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DIRECT LIQUEFACTION PROOF-OF-CONCEPT PROGRAM
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FINAL

Topical Report
POC Bench Option Run 01 (227-90)

Work Performed Under Contract No. AC22-92PC92148

For

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ABSTRACT

This report presents the results of bench-scale work, Bench Run PB-01, conducted under the DOE Proof of Concept - Bench Option Program in direct coal liquefaction at Hydrocarbon Technologies, Inc. in Lawrenceville, New Jersey. The Bench Run PB-01 was the first of nine runs planned under the POC Bench Option Contract between the U.S. DOE and Hydrocarbon Technologies, Inc. The primary goal of this bench run was to evaluate the most successful of the process improvements concepts, evolving out of the earlier CMSL Project, for conventional direct liquefaction as well as coprocessing of a sub-bituminous Black Thunder mine coal with waste organics such as waste plastics and heavy resid. The interstage separation of light ends and gases was indeed found to reduce the overall light gas-make from the liquefaction process. The organic waste feeds such as mixed plastics and vacuum resid, employed during Bench Run PB-01, in combined processing with coal, resulted in making the overall process more hydrogen efficient by virtue of reducing the light gas make and also decreasing the hydrogen consumption from the process, while at the same time improving the yields and quality of the distillate products. A definite synergy was found during the combined processing of coal with mixtures of vacuum resid and mixed waste plastics. The application of an all dispersed catalyst conversion reactor resulted in higher feed throughput at equivalent process performance, but also necessitated the use of an in-line hydrotreater for improving the quality of IBP-400°C distillate products. The combination of HTI's iron gel catalyst and Molyvan-A was found very effective in achieving high levels of process performance; although, in recycled form, these catalysts were not as effective as the freshly added precursors.

EXECUTIVE SUMMARY

The first Bench Run PB-01 in DOE's POC (Proof-of-Concept) Bench Option Program evaluated the long-duration continuous processing of organic wastes with sub-bituminous coal along with the demonstration of some of the most successful process concepts emerging out of the earlier CMSL Project. Bench Run PB-01 employed an all dispersed slurry catalyst system of two-stage coal conversion reactors with an interstage high-pressure product separator and an in-line fixed bed hydrotreater. The overall run plan consisted of nine operating conditions which included coal-only feed, resid only feed, coal/resid combination feed, resid/plastics combined feed, and coal/resid/plastics combined feed. The flexibility of the unit configuration and operating conditions, such as feed space velocities, reactor temperatures, and dispersed catalyst types and loadings were demonstrated for five different feed combinations over a span of 41 days. During the entire run (except Condition 7), 50 ppm of molybdenum from Molyvan-A was introduced with the feed to reactor K-1, and 5000 ppm iron from HTI's iron catalyst was added only to reactor K-2 through the pump buffers. The reactor location of catalyst addition was switched during Condition 7 to see if it made any difference in process performance. Following are the highlights of Bench-Run PB-01:

- During the 'coal-only' feed conditions, coal conversion (based upon quinoline solubility) varied between 92.8 and 94.7 W% maf; 524°C+ resid conversions varied between 82.6 and 88.0 W% maf, while C_4-524°C distillate yield changed from 61.4 to 62 W% maf. Hydrogen consumption was about 6 % (maf), and C_1-C_3 light gas yield varied between 8.5 and 11.7 W% (dry).

- The recycle of catalyst from the unit pressure filter cake in the ashy recycle mode, condition 2, did not improve process performance. On the contrary, it resulted in a slight drop in total coal conversion as compared to Condition 1. Condition 3, with higher space velocity (876 kg/h/m^3) and higher (by 10°C) first stage reactor temperature, resulted in the lowest light gas formation and coal and resid conversions among the 'coal-only' feed conditions.

- Condition 4 was conducted with heavy oil (Hondo resid) alone at similar temperatures and space velocity (based upon the 524°C+ resid content of Hondo resid) as in Condition 3. The conversion, based on quinoline solubility, was 99.9 W%, indicating that no coke was formed during the heavy oil conversion.

The light gas yield was about 5 W%, while the resid conversion was over 83 W%, and distillate yield was as high as 76 W% (all maf); all this at a low hydrogen consumption of 1.72 W% (dry).

- When feed was changed from 100% Hondo resid to 50 w% coal/50 w% Hondo (coal/oil coprocessing mode), the light gas make increased slightly to 7.2 W% (still lower than during 'coal-only' feed conditions), while the combined feed conversion was 96.1 W% (coal conversion of 92.2 W% assuming complete conversion of Hondo resid to quinoline soluble materials). The distillate yield was lower (69.7 W% maf) than during the 'oil-only' condition but much higher than during the 'coal-only' conditions. The 524°C+ resid conversion levels were about the same for Conditions 3, 4, and 5. It is important to note that the recycle to feed ratio was reduced from 1.0 (during the 'coal-only' conditions) to 0.17 during the conditions employing Hondo resid. This was done because of the potential cost-reduction that can be brought about by lessening of recycle requirements. This adjustment in the recycle ratio seems to have had an adverse impact on the 524°C+ resid conversion levels, as the amount of resid material converted in a single-pass operation was less than desired (only in the lower 80s). It will be interesting to consider this unconverted 'resid stream' as an independent waste organic stream and coprocess it again, either with coal or plastics, so that valuable hydrogen in that stream can be extracted further before it goes to partial oxidation or steam reforming.

- Conditions 6 through 8 were conducted with a uniform feed comprised of equal parts of coal, Hondo resid and waste plastics. Reactor temperatures were raised by 10°C each during these conditions to achieve high cracking conversion of plastics, especially HPDE. To maintain overall process severity about the same as the earlier process conditions, feed space velocity was increased by 25 %. The overall performance during this 'semi-long-term' testing (12 days) of combined feed operation was very good and held fairly uniform. Total feed conversions of over 96 W% were obtained with 524°C+ resid conversion of about 84% and C_4-524°C distillate yield of about 73.5 W% (all maf). Light gas yields were low (5-7.5 W%), and hydrogen consumption was also low (3.1 to 3.34 W% dry). The switching of dispersed catalyst addition mode during Condition 7, during which HTI's iron catalyst was added to reactor K-1 and Molyvan-A to reactor K-2, resulted in a slight increase in hydrogen consumption, light gas yield, and 524°C+ resid conversion. This could be an effect of the iron catalyst, which, in the new mode of addition, was residing in the system for a longer time and bringing about more hydrocracking than is done by the molybdenum catalyst. The ashy recycle mode, practiced again during Condition 8, did not improve process performance, confirming earlier results with the 'coal-only' Condition 2. The best part of the product distribution during these three combined feed conditions was that much higher (than at any other conditions) yields of naphtha and middle distillates were obtained.

- The last test Condition 9 was operated without any coal in the feed (50 w% of waste plastics/50 w% Hondo resid). Interestingly, the distillate yield increased (to 76.2 W% maf), while the light gas make (4.27 W% dry) and chemical hydrogen consumption (1.34 W%) decreased. Overall performance during Condition 9 was very similar to that obtained during earlier Condition 4 which employed Hondo resid alone in the feed at comparable process severity.

- The hydrotreated second stage separator overheads (SOH) represent the net light distillate product from the process. The quality of these distillates was excellent starting with the 'coal-only' feed conditions: high API gravities (38-42°), low heteroatom contents (less than 60 ppm nitrogen and sulfur), and high hydrogen contents (H/C ratios of above 1.8). The quality of SOH oil improved very significantly in the remaining conditions that employed various combinations of Hondo resid, coal, and waste plastics. During coprocessing conditions, API gravities increased to about 48-50°, while the heteroatom contents were reduced to below 30 ppm for nitrogen and sulfur. The H/C ratio increased to 1.9-2.0. The weight percent of the lightest naphtha fraction also increased to over 50 W% during coprocessing conditions.

- The technical assessment of the performance of bench run PB-01 indicates that using HTI's iron and molybdenum dispersed catalysts, the crude oil equivalent price from 'coal-only' feed condition is about $32.50 per barrel, a tad lower than that obtained from a simulated base-case employing the conventional supported extrudate catalyst in both liquefaction reactor stages.

- Partial replacement of coal in the feed to liquefaction with either heavy petroleum oil, waste plastics, or mixtures thereof, results in a substantial cost savings, primarily because the distillate production is markedly improved and hydrogen consumption in substantially reduced. For example, the crude oil equivalent price for coal/oil coprocessing type operation was $26.86 per barrel; that for a combined coal/oil/plastics operation was only $21.92 per barrel; while for plastics/oil operation without any coal, this price was only $20.48 per barrel.

BACKGROUND, OBJECTIVE, AND SCOPE OF WORK

The POC Bench Option Project (PB-Series) is geared to evaluate different novel processing concepts in catalytic coal liquefaction and coprocessing of organic wastes, such as plastics, heavy resids, waste oils, and ligno-cellulose wastes, with coal. The long-term performance data at the bench scale of operations (30 kg/day) will be used to complement the larger scale process demonstration "proof-of-concept" studies for the U.S. DOE. The new ideas being explored in this program include using novel dispersed slurry catalysts, combinations of dispersed and supported catalysts (hybrid mode), coprocessing of coal with waste plastics, low quality resids, waste oils, ligno-cellulosic wastes, etc. As the POC Bench Option Program followed a recently completed Catalytic Multi-Stage Liquefaction (CMSL) Project, one of the primary objectives of the first bench run, PB-01, was to implement the most successful and promising process improvement concepts emerging from the CMSL Project for direct liquefaction and coprocessing of a subbituminous Black Thunder mine coal with a vacuum resid and waste plastics from a northern New Jersey recovery facility.

The modified run plan for the first bench run of the POC Bench Option Contract is summarized in *Table 1*. This run was designated as PB-01 and was carried out for 41 continuous operating days. The run studied the direct liquefaction of a subbituminous Wyoming Black Thunder mine coal, and also its coprocessing with low value (and difficult to upgrade by themselves) feedstocks such as vacuum resid and waste mixed plastics. The process confirguration consisted of a preheater coil, two-stage backmixed reactors with internal recirculation, an interstage light products separator, and an in-line fixed-bed hydrotreater. Iron-and molybdenum based dispersed slurry catalysts were employed in the back-mixed reactors, and a supported NiMo/Alumina catalyst (Criterion C-411 trilobe extrudates), in the in-line hydrotreater.

Bench Run PB-01 had the following technical objectives:

- To apply the effects of some of the most successful process improvements concepts resulting from the CMSL contract work with high volatile bituminous Illinois No.6 coal, such as interstage products separation/concentration, in-line hydrotreating of distillates, use of dispersed-catalysts-only reactors, and low solvent-to-coal ratios, to direct liquefaction of sub-bituminous Wyoming Black Thunder mine coal with vacuum resid and waste mixed-plastics.

- To study the effects of coprocessing vacuum resids, derived from petroleum, with waste mixed-plastics, with and without the presence of the coal.

- To investigate the feasibility of recycle free (or very low recycle) and 'once through' processing modes of operation when coprocessing.

- To investigate the effects of dispersed catalyst staging for better performance, i.e., adding molybdenum-based fresh catalyst to the lower temperature first stage reactor, K-1, for hydrogenation and iron-based fresh catalyst to the higher temperature stage, K-2, for hydrocracking.

- To study the effects of recycled dispersed slurry catalyst and process severity in the presence of an interstage separator on the overall process performance.

As mentioned earlier, an in-line hydrotreater was used during this run. Separator overheads from both the first and second stages were sent through the hydrotreater, along with the atmospheric still overheads and process knock-outs.

The run plan, shown in *Table 1*, included nine run conditions that were selected to meet the technical objectives specified above. Only the first three run conditions were carried out in a conventional direct coal liquefaction mode while the remaining six conditions looked at the coprocessing of different combinations of coal/waste plastics/vacuum resid. The conditions were chosen so that comparisons could be made with the results obtained during CMSL-10 and CMSL-11 bench runs (with similar catalyst types but different mode of utilization, and with no interstage products separation) and also between the 'coal only', 'resid only', and 'coal-waste plastics' (from CMSL-09 and CMSL-11) vs. the 'coal-resid', 'coal-plastics-resid', and 'resid-plastics' coprocessing conditions.

Overall, in the modified run plan for PB-01, the reactor temperatures (thermal severity) were reduced from the original plan and also from the temperature used during the CMSL Bench Runs 9 through 11, as a very high light hydrocarbon gas make (12-18% maf coal) had been obtained during the "coal-only" or "non-plastic" feed conditions. Conditions 1 and 2 of the modified run plan were to delineate the effects of ashy vs. ash-free recycle in order to shed some light on the effects of the dispersed slurry catalysts in "recycled-form" upon process performance. Condition 3 addressed the effects of process severity; both reactor temperatures were increased, and the feed space velocity was also increased. For Conditions 3 through the end of the run, the high space velocities were maintained, but the amount of total recycle solvent was significantly reduced during the last four Conditions, from 1:1 to coal to 0.17:1 to total fresh feed. These were coprocessing conditions, with Condition 4 looking at the processing of vacuum resid alone under comparable process severities and catalytic conditions.

A short residence time (5 min) pretreater/preheater coil was employed preceding the conversion reactors; dispersed catalyst was added fresh to individual reactor stages (50 ppm moly to K-1 and 5000 ppm iron to K-2); interstage product separation was also employed to improve the kinetics of conversion in the second stage reactor and to improve overall hydrogen utilization; an in-line hydrotreater was used for upgrading the process distillates. A number of samples of the process streams (liquids, solids, and slurries), both first and the second stages, were obtained during the work-up periods for in-house analyses and also for Consol, Inc.

SYSTEM CONFIGURATION

Bench Run PB-01 involved two equal volume back-mixed reactors with internal re-circulation. Other key features of this run included coprocessing of vacuum resids and waste plastics with coal, staged fresh dispersed catalyst addition, interstage separation, and on-line hydrotreating of light products from both stages.

Unit 227 and a part of Unit 238 were used in this run. Coal, resid, and waste plastics were introduced through the feed system of Unit 227. Light products and gases from the first stage were removed from the hot separator of Unit 238. After separating the process water, the oil fraction was repressurized and combined with ASOH and the second stage hot separator (O-1) overheads for feeding to the in-line hydrotreater. A slurry product was removed from the bottom of the hot separator. An off-line pressure filtration unit was used to recover a solid-free liquid (recycle solvent) from the slurry product. The overall configuration of the bench unit and accessories put together for PB-01 is displayed in *Figure 1*.

Two independent gas feed and discharge systems are required to handle gas in the two-stage-interstage separation configuration. The first stage off-gas was vented through the cold separator of Unit 238.

FEED MATERIALS - COAL, HONDO RESID AND WASTE PLASTICS

Wyoming Black Thunder mine coal, the same coal that was used in the PDU 260-005 operations, was used for PB-01 (227-90) Bench Run. The analyses of coal, Hondo resid, and waste plastics are shown in *Tables 2* and *3*.

START-UP AND MAKE-UP OIL

A mixture of coal-derived distillate and petroleum-derived, hydrotreated FCC decant oil, L-814, was employed as start-up and make-up oil; the analysis is shown in *Table 4*.

CATALYSTS

Hydrotreater:	Criterion C-411 Trilobe (HRI-6135)
K-1:	Fresh Molyvan-A, slurried with unit feed, at 50 ppm to dry coal
K-2:	Fresh HTI iron catalyst, slurried with recycle solvent, at 5000 ppm of iron relative to dry feed coal

CAS Bottoms and pressure filter cake were employed during Condition 2 to evaluate the effects of recycled dispersed catalyst on performance.

INTERSTAGE (Reactor K-1) SLURRY SAMPLES

Seven interstage (reactor K-1) slurry samples, one for each condition, were planned. Only one was actually taken for the first condition. These samples were to be taken immediately after the completion of each of the work-up periods.

EXTERNAL SAMPLES

Samples of feed materials and a number of different product streams, such as SOH, PFL, PFS, and K-1 slurry, were collected from the run operation for detailed analyses and characterization by Consol, Inc.

SUMMARY OF OPERATIONS

Unit Modification and Configuration

The schematic for Unit 227, as configured for Run 227-90, is shown in *Figure 1*. Six-hour blends of feed slurry were prepared in a separate mix tank (P-7), transferred to the feed tank (P-2), and pumped to the first stage reactor (K-1) via a short-residence-time (approximately 5 minutes) preheater coil. No supported catalyst was in either of the two back-mixed reactors. However, slurry catalysts were added continuously to the feed slurry, and a second slurry catalyst was injected using a separate feed system into the second stage reactor (K-2). An adjacent hot separator (and pressure-letdown system) was used as an interstage separator (O-1A), removing lighter liquids and gases before the second stage reactor. Overheads from the second stage hot separator (O-1) flowed through an in-line hydrotreater (K-3). Also, overhead liquids from the first-stage separation and the atmospheric still (CAS) were pumped to the hydrotreater. The bottoms from O-1 were sent to a pressure filter or recycled to the feed (Condition 2). Filtered liquids, combined with similar liquids extracted by toluene from the filter cake, provided the liquid for slurrying the coal feed for Condition 1 and 3, during which the fresh feed did not include Hondo Resid.

Startup

Startup consisted of establishing the proper flows of oil and gases, setting vessel temperatures, and increasing the reactor temperatures to 413 °C. With no supported catalyst in the reactors, the usual sulfiding and ebullation steps were not performed. Filtered L-814 heavy gas oil was used as a startup oil for this run. The recycle material generated during the reactor heat-up period was used to slurry the coal at the beginning of Period 1. Startup operations proceeded smoothly with few mechanical problems.

Condition 1 (Periods 1 through 5)

Period 1 started with the introduction of coal feed at 0400 hours on September 23, 1995. The coal feed rate and reactor temperatures were gradually increased, reaching full coal rate at 2400 hours, and Condition 1 temperatures of 432 °C (K-1) and 449 °C (K-2) at 0800 hours of Period 2. The hydrogen flow to the

K-2 ebullating line was increased from 35 SCFH to the specified Condition 1 rate of 45 SCFH at 0830 hours of Period 4.

Only minor problems occurred during Condition 1. The checks on the hydrotreater-feed pump and the water-injection pump had to be changed, and there were momentary feed pump stoppages. The first-stage sample could not be withdrawn from the isolation vessel, due to inoperability of the first-stage sampling system.

Condition 2 (Periods 6 through 10)

In Condition 2, the 1465 g/h filter liquid (PFL) recycle component of the slurry feed was replaced with an equal amount of CAS bottoms plus 66 g/h of filter cake (PFC). This transition was completed by 2200 hours of Period 6. During Period 7 (and for the remainder of the run) the atmospheric still (CAS) was shut down because of CAS operating irregularities and to decrease the long filtration times. For the remainder of Condition 2 all separator bottoms were filtered, and an appropriate amount of PFC solids were added instead of using CAS bottoms recycle.

As Condition 2 progressed, slurry feed interruptions became more frequent. These circulating line blockages were cleared by charging L-814 wash oil. In one instance the feed outage was extended, and the wash oil was charged to the reactors through the buffer pumps.

During Period 6 the left-side separator bottoms control valve stuck open, causing a unit back pressure drop of about 7 MPa, loss of all separator levels, and loss of process oil through V-100 pressure-relief valve. The pressure and levels were recovered using the right-side control valve, but temporarily, some manual bypass was required because of an insufficient maximum flow rate through the valve. Also during Condition 2, the hydrotreater feed pump was intermittently not pumping and had to be repaired, and one of the K-2 heating rods was off for 15 hours. The slurry preparation tank (P-7) circulating lines became plugged once, requiring the slurry to be drained manually.

Condition 3 (Periods 11 through 15)

In Condition 3 there was a return to solids-free recycle, the space velocity was increased from 640 to 800 $kg/h/m^3$ in each reactor, and the K-1 temperature was increased from 432 to 441 °C. These changes were fully in place 16 hours into Period 11.

Primarily during the first two periods of Condition 3, there were slurry preparation and charge pump problems. Cleaning the charge pump checks usually corrected the problem, but in one occurrence the reactors received no slurry feed for over 2 1/2 hours. In another occurrence the L-814 wash oil had to be added to P-2 to decrease the viscosity and get mixing and pumping restarted.

The hydrotreater feed pump was off-line for a total of 16 hours during Condition 3.

Condition 4 (Periods 16 through 20)

In Condition 4 the coal and PFL feed was changed to Hondo Resid and PFL feed. The PFL recycle to Hondo feed ratio was chnaged to 0.17:1 while the total feed space velocity was increased to 1059 kg/h/m^3 reactor to correspond to a space velocity of 870 kg/h/m^3, employed during Condition 3. This adjustment in the feed rate had to be made due to the fact that Hondo VTB resid contained about 81 w% of "524°C+ resid" material and the space velocity during Condition 4 was maintained the same as that during Condition 3, on the basis of Hondo VTB's "resid content". All other conditions remained the same; the condition change was completed by 2200 hours in Period 16. Operations were smooth during all of Condition 4. There were only very brief outages of the hydrotreater feed pump and the iron-catalyst-slurry circulation and injection pumps.

Condition 5 (Periods 21 through 25)

In Condition 5 the feed was changed to equal amounts of coal and Hondo Resid. The feed rate was reduced during Condition 5 to correspond to that during Condition 3. This change was completed by 2200 hours of Period 21. All other conditions remained the same.

Several flow restrictions developed during Condition 5. In Period 21 the line between O-1A and K-2 became restricted. The restriction broke when the pressure drop increased to about 2 MPa. The line was washed with L-814 wash oil by injection with the K-2 catalyst charge pump. In Period 22 the preheater coil plugged, and the inlet pressure increased to 22 MPa. Because there was no fresh feed, the buffer pumps were used to charge oil to the reactors. When the back pressure was lowered, the restriction broke, and the unit was back at specified conditions one hour after the plug had developed. In Period 23 when the inlet to K-2 became restricted, the reactor temperatures were lowered to 413 °C. After 25 minutes the restriction broke, and conditions were reset for Condition 5 levels. Also during Condition 5, the O-1A level control was often erratic.

Condition 6 (Periods 26 through 30)

In Condition 6 mixed waste plastic (L-854) feed was started. The ratio of coal: Hondo resid:plastics was 1:1:1. Temperatures were also increased (from 441 to 449 °C for K-1 and from 449 to 460 °C for K-2). The condition change was completed by 2200 hours. However, starting at 1650 hours in Period 27, the mixed waste plastic feed was changed to a mixture of 76% L-854, 16% HDPE (HTI-6235), and 8% polystyrene (HTI-6236).

There was some difficulty mixing and transferring the Condition 6 feed blends in Periods 27, 28, and 29. In two cases the feed blend was manually drained from P-7 and charged to P-2. Also in Period 29, L-814 was added directly to the charge pot because the blend was too viscous.
Charge pump checks were changed during Period 28 to increase the flow rate.

Ebullating system problems started during Condition 6. The K-1 left-side ebullating pump was off-line for 3 hours to replace the diaphragm, and both K-1 hot checks were flushed with PFL because of decreased flow. Also, the K-1 right-side buffer pump shut off on high pressure because of a blockage in the ebullating line.

Other problems during Condition 6 included a large loss of feed slurry from the circulating pump, significant leakage of L-814 from the wash oil tank into P-2, and loss of the O-1A bottom winding for two days.

Condition 7 (Periods 31 through 34)

In Condition 7 the order of the slurry catalyst injections was reversed. The iron catalyst was charged to K-1, and the Molyvan-A was charged to K-2.

Shutdown

At 0800 hours in Period 31 the feed line to K-1 became plugged, and unit shutdown was started. Flows through the buffer pumps and K-2 catalyst injection pump were increased to wash the unit with L-814 wash oil until 2330 hours (232 °C) and with No. 2 fuel until 0400 hours (149 °C). Hard material was found in the feed line, preheater coil, and K-1 bubble cap.

Restart

Flows and temperatures were established as had been done for the original startup. Period 31 was restarted at 0400 hours October 28. Specified Condition 7 coal feed rate was achieved at 0400 hours, Condition 7 Hondo resid feed rate was achieved at 2200 hours, and Condition 7 plastics feed rate was attained at 1600 hours in Period 32. Period 25 was 25 hours long because of the change back to EST.

