

REFINING AND UPGRADING OF SYNFUELS
FROM COAL AND OIL SHALES
BY ADVANCED CATALYTIC PROCESSES

Quarterly Report for the
Period April-June 1979

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I. Abstract

Pilot plant tests on the hydrotreating of SRC-II process product indicate that this coal-derived feed is suitable for refining using advanced commercial petroleum processing technology. Experiments were completed to evaluate several different combinations of refinery processes for conversion of SRC-II to transportation fuels. Nitrogen in the whole SRC-II process product can be reduced to a concentration of less than 0.5 ppm in a single catalytic stage. Sulfur and oxygen can also be reduced to low levels; and at high severity, most of the aromatic compounds are converted to naphthenes. The naphtha appears to be an excellent catalytic reformer feed, and the middle distillate meets the smoke point and stability specifications for jet fuel. As the processing severity is decreased, product nitrogen increases; and the product becomes more aromatic. In the latter case, further hydrotreating of the naphtha is required before it can be fed to the second stage of a catalytic reformer. Depending on the severity employed, it may be necessary to further hydrogenate the jet boiling range product for specification jet fuel. Experiments were made to determine appropriate conditions for these processing steps. Alternate processing schemes include hydrocracking and catalytic cracking. In this report, pilot plant results for a two-stage hydrocracker are presented.

Early pilot plant results indicate that H-Coal whole process product can be hydrotreated to make a jet fuel similar to the jet fuel from SRC-II whole process product. Since H-Coal whole process product contains 1.5 wt % more hydrogen than does SRC-II product, the H-Coal product requires 700 SCFB less hydrogen during hydrotreating. Unfortunately, the ash and asphaltene impurities in the H-Coal product we have processed have made the pilot plant operation difficult.

Encl. - See Index of Enclosures

II. Contract Objectives and Scope of Work

The objective of the program as originally defined is to determine the feasibility and estimate the costs of hydroprocessing four synthetic crude feedstocks to distillate fuels, including high octane gasoline, using presently available technology.

Studies of the processing of Paraho shale oil are complete and are described in an Interim Report (FE-2315-25) issued in April 1978. Studies of the processing of the second feedstock, solvent-refined coal, are being completed. This study has been subdivided to include two types of solvent-refined coal from the SRC process, both produced at the DOE pilot plant in Tacoma, Washington. Experimental work on both SRC-I product and SRC-II product is complete, except for a few analyses of product. Engineering studies of SRC-II processing are also nearing completion. During the next quarter, we expect to transmit an Interim Report describing all of our SRC-I and SRC-II studies.

Work has started on the third feed, H-Coal process product, supplied by Hydrocarbon Research, Inc. The fourth feedstock is to be another coal-derived liquid to be selected by the mutual agreement of DOE and Chevron.

According to the contract, the feasibility of hydroprocessing each of the synthetic liquids mentioned above will be compared through catalyst tests and evaluations from which commercial plant yields, hydrogen consumption, product distribution, and product inspection will be estimated. The necessary tests and evaluations for each feedstock will be done to support "process comparison"-type estimates for each of the major refining steps. The results of the contract, insofar as hydroprocessing is concerned, will be obtained with Chevron commercial catalysts.

Catalyst activity and stability information for each feedstock will be obtained as needed to define commercial operating conditions. These data will provide the basis for the overall refining plan, plant cost estimates, utility and hydrogen requirements, etc. If tests show that refining a particular feedstock using presently existing technology is not feasible, it is not intended under this program to conduct any research or development work to solve the problems encountered.

Tests will be conducted only to the extent needed to enable making reasonable estimates of commercial plant performance and only to the extent a commercial plant is feasible using presently existing technology, subject to the mutual agreement of DOE and Chevron Research.

Tests will be made for each whole synthetic oil and, where appropriate, for the fractions derived therefrom. Tests will not be carried out for processes which can be reliably estimated.

III. Summary of Progress to Date

According to the original timing estimate for an individual feedstock, the preliminary feed analyses and pilot plant program for each feedstock will require one year, followed by an additional 14 weeks for completion of the product analyses, pilot plant report, and final process design. Experience shows that the actual timing on a given feedstock will vary as the program is adapted to the processing route or routes selected for a particular feed.

Delays in obtaining feedstocks have resulted in postponements of the program beyond the original schedule. The schedule for the second feedstock, solvent-refined coal, was further altered because SRC-II was added to the program as Feedstock 2B after completion of pilot plant tests on SRC-I, now referred to as Feedstock 2A.

Figure 1 shows the work completed thus far and the anticipated timing for Feedstocks 3 and 4. In a recent contract modification, the date for completion of the contract was extended to February 27, 1981, as shown in the figure.

Work on Feed 2B was started in April 1978. Figure 2 is the schedule for processing Feed 2B, SRC-II, as shown in FE-2315-28 and a summary of the timing of the work completed.

Work on Feedstock 3, H-Coal process product, was started in April 1979. Sufficient feedstocks to meet the anticipated requirements for the program were received from Hydrocarbon Research, Inc., on March 23, 1979. Figure 3 shows the schedule for processing this feed. The schedule is set up in a manner generally similar to that for SRC-II with some adjustments as a result of our experience with the latter feed. For example, the projected times for starting Tasks 2, 3, 4, and 4A have been moved forward one to two months to allow additional time for process engineering studies at the end of the program. Also, more time is allowed for the hydrocracking program for H-Coal than was scheduled in the program for SRC-II. (Hydrocracking proved to be a more promising processing route for SRC-II than was originally anticipated.) The time expected for Task 2A (separate processing of the H-Coal naphtha and gas oils) has been reduced by one month, also based on our experience with SRC-II.

IV. Description of Technical
Progress - SRC-II Processing
(Feedstock 2B)

Task 1 - Preliminary
Feed Analysis

At the request of the DOE Technical Representative, the following samples of SRC-II were sent to Chevron from the Solvent-Refined Coal Pilot Plant of the Pittsburgh and Midway Coal Mining Company, Du Pont, Washington.

No. 1113 - Five drums of naphtha (Chevron Identification
WOW 3631)

No. 1114 - Six drums of middle distillate (Chevron
Identification WOW 3632)

No. 1115 - Three drums of heavy distillate (Chevron
Identification WOW 3633)

The inspections of these samples were summarized in the April-June 1978 Quarterly Report (FE-2315-28).

Table I shows the inspections of a blend of the three fractions in the appropriate ratios as recommended by the DOE Technical Project Officer to constitute the whole liquid process product from "typical" SRC-II operation. Also shown in Table I are properties of the start-400°F naphtha and the 400°F+ gas oil fractions used as feedstocks in Task 2A.

According to our information, a large portion of the SRC-II blend was prepared from Kentucky No. 9 and Kentucky No. 14 coals. Some of the product, however, was prepared from Illinois No. 6 coal (River King Mine) and a small portion from West Virginia coal (Pitt-Seams Blackville No. 2 Mine).

Task 2 - Whole Oil
Hydrotreating

Results of Task 2, whole oil hydrotreating, were described in previous quarterly reports, FE-2315-28, -31, -34, and -37. In addition, a paper, "Refining the Products from the SRC Coal Liquefaction Process," by R. F. Sullivan, B. E. Stangeland, and H. A. Frumkin presented at the 44th Midyear Refining Meeting of the American Petroleum Institute in the "Session on Processing New Feedstocks" on Thursday, May 17, 1979, summarizes many of the important results on whole oil

hydrotreating. It is available from the American Petroleum Institute as Preprint No. 40-79. Cost of preparation and presentation of the paper was paid for by Chevron.

Chevron Research hosted the DOE Contractor's Conference on "Refining of Syncrudes" in Richmond, California, on May 7-8, 1979. A summary of our recent work, "Refining of SRC-I and SRC-II," was presented at this conference; and the work on whole oil hydrotreating of SRC-II under Task 2 was emphasized.

Task 2A - Alternate to
Whole Oil Hydrotreating:
Separate Hydrotreating of
SRC-II Naphtha and 400°F+
SRC-II Gas Oil

Runs were made in which the 400°F- SRC-II naphtha and the 400°F+ gas oil fractions were processed separately. Details of these runs were presented in FE-2315-34 and -37.

Task 3 - Naphtha and Middle
Distillate Hydrotreating

Results of hydrofinishing partially hydrotreated naphtha and jet boiling range product from the less severe whole oil hydrotreating runs were presented in the most recent quarterly report, FE-2315-37.

Task 4 - Two-Stage
Hydrocracking of Partially
Hydrotreated SRC-II

A. First-Stage Results

Runs 72-327 and 72-328 were two runs for the first stage of a two-stage hydrocracker to denitrify partially hydrotreated SRC-II for further hydrocracking in a second stage. (Note: To be consistent with our nomenclature in petroleum processing, the "whole oil hydro-treater" is not referred to as a first stage, although much of the nitrogen is removed in the whole oil hydrotreater. The hydrocracker is referred to as a "two-stage hydrocracker" although, if the whole oil hydrotreater is included, the entire processing configuration consists of three stages.)

Tables II and III summarize the properties of the feeds to the first-stage hydrocracker. Because of limited feed availability, both the 350°F+ portion of partially hydrotreated whole SRC-II and hydrotreated 400°F+ SRC-II product were used as feeds.

Run 72-327 was made using ICR 113 catalyst (containing nickel, molybdenum, silica, and alumina). Run 72-328 was made using ICR 106 catalyst (containing nickel, tungsten, silica, and alumina).

Run conditions and results of the two runs are summarized in Table IV and discussed in the paragraphs below.

Tests with ICR 113. Initial test conditions for ICR 113 were as follows:

1.5 LHSV
1150 psia Hydrogen (1300 psig Total Pressure)
643°F Average Catalyst Temperature
4000 SCF/Bbl Recycle Gas Rate

The first feed, SGQ 6554 (hydrotreated 400°F+ SRC-II prepared at 2300 psia hydrogen), contained 60 ppm nitrogen and 42% aromatics.

At the above conditions, nitrogen removal occurred easily; the product contained less than 0.2 ppm nitrogen and about 36-38% aromatics. Hydrogen consumption was 250 SCF/bbl. Results from two yield periods are shown in the first two columns of Table V.

The second feed tested with ICR 113 was a more difficult feed, SGQ 6631, containing 608 ppm nitrogen and 68 LV % aromatics. It was the 350°F+ portion of a blend of whole SRC-II that had been partially hydrotreated at 1750 psia hydrogen pressure.

Initial conditions were the same as those for the above test. The product nitrogen was high, and the temperature was increased to 700°F. Product nitrogen decreased to 12 ppm; product aromatics were 65 LV %; and the hydrogen consumption was about 300 SCF/bbl.

A further increase of temperature to 735°F brought the product nitrogen to 3 ppm. The aromatics in the product remained at 64%. A yield period is shown in the third column of Table V.

Because nitrogen removal and the saturation of aromatic rings in nitrogen-containing compounds are known to be related,^{1,2} it was felt

that a higher hydrogen pressure and more complete hydrogenation were necessary for complete nitrogen removal. The hydrogen pressure was increased to 1400 psia. Based on only 24-hour test, the nitrogen decreased a small amount to 3 ppm. Any change in aromatics was not measurable. Insufficient feed was available to continue this test at higher pressures. However, the superior performance of ICR 106 (described below) compared to ICR 113 indicates that ICR 106 would be the catalyst of choice for the more difficult feeds.

Tests with ICR 106. The first test with ICR 106 was with SGQ 6631 (608 ppm nitrogen, 68% aromatics), the same feed described in the preceding paragraphs. Conditions were the same as for the last ICR 113 test described above, except that the temperature was 695°F, about 40°F lower than in the ICR 113 test. Conditions were as follows:

1.5 LHSV
1400 psia Hydrogen (1600 psig Total Pressure)
695°F Average Catalyst Temperature

Product nitrogen was 3 ppm; approximately the same as obtained with ICR 113 at 735°F, indicating ICR 106 catalyst is about 30-40°F more active than ICR 113 in this service. Hydrogen consumption was 520 SCF/bbl, and the product contained 62% aromatics. Yields are shown in Table VI.

No additional SGQ 6631 (608 ppm nitrogen) was available; therefore, product from the preceding tests with both the ICR 113 and ICR 106 runs was blended and reprocessed at the above conditions. The blends were labeled SGQ 6664-1 and -2 (Table I). Hydrogen consumption for the second pass was about 425 SCF/bbl. The nitrogen is 0.2 ppm or less; product aromatics are 48 LV %. Yields are shown in Table VI.

Additional first-stage processing with ICR 106 was carried out with a feed containing 22 ppm nitrogen, 44% aromatics (SGQ 6621 prepared from 400°F+ SRC-II at 2300 psia hydrogen). Conditions for processing this feed were as follows:

1130 psia Hydrogen (1300 psig Total Pressure)
1.5 LHSV
695°F Average Catalyst Temperature

Product nitrogen was 0.2 ppm or less; there was little, if any, reduction of aromatics (41-44% product aromatics). The hydrogen consumption was 125 SCF/bbl. Again, Table VI shows yield periods.

Conclusions: First-Stage Processing. Based on these runs, it is concluded that:

1. ICR 106 is the superior catalyst for nitrogen removal.
2. Both catalysts are very effective for removal of nitrogen to 0.2 ppm or less for feeds containing less than 60 ppm nitrogen and about 40-45% aromatics.
3. Based on the two-pass processing sequence described above, ICR 106 catalyst can completely denitrify feed containing 608 ppm, 68% aromatics, at about 1400 psig hydrogen, 0.75 LHSV. Hydrogen consumption is less than 950 SCF/bbl. The hydrogenation of aromatics appears to be rate limiting.

B. Second-Stage Results

Properties of the second-stage feeds, blended from product of the first-stage runs, are shown in Table VII. The second-stage catalyst was ICR 202 catalyst, containing a Group VIII metal on silica alumina. Pilot Plant Run 45-182 was made with extinction recycle of all material boiling above the recycle cut point. Target conditions were as follows:

1200 psia Hydrogen (1400 psig Total Pressure)
1.1 LHSV
5600 SCF/Bbl Recycle Gas Rate

Conversion and recycle cut point were varied as follows:

1. 60% Per-Pass Conversion Below 350°F
2. 80% Per-Pass Conversion Below 350°F
3. 60-70% Per-Pass Conversion Below 310-320°F

Average catalyst temperatures ranged from 580°F to 615°F, depending on recycle cut point and per-pass conversion.

Table VIII shows results for the denitrified 400°F+ SRC-II feed (SCQ 6671) at 60% per-pass conversion below 350°F. This feed was used for the first 225 hours of the run.

Table IX shows the results for the 350°F+ fraction of denitrified SRC-II (SGQ 6668) at both 60% and 80% conversion below 350°F. These results were obtained between 225 and 385 hours on stream.

Table X shows analyses of the 180-280°F and 280-350°F fractions obtained from the yield periods shown in Table IX. More detailed

compositions of the 180-280°F fractions by two chromatographic and one mass spectrometric method are given in Table XI.

Table XII shows the results for the 350°F+ fraction of denitrified SRC-II (WOW 6668) at a target recycle cut point was 310°F. Actually, the results show that the first yield period (409-457 hours) has a cut point of about 320°F, the second (433-457 hours) a cut point of about 315°F, and the last (505-529 hours) has a cut point close to 310°F. Detailed mass spectrometers and chromatographic analyses of the 180°F+ fractions are given in Table XIII.

Table XIV shows detailed chromatographic analyses of the C₅-180°F fractions obtained at the various conditions describe above.

Conclusions: Second-Stage Hydrocracking. Based on the pilot plant tests, it is concluded that high yields of naphtha suitable for catalytic reforming can be obtained at the conditions studied (1200 psia hydrogen, 1.1 LHSV) by second-stage hydrocracking of denitrified SRC-II process product. Hydrogen consumption is high, ranging from 1550 to 2250 SCF/bbl depending on the feed aromatics (40-50% in the feeds studied), amount of overlap (fresh feed boiling below the recycle cut point), and the recycle cut point. However, depending on the reforming severity, much of the hydrogen can be recovered when the hydrocracked naphtha is converted to high octane gasoline.

Task 4A - Catalytic
Cracking of Partially
Hydrotreated SRC-II

Runs were made in which three hydrotreated SRC-II fractions (350°F+, 400°F+, and 450°F+) were catalytically cracked using an equilibrium catalyst withdrawn from an operating FCC unit. These results will be summarized in the Interim Report now being prepared.

Conclusions and Program
SRC-II Processing

Results on hydrotreating of SRC-II process product with ICR 106 and ICR 113 catalysts are encouraging. Nitrogen removal is less difficult than anticipated; product containing less than 0.5 ppm nitrogen can be obtained in a single catalytic stage. Sulfur and oxygen also can be reduced to low levels; and at high severity, most of the aromatic compounds are converted to naphthenes. As the processing severity is decreased, product nitrogen increases; and the product becomes more aromatic. Of particular interest is the result that at high severity the product includes a jet fraction that passes the stringent JFTOT

thermal stability test and appears to be of premium quality. The naphtha product should be an excellent feed to a catalytic reformer.

At comparable conditions, ICR 106 is more active for nitrogen removal and hydrogenation than is ICR 113. Also, ICR 113 deactivates at a somewhat higher rate. However, ICR 113 is a less expensive catalyst; and the catalyst of choice will depend on the particular refining scheme selected.

Naphtha from the lower severity hydrotreating tests was further hydrotreated using ICR 113 catalyst to make a premium feed for the second stage of a catalytic reformer.

Tests were made in which the 300-550°F product from the lower severity hydrotreating tests were further hydrotreated using either ICR 113 or ICR 106 catalyst to determine the appropriate catalyst and conditions to make jet fuel. ICR 106 proved to be the catalyst of choice.

Experiments were also made in which the 400°F+ SRC-II is initially hydrotreated separately from the naphtha. Based on our results, we see little cost incentive for this alternative processing route; however, in larger refineries some added processing flexibility may be gained.

Tests were reported this quarter in which the partially hydrotreated product from the lower severity tests was hydrocracked to make naphtha using a two-stage hydrocracking process. This appears to be an attractive route to maximize gasoline production.

Process Engineering and cost studies are being completed which include the following cases:

1. A single-stage hydrotreater operated at very high severity with ICR 106 catalyst directly producing reformer feed and acceptable jet fuel.
2. Less severe hydrotreating with ICR 106 to produce naphtha which must be further hydrotreated before reforming and jet fuel which must be further hydrotreated to make smoke point and other specifications.
3. Hydrotreating at lower severity with ICR 113 catalyst to produce a naphtha which must be further hydrotreated before reforming and a feed for a fluid catalytic cracker for gasoline production.
4. Hydrotreating followed by hydrocracking for maximum gasoline production.

5. Hydrotreating at lower severity with ICR 113 catalyst to produce a fuel such as No. 2 heating oil and a naphtha to be further hydrotreated before reforming.

An interim report is being prepared which will include detailed results of all of the pilot plant work on both SRC-I and SRC-II processing and the cost and engineering studies for SRC-II processing.

V. Processing of H-Coal Process Development

Samples of H-Coal process products, both atmospheric overhead and atmospheric bottoms, were received from Hydrocarbon Research, Inc. (HRI). In this section, the properties of these products are described; and early pilot plant results are presented. Comparisons are made with SRC-II.

A. Task 1 - Feedstock Analysis; Properties of H-Coal Process Products

Illinois No. 6 Coal (Burning Star Mine) was liquefied during September 1977 by HRI using the H-Coal process operated in the syncrude mode. Atmospheric overhead and atmospheric bottoms products were sent separately to Chevron Research. The properties of the H-Coal atmospheric overhead and bottoms as analyzed by Chevron Research are shown in Tables XV and XVI, respectively. The net whole process product was reconstituted by blending the atmospheric overhead and bottoms according to instructions from HRI (79 wt % overhead in the whole process product). Most of the properties of the H-Coal whole process product suggest that it will be easier to hydrotreat than SRC-II (Table XVII) described in our previous reports. Compared to SRC-II, the H-Coal whole process product has a seven-degree higher API gravity, approximately 1.5 wt % more hydrogen, 2% less oxygen, and half the nitrogen. However, the H-Coal product has more asphaltenes and ash than does the SRC-II product; and our tests thus far indicate that these properties have made the H-Coal product more difficult to hydroprocess than the SRC-II product.

When we compare the SRC-II and H-Coal process products used as feeds in our studies, we emphasize that these products were made from different coals. The SRC-II is a blend of products, mainly from Kentucky No. 9 and Kentucky No. 14 coals. The SRC-II also includes some products derived from Illinois No. 6 Coal (River King Mine) and West Virginia Coal (Pitt-Seams Blackville No. 2). As noted above, the H-Coal product was derived entirely from Illinois No. 6 Coal and from the Burning Star Mine rather than the River King Mine. According to Dr. E. C. Moroni of the Department of Energy (private communication), Illinois No. 6 River King is more reactive in the liquefaction process than Kentucky No. 9 or No. 13, which are more reactive than Illinois No. 6 Burning Star. Also, although the products from both processes were selected as being "representative," both processes are being

developed; and the ultimate commercial yields and product properties are unknown.

The H-Coal whole process product contains 32 ppm chloride. This is a potential problem since it can form ammonium chloride in the hydrotreater reactor exit line, unless that line is held at a high temperature. Therefore, a portion of the blend was water washed at room temperature. The chloride content of the water-washed portion (WOW 3920) was 1.2 ppm. The inspections in Table XVII indicate that the water wash also removed some heteroatoms. During the wash, 3.7 wt % of the oil was lost. Most of this loss was due to oil which came out of the mixing tank as a separate phase with the last wash water.

