liquid product 3532-5. The first, designated as hydrotreated EDS liquid product 3532-12, was produced by moderate hydrotreatment. The second, designated as hydrotreated EDS liquid product 3532-15, was the topped 204°C$^+$ fraction of a severely hydrotreated gas oil, designated as hydrotreated EDS liquid product 3532-13. Inspections of these two FCC feedstocks are listed in Tables 6 and 7. Figure 3 shows the steps involved in their preparation as well as those for the EDS gas oils 3532-10 and 3532-27.

4. RESULTS AND DISCUSSION

4.1. Gas Oil Hydrotreating

The primary objective in the hydrotreating of coal derived gas oil is to improve the cracking characteristics of the gas oil by reducing nitrogenous poisons and coke precursors, and to provide points of catalytic attack on condensed ring structures by partial saturation of aromatic rings.

4.1.1. Selection of Hydrotreating Catalyst

A commercial black oil conversion catalyst was selected for hydrotreating EDS distillates. This is the same catalyst that was used for upgrading primary coal liquids (SRC-I, Synthoil, H-Coal) under Contract No. E(49-18)2010, as described in Report FE-2010-07, March, 1977. The data on which this selection was based are being reported in a concurrent Interim Report, "Hydrocarcking of EDS Process Derived Gas Oils", FE-2566-33.

A different catalyst, UOP-DCB, a first-stage hydrocracking catalyst, was used to upgrade H-Coal gas oil to produce FCC feedstocks (Interim Report FE-2566-20, August, 1978). Catalysts of this type are sensitive to heptane insolubles. The high level of heptane insolubles in the EDS gas oil, the difficulty of removing them by conventional rerunning, as well as the high losses to bottoms incurred in rerunning, all contraindicated the use of UOP-DCB catalyst. The UOP black oil conversion catalyst is designed to convert heptane insolubles and was, therefore, the catalyst of choice for processing EDS distillate.

Base conditions for conversion of non-distillate petroleum stocks with black oil conversion catalyst are more severe than those for conversion of distillates with DCB catalyst. However, to afford easier comparison of the results obtained with hydrotreating various coal derived distillates, base conditions appropriate to DCB catalyst have been retained in this report in reference to black oil conversion catalyst.

4.1.2. Preparation of Hydrotreated EDS Gas Oils

Two hydrotreating preparative runs were carried out for the purpose of preparing two feedstocks for FCC studies. Inspections of the feedstock, raw EDS liquid product 3532-5, are given in Table 1.

Plant 638H, Run 21B. This run was the second part of Run 21. It ran for 117 hours (∿4.9 days) to produce 9 gallons of blended hydrotreated feed containing 10.66 wt-% hydrogen. The run was made at base space velocity and 750 psi below base pressure. The temperature was raised 13°C during the run to a final value 5°C above base temperature in order to reach target hydrogen content. The operation and analyses are logged in Table 8.

Table 9 summarizes the overall material balance for Run 21B. At the mild conditions used, losses to C_1 - C_4 gas were low, 0.89 wt-%. A 95.5 wt-% recovery of hydrotreated oil was obtained. This liquid product was designated as hydrotreated EDS liquid product 3532-12. Engler distillation (Table 6) indicated only 2% naphtha in the product. It was not topped prior to catalytic cracking.

A hydrogen balance was made to obtain the distribution of hydrogen consumed. The results are summarized in Table 10. The results show that 16.2 wt-% of the hydrogen consumed was involved in denitrogenation, desulfurization, and deoxygenation. Of the remainder, 75.4 wt-% was used to effect an increase in hydrogen content of the feed.

Plant 638H, Run 22. The second hydrotreating preparative run was carried out in Plant 638H, Run 22. The objectives was to prepare a high hydrogen content (∿12 wt-%) gas oil for FCC studies. The operation was started at 1050 psi above base pressure, 0.3 x base space velocity and 6°C below base temperature. The plant was operated by monitoring the hydrogen content of the liquid product and adjusting temperature upward to obtain the desired hydrogen analysis. The operation and analyses are logged in Table 11. At 133 hours on stream, the LHSV was adjusted downward to 0.25 x base space velocity to reduce the temperature requirement, and thus keep undesirable side reactions such as cracking to a minimum. The plant was again lined out, after making a minor temperature adjustment to obtain the desired hydrogen content product. From 169 hours to the end of the run at 709 hours, some minor catalyst deactivation was noted as seen by the temperature requirement increase and decreasing product hydrogen content.

Hrs. on Stream	T-T (base) °C	Product Hydrogen Content, Wt-%
169-181	21	12.06
277-289	22	11.95
397-409	23	11.83
493-505	24	11.86
613-625	24	11.81
697-709	25	11.67

Table 12 summarizes the overall material balance made for Run 22. At the more severe conditions used, an 84.0 wt-% recovery of stripper bottoms was obtained. Losses to C_1-C_4 gas amounted to 3.6 wt-%.

The hydrogen consumption amounted to 4.0 wt-% of the feed. The distribution of hydrogen consumed is summarized in Table 13. At the severe operating conditions some 14.5 wt-% of hydrogen was used to supply the cracked C_1-C_6 products, and 74.1 wt-% of the hydrogen consumed went to hydrogenation of the liquid product.

The hydrotreated products from the severe hydrotreating were blended. Table 14 gives the inspections of this liquid product (hydrotreated EDS liquid product 3532-13). This stock was vacuum fractionated (Table 15) to obtain 85.2 wt-% of a 400°F$^+$ (204°C$^+$) fraction for FCC studies. Inspections of this feedstock (hydrotreated EDS liquid product 3532-15) are shown in Table 7.

Table 16 lists inspections of the 204°C$^-$ fraction, designated hydrotreated liquid product 3532-14. This naphtha can be processed into a high octane gasoline by further hydrotreating and reforming. Like naphthas obtained by hydrocracking EDS gas oil (FE-2566-25, Tables 14, 15), it will be highly naphthenic. Reforming can be accomplished at high space velocity and relatively low temperatures with high gasoline and hydrogen yields.

Figure 3 is a summary of the basic steps involved and yield data obtained in the preparation of the two hydrotreated FCC feedstocks. In this figure, the yield data and hydrogen additions are expressed as weight percent of raw EDS liquid product 3532-5. The yields of hydrotreated EDS liquid products 3532-12 and 3532-15 are 95.5 wt-% and 71.6 wt-%, respectively. The figure also shows the preparation and yield data for the two FCC feedstocks prepared by vacuum flashing.

4.2. Fluid Catalytic Cracking of EDS Process Derived Gas Oils

Fluid catalytic cracking of EDS process derived liquids was carried out in Plant 593, as described in paragraph 2.2. above.

In the current program, with the exception of the raw and rerun EDS liquid products, multiple tests were made at each set of conditions to obtain four or more independent sets of experimental data, and to provide sufficient liquid product for fractionation and analyses of the fractions.

FCC studies were carried out on five feedstocks. One was the topped rerun EDS liquid product 3532-27. The second was the raw EDS liquid product 3532-5. The third was the rerun EDS liquid product 3532-10. A fourth was moderately hydrotreated gas oil (hydrotreated EDS liquid product 3532-12). The final charge stock was the topped 204°C$^+$ fraction of severely hydrotreated gas oil (hydrotreated EDS liquid product 3532-15). The hydrogen contents of these five feedstocks are 7.41, 8.66, 8.97, 10.66 and 11.95 wt-%, respectively (Tables 5, 1, 3, 6 and 7).

All tests were conducted at 10 psi below base pressure. The results are presented in terms of increasing hydrogen content of the feed.

4.2.1. Topped Rerun EDS Liquid Product 3532-27

The reason for cracking this stock, from which the 650°F$^-$ (343°C) material had been removed, was to produce fuel oil. It was speculated that mild cracking could convert a substantial amount of feed to 650°F$^-$ liquid, which could be hydrogenated to acceptable quality fuel oil. Advantages would accrue by adding hydrogen after catalytic cracking rather than before. Both amorphous and zeolitic catalysts were used.

Amorphous Catalyst. Two tests were made at one condition using this catalyst. Results are summarized in Table 17, which lists cracking conditions, product distributions, and product inspections.

Some results of the two tests are shown below:

Experiment No.	278/1	278/2
T-T base, °C	-35	-25
Cat/Oil / Cat/Oil Base	0.74	0.86
Conversion, Vol-%	25.0	25.2
C_5^+ Gasoline, Vol-%	1.2	1.6
400-650°F, Vol-%	9.4	-
Carbon, Wt-%	16.5	18.5

The conversion to gasoline was low as expected, because of the low activity associated with amorphous catalyst. However, yield of fuel oil range liquids was also low. Carbon production was very high. A zeolitic catalyst was then tried, in order to provide more cracking activity.