During Period 31 both J-1 and J-2 became inoperable for about 2 hours. The buffer flows were increased to maintain liquid flow to the reactors. Twice in Period 32 the spare charge pump had to be put on line while the primary pump checks were changed. Also during Period 32, there was a 6-hour delay due to line restriction in transferring the feed blend to P-2. The feed blends were getting more viscous, requiring a P-2 temperature of 217 °C. The Molyvan A feed to K-2 was off line (on wash) due to a restriction for about 4 hours.

During Period 33 the flex line from P-2 to the circulator pump broke, requiring connection of P-2 to the wash-system for slurry feed until the flex line was replaced. Also during Period 33, the fuse for the K-2 top heater blew, causing that temperature to decrease by 11 °C for a short time.

Operations went smoothly during Period 34.

Condition 8 (Periods 35 through 37)

In Condition 8, minus-70-mesh screened PFC was recycled in the feed blend. The feed rates of coal, Hondo resid, and mixed waste plastics (mixture of L-854, HTI-6235, and HTI 6236) remained the same.

Operations were smooth during Condition 8 except for one 40-minute slurry feed outage in Period 36. In Period 37 the backup charge pump had to be put on line, and the feed circulating pump required repacking.

Condition 9 (Periods 38 through 41)

In Condition 9 the coal and PFC feeds were eliminated and the Hondo resid and plastics (mixture of L-854, HTI-6235, and HTI-6236) feed rates were increased to the same total feed rate. These changes were completed at 2200 hours in Period 38.

During Condition 9, there were numerous problems with ebullating pumps and checks. Backmix flow through the reactors was often decreased and sometimes stopped completely. The checks were flushed several times. One K-2 flow outage was the result of solid material packed in the pump heads.

Other problems during Condition 9 included erratic O-1 and O-1A levels, plugged O-1 left-side control valve, and high K-2 pressure drops. There were only very brief feed pump and hydrotreater feed pump stoppages.

Shutdown

Shutdown commenced at the end of Period 41 (0400 hours November 8). The process equipment was generally in satisfactory condition, but there were restrictions in the K-1 and K-2 ebullation lines, and the K-2 surge-line knockouts and the K-2 left-side ebullation pump head were full of solid material. A 365g first stage sample from Condition 1 was removed from the isolation vessel. A plug of dry solids had prevented the removal of this sample during the run.

Operating Conditions and Material Recovery Balances

The exact feed composition, in terms of relative amounts of coal, Hondo resid, and waste plastics for different run conditions, is depicted in *Figure* 2. An average material recovery balance (the daily material balance summary is attached in the appendix) of about 98 W% was obtained (*Figure 4*) for the entire Bench Run PB-01. The operating summary of individual periods during PB-01 is shown in Table 6a and *6b*. *Figure 3* shows the operating conditions during PB-01 in terms of feed space velocities and reactor temperatures. As shown in *Figure 3*, the increased reactor temperatures during Periods 11 and 27 were accompanied by increases in feed space velocity in order to maintain overall process thermal severity. The space velocity of the total feed was adjusted during the conditions employing Hondo resid to account for the fact that this heavy oil fraction contained only about 82 W% resid (524°C+) material. Typically, under the operating conditions selected for PB-01, there was a net excess production of PFL stream, i.e., the "recycle solvent balance" was always positive except for a few select periods when extraneous make-up oil had to be used to make up for recycle solvent. The recycle solvent balances for the Work-Up Periods of Bench Run PB-01 are shown in Tables 6a and 6b.

PROCESS PERFORMANCE RESULTS

The conversions and yields of different products, process performance, and product quality for PB-01 are addressed in this section. The calculation of daily material recovery balances, coal conversions, normalized product yields, and other process performance related indicators were carried out using programs available in the CTSL database. Some programs were also modified as per the requirement of the process configuration for PB-01. Overall process performance during PB-01 is summarized in *Tables 6a* and *6b,* depicted in *Figures 5* through *9* ,and discussed in detail in the following sections.

Total Feed Conversion

Typical feed conversions (based on the solubility of pressure filter solids in quinoline), obtained during equilibrated periods of different conditions of PB-01, are shown in *Figure 5.* Feed conversions (W% maf feed) varied beween about 93 to 99.6 % maf throughout the course of the run. During the 'coal-only' feed conditions, conversions varied only slightly (between 92.8 and 94.7 W% maf). The ashy-recycle mode of operation did not improve conversion. The change in the type of feed from coal-only to combinations of coal/resid and coal/plastics or coal/resid/plastics improved overall feed conversion levels to about 96-97 W% maf. During the conditions when no coal was present in the feed to the unit, total conversion was as high as 99 W%+ maf, indicating that little or no char (quinoline insoluble material) was formed in the reactors.

524°C+ Residuum Conversion

As shown in *Figure 5*, residuum conversion values varied between 82.6 to 88.0 W% (maf feed). Most of the variation in the residuum conversion values was observed during the 'coal-only' feed Condition 3, during which ashy-recycle mode was practiced and space velocity was increased during. During the combined feed or 'coprocessing' conditions, residuum conversion values held steady at about 84 W% maf. During Condition 7 with coal/resid/plastics combined feed, when the dispersed slurry catalyst addition mode was switched so that iron was added to reactor K-1 and molybdenum to K-2, residuum conversion level increased by about 2 W%. It is believed that the reduction in the recycle ratio (from 1:1 to 0.17:1) during the coprocessing conditions (or when Hondo resid was treated alone) had an overall negative impact on the conversion of 524°C+ residuum material. With the low recycle-ratio operation, the overall residuum conversions during the coprocessing periods of PB-01, are essentially the 'single-pass'residuum conversion. The heavy product from the bench unit (PFL or CAS bottoms) contained as high as 30-35 W% 524°C+ residuum material. During the 'coal-only' feed conditions, a significant portion of this material gets recycled for further conversion; and, thus, the overall unit residuum conversion is increased. During the coprocessing conditions, only a small fraction of the heavier unit product was being recycled. As a result, the overall residuum conversion levels were comparitively lower.

C_4-524°C Distillate Yield and 524°C+ Residuum Yield

Distillate yields and 524°C+ residuum yields are shown in *Figure 6*. Distillate yields were steady, around 62 W% maf, during the coal-only feed conditions. The upgrading of Hondo resid alone resulted in as high as 76 W% maf distillate yield. The yield dropped to about 70 W% maf during the coal/oil coprocessing condition. Similar to what was observed during the earlier bench runs with waste plastics in feed with coal, with the introduction of waste plastics in the feed (during Conditions 6 through 9), the distillate yields took off and reached an average high level of 74 W%. This, once again, confirms our finding that waste plastics have a significant positive effect on conversion of coal to distillates. The 524°C+ residuum yield varied between 7 to 16 W%, with higher residuum yields obtained during conditions when the recycle ratio was reduced from 1 to 0.17 and space velocity was increased.

Distillate Yield and Selectivity

The yields of distillate fractions, such as naphtha (IBP-177°C), middle distillates (177-343°C), and heavy distillates (343 C+), are shown in *Figure 7*. The values plotted in this figure, converted to a selectivity basis, are shown in *Figure 8*. The distribution of the full range distillate into different fractions was uniform across the board. It is speculated that due to the reduction in recycle of heavier fractions, the heavy distillate fraction yield/selectivity had increased during the coprocessing conditions.

Hydrogen Consumption and Light Gas (C_1-C_3) Yield

Hydrogen consumption *(Figure 9)* based on maf feed varied between 1.4 to 6.2 W%. During the coal-only conditions, the chemical hydrogen consumption varied slightly (between 5 - 6 W%). Hydrogen consumption decreased significantly, as expected, during the Hondo resid alone feed condition (1.7 W%); H_2 consumption was also low (4.1 W%) during the coal/oil coprocessing condition. The coal/resid/plastics combined feed Conditions 6 through 8 resulted in a little over 3 W% hydrogen consumption. The effect of waste plastics in the feed on reducing the hydrogen consumption, observed here, is similar to that found during some earlier bench runs. The lowest hydrogen consumtion of 1.4 W% occurred during the last run Condition 9, when no coal was used in the feed, and Hondo resid was coprocessed with waste plastics. The yield of light hydrocarbon gases (C_1-C_3) was highest during coal-only feed conditions, varying between 9 to 12.2 W% maf. The yield decreased in general during the coprocessing conditions. Both plastics and Hondo resid resulted in lowering the light gas yield from coal as shown in *Figure 9*.

Hydrogen Utilization

Hydrogen utilization during coal conversion is characterized by two indicators: hydrogen efficiency and C_1-C_3 gas selectivity. The former is defined as the amount of C_4-524°C distillates obtained per unit weight of hydrogen consumed, while the latter is the amount of light hydrocarbon gases produced per unit weight of distillates. As shown in *Figure 10*, hydrogen efficiency improved substantially when coal was coprocessed with Hondo resid and waste plastics. Similarly, light gas selectivity dropped significantly in going from the coal-only feed condition to coprocessing (or Hondo resid alone) feed conditions. This behavior establishes the beneficial role of organic wastes, such as MSW plastics and Hondo resid, in substantially improving hydrogen utilization during coal processing (liquefaction) and, therefore, having a net positive impact on overall economics.

PRODUCT QUALITY

Different product fractions (first-stage/second-stage vent gases, SOH, PFL, and PFS) from Work-up Periods 5, 10, 15, 20, 25, 30, 34, 37, and 41 were analyzed in detail for composition. These analyses are listed in Tables 7 through 9.

Separator Overhead Product (SOH)

The SOH oil stream represents the net light distillate (IBP-343°C) from PB-01. While the hydrotreater unit was on-line during the run, the only major distillate stream out of the unit was the SOH stream, as the O-1 hot separator overheads, interstage separator overheads, ASOH, and unit knockouts were being fed directly to the hydrotreater. The properties of SOH oil for the work-up periods are shown in *Table 7*. The SOH oils had a typical boiling range of 50-380°C. The API gravities were high (> 45), and H/C atomic ratios were also high (> 1.95), especially during coal-plastics-resid coprocessing operations. IBP-177°C, the lightest fraction of the SOH-oil, was also higher during coprocessing operations than during coal-only conditions. The heteroatom levels (nitrogen and sulfur) were low throughout the run, indicating a very successful operation of an in-line hydrotreater. Typically, sulfur levels below 75 ppm and nitrogen levels below 50 ppm were obtained for the SOH oil. The quality of SOH process distillates, in terms of heteroatoms content and H/C ratios, is depicted in *Figures 11* and *12*.

Pressure Filter Liquid (PFL) and Pressure Filter Solids (PFS)

The separator bottoms go through pressure filtration for separation of solids from heavy liquid product and recycle oil. The liquid oil, called pressure filter liquid (PFL), is usually heavier than 343°C boiling point and contains unreacted heavy residuum material to a varying degree. The solids from filtration, PFS, are oil-containing solids, normally extracted with toluene for oil recovery. The oil-free solids are then used for determining the extent of coal or total feed conversion, based upon the solubility of the PFS material in a solvent such as quinoline. Detailed analyses of the PFL and PFS streams from PB-01 are listed in Tables 8 and 9. The PFL API gravity was lower for all the coal-only feed conditions. API gravities increased during coprocessing conditions. At the same time, the hydrogen content of PFL increased significantly from about 6.8% to about 10.8% in going from coal-only feed operation to coprocessing conditions (*Figure 12*). This observation confirms the positive impact of coprocessing organic wastes with coal on the overall hydrogen content of the products. The 524°C+ residuum contents of the PFL were around 40 W% during the coal-only conditions; these decreased significantly and steadied around 30 W% during coprocessing conditions. The amount of preasphaltenes and asphaltenes in the PFL, characterized by solubilities in toluene and cyclohexane respectively (*Figure 13*), also decreased substantially in the transition from coal-only feed operation to coprocessing conditions.

Analysis of True Boiling Point (TBP) Fractions

As shown in Tables 11 through 14, the detailed analyses of the TBP fractions of the net distillate oil, SOH, from the Bench Run PB-01 was carried out. Periods 9, 25, 30, and 41 were selected to represent the TBP fraction analyses from Conditions 2, 5, 6, and 9 respectively. It is seen from the PONA analyses of the TBP fractions that in going from the 'coal-only' feed condition, first to a coal/oil coprocessing condition, and then to coal/oil/plastics condition, the naphthenic content decreased while the paraffinic and aromatic content increased. In general, the API gravities of naphtha and mid-distillate ranges of TBP fractions are high; their heteroatom contents are low and hydrogen contents are high. Also, the introduction of waste plastics in the combined feed significantly increased the selectivity to lightest naphtha fraction at the expense of heavier distillate fractions. The aromaticity of the gas oil (343°C$^+$) fraction decreased with the replacement of coal in the feed with either heavy oil or plastics or their combination.

DISCUSSION OF PROCESS PERFORMANCE RESULTS

Effects of Catalysts

Based upon the results obtained during the coal-only feed Condition 1 of Bench Run PB-01, in comparison with the earlier bench data (as shown in *Table 10*), it can be said that under similar process severity conditions, the yield of light hydrocarbon gases and chemical hydrogen consumption are lower for PB-01, where interstage product separation was used. For the earlier bench runs, CMSL-09, 10, and 11, no interstage separation was employed. Also, the staged addition of dispersed catalyst, i.e., molybdenum to reactor K-1 and iron to K-2, seems to have an enhanced effect on overall process performance, compared to adding both dispersed catalyst to the first reactor. This is because during PB-01, the amount of molybdenum catalyst used was reduced by half as compared with the earlier bench runs, while process performance was maintained in terms of coal and resid conversions and distillate yields for PB-01 *(See Table 10).* It was also found that staged catalyst addition, where iron is added to reactor K-1 feed and molybdenum to reactor K-2, was better than the reversed addition mode employed during the earlier parts of the bench run PB-01, as seen from the resid conversion and C_4-343°C yield data. Ashy-recycle operation, did not improve process performance.

Effects of Feed Type and Composition

The combined feed mode which coprocessed different combinations of waste materials, such as MSW plastics and heavy vacuum resid, with coal clearly demonstrated a positive performance impact during PB-01. Distillate yields were higher, while light hydrocarbon gas yields were lower at a much reduced hydrogen consumption. Overall hydrogen utilization, thus, is much better during coprocessing conditions than during the coal-only feed conditions. In general, the process conditions employed during PB-01 and the dispersed slurry catalysts were found to be very versatile for obtaining high levels of conversion for different kinds of feedstocks, including coal, heavy vacuum resid, waste plastics, and combinations thereof. No clear evidence of synergism was found when coal and vacuum resid or mixtures of coal, waste plastics, and vacuum resid were coprocessed. Improved residuum conversions and distillate yields were obtained when coal was coprocessed with a mixture of resid and waste plastics (*Figure 14*) compared to either coal alone or coprocessing of heavy resid and plastics mixture. It can, therefore, be said that HTI's system of dispersed slurry catalysts is applicable for hydroprocessing of different types of organic carbonaceous materials, such as fossil fuels and waste hydrocarbons. The combined feed mode, which comprises coprocessing of different ratios of heavy oil, coal, and MSW plastics, appears to have great promise to be the most feasible and economically favorable mode of operation in a coal-waste coprocessing facility.

TECHNO-ECONOMIC ASSESSMENT

A technical assessment has been made of the results of POC PB-01 (Run 227-90), using final yields and material balances. The run is the first in the POC Bench Option Contract series, and the feed contained Black Thunder subbituminous coal, California (Hondo) heavy oil and mixed waste plastics. An all-dispersed catalyst system was used, with 50 ppm Molyvan A to the first-stage reactor and 5,000 ppm iron to the second stage. Interstage separation and in-line hydrotreating were used in the run.

Five conditions of the run were analyzed:

- Period 15, coal only operation
- Period 19, oil-only operation
- Period 25, coal/oil feed (50/50)
- Period 30, coal/oil/plastics feed (one-third each)
- Period 41, oil/plastics feed (50/50)

Also included for comparison is a base case for the technical assessment of the results of the POC Run PB-01. This base case used supported catalyst in both reactors, instead of dispersed catalyst. Process performance and yields for this base case were developed from data obtained in an earlier CMSL-series run, using a coal with slightly different composition and using slightly different processing conditions. These earlier yields were adjusted to POC PB-01 coal-only operating conditions and to the presently-used feed coal analysis, with the aid of an in-house process simulator. These adjusted base case yields were found to differ only slightly from those observed for the coal-only operation in POC PB-01. Note that the base case equivalent crude oil price is just slightly higher than for Period 15, namely $32.62/Bbl versus $32.56/Bbl. If the yields were assumed to be the same as for Period 15, the base case equivalent crude oil price would drop to $32.47/Bbl.

Table 15 summarizes the material balances for the run periods studied. Comparison was made at a total liquefaction feed rate of 12,000 T/D, which for coal-only operation utilizes maximum-sized reactors in four operating trains. This total feed rate is significantly higher than that used in the recently completed CMSL economic studies, due to the presence of the interstage separator. In comparing cases with nearly identical process yields, the maximum reactor throughput is set by the superficial gas velocity. In the absence of contrary experimental data, the gas velocity limitation was assumed the same for use of dispersed catalyst as for supported catalyst. As shown, with oil-only and with oil/plastics operation, the number of liquefaction trains was reduced at constant feed capacity. The high liquids production per ton of feed has been demonstrated in CMSL runs with plastics. As indicated in Table 16, partial oxidation of unconverted feed satisfies the hydrogen needs in all cases except with the coal-only operation. As a matter of fact, only a portion of the unconverted feed was required in the other cases, and the rest was sent to disposal. Table 16 also presents the utilities demands and the calculated thermal efficiencies for the cases.

The liquefaction plant investment details are furnished in Table 17, showing significantly reduced costs for all mixed feed cases below that of coal-only operation. Table 18 presents the total plant investment summary. Operation with coal/oil and coal/oil/plastics results in total plant investment 15 to 30 percent below that of coal-only operation. Table 19 shows the product cost for these cases. Comparing coal-only operation with oil-only and with coal/oil feeds shows almost a 20 percent reduction in the equivalent crude oil price, while with plastics the reduction is over 30 percent. The equivalent crude oil price reduction in the CMSL series was less than 20 percent with coal/plastics mixtures, so addition of oil is an outstanding contribution to overall economics. Table 20 is the breakdown of the equivalent crude price for these cases. These prices for different feed types are plotted in Figure 15. Table 21 presents the economic comparison of these cases at maximum-reactor throughput, showing even more dramatic savings in all cases. It is noteworthy, however, that in all price scenarios operation with coal/oil/plastics mixtures is more economically attractive than operation with coal-only, oil-only or coal/oil feed mixtures. The effect of eliminating the recycle stream was briefly investigated for one of the cases (Period 25). The results showed a total plant investment reduction of about 2.5 percent, as well as reduction in power and fuel requirements. The bottom line was an equivalent crude oil price reduction from $26.86/Bbl to $26.09/Bbl. In view of the indicated savings, it is suggested that future runs consider elimination of recycle. Overall, the partial replacement of coal with heavy oil and with mixed waste plastics results in significant economic savings in combined liquefaction. Distillate production is markedly improved, and hydrogen consumption is substantially reduced. Savings are observed in plant investment and in equivalent crude oil price, for all envisioned pricing scenarios with these feed substitutes. Elimination of the recycle stream would result in further savings.

CONCLUSIONS

The following conclusions can be drawn based upon the data obtained from Bench Run PB-01:

1. Interstage separation of light products and gases helps to reduce the light gas make.

2. Staged addition of dispersed catalyst is beneficial for improving overall process performance compared to the combined catalyst addition to the first stage reactor. In the staged catalyst addition mode, iron to K-1 and molybdenum to K-2 is the preferred addition mode.

3. Dispersed catalysts in the ashy recycle did not improve the process performance.

4. HTI's dispersed slurry catalyst system, based on iron and molybdenum, is highly versatile and flexible for achieving high conversions during hydroprocessing of high molecular weight carbonaceous materials, such as fossil fuels, low quality vacuum resids, waste plastics, etc.

5. Both heavy vacuum resids and waste plastics, when coprocessed with coal, result in higher distillate yields and lower light gas make. These feed stocks have higher H/C ratios than coal and require less hydrogen to form premium produts.

6. Overall process performance with the combined feed system of coal/Hondo resid/waste plastics was much better than when these feeds were individually processed under similar process severity and catalysts conditions.

7. The partial replacement of coal in the feed to liquefaction with either heavy petroleum oil, waste plastics or mixtures thereof, results in a substantial cost-savings, primarily because distillate production is markedly improved and hydrogen consumption in substantially reduced. For example, the crude oil equivalent price for coal/oil coprocessing type operation was $26.86 per barrel (as compared to about $32.50 per barrel for coal-only feed condition); that for a combined coal/oil/plastics operation was only $21.92 per barrel, while for plastics/oil operation without any coal, this price was only $20.48 per barrel.

8. It is believed that yields and overall process performance during coal and waste coprocessing could be further improved by increasing the recycle of partially converted 400°C+ heavy distillate/residuum material. This is especially true when heavy petroleum resid and mixed waste plastics are used in the combined feed.

Table 1. Revised Run Plan for Bench Run PB-01

Condition		1	2	3	4	5	6	7[(1)]	8	9
Period Number		1-5	6-10	11-15	16-20	21-25	26-30	31-34	35-37	38-41
Work-Up Period		5	10	15	20	21	30	34	37	41
Dispersed Catalyst ppm*:	Fresh Mo	---- 50 ---- (all conditions)								
	Fresh Iron	---- 5000 ---- (all conditions)								
Feed Composition, W%										
	Coal	100	100	100	0	50	33.33	33.33	33.33	0
	Plastics	0	0	0	0	0	33.33	33.33	33.33	50
	Hondo Oil	0	0	0	100	50	33.33	33.33	33.33	50
Recycle Type[(2)]		N-ashy	Ashy	N-ashy	N-ashy	N-ashy	N-ashy	N-ashy	Ashy	N-Ashy
Recycle Ratio		1.0	1.0	1.0	0.17	0.17	0.17	0.17	0.17	0.17
Space Velocity, kg/hr/m^3 react		694	633	876	1059	870	976	1033	1086	1250
Temperatures, °C										
	K-1	433	433	441	441	442	449	450	450	451
	K-2	449	448	450	451	450	459	461	460	460
	In-line HTU	379	379	379	379	379	379	379	379	379

(1) During Condition 7, the dispersed catalyst addition mode was switched so that iron was added to reactor K-1 and molybdenum to K-2.

(2) During the ashy recycle mode of operations, the catalyst concentration multiplier of about 1.5 was obtained by recycling the filter cake.

Table 2. Analysis of Feed Black Thunder Mine Feed Coal

HTI Designation	HTI 6213
Moisture Content, W%	10.01
Proximate Analysis, W% Dry	
Volatile Matter	43.48
Fixed Carbon	50.52
Mineral Matter	6.00
Ultimate Analysis, W% Dry	
Carbon	70.12
Hydrogen	5.11
Nitrogen	0.99
Sulfur	0.35
Ash	6.19
Oxygen (Diff.)	17.24
H/C Atomic Ratio	0.875

Table 3. Analysis of Heavy Oil and Waste Plastics Feed

Feed Type		Hondo VTB Resid	Waste Plastics
Gravity, API°		6.2	N/A
524°C+ Resid Content, V%		82.0	N/A
Ultimate Analysis, W% Dry			
	Carbon	83.84	80.51
	Hydrogen	10.13	11.42
	Nitrogen	0.90	0.00
	Sulfur	4.39	0.21
	Oxygen	0.59	6.06
	Ash	0.15	1.64
	Chlorine	N/A	0.16

Table 4. Analysis of Start-up/Make-up Oil

HTI Designation		Filtered L-814
API Gravity, °		0.40
ASTM D-1160 Distillation, °C		
	IBP	309
	5 V%	351
	10 V%	374
	20 V%	394
	30 V%	409
	40 V%	426
	50 V%	437
	60 V%	449
	70 V%	467
	80 V%	507
	84 V%	524
Weight Percents		
	IBP-343°C	5.47
	343-454°C	53.99
	454-524°C	22.18
	524°C$^+$	18.36
Elemental Analysis, W%		
	Carbon	88.96
	Hydrogen	8.25
	Sulfur	2.22
	Nitrogen	0.19
NMR Data		
	W% Aromatic Carbon	88.03
	W% Cyclic Hydrogen	44.36

Table 5. List of Samples Provided to Consol, Inc.