B. Task 2 - Hydrotreating of
H-Coal Whole Process
Product; Early Pilot
Plant Results

The pilot plant hydrotreating of the H-Coal whole process product is described in three sections: run conditions and startup procedure, pilot plant operation, and early pilot plant yields and product properties.

1. Run Condition and
Startup Procedure

A pilot plant run (76-170) was started with the H-Coal whole process product (WOW 3919) and ICR 106 catalyst. The process conditions at startup run were 1.0 LHSV, 750°F, 2500 psig, 2300 psia hydrogen, and 15,000 SCFB recycle gas. The large recycle gas rate was used to compensate for expected ammonium chloride plugs from the nonwashed feed. After 563 hours, the water-washed feed (WOW 3920) was used; and the recycle gas rate was reduced to 8000 SCFB. The startup procedure simulated a commercial procedure and was the same as that used previously in our SRC-II and shale oil studies. The liquid hourly space velocity was changed to give data at a variety of severities (Table XVIII).

2. Pilot Plant Operation

Throughout all of this run, the pilot plant operated erratically due to flow restrictions. On several occasions, these restrictions caused a temporary reduction in the recycle gas rate. This is believed to be the cause of the activity loss noted in our last report. At 1411

hours a flow restriction blocked the reactor completely. The reactor was cooled, depressurized, and disassembled. Ammonium chloride plugs in the reactor exit were not found, but the top 3 in. of the alundum preheat section were found to be plugged. A preliminary analysis showed that the deposit contained approximately 20% iron and the remainder mostly carbon. We believe the ash and asphaltenes in the oil caused this plug. The H-Coal whole process blend is being filtered through diatomaceous earth in an attempt to remove the ash and some of the asphaltenes. If this fails, we will rerun the oil. We are hesitant to rerun the oil because it may be contaminated by the 800°F+ chaser oil that must be used in the distillation. We believe that the ash and most of the asphaltenes will not be present in a commercial product since the commercial distillation equipment can be designed to remove them. The asphaltenes could have been caused by oxidation during the two years that this oil has been stored.

The nonporous alundum preheat was replaced, and the ICR 106 catalyst was not disturbed. The reactor was placed in service with the water-washed feed (WOW 3920). Currently, the product nitrogen is 0.5 ppm (Table XVIII). This run will be continued to see if a considerable amount of hydrogenation activity has been lost. If this has happened, a new run will be started. We have confidence that the data taken prior to the plug are acceptable.

3. Yields and Product Properties

The yields and product properties that are currently available will be described first. Then a comparison will be made with the data from SRC-II.

The yields and whole liquid product inspections are shown in these tables:

	LHSV	Hr
Table XIX	1.0	70-334
Table XX	1.5	803-923
Table XXI	0.5	1139-1235

The yields and inspections of the distilled products that are currently available are also shown in three tables.

	LHSV	Hr
Table XXII	1.0	539-707
Table XXIII	1.5	875-923
Table XXIV	0.5	1163-1235

At 1.0 LHSV and prior to any deactivation by flow restrictions, the yield of C_1-C_4 gas was less than 1 wt %; and yield of C_5+ liquid was 108 LV %. Hydrogen consumption was 2100 SCFB, and the whole liquid product contained approximately 10 LV % aromatics and <0.5 ppm nitrogen. The smoke point of the whole liquid product was greater than 20, the jet fuel specification minimum, but the smoke point of the 300°F+ product was only approximately 17.

At 1.5 LHSV, the yield of C_5+ liquid product was 105 LV %; and the hydrogen consumption was 1300 SCFB. The whole liquid product contained approximately 10 ppm nitrogen and approximately 38 LV % aromatics. The smoke point of the 300°F+ product was only 13.

The data at 0.5 LHSV were taken after some loss of activity from the flow restrictions. Consequently, the data at 0.5 LHSV are only slightly better than those taken 1.0 LHSV early in the run. At 0.5 LHSV the aromatics are still at 10 LV %, hydrogen consumption is 2100 SCFB, and the whole liquid product contains <0.5 ppm nitrogen. Smoke points are incomplete.

At all severities, the yield of light naphtha ($C_5-180^\circ\text{F}$) is between 4.5 and 6.5 LV %. Inspections of this material are incomplete.

The yield of heavy naphtha increased from 24 LV % at 1.5 LHSV to 26 LV % at 0.5 LHSV. Inspections of this material are incomplete.

A very important difference between SRC-II and H-Coal whole process products is the 1.5 wt % higher hydrogen content of the H-Coal product. To make a low aromatic product, less hydrogen has to be consumed with the H-Coal whole process product than SRC-II product. This advantage is about 700 SCFB (Figure 4). However, we realize that this advantage is only in hydroprocessing of the liquefied product. The hydrogen consumption during the liquefaction must be included, and we do not know this information. H-Coal whole process product could also

be hydroprocessed at a higher LHSV, although the amount of this benefit is not known yet. When SRC-II product was processed at 0.5 LHSV, an acceptable jet product (smoke point greater than 20) was made. We anticipate that an acceptable jet product can be made when H-Coal whole process product is processed at 0.5 LHSV on a catalyst which has not been deactivated.

In summary, these early results indicate that the H-Coal whole process product can be hydroprocessed to make a jet fuel similar to that from SRC-II. H-Coal whole process product requires 700 SCFB less hydrogen during hydrotreating than does the SRC-II product. However, the ash and asphaltene content of the sample of H-Coal whole process product that we have used has made this oil difficult to hydroprocess.

This run will be continued to determine how much activity was lost during the plugging. We will also determine the yields and product properties at other severities and the rate of catalyst deactivation.

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FROM COAL AND OIL SHALES
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TABLE I

DOE CONTRACT EF-76-C-01-2315
PROPERTIES OF SRC-II PROCESS PRODUCTS

Description	Whole SRC-II WOW 3666	SRC-II Naphtha WOW 3750	400°F+ SRC-II WOW 3751
Chevron Identification			
Wt % of Whole SRC-II	100	29	71
<u>Inspections</u>			
Gravity, °API	18.6	36.2	10.7
Aniline Point, °F	<30	56.4	-
Sulfur, Wt %	0.29	0.26	0.25
Total Nitrogen, Wt %	0.85	0.42	0.99
Basic Nitrogen, Wt %	0.7		0.82
Oxygen, Wt %	3.79	3.51	3.63
Carbon, Wt %*	82.82	84.22	86.61/86.18
Hydrogen, Wt %*	9.24	12.23	8.77/9.54
Hydrogen/Carbon Atom Ratio*	1.33	1.73	1.21/1.32
Chloride, ppm	50	18/20	77/62/81
Pour Point, °F	Below -80	-	-50
<u>Group Type, LV %</u>			
Paraffins	-	23	-
Naphthenes	-	38	-
Olefins	-	5	-
Aromatics	-	34	-
Ramsbottom Carbon, Wt %	0.70	-	0.81
Hot Heptane Asphaltenes, ppm	468	-	2200
Benzene Insolubles, Wt %	<0.03	-	<0.03
Refractive Index (80°C)	1.5073	-	1.5340
Ash, Wt %	0.004	-	0.010
Molecular Weight	132	118	160
Bromine Number	70	49/52	69
<u>Viscosity, cSt</u>			
at 100°F	2.196	0.8933	4.213
at 130°F	1.617	-	-
at 210°F	-	-	1.238
<u>ASTM Distillation, °F</u>	D 86/D 1160	D 86	D 1160
St/5	154/217	151/179	393/413
10/30	281/382	197/249	427/448
50	438	290	471
70/90	484/597	332/366	506/590
95/EP	699/850	380/393	662/847
% Overhead (Excl. Trap)	98	98	99
% in Flask	0	1	1
% Trap	2	1	0
<u>TBP Distillation, °F</u> (Simulated by Chromatography)			
St/5	56/189	53/153	233/366
10/30	241/379	173/235	382/430
50	424	291	477
70/90	473/562	345/395	527/639
95/99	642/820	408/442	707/849

*Analysis being checked.

TABLE II

DOE CONTRACT EF-76-C-01-2315
FEEDS FOR HYDROCRACKER FIRST-STAGE PILOT PLANT TESTS

Feed Identification	350°F+ From Hydrotreated Whole SRC II			Hydrotreated 400°F+ SRC II	
	SGQ 6631	SGQ 6664-1	SGQ 6664-2	SGQ 6554	SGQ 6621
Gravity, °API	22.0	24.2	24.8	29.7	29.1
Aniline Point, °F	<32	37.1	44.6	68.6	
Sulfur, ppm	6.3				
Nitrogen, ppm	608	8.7	7.5	60	22
Oxygen, ppm	4700			820	
Group Type, LV %	*				
Paraffins	5.1/6.8	3.7	3.8	2.0	2.2
Naphthenes	26.9/27.1	33.3	35.7	55.4	53.9
Aromatics	68.0/66.2	63.0	60.6	42.5	43.9
TBP Distillation, °F (Simulated by Chromatography)					
ST/5	317/363	100/336	136/335	94/212	98/220
10/30	380/418	363/408	363/407	240/356	257/370
50	452	445	443	413	424
70/90	494/568	486/551	483/549	465/544	473/549
95/99	612/715	597/698	593/694	597/708	608/729
ASTM D 86 Distillation, °F					
ST/5	388/402			225/254	
10/30	408/423			280/366	
50	433			419	
70/90	467/539			459/529	
95/EP	590/676			584/645	
% Overhead	99			98.5	
Overlap, Wt % Below 350°F by TBP	2.2	6.5	6.6	26.7	23.3

*Second set of numbers shown for the group type of SGQ-6631 are by the "22-component" method (see Table III); all other group-type analyses by the "high mass" method.

TABLE III

DOE CONTRACT EF-76-C-01-2315
 DETAILED MASS SPECTROMETRIC ANALYSIS
 OF 350°F+ HYDROTREATED SRC-II, SGQ 6631,
 BY 22-COMPONENT METHOD

Composition, LV %	
C(N)H(2N+2) Paraffins	6.8
C(N)H(2N) Monocycloparaffins	10.0
C(N)H(2N-2) Dicycloparaffins	9.3
C(N)H(2N-4) Tricycloparaffins	7.8
Total Saturates	33.9
Monoaromatics	
C(N)H(2N-6) Alkylbenzenes	19.3
C(N)H(2N-8) Benzocycloparaffins	24.7
C(N)H(2N-10) Benzodicycloparaffins	6.0
Diaromatics	
C(N)H(2N-12) Naphthalenes	9.3
C(N)H(2N-14)	3.4
C(N)H(2N-16)	3.0
Triaromatics	
C(N)H(2N-18)	0.4
Total Aromatics	66.1
Calculated Weight % Carbon = 88.5	
Calculated Weight % Hydrogen = 11.4	

TABLE IV

DOE CONTRACT EF-76-C-01-2315
 SUMMARY OF RESULTS: FIRST-STAGE HYDROCRACKER

HDN of Partially Hydrotreated SRC-II
Runs 72-327, 72-328

Catalyst	Conditions			Nitrogen, ppm		Aromatics, LV %		H ₂ Consumption, SCF/B
	Temp., °F	H ₂ , psia	LHSV	Feed	Product	Feed	Product	
ICR 113	643	1150	1.5	60	0.2	42	38	250
	700	1150	1.5	608	12	68	65	300
	736	1150	1.5	608	4	68	64	300
	736	1375	1.5	608	3	68	64	330
ICR 106	695	1375	1.5	608	3.5	68	62	525
	695	1400	1.5	8	0.2	62	48	425
	695	1130	1.5	22	0.2	44	42	125

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TABLE V
DOE CONTRACT EF-76-C-01-2315
FIRST-STAGE HYDROCRACKER WITH ICR 113
HDN OF PARTIALLY HYDROTREATED SRC-II - RUN 72-327

Feed	SGQ 6554		SGQ 6554		SGQ 6631		SGQ 6631	
	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
Feed Nitrogen, ppm	60		60		608		608	
Feed Aromatics, Wt %	42		42		68		68	
Run Hours	61-85		85-107		169-181		193-205	
Avg. Cat. Temp., °F	643		643		736		736	
LHSV	1.52		1.52		1.52		1.51	
Total Pressure, psig	1297		1301		1305		1601	
H ₂ Mean Pressure, psia	1150		1159		1142		1381	
Total Gas In, SCF/Bbl	4360		4460		4682		4241	
Recycle Gas, SCF/Bbl	4079		4136		4335		3849	
No Loss Prod. Yields	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
C ₁	0.01		0.01		0.03		0.05	
C ₂	0.01		0.01		0.07		0.10	
C ₃	0.07		0.05		0.08		0.11	
iC ₄	0.01	0.02	0.02	0.03	0.01	0.01	0.01	0.01
nC ₄	0.04	0.05	0.04	0.05	0.03	0.04	0.03	0.05
Total C ₅	100.19	101.07	100.28	100.91	99.69	100.73	99.68	101.04
Act./No Loss Recovery	100.52/100.39		100.45/100.46		100.50/100.50		98.06/100.55	
H ₂ Cons. (Gross), SCF/Bbl	281		323		347		391	
H ₂ Cons. (Chemical), SCF/Bbl	222		267		300		332	
Whole Liquid Prod. Prop.								
Gravity, °API	31.1		30.7		23.6		24.1	
Aniline Point, °F	78.3		77.3		32.0		35.9	
Nitrogen, ppm	0.16		0.23		3.9		2.6	
Group Type, LV %								
Paraffins	1.8		1.7		3.7		3.9	
Naphthenes	62.0		60.2		32.0		32.3	
Aromatics	36.2		38.0		64.2		63.8	
TBP Distillation, °F (Simulated by Chromatography)								
St/5	82/217		96/217		52/338		96/337	
10/30	243/362		244/363		364/409		363/408	
50	410		412		446		445	
70/90	464/538		466/540		488/555		486/551	
95/99	592/713		594/712		603/706		598/700	

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TABLE VI
DOE CONTRACT EF-76-C-01-2315
FIRST-STAGE HYDROCRACKER WITH ICR-106 CATALYST
HDN OF PARTIALLY HYDROTREATED SRC-II
RUN 72-328

Feed Identification	SGQ 6631		SGQ 6664				SGQ 6621			
	Feed Nitrogen, ppm	608		8				22		
Feed Aromatics, %	68		62				44			
Run Hours	93-117		261-285		285-309		381-405		429-453	
Avg. Cat. Temp., °F	698		695		695		695		696	
LHSV	1.50		1.50		1.50		1.50		1.50	
Total Pressure, psig	1601		1596		1593		1291		1296	
H ₂ Mean Pressure, psia	1455		1415		1409		1138		1134	
Total Gas in, SCF/Bbl	6282		4664		4745		4376		3828	
Recycle Gas, SCF/Bbl	5702		4163		4262		4177		3754	
No Loss Prod. Yields	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
C ₁	0.02		0.01		0.01		0.01		0.01	
C ₂	0.04		0.01		0.04		0.03		0.02	
C ₃	0.10		0.16		0.17		0.10		0.09	
iC ₄	0.01	0.02	0.02	0.03	0.02	0.04	0.01	0.02	0.02	0.02
nC ₄	0.03	0.05	0.05	0.07	0.04	0.06	0.04	0.06	0.04	0.06
Total C ₅ ⁺	100.08	101.78	100.52	102.72	100.45	102.52	100.07	100.91	100.05	100.76
Actual/No Loss Recov.	101.53/100.86		100.55/100.75		101.20/100.72		100.89/100.23		100.43/100.20	
H ₂ Cons. (Gross), SCF/Bbl	577		503		480		195		171	
H ₂ Cons. (Chemical), SCF/Bbl	520		447		427		134		115	
Whole Liquid Product Properties										
Gravity, °API	24.6		27.7		27.5		30.8		30.2	
Aniline Point, °F	40.5		65.3				68.7		70.8	
Sulfur, ppm							2.6			
Nitrogen, ppm	3.5		0.24		0.21		0.1		0.2	
Oxygen, ppm	330						110			
Group Type, LV %										
Paraffins	3.8		4.5				2.3		2.2	
Naphthenes	34.0		47.1				53.5		57.2	
Aromatics	62.2		48.4				44.2		40.6	
TBP Distillation, °F (Simulated by Chromatography)										
St/5	51/335		48/278				46/214		85/216	
10/30	362/408		346/394				243/360		248/362	
50	444		425				410		413	
70/90	484/549		467/532				460/538		463/542	
95/99	591/689		575/675				542/719		597/715	

TABLE VII

DOE CONTRACT EF-76-C-01-2315

DOE: Feeds for Second-Stage Hydrocracker*

	SGQ 6668	SGQ 6671-1	SGQ 6771-2
Gravity, °API	27.7	30.4	30.2
Aniline Point, °F	63.3	68.7	70.8
Sulfur, ppm	5.5	2.6	
Nitrogen, ppm	0.39/0.42	0.23/0.1	0.20/0.19
Oxygen, ppm		110	
Group Type, LV %			
Paraffins	4.5	2.3	2.2
Naphthenes	46.3	53.5	57.2
Aromatics	49.2	44.2	40.6
Hydrogen, Wt %	I	12.82	12.79
Carbon, Wt %	I	87.50	87.20
Molecular Weight	162		
Density at 70°C	0.8500		
Refractive Index at 80°C	1.4644		
TBP Distillation, °F (Simulated by Chromatography)			
St/5	52/274	58/216	85/216
10/30	344/396	252/364	248/362
50	428	410	413
70/90	469/536	460/538	463/542
95/99	579/684	588/699	597/715
Overlap, Wt % Below 350°F by TBP	10.2	23.8	25.1

*Second-stage feeds prepared over ICR 106 catalyst in Run 72-328 as follows:

SGQ 6668 = HDN product from SGQ 6631 (hydrotreated 350°F+ fraction of whole SRC-II).

SGQ 6671-1 and SGQ 6671-2 = HDN product from SGQ 6621 (hydrotreated 400°F+ SRC-II).

I = Incomplete

TABLE VIII

DOE CONTRACT EF-76-C-01-2315
HYDROCRACKING OF DENITRIFIED 400°F+ SRC-II
WITH ICR 202 CATALYST AT 350°F RECYCLE CUT POINT

Pilot Plant Run 45-182; Feed - SQG 6671

Run Hours	97-121		169-193		193-217	
Average Cat. Temp., °F	569		581		586	
LHSV	1.10		1.10		1.10	
Per Pass Conversion	55.01		58.07		60.27	
Total Pressure, psig	1397		1396		1396	
H ₂ Mean Pressure, psia	1223		1219		1222	
Total Gas in, SCF/B	6781		6786		6792	
Recycle Gas, SCF/B	5865		5785		5761	
No Loss Prod. Yields	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
C ₁	0.01		0.01		0.01	
C ₂	0.07		0.08		0.08	
C ₃	1.80		1.98		1.97	
iC ₄	10.75	16.68	11.37	17.67	11.23	17.44
nC ₄	1.77	2.66	1.99	2.98	1.97	2.94
C ₅ -180°F	16.15	20.42	17.44	22.13	16.92	21.47
180-350°F	69.44	77.03	70.03	77.83	70.69	78.82
Total C ₅ +	85.59	97.45	87.47	99.96	87.60	100.30
Act./No Loss Recov.	98.75/102.73		100.41/102.86		99.51/102.83	
H ₂ Cons. (Gross), SCF/B	1664		1722		1711	
H ₂ Cons. (Chemical), SCF/B	1569		1649		1628	
Inspections						
C ₅ -180°F						
Gravity, °API	73.2		73.7		73.8	
Octane No.						
F-1 Clear	90.6		90.0		90.5	
F-2 Clear	85.0		84.9		84.7	
Group Type, LV %						
Paraffins	60.5		59.4		62.5	
Naphthenes	33.2		35.1		32.3	
Aromatics	6.4		5.5		5.1	
180-350°F						
Gravity, °API	48.1		48.2		48.8	
Aniline Point, °F	110.6		110.3		110.4	
Octane No.						
F-1 Clear			68.8/68.4		69.1	
F-2 Clear	67.4		68.4		68.9	
Group Type, LV %						
(Low Mass)						
Paraffins	6.4		I		7.6	
Naphthenes	85.8				85.6	
Aromatics	7.8				6.8	
Group Type, LV %						
(By Chromatography)						
Paraffins	7.4		10.2		7.7	
Naphthenes	85.0		82.3		84.8	
Aromatics	5.6		7.5		7.5	
TBP Distillation, °F						
(Simulated By Chromatography)						
ST/5	165/197		163/196		134/187	
10/30	211/238		202/235		196/228	
50	271		269		258	
70/90	312/340		309/340		301/336	
95/99	346/354		348/356		344/354	
ASTM D 86 Distillation, °F						
ST/5			222/228		220/228	
10/30			232/243		231/246	
50			262		263	
70/90			287/319		290/320	
95/EP			326/330		327/364	
% Overhead (Excl. Trap)			99		98.5	
% in Trap			-		1.0	

I = Incomplete.