Zeolitic Catalyst. Two tests were made at conditions similar to those used with the amorphous catalyst. The results are listed in Table 18 which shows product distribution, inspections and the cracking conditions. They are summarized as follows:

Experiment No.	279/1	279/2
T-T base, °C	-33	-33
Cat/Oil / Cat/Oil Base	0.68	0.88
Conversion, Vol-%	21.2	20.3
C_5^+ Gasoline, Vol-%	2.5	1.3
400-650°F, Vol-%	10.6	14.4
Carbon, Wt-%	15.9	20.2

The C_5^+ gasoline and carbon yields were essentially the same as obtained with amorphous catalyst. Middle distillate yield was only slightly higher. It is concluded that 650°F$^+$ (343°C$^+$) EDS liquid product is a poor FCC feed, and will require hydrogenation, even to obtain middle distillate in the fuel oil range.

4.2.2. Raw EDS Liquid Product 3532-5

Fluid catalytic cracking of the raw EDS liquid product 3532-5 was conducted at one condition. Results are summarized in Table 19. The table shows the cracking conditions, product distributions, inspections of the gasoline products, and properties of the cycle oils. The Research octane number (RON) of the leaded and unleaded gasolines could not be obtained because of insufficient product.

At low conversions the operation of the plant fractionator was unsatisfactory. The small amount of low boiling material in the product made it difficult to produce a sharp cutpoint at the end of the gasoline boiling range. The plant gasoline fractions were contaminated with cycle oil. To correct for this discrepancy, the observed yields and gravities were adjusted, based on a 380°F temperature at the 90 vol-% point of the Engler distillation.

Experiment No.	274/1	274/2
T-T (base), °C	35	30
Cat/Oil / Cat/Oil Base	1.51	1.22
Conversion, Vol-%	43.9	46.4
C_5^+ Gasoline, Vol-%(a)	18.0	22.5
Carbon, Wt-%	19.6	18.4

(a) Adjusted

Results of the two tests are listed above and show a very high carbon make for the rather low level of conversion and C_5^+ gasoline yield. This was expected because of the low hydrogen content and high aromatics and nitrogen in the feed (Table 1).

4.2.3. Rerun EDS Liquid Product 3532-10

The EDS liquid product 3532-10 was prepared by rerunning the raw EDS liquid product 3532-5, taking 84.1 vol-% overhead. The objective was to improve the cracking characteristics of the feed by removal of coke precursor material. The steam jet gum and Conradson carbon were very markedly reduced. The heptane insolubles were reduced by some 30% as was the nitrogen content. Inspections of this feedstock are given in Table 3.

Fluid catalytic cracking of the rerun liquid product 3532-10 was conducted at two sets of conditions. The results are summarized in Tables 20 and 21. Each of the tables shows the cracking conditions, product distributions, inspections of the gasoline products, and properties of the gas oils. The table also includes the Research octane number (RON) and Motor octane number (MON) of the leaded and unleaded gasolines. Table 20 contains data from two tests at near base temperature and base catalyst/oil ratio. Similarly, Table 21 contains data from two tests at a higher temperature and catalyst/oil ratio.

Since the first set of conditions in Table 20 resulted in a low conversion, it was necessary again to adjust the gasoline and cycle oil yields as well as the corresponding API and specific gravities based on a 380°F temperature at the 90 vol-% point of the Engler.

Conversion was low and carbon deposition high at near base conditions. At more severe conditions conversion increased slightly, gasoline yield remained the same, and carbon deposition increased.

Experiment No.	272/2	272/6
T-T (base), °C	4	31
Cat/Oil / Cat/Oil Base	1.06	1.36
Conversion, Vol-%	45.3	49.7
C_5^+ Gasoline, Vol-%	25.1[a]	24.6
Carbon, Wt-%	12.5	15.4

[a] Adjusted

Low conversions and high carbon yields were again expected because this feed was still low in hydrogen and very high in aromatics. Removal of most of the steam jet gum and Conradson carbon did effect a substantial reduction in carbon make.

4.2.4. Hydrotreated EDS Liquid Product 3532-12

The hydrotreated EDS liquid product 3532-12 was prepared by moderate hydrotreatment which raised the hydrogen content from 8.66 to 10.66 wt-%, and reduced the nitrogen content from 7130 to 1388 wt-ppm (Table 6). The concentration of aromatics is still high, but the condensed ring structures are partially hydrogenated. Data obtained at two sets of conditions are listed in Tables 22 and 23 and summarized below:

Experiment No.	271/1	271/8
T-T (base), °C	4.5	32
Cat/Oil / Cat/Oil Base	1.14	1.43
Conversion, Vol-%	65.6	66.8
C_5^+ Gasoline, Vol-%	46.7	43.0
Carbon, Wt-%	8.6	9.0

At near base conditions this hydrotreated feed exhibited much higher conversions and gasoline yields with lower carbon make when compared to the untreated stocks. The data also showed no increase in conversion and gasoline yield at the more severe conditions.

4.2.5. Hydrotreated EDS Liquid Product 3532-15

Hydrotreated EDS liquid product 3532-15 was the 204°C$^+$ fraction of a severely hydrotreated EDS liquid product. This fraction represents 85.2 wt-% of the total hydrotreated product, and 71.6 wt-% of the raw EDS product. Table 7 shows that this feedstock contained 11.95 wt-% H, 2.6 wt-ppm N, and 52.5 vol-% aromatics.

Four separate tests were conducted at each set of conditions. Data are presented on Tables 24 and 25. Data on Table 24 were obtained at near base conditions while those on Table 25 were obtained at more severe conditions.

Experiment No.	273/2	273/6
T-T (base), °C	3	32
Cat/Oil / Cat/Oil Base	1.01	1.44
Conversion, Vol-%	71.3	77.5
C_5^+ Gasoline, Vol-%	53.4	54.7
Carbon, Wt-%	6.4	6.8

A fairly high conversion and gasoline yield with reduced carbon deposition were observed at near base conditions. At more severe conditions conversion went up slightly with little or no change in C_5^+ gasoline yield and carbon deposition.

4.2.6. Discussion

It was not surprising that the raw and rerun EDS liquid products 3532-5, 3532-10 and 3532-27 showed low conversions and high carbon yields in fluid catalytic cracking studies. Analyses showed these stocks to contain less than 9 wt-% hydrogen, at least 86 vol-% aromatics and 4900 to 9400 wt-ppm nitrogen. The raw EDS stock also has 6.66 wt-% Conradson carbon and very high contents of heptane insolubles and steam jet gum.

Polycondensed aromatic molecules are known coke formers, and offer few points of catalytic attack for carbon-carbon bond cleavage and ring opening. Basic nitrogen compounds are at least transient poisons to the catalytic acid sites on FCC catalysts. Oxygenates, gum, and heptane insolubles are coke precursors and are responsible for high Conradson carbon.

Hydrotreatment is a broad spectrum remedy for all of these feedstock deficiencies, and overall, hydrogen content is the most important factor in fluid catalytic cracking of coal-derived feedstocks. This is clear in comparing the FCC conversion and yield pattern obtained with the five EDS-derived feedstocks investigated.

Feed Hydrogen Content, Wt-%	7.41	8.66	8.97	10.66	11.95
Conversion, Vol-%	20.3	43.9	49.7	66.8	77.5
C_5^+ Gasoline, Vol-%	1.3	18.0	24.6	43.0	54.7
C_4^-, Wt-%	0.8	7.0	8.0	14.8	17.7
Carbon, Wt-%	20.2	19.6	15.4	9.0	6.8

These data are illustrated in Figure 4, and compared with data plotted from a West Coast refinery feed, hydrotreated to various levels of hydrogen:

West Coast Refinery Feed

Feed Hydrogen Content, Wt-%	11.78	12.46	12.50	13.47
Conversion, Vol-%	67.8	74.6	78.9	87.2
C_5^+ Gasoline, Vol-%	50.9	59.0	61.8	71.0
C_4^-, Wt-%	15.2	16.5	18.9	21.2
Carbon, Wt-%	7.4	5.7	5.5	4.8

While the correlations for the coal derived gas oil and the petroleum derived gas oil do not overlap in a very wide range of hydrogen contents, they are reasonably consistent. It should be noted that at the point of overlap, the nitrogen contents of the two stocks are widely different, about 3000 wt-ppm in the case of the West Coast fuel, and practically nil in the case of the severely hydrotreated EDS gas oil.

Although all the cracked gasolines obtained from these FCC studies are high in octane number, 95-101 RON, data indicate that at comparable conditions, octane numbers of cracked gasoline begin to decrease as the feed hydrogen content increases beyond the level of 10.66 wt-%.