Sample Description	*Typical Amount, g*	*Periods*
Feed Slurry	250	5, 9, 15, 19, 25, 30, 34, 37, and 41
CAS Bottoms	350	5, 9, 15, 19, 25, 30, 34, 37, and 41
SOH Oil	250	5, 9, 15, 19, 25, 30, 34, 37, and 41
Pressure Filter Solids	350	5, 9, 15, 19, 25, 30, 34, 37, and 41
Pressure Filter Liquid	250	5, 9, 15, 19, 25, 30, 34, 37, and 41

Table 6a. Run 227-90: Process Performance Summary

Condition	1	2	3	4	5
Period Number	5	9	15	19	25
Hours of Run	120	216	360	456	600
Dispersed Catalyst ppm*: Fresh Mo			50		
Fresh Iron			5000		
Feed Composition, W%					
Coal	100	100	100	0	50
Waste Plastics	0	0	0	0	0
Hondo Resid	0	0	0	100	50
Space Velocity, $kg/hr/m^3$ reactor stg	694	633	876	1059	870
Temperatures, °C					
First Stage	433	433	441	441	442
Second Stage	449	448	450	451	450
Material Balance (%) (gross)	98.97	92.26	96.23	100.06	97.87
Recycle Solvent Balance, W % Dry Feed	22.60	19.99	24.84	51.52	34.14
Estimated Normalized Yields, W% Dry Fresh Feed:					
C1-C3 in Gases	11.72	10.37	8.49	4.99	7.15
C4-C7 in Gases	4.75	4.14	3.19	2.95	2.94
IBP-177°C in Liquids	15.20	15.83	18.67	13.23	16.28
177-260°C in Liquids	11.57	10.62	10.87	13.80	13.65
260-343°C in Liquids	14.81	11.98	11.01	13.83	12.69
343-454°C in Liquids	9.52	12.31	11.66	21.06	15.87
454-524°C in Liquids	2.45	3.02	3.04	11.05	6.27
524°C+	6.18	9.05	9.46	16.50	13.07
Unconverted Feed	4.99	6.58	6.80	0.12	3.76
Ash	5.75	5.75	5.75	0.15	2.95
Water	12.25	11.00	12.68	0.06	4.99
CO	1.10	1.45	0.72	0.08	0.62
CO_2	4.71	3.98	2.52	0.04	1.73
NH_3	0.95	0.85	0.72	0.23	0.48
H_2S	-0.04	-0.24	-0.16	3.64	1.65
Hydrogen Consumption	5.91	4.90	5.44	1.72	4.09
Process Performance, W% MAF Feed					
Feed Conversion	94.7	93.0	92.8	99.9	96.1
C4-524°C Distillate Yield	61.8	61.4	62.0	76.0	69.7
524°C+ Conversion	88.0	85.2	82.6	83.3	82.7

Table 6b. Run 227-90: Process Performance Summary

Condition	6	7	8	9
Period Number	30	34	37	41
Hours of Run	720	816	888	984
Dispersed Catalyst ppm*: Fresh Mo	50			
Fresh Iron	5000			
Feed Composition, W%				
Coal	33.33	33.33	33.33	0
Waste Plastics	33.33	33.33	33.33	50
Hondo Resid	33.33	33.33	33.33	50
Space Velocity, kg/hr/m^3 reactor stg.	976	1033	1086	1250
Temperatures, °C				
First Stage	449	450	450	451
Second Stage	459	461	460	460
Material Balance (%) (gross)	98.78	96.46	92.99	94.15
Recycle Solvent Balance, W% Dry Feed	40.34	35.98	36.91	49.79
Estimated Normalized Yields, W% Dry Fresh Feed:				
C1-C3 in Gases	5.18	7.43	5.64	4.27
C4-C7 in Gases	2.82	4.30	3.50	3.26
IBP-177°C in Liquids	21.28	21.20	20.07	17.98
177-260°C in Liquids	11.32	12.99	12.15	12.85
260-343°C in Liquids	11.50	11.04	10.65	11.23
343-454°C in Liquids	18.04	15.99	17.39	20.35
454-524°C in Liquids	7.08	5.46	6.92	9.90
524°C+	12.71	10.65	13.57	15.61
Unconverted Feed	3.17	3.58	2.96	0.26
Ash	2.47	2.47	2.47	0.84
Water	5.19	5.77	5.71	2.70
CO	0.43	0.43	0.51	0.07
CO_2	0.70	0.84	0.55	0.04
NH_3	0.33	0.28	0.23	0.06
H_2S	0.87	0.91	0.78	1.94
Hydrogen Consumption	3.09	3.34	3.09	1.34
Process Performance, W% MAF Feed				
Feed Conversion	96.7	96.3	97.0	99.7
C4-524°C Distillate Yield	73.9	72.8	72.5	76.2
524°C+ Conversion	83.7	85.4	83.1	84.0

Table 7. Separator Overhead (SOH) Properties

Condition	1	2	3	4	5	6	7	8	9
Period	5	10	15	20	25	30	34	37	41
Gravity °API	37.7	38.8	42.0	49	46.0	46.3	47.9	48.0	51.0
IBP, °C	51	55	54	49	48	53	55	56	56
FBP, °C	372	380	376	392	384	384	368	373	375
Elemental Analysis									
Carbon, W%	86.57	86.49	86.11	85.18	85.35	85.70	86.49	86.03	85.36
Hydrogen, W%	12.94	13.05	13.41	14.10	13.92	13.58	13.77	13.65	14.01
Sulfur (Antek), ppm	71.4	95.3	77.4	96.9	52.7	46.2	26.1	12.9	17.5
Nitrogen (Antek), ppm	27.2	59.8	57.5	32.2	15.5	17.9	5.7	<1.0	5.4
H/C Ratio	1.79	1.81	1.87	1.99	1.96	1.90	1.91	1.90	1.97
ASTM D-86 Distillation, Composition, W%									
IBP-177oC	36.7	40.9	46.9	39.1	41.4	51.8	53.2	54.9	52.9
199-260oC	25.6	23.3	22.9	28.6	28.4	23.0	23.7	22.7	25.4
260-343oC	29.8	26.0	22.2	23.5	22.5	17.7	18.0	16.9	16.3
343oC+	7.2	8.2	7.1	8.3	7.0	6.9	4.2	4.7	4.9
LOSS	0.7	1.6	0.9	0.5	0.7	0.6	0.9	0.8	0.5

Table 8. Pressure Filter Liquid (PFL) Properties

Condition	1	2	3	4	5	6	7	8	9
Period	5	10	15	20	25	30	34	37	41*
Gravity °API	-11.2	-11.9	-9.4	7.8	2.3	7.8	6.2	9.2	11.9
IBP, °C	248	233	236	185	218	226	197	199	199
Elemental Analysis, W%									
Carbon	85.21	82.14	85.47	87.15	87.31	87.65	87.74	87.14	86.49
Hydrogen	6.63	6.70	6.82	9.75	8.75	9.89	9.45	10.18	10.77
Sulfur	1.15	1.09	0.85	1.74	1.13	1.12	1.02	0.84	1.14
Nitrogen	0.78	0.84	1.10	1.25	1.22	0.73	0.91	0.86	0.91
H/C Ratio	0.93	0.98	0.96	1.34	1.2	1.35	1.29	1.40	1.49
ASTM D-86 Distillation, Composition, W%									
IBP-343oC	8.42	11.16	11.82	17.45	16.07	14.17	18.83	17.72	17.63
343-454oC	37.16	35.93	34.77	32.75	33.74	37.21	37.96	35.25	30.80
454-524oC	14.03	12.17	11.99	19.80	16.07	17.32	14.47	15.54	17.63
524oC+	39.80	40.07	40.90	29.61	33.55	31.10	28.25	30.50	33.64
LOSS	0.59	0.67	0.52	0.39	0.57	0.20	0.49	0.99	0.30
On 524°C+ Residuum:									
Cyclohexane Insols, W%	74.95	70.02	71.24	31.34	45.41	43.81	47.81	40.35	36.93
Toluene Insolubles, W%	38.45	45.58	34.46	7.46	14.10	14.37	12.60	17.55	35.71

Period 41 PFL was not available. Data is analysis of separator bottoms. Quinoline Insolubes, W%: 35.84

Table 9. Pressure Filter Solids (PFS) Properties

Condition	1	2	3	4	5	6	7	8	9
Period	5	10	15	20	25	30	34	37	41*
Elemental Analysis, W%									
Carbon	56.55	65.09	62.22	56.19	62.83	61.36	58.10	59.67	
Hydrogen	3.54	4.77	4.21	4.31	4.74	3.74	3.88	4.37	
Sulfur	1.90	2.30	2.16	10.7	3.89	4.70	5.59	5.55	
Nitrogen	0.57	0.72	0.93	1.44	1.21	1.08	1.05	1.07	
H/C Ratio	0.75	0.88	0.81	0.92	0.91	0.73	0.8	0.88	
Composition, W%									
Quinoline Insolubles	52.69	43.94	49.14	53.53	51.51	58.61	64.68	57.19	
Ash (in Quinoline Filt.)	31.21	24.42	26.42	32.94	29.70	32.08	35.02	34.00	
Sulfur in Ash	3.85	6.42	5.92	4.40	9.52	8	9.84	9.36	
ASTM Ash	32.23	26.61	26.62	34.18	29.84	32.60	34.70	33.48	
Sulfur in Ash	4.51	5.78	5.97	5.49	9.15	7.83	8.52	8.21	

*No solids were found in CAS bottoms.

Table 10. Dispersed Catalyst - Process Performance Comparisons

Unit	227	227	227	227
Run	90	89	88	87
Run ID	PB-1	CMSL-11	CMSL-10	CMSL-9
Period Number	5	10	14	15
Hours of Run (end of period)	120	240	336	360
Dispersed Catalyst ppm:Fresh Mo	50	100	100	150
Fresh Iron	5000	5000	5000	0
Recycled Mo	0	0	0	150
First Stage SV, Kg Coal/hr/m^3	694	671	655	659
First Stage SV, Lb Coal/hr/ft^3	43.3	41.9	40.9	41.1
Temperatures, °C				
Pretreater Coil	302	302	304	302
First Stage	433	450	444	445
Second Stage	449	459	451	450
Material Balance (%) (gross)	98.97	102.82	102.2	98.5
Estimated Normalized Yields, W% Dry Feed:				
C1-C3 in Gases	11.72	17.17	12.20	12.08
C4-C7 in Gases	4.75	8.07	4.56	4.96
IBP-177°C in Liquids	15.20	12.41	12.81	14.26
177-260°C in Liquids	11.57	11.66	9.69	14.62
260-343°C in Liquids	14.81	14.41	13.96	15.71
343-454°C in Liquids	9.52	10.49	12.73	6.77
454-524°C in Liquids	2.45	2.27	3.39	2.26
524°C+	6.18	5.68	8.60	5.78
Unconverted Feed	4.99	4.58	5.16	4.55
Water	12.25	7.28	10.96	13.22
CO_x	5.81	6.38	5.63	5.59
NH_3	0.95	0.92	0.86	0.97
H_2S	-0.04	-0.57	-0.19	0.16
Hydrogen Consumption	5.91	6.51	6.12	6.69
Process Performance, W% MAF Feed				
Feed Conversion	94.7	95.1	94.5	95.2
C4-524°C Distillate Yield	61.8	62.9	60.9	62.2
524°C+ Conversion	88.0	89.1	85.4	89.0

Table 11. Analysis of TBP Fractions: PB-01 Period 09

TBP Distillation, % IBP = 37°C

	W%
IBP-177°C	42.26
177-260°C	23.83
260-343°C	27.83
343°C+	6.08

TBP FRACTION [°C]	IBP-177	177-260	260-343	343+
API Gravity	55.4	32.1	21.5	20.1
Elemental Analysis [W%]				
Carbon	85.39	87.62	88.56	87.88
Hydrogen	14.71	12.62	11.55	11.94
Antek S, ppm	9.2	63.5	150.4	617.3
Antek N, ppm	15.4	67.5	59.1	119.0
Bromine No. [g/100g]	N/A	N/A	N/A	
Aniline Point, [°C]	51.4	32.2	33.3	
Flash Point, [°C]	<-17.8	64	124	
PONA [V%] -				
Paraffins	47.63	10.60		
Olefins	0.80	2.40		
Naphthenics	46.51	52.79		
Aromatics	5.06	34.21		
Aromatics (ASTM D2549)			54.13	

Table 12. Analysis of TBP Fractions: PB-01 Period 25

TBP Distillation, % IBP = 39°C

	W%
IBP-177°C	42.75
177-260°C	27.17
260-343°C	23.92
343°C+	6.16

TBP FRACTION [°C]	IBP-177	177-260	260-343	343+
API Gravity	58.5	39.7	31.1	30.3
Elemental Analysis [W%]				
Carbon	84.85	86.94	87.14	86.62
Hydrogen	14.83	13.43	13.08	13.60
Antek S, ppm	19	89.7	120.4	540.0
Antek N, ppm	1.5	12.7	6.3	111.0
Bromine No. [g/100g]	N/A	N/A	N/A	
Aniline Point, [°C]	56.7	51.7	64.4	
Flash Point, [°C]	<-17.8	60	126.7	
PONA [V%] -				
Paraffins	60.09	33.92		
Olefins	0.60	1.60		
Naphthenics	34.48	44.44		
Aromatics	4.83	20.04		
Aromatics (ASTM D2549)			30.22	

Table 13. Analysis of TBP Fractions: PB-01 Period 30

TBP Distillation, % IBP = 39°C

	W%
IBP-177°C	50.00
177-260°C	23.00
260-343°C	24.17
343°C+	2.83

TBP FRACTION [°C]	IBP-177	177-260	260-343	343+
API Gravity	53.7	43.3	32.5	29.5
Elemental Analysis [W%]				
Carbon	86.21	86.45	86.97	86.29
Hydrogen	13.62	13.73	13.14	13.20
Antek S, ppm	23.8	81.2	134.5	476.9
Antek N, ppm	0.84	9.2	21.1	112.6
Bromine No. [g/100g]	N/A	N/A	N/A	
Aniline Point, [°C]	39	58.3	66.7	
Flash Point, [°C]	<-17.8	51.7	126.7	
PONA [V%] -				
Paraffins	54.32	51.52		
Olefins	0.50	1.70		
Naphthenics	22.82	29.32		
Aromatics	22.36	17.46		
Aromatics (ASTM D2549)			28.94	

Table 14.Analysis of TBP Fractions: PB-01 Period 41

TBP Distillation, %	IBP = 41°C			
		W%		
IBP-177°C		54.25		
177-260°C		24.84		
260-343°C		18.08		
343°C$^+$		2.83		

TBP FRACTION [°C]	IBP-177	177-260	260-343	343+
API Gravity	58.7	45.6	36.4	33.4
Elemental Analysis [W%]				
Carbon	85.05	86.18	86.67	86.36
Hydrogen	14.47	14.20	13.68	13.87
Antek S, ppm	11.8	< 1	5.8	211.5
Antek N, ppm	<0.01	34.3	46.9	66.7
Bromine No. [g/100g]	N/A	N/A	N/A	
Aniline Point, [°C]	52.2	67.2	76.1	
Flash Point, [°C]	<-17.8	65.5	113.3	
PONA [V%] -				
Paraffins	66.11	59.43		
Olefins	0.50	0.60		
Naphthenics	20.41	28.12		
Aromatics	12.98	11.85		
Aromatics (ASTM D2549)			19.33	

Table 15. Material Balance for Economic Assessment

POC PB-01 (Run 227-90)
Material Balance for Economic Assessment

	Base Case	Period 15	Period 19	Period 25	Period 30	Period 41
Number of Liquefaction trains	4	4	3	4	4	3
Feed, T/D						
Coal	12,000	12,000	0	6,000	4,000	0
Oil	0	0	12,000	6,000	4,000	6,000
Plastics	0	0	0	0	4,000	6,000
Total	12,000	12,000	12,000	12,000	12,000	12,000
Oil feed, B/D	0	0	66,730	33,365	22,243	33,365
Liquid Products, B/D						
Gasoline	13,031	12,922	15,148	14,339	15,192	15,328
Diesel Fuel	31,646	31,382	36,787	34,822	36,896	37,225
Total	44,677	44,304	51,935	49,161	52,088	52,553
Barrels of Products/Ton feed	3.72	3.69	4.33	4.10	4.34	4.38
Byproducts						
Propane, B/D	3,396	3,920	2,416	3,197	2,556	2,384
Butane, B/D	2,097	2,270	1,877	1,901	1,510	1,546
Sulfur, LT/D	53	49	385	227	127	201
Ammonia, T/D	130	86	28	58	40	7
Waste to Disposal, T/D	798	1,114	2,220	675	1,303	2,438

Table 16. Hydrogen Balance, Utilities Production, and Thermal Efficiency

	Base Case	Period 15	Period 19	Period 25	Period 30	Period 41
Hydrogen Balance						
Hydrogen Consumption, MMSCFD						
Liquefaction	288.9	272.1	78.3	185.5	141.7	63.9
Product Upgrading	43.6	36.0	17.2	19.4	7.7	2.8
Solution & Purge Loss	4.3	4.1	1.2	2.8	2.1	1.0
Total	336.8	312.2	96.7	207.7	151.5	67.7
Hydrogen production, MMSCFD						
via Partial Oxidation	173.9	159.9	96.7	207.7	151.5	67.7
via Steam Reforming	162.9	152.3	0.0	0.0	0.0	0.0
Total	336.8	312.2	96.7	207.7	151.5	67.7
Utilities Produced or Purchased						
Power, Mw	239	233	114	198	157	96
Steam (600 Psig), 1000 Lb/hr	58	131	387	280	169	220
Cooling water, 1000 GPM	135	143	152	152	111	105
Purchased Natural Gas, MMMBTU/D	94.9	89.7	26.8	15.9	21.6	25.5
Raw water, 1000 Gal/D	5,702	6,324	8,584	8,830	6,369	5,822
Thermal Efficiency						
Inputs, MMMBTU/D						
Feed	291.5	291.5	451.1	371.3	395.6	447.6
Natural Gas	94.9	89.7	26.8	15.9	21.6	25.5
Total	386.4	381.2	477.9	387.2	417.2	473.1
Outputs, MMMBTU/D						
Gasoline	72.9	72.3	84.8	80.2	85.0	85.8
Diesel	183.7	182.2	213.7	202.2	214.3	216.2
Propane	13.1	15.1	9.3	12.3	9.8	9.2
Butane	9.1	9.9	8.2	8.3	6.6	6.7
Sulfur & Ammonia	3.0	2.1	3.9	3.1	1.9	1.9
Total	281.8	281.6	319.9	306.1	317.6	319.8
Thermal Efficiency, %	72.9	73.9	66.9	79.1	76.1	67.6

Table 17. Liquefaction Plant Investment Details

POC PB-01 (Run 227-90)
Liquefaction Plant Investment Details

	Base Case	Period 15	Period 19	Period 25	Period 30	Period 41
Major Equipment Cost, $M						
Pumps	26047	24,395	17,228	18,798	18,154	16,194
Reactors & Hydrotreater	39691	38,952	25,342	32,849	31,170	23,682
Fired Heaters	17692	17,265	8,169	10,137	9,711	8,162
Exchangers	21777	21,180	13,197	16,046	15,639	13,451
Drums & Towers	43592	34,336	19,407	25,375	24,886	20,618
Compressors	36709	35,761	19,872	30,625	27,615	18,618
HPU	18858	17,939	11,415	15,079	14,595	12,035
Total	204,366	189,828	114,630	148,909	141,770	112,760
Plant Investment, $MM						
Materials & Equipment	370.3	344.0	207.6	269.9	256.9	204.4
Labor & Subcontracts	160.2	148.8	89.9	116.7	111.1	88.4
Indirects	133.3	123.8	74.8	97.1	92.5	73.5
Total Liquefaction Plant Investment, $MM	663.8	616.6	372.3	483.7	460.5	366.3

Table 18. Total Plant Investment Summary

POC PB-01 (Run 227-90)
Total Plant Investment Summary
(Plant Investment in $MM, 1994 US Gulf Coast basis)

Plant Section	Base Case	Period 15	Period 19	Period 25	Period 30	Period 41
Coal Preparation	239.7	239.7	0.0	137.7	99.6	0.0
Oil Storage & Handling	0.0	0.0	48.5	29.9	22.5	29.9
Plastics Preparation	0.0	0.0	0.0	0.0	16.8	23.2
Liquefaction	663.8	616.6	372.3	483.7	460.5	366.3
Hydrogen Manufacture	295.2	279.0	102.8	175.7	140.8	80.2
Oxygen Plant	80.0	75.4	53.0	90.4	72.5	41.3
Treating	253.8	278.5	232.6	266.7	210.3	195.1
Product Upgrading	117.7	118.2	106.9	100.4	107.7	106.7
Utilities	293.5	289.8	319.8	285.5	224.0	227.1
Tankage, Waste Handling	134.5	149.4	178.7	157.1	170.9	181.9
General Offsites	223.6	211.0	211.0	211.0	211.0	211.0
Subtotal	2301.8	2257.6	1625.6	1938.1	1736.6	1462.7
Fee, Contingency	459.8	451.0	324.8	387.1	346.9	292.1
Total Plant Investment	2761.6	2708.6	1950.4	2325.2	2083.5	1754.8
$/BPD of Product	61,813	61,137	37,555	47,298	40,000	33,391

Table 19. Product Cost Calculation

POC PB-01 (Run 227-90)
Product Cost Calculation

	Base Case	Period 15	Period 19	Period 25	Period 30	Period 41
Operating Costs, $MM/year						
Coal, as received ($7.00/T)	32.46	32.46	0.00	16.23	10.82	0.00
Oil ($8.00/B)	0.00	0.00	175.37	87.68	58.46	87.68
Plastics ($0.00/Ton)	0.00	0.00	0.00	0.00	0.00	0.00
Natural gas ($2.00/MMBTU)	62.32	58.93	17.58	10.45	14.22	16.76
River Water ($2.50/Mgal)	4.68	5.19	7.05	7.25	5.23	4.78
Catalysts & Chemicals	12.68	12.15	4.40	4.68	3.64	3.24
Dispersed Catalyst	0.00	32.72	32.72	32.72	32.72	32.72
Supported Catalyst	26.61	0.00	0.00	0.00	0.00	0.00
Ash disposal($5.00/T)	1.31	1.83	3.65	1.11	2.14	4.00
Labor	24.43	24.43	24.43	24.43	24.43	24.43
Maintenance	21.89	21.89	21.89	21.89	21.89	21.89
Capital-Related	411.40	403.79	301.99	352.82	320.59	275.03
Total	597.78	593.39	589.08	559.26	494.14	470.53
Byproduct credits, $MM/year						
Propane ($12.50/B)	13.94	16.10	9.92	13.13	10.50	9.79
Butane ($14.50/B)	9.99	10.81	8.94	9.05	7.19	7.37
Sulfur ($52.00/T)	0.90	0.84	6.58	3.88	2.16	3.43
Ammonia ($120.00/T)	5.13	3.41	1.09	2.27	1.56	0.28
Total	29.96	31.16	26.53	28.33	21.41	20.87
Net Product Cost, $MM/year	567.82	562.23	562.55	530.93	472.73	449.66
Net Product Cost, $/B	38.69	38.63	32.97	32.88	27.63	26.05
Crude Oil Equivalent Factor	0.843	0.843	0.817	0.817	0.793	0.786
Equivalent Crude Oil Price, $/B	**32.62**	**32.56**	**26.95**	**26.86**	**21.92**	**20.48**