TABLE IX

DOE CONTRACT EF-76-C-01-2315
 HYDROCRACKING OF DENITRIFIED 350°F+ SRC-II WITH ICR 202 CATALYST
 AT 350°F RECYCLE CUT POINT; EFFECT OF PER PASS CONVERSION (60% TO 80%)

Pilot Plant Run 45-182; Feed - SQQ 6668

Run Hours	241-265		265-289		337-361		361-385	
Avg. Cat. Temp., °F	592		593		614		616	
LHSV	1.10		1.10		1.10		1.10	
Per Pass Conversion	58.16		58.52		80.81		81.46	
Total Pressure, psig	1398		1397		1397		1397	
H ₂ Mean Pressure, psia	1219		1212		1183		1192	
Total Gas in, SCF/B	7025		6965		7313		7331	
Recycle Gas, SCF/B	5859		5779		5647		5657	
No Loss Prod. Yields	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
C ₁	0.01		0.01		0.01		0.01	
C ₂	0.10		0.10		0.14		0.13	
C ₃	2.27		2.43		2.73		2.58	
iC ₄	12.79	20.18	13.48	21.28	13.03	20.57	12.48	19.71
nC ₄	2.36	3.58	2.61	3.97	2.88	4.38	2.80	4.26
C ₅ -180°F	19.80	25.47	19.28	25.03	22.71	29.19	22.19	28.47
180-350°F	65.98	74.40	65.46	74.01	61.95	70.35	63.22	71.62
Total C ₅ +	85.78	99.88	84.74	99.03	84.66	99.54	85.41	100.09
Act./No Loss Recov.	101.30/103.28		102.71/103.35		101.27/103.41		100.38/103.39	
H ₂ Cons. (Gross), SCF/B	2005		2027		2061		2053	
H ₂ Cons. (Chemical), SCF/B	1918		1960		1999		1985	
Product Inspections								
C ₅ -180°F								
Gravity, °API	73.4		75.1		73.1		72.9	
Octane No.								
F-1 Clear	90.5		90.0		90.4			
F-2 Clear	84.3		85.0		84.5			
Group Type, LV %								
Paraffins	61.8		63.2		60.4			
Naphthenes	32.3		31.8		33.8			
Aromatics	5.9		5.0		5.8			
180-350°F								
Gravity, °API	48.0		48.5		48.6		48.8	
Aniline Point, °F	110.7		109.4		109.1			
Octane No.								
F-1 Clear	69.6		69.1		69.6		70.6	
F-2 Clear	68.8		69.1		69.0		69.4	
Group Type, LV % (Low Mass)								
Paraffins	8.8		9.4		10.1		6.9	
Naphthenes	83.7		83.2		81.2		86.1	
Aromatics	7.5		7.4		8.6		6.9	
Group Type, LV % (By Chromatography)								
Paraffins			13.0					
Naphthenes			78.9					
Aromatics			8.0					
TBP Distillation, °F (Simulated By Chromatography)								
ST/5	160/195		140/185		162/195		143/190	
10/30	200/232		196/224		202/227		198/226	
50	269		259		257		256	
70/90	317/344		314/342		304/343		301/342	
95/99	350/358		349/358		353/363		351/362	
ASTM D 86 Distillation, °F								
ST/5	222/226		212/220		213/223		213/211	
10/30	231/250		227/240		227/242		224/239	
50	271		262		259		259	
70/90	301/326		292/322		288/322		288/322	
95/EP	333/353		328/332		331/352		331/376	
% Overhead (Excl. Trap)	97.5		98		98		98	
% in Trap	2.0		1		1.5		1.5	

TABLE X

DOE CONTRACT EF-76-C-01-2315
 PROPERTIES OF 180-280°F AND 280°F+ PRODUCT
 HYDROCRACKING OF DENITRIFIED 350°F+ SRC-II
 WITH ICR 202 CATALYST AT 350°F RECYCLE CUT POINT
 PILOT PLANT RUN 45-182; FEED - SGQ 6668

Run Hours	265-289	337-361	361-385
Average Catalyst Temperature, °F	593	614	616
LHSV	1.10	1.10	1.10
180-280°F Product			
Wt % of Fresh Feed	37.55	37.25	38.18
LV % of Fresh Feed	43.59	43.22	44.23
Gravity, °API	53.3	53.2	52.9
Aniline Point, °F	106.1	106.5	104.6
Octane Number			
F-1 Clear	77.3	77.1	77.3
F-2 Clear	74.5	74.1	74.2
Group Type, LV % (Low Mass)			
Paraffins	12.3	15.1	14.6
Naphthenes	79.4	76.0	75.7
Aromatics	8.3	9.0	9.7
Group Type, LV % (By Chromatography)			
Paraffins	12.6		
Naphthenes	78.6		
Aromatics	8.8		
TBP Distillation, °F (Simulated by Chromatography)			
St/5	139/168	157/189	139/175
10/30	194/214	197/217	195/217
50	229	230	230
70/90	250/271	250/273	250/274
95/99	281/290	281/291	282/294
280-350°F Product			
Wt % of Fresh Feed	27.91	24.70	25.04
LV % of Fresh Feed	30.42	27.13	27.39
Gravity, °API	42.0	43.4	42.6
Aniline Point, °F	117.5	114.8	114.0
Octane Number			
F-1 Clear	58.4		
F-2 Clear	60.0		
Group Type, LV % (Low Mass)			
Paraffins	8.5	9.6	9.5
Naphthenes	84.5	81.7	81.4
Aromatics	7.0	8.7	9.2
TBP Distillation, °F (Simulated by Chromatography)			
St/5	258/285	251/279	253/278
10/30	296/322	287/313	286/313
50	338	331	331
70/90	350/362	345/360	345/360
95/99	365/371	364/370	365/370

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DOE CONTRACT EF-76-C-01-2315
 DETAILED COMPOSITION OF 180-280°F PRODUCT BY THREE ANALYTICAL METHODS
 HYDROCRACKING OF SRC-II WITH ICR 202
 PILOT PLANT RUN 45-182

Time Onstream, Hr Method	265-289			337-361		361-385	
	Chromatographic Procedure 1001	PNA By Chromatography	Low Mass	Chromatographic Procedure 1001	Low Mass	Chromatographic Procedure 1001	Low Mass
Composition, LV %	(*)			(*)		(*)	
Paraffins							
C ₆ -	0.7	0.7		0.1		0.4	
iC ₇	6.2	6.6		6.6		6.0	
nC ₇	0.4			0.4		0.4	
iC ₈	4.0	4.4		3.9		4.1	
nC ₈	0.2			0.3		0.2	
iC ₉	3.9	0.9		3.0		3.2	
nC ₉	-	-		-		0.05	
C ₁₀ 's	0.3	-		0.4		0.3	
Total Paraffins	15.7	12.6	12.3	14.7	15.1	14.7	14.6
Naphthenes							
Methylcyclopentane	4.4	5.8		1.8		3.6	
Cyclohexane	1.5			1.3		1.3	
C ₇ -Cyclopentanes	23.6	38.5		25.6		23.4	
Methylcyclohexane	18.2			18.9		17.9	
C ₈ -Cyclopentanes	8.6	29.5		12.0		9.3	
C ₈ -Cyclohexanes	15.3			15.5		14.6	
C ₉ -Cyclopentanes	0.2	4.9		0.3		0.7	
C ₉ -Cyclohexanes	1.3			2.2		2.5	
Total Naphthenes	73.1	78.6	79.4	77.6	76.0	73.3	75.7
Aromatics							
Benzene	0.9	0.9	0.7	0.3	0.5	0.7	0.8
Toluene	4.9	4.9	4.9	1.4	5.8	5.8	6.0
Ethylbenzene	3.1	3.0	2.7	3.2	2.7	3.4	2.8
Xylenes	1.4			1.6		1.3	
Total Aromatics	10.3	8.8	8.3	6.5	9.0	11.2	9.7
Unidentified	0.9	-	-	1.2	-	0.8	-

*Although Chromatographic Procedure 1001 gives the most detailed breakdown, some C₈-C₉ naphthenes are misidentified as C₉-C₁₀ paraffins by this method. Also, the peak identified as ethylbenzene appears to contain saturates.

TABLE XII

DOE CONTRACT EF-76-C-01-2315
 HYDROCRACKING OF DENITRIFIED 350°F+
 SRC-II WITH ICR 202 CATALYST AT 310°F RECYCLE CUT POINT*

Pilot Plant Run 45-182; Feed - SGQ 6668

Run Hours	409-433		433-457		505-529	
Avg. Cat. Temp., °F	614		615		612	
LHSV	1.10		1.10		1.10	
Per Pass Conversion	68.55		67.92		58.29	
Total Pressure, psig	1397		1397		1396	
H ₂ Mean Pressure, psia	1193		1194		1206	
Total Gas in, SCF/B	7228		7255		7052	
Recycle Gas, SCF/B	5671		5699		5706	
No Loss Prod. Yields	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
C ₁	0.02		0.02		0.01	
C ₂	0.16		0.15		0.15	
C ₃	3.28		3.08		3.33	
iC ₄	16.83	26.55	16.21	25.58	18.24	28.79
nC ₄	3.37	5.12	3.19	4.85	3.40	5.17
C ₅ -180°F	26.29	33.76	27.72	35.44	28.14	36.01
180-310°F*	53.92	62.15	53.44	61.50	50.53	58.20
Total C ₅ +	80.21	95.91	81.18	96.94	78.68	94.22
Act./No Loss Recov.	103.98/103.83		100.96/103.79		103.28/103.78	
H ₂ Cons. (Gross), SCF/B	2270		2291		2310	
H ₂ Cons. (Chemical), SCF/B	2242		2214		2208	
Inspections						
C ₅ -180°F						
Gravity, °API	73.0		72.0		72.2	
Octane No.						
F-1 Clear	90.2		I			
F-2 Clear	84.5		84.0			
Group Type, LV %						
Paraffins	60.3		56.3			
Naphthenes	34.8		38.8			
Aromatics	4.9		4.9			
180-310°F						
Gravity, °API	52.0		51.7		51.9	
Aniline Point, °F	108.1		107.8		108.7	
Octane No.						
F-1 Clear	75.1		74.9		74.3	
F-2 Clear	74.1					
Group Type, LV % (Low Mass)						
Paraffins	13.4		10.8		10.4	
Naphthenes	75.9		80.0		81.8	
Aromatics	10.7		9.2		7.8	
Group Type, LV %						
(By Chromatography)						
Paraffins	11.9		11.9		11.9	
Naphthenes	78.8		79.9		79.3	
Aromatics	9.4		8.2		8.8	
TBP Distillation, °F						
(Simulated By Chromatography)						
ST/5	150/190		142/186		159/194	
10/30	198/223		196/222		201/224	
50	247		244		245	
70/90	276/310		273/305		273/302	
95/11	320/327		315/324		309/318	
ASTM D 86 Distillation, °F						
ST/5	210/218		208/216		212/218	
10/30	221/230		218/229		220/230	
50	240		239		238	
70/90	259/288		256/286		255/280	
95/EP	296/326		297/303		288/322	
% Overhead (Excl. Trap)	99		97		99	
% in Trap	-		2.5		-	

I = Incomplete.

*Although the nominal cut point was 310°F for these three periods, the results show the actual cut point is about 5°F lower in the second period than in the first and 10°F lower in the third than the first.

TABLE XIII

DOE CONTRACT EF-76-C-01-2315
 DETAILED COMPOSITION OF 180°F+ PRODUCT BY
 THREE ANALYTICAL METHODS; HYDROCRACKING OF
 HYDROTREATED SRC-II WITH ICR 202; PILOT PLANT RUN 45-182

Approximate Boiling Range, °F	180-320			180-315			180-310		
	409-433			433-457			515-529		
	Chromatographic Procedure 1001 ¹	PNA by Chromatography	Low Mass	Chromatographic Procedure 1001 ¹	PNA by Chromatography	Low Mass	Chromatographic Procedure 1001 ¹	PNA by Chromatography	Low Mass
Time Onstream, Hr									
Method									
Composition, LV %									
Paraffins									
C ₆ -	0.2	0.2		0.2	0.3		-	0.03	
iC ₇	4.6	5.0		4.5	4.9		4.8	5.3	
nC ₇	0.3			0.3			0.3		
iC ₈	3.2	3.6		3.3	3.7		3.2	3.5	
nC ₈	0.2			0.2			0.2		
C ₉ 's	(5.0)	2.0		(4.5)	2.0		(4.8)	2.2	
C ₁₀ 's	(4.4)	1.1		(6.2)	1.0		(4.9)	1.0	
Total Paraffins	(17.9)	11.9	13.4	(19.2)	11.9	10.8	(18.2)	12.0	10.4
Naphthenes									
Methylcyclopentane	2.1	3.0		2.7	3.7		1.1	1.9	
Cyclohexane	0.9			1.1			0.9		
C ₇ -Cyclopentanes	17.8	28.4		17.6	29.0		18.6	30.6	
Methylcyclohexane	14.2			14.5			13.4		
C ₈ -Cyclopentanes	(6.8)	22.3		(7.0)	23.2		(8.9)	23.4	
C ₈ -Cyclohexanes	(11.3)			(11.6)			(12.0)		
C ₉ -Cyclopentanes	(1.5)	16.4		(1.9)	16.8		(1.8)	18.4	
C ₉ -Cyclohexanes	(7.9)			(7.8)			(8.6)		
C ₁₀ -Naphthenes	-	8.6		-	7.2		-	4.9	
Total Naphthenes	62.5	78.7	75.9 ²	(64.2)	79.9	80.0 ³	(65.3)	79.2	81.8 ⁴
Aromatics									
Benzene	0.3	0.3	0.6	0.3	0.4	0.5	0.1	0.1	0.2
Toluene	4.2	4.0	4.8	4.4	2.8	4.5	4.0	4.2	4.1
Ethylbenzene	(2.9)	3.5	3.8	(3.0)	3.8	3.3	(1.2)	3.8	3.1
Xylenes	2.5						2.5		
C ₉ Aromatics	(2.8)	1.5	1.6	(2.1)	1.2	0.4	(2.2)	0.6	0.4
Total Aromatics	(12.7)	9.3	10.7	(12.3)	8.2	9.2	(11.7)	8.7	7.8
Unidentified	6.9	-	-	4.3	-	-	4.8	-	-

¹Although chromatographic procedure 1001 gives the most detailed breakdown, it is obvious that there is a considerable amount of misidentification of peaks due to the large number of compounds present. Numbers shown in parenthesis appear to be in error.

²Includes 4.3 LV % dinaphthenes.

³Includes 3.1 LV % dinaphthenes.

⁴Includes 2.2 LV % dinaphthenes.

TABLE XIV

DOE CONTRACT EF-76-C-01-2315
 DISTRIBUTION OF C₅-180°F PRODUCT FROM
 SECOND-STAGE HYDROCRACKER - RUN 45-182

Time Onstream, Hr	97-121	169-193	193-217	241-265	265-289	337-361	409-433	433-457
Avg. Catalyst Temperature, °F	569	581	586	592	593	614	614	615
Composition, LV % of C ₅ -180°F (By Chromatography)								
n-Butane	0.02	0.02	-	0.03	0.03	0.02	0.03	0.03
Isopentane	37.4	37.3	38.0	38.0	40.1	34.9	35.1	(28.9)*
n-Pentane	2.0	2.2	2.4	2.4	2.6	2.5	2.0	2.7
2,2-Dimethylbutane	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05
2,3-Dimethylbutane	2.6	2.4	2.6	2.5	2.4	2.8	2.7	2.8
2-Methylpentane	9.8	9.1	9.6	9.8	9.4	10.7	10.4	10.9
3-Methylpentane	6.0	5.6	5.8	6.1	5.8	6.6	6.4	6.6
n-Hexane	1.1	1.0	1.0	1.0	0.9	1.0	1.0	1.0
Isoheptanes	1.6	1.7	3.1	1.9	1.9	1.8	2.6	3.3
n-Heptane	-	-	-	-	-	-	-	-
C ₈ Isoparaffins	-	-	-	-	-	-	-	-
Total Paraffins	60.5	59.4	62.5	61.8	63.2	60.4	60.3	56.3
Cyclopentane	0.9	0.9	1.0	1.0	0.9	1.3	1.2	1.3
Methylcyclopentane	27.6	29.8	24.8	27.9	27.6	29.2	29.7	31.6
Cyclohexane	3.8	3.5	4.1	2.3	2.1	2.4	2.2	3.4
Dimethylcyclopentanes, Ethylcyclopentane	0.9	0.9	2.4	1.1	1.2	0.9	1.6	2.4
Methylcyclohexane	-	0.02	-	-	0.04	-	-	0.1
Total Naphthenes	33.2	35.1	32.3	32.2	31.8	33.8	34.8	38.8
Benzene	6.4	5.5	5.1	5.9	5.0	5.8	4.9	4.9
Toluene	-	-	-	-	-	-	0.02	0.01
Total Aromatics	6.4	5.5	5.1	5.9	5.0	5.8	4.9	4.9
Isopentane/n-Pentane	18	17	16	16	16	14	17	(11)*
Isohexane/n-Hexane	17	17	18	19	20	19	20	21

*Measured isopentane appears low; probable loss in sample handling.

TABLE XV

DOE CONTRACT EF-76-C-01-2315
 PROPERTIES OF H-COAL ATMOSPHERIC OVERHEAD PRODUCT FROM HRI

Chevron Identification WOW- HRI Identification LO-	3895 1460	3896 1461	3897 1462	3898 1463	3899 1464	3900 1465	3752-1 1412	3752-2* 1413
Gravity, °API	29.7	30.2	30.3	29.2	29.8	29.7	31.4	30.9
Aniline Point, °F	29.5	31.6	32.2	32.0	30.3	29.7	34.0	34.1
Refractive Index, 80°C	1.4719	1.4694	1.4685	1.4739	1.4693	1.4689	-	-
Molecular Weight	196	181	211	201	187	194	-	-
Carbon, Wt %	82.73	(78.01)	(77.02)	87.16	85.45	85.39	85.07	85.41
Hydrogen, Wt %	11.37	(10.96)	(10.75)	11.92	11.22	11.17	11.14	11.49
Sulfur, Wt %	0.20	0.19	0.19	0.26	0.21	0.21	0.38	0.19
Oxygen, Wt %	1.90	1.67	1.77	1.91	1.94	1.98	1.71	1.80
Total Nitrogen, Wt %	0.38	0.35	0.39	0.41	0.37	0.40	0.43	0.42
Basic Nitrogen, Wt %	0.30	0.29	0.30	0.28	0.34	0.31	0.32	0.31
Chloride, ppm	27	27	22	I	38	27	7	10
TBP Distillation, °F (Simulated by Chromatography)								
St/5	42/173	35/172	35/176	78/176	34/165	34/165	43/162	53/170
10/30	201/308	190/298	185/296	211/316	183/305	176/299	180/281	180/285
50	377	375	375	386	381	387	367	367
70/90	436/510	435/508	435/507	438/508	437/507	439/509	425/502	427/503
95/99	542/615	541/612	539/601	540/607	538/596	541/609	536/599	536/603

I = Incomplete.

() = Result is suspect.

*Drum leaked in shipment.

TABLE XVI

DOE CONTRACT EF-76-C-01-2315
 PROPERTIES OF H-COAL ATMOSPHERIC BOTTOMS FROM HRI

Chevron Identification WOW 3749-	1	2	3	4	5
HRI Identification LO-	1408	1407	1411	1410	1409
Gravity, °API	7.9	7.8	7.7	7.4	8.0
Refractive Index, 80°C	1.5504				
Density, 70°C	0.9744				
Molecular Weight	286				
Ramsbottom Carbon, Wt %	1.19				
Hot C ₇ Asphaltenes, Wt %	1.65				
Pour Point, °F	-5				
Bromine No.	32	34			
Carbon, Wt %	89.22	89.84	89.15	89.52	89.57
Hydrogen, Wt %	8.85	8.85	8.79	8.70	8.86
Sulfur, Wt %	0.11	0.11	0.12	0.11	0.094
Oxygen, Wt %	1.18	1.13	1.12	1.15	1.07
Total Nitrogen, Wt %	0.62	0.59	0.67	0.67	0.64
Basic Nitrogen, Wt %	0.37	0.38	0.41	0.41	0.40
Chloride, ppm	90	22	18	22	17
Ash, ppm	200				
TBP Distillation, °F (Simulated by Chromatography)					
St/5	275/421	258/429	257/414	287/427	254/413
10/30	455/542	460/543	451/540	458/542	450/537
50	592	592	592	590	588
70/90	650/735	647/732	652/739	647/734	649/737
95/99	788/906	785/902	792/905	789/905	791/910
Emission Spectrum, ppm					
Al/B	0.3/4.3				
Cr/Cu	0.2/0.1				
Fe/Mn	(101.0)/1.5				
Na/Si	0.7/0.8				

() = Result is suspect.

TABLE XVII

DCE CONTRACT EF-76-C-01-2315
PROPERTIES OF H-COAL AND SRC-II WHOLE PROCESS PRODUCTS

	H-Coal Whole Process Product	Washed Water H-Coal Product	SRC-II Whole Process Product
Chevron Identification WOW-	3919	3920	3666
Gravity, °API	25.8	25.4	18.6
Aniline Point, °F	<32	<32	<30
Refractive Index, 20°C	1.5050	I	-
Refractive Index, 80°C	I	1.4801	1.5073
Molecular Weight	147	149	132
Viscosity, cSt			
At 100°F	1.645	1.646	2.196
At 130°F	-	-	1.617
Ramsbottom Carbon, Wt %	0.29/0.30	I	0.70
Hot C ₇ Asphaltenes, Wt %	0.35	0.19/0.21	0.0468
Ash, ppm	90	30	40
Pour Point, °F	-	-	<-80
Bromine No.	37/48	38	70
Maleic Diene No.	10.4	8.56	-
Carbon, Wt %	86.08*	I	82.82
Hydrogen, Wt %	10.70*	I	9.24
Sulfur, Wt %	(0.31/0.33)	0.18	0.29
Oxygen, Wt %	1.88/1.71	1.45	3.79
Total Nitrogen, Wt %	0.44/0.48	0.43	0.85
Basic Nitrogen, Wt %	0.31/0.30	0.27	0.70
Chloride, ppm	32	1.2	50.
Hydrogen/Carbon Atom Ratio	1.48*	I	1.33
H ₂ O, ppm	2217	1682	-
ASTM Distillation, °F	D 86/D 1160-10	I	D 86/D 1160-10
St/5	140/204		154/217
10/30	235/329		281/382
50	398		438
70/90	466/582		484/597
95/EP	648/704		699/850
% Overhead (Excluding Trap)	98.5		98.0
% In Flask	1.5		0.0
% Trap	0.0		2.0
TBP Distillation, °F (Simulated by Chromatography)			
St/5	56/177	55/176	56/189
10/30	213/333	213/341	241/379
50	404	412	424
70/90	476/588	483/588	473/562
95/99	654/765	654/774	642/820

I = Incomplete.