Based on data obtained, it is concluded that with an appropriate degree of hydrotreatment the EDS process derived gas oil, or any other coal derived distillate of similar quality, can be readily processed into high quality gasolines by applying advanced commercial fluid catalytic cracking technology. The FCC process, in conjunction with a hydrotreater, shows potential in playing a major role in future commercial refining operations of coal-derived liquids.

Table 1

Inspections of Raw EDS Liquid Product

Drum No.	1	
Sample No.	3532-5	
°API @ 60°F	3.5	
Sp. Gr. @ 60°F	1.0481	
Distillation, ASTM D-1160		
IBP, °F	403	
5%	447	
10%	454	
20%	471	
30%	511	
40%	563	
50%	620	
60%	690	
70%	778	
80%	878	
90%	930	(85%)
95%		
EP		
% Over	85.0	
% Bottoms	15.0	
Hydrogen, Wt-%	8.66	
Carbon, Wt-%	89.22	
Sulfur, Wt-ppm	4900	
Nitrogen, Wt-ppm	7130	
Oxygen, Wt-ppm	19300	
Con. Carbon, Wt-%	6.66	
Heptane Insolubles, Wt-%	6.45	
Stm. Jet Gum, mg/100 ml	10063	

Table 2

Vacuum Flash Distillation of Raw EDS Liquid Product 3532-5

Cut Number	Boiling Range, °C	Volume, ml	Vol-%	Wt., Grams	Wt-%
1[(a)]	IBP-526°	42,577	84.1	43,186	81.3
Botts.	526°+	8,079	15.9	9,906	18.7
		50,656	100.0	53,092	100.0

[(a)] Designated as Rerun EDS Liquid Product 3532-10.

Table 3

Inspections of Rerun EDS Liquid Product 3532-10

Sample No.	3532-10
°API @ 60°F	8.0
Sp. Gr @ 60°F	1.0143
Distillation, ASTM D-1160	
IBP, °F	422
5%	446
10%	453
20%	470
30%	495
40%	530
50%	573
60%	622
70%	686
80%	760
90%	850
95%	905
EP	940
% Over	98.0
% Bottoms	2.0
Hydrogen, Wt-%	8.97
Carbon, Wt-%	87.93
Sulfur, Wt-ppm	2036
Nitrogen, Wt-ppm	4900
Oxygen, Wt-ppm	28400
Con. Carbon, Wt-%	0.95
Heptane Insolubles, Wt-%	4.14
Steam Jet Gum, mg/100 ml	2.66
FIA, Vol-%	
A	85.6
O	0.0
P&N	14.4

Table 4

Vacuum Flash Distillation of Rerun EDS Liquid Product 3532-10

Cut Number	Boiling Range °C	Volume ml	Vol-%	Wt. Grams	Wt-%
1	IBP-343°	14844	60.4	16338	60.2
Botts.[a]	343° +	9752	39.6	10823	39.8
		24596	100.0	27161	100.0

(a) Designated as Topped Rerun EDS Liquid Product 3532-27

Table 5

Inspections of Topped Rerun EDS Liquid Product 3532-27

Sample No.	3532-27
°API @ 60°F	-4.0
Sp. Gr. @ 60°F	1.1098
Distillation, ASTM D-86	
IBP, °F	598
5%	645
10%	675
20%	720
30%	751
40%	780
50%	803
60%	830
70%	857
80%	874
90%	
95%	
EP	
% Over	80.0
% Bottoms	20.0
Hydrogen, Wt-%	7.41
Carbon, Wt-%	87.75
Sulfur, Wt-ppm	6500
Nitrogen, Wt-ppm	9400
FIA, Elution, Wt-%	
Aromatic	88.9
Non-aromatic	2.9
Loss	8.2
Heptane Insolubles, Wt-%	4.17
Conradson Carbon, Wt-%	3.67
Molecular Weight	273

Table 6

Inspections of Hydrotreated EDS Liquid Product 3532-12

Sample No.	3532-12
°API @ 60°F	15.3
Sp. Gr. @ 60°F	0.9639
Distillation, ASTM D-1160	
IBP, °F	380
5%	422
10%	443
20%	468
30%	499
40%	538
50%	579
60%	628
70%	680
80%	750
90%	850
95%	950
EP	
% Over	95.0
% Bottoms	5.0
Hydrogen, Wt-%	10.66
Carbon, Wt-%	88.39
Sulfur, Wt-ppm	48
Nitrogen, Wt-ppm	1388
Oxygen, Wt-ppm	1583
Con. Carbon, Wt-%	0.18
Heptane Insolubles, Wt-%	0.06
Molecular Weight, Average	225
FIA, Vol-%	
A	86.6
O	0.0
P&N	13.4

Table 7

Inspections of Hydrotreated EDS Liquid Product 3532-15

Sample No.	3532-15
°API @ 60°F	21.0
Sp. Gr. @ 60°F	0.9279
Distillation, ASTM D-1160	
IBP, °F	419
5%	449
10%	462
20%	471
30%	487
40%	507
50%	526
60%	555
70%	585
80%	621
90%	676
95%	717
EP	801
% Over	99.0
% Bottoms	1.0
Hydrogen, Wt-%	11.95
Carbon, Wt-%	87.85
Sulfur, Wt-ppm	11
Nitrogen, Wt-ppm	2.6
Oxygen, Wt-ppm	367
Con. Carbon, Wt-%	<0.01
Heptane Insolubles, Wt-%	<0.01
Molecular Weight, Average	225
FIA, Vol-%	
A	52.5
O	0.0
P&N	47.5

Table 8

Hydrotreating Raw EDS Liquid Product 3532-5

Plant 638H, Run 21B

[Hydrotreating (for FCC) Preparative Run No. 1]

P-P (base) psi: -750

Period No.	Hours on Stream	LHSV / LHSV(base)	T-T(base), °C	Product Analysis, Wt-% H	Product Analysis, Wt-% C
Feed				8.66	89.22
22	232-242	0.99	-8	10.12	89.06
23	242-252	1.01	-7	10.18	89.51
24	252-262	0.99	-3	10.57	90.29
25	262-272	0.99	1	10.32	88.67
26	272-282	1.01	0	10.44	89.86
27	282-292	1.00	5	10.42	89.71
28	292-302	1.00	4	10.53	89.22
29	302-312	1.01	5	10.44	89.08
30	312-322	1.00	3	10.64	89.64
31	322-332	1.01	2	10.66	89.95
32	332-342	1.00	5	10.48	89.47
33	342-349	1.00	4		

Table 9

Hydrotreating Raw EDS Liquid Product 3532-5

Overall Product Distribution

Plant 638H, Run 21B

Product Distribution, Wt-% of Feed	
C_1	0.19
C_2	0.27
C_3	0.25
C_4	0.18
C_5 (in Plant Gas)	0.08
C_6 (in Plant Gas)	1.08
Stripper Overhead	1.64
Stripper Bottoms[a]	95.51
H_2O	2.00
NH_3	0.70
H_2S	0.51
Total	102.41
H_2 Consumption, Wt-% of Feed	2.41
H_2 Consumption, SCF/bbl	1700

[a] Designated as Hydrotreated EDS Liquid Product 3532-12.

Table 10

Hydrotreating Raw EDS Liquid Product 3532-5

Distribution of Hydrogen Consumption

Plant 638H, Run 21B

	Wt-%
$C_1 - C_4$	4.38
$C_5 - C_6$ (in Plant Gas)	3.95
Liquid Product[(a)]	75.44
H_2O	9.65
H_2S	1.32
NH_3	5.26
Total	100.00
Total Hydrogen Consumption SCF/bbl	1700

(a) Designated as Hydrotreated EDS Liquid Product 3532-12.