Table 20. Breakdown of Equivalent Crude Oil Price

POC PB-1 (Run 227-90)
Breakdown of Equivalent Crude Oil Price

	Base Case	Period 15	Period 19	Period 25	Period 30	Period 41
Contribution to Price, $/B						
Coal	1.86	1.88	0.00	0.82	0.50	0.00
Oil	0.00	0.00	8.40	4.44	2.71	3.99
Plastics	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	3.58	3.41	0.84	0.53	0.66	0.76
Water	0.27	0.30	0.34	0.37	0.24	0.22
Dispersed Catalyst	0.00	1.90	1.57	1.66	1.52	1.49
Supported Catalyst	1.53	0.00	0.00	0.00	0.00	0.00
Other Catalysts & Chemicals	0.73	0.70	0.21	0.24	0.17	0.15
Waste disposal	0.08	0.11	0.17	0.06	0.10	0.18
Labor	1.40	1.41	1.17	1.24	1.13	1.11
Maintenance	1.26	1.27	1.05	1.11	1.01	1.00
Capital Related Costs	23.63	23.39	14.47	17.85	14.87	12.53
By-product Credit	-1.72	-1.80	-1.27	-1.43	-0.99	-0.95
Equivalent Crude Oil Price, $/B	**32.62**	**32.56**	**26.95**	**26.86**	**21.92**	**20.48**

Table 21. Economic Comparison of Cases at Maximum Reactor Throughput

POC PB-01 (Run 227-90)
Economic Comparison of Cases at Maximum Reactor Throughput

	Period 15	Period 19	Period 25	Period 30	Period 41
Total Feed to Liquefaction, T/D	12,000	18,100	16,500	18,000	16,500
Number of Liquefaction trains	4	3	4	4	3
Total feed, T/D per train	3,000	6,033	4,125	4,500	5,500
Liquid Product, B/D	44,304	78,236	67,524	78,036	72,188
Liquefaction Plant Cost, $MM	616.6	505.8	614.9	617.3	466.3
Total Plant Investment, $MM	2708.6	2577.7	2928.8	2774.9	2170.3
Net Annual operating Cost, $MM	562.24	771.26	673.28	634.73	564.93
Net Product Cost, $/B	38.63	30.01	30.35	24.76	23.82
Equivalent Crude Oil Price, $/B	32.56	24.13	24.45	19.32	18.49