() = Result is suspect.

*Calculated from a blend of the components.

TABLE XVIII

DOE CONTRACT EF-76-C-01-2315
 HYDROTREATING OF H-COAL WHOLE PROCESS PRODUCT
 WITH ICR 106 CATALYST AT 750°F, 2500 PSIG
 RUN CONDITIONS AND PRODUCT PROPERTIES

Time On Stream, Hr	LHSV	Product Nitrogen, ppm	Product Aromatics, LV %
0-885	1.0	<0.5	6-20
885-955	1.5	10	35-40
995-1411	0.5	<0.5	9-14
Shutdown for 100 Hours Due to Plug in Reactor Preheat			
1422-Current	0.5	0.5	Incomplete

TABLE XIX

 YIELDS AND WHOLE LIQUID PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
 AND SRC II WHOLE PROCESS PRODUCTS OVER ICR106 AT 1.0 LHSV

RUN	H-COAL WHOLE PROCESS PRODUCT				SRC-II WHOLE PROCESS PRODUCT			
	76- 170	76- 170	76- 170	76- 170	76- 165	76- 165	76- 165	76- 165
FEED	WOW 3919	WOW 3919	WOW 3919	WOW 3919	WOW 3666	WOW 3666	WOW 3666	WOW 3666
RUN HOURS	70.- 94.	144.- 168.	214.- 238.	310.- 334.	371.- 395.	371.- 395.	395.- 419.	395.- 419.
AVG.CAT.TEMP., F.	750.	749.	749.	750.	750.	750.	749.	749.
LHSV	0.94	1.01	0.99	0.98	1.01	1.01	1.01	1.01
TOTAL PRESSURE,PSIG	2504.	2497.	2504.	2498.	2499.	2499.	2497.	2497.
H2 MEAN PRESS.,PSIA	2323.	2316.	2341.	2342.	2327.	2327.	2338.	2338.
TOTAL GAS IN,SCF/R	14714.	14445.	17881.	17681.	17318.	17318.	17328.	17328.
RECYCLE GAS, SCF/R	12587.	12329.	15934.	15756.	14555.	14555.	14703.	14703.
NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.
C1	0.03	0.08	0.06	0.06	0.10	0.10	0.09	0.09
C2	0.05	0.12	0.08	0.09	0.17	0.17	0.17	0.17
C3	0.07	0.18	0.12	0.14	0.21	0.21	0.22	0.22
I-C4	0.01 0.01	0.02 0.03	0.01 0.01	0.01 0.02	0.02 0.03	0.02 0.03	0.02 0.03	0.02 0.03
N-C4	0.04 0.06	0.10 0.15	0.06 0.09	0.07 0.11	0.10 0.16	0.10 0.16	0.11 0.18	0.11 0.18
C5- EP F.	100.48 108.74	100.10 107.77	99.97 107.18	99.87 106.77	98.09 110.64	98.09 110.64	97.85 109.72	97.85 109.72
TOTAL C5+	100.48 108.74	100.10 107.77	99.97 107.18	99.87 106.77	98.09 110.64	98.09 110.64	97.85 109.72	97.85 109.72
ACT./NO LOSS RECOV.	104.17/103.54	99.96/103.44	101.11/103.16	99.48/103.11	98.65/104.25	98.65/104.25	99.64/104.03	99.64/104.03
H2 CONS(GROSS),SCF/R	2127.	2116.	1947.	1925.	2763.	2763.	2625.	2625.
H2 CONS(H2CON),SCF/R	2097.	2040.	1875.	1844.	2637.	2637.	2501.	2501.

....LIQUID PRODUCT INSPECTIONS....

WHOLE LIQUID PRODUCT

GRAVITY, API	38.7	37.8	37.1	36.6	37.1	36.4
ANILINE PT., F.	117.7	112.0	107.0	102.2	98.7	96.8
SULFUR, PPM.	10.0	10.0	10.0	10.0	4.1	10.0
NITROGEN, PPM.	0.49	0.23	0.47	0.47	0.45	0.24
OXYGEN, WT.PC.	0.011	0.009	0.009	0.009	0.009	0.009
SMOKE PT.,ASTM, MM		21.	21.	20.		
FREEZE PT.,ASTM, F.		-22.	-23.	-9.		
HIGH MASS.LV.PC.						
PARAFFINS	3.5	3.1	3.1	3.2	3.5	3.7
NAPHTHENES	91.5	86.2	83.5	79.3	76.8	75.9
AROMATICS	6.0	10.7	13.4	17.5	19.7	20.4
MOLECULAR WEIGHT	151.	154.	154.	151.		
TBP DIST., F.						
ST/ 5	53./ 174.	53./ 178.	55./ 173.	49./ 179.		62./ 177.
10/30	208./ 284.	212./ 285.	207./ 285.	214./ 290.		210./ 278.
50	359.	365.	361.	368.		364.
70/90	423./ 516.	433./ 529.	432./ 527.	481./ 537.		419./ 505.
95/99	564./ 653.	578./ 670.	577./ 674.	588./ 694.		553./ 662.

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TABLE XX

YIELDS AND WHOLE LIQUID PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
WHOLE PROCESS PRODUCT OVER ICR106 AT 1.5 LHSV

76- 170	76- 170	76- 170	76- 170
WOW 3920	WOW 3920	WOW 3920	WOW 3920
RUN FEED	803.- 827.	827.- 851.	875.- 899.
RUN HOURS			899.- 923.
AVG.CAT.TEMP., F.	751.	750.	751.
LHSV	1.48	1.50	1.45
TOTAL PRESSURE,PSIG	2500.	2502.	2500.
H2 MEAN PRESS.,PSIA	2232.	2200.	2267.
TOTAL GAS IN,SCF/R	8274.	8058.	9684.
RECYCLE GAS, SCF/R	6808.	6727.	8258.
NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.
C1	0.06	0.04	0.05
C2	0.10	0.06	0.08
C3	0.10	0.07	0.08
I-C4	0.01 0.02	0.01 0.01	0.01 0.02
N-C4	0.06 0.10	0.05 0.07	0.06 0.09
C5- EP F.	100.21 105.29	100.10 105.25	4.44 5.50
TOTAL C5+	100.21 105.29	100.10 105.25	21.02 24.27
ACT./NO LOSS RECOV.	97.17/102.36	99.16/102.14	74.72 75.53
H2 CONS(GROSS),SCF/B	1466.	1331.	100.19 105.32
H2 CONS(HCSON),SCF/B	1401.	1273.	101.58/102.28
ACT./NO LOSS RECOV.			101.10/102.27
H2 CONS(GROSS),SCF/B			1426.
H2 CONS(HCSON),SCF/B			1356.
.....LIQUID PRODUCT INSPECTIONS.....			
WHOLE LIQUID PROD		WHOLE LIQUID PROD	

GRAVITY, API	33.3	33.1	33.2
ANILINE PT., F.		76.1	78.4
SULFUR, PPM.			7.61
NITROGEN, PPM.	3.45	9.45	
HIGH MASS,LV.PC.			
PARAFFINS	3.4		3.6
NAPHTHENES	58.0		59.3
AROMATICS	38.5		37.1

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TABLE XXI

YIELDS AND WHOLE LIQUID PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
WHOLE PROCESS PRODUCT OVER ICR106 AT 0.5 LHSV

RUN	76- 170	RUN	76- 170	76- 170	76- 170
FEED	WOW 3920	FEED	WOW 3920	WOW 3920	WOW 3920
RUN HOURS	1139.- 1163.	RUN HOURS	1163.- 1187.	1187.- 1211.	1211.- 1235.
AVG.CAT.TEMP., F.	747.	AVG.CAT.TEMP., F.	746.	746.	748.
LHSV	0.46	LHSV	0.44	0.46	0.42
TOTAL PRESSURE,PSIG	2500.	TOTAL PRESSURE,PSIG	2500.	2501.	2501.
H2 MEAN PRESS.,PSIA	2265.	H2 MEAN PRESS.,PSIA	2283.	2281.	2282.
TOTAL GAS IN,SCF/R	11159.	TOTAL GAS IN,SCF/R	11667.	10716.	11644.
RECYCLE GAS, SCF/R	8962.	RECYCLE GAS, SCF/R	9537.	8543.	9455.
NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.
C1	0.05	C1	0.05	0.07	0.05
C2	0.08	C2	0.08	0.13	0.09
C3	0.11	C3	0.12	0.17	0.12
I-C4	0.01 0.02	I-C4	0.01 0.02	0.02 0.03	0.01 0.02
N-C4	0.05 0.08	N-C4	0.06 0.09	0.08 0.13	0.05 0.08
C5- EP F.	101.45 108.52	C5-180 F.	3.57 4.44	3.80 4.73	3.73 4.64
TOTAL C5+	101.45 108.52	180-300 F.	21.33 24.88	21.56 25.15	22.40 26.15
ACT./NO LOSS RECOV.	102.35/103.59	300- EP F.	76.42 79.64	75.83 79.07	75.30 78.66
H2 CONS(GROSS),SCF/B	2197.	TOTAL C5+	101.34 108.97	101.19 108.96	101.44 109.46
H2 CONS(HCSON),SCF/B	2131.	ACT./NO LOSS RECOV.	102.28/103.47	102.31/103.47	103.54/103.57
....LIQUID PRODUCT INSPECTIONS....		H2 CONS(GROSS),SCF/B	2130.	2173.	2189.
		H2 CONS(HCSON),SCF/B	2064.	2062.	2120.
WHOLE LIQUID PROD	LIQUID PRODUCT INSPECTIONS....			
-----		WHOLE LIQUID PROD			
GRAVITY, API	36.3	-----			
ANILINE PT., F.	110.3	GRAVITY, API	36.6	36.8	37.3
NITROGEN, PPM.	0.21	ANILINE PT., F.	113.7	113.2	115.8
OXYGEN, WT.PC.	0.016	NITROGEN, PPM.	0.21	0.37	0.37
HIGH MASS,LV.PC.		OXYGEN, WT.PC.	0.008	0.014	
PARAFFINS	4.8	HIGH MASS,LV.PC.			
NAPHTHENES	81.3	PARAFFINS	2.8	3.0	3.0
AROMATICS	13.9	NAPHTHENES	85.5	86.2	87.9
		AROMATICS	11.7	10.8	9.2
		TBP DIST., F.			
		ST/ 5		41./ 180.	
		10/30		216./ 316.	
		50		383.	
		70/90		452./ 541.	
		95/99		594./ 765.	

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TABLE XXII
 YIELDS AND PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
 WHOLE PROCESS PRODUCT OVER ICR106 AT 1.0 LHSV

RUN	76- 170	76- 170	76- 170	76- 170
FEED	WOW 3619	WOW 3920	WOW 3920	WOW 3920
RUN HOURS	539.- 563.	635.- 659.	659.- 683.	683.- 707.
AVG.CAT.TEMP., F.	750.	751.	753.	752.
LHSV	0.97	0.94	0.93	0.93
TOTAL PRESSURE,PSIG	2503.	2502.	2500.	2498.
H2 MEAN PRESS.,PSIA	2260.	2222.	2256.	2250.
TOTAL GAS IN,SCF/R	15338.	10173.	10137.	9928.
RECYCLE GAS, SCF/R	13420.	8338.	8362.	8156.
NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.
C1	0.07	0.08	0.07	0.06
C2	0.11	0.12	0.10	0.09
C3	0.16	0.14	0.13	0.11
I-C4	0.01 0.02	0.01 0.02	0.01 0.02	0.01 0.01
N-C4	0.09 0.13	0.09 0.13	0.07 0.11	0.06 0.10
C5-180 F.	4.99 6.11	4.65 5.76	4.34 5.40	4.52 5.61
180-300 F.	24.71 28.54	21.41 24.75	21.82 25.30	21.54 24.95
300- EP F.	70.09 72.01	74.64 76.54	74.49 76.77	74.65 76.55
TOTAL C5+	99.80 106.67	100.71 107.06	100.66 107.48	100.71 107.12
ACT./NO LOSS RECOV.	102.03/103.10	103.07/102.96	101.24/102.86	102.54/102.86
H2 CONS(GROSS),SCF/R	1918.	1835.	1775.	1772.
H2 CONS(HCSON),SCF/R	1837.	1757.	1699.	1698.
....LIQUID PRODUCT INSPECTIONS....				
C5-180 F. PRODUCT				
GRAVITY, API	61.2	63.0	63.9	63.1
180-300 F. PRODUCT				
GRAVITY, API	50.2	49.9	50.4	50.3
OXYGEN, WT.PC.	(0.290)*	(0.300)*	0.016	0.014
LOW MASS, LV.PC.		13.1		13.0
PARAFFINS		74.0		74.0
NAPHTHENES		13.0		13.0
AROMATICS				
ASTM D-86 DIST., F				
ST/ 5	204./ 214.	216./ 220.	215./ 218.	215./ 220.
10/30	217./ 224.	222./ 227.	220./ 227.	222./ 228.
50	232.	235.	235.	235.
70/90	245./ 267.	246./ 263.	249./ 265.	246./ 265.
95/EP	276./ 338.	269./ 306.	274./ 332.	270./ 312.
LV.PC.OVHD	9.0	99.5	99.0	99.5
300- EP F. PRODUCT				
GRAVITY, API	30.1	29.4	30.2	29.4
ANILINE PT., F.	101.0	100.1	100.2	99.9
SULFUR, PPM.	13.4	10.0	25.0	10.0
OXYGEN, WT.PC.	(0.280)*	(0.239)*	0.036	0.050
MOLECULAR WEIGHT		171.	163.	164.
POUR PT.,ASTM, F.	-60.	-60.	-65.	-60.
SMOKE PT.,ASTM, MM	14.	17.	13.	19.
FREEZE PT.,ASTM, F.	-94.	-70.	-41.	-70.
HIGH MASS, LV.PC.				
PARAFFINS	3.1	3.0	3.0	3.1
NAPHTHENES	73.1	72.9	71.9	72.6
AROMATICS	23.9	24.2	25.0	24.3
VISCOSITY, CS, F.	10.940			
VISCOSITY, CS, 40F.	3.937	3.995		4.067
VISCOSITY, CS, 130F.	1.545	1.567		1.550
ASTM D-86 DIST., F				
ST/ 5	342./ 354.	349./ 355.	347./ 360.	342./ 358.
10/30	365./ 390.	360./ 394.	368./ 390.	366./ 390.
50	425.	430.	427.	425.
70/90	474./ 552.	476./ 555.	474./ 549.	470./ 538.
95/EP	585./ 653.	584./ 648.	595./ 615.	583./ 643.
LV.PC.OVHD	99.5	99.5	98.0	99.0
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* Probably high

TABLE XXIII

YIELDS AND PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
WHOLE PROCESS PRODUCT OVER ICR106 AT 1.5 LHSV

RUN	76- 170		76- 170	
FEED	WOW 3920		WOW 3920	
RUN HOURS	875.-	899.	899.-	923.
AVG.CAT.TEMP., F.	751.		751.	
LHSV	1.45		1.44	
TOTAL PRESSURE,PSIG	2500.		2501.	
H2 MEAN PRESS.,PSIA	2267.		2233.	
TOTAL GAS IN,SCF/B	9684.		9366.	
RECYCLE GAS, SCF/B	8258.		7952.	
NO LOSS PROD.YIELDS	WT.PC.	VOL.PC.	WT.PC.	VOL.PC.
C1	0.05		0.05	
C2	0.08		0.08	
C3	0.08		0.08	
I-C4	0.01	0.02	0.01	0.01
N-C4	0.06	0.09	0.05	0.07
C5-180 F.	4.44	5.50	4.50	5.55
180-300 F.	21.02	24.27	20.93	24.17
300- EP F.	74.72	75.53	74.77	75.58
TOTAL C5+	100.19	105.32	100.21	105.32
ACT./NO LOSS RECOV.	101.58/102.28		101.10/102.27	
H2 CONS(GROSS),SCF/B	1426.		1414.	
H2 CONS(HCSON),SCF/B	1356.		1351.	

....LIQUID PRODUCT INSPECTIONS....

C5-180 F. PRODUCT

GRAVITY, API	62.9	62.0
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180-300 F. PRODUCT

GRAVITY, API	49.7	49.7
SULFUR, PPM.	0.4	1.0
OXYGEN, WT.PC.	0.014	0.016

300- EP F. PRODUCT

GRAVITY, API	27.1	27.1
ANILINE PT., F.	76.5	76.0
SULFUR, PPM.	0.7	0.8
OXYGEN, WT.PC.	0.019	0.026
SMOKE PT.,ASTM, MM	13.	
NITROGEN, PPM.		10.50
HIGH MASS,LV.PC.		
PARAFFINS	4.3	3.4
NAPHTHENES	55.3	55.4
AROMATICS	40.4	41.2

TABLE XXIV

YIELDS AND PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
WHOLE PROCESS PRODUCT OVER ICR106 AT 0.5 LHSV

RUN	76- 170		76- 170		76- 170	
FEED	WOW 3920		WOW 3920		WOW 3920	
RUN HOURS	1163.-	1187.	1187.-	1211.	1211.-	1235.
AVG.CAT.TEMP., F.	746.		746.		748.	
LHSV	0.44		0.46		0.42	
TOTAL PRESSURE,PSIG	2500.		2501.		2501.	
H2 MEAN PRESS.,PSIA	2283.		2281.		2282.	
TOTAL GAS IN,SCF/B	11667.		10716.		11644.	
RECYCLE GAS, SCF/B	9537.		8543.		9455.	
NO LOSS PROD.YIELDS	WT.PC.	VOL.PC.	WT.PC.	VOL.PC.	WT.PC.	VOL.PC.
C1	0.05		0.07		0.05	
C2	0.08		0.13		0.09	
C3	0.12		0.17		0.12	
I-C4	0.01	0.02	0.02	0.03	0.01	0.02
N-C4	0.06	0.09	0.08	0.13	0.05	0.08
C5-180 F.	3.57	4.44	3.80	4.73	3.73	4.64
180-300 F.	21.33	24.88	21.56	25.15	22.40	26.15
300- EP F.	76.42	79.64	75.83	79.07	75.30	78.66
TOTAL C5+	101.34	108.97	101.19	108.96	101.44	109.46
ACT./NO LOSS RECOV.	102.28/103.47		102.31/103.47		103.54/103.57	
H2 CONS(GROSS),SCF/B	2130.		2173.		2189.	
H2 CONS(HCSON),SCF/B	2064.		2062.		2120.	

....LIQUID PRODUCT INSPECTIONS....

C5-180 F. PRODUCT

GRAVITY, API 63.7 63.4
O.N.,F-1 CLEAR

180-300 F. PRODUCT

GRAVITY, API 51.6 51.7
OXYGEN, WT.PC.