Table 11

Hydrotreating Raw EDS Liquid Product 3532-5

Plant 638H, Run 22

[Hydrotreating (for FCC) Preparative Run No. 22]

P-P (base) psi: 1050

Period No.	Hours on Stream	LHSV / LHSV(base)	T-T(base) °C	Product Analysis, Wt-% H	C
Feed				8.66	89.22
1	24-36	0.30	-6	11.08	87.26
2	36-48	0.31	-4	11.40	87.36
3	48-60	0.30	-2	11.37	88.15
4	60-73	0.30	-	11.64	87.27
5	73-85	0.30	7	11.35	87.66
6	85-97	0.30	7	11.27	87.45
7	97-109	0.29	16	11.80	89.18
8	109-121	0.30	13	11.73	88.69
9	121-133	0.30	14	11.25	87.75
10	133-145	0.26	19	11.61	89.23
11	145-157	0.25	16	11.67	88.40
12	157-169	0.24	15	11.72	87.71
13	169-181	0.25	21	12.06	87.69
14	181-193	0.25	20	12.25	87.74
15	193-205	0.25	19	12.00	87.87
16	205-217	0.24	19	11.92	86.95
17	217-229	0.26	19	12.06	87.94
18	229-241	0.25	18	12.03	88.51
19	241-253	0.26	19	11.62	87.55
20	253-265	0.25	19	11.93	88.44
21	265-277	0.26	18	11.60	89.06
22	277-289	0.25	22	11.95	88.82
23	289-301	0.25	23	11.84	88.17
24	301-313	0.25	24	12.02	88.09
25	313-325	0.25	23	11.98	88.77
26	325-337	0.26	26	11.90	88.10
27	337-349	0.25	-	12.05	88.17
28	349-361	0.25	22	11.94	88.59
29	361-373	0.26	22	11.76	88.58
30	373-385	0.25	24	11.85	88.82
31	385-397	0.25	21	11.89	88.77
32	397-409	0.25	23	11.83	88.03
33	409-421	0.25	24	11.66	87.96
34	421-433	0.25	24	11.83	88.32
35	433-445	0.25	23	11.70	88.16
36	445-469	0.25	24	11.56	88.34
37	469-481	0.25	23	11.72	88.21

Table 11, Cont'd.

Period No.	Hours on Stream	LHSV LHSV(base)	T-T(base) °C	Product Analysis, Wt-% H	C
38	481-493	0.25	26	11.64	88.63
39	493-505	0.26	24	11.86	88.57
40	505-517	0.25	26	11.88	88.22
41	517-528	0.25	25	11.75	88.45
42	528-541	0.25	26	11.69	88.22
43	541-553	0.26	24	11.69	88.25
44	553-565	0.25	24	11.83	88.05
45	565-577	0.25	24	11.73	88.48
46	577-589	0.25	24	11.76	88.93
47	589-601	0.25	24	11.85	88.93
48	601-613	0.25	24	11.59	87.37
49	613-625	0.26	24	11.81	88.93
50	625-637	0.25	25	11.67	88.91
51	637-649	0.26	25	11.56	88.99
52	649-661	0.24	-	11.77	88.51
53	661-673	0.25	26	11.96	88.22
54	673-685	0.25	26	11.81	88.75
55	685-697	0.26	27	11.43	88.89
56	697-709	0.24	26	11.67	88.23

Table 12

Hydrotreating Raw EDS Liquid Product 3532-5

Overall Product Distribution

Plant 638H, Run 22

Product Distribution, Wt-% of Feed

C_1	0.54
C_2	0.82
C_3	1.06
C_4	1.21
C_5 (in Plant Gas)	0.37
C_6 (in Plant Gas)	1.43
Stripper Overhead	10.90
Stripper Bottoms[a]	84.02
H_2O	2.22
NH_3	0.91
H_2S	0.55
Total	104.03
H_2 Consumption, Wt-% of Feed	4.03
H_2 Consumption, SCF/bbl	2760

(a) Designated as Hydrotreated EDS Liquid Product 3532-13.

Table 13

Hydrotreating Raw EDS Liquid Product 3532-5

Distribution of Hydrogen Consumption

Plant 638H, Run 22

	Wt-%
$C_1 - C_4$	10.77
$C_5 - C_6$ (in Plant Gas)	3.73
Liquid Product[(a)]	74.10
H_2O	6.40
H_2S	0.83
NH_3	4.17
Total	100.00
Total Hydrogen Consumption SCF/bbl	2760

(a) Designated as Hydrotreated EDS Liquid Product 3532-13.

Table 14

Inspections of Hydrotreated EDS Liquid Product 3532-13

Sample No.	3532-13
°API @ 60°F	22.7
Sp. Gr. @ 60°F	0.9176
Distillation, ASTM D-1160	
IBP, °F	322
5%	393
10%	410
20%	435
30%	463
40%	494
50%	518
60%	548
70%	580
80%	620
90%	678
95%	721
EP	794
% Over	99.0
% Bottoms	1.0
Hydrogen, Wt-%	11.80
Carbon, Wt-%	87.80
Sulfur, Wt-ppm	11
Nitrogen, Wt-ppm	14
Oxygen, Wt-ppm	450
Con. Carbon, Wt-%	<0.01
Heptane Insolubles, Wt-%	0.01
FIA, Vol-%	
A	48.3
O	0.0
P&N	51.7

Table 15

Vacuum Fractionation of Hydrotreated EDS Liquid Product 3532-13

Cut Number	Boiling Range °C	Volume, ml	Vol-%	Weight Grams	Wt-%
1[a]	IBP-400°F	5,087	15.8	4,379	14.8
Botts.[b]	400°F+	27,091	84.2	25,138	85.2
		32,178	100.0	29,517	100.0

(a) Designated as Hydrotreated EDS Liquid Product 3532-14.

(b) Designated as Hydrotreated EDS Liquid Product 3532-15

Table 16

Inspections of Hydrotreated EDS Liquid Product 3532-14

Sample No.	3532-14
°API @ 60°F	32.3
Sp. Gr. @ 60°F	0.8639
Distillation, ASTM D-86	
IBP, °F	297
5%	314
10%	326
20%	341
30%	350
40%	358
50%	364
60%	369
70%	372
80%	378
90%	386
95%	391
EP	393
% Over	98.5
% Bottoms	1.5
Hydrogen, Wt-%	12.75
Carbon, Wt-%	87.63
Sulfur, Wt-ppm	49
Nitrogen, Wt-ppm	3
Oxygen, Wt-ppm	194
FIA, Vol-%	
A	32.0
O	0.0
P&N	68.0
RON, Clear	68.6
RON, 3 ml TEL/Gallon	82.6

Table 17

Fluid Catalytic Cracking of Topped Rerun EDS Liquid Product 3532-27
Plant 593, Run 278 (amorphous catalyst)

Test No.	1	2
Operating Conditions		
P-P (base), psig	-10	-10
T-T (base), °C	-35	-25
[Cat./Oil / Cat./Oil (base)]	0.74	0.86
Conversion, Vol-%	25.0	25.2
Product Distribution, Wt-%		
C_3^-	1.0	0.9
C_4	0.3	0.1
C_5	0.1	0.0
C_6-EP Gasoline	0.8	1.2
Cycle Oil	73.9	73.5
Carbon	16.5	18.5
Wt. Recovery	92.6	94.1
Products, Vol-%		
C_5-EP Gasoline	1.2	1.6
400-650°F	9.4	74.8
650°F + Cycle Oil	65.6	
Properties of Cycle Oil		
°API @ 60°F	-2.2	-3.3
Sp. Gr.@ 60°F	1.0944	1.1037
Distillation, UOP - No. 1		
IBP, °F	533	
5%	610	
10%	640	
15%		
% Over at 650°F	12.5	
°API of 650°F- @ 60°F	-5.4	
Sp. Gr of 650°F$^-$	1.1221	
°API of 650°F$^+$ @ 60°F	-1.6	
Sp. Gr. of 650°F$^+$ @ 60°F	1.0893	
C_3^-, Mole %		
H_2	25.8	71.5
C_1	22.7	10.5
C_2(Total)	28.5	9.5
C_3 Olefins	17.3	6.3
C_3	5.8	2.2
Total	100.0	100.0
C_4, Vol-%		
C_4 Olefins	100.0	100.0
i-C_4	0.0	0.0
n-C_4	0.0	0.0
Total	100.0	100.0
C_5, Vol-%		
C_5 Olefins	99.1	93.2
i-C_5	0.0	0.0
n-C_5	0.9	6.8
Total	100.0	100.0

Table 18

Fluid Catalytic Cracking of Topped Rerun EDS Liquid Product 3532-27
Plant 593, Run 279 (zeolitic catalyst)