Figure 1. Simplified Schematic of HTI's Bench Unit Configured for Run PB-01

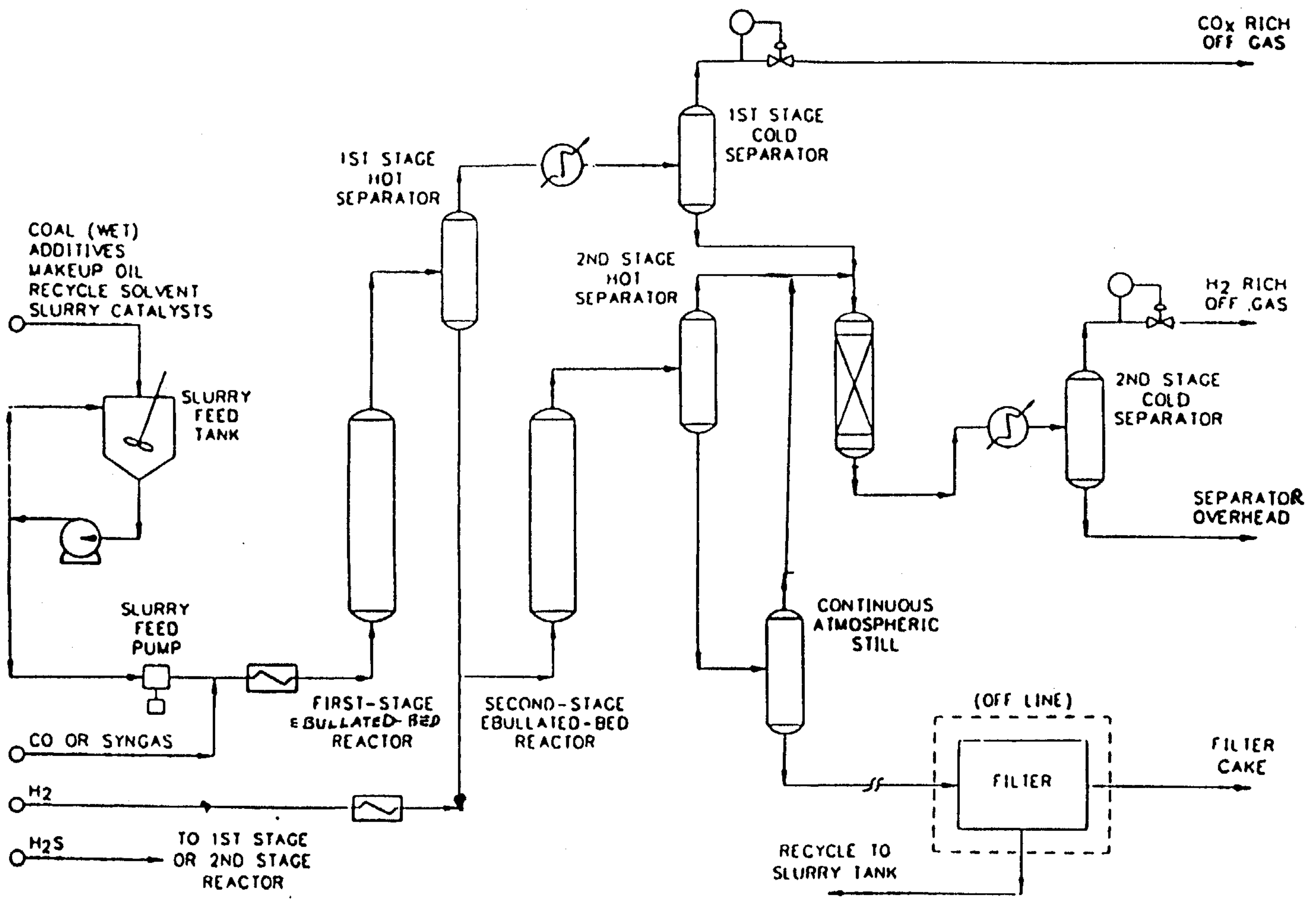


Figure 2. PB-01: Feed Composition

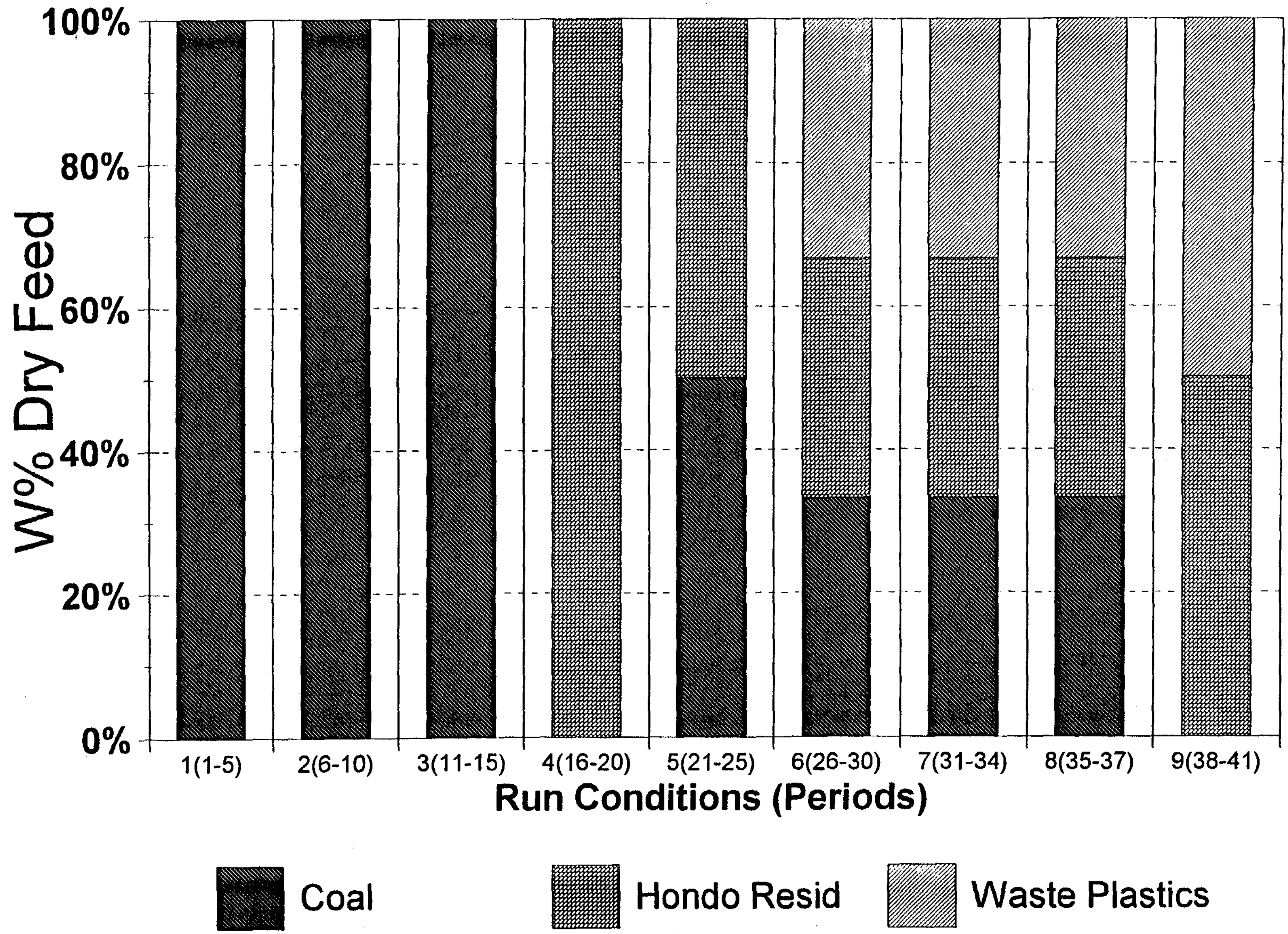


Figure 3. PB-01: Daily Operating Conditions

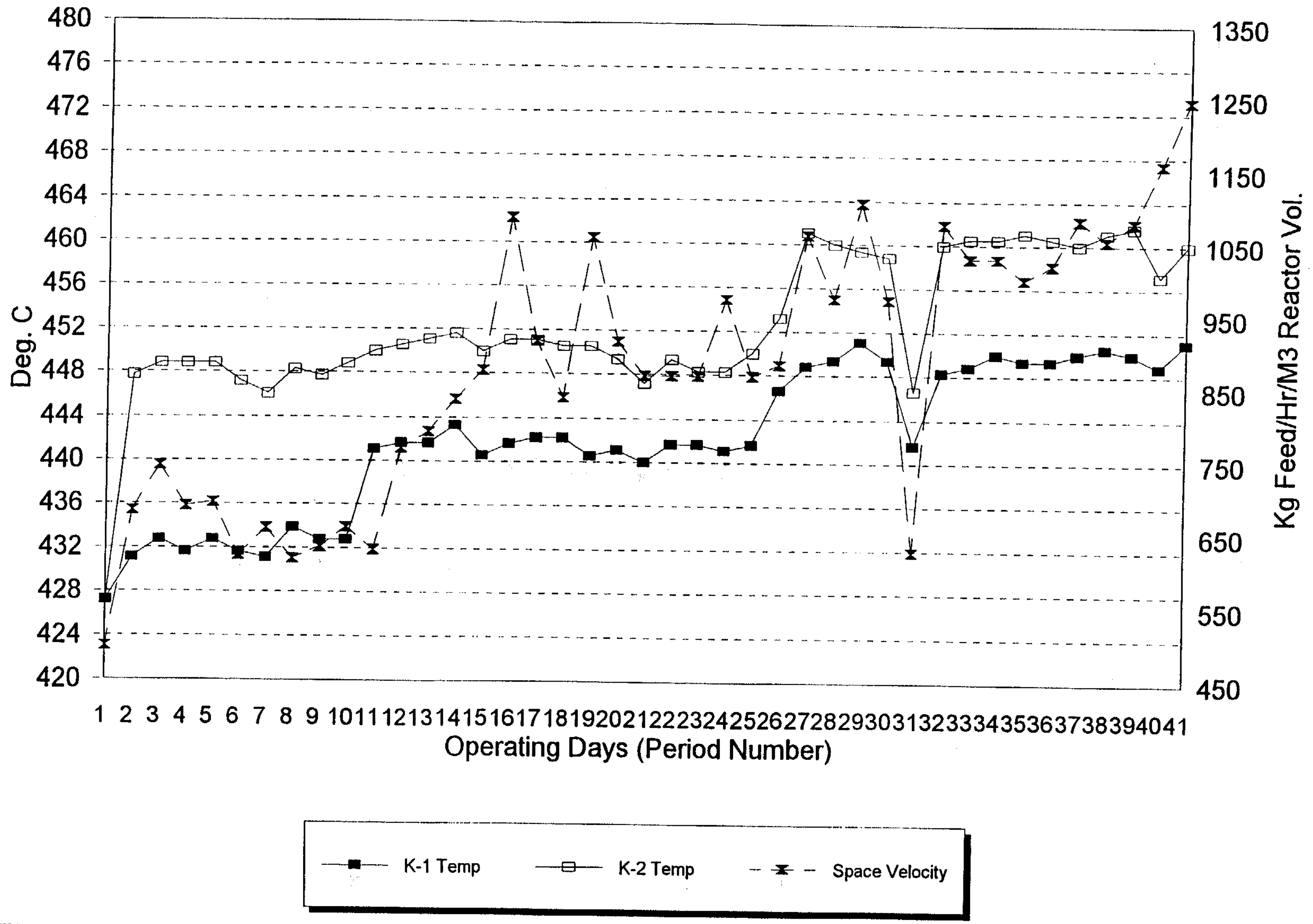


Figure 4. PB-01: Daily Material Recovery Balance

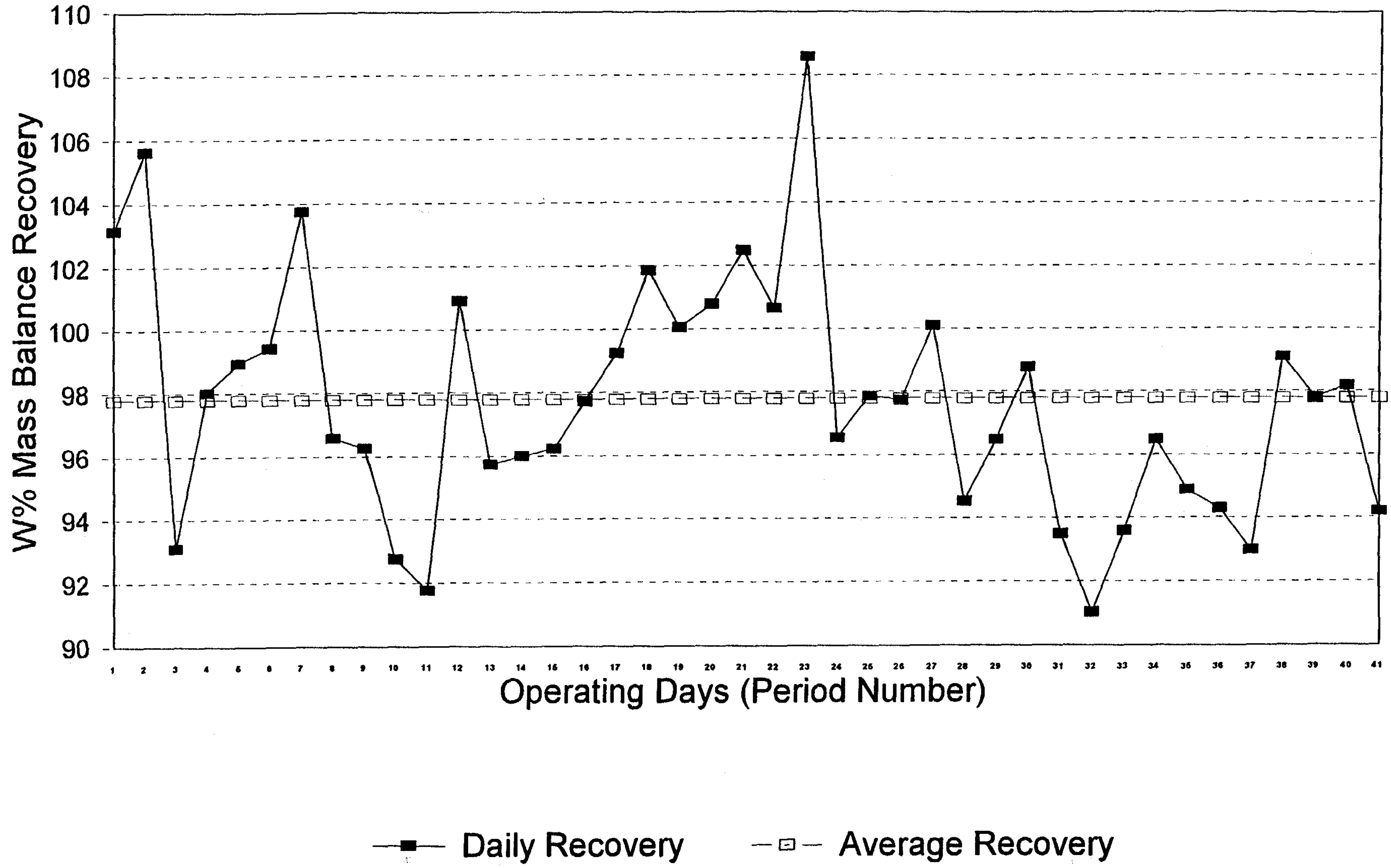


Figure 5. PB-01: Feed and Residuum Conversions

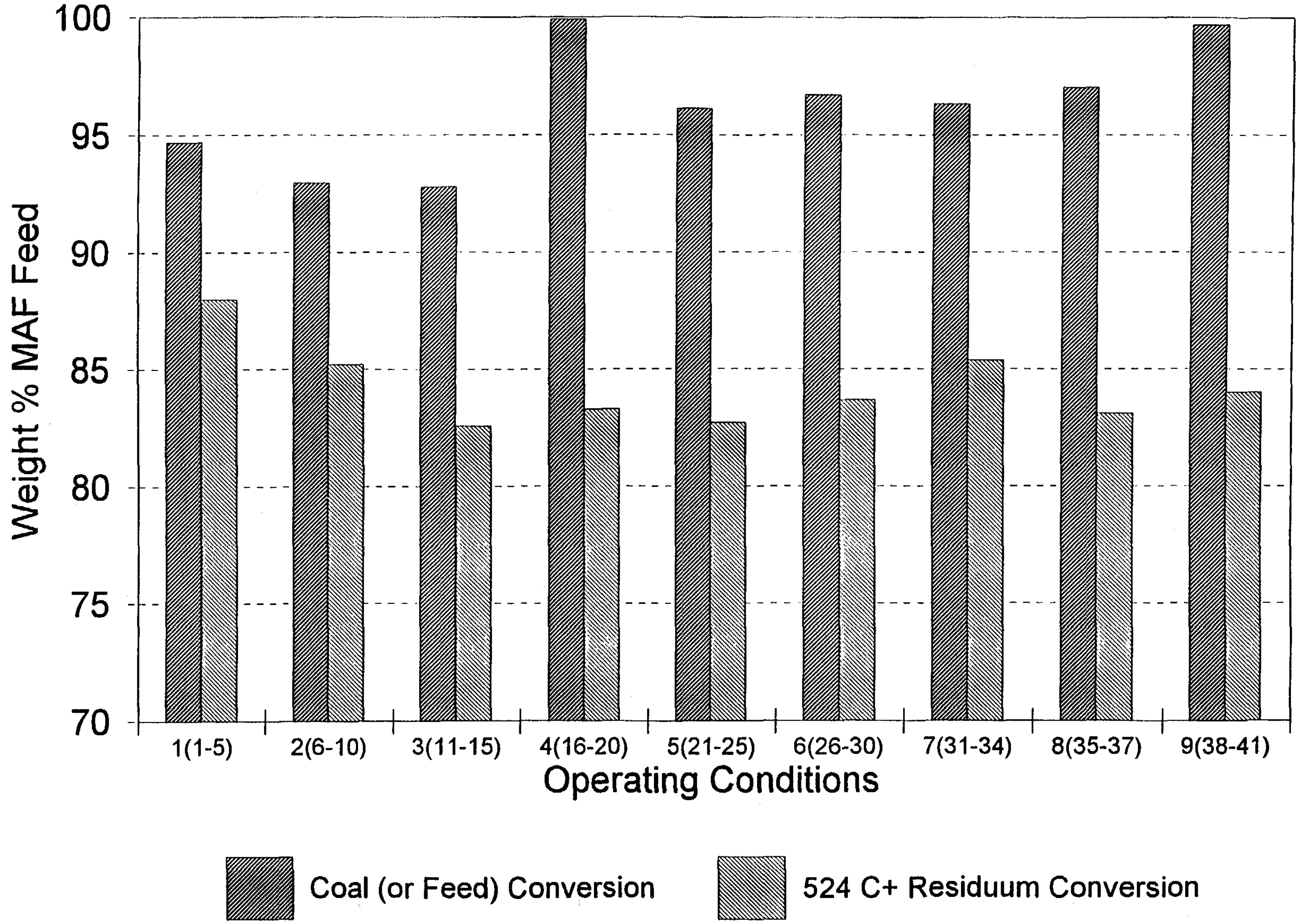


Figure 6. PB-01: C_4-524°C Distillate Yield and 524°C$^+$ Residuum Yield

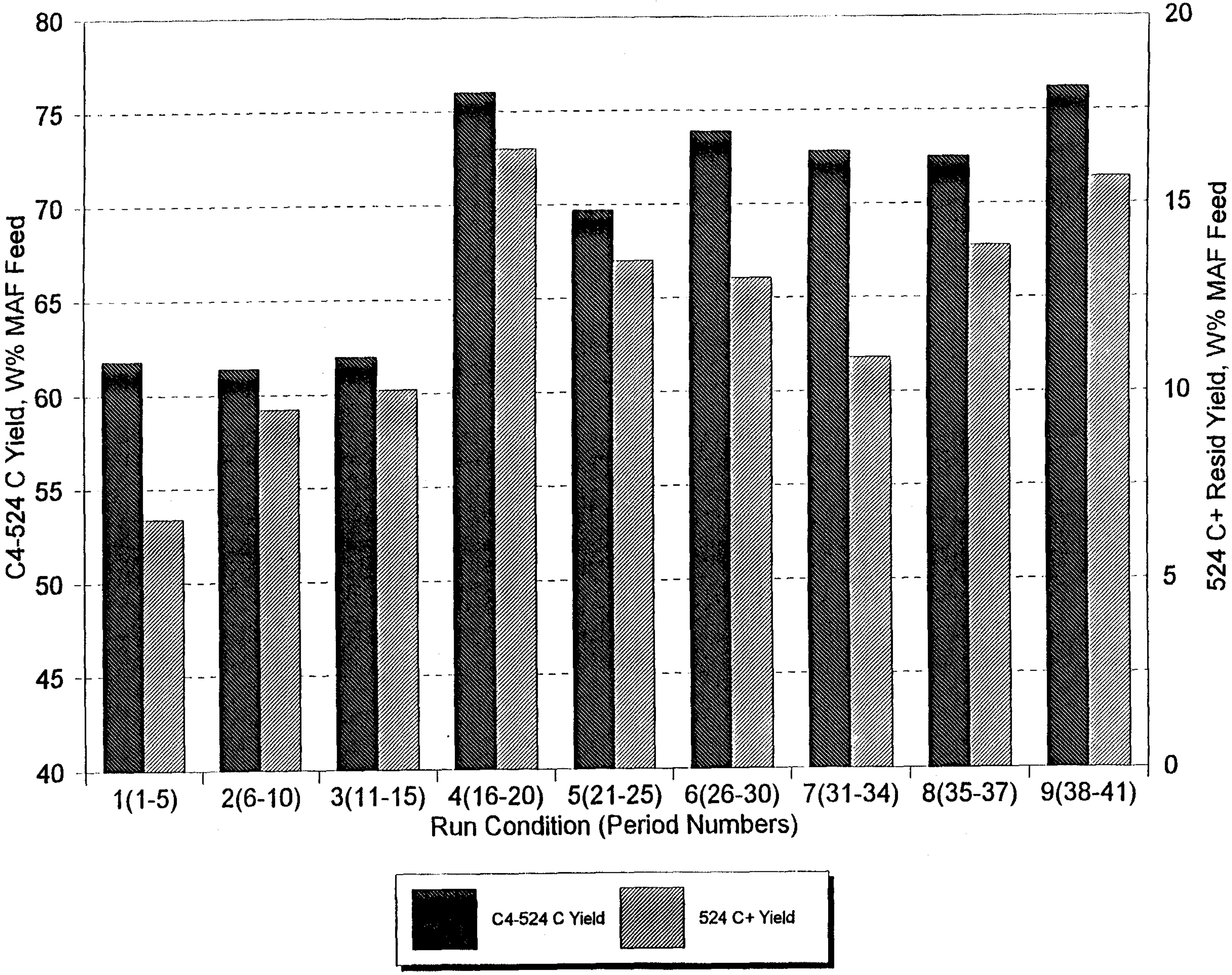


Figure 7. PB-01: Distillate Fraction Yield

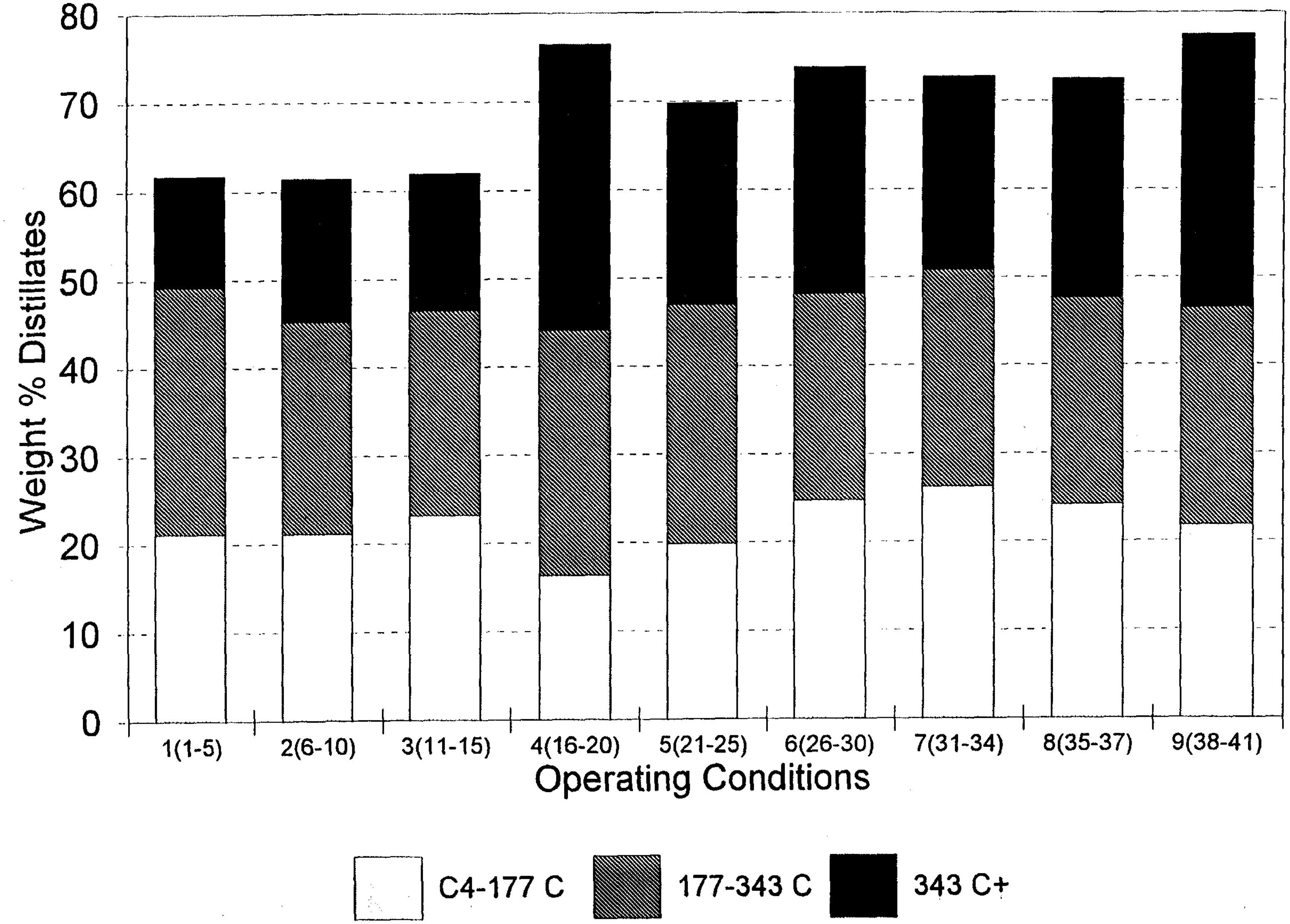


Figure 8. PB-01: Distillate Fraction Selectivity

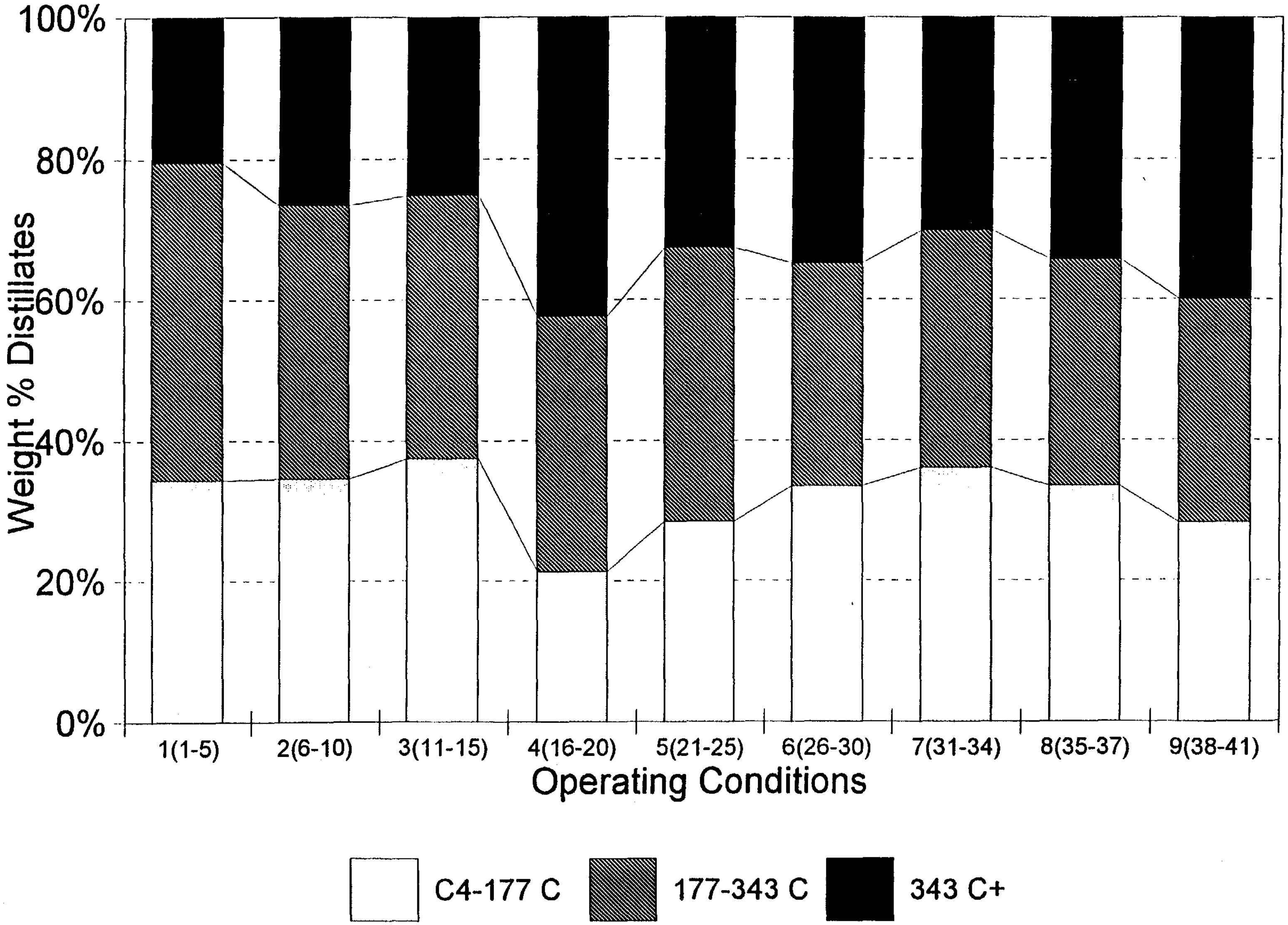


Figure 9. PB-01: Hydrogen Consumption and Light C_1-C_3 Gas Yield

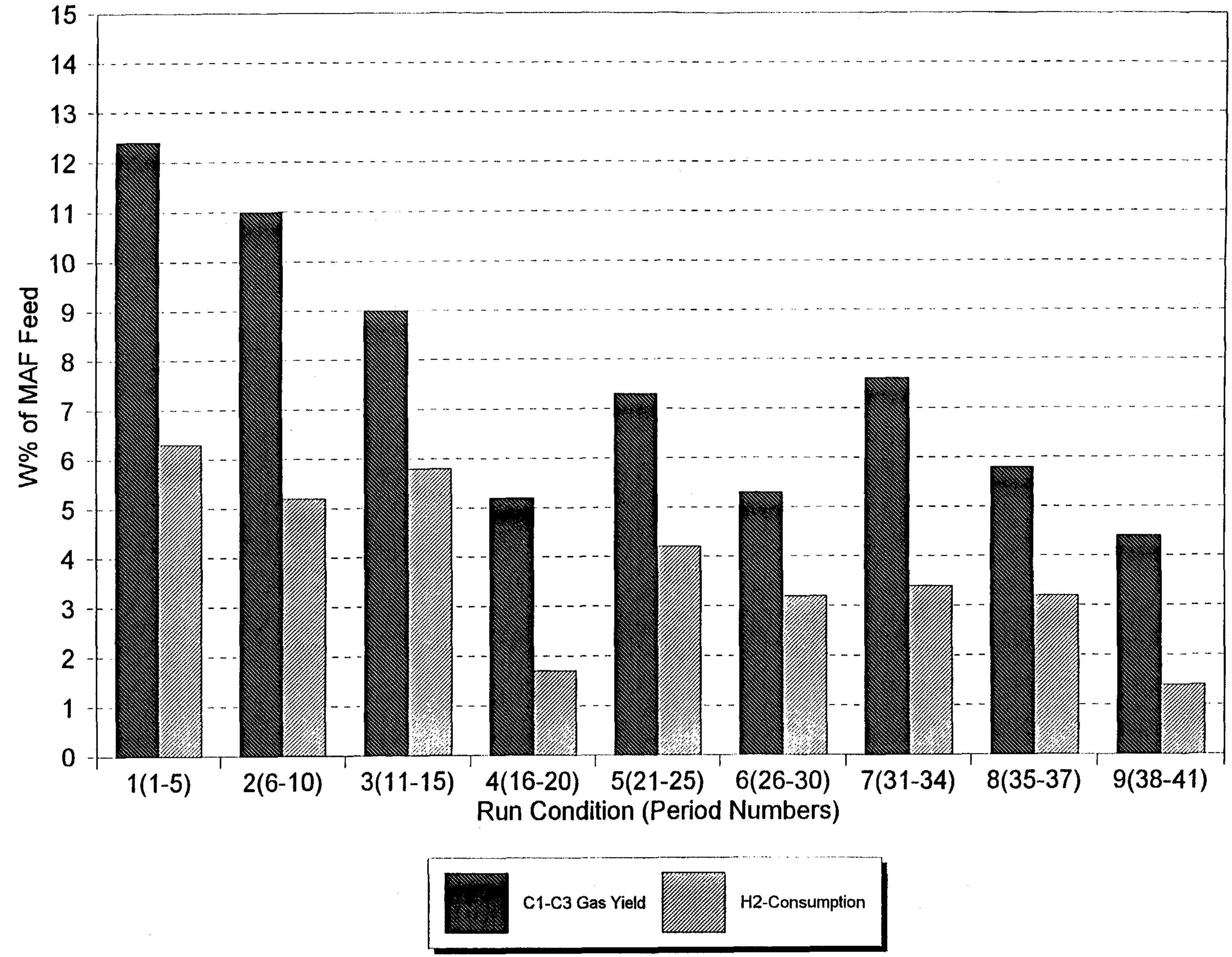


Figure 10. PB-01: Hydrogen Efficiency and C_1-C_3 Gas Selectivity

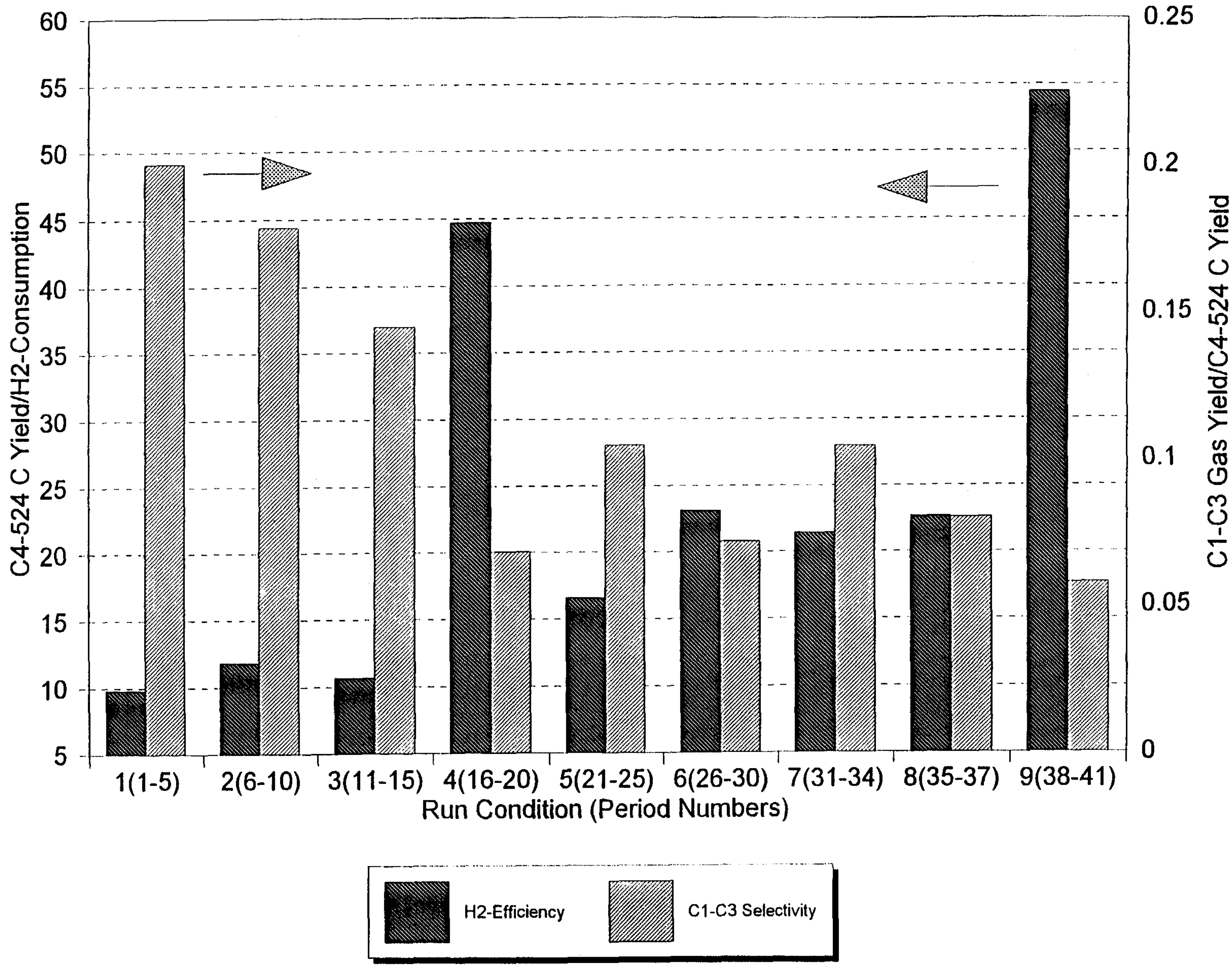


Figure 11. PB-01: Quality of SOH Distillates

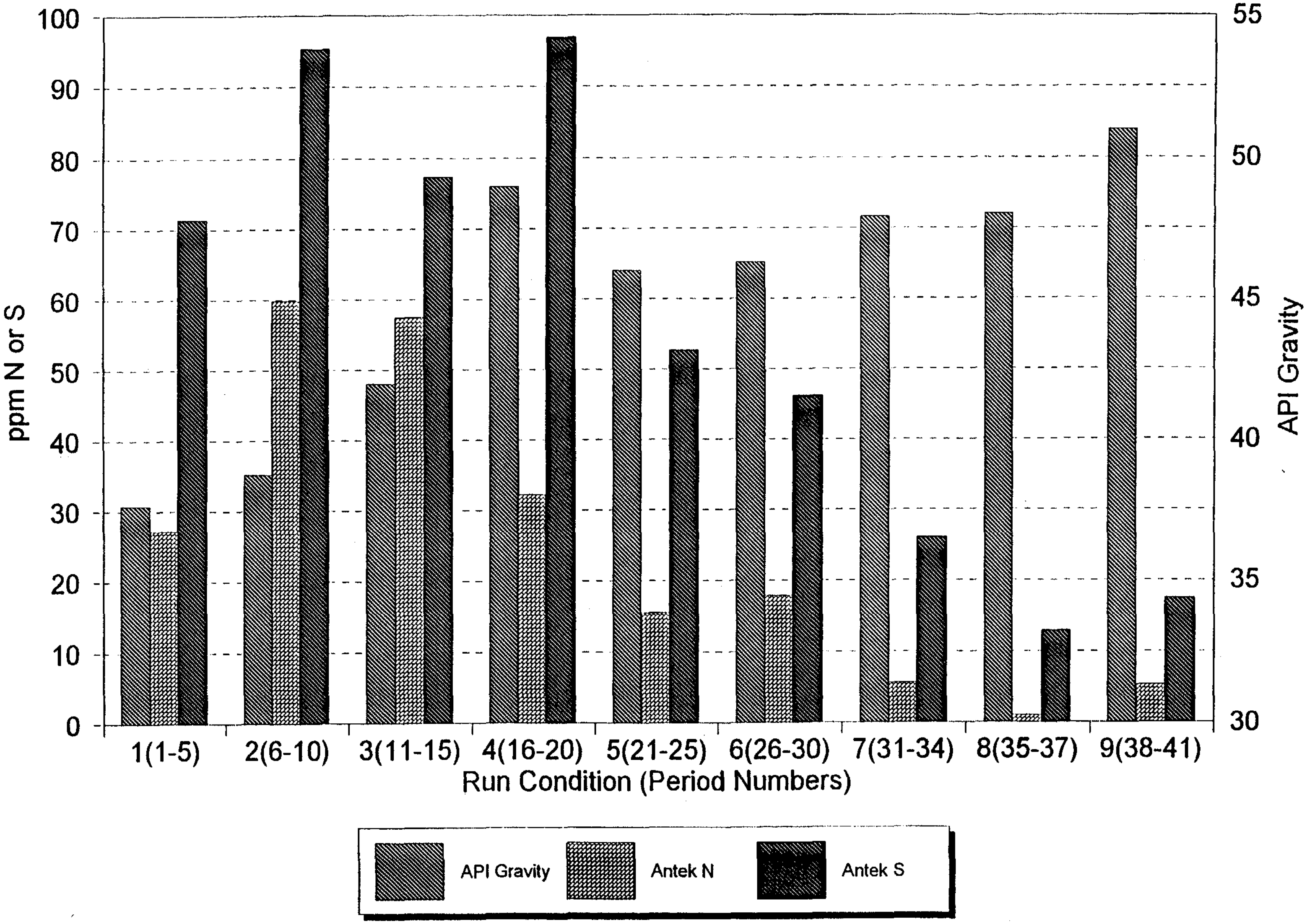


Figure 12. PB-01: Product H/C Ratios

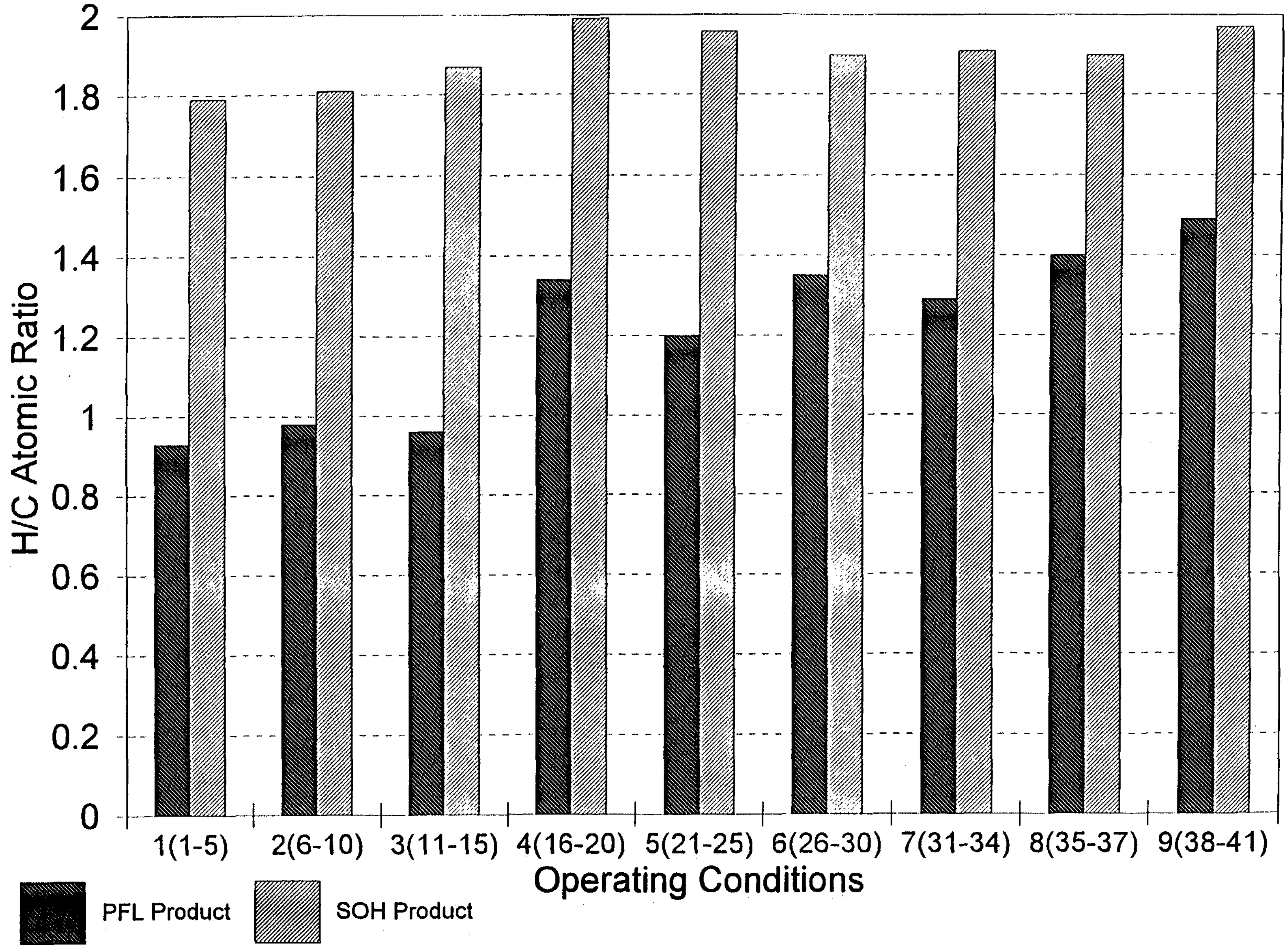


Figure 13. PB-01: Solubility of PFL Product

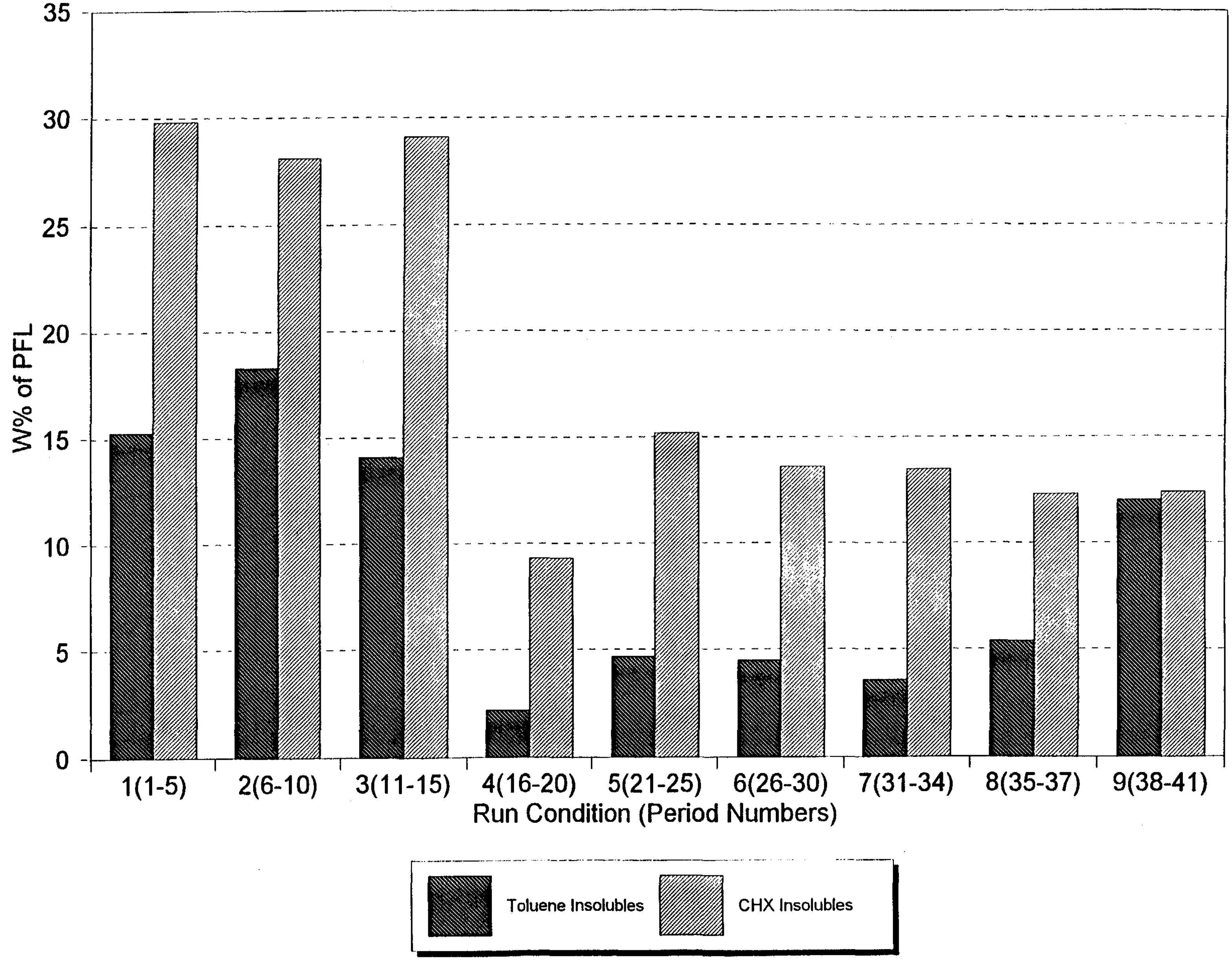


Figure 14. PB-01: Feed Type vs. Performance

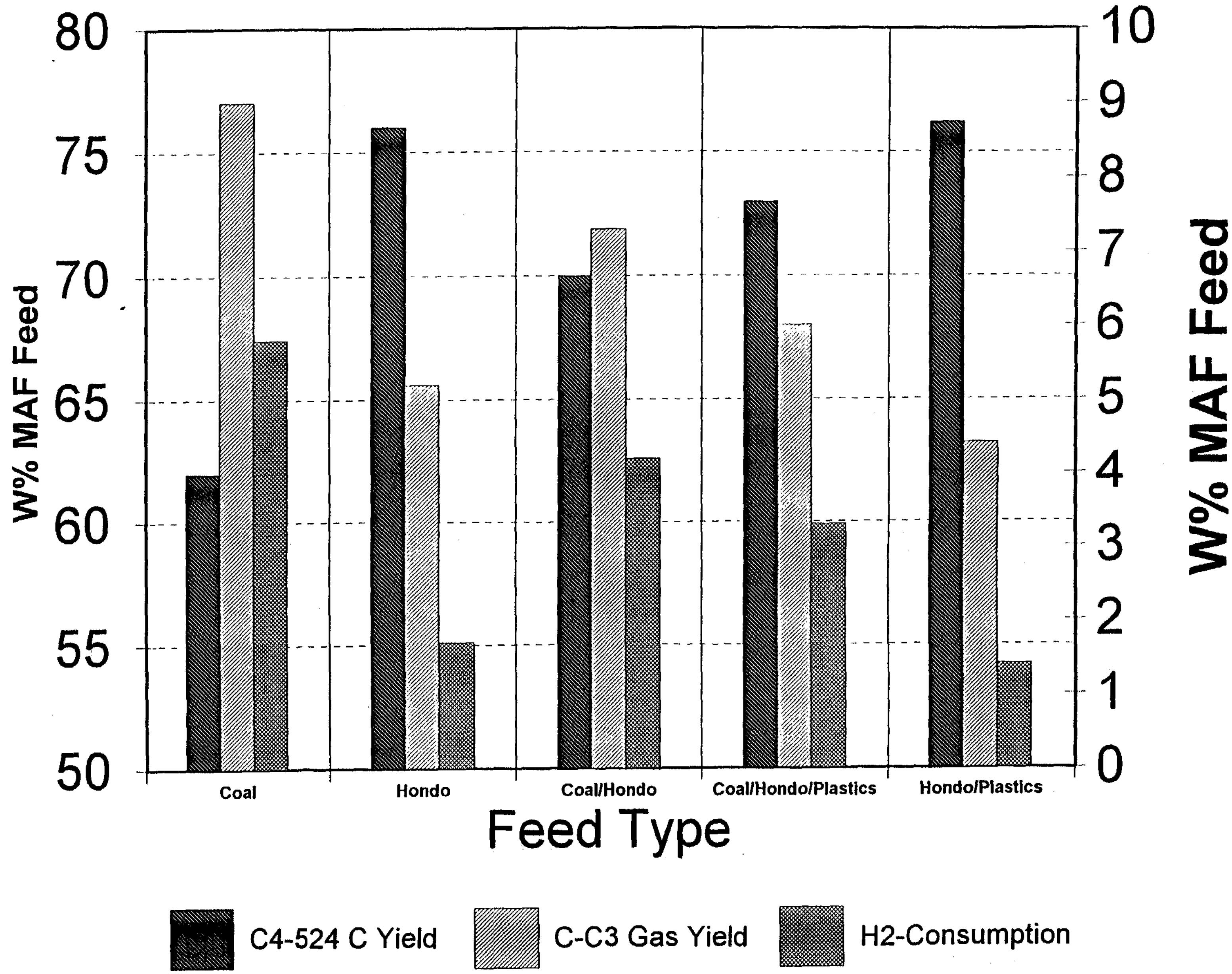
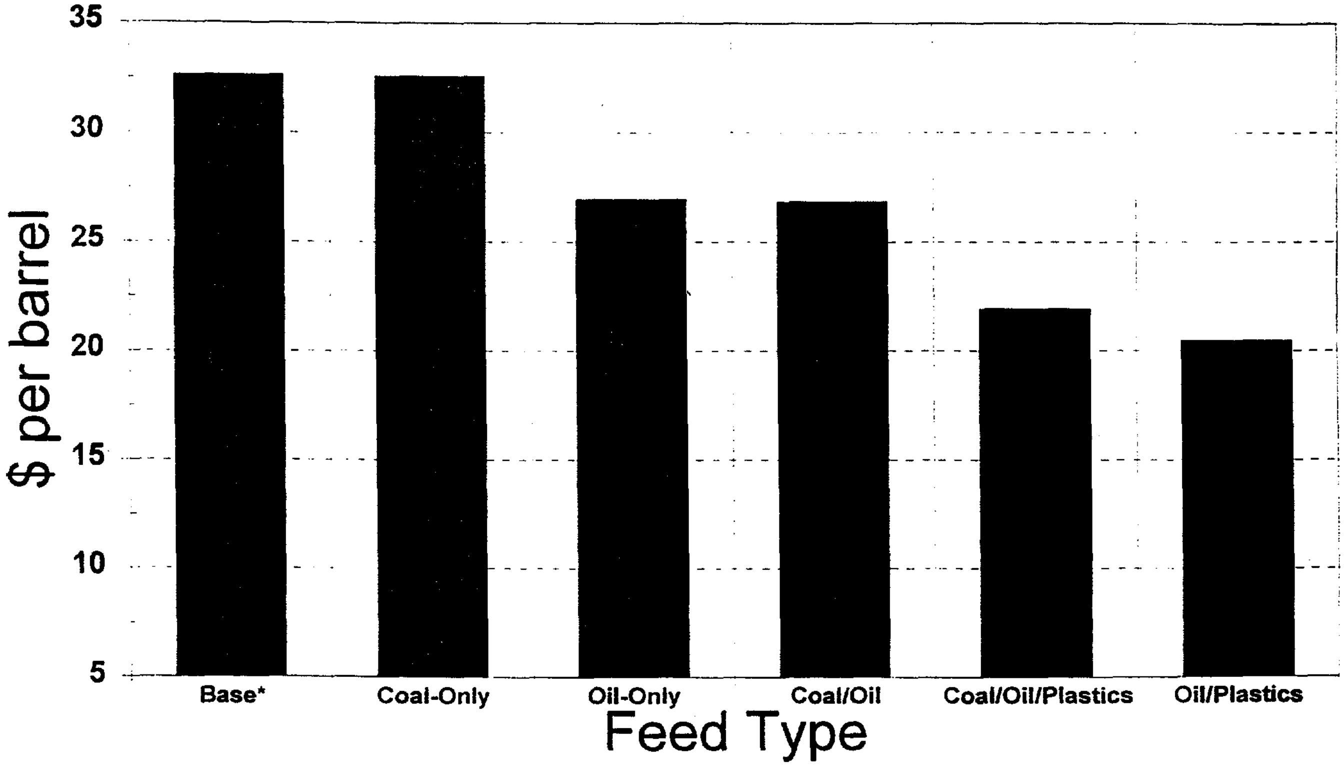


Figure 15. Equivalent Crude Oil Price - Effect of Feed Type



APPENDIX [Daily Material Recovery Balance Data]

RUN 227-90 (POC PB-01) MATERIAL BALANCE

Coal-Waste Coprocessing using Dispersed Slurry Fe/Mo Catalysts

FEED: BLACK THUNDER MINE: POC-02 COAL (HRI-6213)
Hondo VTB Oil and Waste Plastics
CATALYSTS: HTI'S Fe (5000 ppm to K-2) + MOLYVAN-A (50 ppm to K-1)

iod Number	01T	02T	03T	04T	05T	06T	07T
e (Start of Period)	09/23/95	09/24/95	09/25/95	09/26/95	09/27/95	09/28/95	09/29/95
ation, hrs	24.	24.	24.	24.	24.	24.	24.
rs of Run (End of Period)	24.	48.	72.	96.	120.	144.	168.
UTS, GRAMS							
Total Feed	26460.0	36394.7	39710.0	36705.3	36950.6	33173.4	35102.6
Makeup Oil to Charge (L-814/extracted oil)	0.0	9489.7	0.0	0.0	0.0	0.0	0.0
Makeup Oil to Buffer (L-814/extracted oil)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl Recycled to Charge+K-2 Cat Addition	48595.0	32356.4	43908.3	41532.4	41994.9	11393.0	39511.5
CAS Btms Recycled to Charge	0.0	0.0	0.0	0.0	0.0	26581.4	0.0
Filter Cake Recycled to Charge	0.0	0.0	0.0	0.0	0.0	1494.5	5008.8
Pfl to Stage 1 Buffer	711.0	689.0	640.0	860.0	912.0	705.0	668.0
Pfl to Stage 2 Buffer	828.0	833.0	765.0	849.0	957.0	790.0	690.0
Water to Hot Separators	9734.0	9566.0	9841.0	9045.0	9892.0	10197.0	9432.0
Total Sulfur Added	2124.4	1953.3	1941.1	1956.9	1944.0	1886.0	1887.0
Additive (Fe+Mo Catalysts)	745.0	1015.6	1010.0	933.5	939.4	846.0	822.0
H2 to 1st Stage	4627.2	4628.1	4627.6	4628.1	4629.5	4627.8	4628.1
H2 to 2nd Stage	2026.2	2026.5	2026.5	2495.0	2601.8	2602.6	2603.0
Hydrogen Bleed	698.8	698.8	698.8	696.4	695.9	695.9	695.9
TOTAL GRAMS IN	96549.6	99651.1	105168.2	99701.7	101517.1	94992.6	101048.9
PUTS, GRAMS							
Hydrogen Out	5917.4	5893.4	5445.9	5708.9	5517.1	5710.3	5800.9
Total Gas Product (N2,H2 Free)	10289.8	9938.1	9587.6	9521.7	10481.7	8098.5	10010.2
Unit Knockouts	55.0	6.0	54.0	9.0	36.0	123.0	995.0
Separator Overhead (HTU) Product	32435.0	30583.0	31591.0	30988.0	29385.0	28871.0	26805.0
Atmospheric Overhead Product (Sample)	300.0	334.0	770.0	965.0	913.0	1359.0	150.0
CAS Bottoms	50486.0	58190.0	50365.0	50411.0	53777.0	50155.0	61004.0
Feed + Interstage Slurry Sample	113.0	340.0	114.0	130.0	358.0	131.0	91.0
TOTAL GRAMS OUT	99596.3	105284.5	97927.5	97733.6	100467.9	94447.9	104856.1
% Total Material Recovery (Gross)	103.16	105.65	93.12	98.03	98.97	99.43	103.77

iod Number	01T	02T	03T	04T	05T	06T	07T
--CHARGE, PRODUCT, AND RECYCLE RATES-----							
EED RATES, GRAMS/HOUR							
Total Carbonaceous Feed	1102.5	1516.4	1654.6	1529.4	1539.6	1382.2	1462.6
Dry Carbonaceous Feed	992.3	1364.8	1489.1	1376.4	1385.6	1244.0	1316.3
Total Makeup Oil Rate	0.0	395.4	0.0	0.0	0.0	0.0	0.0