300- EP F. PRODUCT

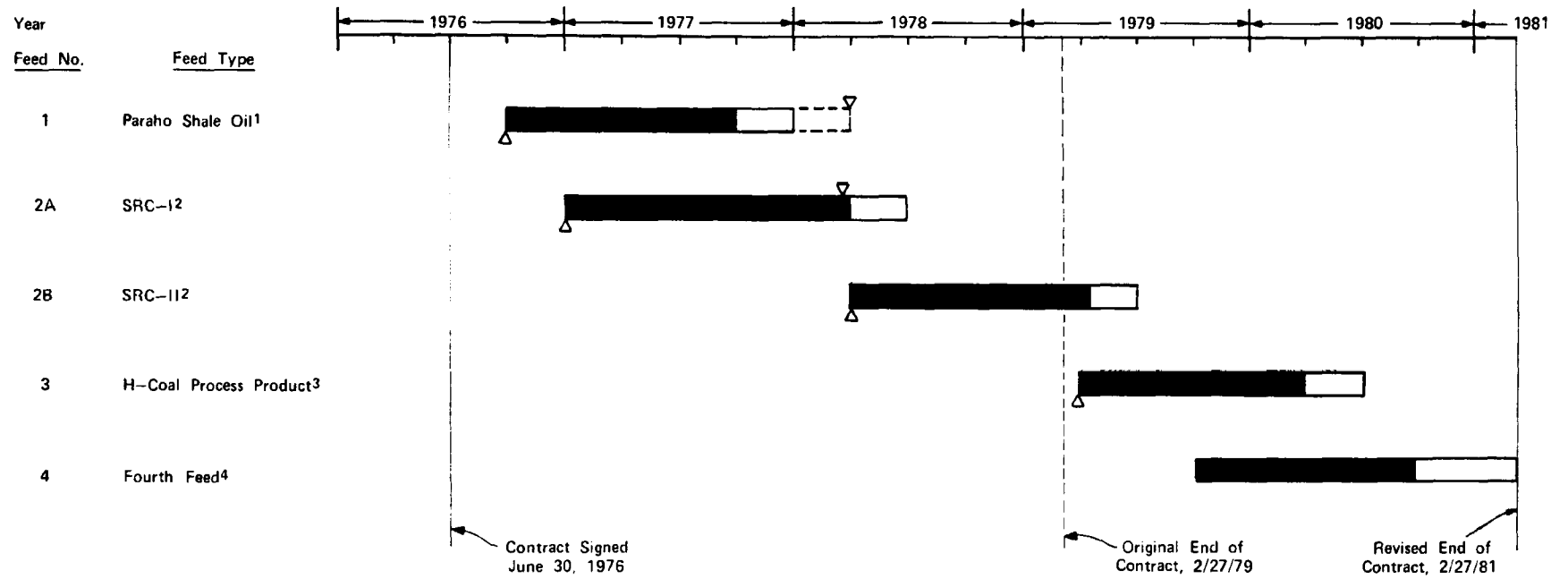
GRAVITY, API 32.1 32.4
ANILINE PT., F.
SULFUR, PPM.
OXYGEN, WT.PC.
MOLECULAR WEIGHT
SMOKE PT.,ASTM, MM

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DOE CONTRACT EF-76-C-01-2315

DJO RE 790339

FIGURE 1
DOE CONTRACT EF-76-C-01-2315
FEED TIMING SCHEDULE (REVISED, APRIL 1979)



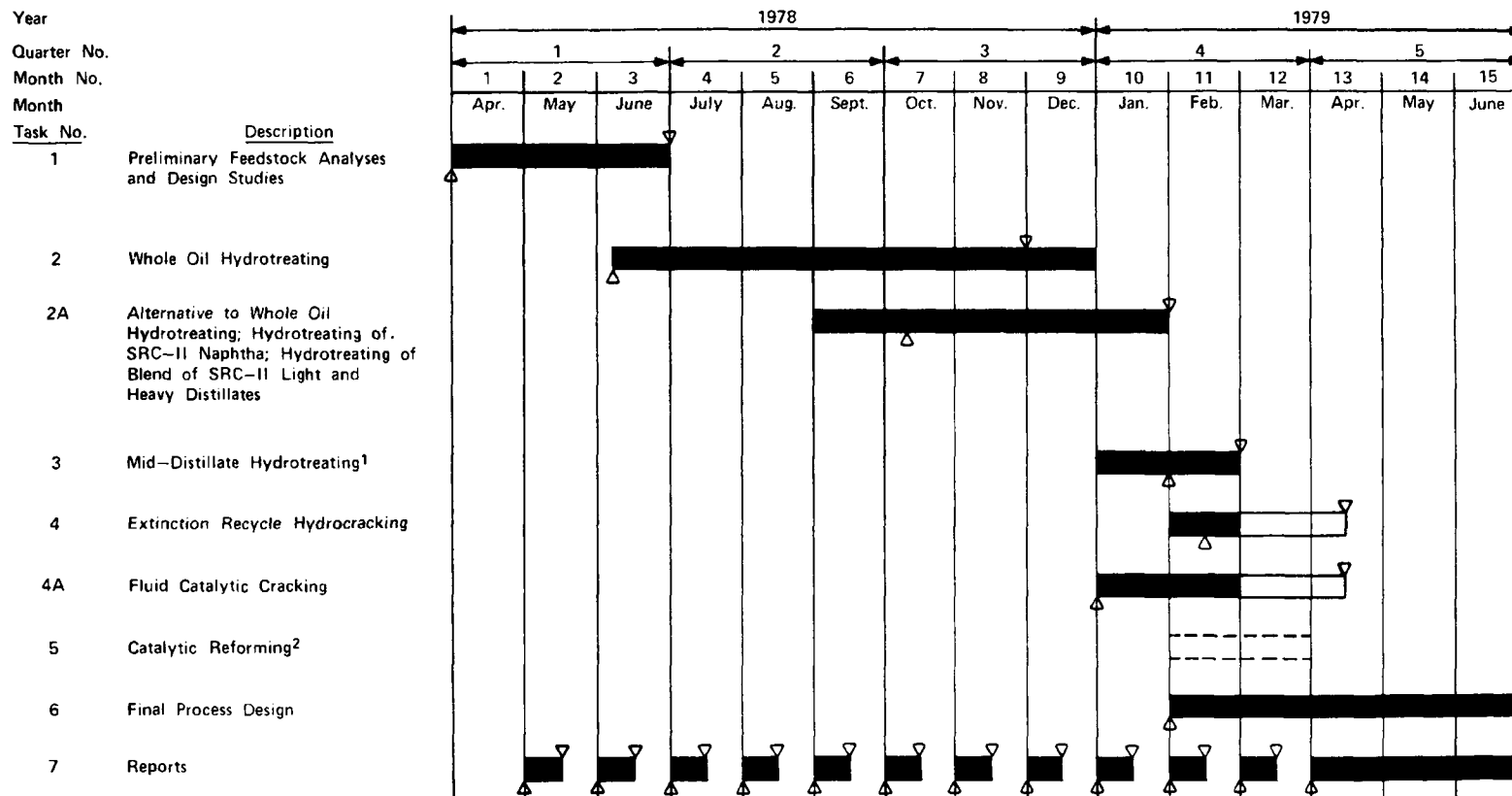
¹With the permission of the DOE Technical Representative, work on the Paraho Shale Oil was extended to include added tasks and evaluation of additional design cases.
²Work on SRC-I was suspended and SRC-II was added as Feed 2B.
³H Coal Process Product, sufficient for the full program on this feed, was received on 3/23/79.
⁴The fourth feed to be selected by mutual agreement between DOE and Chevron.

- Schedule - Feed Analysis and Pilot Plant Work
- Schedule - Final Report and Design
- Schedule Extension
- Actual Start of Work on Feedstock
- Actual End of Work on Feedstock

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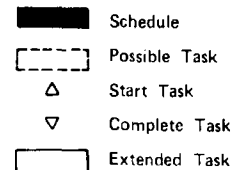
FIGURE 2

DOE CONTRACT EF-76-C-01-2315
 SCHEDULE FOR FEED 2B (SRC-II)



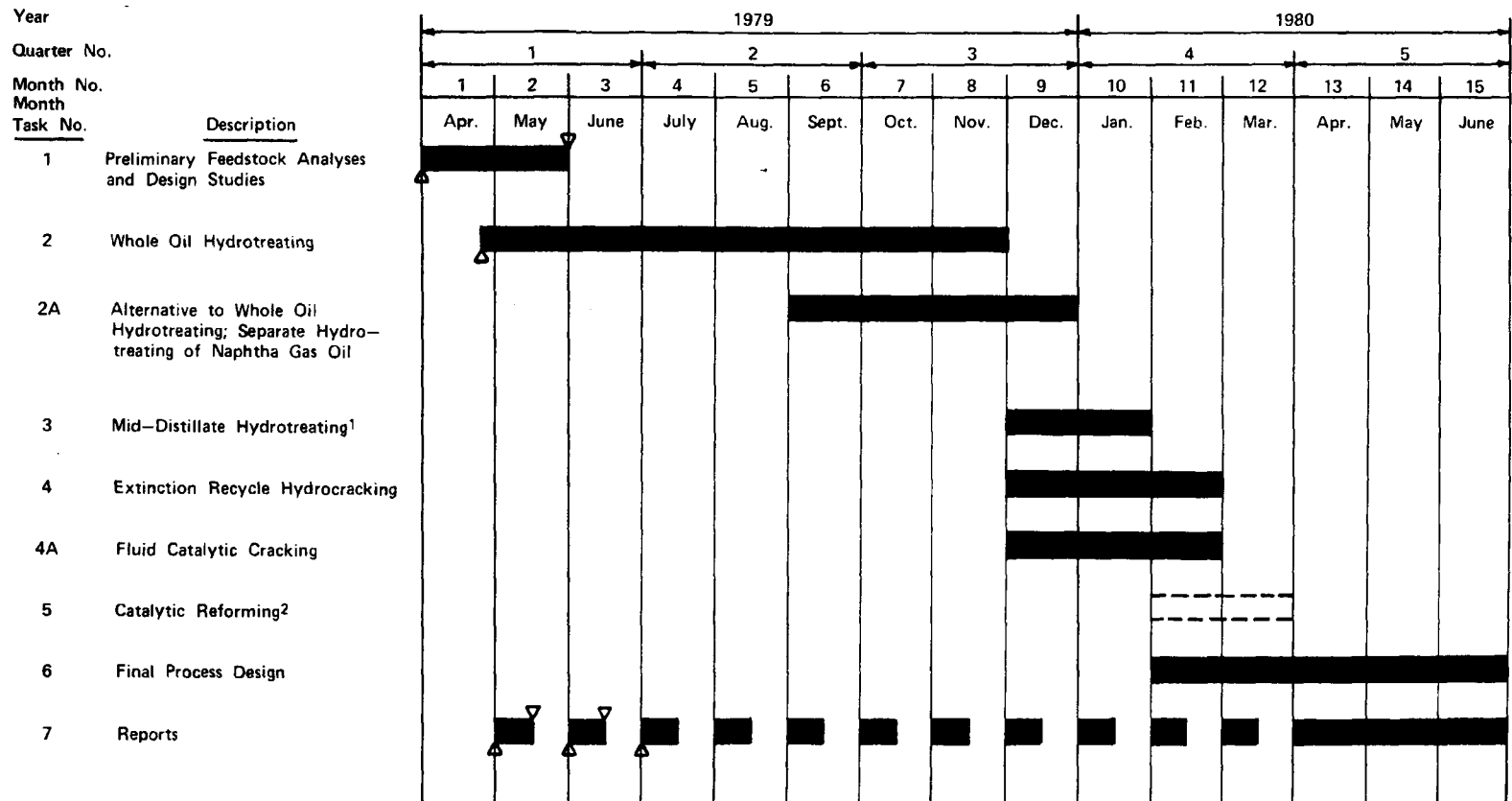
¹Task also includes naphtha hydrotreating.

²Task 5 is to be included only if deemed appropriate by mutual agreement of the DOE Technical Representative and Chevron Research, subject of a contract modification. (No Task 5 work is anticipated for SRC II.)

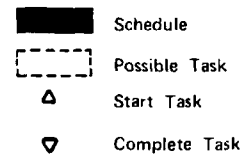


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FIGURE 3
DOE CONTRACT EF-76-C-01-2315
SCHEDULE FOR FEED 3 (H-COAL)



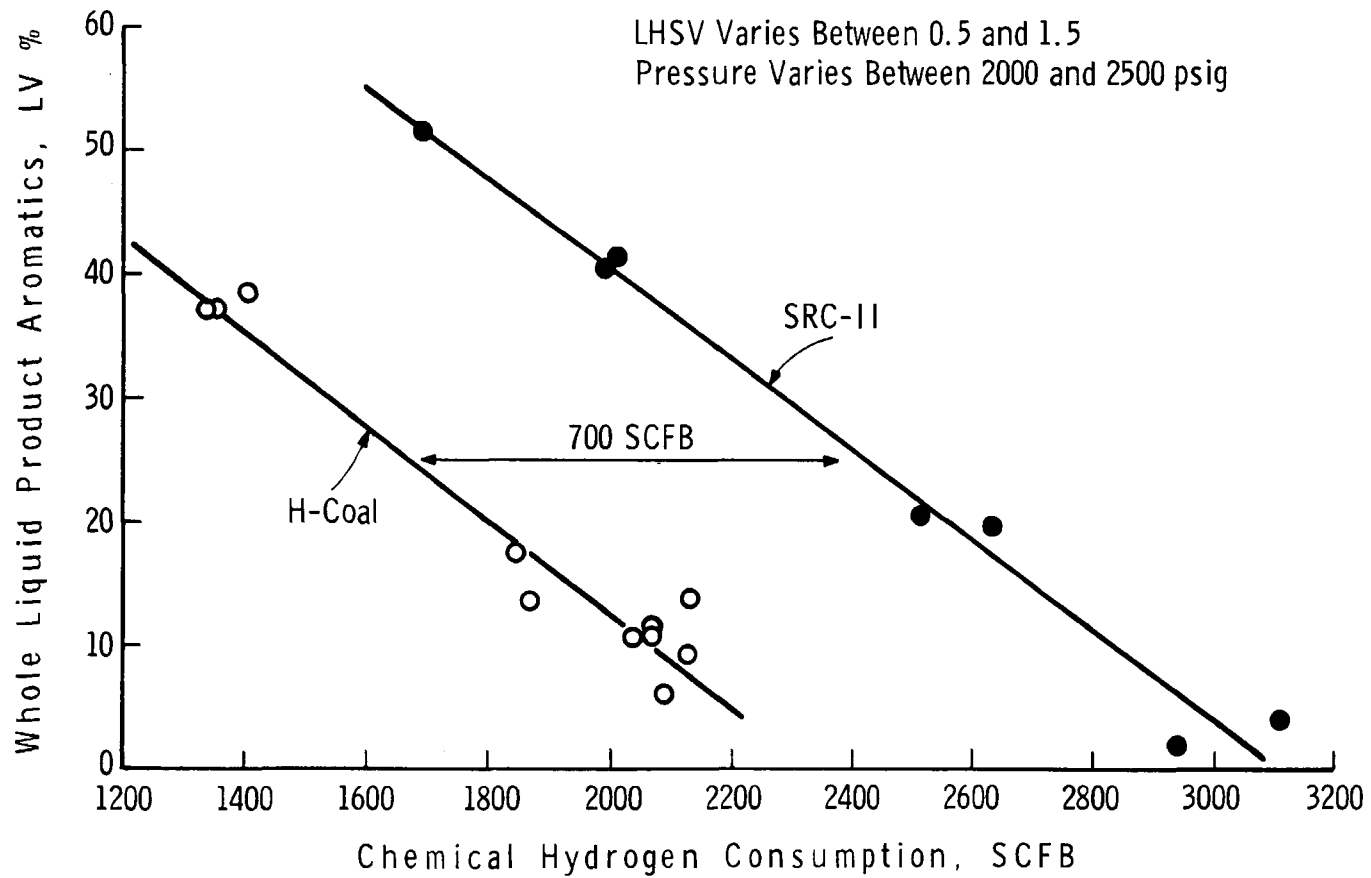
¹Task also includes further hydrotreating of partially hydrotreated naphtha.
²Task 5 is to be included only if deemed appropriate by mutual agreement of the DOE Technical Representative and Chevron Research, subject of a contract modification.



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FIGURE 4

DOE CONTRACT EF-76-C-01-2315
WHOLE LIQUID PRODUCT AROMATICS, LV %, FROM
HYDROTREATING SRC-II AND H-COAL WHOLE PROCESS PRODUCTS
OVER ICR 106 AT 750°F



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TABLE I
DOE CONTRACT EF-76-C-01-2315
PROPERTIES OF SRC-II PROCESS PRODUCTS

Description	Whole SRC-II WOW 3666	SRC-II Naphtha WOW 3750	400°F+ SRC-II WOW 3751
Chevron Identification			
Wt % of Whole SRC-II	100	29	71
<u>Inspections</u>			
Gravity, °API	18.6	36.2	10.7
Aniline Point, °F	<30	56.4	-
Sulfur, Wt %	0.29	0.26	0.25
Total Nitrogen, Wt %	0.85	0.42	0.99
Basic Nitrogen, Wt %	0.7		0.82
Oxygen, Wt %	3.79	3.51	3.63
Carbon, Wt %*	82.82	84.22	86.61/86.18
Hydrogen, Wt %*	9.24	12.23	8.77/9.54
Hydrogen/Carbon Atom Ratio*	1.33	1.73	1.21/1.32
Chloride, ppm	50	18/20	77/62/81
Pour Point, °F	Below -80	-	-50
<u>Group Type, LV %</u>			
Paraffins	-	23	-
Naphthenes	-	38	-
Olefins	-	5	-
Aromatics	-	34	-
Ramsbottom Carbon, Wt %	0.70	-	0.81
Hot Heptane Asphaltenes, ppm	468	-	2200
Benzene Insolubles, Wt %	<0.03	-	<0.03
Refractive Index (80°C)	1.5073	-	1.5340
Ash, Wt %	0.004	-	0.010
Molecular Weight	132	118	160
Bromine Number	70	49/52	69
<u>Viscosity, cSt</u>			
at 100°F	2.196	0.8933	4.213
at 130°F	1.617	-	-
at 210°F	-	-	1.238
<u>ASTM Distillation, °F</u>	D 86/D 1160	D 86	D 1160
St/5	154/217	151/179	393/413
10/30	281/382	197/249	427/448
50	438	290	471
70/90	484/597	332/366	506/590
95/EP	699/850	380/393	662/847
% Overhead (Excl. Trap)	98	98	99
% in Flask	0	1	1
% Trap	2	1	0
<u>TBP Distillation, °F</u> (Simulated by Chromatography)			
St/5	56/189	53/153	233/366
10/30	241/379	173/235	382/430
50	424	291	477
70/90	473/562	345/395	527/639
95/99	642/820	408/442	707/849

*Analysis being checked.

TABLE II

DOE CONTRACT EF-76-C-01-2315
FEEDS FOR HYDROCRACKER FIRST-STAGE PILOT PLANT TESTS

Feed Identification	350°F+ From Hydrotreated Whole SRC III			Hydrotreated 400°F+ SRC II	
	SGQ 6631	SGQ 6664-1	SGQ 6664-2	SGQ 6554	SGQ 6621
Gravity, °API	22.0	24.2	24.8	29.7	29.1
Aniline Point, °F	<32	37.1	44.6	68.6	
Sulfur, ppm	6.3				
Nitrogen, ppm	608	8.7	7.5	60	22
Oxygen, ppm	4700			820	
Group Type, LV %	*				
Paraffins	5.1/6.8	3.7	3.8	2.0	2.2
Naphthenes	26.9/27.1	33.3	35.7	55.4	53.9
Aromatics	68.0/66.2	63.0	60.6	42.5	43.9
TBP Distillation, °F (Simulated by Chromatography)					
ST/5	317/363	100/336	136/335	94/212	98/220
10/30	380/418	363/408	363/407	240/356	257/370
50	452	445	443	413	424
70/90	494/568	486/551	483/549	465/544	473/549
95/99	612/715	597/698	593/694	597/708	608/729
ASTM D 86 Distillation, °F					
ST/5	388/402			225/254	
10/30	408/423			280/366	
50	433			419	
70/90	467/539			459/529	
95/EP	590/676			584/645	
% Overhead	99			98.5	
Overlap, Wt % Below 350°F by TBP	2.2	6.5	6.6	26.7	23.3

*Second set of numbers shown for the group type of SGQ-6631 are by the "22-component" method (see Table III); all other group-type analyses by the "high mass" method.

TABLE III

DOE CONTRACT EF-76-C-01-2315
DETAILED MASS SPECTROMETRIC ANALYSIS
OF 350°F+ HYDROTREATED SRC-II, SGQ 6631,
BY 22-COMPONENT METHOD

Composition, LV %	
C(N)H(2N+2) Paraffins	6.8
C(N)H(2N) Monocycloparaffins	10.0
C(N)H(2N-2) Dicycloparaffins	9.3
C(N)H(2N-4) Tricycloparaffins	7.8
Total Saturates	33.9
Monoaromatics	
C(N)H(2N-6) Alkylbenzenes	19.3
C(N)H(2N-8) Benzocycloparaffins	24.7
C(N)H(2N-10) Benzodicycloparaffins	6.0
Diaromatics	
C(N)H(2N-12) Naphthalenes	9.3
C(N)H(2N-14)	3.4
C(N)H(2N-16)	3.0
Triaromatics	
C(N)H(2N-18)	0.4
Total Aromatics	66.1

Calculated Weight % Carbon = 88.5
Calculated Weight % Hydrogen = 11.4

TABLE IV

DOE CONTRACT EF-76-C-01-2315
SUMMARY OF RESULTS: FIRST-STAGE HYDROCRACKER

HDN of Partially Hydrotreated SRC-II
Runs 72-327, 72-328

Catalyst	Conditions			Nitrogen, ppm		Aromatics, LV %		H ₂ Consumption, SCF/B
	Temp., °F	H ₂ , psia	LHSV	Feed	Product	Feed	Product	
ICR 113	643	1150	1.5	60	0.2	42	38	250
	700	1150	1.5	608	12	68	65	300
	736	1150	1.5	608	4	68	64	300
	736	1375	1.5	608	3	68	64	330
ICR 106	695	1375	1.5	608	3.5	68	62	525
	695	1400	1.5	8	0.2	62	48	425
	695	1130	1.5	22	0.2	44	42	125

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TABLE V
DOE CONTRACT EF-76-C-01-2315
FIRST-STAGE HYDROCRACKER WITH ICR 113
HDN OF PARTIALLY HYDROTREATED SRC-II - RUN 72-327

Feed	SGQ 6554		SGQ 6554		SGQ 6631		SGQ 6631	
	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
Feed Nitrogen, ppm	60		60		608		608	
Feed Aromatics, Wt %	42		42		68		68	
Run Hours	61-85		85-107		169-181		193-205	
Avg. Cat. Temp., °F	643		643		736		736	
LHSV	1.52		1.52		1.52		1.51	
Total Pressure, psig	1297		1301		1305		1601	
H ₂ Mean Pressure, psia	1150		1159		1142		1381	
Total Gas In, SCF/Bbl	4360		4460		4682		4241	
Recycle Gas, SCF/Bbl	4079		4136		4335		3849	
No Loss Prod. Yields								
C ₁	0.01		0.01		0.03		0.05	
C ₂	0.01		0.01		0.07		0.10	
C ₃	0.07		0.05		0.08		0.11	
iC ₄	0.01	0.02	0.02	0.03	0.01	0.01	0.01	0.01
nC ₄	0.04	0.05	0.04	0.05	0.03	0.04	0.03	0.05
Total C ₅	100.19	101.07	100.28	100.91	99.69	100.73	99.68	101.04
Act./No Loss Recovery	100.52/100.39		100.45/100.46		100.50/100.50		98.06/100.55	
H ₂ Cons. (Gross), SCF/Bbl	281		323		347		391	
H ₂ Cons. (Chemical), SCF/Bbl	222		267		300		332	
Whole Liquid Prod. Prop.								
Gravity, °API	31.1		30.7		23.6		24.1	
Aniline Point, °F	78.3		77.3		32.0		35.9	
Nitrogen, ppm	0.16		0.23		3.9		2.6	
Group Type, LV %								
Paraffins	1.8		1.7		3.7		3.9	
Naphthenes	62.0		60.2		32.0		32.3	
Aromatics	36.2		38.0		64.2		63.8	
TBP Distillation, °F (Simulated by Chromatography)								
St/5	82/217		96/217		52/338		96/337	
10/30	243/362		244/363		364/409		363/408	
50	410		412		446		445	
70/90	464/538		466/540		488/555		486/551	
95/99	592/713		594/712		603/706		598/700	