Test No.	1	2
Operating Conditions		
P-P (base), psig	-10	-9
T-T (base), °C	-33	-33
[Cat./Oil / Cat./Oil (base)]	.68	.88
Conversion, Vol-%	21.2	20.3
Product Distribution, Wt-%		
C_3-	1.9	0.6
C_4	0.7	0.2
C_5	0.6	0.0
C_6-EP Gasoline	1.1	1.0
Cycle Oil	77.8	78.0
Carbon	15.9	20.2
Wt. Recovery	98.0	100.1
Products, Vol-%		
C_5-EP Gasoline	2.5	1.3
Cycle Oil	78.8	79.7
Properties of Cycle Oil		
°API @ 60°F	-2.5	-1.3
Sp. Gr. @ 60°F	1.0969	1.0868
Distillation, UOP - No. 1		
IBP, °F	400	458
5%	580	575
10%	641	628
15%		642
% Over at 650°F	13.5	18.0
°API of 650°F⁻@ 60°F	6.1	5.4
Sp. Gr. of 650°F⁻ @ 60°F	1.0283	1.0336
°API of 650°F⁺@ 60°F	-3.5	-3.0
Sp. Gr. of 650°F⁺@ 60°F	1.1055	1.1012
C_3^-, Mole %		
H_2	39.4	26.1
C_1	20.9	26.1
C_2 (Total)	15.8	13.0
C_3 Olefins	18.5	26.1
C_3	5.4	8.7
Total	100.0	100.0
C_4, Vol-%		
C_4 Olefins	79.0	100.0
i-C_4	21.0	0.0
n-C_4	0.0	0.0
Total	100.0	100.0
C_5, Vol-%		
C_5 Olefins	67.9	87.1
i-C_5	31.7	6.5
n-C_5	0.4	6.4
Total	100.0	100.0

Table 19

Fluid Catalytic Cracking of Raw EDS Liquid Product 3532-5
Plant 593, Run 274

Test No.	1	2
Operating Conditions		
P-P (base), psig	-9	-10
T-T (base), °C	35	30
[Cat./Oil / Cat./Oil (base)]	1.51	1.22
Conversion, Vol-%	43.9	46.4
Product Distribution, Wt-%		
C_3-	4.9	3.8
C_4	2.1	1.1
C_5 / C_6-EP Gasoline	15.1(c)	18.3(c)
Cycle Oil	59.0	58.2
Carbon	19.6	18.4
Wt. Recovery	100.8	99.8
Products, Vol-%		
C_5-EP Gasoline	18.0(c)	22.5(c)
Cycle Oil	57.8(c)	56.9(c)
Inspections of C_5-EP Gasoline		
°API @ 60°F	30.1(c)	34.7(c)
Sp. Gr. @ 60°F	0.8756(c)	0.8514(c)
FIA, Vol-%		
A	64.3	71.0(b) (a)
O	12.2	
P&N	11.1	19.1
Color band(a)	12.4	9.9
Properties of Cycle Oil		
°API @ 60°F	0.8(c)	0.5(c)
Sp. Gr. @ 60°F	1.0699(c)	1.0721(c)
Distillation, UOP - No. 1		
IBP, °F	463	496
5%	475	508
10%	488	523
15%	501	535
% Over at 650°F	58.5	55.0
°API of 650°F-@ 60°F	8.7	9.2
Sp. Gr. of 650°F-@ 60°F	1.0093	1.0057
°API of 650°F+@ 60°F	-8.4	-7.8
Sp. Gr. of 650°F+@ 60°F	1.1495	1.1439
C_3-, Mole %		
H_2	9.3	20.5
C_1	38.0	35.9
C_2 (Total)	34.0	24.3
C_3 Olefins	14.1	14.9
C_3	4.6	4.3
Total	100.0	100.0

[a] Color band follows Aromatic band in FIA test and represents highly polar compounds containing oxygen, sulfur and nitrogen

[b] Aromatics and olefins did not separate

[c] Adjusted numbers

Table 19, Cont'd.

Fluid Catalytic Cracking of Raw EDS Liquid Product 3532-5
Plant 593, Run 274

Test No.	1	2
C_4, Vol-%		
C_4 Olefins	37.5	78.2
i-C_4	11.6	14.1
n-C_4	50.9	7.7
Total	100.0	100.0
C_5, Vol-%		
C_5 Olefins	66.1	81.5
i-C_5	10.8	14.1
n-C_5	23.2	4.5
Total	100.0	100.0

Table 20

Fluid Catalytic Cracking of Rerun EDS Liquid Product 3532-10
Plant 593, Run 272

Test No.	1	2
Operating Conditions		
P-P (base), psig	-11	-10
T-T (base), °C	4	4
[Cat./Oil / Cat./Oil (base)]	1.02	1.06
Conversion, Vol-%	45.9	45.3
Product Distribution, Wt-%		
C_3-	4.2	4.1
C_4	2.2	1.7
C_5 / C_6-EP Gasoline	21.3(b)	21.3(b)
Cycle Oil	57.5	58.1
Carbon	12.8	12.5
Wt. Recovery	98.0	97.6
Products, Vol-%		
C_5-EP Gasoline	25.1(b)	24.9(b)
Cycle Oil	56.2(b)	56.5(b)
Inspections of C_5-EP Gasoline		
°API @ 60°F	32.6(b)	31.4(b)
Sp. Gr. @ 60°F	0.8623(b)	0.8686(b)
RON, Clear	← 96.8 →	
RON, 3 ml TEL/Gallon	← 101.8 →	
MON, Clear	← 86.8 →	
MON, 3 ml TEL/Gallon	← 90.2 →	
FIA, Vol-%		
A	69.5	68.1
O	7.1	9.3
P&N	17.4	17.1
Color Band(a)	5.9	5.5
Properties of Cycle Oil		
°API @ 60°F	4.9(b)	4.2(b)
Sp. Gr. @ 60°F	1.0377(b)	1.0430(b)
Distillation, UOP - No. 1		
IBP, °F	464	466
5%	476	476
10%	485	484
15%	496	495
% Over at 650°F	72.0	71.0
°API of 650°F-@ 60°F	10.2	9.6
Sp. Gr. of 650°F-@ 60°F	0.9986	1.0028
°API of 650°F+@ 60°F	-6.8	-6.8
Sp. Gr. of 650°F+@ 60°F	1.1349	1.1344

[a] Color Band follows Aromatic band in FIA test and represents highly polar compounds containing oxygen, sulfur, and nitrogen.

[b] Adjusted numbers

Table 20, Cont'd.

Fluid Catalytic Cracking of Rerun EDS Liquid Product 3532-10
Plant 593, Run 272

Test No.	1	2
C_3-, Mole %		
H_2	33.4	33.2
C_1	22.9	24.6
C_2 (Total)	18.3	18.7
C_3 Olefins	18.5	17.8
C_3	6.9	5.7
Total	100.0	100.0
C_4, Vol-%		
C_4 Olefins	55.2	65.5
i-C_4	29.4	23.2
n-C_4	15.4	11.3
Total	100.0	100.0
C_5, Vol-%		
C_5 Olefins	66.6	71.5
i-C_5	29.4	24.0
n-C_5	4.0	4.4
Total	100.0	100.0

Table 21

Fluid Catalytic Cracking of Rerun EDS Liquid Product 3532-10
Plant 593, Run 272

Test No.	5	6
Operating Conditions		
P-P (base), psig	-9.4	-10
T-T (base), °C	32	31
[Cat./Oil / Cat./Oil (base)]	1.44	1.36
Conversion, Vol-%	50.3	49.7
Product Distribution, Wt-%		
C_3-	6.7	6.2
C_4	2.1	1.8
C_5	2.3	1.2
C_6-EP Gasoline	18.2	19.9
Cycle Oil	51.7	52.1
Carbon	15.5	15.4
Wt. Recovery	96.4	96.6
Products, Vol-%		
C_5-EP Gasoline	24.4	24.6
Cycle Oil	49.7	50.3
Inspections of C_5-EP Gasoline		
°API @ 60°F	32.6	32.2
Sp. Gr. @ 60°F	.8623	0.8644
Distillation, ASTM D-86		
IBP, °F	129	118
5%	167	151
10%	192	182
50%	320	320
90%	404	414
95%	413	
EP	440	433
RON, Clear	<------- 100.7 ----->	
RON, 3 ml TEL/Gallon	<------- 104.0 ----->	
FIA, Vol-%		
A	74.4	74.1
O	7.1	7.2
P&N	14.8	14.8
Color band (A)	3.7	3.9
Properties of Cycle Oil		
°API @ 60°F	2.7	3.1
Sp. Gr. @ 60°F	1.0544	1.0513
Distillation, UOP - No. 1		
IBP, °F	438	460
5%	452	472
10%	462	484
15%	471	494
% Over at 650°F	70.0	72.5

(A) Color band follows Aromatic band in FIA test and represents highly polar compounds containing oxygen, sulfur and nitrogen.

Table 21, Cont'd.