Water to Hot Separator	405.6	398.6	410.0	376.9	412.2	424.9	393.0
H2 to 1st Stage	192.8	192.8	192.8	192.8	192.9	192.8	192.8
H2 to 2nd Stage	84.4	84.4	84.4	104.0	108.4	108.4	108.5
ECYCLE RATES TO REACTOR, GRAMS/HOUR							
PFL Recycled to Slurry + Pretreater Buffer	2024.8	1348.2	1829.5	1730.5	1749.8	474.7	1646.3
CAS Bottoms Recycled	0.0	0.0	0.0	0.0	0.0	1107.6	0.0
Pfl to 1st Stage Buffer	29.6	28.7	26.7	35.8	38.0	29.4	27.8
Pfl to 2nd Stage Buffer	34.5	34.7	31.9	35.4	39.9	32.9	28.8
ET COLLECTED PRODUCTS (INCLUDING SAMPLES), GRAMS/HOUR							
Total Gas (incl. N2)	872.2	793.0	824.6	800.1	798.9	675.5	768.3
(N2 free)	675.3	659.6	626.4	634.6	666.6	575.4	658.8
SOH	841.7	664.2	638.7	669.5	562.4	558.4	520.8
SOH-H2O	509.8	610.1	677.6	621.7	662.0	644.6	596.0
SOH-NET WATER	104.2	211.5	267.5	244.8	249.8	219.7	203.0
Knockouts	2.3	0.3	2.3	0.4	1.5	5.1	41.5
Filter Cake	83.0	119.4	269.1	143.1	93.8	16.1	162.1
Filter Liquid	-82.3	830.4	-71.7	139.3	183.5	70.2	734.2
Asoh + KO	14.8	14.2	34.3	40.6	39.5	61.8	47.7
Total CAS Bottoms	2103.6	2424.6	2098.5	2100.5	2240.7	2089.8	2541.8
Reactor 1 Liquid Sample	4.7	14.2	4.8	5.4	14.9	5.5	3.8
Separator Bottoms to CAS	2116.1	2438.5	2130.6	2140.7	2278.8	2146.4	2548.1
Total Asoh	14.8	14.2	34.3	40.6	39.5	61.8	47.7
CAS Bottoms to Pressure Filter	2089.6	2361.4	2085.4	2084.1	2105.0	623.3	2599.2
Total Filter Cake	83.0	119.4	269.1	143.1	93.8	16.1	162.1
Total Filter Liquid	2006.6	2242.0	1816.3	1941.0	2011.2	607.2	2437.1
--NET ADJ. PRODUCTS, W% DRY Total Feed -----							
Total CO + CO2	9.76	5.87	5.47	6.10	5.86	4.11	6.62
Total C1-C3	12.55	10.91	9.45	11.03	11.82	9.91	11.31
Total C4-C7	5.36	3.53	3.66	3.32	4.79	3.40	4.02
SOH TOTAL H2O	51.38	44.70	45.50	45.17	47.78	51.82	45.28
SOH NET WATER	10.50	15.50	17.97	17.79	28.00	17.66	15.42
SOH Distillate Oil	84.82	48.66	42.89	48.64	40.59	44.89	39.57
Asoh + KO	1.49	1.04	2.31	2.95	2.85	4.96	3.62
Pfl	-6.95	65.24	-4.05	11.22	22.60	33.75	51.69
Pfs	8.42	8.98	18.18	10.48	7.21	-2.97	-3.81
CAS Bottoms	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reactor 1 Liquid Sample	0.47	1.04	0.32	0.39	1.08	0.44	0.29

iod number	01T	02T	03T	04T	05T	06T	07T
D GAS (STAGE I VENT GAS), V%							

	90.37	91.20	90.87	91.79	89.50	91.81	89.52
4	2.03	1.97	1.89	1.96	1.99	1.42	2.55
H4	0.04	0.03	0.04	0.04	0.00	0.04	0.04
H6	0.85	0.76	0.78	0.87	1.03	0.70	1.00
H6	0.09	0.06	0.08	0.06	0.08	0.06	0.08
H8	0.36	0.44	0.47	0.54	0.76	0.49	0.63
H8	0.08	0.06	0.07	0.05	0.05	0.04	0.06
C4H10	0.25	0.19	0.18	0.22	0.37	0.22	0.26
C4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5H12	0.10	0.07	0.06	0.07	0.11	0.07	0.08
C5H12	0.07	0.04	0.04	0.04	0.07	0.04	0.05
THYL-CYCLOPENTANE	0.01	0.00	0.01	0.00	0.01	0.00	0.00
CLOHEXANE	0.01	0.02	0.05	0.01	0.02	0.01	0.04
C6H14	0.02	0.01	0.02	0.02	0.03	0.02	0.02
+ 3-METHYLPENTANE	0.00	0.01	0.00	0.00	0.00	0.00	0.00
-C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.45	0.33	0.43	0.54	0.61	0.50	0.72
2	1.99	1.65	1.68	1.76	1.73	0.87	1.71
S	2.41	2.02	1.82	1.95	2.50	1.89	2.07
TROGEN	0.83	1.11	1.48	0.05	1.09	1.65	1.13
YGEN	0.04	0.03	0.03	0.03	0.05	0.17	0.04
S GAS (STAGE II VENT GAS), V%							

	76.15	77.40	71.48	77.84	80.11	82.89	82.67
4	2.67	4.62	4.03	3.82	3.62	2.96	3.13
H4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H6	0.93	1.54	1.54	1.56	1.66	1.38	1.24
H6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H8	0.70	0.90	1.03	0.98	1.13	0.87	0.61
H8	0.00	0.00	0.01	0.00	0.00	0.00	0.00
C4H10	0.34	0.48	0.47	0.44	0.54	0.43	0.38
C4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5H12	0.12	0.15	0.15	0.11	0.14	0.10	0.11
C5H12	0.10	0.09	0.08	0.05	0.07	0.05	0.06
THYL-CYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CLOHEXANE	0.03	0.02	0.16	0.06	0.11	0.05	0.11
C6H14	0.03	0.04	0.06	0.03	0.05	0.01	0.03
+ 3-METHYLPENTANE	0.01	0.00	0.02	0.00	0.01	0.00	0.00
-C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.09	0.11	0.12	0.16	0.12	0.19	0.16
2	0.12	0.14	0.21	0.20	0.23	0.26	0.25
S	4.55	4.45	4.42	3.30	3.17	3.83	3.69
TROGEN	14.11	10.01	16.08	11.36	8.99	6.93	7.44
YGEN	0.05	0.05	0.14	0.09	0.05	0.05	0.12