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TABLE VI
DOE CONTRACT EF-76-C-01-2315
FIRST-STAGE HYDROCRACKER WITH ICR-106 CATALYST
HDN OF PARTIALLY HYDROTREATED SRC-II
RUN 72-328

Feed Identification	SGQ 6631		SGQ 6664				SGQ 6621			
	Feed Nitrogen, ppm	608		8				22		
Feed Aromatics, %	68		62				44			
Run Hours	93-117		261-285		285-309		381-405		429-453	
Avg. Cat. Temp., °F	698		695		695		695		696	
LHSV	1.50		1.50		1.50		1.50		1.50	
Total Pressure, psig	1601		1596		1593		1291		1296	
H ₂ Mean Pressure, psia	1455		1415		1409		1138		1134	
Total Gas in, SCF/Bbl	6282		4664		4745		4376		3828	
Recycle Gas, SCF/Bbl	5702		4163		4262		4177		3754	
No Loss Prod. Yields	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
C ₁	0.02		0.01		0.01		0.01		0.01	
C ₂	0.04		0.01		0.04		0.03		0.02	
C ₃	0.10		0.16		0.17		0.10		0.09	
iC ₄	0.01	0.02	0.02	0.03	0.02	0.04	0.01	0.02	0.02	0.02
nC ₄	0.03	0.05	0.05	0.07	0.04	0.06	0.04	0.06	0.04	0.06
Total C ₅ ⁺	100.08	101.78	100.52	102.72	100.45	102.52	100.07	100.91	100.05	100.76
Actual/No Loss Recov.	101.53/100.86		100.55/100.75		101.20/100.72		100.89/100.23		100.43/100.20	
H ₂ Cons. (Gross), SCF/Bbl	577		503		480		195		171	
H ₂ Cons. (Chemical), SCF/Bbl	520		447		427		134		115	
Whole Liquid Product Properties										
Gravity, °API	24.6		27.7		27.5		30.8		30.2	
Aniline Point, °F	40.5		65.3				68.7		70.8	
Sulfur, ppm							2.6			
Nitrogen, ppm	3.5		0.24		0.21		0.1		0.2	
Oxygen, ppm	330						110			
Group Type, LV %										
Paraffins	3.8		4.5				2.3		2.2	
Naphthenes	34.0		47.1				53.5		57.2	
Aromatics	62.2		48.4				44.2		40.6	
TBP Distillation, °F (Simulated by Chromatography)										
St/5	51/335		48/278				46/214		85/216	
10/30	362/408		346/394				243/360		248/362	
50	444		425				410		413	
70/90	484/549		467/532				460/538		463/542	
95/99	591/689		575/675				542/719		597/715	

TABLE VII

DOE CONTRACT EF-76-C-01-2315DOE: Feeds for Second-Stage Hydrocracker*

	SGQ 6668	SGQ 6671-1	SGQ 6771-2
Gravity, °API	27.7	30.4	30.2
Aniline Point, °F	63.3	68.7	70.8
Sulfur, ppm	5.5	2.6	
Nitrogen, ppm	0.39/0.42	0.23/0.1	0.20/0.19
Oxygen, ppm		110	
Group Type, LV %			
Paraffins	4.5	2.3	2.2
Naphthenes	46.3	53.5	57.2
Aromatics	49.2	44.2	40.6
Hydrogen, Wt %	I	12.82	12.79
Carbon, Wt %	I	87.50	87.20
Molecular Weight	162		
Density at 70°C	0.8500		
Refractive Index at 80°C	1.4644		
TBP Distillation, °F (Simulated by Chromatography)			
St/5	52/274	58/216	85/216
10/30	344/396	252/364	248/362
50	428	410	413
70/90	469/536	460/538	463/542
95/99	579/684	588/699	597/715
Overlap, Wt % Below 350°F by TBP	10.2	23.8	25.1

*Second-stage feeds prepared over ICR 106 catalyst in Run 72-328 as follows:

SGQ 6668 = HDN product from SGQ 6631 (hydrotreated 350°F+ fraction of whole SRC-II).

SGQ 6671-1 and SGQ 6671-2 = HDN product from SGQ 6621 (hydrotreated 400°F+ SRC-II).

I = Incomplete

TABLE VIII
DOE CONTRACT EF-76-C-01-2315
HYDROCRACKING OF DENITRIFIED 400°F+ SRC-II
WITH ICR 202 CATALYST AT 350°F RECYCLE CUT POINT

Pilot Plant Run 45-182; Feed - SQG 6671

Run Hours	97-121		169-193		193-217	
Average Cat. Temp., °F	569		581		586	
LHSV	1.10		1.10		1.10	
Per Pass Conversion	55.01		58.07		60.27	
Total Pressure, psig	1397		1396		1396	
H ₂ Mean Pressure, psia	1223		1219		1222	
Total Gas in, SCF/B	6781		6786		6792	
Recycle Gas, SCF/B	5865		5785		5761	
No Loss Prod. Yields	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
C ₁	0.01		0.01		0.01	
C ₂	0.07		0.08		0.08	
C ₃	1.80		1.98		1.97	
iC ₄	10.75	16.68	11.37	17.67	11.23	17.44
nC ₄	1.77	2.66	1.99	2.98	1.97	2.94
C ₅ -180°F	16.15	20.42	17.44	22.13	16.92	21.47
180-350°F	69.44	77.03	70.03	77.83	70.69	78.82
Total C ₅ +	85.59	97.45	87.47	99.96	87.60	100.30
Act./No Loss Recov.	98.75/102.73		100.41/102.86		99.51/102.83	
H ₂ Cons. (Gross), SCF/B	1664		1722		1711	
H ₂ Cons. (Chemical), SCF/B	1569		1649		1628	
Inspections						
C ₅ -180°F						
Gravity, °API	73.2		73.7		73.8	
Octane No.						
F-1 Clear	90.6		90.0		90.5	
F-2 Clear	85.0		84.9		84.7	
Group Type, LV %						
Paraffins	60.5		59.4		62.5	
Naphthenes	33.2		35.1		32.3	
Aromatics	6.4		5.5		5.1	
180-350°F						
Gravity, °API	48.1		48.2		48.8	
Aniline Point, °F	110.6		110.3		110.4	
Octane No.						
F-1 Clear			68.8/68.4		69.1	
F-2 Clear	67.4		68.4		68.9	
Group Type, LV %						
(Low Mass)						
Paraffins	6.4		I		7.6	
Naphthenes	85.8				85.6	
Aromatics	7.8				6.8	
Group Type, LV %						
(By Chromatography)						
Paraffins	7.4		10.2		7.7	
Naphthenes	85.0		82.3		84.8	
Aromatics	5.6		7.5		7.5	
TBP Distillation, °F						
(Simulated By Chromatography)						
ST/5	165/197		163/196		134/187	
10/30	211/238		202/235		196/228	
50	271		269		258	
70/90	312/340		309/340		301/336	
95/99	346/354		348/356		344/354	
ASTM D 86 Distillation, °F						
ST/5			222/228		220/228	
10/30			232/243		231/246	
50			262		263	
70/90			287/319		290/320	
95/EP			326/330		327/364	
% Overhead (Excl. Trap)			99		98.5	
% in Trap			-		1.0	

I = Incomplete.

TABLE IX

DOE CONTRACT EF-76-C-01-2315
 HYDROCRACKING OF DENITRIFIED 350°F+ SRC-II WITH ICR 202 CATALYST
 AT 350°F RECYCLE CUT POINT; EFFECT OF PER PASS CONVERSION (60% TO 80%)

Pilot Plant Run 45-182; Feed - SQQ 6668

Run Hours	241-265		265-289		337-361		361-385	
Avg. Cat. Temp., °F	592		593		614		616	
LHSV	1.10		1.10		1.10		1.10	
Per Pass Conversion	58.16		58.52		80.81		81.46	
Total Pressure, psig	1398		1397		1397		1397	
H ₂ Mean Pressure, psia	1219		1212		1183		1192	
Total Gas in, SCF/B	7025		6965		7313		7331	
Recycle Gas, SCF/B	5859		5779		5647		5657	
No Loss Prod. Yields	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
C ₁	0.01		0.01		0.01		0.01	
C ₂	0.10		0.10		0.14		0.13	
C ₃	2.27		2.43		2.73		2.58	
iC ₄	12.79	20.18	13.48	21.28	13.03	20.57	12.48	19.71
nC ₄	2.36	3.58	2.61	3.97	2.88	4.38	2.80	4.26
C ₅ -180°F	19.80	25.47	19.28	25.03	22.71	29.19	22.19	28.47
180-350°F	65.98	74.40	65.46	74.01	61.95	70.35	63.22	71.62
Total C ₅ +	85.78	99.88	84.74	99.03	84.66	99.54	85.41	100.09
Act./No Loss Recov.	101.30/103.28		102.71/103.35		101.27/103.41		100.38/103.39	
H ₂ Cons. (Gross), SCF/B	2005		2027		2061		2053	
H ₂ Cons. (Chemical), SCF/B	1918		1960		1999		1985	
Product Inspections								
C ₅ -180°F								
Gravity, °API	73.4		75.1		73.1		72.9	
Octane No.								
F-1 Clear	90.5		90.0		90.4			
F-2 Clear	84.3		85.0		84.5			
Group Type, LV %								
Paraffins	61.8		63.2		60.4			
Naphthenes	32.3		31.8		33.8			
Aromatics	5.9		5.0		5.8			
180-350°F								
Gravity, °API	48.0		48.5		48.6		48.8	
Aniline Point, °F	110.7		109.4		109.1			
Octane No.								
F-1 Clear	69.6		69.1		69.6		70.6	
F-2 Clear	68.8		69.1		69.0		69.4	
Group Type, LV % (Low Mass)								
Paraffins	8.8		9.4		10.1		6.9	
Naphthenes	83.7		83.2		81.2		86.1	
Aromatics	7.5		7.4		8.6		6.9	
Group Type, LV % (By Chromatography)								
Paraffins			13.0					
Naphthenes			78.9					
Aromatics			8.0					
TBP Distillation, °F (Simulated By Chromatography)								
ST/5	160/195		140/185		162/195		143/190	
10/30	200/232		196/224		202/227		198/226	
50	269		259		257		256	
70/90	317/344		314/342		304/343		301/342	
95/99	350/358		349/358		353/363		351/362	
ASTM D 86 Distillation, °F								
ST/5	222/226		212/220		213/223		213/211	
10/30	231/250		227/240		227/242		224/239	
50	271		262		259		259	
70/90	301/326		292/322		288/322		288/322	
95/EP	333/353		328/332		331/352		331/376	
% Overhead (Excl. Trap)	97.5		98		98		98	
% in Trap	2.0		1		1.5		1.5	

TABLE X

DOE CONTRACT EF-76-C-01-2315
 PROPERTIES OF 180-280°F AND 280°F+ PRODUCT
 HYDROCRACKING OF DENITRIFIED 350°F+ SRC-II
 WITH ICR 202 CATALYST AT 350°F RECYCLE CUT POINT
 PILOT PLANT RUN 45-182; FEED - SGQ 6668

Run Hours	265-289	337-361	361-385
Average Catalyst Temperature, °F	593	614	616
LHSV	1.10	1.10	1.10
180-280°F Product			
Wt % of Fresh Feed	37.55	37.25	38.18
LV % of Fresh Feed	43.59	43.22	44.23
Gravity, °API	53.3	53.2	52.9
Aniline Point, °F	106.1	106.5	104.6
Octane Number			
F-1 Clear	77.3	77.1	77.3
F-2 Clear	74.5	74.1	74.2
Group Type, LV % (Low Mass)			
Paraffins	12.3	15.1	14.6
Naphthenes	79.4	76.0	75.7
Aromatics	8.3	9.0	9.7
Group Type, LV % (By Chromatography)			
Paraffins	12.6		
Naphthenes	78.6		
Aromatics	8.8		
TBP Distillation, °F (Simulated by Chromatography)			
St/5	139/168	157/189	139/175
10/30	194/214	197/217	195/217
50	229	230	230
70/90	250/271	250/273	250/274
95/99	281/290	281/291	282/294
280-350°F Product			
Wt % of Fresh Feed	27.91	24.70	25.04
LV % of Fresh Feed	30.42	27.13	27.39
Gravity, °API	42.0	43.4	42.6
Aniline Point, °F	117.5	114.8	114.0
Octane Number			
F-1 Clear	58.4		
F-2 Clear	60.0		
Group Type, LV % (Low Mass)			
Paraffins	8.5	9.6	9.5
Naphthenes	84.5	81.7	81.4
Aromatics	7.0	8.7	9.2
TBP Distillation, °F (Simulated by Chromatography)			
St/5	258/285	251/279	253/278
10/30	296/322	287/313	286/313
50	338	331	331
70/90	350/362	345/360	345/360
95/99	365/371	364/370	365/370

DOE CONTRACT EF-76-C-01-2315
 DETAILED COMPOSITION OF 180-280°F PRODUCT BY THREE ANALYTICAL METHODS
 HYDROCRACKING OF SRC-II WITH ICR 202
 PILOT PLANT RUN 45-182

Time Onstream, Hr Method	265-289			337-361		361-385	
	Chromatographic Procedure 1001	PNA By Chromatography	Low Mass	Chromatographic Procedure 1001	Low Mass	Chromatographic Procedure 1001	Low Mass
Composition, LV %	(*)			(*)		(*)	
Paraffins							
C ₆ -	0.7	0.7		0.1		0.4	
iC ₇	6.2	6.6		6.6		6.0	
nC ₇	0.4			0.4		0.4	
iC ₈	4.0	4.4		3.9		4.1	
nC ₈	0.2			0.3		0.2	
iC ₉	3.9	0.9		3.0		3.2	
nC ₉	-	-		-		0.05	
C ₁₀ 's	0.3	-		0.4		0.3	
Total Paraffins	15.7	12.6	12.3	14.7	15.1	14.7	14.6
Naphthenes							
Methylcyclopentane	4.4	5.8		1.8		3.6	
Cyclohexane	1.5			1.3		1.3	
C ₇ -Cyclopentanes	23.6	38.5		25.6		23.4	
Methylcyclohexane	18.2			18.9		17.9	
C ₈ -Cyclopentanes	8.6	29.5		12.0		9.3	
C ₈ -Cyclohexanes	15.3			15.5		14.6	
C ₉ -Cyclopentanes	0.2	4.9		0.3		0.7	
C ₉ -Cyclohexanes	1.3			2.2		2.5	
Total Naphthenes	73.1	78.6	79.4	77.6	76.0	73.3	75.7
Aromatics							
Benzene	0.9	0.9	0.7	0.3	0.5	0.7	0.8
Toluene	4.9	4.9	4.9	1.4	5.8	5.8	6.0
Ethylbenzene	3.1	3.0	2.7	3.2	2.7	3.4	2.8
Xylenes	1.4					1.6	
Total Aromatics	10.3	8.8	8.3	6.5	9.0	11.2	9.7
Unidentified	0.9	-	-	1.2	-	0.8	-

*Although Chromatographic Procedure 1001 gives the most detailed breakdown, some C₈-C₉ naphthenes are misidentified as C₉-C₁₀ paraffins by this method. Also, the peak identified as ethylbenzene appears to contain saturates.

TABLE XII

DOE CONTRACT EF-76-C-01-2315
 HYDROCRACKING OF DENITRIFIED 350°F+
 SRC-II WITH ICR 202 CATALYST AT 310°F RECYCLE CUT POINT*

Pilot Plant Run 45-182; Feed - SQ 6668

Run Hours	409-433		433-457		505-529	
Avg. Cat. Temp., °F	614		615		612	
LHSV	1.10		1.10		1.10	
Per Pass Conversion	68.55		67.92		58.29	
Total Pressure, psig	1397		1397		1396	
H ₂ Mean Pressure, psia	1193		1194		1206	
Total Gas in, SCF/B	7228		7255		7052	
Recycle Gas, SCF/B	5671		5699		5706	
No Loss Prod. Yields	Wt %	Vol %	Wt %	Vol %	Wt %	Vol %
C ₁	0.02		0.02		0.01	
C ₂	0.16		0.15		0.15	
C ₃	3.28		3.08		3.33	
iC ₄	16.83	26.55	16.21	25.58	18.24	28.79
nC ₄	3.37	5.12	3.19	4.85	3.40	5.17
C ₅ -180°F	26.29	33.76	27.72	35.44	28.14	36.01
180-310°F*	53.92	62.15	53.44	61.50	50.53	58.20
Total C ₅ +	80.21	95.91	81.18	96.94	78.68	94.22
Act./No Loss Recov.	103.98/103.83		100.96/103.79		103.28/103.78	
H ₂ Cons. (Gross), SCF/B	2270		2291		2310	
H ₂ Cons. (Chemical), SCF/B	2242		2214		2208	
Inspections						
C ₅ -180°F						
Gravity, °API	73.0		72.0		72.2	
Octane No.						
F-1 Clear	90.2		I			
F-2 Clear	84.5		84.0			
Group Type, LV %						
Paraffins	60.3		56.3			
Naphthenes	34.8		38.8			
Aromatics	4.9		4.9			
180-310°F						
Gravity, °API	52.0		51.7		51.9	
Aniline Point, °F	108.1		107.8		108.7	
Octane No.						
F-1 Clear	75.1		74.9		74.3	
F-2 Clear	74.1					
Group Type, LV % (Low Mass)						
Paraffins	13.4		10.8		10.4	
Naphthenes	75.9		80.0		81.8	
Aromatics	10.7		9.2		7.8	
Group Type, LV % (By Chromatography)						
Paraffins	11.9		11.9		11.9	
Naphthenes	78.8		79.9		79.3	
Aromatics	9.4		8.2		8.8	
TBP Distillation, °F (Simulated By Chromatography)						
ST/5	150/190		142/186		159/194	
10/30	198/223		196/222		201/224	
50	247		244		245	
70/90	276/310		273/305		273/302	
95/11	320/327		315/324		309/318	
ASTM D 86 Distillation, °F						
ST/5	210/218		208/216		212/218	
10/30	221/230		218/229		220/230	
50	240		239		238	
70/90	259/288		256/286		255/280	
95/EP	296/326		297/303		288/322	
% Overhead (Excl. Trap)	99		97		99	
% in Trap	-		2.5		-	

I = Incomplete.

*Although the nominal cut point was 310°F for these three periods, the results show the actual cut point is about 5°F lower in the second period than in the first and 10°F lower in the third than the first.

TABLE XIII

DOE CONTRACT EF-76-C-01-2315
 DETAILED COMPOSITION OF 180°F+ PRODUCT BY
 THREE ANALYTICAL METHODS; HYDROCRACKING OF
 HYDROTREATED SRC-II WITH ICR 202; PILOT PLANT RUN 45-182

Approximate Boiling Range, °F	180-320			180-315			180-310		
	409-433			433-457			515-529		
	Chromatographic Procedure 1001 ¹	PNA by Chromatography	Low Mass	Chromatographic Procedure 1001 ¹	PNA by Chromatography	Low Mass	Chromatographic Procedure 1001 ¹	PNA by Chromatography	Low Mass
Time Onstream, Hr									
Method									
Composition, LV %									
Paraffins									
C ₆ -	0.2	0.2		0.2	0.3		-	0.03	
iC ₇	4.6	5.0 }		4.5	4.9 }		4.8	5.3 }	
nC ₇	0.3			0.3			0.3		
iC ₈	3.2	3.6 }		3.3	3.7 }		3.2	3.5 }	
nC ₈	0.2			0.2			0.2		
C ₉ 's	(5.0)	2.0		(4.5)	2.0		(4.8)	2.2	
C ₁₀ 's	(4.4)	1.1		(6.2)	1.0		(4.9)	1.0	
Total Paraffins	(17.9)	11.9	13.4	(19.2)	11.9	10.8	(18.2)	12.0	10.4
Naphthenes									
Methylcyclopentane	2.1	3.0 }		2.7	3.7 }		1.1	1.9 }	
Cyclohexane	0.9			1.1			0.9		
C ₇ -Cyclopentanes	17.8	28.4 }		17.6	29.0 }		18.6	30.6 }	
Methylcyclohexane	14.2			14.5			13.4		
C ₈ -Cyclopentanes	(6.8)	22.3 }		(7.0)	23.2 }		(8.9)	23.4 }	
C ₈ -Cyclohexanes	(11.3)			(11.6)			(12.0)		
C ₉ -Cyclopentanes	(1.5)	16.4 }		(1.9)	16.8 }		(1.8)	18.4 }	
C ₉ -Cyclohexanes	(7.9)			(7.8)			(8.6)		
C ₁₀ -Naphthenes	-	8.6		-	7.2		-	4.9	
Total Naphthenes	62.5	78.7	75.9 ²	(64.2)	79.9	80.0 ³	(65.3)	79.2	81.8 ⁴
Aromatics									
Benzene	0.3	0.3	0.6	0.3	0.4	0.5	0.1	0.1	0.2
Toluene	4.2	4.0	4.8	4.4	2.8	4.5	4.0	4.2	4.1
Ethylbenzene	(2.9)	3.5 }	3.8 }	(3.0)	3.8 }	3.3 }	(1.2)	3.8 }	3.1 }
Xylenes	2.5						2.5		
C ₉ Aromatics	(2.8)	1.5	1.6	(2.1)	1.2	0.4	(2.2)	0.6	0.4
Total Aromatics	(12.7)	9.3	10.7	(12.3)	8.2	9.2	(11.7)	8.7	7.8
Unidentified	6.9	-	-	4.3	-	-	4.8	-	-

¹Although chromatographic procedure 1001 gives the most detailed breakdown, it is obvious that there is a considerable amount of misidentification of peaks due to the large number of compounds present. Numbers shown in parenthesis appear to be in error.