Fluid Catalytic Cracking of Rerun EDS Liquid Product 3532-10
Plant 593, Run 272

Test No.	5	6
°API of 650°F-@ 60°F	8.4	7.1
Sp. Gr. of 650°F- @ 60°F	1.0114	1.0209
°API of 650°F$^+$ @ 60°F	-8.4	2.9
Sp. Gr. of 650°F$^+$ @ 60°F	1.1499	1.0526
C_3-, Mole %		
H_2	35.5	29.6
C_1	27.9	35.0
C_2 (Total)	18.2	16.5
C_3 Olefins	13.2	13.5
C_3	5.1	5.5
Total	100.0	100.0
C_4, Vol-%		
C_4 Olefins	65.8	56.6
i-C_4	22.7	27.3
n-C_4	11.5	16.1
Total	100.0	100.0
C_5, Vol-%		
C_5 Olefins	79.1	60.8
i-C_5	18.2	33.7
n-C_5	2.6	5.5
Total	100.0	100.0

Table 22

Fluid Catalytic Cracking of Hydrotreated EDS Liquid Product 3532-12
Plant 593, Run 271

Test No.	1	2	3	4
Operating Conditions				
P-P (base), psig	-10	-10	-10	-11.9
T-T (base), °C	4.5	2	0	5
[Cat./Oil / Cat./Oil (base)]	1.14	1.13	0.94	1.10
Conversion, Vol-%	65.6	65.4	61.1	63.1
Product Distribution, Wt-%				
C_3-	7.1	5.5	6.3	6.2
C_4	5.6	3.3	3.3	4.4
C_5	3.7	3.6	4.6	3.5
C_6-EP Gasoline	36.3	35.6	35.6	34.8
Cycle Oil	37.2	37.3	41.6	39.7
Carbon	8.6	8.5	7.8	8.4
Wt. Recovery	98.5	93.8	99.2	97.1
Products, Vol-%				
C_5-EP Gasoline	46.7	45.5	47.1	44.1
Cycle Oil	34.4	34.6	38.9	36.9
Inspections of C_5-EP Gasoline				
°API @ 60°F	39.9	39.1	38.8	38.1
Sp. Gr. @ 60°F	.8256	.8294	.8309	.8343
Distillation, ASTM D-86				
IBP, °F	120	148	126	124
5%	143	157	150	147
10%	162	166	170	165
50%	278	275	291	289
90%	395	398	402	403
95%	410	408	417	414
EP	435	435	436	444
RON, Clear	<---------- 96.8 ---------->			
RON, 3 ml TEL/Gallon	<----------101.8 ---------->			
MON, Clear	<---------- 83.8 ---------->			
MON, 3 ml TEL/Gallon	<---------- 88.7 ---------->			
FIA, Vol-%				
A	55.8	56.3	53.5	56.5
O	4.3	4.4	5.3	6.3
P&N	39.9	39.3	41.2	37.2
Properties of Cycle Oil				
°API @ 60°F	4.4	4.7	5.8	4.9
Sp. Gr. @ 60°F	1.0412	1.0389	1.0306	1.0374
Distillation, UOP - No. 1				
IBP, °F	459	463	455	464
5%	473	475	475	476
10%	479	481	484	483
15%	486	489	494	487
% Over at 650°F	78.5	78.0	79.5	77.5

Table 22, Cont'd.

Fluid Catalytic Cracking of Hydrotreated EDS Liquid Product 3532-12
Plant 593, Run 271

Test No.	1	2	3	4
°API of 650°F⁻ @ 60°F	8.4	8.7	9.6	8.6
Sp. Gr. of 650°F⁻ @ 60°F	1.0114	1.0093	1.0028	1.0100
°API of 650°F⁺ @ 60°F	-8.3	-6.7	-6.5	-6.7
Sp. Gr. of 650°F⁺ @ 60°F	1.1490	1.1340	1.1318	1.1340
C_3-, Mole %				
H_2	27.3	31.5	31.7	38.9
C_1	16.2	16.7	17.5	15.6
C_2 (Total)	17.7	17.6	17.5	15.1
C_3 Olefins	24.0	21.6	22.5	20.4
C_3	14.8	12.7	10.8	10.1
Total	100.0	100.0	100.0	100.0
C_4, Vol-%				
C_4 Olefins	34.4	34.1	38.8	42.2
i-C_4	43.2	42.1	45.1	38.8
n-C_4	22.4	23.8	16.1	19.0
Total	100.0	100.0	100.0	100.0
C_5, Vol-%				
C_5 Olefins	22.5	27.8	46.2	31.5
i-C_5	70.9	65.3	48.7	61.9
n-C_5	6.6	6.9	5.1	6.6
Total	100.0	100.0	100.0	100.0

Table 23

Fluid Catalytic Cracking of Hydrotreated EDS Liquid Product 3532-12
Plant 593, Run 271

Test No.	5	6	7	8
Operating Conditions				
P-P (base), psig	-11	-10.8	-10	-10
T-T (base), °C	32	33	32	32
[Cat./Oil / Cat./Oil (base)]	1.42	1.38	1.49	1.43
Conversion, Vol-%	61.0	65.0	62.6	66.8
Product Distribution, Wt-%				
C_3-	10.7	9.6	11.2	9.3
C_4	6.0	4.8	5.9	5.5
C_5	5.0	4.8	4.3	4.8
C_6-EP Gasoline	29.8	33.9	30.6	32.3
Cycle Oil	42.1	38.2	40.5	36.2
Carbon	9.3	9.8	9.4	9.0
Wt. Recovery	103.0	101.8	101.9	97.1
Products, Vol-%				
C_5-EP Gasoline	41.0	45.1	40.8	43.0
Cycle Oil	39.0	35.0	37.4	33.2
Inspections of C_5-EP Gasoline				
°API @ 60°F	39.7	38.5	35.0	38.0
Sp. Gr. @ 60°F	0.8265	0.8324	0.8499	0.8348
Distillation, ASTM D-86				
IBP, °F	124	126	158	115
5%	147	153	182	137
10%	162	171	195	157
50%	269	276	286	276
90%	383	393	393	396
95%	397	410	413	408
EP	427	436	434	439
RON, Clear				
RON, 3 ml TEL/Gallon				
FIA, Vol-%				
A	60.5	62.6	67.7	64.0
O	7.5	6.8	5.6	5.7
P&N	32.0	30.6	26.7	30.3
Properties of Cycle Oil				
°API @ 60°F	4.5	3.3	4.0	3.1
Sp. Gr. @ 60°F	1.0404	1.0497	1.0443	1.0513
Distillation, UOP - No. 1				
IBP, °F	438	454	446	461
5%	453	470	467	475
10%	462	478	476	483
15%	470	544	480	492
% Over at 650°F	77.5	75.5	76.5	74.0

Table 23, Cont'd.

Fluid Catalytic Cracking of Hydrotreated EDS Liquid Product 3532-12
Plant 593, Run 271

Test No.	5	6	7	8
°API of 650°F⁻@ 60°F	8.7	7.9	8.6	7.4
Sp. Gr. of 650°F⁻ @ 60°F	1.0093	1.0151	1.0100	1.0187
°API of 650°F⁺@ 60°F	-7.7	-8.2	-7.9	-7.8
Sp. Gr. of 650°F⁺ @ 60°F	1.1434	1.1475	1.1450	1.1436
C_3-, Mole %				
H_2	34.8	44.0	39.7	36.5
C_1	19.5	19.0	19.6	20.0
C_2 (Total)	16.7	14.3	15.5	16.0
C_3 Olefins	19.6	14.9	16.9	17.8
C_3	9.4	7.8	8.4	9.6
Total	100.0	100.0	100.0	100.0
C_4. Vol-%				
C4 Olefins	41.4	40.7	42.6	41.0
$\underline{i}$-C_4	41.7	42.1	40.8	40.5
$\underline{n}$-C_4	16.9	17.2	16.5	18.5
Total	100.0	100.0	100.0	100.0
C_5, Vol-%				
C_5 Olefins	46.5	45.9	49.7	41.4
$\underline{i}$-C_5	48.8	48.5	45.9	53.1
$\underline{n}$-C_5	4.8	5.5	4.4	5.5
Total	100.0	100.0	100.0	100.0

Table 24

Fluid Catalytic Cracking of Hydrotreated EDS Liquid Product 3532-15
Plant 593, Run 273