RUN 227-90 (POC PB-01) MATERIAL BALANCE

Coal-Waste Coprocessing using Dispersed Slurry Fe/Mo Catalysts

FEED: BLACK THUNDER MINE: POC-02 COAL (HRI-6213)
Hondo VTB Oil and Waste Plastics
CATALYSTS: HTI'S Fe (5000 ppm to K-2) + MOLYVAN-A (50 ppm to K-1)

iod Number	08T	09T	10T	11T	12T	13T	14T
e (Start of Period)	09/30/95	10/01/95	10/02/95	10/03/95	10/04/95	10/05/95	10/06/95
ation, hrs	24.	24.	24.	24.	24.	24.	24.
rs of Run (End of Period)	192.	216.	240.	264.	288.	312.	336.
UTS, GRAMS							
Total Feed	32890.0	33708.5	35160.0	33584.2	40994.2	42224.3	44565.0
Makeup Oil to Charge (L-814/extracted oil)	0.0	0.0	0.0	7402.2	0.0	0.0	0.0
Makeup Oil to Buffer (L-814/extracted oil)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl Recycled to Charge+K-2 Cat Addition	37339.6	37945.0	39960.0	34040.0	45144.5	47024.3	49365.0
CAS Btms Recycled to Charge	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filter Cake Recycled to Charge	4454.0	2668.0	3600.0	0.0	0.0	0.0	0.0
Pfl to Stage 1 Buffer	773.0	815.0	891.0	3868.0	616.0	792.0	692.0
Pfl to Stage 2 Buffer	872.0	853.0	942.0	3990.0	856.0	918.0	807.0
Water to Hot Separators	9860.0	9666.0	10240.0	9985.0	9708.0	9940.0	9960.0
Total Sulfur Added	1904.0	1908.0	1904.0	2281.0	2374.4	2587.0	2586.0
Additive (Fe+Mo Catalysts)	826.0	790.0	894.0	807.0	961.3	1027.0	1211.0
H2 to 1st Stage	4627.7	4628.0	4627.4	4627.0	4626.8	4626.7	4626.4
H2 to 2nd Stage	2602.8	2602.8	2602.5	2602.4	2602.8	2602.8	2602.5
Hydrogen Bleed	695.9	695.9	695.7	695.9	695.9	695.8	695.7
TOTAL GRAMS IN	96845.1	96280.2	101516.6	103882.7	108579.8	112437.9	117110.6
PUTS, GRAMS							
Hydrogen Out	5644.6	5696.2	5803.1	6183.8	5681.7	5520.9	5573.6
Total Gas Product (N2,H2 Free)	10061.3	8639.1	7058.2	9169.2	10897.8	11143.1	10570.9
Unit Knockouts	245.0	243.0	262.0	153.0	467.0	338.0	576.0
Separator Overhead (HTU) Product	26276.0	25450.0	27014.0	24529.0	26619.0	29346.0	27212.0
Atmospheric Overhead Product (Sample)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAS Bottoms	51263.0	52614.0	53949.0	55304.0	65911.0	61226.0	68396.0
Feed + Interstage Slurry Sample	66.0	36.0	90.0	0.0	0.0	70.0	110.0
TOTAL GRAMS OUT	93555.9	92678.3	94176.3	95339.0	109576.5	107644.0	112438.5
% Total Material Recovery (Gross)	96.60	96.26	92.77	91.78	100.92	95.74	96.01

iod Number	08T	09T	10T	11T	12T	13T	14T
--CHARGE, PRODUCT, AND RECYCLE RATES-----							
EED RATES, GRAMS/HOUR							
Total Carbonaceous Feed	1370.4	1404.5	1465.0	1399.3	1708.1	1759.3	1856.9
Dry Carbonaceous Feed	1233.4	1264.1	1318.5	1259.4	1537.3	1583.4	1671.2
Total Makeup Oil Rate	0.0	0.0	0.0	308.4	0.0	0.0	0.0
Water to Hot Separator	410.8	402.8	426.7	416.0	404.5	414.2	415.0
H2 to 1st Stage	192.8	192.8	192.8	192.8	192.8	192.8	192.8
H2 to 2nd Stage	108.5	108.4	108.4	108.4	108.4	108.5	108.4
ECYCLE RATES TO REACTOR, GRAMS/HOUR							
PFL Recycled to Slurry + Pretreater Buffer	1555.8	1581.0	1665.0	1418.3	1881.0	1959.3	2056.9
CAS Bottoms Recycled	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl to 1st Stage Buffer	32.2	34.0	37.1	161.2	25.7	33.0	28.8
Pfl to 2nd Stage Buffer	36.3	35.5	39.3	166.3	35.7	38.3	33.6
ET COLLECTED PRODUCTS (INCLUDING SAMPLES), GRAMS/HOUR							
Total Gas (incl. N2)	723.4	678.7	627.8	700.2	771.4	782.8	765.1
(N2 free)	654.4	597.3	535.9	639.7	690.8	694.3	672.7
SOH	490.1	462.3	509.8	443.5	483.7	579.3	456.1
SOH-H2O	604.7	598.1	615.8	578.5	625.4	643.4	677.8
SOH-NET WATER	193.9	195.4	189.2	162.5	220.9	229.3	262.8
Knockouts	10.2	10.1	10.9	6.4	19.5	14.1	24.0
Filter Cake	223.8	292.2	276.5	287.0	344.0	377.4	321.3
Filter Liquid	263.1	273.5	224.3	452.1	446.9	117.9	397.6
Asoh + KO	10.2	10.1	10.9	6.4	19.5	14.1	24.0
Total CAS Bottoms	2136.0	2192.3	2247.9	2304.3	2746.3	2551.1	2849.8
Reactor 1 Liquid Sample	2.8	1.5	3.8	0.0	0.0	2.9	4.6
Separator Bottoms to CAS	2136.0	2192.3	2247.9	2304.3	2746.3	2551.1	2849.8
Total Asoh	10.2	10.1	10.9	6.4	19.5	14.1	24.0
CAS Bottoms to Pressure Filter	2111.3	2216.2	2242.1	2484.8	2733.3	2525.9	2838.2
Total Filter Cake	223.8	292.2	276.5	287.0	344.0	377.4	321.3
Total Filter Liquid	1887.5	1924.0	1965.6	2197.8	2389.3	2148.5	2516.9
--NET ADJ. PRODUCTS, W% DRY Total Feed -----							
Total CO + CO2	5.86	5.35	3.18	4.03	6.16	5.92	4.66
Total C1-C3	11.40	10.21	8.10	9.48	10.77	10.42	8.22
Total C4-C7	5.15	4.07	3.33	4.19	3.92	3.82	3.77
SOH TOTAL H2O	49.03	47.32	46.71	45.94	40.68	40.63	40.55
SOH NET WATER	15.72	26.00	14.35	12.90	14.37	14.48	15.72
SOH Distillate Oil	39.74	36.57	38.66	35.21	31.47	36.59	27.29
Asoh + KO	0.83	0.80	0.83	0.51	1.27	0.89	1.44
Pfl	23.12	19.99	17.39	23.22	29.81	8.80	24.41
Pfs	3.31	14.07	9.65	21.13	22.48	24.07	19.30
CAS Bottoms	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reactor 1 Liquid Sample	0.22	0.12	0.28	0.00	0.00	0.18	0.27

iod number	08T	09T	10T	11T	12T	13T	14T
D GAS (STAGE I VENT GAS), V%							

	86.86	90.80	93.25	90.43	89.08	88.49	90.28
4	1.81	1.81	1.31	1.81	2.41	2.31	1.60
H4	0.04	0.04	0.03	0.04	0.04	0.05	0.04
H6	0.91	0.87	0.59	0.67	1.06	1.13	0.83
H6	0.09	0.07	0.05	0.09	0.08	0.09	0.09
H8	0.57	0.39	0.38	0.51	0.66	0.77	0.33
H8	0.07	0.06	0.03	0.07	0.04	0.07	0.07
C4H10	0.33	0.27	0.16	0.26	0.27	0.33	0.29
C4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5H12	0.10	0.08	0.05	0.09	0.10	0.12	0.10
C5H12	0.06	0.04	0.03	0.07	0.06	0.06	0.06
THYL-CYCLOPENTANE	0.01	0.01	0.00	0.00	0.00	0.01	0.00
CLOHEXANE	0.06	0.03	0.01	0.01	0.01	0.03	0.05
C6H14	0.02	0.02	0.01	0.01	0.01	0.02	0.02
+ 3-METHYLPENTANE	0.00	0.01	0.00	0.01	0.01	0.00	0.00
-C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.62	0.70	0.53	0.58	0.85	0.78	0.59
2	1.36	1.28	0.68	0.90	1.85	1.94	1.64
S	2.60	1.98	1.58	3.30	2.35	2.67	3.16
TROGEN	3.50	1.14	0.87	1.06	1.08	1.08	0.82
YGEN	0.99	0.40	0.44	0.09	0.04	0.05	0.03
S GAS (STAGE II VENT GAS), V%							

	84.31	83.96	84.63	86.31	83.18	82.55	81.77
4	3.17	2.90	2.46	2.35	3.30	3.24	3.61
H4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H6	1.47	1.36	1.24	0.89	1.57	1.56	1.61
H6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H8	0.81	0.90	0.84	0.64	1.12	1.09	1.12
H8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C4H10	0.49	0.43	0.47	0.35	0.54	0.53	0.52
C4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5H12	0.13	0.11	0.13	0.09	0.15	0.14	0.15
C5H12	0.07	0.05	0.07	0.07	0.08	0.07	0.08
THYL-CYCLOPENTANE	0.00	0.00	0.02	0.00	0.00	0.00	0.01
CLOHEXANE	0.08	0.08	0.08	0.08	0.12	0.04	0.10
C6H14	0.04	0.03	0.05	0.03	0.05	0.04	0.05
+ 3-METHYLPENTANE	0.01	0.00	0.01	0.01	0.01	0.00	0.02
-C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.17	0.15	0.16	0.07	0.18	0.16	0.13
2	0.23	0.18	0.14	0.04	0.27	0.22	0.20
S	3.88	3.19	3.26	3.18	3.73	4.08	4.28
TROGEN	5.05	6.41	6.41	5.45	5.62	6.24	6.35
YGEN	0.09	0.25	0.03	0.44	0.08	0.04	0.00

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RUN 227-90 (POC PB-01) MATERIAL BALANCE

Coal-Waste Coprocessing using Dispersed Slurry Fe/Mo Catalysts

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FEED: BLACK THUNDER MINE: POC-02 COAL (HRI-6213)
Hondo VTB Oil and Waste Plastics
CATALYSTS: HTI'S Fe (5000 ppm to K-2) + MOLYVAN-A (50 ppm to K-1)

iod Number	15T	16T	17T	18T	19T	20T	21T
e (Start of Period)	10/07/95	10/08/95	10/09/95	10/10/95	10/11/95	10/12/95	10/13/95
ation, hrs	24.	24.	24.	24.	24.	24.	24.
rs of Run (End of Period)	360.	384.	408.	432.	456.	480.	504.
UTS, GRAMS							
Total Feed	46692.0	59792.0	43968.0	44768.6	50821.0	43968.0	43968.0
Makeup Oil to Charge (L-814/extracted oil)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Makeup Oil to Buffer (L-814/extracted oil)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl Recycled to Charge+K-2 Cat Addition	51492.0	22188.0	12288.0	12424.0	13455.0	12288.0	12288.0
CAS Btms Recycled to Charge	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filter Cake Recycled to Charge	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl to Stage 1 Buffer	626.0	737.0	705.0	820.0	621.0	739.0	715.0
Pfl to Stage 2 Buffer	777.0	670.0	752.0	890.0	790.0	827.0	870.0
Water to Hot Separators	9732.0	9690.0	9641.0	9776.0	9896.0	10031.0	10089.0
Total Sulfur Added	2586.0	2586.0	2584.0	2584.0	2590.0	2582.0	2586.0
Additive (Fe+Mo Catalysts)	1181.0	1367.0	1112.0	1132.0	1195.0	1112.0	1112.0
H2 to 1st Stage	4628.9	4629.1	4629.2	4629.4	4629.5	4629.2	4628.7
H2 to 2nd Stage	2603.2	2603.3	2603.5	2603.5	2603.4	2603.2	2544.1
Hydrogen Bleed	695.8	695.8	695.9	695.9	695.9	695.9	695.9
TOTAL GRAMS IN	121013.8	104958.2	78978.6	80323.5	87296.8	79475.3	79496.7
PUTS, GRAMS							
Hydrogen Out	5465.5	5866.7	6537.6	6532.9	6759.3	6890.1	6647.6
Total Gas Product (N2,H2 Free)	9649.1	10730.4	8384.8	9378.2	10300.3	9238.2	10870.0
Unit Knockouts	567.0	274.0	79.0	179.0	167.0	282.0	215.0
Separator Overhead (HTU) Product	31515.0	27745.0	25789.0	26689.0	27666.0	26250.0	24858.0
Atmospheric Overhead Product (Sample)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAS Bottoms	69049.0	57905.0	37545.0	38909.0	42343.0	37450.0	38803.0
Feed + Interstage Slurry Sample	200.0	50.0	56.0	141.0	114.0	0.0	81.0
TOTAL GRAMS OUT	116445.6	102571.1	78391.4	81829.1	87349.6	80110.2	81474.6
% Total Material Recovery (Gross)	96.23	97.73	99.26	101.87	100.06	100.80	102.49

iod Number	15T	16T	17T	18T	19T	20T	21T
--CHARGE, PRODUCT, AND RECYCLE RATES-----							
EED RATES, GRAMS/HOUR							
Total Carbonaceous Feed	1945.5	2491.3	1832.0	1865.4	2117.5	1832.0	1832.0
Dry Carbonaceous Feed	1751.0	2491.3	1832.0	1678.8	2117.5	1832.0	1740.4
Total Makeup Oil Rate	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water to Hot Separator	405.5	403.8	401.7	407.3	412.3	418.0	420.4
H2 to 1st Stage	192.9	192.9	192.9	192.9	192.9	192.9	192.9
H2 to 2nd Stage	108.5	108.5	108.5	108.5	108.5	108.5	106.0
ECYCLE RATES TO REACTOR, GRAMS/HOUR							
PFL Recycled to Slurry + Pretreater Buffer	2145.5	924.5	512.0	517.7	560.6	512.0	512.0
CAS Bottoms Recycled	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl to 1st Stage Buffer	26.1	30.7	29.4	34.2	25.9	30.8	29.8
Pfl to 2nd Stage Buffer	32.4	27.9	31.3	37.1	32.9	34.5	36.3
ET COLLECTED PRODUCTS (INCLUDING SAMPLES), GRAMS/HOUR							
Total Gas (incl. N2)	721.4	733.3	707.9	752.9	664.5	665.3	805.7
(N2 free)	629.8	691.5	621.8	663.0	710.8	672.0	729.9
SOH	683.5	577.3	594.8	648.4	689.8	638.3	552.6
SOH-H2O	629.7	578.8	479.8	463.7	463.0	455.4	483.1
SOH-NET WATER	224.2	175.0	78.1	56.3	50.7	37.5	62.8
Knockouts	23.6	11.4	3.3	7.5	7.0	11.8	9.0
Filter Cake	235.2	225.5	192.4	104.5	53.3	33.8	62.9
Filter Liquid	402.0	1187.8	785.4	937.0	1074.5	916.4	943.7
Asoh + KO	23.6	11.4	3.3	7.5	7.0	11.8	9.0
Total CAS Bottoms	2877.0	2412.7	1564.4	1621.2	1764.3	1560.4	1616.8
Reactor 1 Liquid Sample	8.3	2.1	2.3	5.9	4.8	0.0	3.4
Separator Bottoms to CAS	2877.0	2412.7	1564.4	1621.2	1764.3	1560.4	1616.8
Total Asoh	23.6	11.4	3.3	7.5	7.0	11.8	9.0
CAS Bottoms to Pressure Filter	2841.1	2396.4	1550.5	1630.5	1747.2	1527.4	1584.7
Total Filter Cake	235.2	225.5	192.4	104.5	53.3	33.8	62.9
Total Filter Liquid	2605.9	2170.9	1358.1	1526.0	1693.9	1493.7	1521.8
--NET ADJ. PRODUCTS, W% DRY Total Feed -----							
Total CO + CO2	3.25	1.39	0.42	0.20	0.11	0.11	1.45
Total C1-C3	8.51	5.02	5.42	6.51	4.87	5.45	6.57
Total C4-C7	3.20	2.46	2.42	3.45	2.88	3.05	4.12
SOH TOTAL H2O	35.96	23.23	26.19	27.62	21.86	24.86	27.76
SOH NET WATER	28.00	7.02	4.26	3.36	3.00	2.04	3.61
SOH Distillate Oil	39.03	23.17	32.46	38.62	32.57	34.84	31.75
Asoh + KO	1.35	0.46	0.18	0.44	0.33	0.64	0.51
Pfl	24.84	48.27	43.53	55.30	51.52	51.78	56.00
Pfs	13.60	9.11	10.60	6.19	2.54	1.88	3.69
CAS Bottoms	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reactor 1 Liquid Sample	0.48	0.08	0.13	0.35	0.22	0.00	0.19

* 227 UNIT MATERIAL BALANCE (CON'T) *

iod number	15T	16T	17T	18T	19T	20T	21T
ɔ GAS (STAGE I VENT GAS), V%							

	91.15	90.35	93.80	92.77	92.49	92.44	91.14
4	1.56	1.22	0.94	0.96	0.78	0.90	1.14
H4	0.04	0.04	0.03	0.04	0.03	0.03	0.04
H6	0.83	0.68	0.41	0.43	0.42	0.40	0.57
H6	0.08	0.10	0.06	0.08	0.08	0.08	0.09
H8	0.60	0.48	0.15	0.30	0.25	0.23	0.27
H8	0.06	0.10	0.06	0.08	0.11	0.08	0.08
C4H10	0.28	0.28	0.13	0.16	0.17	0.15	0.21
C4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5H12	0.09	0.10	0.06	0.08	0.10	0.08	0.09
C5H12	0.05	0.08	0.05	0.07	0.08	0.07	0.09
THYL-CYCLOPENTANE	0.00	0.00	0.00	0.01	0.01	0.02	0.00
CLOHEXANE	0.05	0.00	0.00	0.00	0.00	0.00	0.05
C6H14	0.02	0.03	0.01	0.01	0.00	0.02	0.03
+ 3-METHYLPENTANE	0.00	0.03	0.00	0.01	0.03	0.00	0.03
-C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.45	0.36	0.15	0.08	0.06	0.05	0.26
2	1.07	0.59	0.07	0.03	0.02	0.01	0.41
S	2.63	4.68	3.00	3.08	4.46	3.47	3.91
TROGEN	0.89	0.84	0.71	1.61	0.84	0.97	1.36
YGEN	0.15	0.04	0.37	0.20	0.07	1.00	0.23
S GAS (STAGE II VENT GAS), V%							

	80.61	82.75	83.60	82.34	82.03	84.10	83.89
	3.92	2.75	2.57	2.49	2.23	2.14	2.30
H4	0.00	0.00	0.00	0.00	0.00	0.00	0.03
H6	1.78	1.30	1.18	1.17	1.03	0.98	1.11
H6	0.00	0.00	0.00	0.01	0.00	0.00	0.00
H8	1.26	1.03	0.89	0.90	0.80	0.75	0.86
H8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C4H10	0.54	0.45	0.40	0.44	0.38	0.35	0.42
C4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5H12	0.14	0.14	0.13	0.17	0.13	0.13	0.17
C5H12	0.07	0.10	0.12	0.15	0.14	0.12	0.14
THYL-CYCLOPENTANE	0.00	0.00	0.00	0.00	0.02	0.03	0.07
CLOHEXANE	0.07	0.04	0.02	0.03	0.01	0.01	0.00
C6H14	0.04	0.03	0.01	0.02	0.01	0.03	0.03
+ 3-METHYLPENTANE	0.00	0.02	0.03	0.04	0.03	0.03	0.03
C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.18	0.10	0.00	0.00	0.00	0.00	0.04
	0.29	0.10	0.03	0.00	0.00	0.01	0.00
	4.09	4.97	5.42	6.25	5.51	5.31	5.67
TROGEN	6.95	5.50	5.60	5.92	5.51	4.66	5.11
YGEN	0.06	0.72	0.00	0.07	2.17	1.35	0.13

RUN 227-90 (POC PB-01) MATERIAL BALANCE

Coal-Waste Coprocessing using Dispersed Slurry Fe/Mo Catalysts

FEED: BLACK THUNDER MINE: POC-02 COAL (HRI-6213)
Hondo VTB Oil and Waste Plastics
CATALYSTS: HTI'S Fe (5000 ppm to K-2) + MOLYVAN-A (50 ppm to K-1)

iod Number	22T	23T	24T	25T	26T	27T	28T
(Start of Period)	10/14/95	10/15/95	10/16/95	10/17/95	10/18/95	10/19/95	10/20/95
tion, hrs	24.	24.	24.	24.	24.	24.	24.
s of Run (End of Period)	528.	552.	576.	600.	624.	648.	672.
TS, GRAMS							
Total Feed	43968.0	43968.0	49262.0	43968.0	43968.0	52839.7	48490.0
Makeup Oil to Charge (L-814/extracted oil)	4740.0	0.0	0.0	0.0	0.0	0.0	0.0
Makeup Oil to Buffer (L-814/extracted oil)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl Recycled to Charge+K-2 Cat Addition	12288.0	12288.0	13045.0	12288.0	12288.0	13794.0	13054.0
CAS Btms Recycled to Charge	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filter Cake Recycled to Charge	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl to Stage 1 Buffer	908.0	1518.0	704.0	797.0	646.0	896.0	2669.0
Pfl to Stage 2 Buffer	1066.0	1726.0	813.0	930.0	800.0	1050.0	2978.0
Water to Hot Separators	9628.0	9676.0	9822.0	9755.0	9545.0	10145.0	11418.0
Total Sulfur Added	2586.0	2586.0	2566.0	2586.0	2586.0	2334.0	2336.0
Additive (Fe+Mo Catalysts)	1112.0	1112.0	1112.0	1112.0	1112.0	1003.0	1003.0
H2 to 1st Stage	4696.1	4642.5	4650.5	4632.3	4632.0	4632.4	4632.1
H2 to 2nd Stage	2603.3	2550.2	2603.4	2603.3	2603.1	2603.0	2602.8
Hydrogen Bleed	695.9	695.9	695.9	695.8	695.8	695.8	695.8
TOTAL GRAMS IN	84291.3	80762.6	85273.8	79367.4	78875.9	89992.9	89878.7
UTS, GRAMS							
Hydrogen Out	6599.4	6274.5	6188.8	6157.0	6095.2	5957.9	6458.1
Total Gas Product (N2,H2 Free)	10388.3	11320.5	9471.5	9213.0	10235.4	13324.5	9643.7
Unit Knockouts	207.0	118.0	143.0	84.0	117.0	174.0	143.0
Separator Overhead (HTU) Product	28481.0	27792.0	29924.0	29485.0	29061.0	32986.0	30752.0
Atmospheric Overhead Product (Sample)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAS Bottoms	39004.0	42251.0	36617.0	32663.0	31378.0	37564.0	28932.0
Feed + Interstage Slurry Sample	168.0	84.0	0.0	72.0	198.0	87.0	68.0
TOTAL GRAMS OUT	84847.7	87840.0	82344.3	77674.0	77084.6	90093.4	75996.8
% Total Material Recovery (Gross)	100.66	108.76	96.56	97.87	97.73	100.11	84.55

iod Number	22T	23T	24T	25T	26T	27T	28T
--CHARGE, PRODUCT, AND RECYCLE RATES-----							
EED RATES, GRAMS/HOUR							
Total Carbonaceous Feed	1832.0	1832.0	2052.6	1832.0	1832.0	2201.7	2020.4
Dry Carbonaceous Feed	1740.4	1740.4	1950.0	1740.4	1770.6	2127.9	1952.7
Total Makeup Oil Rate	197.5	0.0	0.0	0.0	0.0	0.0	0.0
Water to Hot Separator	401.2	403.2	409.3	406.5	397.7	422.7	475.8
H2 to 1st Stage	195.7	193.4	193.8	193.0	193.0	193.0	193.0
H2 to 2nd Stage	108.5	106.3	108.5	108.5	108.5	108.5	108.5
ECYCLE RATES TO REACTOR, GRAMS/HOUR							
PFL Recycled to Slurry + Pretreater Buffer	512.0	512.0	543.5	512.0	512.0	574.8	543.9
CAS Bottoms Recycled	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl to 1st Stage Buffer	37.8	63.3	29.3	33.2	26.9	37.3	111.2
Pfl to 2nd Stage Buffer	44.4	71.9	33.9	38.8	33.3	43.8	124.1
ET COLLECTED PRODUCTS (INCLUDING SAMPLES), GRAMS/HOUR							
Total Gas (incl. N2)	774.5	745.9	719.7	667.9	762.1	901.1	736.2
(N2 free)	707.8	733.1	652.5	640.4	680.4	803.4	670.9
SOH	662.5	596.3	665.7	663.5	655.3	827.2	764.3
SOH-H2O	524.2	561.7	581.2	565.1	555.6	547.3	517.0
SOH-NET WATER	123.0	158.5	171.9	158.6	157.9	124.5	41.3
Knockouts	8.6	4.9	6.0	3.5	4.9	7.3	6.0
Filter Cake	168.6	263.3	208.0	178.2	171.5	164.1	112.9
Filter Liquid	842.6	887.9	694.6	564.7	586.0	716.9	302.5
Asoh + KO	8.6	4.9	6.0	3.5	4.9	7.3	6.0
Total CAS Bottoms	1625.2	1760.5	1525.7	1361.0	1307.4	1565.2	1205.5
Reactor 1 Liquid Sample	7.0	3.5	0.0	3.0	8.3	3.6	2.8
Separator Bottoms to CAS	1625.2	1760.5	1525.7	1361.0	1307.4	1565.2	1205.5
Total Asoh	8.6	4.9	6.0	3.5	4.9	7.3	6.0
CAS Bottoms to Pressure Filter	1605.5	1798.4	1509.4	1326.8	1329.8	1536.8	1194.6
Total Filter Cake	168.6	263.3	208.0	178.2	171.5	164.1	112.9
Total Filter Liquid	1436.9	1535.0	1301.4	1148.6	1158.2	1372.8	1081.7
--NET ADJ. PRODUCTS, W% DRY Total Feed -----							
Total CO + CO2	2.29	2.27	1.89	2.32	1.79	1.16	1.33
Total C1-C3	7.02	8.32	6.14	7.06	7.91	6.94	6.13
Total C4-C7	3.57	3.63	2.75	2.90	3.81	4.99	3.94
SOH TOTAL H2O	30.12	32.27	29.80	32.47	31.38	25.72	26.48
SOH NET WATER	7.07	9.11	8.82	14.00	8.92	5.85	2.11
SOH Distillate Oil	38.07	34.26	34.14	38.12	37.01	38.87	39.14
Asoh + KO	0.50	0.28	0.31	0.20	0.28	0.34	0.31
Pfl	49.43	49.16	36.34	34.14	31.99	34.88	16.00
Pfs	9.81	14.81	10.78	10.50	9.53	7.85	5.84
CAS Bottoms	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reactor 1 Liquid Sample	0.40	0.20	0.00	0.17	0.47	0.17	0.15

od number	22T	23T	24T	25T	26T	27T	28T
) GAS (STAGE I VENT GAS), V%							

	92.14	83.68	91.05	90.86	91.17	88.25	91.72
	1.20	2.89	1.38	1.53	1.83	1.24	1.22
I4	0.03	0.00	0.03	0.04	0.04	0.05	0.05
I6	0.58	1.21	0.70	0.68	0.75	0.89	0.61
I6	0.08	0.00	0.08	0.07	0.09	0.19	0.12
I8	0.41	0.64	0.49	0.45	0.52	0.80	0.50
I8	0.09	0.00	0.08	0.06	0.10	0.21	0.13
4H10	0.20	0.37	0.23	0.20	0.23	0.35	0.21
4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
I10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5H12	0.10	0.14	0.12	0.09	0.13	0.24	0.17
5H12	0.09	0.10	0.08	0.07	0.08	0.11	0.07
HYL-CYCLOPENTANE	0.01	0.00	0.01	0.01	0.00	0.00	0.03
LOHEXANE	0.04	0.01	0.01	0.02	0.00	0.01	0.00
6H14	0.01	0.03	0.02	0.01	0.03	0.05	0.02
3-METHYLPENTANE	0.01	0.02	0.02	0.02	0.05	0.21	0.10
C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.36	0.10	0.36	0.38	0.43	0.27	0.32
	0.66	0.10	0.64	0.72	0.47	0.39	0.37
	3.12	5.17	3.14	2.59	2.82	5.83	2.70
ROGEN	0.82	5.51	1.53	1.77	1.12	0.87	1.15
GEN	0.05	0.03	0.03	0.43	0.14	0.04	0.51
GAS (STAGE II VENT GAS), V%							