²Includes 4.3 LV % dinaphthenes.

³Includes 3.1 LV % dinaphthenes.

⁴Includes 2.2 LV % dinaphthenes.

TABLE XIV

DOE CONTRACT EF-76-C-01-2315
 DISTRIBUTION OF C₅-180°F PRODUCT FROM
 SECOND-STAGE HYDROCRACKER - RUN 45-182

Time Onstream, Hr	97-121	169-193	193-217	241-265	265-289	337-361	409-433	433-457
Avg. Catalyst Temperature, °F	569	581	586	592	593	614	614	615
Composition, LV % of C ₅ -180°F (By Chromatography)								
n-Butane	0.02	0.02	-	0.03	0.03	0.02	0.03	0.03
Isopentane	37.4	37.3	38.0	38.0	40.1	34.9	35.1	(28.9)*
n-Pentane	2.0	2.2	2.4	2.4	2.6	2.5	2.0	2.7
2,2-Dimethylbutane	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05
2,3-Dimethylbutane	2.6	2.4	2.6	2.5	2.4	2.8	2.7	2.8
2-Methylpentane	9.8	9.1	9.6	9.8	9.4	10.7	10.4	10.9
3-Methylpentane	6.0	5.6	5.8	6.1	5.8	6.6	6.4	6.6
n-Hexane	1.1	1.0	1.0	1.0	0.9	1.0	1.0	1.0
Isoheptanes	1.6	1.7	3.1	1.9	1.9	1.8	2.6	3.3
n-Heptane	-	-	-	-	-	-	-	-
C ₈ Isoparaffins	-	-	-	-	-	-	-	-
Total Paraffins	60.5	59.4	62.5	61.8	63.2	60.4	60.3	56.3
Cyclopentane	0.9	0.9	1.0	1.0	0.9	1.3	1.2	1.3
Methylcyclopentane	27.6	29.8	24.8	27.9	27.6	29.2	29.7	31.6
Cyclohexane	3.8	3.5	4.1	2.3	2.1	2.4	2.2	3.4
Dimethylcyclopentanes, Ethylcyclopentane	0.9	0.9	2.4	1.1	1.2	0.9	1.6	2.4
Methylcyclohexane	-	0.02	-	-	0.04	-	-	0.1
Total Naphthenes	33.2	35.1	32.3	32.2	31.8	33.8	34.8	38.8
Benzene	6.4	5.5	5.1	5.9	5.0	5.8	4.9	4.9
Toluene	-	-	-	-	-	-	0.02	0.01
Total Aromatics	6.4	5.5	5.1	5.9	5.0	5.8	4.9	4.9
Isopentane/n-Pentane	18	17	16	16	16	14	17	(11)*
Isohexane/n-Hexane	17	17	18	19	20	19	20	21

*Measured isopentane appears low; probable loss in sample handling.

TABLE XV

DOE CONTRACT EF-76-C-01-2315
PROPERTIES OF H-COAL ATMOSPHERIC OVERHEAD PRODUCT FROM HRI

Chevron Identification WOW- HRI Identification LO-	3895 1460	3896 1461	3897 1462	3898 1463	3899 1464	3900 1465	3752-1 1412	3752-2* 1413
Gravity, °API	29.7	30.2	30.3	29.2	29.8	29.7	31.4	30.9
Aniline Point, °F	29.5	31.6	32.2	32.0	30.3	29.7	34.0	34.1
Refractive Index, 80°C	1.4719	1.4694	1.4685	1.4739	1.4693	1.4689	-	-
Molecular Weight	196	181	211	201	187	194	-	-
Carbon, Wt %	82.73	(78.01)	(77.02)	87.16	85.45	85.39	85.07	85.41
Hydrogen, Wt %	11.37	(10.96)	(10.75)	11.92	11.22	11.17	11.14	11.49
Sulfur, Wt %	0.20	0.19	0.19	0.26	0.21	0.21	0.38	0.19
Oxygen, Wt %	1.90	1.67	1.77	1.91	1.94	1.98	1.71	1.80
Total Nitrogen, Wt %	0.38	0.35	0.39	0.41	0.37	0.40	0.43	0.42
Basic Nitrogen, Wt %	0.30	0.29	0.30	0.28	0.34	0.31	0.32	0.31
Chloride, ppm	27	27	22	I	38	27	7	10
TBP Distillation, °F (Simulated by Chromatography)								
St/5	42/173	35/172	35/176	78/176	34/165	34/165	43/162	53/170
10/30	201/308	190/298	185/296	211/316	183/305	176/299	180/281	180/285
50	377	375	375	386	381	387	367	367
70/90	436/510	435/508	435/507	438/508	437/507	439/509	425/502	427/503
95/99	542/615	541/612	539/601	540/607	538/596	541/609	536/599	536/603

I = Incomplete.
() = Result is suspect.
*Drum leaked in shipment.

TABLE XVI

DOE CONTRACT EF-76-C-01-2315
PROPERTIES OF H-COAL ATMOSPHERIC BOTTOMS FROM HRI

Chevron Identification WOW 3749-	1	2	3	4	5
HRI Identification LO-	1408	1407	1411	1410	1409
Gravity, °API	7.9	7.8	7.7	7.4	8.0
Refractive Index, 80°C	1.5504				
Density, 70°C	0.9744				
Molecular Weight	286				
Ramsbottom Carbon, Wt %	1.19				
Hot C ₇ Asphaltenes, Wt %	1.65				
Pour Point, °F	-5				
Bromine No.	32	34			
Carbon, Wt %	89.22	89.84	89.15	89.52	89.57
Hydrogen, Wt %	8.85	8.85	8.79	8.70	8.86
Sulfur, Wt %	0.11	0.11	0.12	0.11	0.094
Oxygen, Wt %	1.18	1.13	1.12	1.15	1.07
Total Nitrogen, Wt %	0.62	0.59	0.67	0.67	0.64
Basic Nitrogen, Wt %	0.37	0.38	0.41	0.41	0.40
Chloride, ppm	90	22	18	22	17
Ash, ppm	200				
TBP Distillation, °F (Simulated by Chromatography)					
St/5	275/421	258/429	257/414	287/427	254/413
10/30	455/542	460/543	451/540	458/542	450/537
50	592	592	592	590	588
70/90	650/735	647/732	652/739	647/734	649/737
95/99	788/906	785/902	792/905	789/905	791/910
Emission Spectrum, ppm					
Al/B	0.3/4.3				
Cr/Cu	0.2/0.1				
Fe/Mn	(101.0)/1.5				
Na/Si	0.7/0.8				

() = Result is suspect.

TABLE XVII

DOE CONTRACT EF-76-C-01-2315
PROPERTIES OF H-COAL AND SRC-II WHOLE PROCESS PRODUCTS

	H-Coal Whole Process Product	Washed Water H-Coal Product	SRC-II Whole Process Product
Chevron Identification WOW-	3919	3920	3666
Gravity, °API	25.8	25.4	18.6
Aniline Point, °F	<32	<32	<30
Refractive Index, 20°C	1.5050	I	-
Refractive Index, 80°C	I	1.4801	1.5073
Molecular Weight	147	149	132
Viscosity, cSt			
At 100°F	1.645	1.646	2.196
At 130°F	-	-	1.617
Ramsbottom Carbon, Wt %	0.29/0.30	I	0.70
Hot C ₇ Asphaltenes, Wt %	0.35	0.19/0.21	0.0468
Ash, ppm	90	30	40
Pour Point, °F	-	-	<-80
Bromine No.	37/48	38	70
Maleic Diene No.	10.4	8.56	-
Carbon, Wt %	86.08*	I	82.82
Hydrogen, Wt %	10.70*	I	9.24
Sulfur, Wt %	(0.31/0.33)	0.18	0.29
Oxygen, Wt %	1.88/1.71	1.45	3.79
Total Nitrogen, Wt %	0.44/0.48	0.43	0.85
Basic Nitrogen, Wt %	0.31/0.30	0.27	0.70
Chloride, ppm	32	1.2	50.
Hydrogen/Carbon Atom Ratio	1.48*	I	1.33
H ₂ O, ppm	2217	1682	-
ASTM Distillation, °F	D 86/D 1160-10	I	D 86/D 1160-10
St/5	140/204		154/217
10/30	235/329		281/382
50	398		438
70/90	466/582		484/597
95/EP	648/704		699/850
% Overhead (Excluding Trap)	98.5		98.0
% In Flask	1.5		0.0
% Trap	0.0		2.0
TBP Distillation, °F (Simulated by Chromatography)			
St/5	56/177	55/176	56/189
10/30	213/333	213/341	241/379
50	404	412	424
70/90	476/588	483/588	473/562
95/99	654/765	654/774	642/820

I = Incomplete.

() = Result is suspect.

*Calculated from a blend of the components.

TABLE XVIII

DOE CONTRACT EF-76-C-01-2315
 HYDROTREATING OF H-COAL WHOLE PROCESS PRODUCT
 WITH ICR 106 CATALYST AT 750°F, 2500 PSIG
 RUN CONDITIONS AND PRODUCT PROPERTIES

Time On Stream, Hr	LHSV	Product Nitrogen, ppm	Product Aromatics, LV %
0-885	1.0	<0.5	6-20
885-955	1.5	10	35-40
995-1411	0.5	<0.5	9-14
Shutdown for 100 Hours Due to Plug in Reactor Preheat			
1422-Current	0.5	0.5	Incomplete

TABLE XIX

YIELDS AND WHOLE LIQUID PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
AND SRC II WHOLE PROCESS PRODUCTS OVER IC4106 AT 1.0 LHSV

	H-COAL WHOLE PROCESS PRODUCT				SRC-II WHOLE PROCESS PRODUCT			
	76- 170	76- 170	76- 170	76- 170	76- 165	76- 165	76- 165	76- 165
RUN	76- 170	76- 170	76- 170	76- 170	76- 165	76- 165	76- 165	76- 165
FEED	WOW 3919	WOW 3919	WOW 3919	WOW 3919	WOW 3666	WOW 3666	WOW 3666	WOW 3666
RUN HOURS	70.- 94.	144.- 168.	214.- 238.	310.- 334.	371.- 395.	395.- 419.	395.- 419.	395.- 419.
AVG.CAT.TEMP., F.	750.	749.	749.	750.	750.	749.	749.	749.
LHSV	0.94	1.01	0.99	0.98	1.01	1.01	1.01	1.01
TOTAL PRESSURE,PSIG	2504.	2497.	2504.	2498.	2499.	2497.	2497.	2497.
H2 MEAN PRESS.,PSIA	2323.	2316.	2341.	2342.	2327.	2338.	2338.	2338.
TOTAL GAS IN,SCF/R	14714.	14445.	17881.	17681.	17318.	17328.	17328.	17328.
RECYCLE GAS, SCF/R	12587.	12329.	15934.	15756.	14555.	14703.	14703.	14703.
NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.
C1	0.03	0.08	0.06	0.06	0.10	0.09	0.09	0.09
C2	0.05	0.12	0.08	0.09	0.17	0.17	0.17	0.17
C3	0.07	0.18	0.12	0.14	0.21	0.22	0.22	0.22
I-C4	0.01 0.01	0.02 0.03	0.01 0.01	0.01 0.02	0.02 0.03	0.02 0.03	0.02 0.03	0.02 0.03
N-C4	0.04 0.06	0.10 0.15	0.06 0.09	0.07 0.11	0.10 0.16	0.11 0.18	0.11 0.18	0.11 0.18
C5- EP F.	100.48 108.74	100.10 107.77	99.97 107.18	99.87 106.77	98.09 110.64	97.85 109.72	97.85 109.72	97.85 109.72
TOTAL C5+	100.48 108.74	100.10 107.77	99.97 107.18	99.87 106.77	98.09 110.64	97.85 109.72	97.85 109.72	97.85 109.72
ACT./NO LOSS RECOV.	104.17/103.54	99.96/103.44	101.11/103.16	99.48/103.11	98.65/104.25	99.64/104.03	99.64/104.03	99.64/104.03
H2 CONS(GROSS),SCF/R	2127.	2116.	1947.	1925.	2763.	2625.	2625.	2625.
H2 CONS(HCON),SCF/R	2097.	2040.	1875.	1844.	2637.	2501.	2501.	2501.

....LIQUID PRODUCT INSPECTIONS....

WHOLE LIQUID PRODUCT

GRAVITY, API	38.7	37.8	37.1	36.6	37.1	36.4
ANILINE PT., F.	117.7	112.0	107.0	102.2	98.7	96.8
SULFUR, PPM.	10.0	10.0	10.0	10.0	4.1	10.0
NITROGEN, PPM.	0.49	0.23	0.47	0.47	0.45	0.24
OXYGEN, WT.PC.	0.011	0.009	0.009	0.009	0.009	0.009
SMOKE PT.,ASTM, MM		21.	21.	20.		
FREEZE PT.,ASTM, F.		-22.	-23.	-9.		
HIGH MASS, LV.PC.						
PARAFFINS	3.5	3.1	3.1	3.2	3.5	3.7
NAPHTHENES	91.5	86.2	83.5	79.3	76.8	75.9
AROMATICS	6.0	10.7	13.4	17.5	19.7	20.4
MOLECULAR WEIGHT	151.	154.	154.	151.		
TBP DIST., F.						
ST/ 5	53./ 174.	53./ 178.	55./ 173.	49./ 179.		62./ 177.
10/30	208./ 284.	212./ 285.	207./ 285.	214./ 290.		210./ 278.
50	359.	365.	361.	368.		364.
70/90	423./ 516.	433./ 528.	432./ 527.	481./ 537.		419./ 505.
95/99	564./ 653.	578./ 670.	577./ 674.	588./ 694.		553./ 662.

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TABLE XX

YIELDS AND WHOLE LIQUID PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
WHOLE PROCESS PRODUCT OVER ICR106 AT 1.5 LHSV

RUN FEED	76- 170 WOW 3920	76- 170 WOW 3920	RUN FEED	76- 170 WOW 3920	76- 170 WOW 3920
RUN HOURS	803.- 827.	827.- 851.	RUN HOURS	875.- 899.	899.- 923.
AVG.CAT.TEMP., F.	751.	750.	AVG.CAT.TEMP., F.	751.	751.
LHSV	1.48	1.50	LHSV	1.45	1.44
TOTAL PRESSURE,PSIG	2500.	2502.	TOTAL PRESSURE,PSIG	2500.	2501.
H2 MEAN PRESS.,PSIA	2232.	2200.	H2 MEAN PRESS.,PSIA	2267.	2233.
TOTAL GAS IN,SCF/B	8274.	8058.	TOTAL GAS IN,SCF/B	9684.	9366.
RECYCLE GAS, SCF/B	6808.	6727.	RECYCLE GAS, SCF/B	8258.	7952.
NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	WT.PC. VOL.PC.	NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	WT.PC. VOL.PC.
C1	0.06	0.04	C1	0.05	0.05
C2	0.10	0.06	C2	0.08	0.08
C3	0.10	0.07	C3	0.08	0.08
I-C4	0.01 0.02	0.01 0.01	I-C4	0.01 0.02	0.01 0.01
N-C4	0.06 0.10	0.05 0.07	N-C4	0.06 0.09	0.05 0.07
C5- EP F.	100.21 105.29	100.10 105.25	C5-180 F.	4.44 5.50	4.50 5.55
TOTAL C5+	100.21 105.29	100.10 105.25	180-300 F.	21.02 24.27	20.93 24.17
ACT./NO LOSS RECOV.	97.17/102.36	99.16/102.14	300- EP F.	74.72 75.53	74.77 75.58
H2 CONS(GROSS),SCF/B	1466.	1331.	TOTAL C5+	100.19 105.32	100.21 105.32
H2 CONS(HCSON),SCF/B	1401.	1273.	ACT./NO LOSS RECOV.	101.58/102.28	101.10/102.27
....LIQUID PRODUCT INSPECTIONS....			H2 CONS(GROSS),SCF/B	1426.	1414.
WHOLE LIQUID PROD			H2 CONS(HCSON),SCF/B	1356.	1351.
-----		LIQUID PRODUCT INSPECTIONS....		
GRAVITY, API	33.3	33.1	WHOLE LIQUID PROD		
ANILINE PT., F.		76.1	-----		
SULFUR, PPM.			GRAVITY, API	33.2	33.2
NITROGEN, PPM.	3.45	9.45	ANILINE PT., F.	78.4	77.6
HIGH MASS,LV.PC.			SULFUR, PPM.		
PARAFFINS	3.4		NITROGEN, PPM.	7.61	12.85
NAPHTHENES	58.0		HIGH MASS,LV.PC.		
AROMATICS	38.5		PARAFFINS	3.6	3.5
			NAPHTHENES	59.3	59.4
			AROMATICS	37.1	37.1

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TABLE XXI

YIELDS AND WHOLE LIQUID PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
WHOLE PROCESS PRODUCT OVER ICR106 AT 0.5 LHSV

76- 170	76- 170	76- 170	76- 170
WOW 3920	WOW 3920	WOW 3920	WOW 3920
RUN FEED	1139.- 1163.	RUN FEED	1163.- 1187.
RUN HOURS	747.	RUN HOURS	1187.- 1211.
AVG.CAT.TEMP., F.	0.46	AVG.CAT.TEMP., F.	1211.- 1235.
LHSV	2500.	LHSV	746.
TOTAL PRESSURE,PSIG	2265.	TOTAL PRESSURE,PSIG	0.46
H2 MEAN PRESS.,PSIA	11159.	H2 MEAN PRESS.,PSIA	2501.
TOTAL GAS IN,SCF/R	8962.	TOTAL GAS IN,SCF/R	2281.
RECYCLE GAS, SCF/R		RECYCLE GAS, SCF/R	10716.
			11644.
			9455.
NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	NO LOSS PROD.YIELDS	WT.PC. VOL.PC.
C1	0.05	C1	0.07
C2	0.08	C2	0.13
C3	0.11	C3	0.17
I-C4	0.01 0.02	I-C4	0.02 0.03
N-C4	0.05 0.08	N-C4	0.08 0.13
C5- EP F.	101.45 108.52	C5-180 F.	3.80 4.73
TOTAL C5+	101.45 108.52	180-300 F.	21.56 25.15
ACT./NO LOSS RECOV.	102.35/103.59	300- EP F.	76.42 79.64
H2 CONS(GROSS),SCF/B	2197.	TOTAL C5+	101.34 108.97
H2 CONS(HCSON),SCF/B	2131.	ACT./NO LOSS RECOV.	102.28/103.47
		H2 CONS(GROSS),SCF/B	2130.
		H2 CONS(HCSON),SCF/B	2064.
....LIQUID PRODUCT INSPECTIONS....	LIQUID PRODUCT INSPECTIONS....	
WHOLE LIQUID PROD		WHOLE LIQUID PROD	
GRAVITY, API	36.3	GRAVITY, API	36.6
ANILINE PT., F.	110.3	ANILINE PT., F.	113.7
NITROGEN, PPM.	0.21	NITROGEN, PPM.	0.21
OXYGEN, WT.PC.	0.016	OXYGEN, WT.PC.	0.008
HIGH MASS,LV.PC.		HIGH MASS,LV.PC.	
PARAFFINS	4.8	PARAFFINS	2.8
NAPHTHENES	81.3	NAPHTHENES	85.5
AROMATICS	13.9	AROMATICS	11.7
		TBP DIST., F.	
		ST/ 5	41./ 180.
		10/30	216./ 316.
		50	383.
		70/90	452./ 541.
		95/99	594./ 765.