Test No.	1	2	3	4
Operating Conditions				
P-P (base), psig	-10	-10	-9	-10
T-T (base), °C	-2	3	4	4.5
[Cat./Oil / Cat./Oil (base)]	1.03	1.01	1.07	0.92
Conversion, Vol-%	68.7	71.3	72.5	72.0
Product Distribution, Wt-%				
C_3^-	10.8	7.3	10.4	7.2
C_4	8.0	6.9	8.6	7.0
C_5	6.3	5.8	6.4	5.9
C_6-EP Gasoline	37.3	40.3	40.7	41.8
Cycle Oil	33.9	31.3	30.0	30.6
Carbon	6.4	6.4	6.2	6.2
Wt. Recovery	102.8	98.0	102.4	98.7
Products, Vol-%				
C_5-EP Gasoline	51.6	53.4	54.8	55.2
Cycle Oil	31.3	28.7	27.5	28.0
Inspections of C_5-EP Gasoline				
°API @ 60°F	47.4	45.2	44.5	44.4
Sp. Gr. @ 60°F	0.7909	0.8008	0.8040	0.8044
Distillation, ASTM D-86				
IBP, °F	124	122	115	125
5%	146	146	134	145
10%	158	159	145	157
50%	233	250	235	245
90%	350	384	382	384
95%	375	399	400	404
EP	415	431	424	434
RON, Clear	← 94.6 →			
RON, 3 ml TEL/Gallon	← 101.4 →			
MON, Clear	← 82.5 →			
MON, 3 ml TEL/Gallon	← 89.5 →			
FIA, Vol-%				
A	44.3	45.4	46.3	44.8
O	5.7	5.6	5.5	6.3
P&N	50.0	49.0	48.2	48.9
Properties of Cycle Oil				
°API @ 60°F	9.1	8.3	8.6	8.2
Sp. Gr. @ 60°F	1.0064	1.0122	1.0100	1.0129
Distillation, UOP - No. 1				
IBP, °F	434	438	425	461
5%	450	456	458	470
10%	455	465	471	475
15%	461	475	478	479
% Over at 650°F	85.5	84.5	83.5	85.0

Table 24, Cont'd.

Fluid Catalytic Cracking of Hydrotreated EDS Liquid Product 3532-15
Plant 593, Run 273

Test No.	1	2	3	4
°API of 650°F-@ 60°F	12.2	11.3	11.5	11.2
Sp. Gr. of 650°F-@ 60°F	0.9847	0.9909	0.9895	0.9916
°API of 650°F+@ 60°F	-6.8	-6.8	-5.8	-6.6
Sp. Gr. of 650°F+@ 60°F	1.1347	1.135	1.1255	1.133
C_3-, Mole %				
H_2	37.2	43.5	42.3	37.6
C_1	16.3	13.5	14.1	14.8
C_2 (Total)	12.6	10.9	11.5	12.3
C_3 Olefins	21.6	20.1	20.7	22.6
C_3	12.3	12.0	11.5	12.6
Total	100.0	100.0	100.0	100.0
C_4, Vol-%				
C_4 Olefins	25.2	31.9	29.5	32.3
i-C_4	53.9	48.4	51.0	48.2
n-C_4	20.9	19.8	19.5	19.5
Total	100.0	100.0	100.0	100.0
C_5, Vol-%				
C_5 Olefins	14.8	16.3	14.7	17.2
i-C_5	78.4	76.1	77.6	75.1
n-C_5	6.8	7.6	7.7	7.6
Total	10010	100.0	100.0	100.0

Table 25

Fluid Catalytic Cracking of Hydrotreated EDS Liquid Product 3532-15
Plant 593, Run 273

Test No.	5	6	7	8
Operating Conditions				
P-P (base), psig	-10	-9	-11	-9
T-T (base), °C	31	32	32.5	28
[Cat./Oil / Cat./Oil (base)]	1.41	1.44	1.58	1.43
Conversion, Vol-%	74.8	77.5	72.6	71.3
Product Distribution, Wt-%				
C_3-	15.0	10.2	15.1	10.0
C_4	10.2	7.5	9.6	7.0
C_5	6.7	6.5	6.2	4.0
C_6-EP Gasoline	39.9	41.5	38.4	37.4
Cycle Oil	28.0	25.2	30.6	31.7
Carbon	7.2	6.8	7.4	7.2
Wt. Recovery	107.1	97.6	107.4	97.3
Products, Vol-%				
C_5-EP Gasoline	53.5	54.7	51.1	47.2
Cycle Oil	25.2	22.5	27.4	28.7
Inspections of C_5-EP Gasoline				
°API @ 60°F	42.2	42.7	42.9	42.5
Sp. Gr. @ 60°F	0.8146	0.8123	0.8114	0.8132
Distillation, ASTM D-86				
IBP, °F	124	116	124	114
5%	143	134	142	135
10%	155	148	155	151
50%	251	248	248	249
90%	390	397	385	386
95%	410	418	400	401
EP	438	441	423	448
RON, Clear	← 96.5 →			
RON, 3 ml TEL/Gallon	← 102.8 →			
MON, Clear	← 83.7 →			
MON, 3 ml TEL/Gallon	← 90.0 →			
FIA, Vol-%				
A	52.2	53.4	51.8	52.1
O	7.1	6.5	7.9	8.4
P&N	40.7	40.1	40.3	39.5
Properties of Cycle Oil				
°API @ 60°F	5.8	4.7	5.1	6.8
Sp. Gr. @ 60°F	1.0306	1.0389	1.0359	1.0231
Distillation, UOP - No. 1				
IBP, °F	463	466	458	440
5%	469	476	470	460
10%	477	478	476	468
15%	482	488	480	471
% Over at 650°F	79.0	78.0	80.0	80.0

Table 25, Cont'd.

Fluid Catalytic Cracking of Hydrotreated EDS Liquid Product 3532-15
Plant 593, Run 273

Test No.	5	6	7	8
°API of 650°F-@ 60°F	9.8	9.2	9.0	10.8
Sp. Gr. of 650°F-@ 60°F	1.0014	1.0057	1.0071	0.9944
°API of 650°F+@ 60°F	-6.9	-8.7	-8.6	-7.8
Sp. Gr. of 650°F+@ 60°F	1.1357	1.1523	1.1512	1.1439
C_3-, Mole %				
H_2	42.8	32.4	39.8	47.2
C_1	15.3	20.4	19.0	15.9
C_2 (Total)	13.2	14.5	12.7	11.3
C_3 Olefins	19.0	21.3	19.0	17.4
C_3	9.7	11.3	9.6	8.2
Total	100.0	100.0	100.0	100.0
C_4, Vol-%				
C_4 Olefins	36.9	36.1	35.5	33.4
i-C_4	46.3	46.2	47.5	48.3
n-C_4	16.8	17.8	16.9	18.3
Total	100.0	100.0	100.0	100.0
C_5, Vol-%				
C_5 Olefins	27.9	22.7	22.0	27.3
i-C_5	65.0	70.7	71.3	66.5
n-C_5	7.0	6.6	6.7	6.2
Total	100.0	100.0	100.0	100.0