	84.58	90.96	85.45	84.92	81.89	81.76	85.57
	2.71	1.54	2.48	2.57	2.84	2.61	2.20
I4	0.00	0.04	0.00	0.00	0.00	0.00	0.00
I6	1.21	0.73	1.09	1.15	1.29	1.25	1.02
I6	0.00	0.08	0.00	0.00	0.00	0.00	0.00
I8	0.79	0.45	0.79	0.84	0.94	0.97	0.84
I8	0.00	0.08	0.00	0.00	0.00	0.00	0.00
4H10	0.41	0.22	0.35	0.36	0.45	0.46	0.35
4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
I10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5H12	0.14	0.11	0.12	0.13	0.18	0.20	0.17
5H12	0.11	0.09	0.09	0.11	0.11	0.11	0.09
HYL-CYCLOPENTANE	0.02	0.01	0.00	0.00	0.00	0.00	0.00
LOHEXANE	0.00	0.01	0.00	0.01	0.03	0.01	0.04
6H14	0.02	0.03	0.01	0.02	0.03	0.05	0.03
3-METHYLPENTANE	0.03	0.03	0.01	0.00	0.05	0.10	0.11
C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.06	0.47	0.07	0.08	0.06	0.07	0.07
	0.07	1.06	0.05	0.06	0.07	0.06	0.06
	5.49	3.02	4.85	4.96	5.45	5.41	4.89
ROGEN	4.31	1.02	4.61	4.16	6.33	6.84	4.47
GEN	0.05	0.05	0.03	0.63	0.28	0.10	0.09

RUN 227-90 (POC PB-01) MATERIAL BALANCE

Coal-Waste Coprocessing using Dispersed Slurry Fe/Mo Catalysts

FEED: BLACK THUNDER MINE: POC-02 COAL (HRI-6213)
Hondo VTB Oil and Waste Plastics
CATALYSTS: HTI'S Fe (5000 ppm to K-2) + MOLYVAN-A (50 ppm to K-1)

od Number	29T	30T	31T	32T	33T	34T	35T
(Start of Period)	10/21/95	10/22/95	10/28/95	10/29/95	10/30/95	10/31/95	11/01/95
tion, hrs	24.	24.	24.	24.	24.	24.	24.
s of Run (End of Period)	696.	720.	744.	768.	792.	816.	840.
TS, GRAMS							
Total Feed	55084.0	48466.0	31226.0	53614.0	51324.0	51324.0	49873.0
Makeup Oil to Charge (L-814/extracted oil)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Makeup Oil to Buffer (L-814/extracted oil)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl Recycled to Charge+K-2 Cat Addition	14176.0	12766.0	39430.0	15799.0	13536.0	13536.0	13289.0
CAS Btms Recycled to Charge	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filter Cake Recycled to Charge	0.0	0.0	0.0	0.0	0.0	0.0	2280.0
Pfl to Stage 1 Buffer	859.0	800.0	1569.0	790.0	782.0	704.0	725.0
Pfl to Stage 2 Buffer	796.0	929.0	2018.0	820.0	874.0	872.0	803.0
Water to Hot Separators	9845.0	9611.0	10889.0	10425.0	10597.0	10002.0	10410.0
Total Sulfur Added	2592.0	2592.0	2586.0	2592.0	2588.0	2588.0	2592.0
Additive (Fe+Mo Catalysts)	1595.0	1217.0	1268.0	1410.0	1288.0	1288.0	1401.0
H2 to 1st Stage	4632.0	4632.0	4646.3	4648.0	4648.4	4648.1	4648.2
H2 to 2nd Stage	2602.1	2601.2	2619.0	2619.2	2620.1	2619.9	2620.0
Hydrogen Bleed	695.7	695.8	696.5	696.5	696.5	696.5	696.5
TOTAL GRAMS IN	92876.8	84310.1	96947.8	93413.6	88954.1	88278.5	89337.8
UTS, GRAMS							
Hydrogen Out	6481.4	6544.4	6736.9	6292.5	6072.7	6050.4	6248.7
Total Gas Product (N2,H2 Free)	9908.7	8305.9	12439.4	9297.9	11291.1	11430.8	10891.7
Unit Knockouts	329.0	227.0	175.0	170.0	116.0	226.0	26.0
Separator Overhead (HTU) Product	30976.0	31445.0	25181.0	28504.0	29204.0	31308.0	32785.0
Atmospheric Overhead Product (Sample)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CAS Bottoms	41863.0	36695.0	46037.0	40588.0	36478.0	36044.0	34799.0
Feed + Interstage Slurry Sample	68.0	61.0	65.0	184.0	70.0	97.0	63.0
TOTAL GRAMS OUT	89626.1	83278.4	90634.3	85036.4	83231.8	85156.1	84813.4
% Total Material Recovery (Gross)	96.50	98.78	93.49	91.03	93.57	96.46	94.94

iod Number	29T	30T	31T	32T	33T	34T	35T
--CHARGE, PRODUCT, AND RECYCLE RATES-----							
EED RATES, GRAMS/HOUR							
Total Carbonaceous Feed	2295.2	2019.4	1301.1	2233.9	2138.5	2138.5	2078.0
Dry Carbonaceous Feed	2218.3	1951.8	1257.5	2159.1	2066.9	2066.9	2008.4
Total Makeup Oil Rate	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water to Hot Separator	410.2	400.5	453.7	434.4	441.5	416.8	433.8
H2 to 1st Stage	193.0	193.0	193.6	193.7	193.7	193.7	193.7
H2 to 2nd Stage	108.4	108.4	109.1	109.1	109.2	109.2	109.2
ECYCLE RATES TO REACTOR, GRAMS/HOUR							
PFL Recycled to Slurry + Pretreater Buffer	590.7	531.9	1642.9	658.3	564.0	564.0	553.7
CAS Bottoms Recycled	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pfl to 1st Stage Buffer	35.8	33.3	65.4	32.9	32.6	29.3	30.2
Pfl to 2nd Stage Buffer	33.2	38.7	84.1	34.2	36.4	36.3	33.5
ET COLLECTED PRODUCTS (INCLUDING SAMPLES), GRAMS/HOUR							
Total Gas (incl. N2)	752.2	669.3	897.3	728.0	828.5	805.4	777.8
(N2 free)	682.9	618.8	799.0	649.6	723.5	728.4	714.2
SOH	779.5	800.6	491.4	627.2	681.7	791.6	853.5
SOH-H2O	511.2	509.6	557.8	560.5	535.2	512.9	512.6
SOH-NET WATER	101.0	109.1	104.1	126.1	93.6	96.1	78.8
Knockouts	13.7	9.5	7.3	7.1	4.8	9.4	1.1
Filter Cake	128.4	138.7	59.5	117.4	125.0	125.9	135.0
Filter Liquid	942.0	798.5	64.9	848.4	753.3	716.2	637.1
Asoh + KO	13.7	9.5	7.3	7.1	4.8	9.4	1.1
Total CAS Bottoms	1744.3	1529.0	1918.2	1691.2	1519.9	1501.8	1450.0
Reactor 1 Liquid Sample	2.8	2.5	2.7	7.7	2.9	4.0	2.6
Separator Bottoms to CAS	1744.3	1529.0	1918.2	1691.2	1519.9	1501.8	1450.0
Total Asoh	13.7	9.5	7.3	7.1	4.8	9.4	1.1
CAS Bottoms to Pressure Filter	1730.0	1541.2	1916.8	1691.2	1511.3	1471.8	1389.5
Total Filter Cake	128.4	138.7	59.5	117.4	125.0	125.9	135.0
Total Filter Liquid	1601.6	1402.5	1857.3	1573.8	1386.3	1345.9	1254.5
--NET ADJ. PRODUCTS, W% DRY Total Feed -----							
Total CO + CO2	1.01	1.15	2.75	1.08	1.29	1.24	1.06
Total C1-C3	5.51	5.24	14.52	6.31	7.42	7.27	6.82
Total C4-C7	3.28	2.85	5.92	2.72	4.48	4.21	4.26
SOH TOTAL H2O	23.05	26.11	44.36	25.96	25.89	24.81	25.52
SOH NET WATER	4.55	12.00	8.28	5.84	4.53	12.00	3.93
SOH Distillate Oil	35.14	41.02	39.08	29.05	32.98	38.30	42.49
Asoh + KO	0.62	0.48	0.58	0.33	0.23	0.46	0.05
Pfl	43.06	40.34	5.27	39.29	36.83	35.98	34.44
Pfs	5.84	7.05	4.74	5.44	6.08	6.22	2.29
CAS Bottoms	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reactor 1 Liquid Sample	0.13	0.13	0.22	0.36	0.14	0.20	0.13

iod number	29T	30T	31T	32T	33T	34T	35T
D GAS (STAGE I VENT GAS), V%							

	91.16	92.77	89.89	91.08	89.53	88.69	90.00
4	1.58	1.23	2.40	1.80	1.93	1.89	1.65
H4	0.04	0.04	0.04	0.03	0.05	0.05	0.05
H6	0.68	0.53	0.81	0.69	0.94	0.97	0.81
H6	0.11	0.09	0.10	0.09	0.14	0.15	0.14
H8	0.51	0.38	0.65	0.59	0.93	0.98	0.78
H8	0.12	0.09	0.10	0.09	0.15	0.16	0.15
C4H10	0.22	0.15	0.29	0.21	0.34	0.37	0.31
C4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5H12	0.17	0.13	0.11	0.11	0.19	0.20	0.18
C5H12	0.11	0.05	0.12	0.06	0.12	0.13	0.09
THYL-CYCLOPENTANE	0.00	0.02	0.00	0.00	0.00	0.00	0.00
CLOHEXANE	0.03	0.00	0.01	0.01	0.03	0.02	0.01
C6H14	0.01	0.01	0.01	0.01	0.02	0.03	0.02
+ 3-METHYLPENTANE	0.07	0.06	0.02	0.04	0.10	0.11	0.08
-C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.31	0.30	0.24	0.30	0.33	0.32	0.36
2	0.31	0.31	0.59	0.36	0.44	0.41	0.28
S	3.04	2.28	3.06	2.94	3.79	4.22	3.85
TROGEN	1.49	1.12	1.51	1.51	0.90	1.25	1.19
YGEN	0.04	0.44	0.05	0.08	0.07	0.06	0.05
S GAS (STAGE II VENT GAS), V%							

	85.98	87.32	81.32	85.38	83.53	85.32	86.01
4	2.04	1.91	3.72	2.44	2.07	1.97	1.86
H4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H6	0.91	0.84	1.18	1.05	0.98	0.90	0.89
H6	0.00	0.00	0.00	0.00	0.01	0.00	0.00
H8	0.75	0.70	1.03	0.98	0.95	0.85	0.89
H8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C4H10	0.33	0.29	0.43	0.40	0.41	0.37	0.41
C4H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C5H12	0.17	0.16	0.14	0.16	0.22	0.19	0.25
C5H12	0.08	0.08	0.11	0.10	0.10	0.10	0.11
THYL-CYCLOPENTANE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CLOHEXANE	0.04	0.01	0.03	0.02	0.05	0.02	0.01
C6H14	0.02	0.01	0.05	0.01	0.05	0.02	0.04
- 3-METHYLPENTANE	0.06	0.07	0.03	0.05	0.12	0.05	0.11
-C7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.05	0.05	0.06	0.04	0.05	0.05	0.05
2	0.04	0.05	0.04	0.03	0.02	0.03	0.02
S	5.07	4.87	5.91	4.15	4.46	4.66	4.83
TROGEN	4.42	3.54	5.90	5.15	6.94	5.39	4.41
YGEN	0.04	0.10	0.05	0.04	0.04	0.08	0.11

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RUN 227-90 (POC PB-01) MATERIAL BALANCE

Coal-Waste Coprocessing using Dispersed Slurry Fe/Mo Catalysts

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FEED: BLACK THUNDER MINE: POC-02 COAL (HRI-6213)
Hondo VTB Oil and Waste Plastics
CATALYSTS: HTI'S Fe (5000 ppm to K-2) + MOLYVAN-A (50 ppm to K-1)

od Number	36T	37T	38T	39T	40T	41T
(Start of Period)	11/02/95	11/03/95	11/04/95	11/05/95	11/06/95	11/07/95
tion, hrs	24.	24.	24.	24.	24.	24.
s of Run (End of Period)	864.	888.	912.	936.	960.	984.
TS, GRAMS						
Total Feed	50828.0	53938.0	50763.0	51940.0	55827.0	59950.0
Makeup Oil to Charge (L-814/extracted oil)	0.0	0.0	0.0	0.0	0.0	0.0
Makeup Oil to Buffer (L-814/extracted oil)	0.0	0.0	0.0	0.0	0.0	0.0
Pfl Recycled to Charge+K-2 Cat Addition	13452.0	13981.0	13552.0	13646.0	13502.0	15004.0
CAS Btms Recycled to Charge	0.0	0.0	0.0	0.0	0.0	0.0
Filter Cake Recycled to Charge	2280.0	2185.0	0.0	0.0	0.0	0.0
Pfl to Stage 1 Buffer	659.0	849.0	976.0	1803.0	1600.0	879.0
Pfl to Stage 2 Buffer	874.0	930.0	1079.0	1552.0	1664.0	884.0
Water to Hot Separators	9769.0	10246.0	10042.0	10141.0	9783.0	9976.0
Total Sulfur Added	2590.0	2592.0	2590.0	2590.0	2590.0	2592.0
Additive (Fe+Mo Catalysts)	1307.0	1620.0	1301.0	1215.0	1410.0	1516.0
H2 to 1st Stage	4647.8	4648.1	4646.4	4648.8	4648.7	4648.0
H2 to 2nd Stage	2619.8	2620.0	2620.1	2620.0	2612.0	2620.3
Hydrogen Bleed	696.5	696.5	696.5	696.5	696.5	696.5
TOTAL GRAMS IN	89723.1	94305.5	88266.0	90852.4	94333.2	98765.8
UTS, GRAMS						
Hydrogen Out	6269.4	6366.2	6318.8	6561.6	6513.4	6784.9
Total Gas Product (N2,H2 Free)	11135.4	9374.3	10381.3	11797.6	12301.4	9052.3
Unit Knockouts	136.0	116.0	86.0	262.0	695.0	450.0
Separator Overhead (HTU) Product	31054.0	30147.0	30200.0	29962.0	31069.0	29800.0
Atmospheric Overhead Product (Sample)	0.0	0.0	0.0	0.0	0.0	0.0
CAS Bottoms	35890.0	41632.0	40320.0	40203.0	41921.0	46815.0
Feed + Interstage Slurry Sample	83.0	60.0	172.0	83.0	117.0	83.0
TOTAL GRAMS OUT	84567.8	87695.5	87478.0	88869.2	92616.8	92985.2
% Total Material Recovery (Gross)	94.25	92.99	99.11	97.82	98.18	94.15

od Number	36T	37T	38T	39T	40T	41T
-CHARGE, PRODUCT, AND RECYCLE RATES-----						
ED RATES, GRAMS/HOUR						
Total Carbonaceous Feed	2117.8	2247.4	2115.1	2164.2	2326.1	2497.9
Dry Carbonaceous Feed	2046.9	2172.1	2115.1	2164.2	2326.1	2497.9
Total Makeup Oil Rate	0.0	0.0	0.0	0.0	0.0	0.0
Water to Hot Separator	407.0	426.9	418.4	422.5	407.6	415.7
H2 to 1st Stage	193.7	193.7	193.6	193.7	193.7	193.7
H2 to 2nd Stage	109.2	109.2	109.2	109.2	108.8	109.2
CYCLE RATES TO REACTOR, GRAMS/HOUR						
PFL Recycled to Slurry + Pretreater Buffer	560.5	582.5	564.7	568.6	562.6	625.2
CAS Bottoms Recycled	0.0	0.0	0.0	0.0	0.0	0.0
Pfl to 1st Stage Buffer	27.5	35.4	40.7	75.1	66.7	36.6
Pfl to 2nd Stage Buffer	36.4	38.8	45.0	64.7	69.3	36.8
T COLLECTED PRODUCTS (INCLUDING SAMPLES), GRAMS/HOUR						
Total Gas (incl. N2)	814.5	744.4	762.6	780.2	859.7	721.0
(N2 free)	725.2	655.9	695.8	765.0	784.0	659.9
SOH	797.9	740.4	779.4	768.0	846.5	791.3
SOH-H2O	496.0	515.7	479.0	480.4	448.1	450.3
SOH-NET WATER	89.0	88.8	60.5	57.8	40.5	34.7
Knockouts	5.7	4.8	3.6	10.9	29.0	18.8
Filter Cake	170.4	270.2	200.6	116.7	8.3	8.3
Filter Liquid	724.3	769.4	802.9	850.1	1039.8	1243.7
Asoh + KO	5.7	4.8	3.6	10.9	29.0	18.8
Total CAS Bottoms	1495.4	1734.7	1680.0	1675.1	1746.7	1950.6
Reactor 1 Liquid Sample	3.5	2.5	7.2	3.5	4.9	3.5
Separator Bottoms to CAS	1495.4	1734.7	1680.0	1675.1	1746.7	1950.6
Total Asoh	5.7	4.8	3.6	10.9	29.0	18.8
CAS Bottoms to Pressure Filter	1519.0	1696.3	1653.8	1675.1	1746.7	1950.6
Total Filter Cake	170.4	270.2	200.6	116.7	8.3	8.3
Total Filter Liquid	1348.6	1426.0	1453.2	1558.5	1738.4	1942.3
-NET ADJ. PRODUCTS, W% DRY Total Feed -----						
Total CO + CO2	1.05	1.01	0.68	0.33	0.14	0.10
Total C1-C3	6.27	5.34	6.01	5.95	5.85	4.03
Total C4-C7	4.28	3.31	3.44	4.60	5.13	3.07
SOH TOTAL H2O	24.23	23.74	22.64	22.20	19.26	18.03
SOH NET WATER	4.35	12.00	2.86	2.67	1.74	5.00
SOH Distillate Oil	38.98	34.09	36.85	35.49	36.39	31.68
Asoh + KO	0.28	0.22	0.17	0.50	1.24	0.75
Pfl	34.36	36.91	39.05	39.28	44.70	49.79
Pfs	3.55	8.53	9.63	5.39	0.36	0.33
CAS Bottoms	0.00	0.00	0.00	0.00	0.00	0.00
Reactor 1 Liquid Sample	0.17	0.12	0.34	0.16	0.21	0.14

od number	36T	37T	38T	39T	40T	41T
GAS (STAGE I VENT GAS), V%						

	89.98	92.40	90.19	88.82	91.89	94.18
	1.45	1.36	1.39	1.08	1.16	1.07
4	0.05	0.05	0.05	0.06	0.05	0.03
6	0.76	0.59	0.72	0.79	0.59	0.42
6	0.16	0.10	0.18	0.30	0.15	0.10
8	0.73	0.47	0.72	1.02	0.59	0.32
8	0.17	0.09	0.17	0.34	0.19	0.10
4H10	0.31	0.17	0.26	0.40	0.23	0.13
4H10	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00
5H12	0.20	0.12	0.16	0.28	0.18	0.13
5H12	0.10	0.06	0.07	0.12	0.10	0.06
HYL-CYCLOPENTANE	0.00	0.00	0.00	0.02	0.01	0.00
LOHEXANE	0.01	0.01	0.01	0.00	0.01	0.02
6H14	0.02	0.01	0.01	0.02	0.02	0.01
3-METHYLPENTANE	0.05	0.03	0.08	0.11	0.08	0.05
C7	0.00	0.00	0.00	0.00	0.00	0.00
	0.35	0.37	0.26	0.09	0.08	0.06
	0.28	0.26	0.17	0.06	0.02	0.02
	4.40	2.72	3.91	6.35	3.60	2.37
ROGEN	0.95	1.14	1.53	0.12	0.93	0.86
GEN	0.03	0.05	0.12	0.02	0.12	0.07
GAS (STAGE II VENT GAS), V%						

	85.09	83.79	86.29	92.53	81.43	85.46
	1.73	1.91	1.70	1.18	2.09	1.74
4	0.00	0.00	0.00	0.04	0.00	0.00
6	0.83	0.92	0.83	0.52	1.08	0.81
6	0.00	0.01	0.01	0.14	0.01	0.00
8	0.81	0.90	0.82	0.48	1.21	0.88
8	0.00	0.00	0.00	0.15	0.01	0.00
4H10	0.38	0.38	0.34	0.16	0.61	0.40
4H10	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00
5H12	0.25	0.22	0.18	0.14	0.50	0.31
5H12	0.13	0.12	0.09	0.07	0.23	0.16
HYL-CYCLOPENTANE	0.00	0.00	0.00	0.00	0.01	0.00
LOHEXANE	0.02	0.23	0.03	0.00	0.01	0.02
6H14	0.04	0.02	0.02	0.01	0.07	0.03
3-METHYLPENTANE	0.12	0.08	0.06	0.05	0.23	0.16
C7	0.00	0.00	0.00	0.00	0.00	0.00
	0.05	0.07	0.04	0.09	0.00	0.00
	0.03	0.04	0.02	0.04	0.01	0.00
	4.74	4.99	5.07	2.90	6.98	5.98
ROGEN	5.74	6.15	4.43	1.38	5.34	3.97
GEN	0.04	0.17	0.07	0.12	0.18	0.08