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TABLE XXII

YIELDS AND PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
WHOLE PROCESS PRODUCT OVER ICR106 AT 1.0 LHSV

RUN	76- 170	76- 170	76- 170	76- 170
FEED	WOW 3619	WOW 3920	WOW 3920	WOW 3920
RUN HOURS	539.- 563.	635.- 659.	659.- 683.	683.- 707.
AVG.CAT.TEMP., F.	750.	751.	753.	752.
LHSV	0.97	0.94	0.93	0.93
TOTAL PRESSURE,PSIG	2503.	2502.	2500.	2498.
H2 MEAN PRESS.,PSIA	2260.	2222.	2256.	2250.
TOTAL GAS IN,SCF/B	15338.	10173.	10137.	9928.
RECYCLE GAS, SCF/B	13420.	8338.	8362.	8156.
NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.
C1	0.07	0.08	0.07	0.06
C2	0.11	0.12	0.10	0.09
C3	0.16	0.14	0.13	0.11
I-C4	0.01 0.02	0.01 0.02	0.01 0.02	0.01 0.01
N-C4	0.09 0.13	0.09 0.13	0.07 0.11	0.06 0.10
C5-180 F.	4.99 6.11	4.65 5.76	4.34 5.40	4.52 5.61
180-300 F.	24.71 28.54	21.41 24.75	21.82 25.30	21.54 24.95
300- EP F.	70.09 72.01	74.64 76.54	74.49 76.77	74.65 76.55
TOTAL C5+	99.80 106.67	100.71 107.06	100.66 107.48	100.71 107.12
ACT./NO LOSS RECOV.	102.03/103.10	103.07/102.96	101.24/102.86	102.54/102.86
H2 CONS(GROSS),SCF/B	1918.	1835.	1775.	1772.
H2 CONS(HCSON),SCF/B	1837.	1757.	1699.	1698.
....LIQUID PRODUCT INSPECTIONS....				
C5-180 F. PRODUCT				
GRAVITY, API	61.2	63.0	63.9	63.1
180-300 F. PRODUCT				
GRAVITY, API	50.2	49.9	50.4	50.3
OXYGEN, WT.PC.	(0.290)*	(0.300)*	0.016	0.014
LOW MASS, LV.PC.				
PARAFFINS		13.1		13.0
NAPHTHENES		74.0		74.0
AROMATICS		13.0		13.0
ASTM D-86 DIST., F				
ST/ 5	204./ 214.	216./ 220.	215./ 218.	215./ 220.
10/30	217./ 224.	222./ 227.	220./ 227.	222./ 228.
50	232.	235.	235.	235.
70/90	245./ 267.	246./ 263.	249./ 265.	246./ 265.
95/EP	276./ 33A.	269./ 306.	274./ 332.	270./ 312.
LV.PC.OVHD	9.0	99.5	99.0	99.5
300- EP F. PRODUCT				
GRAVITY, API	30.1	29.4	30.2	29.4
ANILINE PT., F.	101.0	100.1	100.2	99.9
SULFUR, PPM.	13.4	10.0	25.0	10.0
OXYGEN, WT.PC.	(0.280)*	(0.239)*	0.036	0.050
MOLECULAR WEIGHT		171.	163.	164.
POUR PT.,ASTM, F.	-60.	-60.	-65.	-60.
SMOKE PT.,ASTM, MM	14.	17.	13.	19.
FREEZE PT.,ASTM, F.	-94.	-70.	-41.	-70.
HIGH MASS, LV.PC.				
PARAFFINS	3.1	3.0	3.0	3.1
NAPHTHENES	73.1	72.9	71.9	72.6
AROMATICS	23.9	24.2	25.0	24.3
VISCOSITY, CS, F.	10.940			
VISCOSITY, CS, 40F.	3.937	3.995		4.067
VISCOSITY, CS, 130F.	1.545	1.567		1.550
ASTM D-86 DIST., F				
ST/ 5	342./ 354.	349./ 355.	347./ 360.	342./ 358.
10/30	365./ 390.	360./ 394.	369./ 390.	366./ 390.
50	425.	430.	427.	425.
70/90	474./ 552.	476./ 555.	474./ 549.	470./ 538.
95/EP	585./ 653.	584./ 648.	595./ 615.	583./ 643.
LV.PC.OVHD	99.5	99.5	98.0	99.0
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* Probably high

TABLE XXIV

YIELDS AND PRODUCT PROPERTIES FOR HYDROTREATING H-COAL
WHOLE PROCESS PRODUCT OVER ICR106 AT 0.5 LHSV

RUN	76- 170	76- 170	76- 170
FEED	WOW 3920	WOW 3920	WOW 3920
RUN HOURS	1163.- 1187.	1187.- 1211.	1211.- 1235.
AVG.CAT.TEMP., F.	746.	746.	748.
LHSV	0.44	0.46	0.42
TOTAL PRESSURE,PSIG	2500.	2501.	2501.
H2 MEAN PRESS.,PSIA	2283.	2281.	2282.
TOTAL GAS IN,SCF/B	11667.	10716.	11644.
RECYCLE GAS, SCF/B	9537.	8543.	9455.
NO LOSS PROD.YIELDS	WT.PC. VOL.PC.	WT.PC. VOL.PC.	WT.PC. VOL.PC.
C1	0.05	0.07	0.05
C2	0.08	0.13	0.09
C3	0.12	0.17	0.12
I-C4	0.01 0.02	0.02 0.03	0.01 0.02
N-C4	0.06 0.09	0.08 0.13	0.05 0.08
C5-180 F.	3.57 4.44	3.80 4.73	3.73 4.64
180-300 F.	21.33 24.88	21.56 25.15	22.40 26.15
300- EP F.	76.42 79.64	75.83 79.07	75.30 78.66
TOTAL C5+	101.34 108.97	101.19 108.96	101.44 109.46
ACT./NO LOSS RECOV.	102.28/103.47	102.31/103.47	103.54/103.57
H2 CONS(GROSS),SCF/B	2130.	2173.	2189.
H2 CONS(HCSON),SCF/B	2064.	2062.	2120.

....LIQUID PRODUCT INSPECTIONS....

C5-180 F. PRODUCT

GRAVITY, API 63.7 63.4
O.N.,F-1 CLEAR

180-300 F. PRODUCT

GRAVITY, API 51.6 51.7
OXYGEN, WT.PC.

300- EP F. PRODUCT

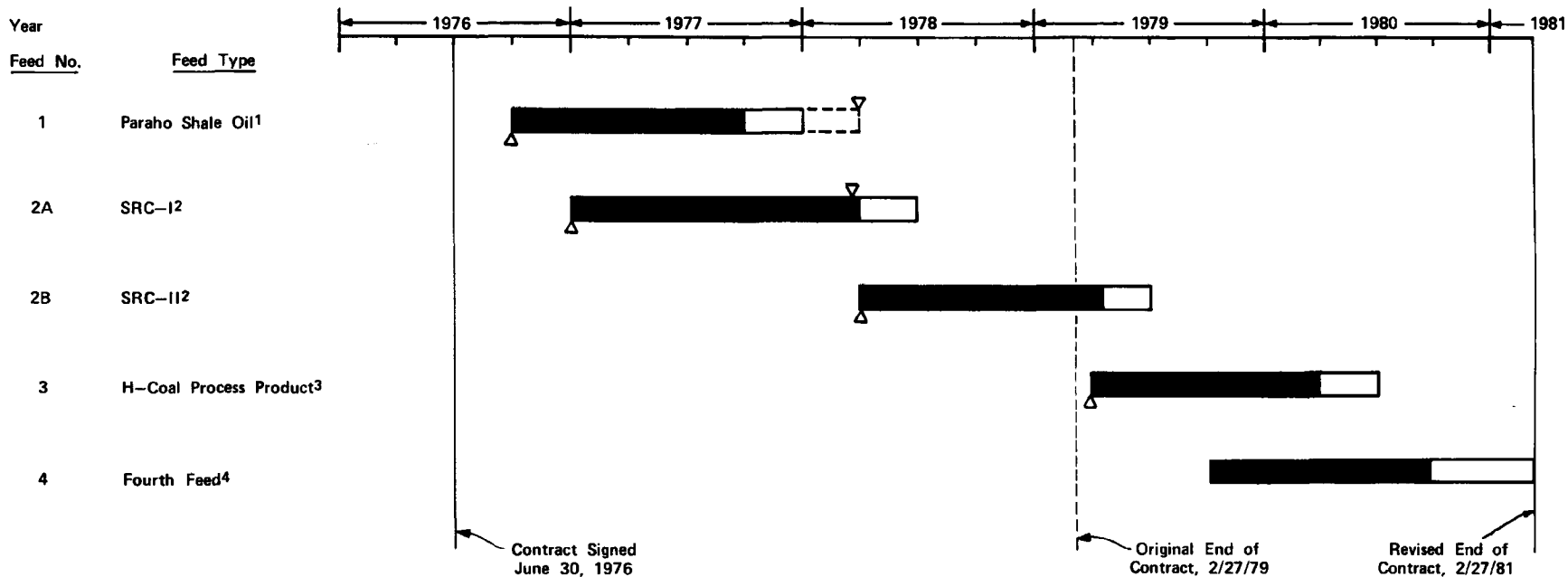
GRAVITY, API 32.1 32.4
ANILINE PT., F.
SULFUR, PPM.
OXYGEN, WT.PC.
MOLECULAR WEIGHT
SMOKE PT.,ASTM, MM

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FIGURE 1
DOE CONTRACT EF-76-C-01-2315
FEED TIMING SCHEDULE (REVISED, APRIL 1979)



¹With the permission of the DOE Technical Representative, work on the Paraho Shale Oil was extended to include added tasks and evaluation of additional design cases.

²Work on SRC-I was suspended and SRC-II was added as Feed 2B.

³H Coal Process Product, sufficient for the full program on this feed, was received on 3/23/79.

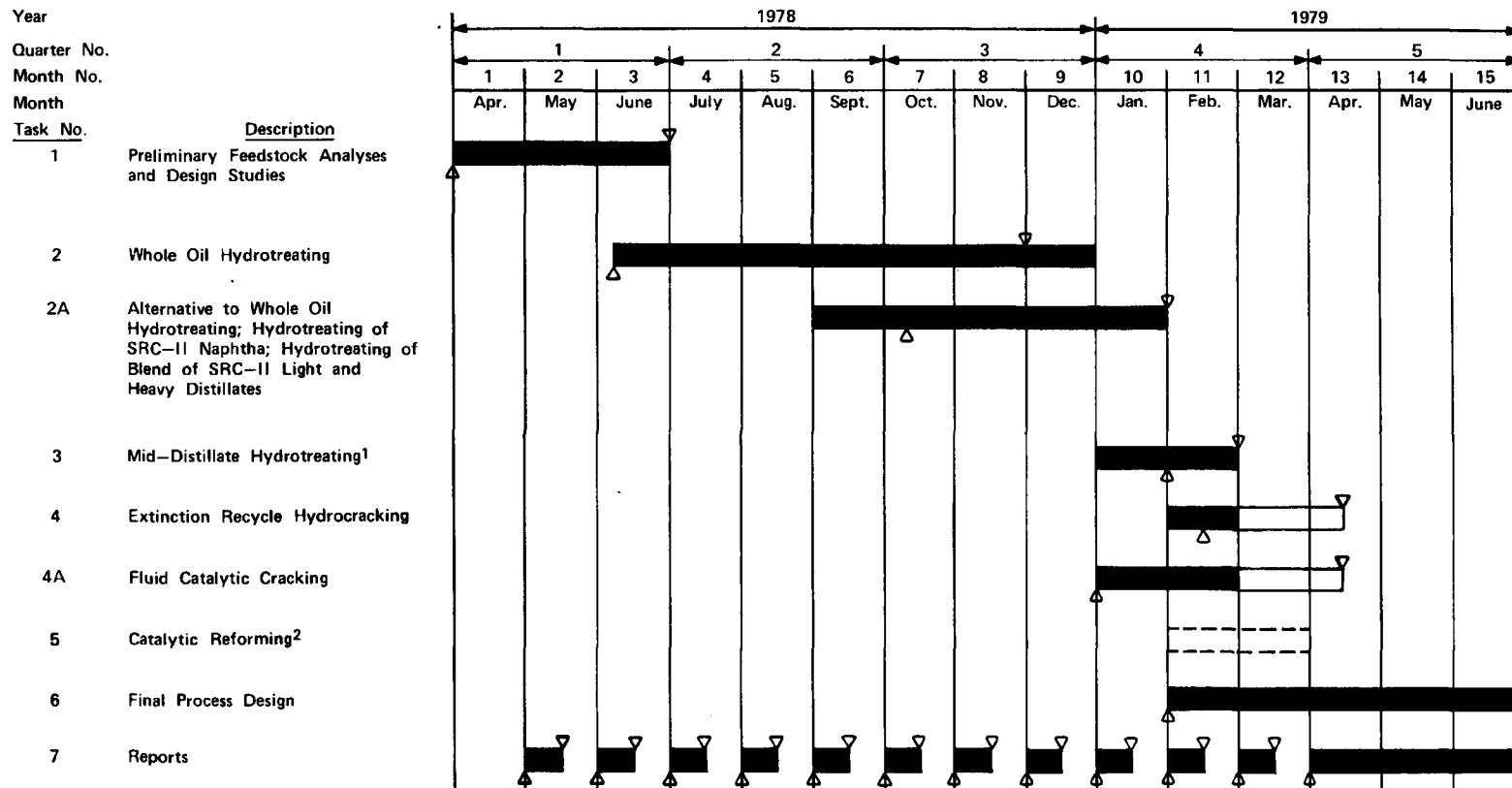
⁴The fourth feed to be selected by mutual agreement between DOE and Chevron.

- Schedule - Feed Analysis and Pilot Plant Work
- Schedule - Final Report and Design
- Schedule Extension
- Actual Start of Work on Feedstock
- Actual End of Work on Feedstock

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FIGURE 2

DOE CONTRACT EF-76-C-01-2315
 SCHEDULE FOR FEED 2B (SRC-II)



¹Task also includes naphtha hydrotreating.

²Task 5 is to be included only if deemed appropriate by mutual agreement of the DOE Technical Representative and Chevron Research, subject of a contract modification. (No Task 5 work is anticipated for SRC II.)

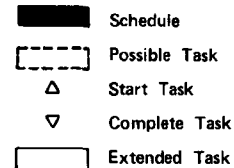
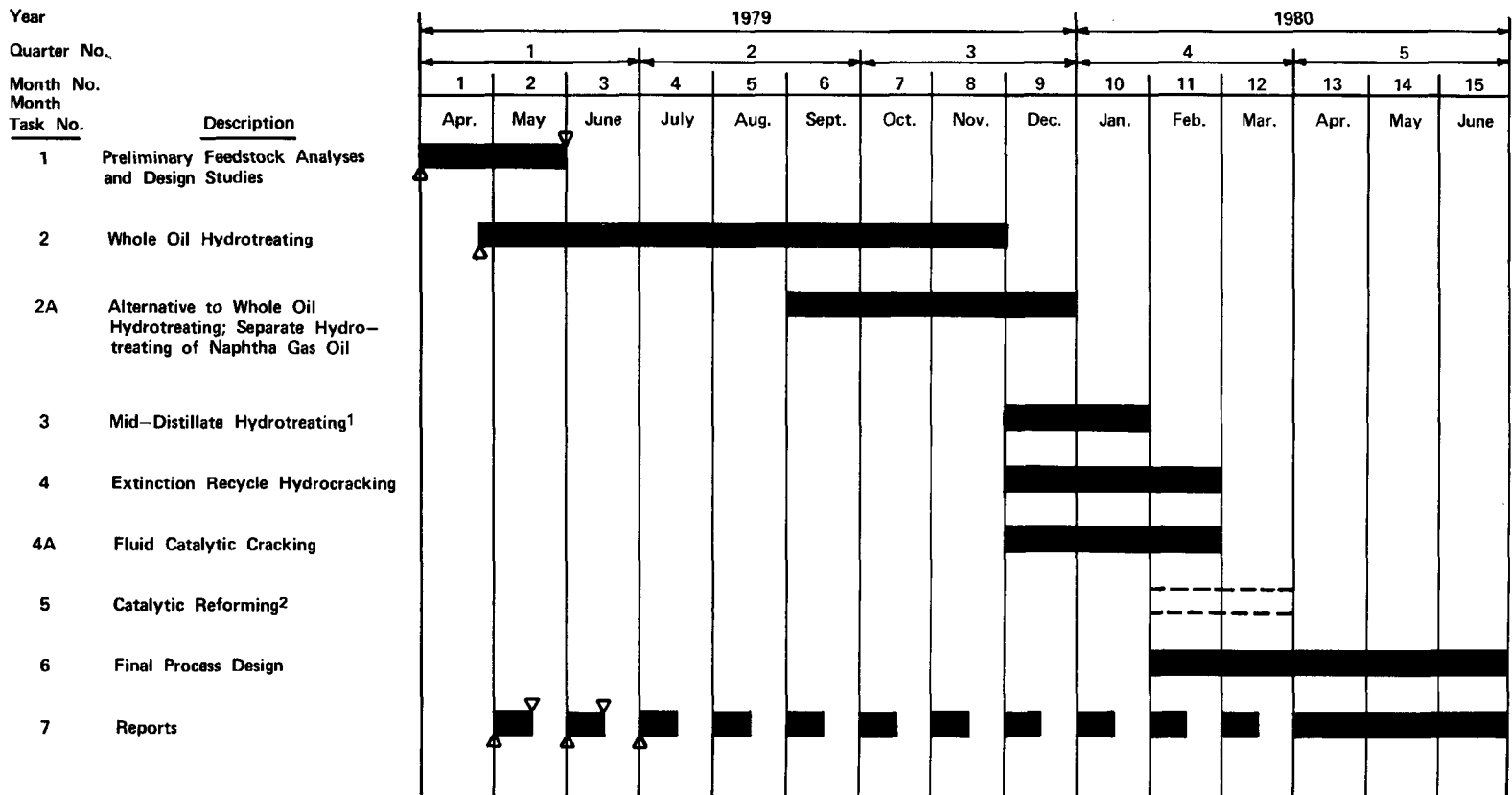
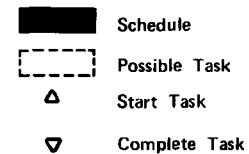


FIGURE 3
DOE CONTRACT EF-76-C-01-2315
SCHEDULE FOR FEED 3 (H-COAL)

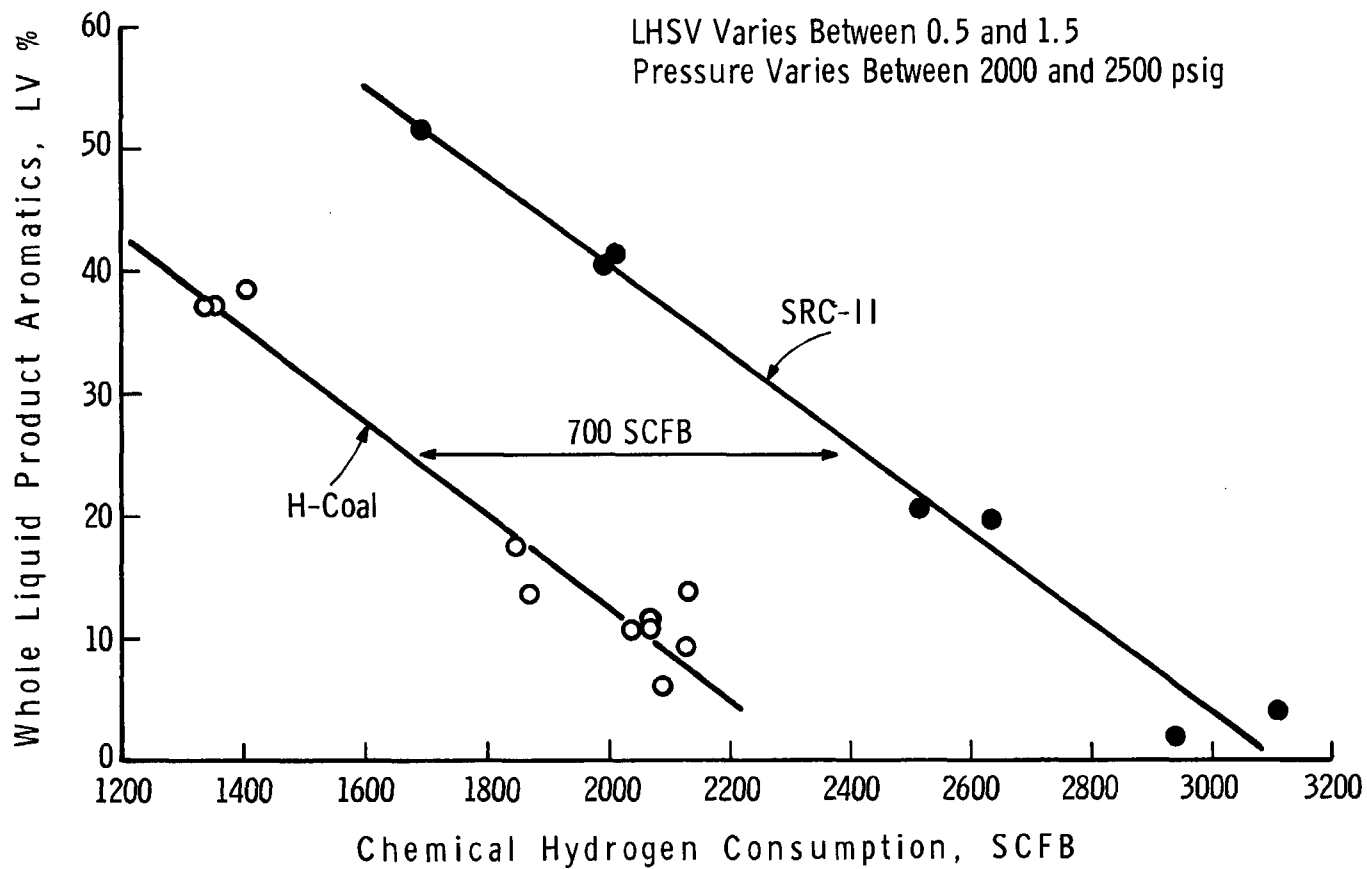


¹Task also includes further hydrotreating of partially hydrotreated naphtha.
²Task 5 is to be included only if deemed appropriate by mutual agreement of the DOE Technical Representative and Chevron Research, subject of a contract modification.



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FIGURE 4
 DOE CONTRACT EF-76-C-01-2315
 WHOLE LIQUID PRODUCT AROMATICS, LV %, FROM
 HYDROTREATING SRC-II AND H-COAL WHOLE PROCESS PRODUCTS
 OVER ICR 106 AT 750°F



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