FIGURE 1

GAS OIL HYDROTREATING PLANT

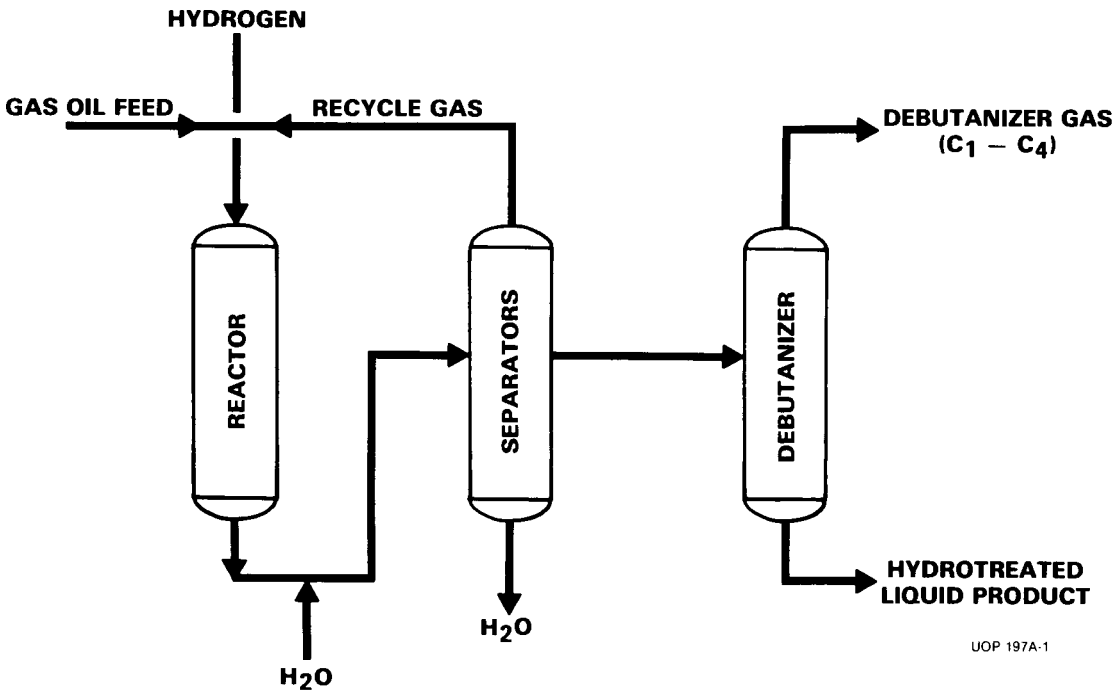
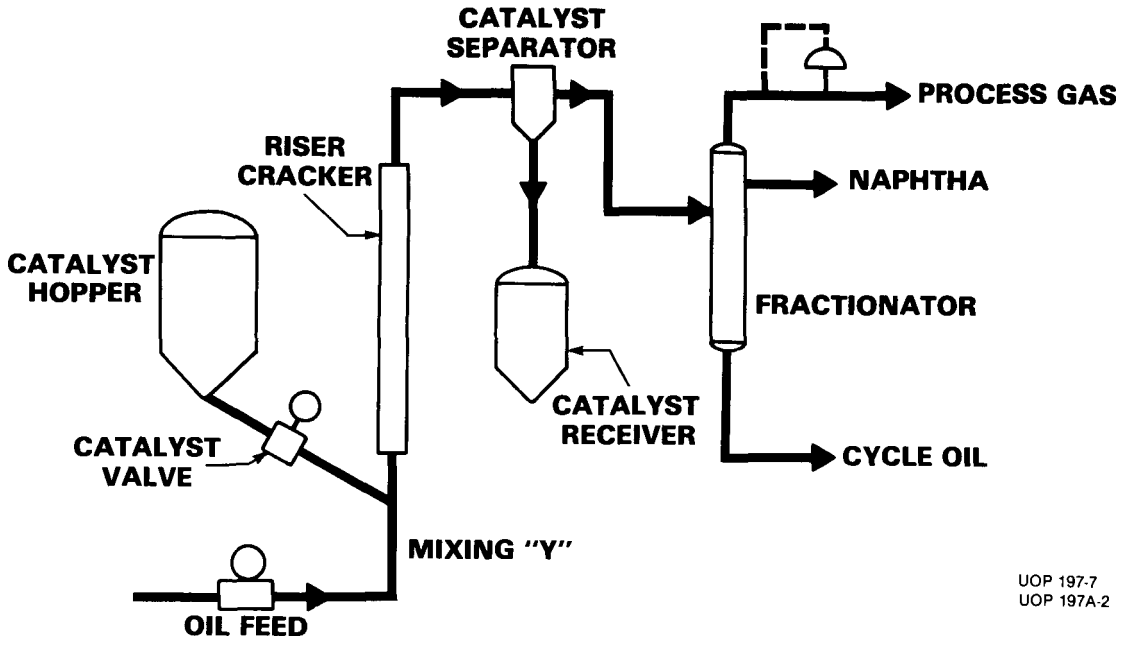


FIGURE 2

SMALL SCALE FLUID CATALYTIC CRACKER



UOP 197-7
UOP 197A-2

FIGURE 3

PREPARATION OF EDS DERIVED FCC FEEDSTOCKS

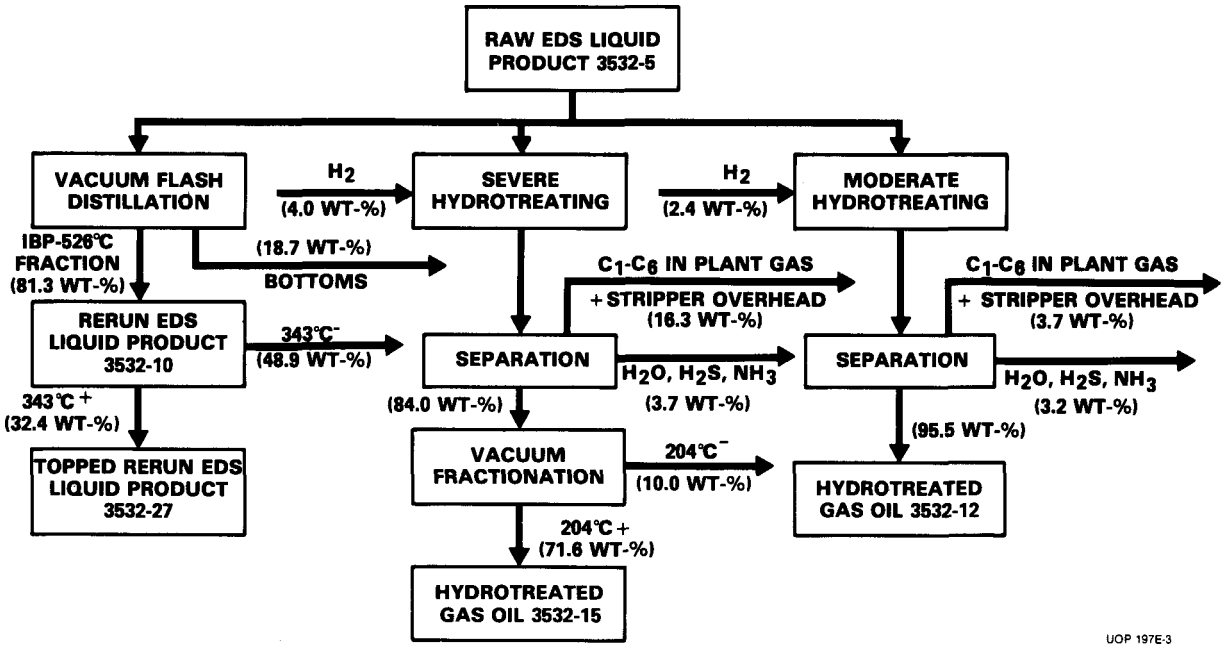
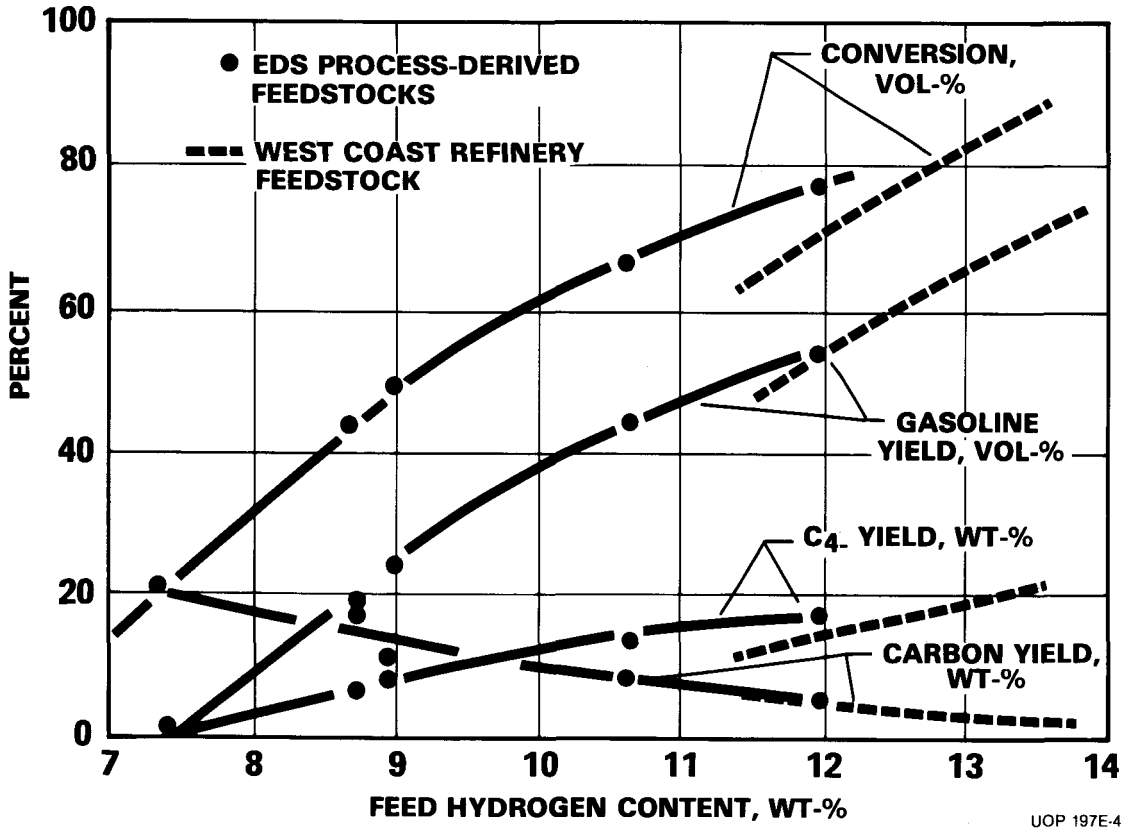


FIGURE 4

EFFECT OF FEEDSTOCK HYDROGEN CONTENT ON RESPONSE TO FLUID CATALYTIC CRACKING



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