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UPGRADING OF COAL LIQUIDS

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for
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ABSTRACT

Series flow hydrocracking of high nitrogen-containing Exxon Donor Solvent (EDS) process liquid to gasoline was continued at base pressure. Studies were carried out at two additional sets of conditions.

Each of the two liquid products obtained from hydrocracking hydrotreated EDS liquid product to fuel oil has been fractionated to give a naphtha fraction and a fuel oil fraction. Routine inspections on these fuel oils and naphthas have been obtained.

Fluid catalytic cracking of two EDS derived distillate feeds was carried out over a commercial zeolite catalyst. Two sets of conditions were employed for each feedstock.

The EDS hydrocrackate naphtha from the first series flow hydrocracking run was reformed over a commercial Platforming® catalyst. Studies were conducted over a series of conditions for the purpose of obtaining data for a yield octane curve.

Task 1

Work Accomplished

Series flow hydrocracking of a high nitrogen-containing EDS derived liquid to gasoline was continued in Plant 601. The feedstock was a blend of hydrotreated EDS liquid products from Plant 638H, Runs 20 and 21A. Table 1 gives the inspections of this charge stock.

Series flow hydrocracking was carried out over UOP-DCB (Reactor 1) and UOP-HCA (Reactor 2) catalysts (see Table 13, FE-2566-07). The fractionator was operated at maximum gasoline yield mode with 375°F$^+$ fractionator bottoms

recycled back to the first reactor. Operating procedure was described in the preceding report (FE-2566-18).

The first run (Run 777), started in late July (described in FE-2566-18), was completed during early August. Figures 1 and 2 are summaries of reactor temperatures required to attain 100% conversion of feedstock to 375°F⁻ distillate at 500 psig above base pressure and two space velocities. These data illustrate that the series flow system was reasonably stable during the 19 days on stream.

The second series flow hydrocracking run (Run 778) was started at base pressure, base fresh feed space velocity, and 1.18 X base combined feed ratio (CFR). Data show that 100% conversion was first attained when the temperature in the second reactor reached base temperature with the first reactor at about 10°C below base (Figures 3 and 4). At 307 hours on stream the fresh feed space velocity was reduced from base to 0.5 X base space velocity at otherwise identical pressure and CFR. Figure 4 shows that 100% conversion to 375°F⁻ distillate was again attained when the second reactor reached a temperature of 10°C below base with the first reactor at near-base temperature. The run was terminated after about 21 days on stream. Data again show that reasonable stability was maintained at base pressure.

Table 2 gives the inspections of the hydrocrackate obtained from the hydrocracking of hydrotreated EDS Liquid Product 3532-8 to fuel oil at 500 psig above base (Plant 638H, Run 23A). Table 3 is a summary of an overall material balance made for the purpose of obtaining product distribution and hydrogen consumption data. This hydrocrackate was fractionated (Table 4) to obtain both a fuel oil fraction and a naphtha fraction. These naphthas and fuel

oils have been analyzed. Results are listed in Tables 5 and 6.

Similarly, the inspections of the hydrocrackate obtained at base pressure (Plant 638H, Run 23B) are shown in Table 7. Table 8 shows the product distribution and hydrogen consumption data obtained for Run 23B. The hydrocrackate was then frationated (Table 9). Tables 10 and 11 show the inspections of the naphtha and the fuel oil.

Task 1

Work Forecast

Series flow hydrocracking of high nitrogen EDS liquid will continue into September. Studies will be conducted at two additional sets of conditions. These studies should be completed by late September.

Task 2

Work Accomplished

Fluid catalytic cracking of two EDS distillate feeds was carried out over a commercial zeolite catalyst in Plant 593 (Runs 272 and 273). One feed was a rerun EDS liquid product (Table 12), and the other was the Hydrotreated EDS Liquid Product 3532-15 (Table 13). The hydrogen contents of these feedstocks are 8.97 and 10.87 wt-%, respectively.

Preliminary results are summarized as follows:

Feed Hydrogen Content, Wt-%	8.97		10.87	
T-T (base), °C	3	30	3	30
Catalyst/Oil	7.2	9.5	7.1	9.8
Catalyst/Oil (base)				
Conversion, Wt-%	43.3	47.7	68.6	72.4

Task 2

Work Forecast

Fluid catalytic cracking of EDS derived distillate feedstocks over a second FCC catalyst will be started in September. These studies should be completed in October.

Task 3

Work Accomplished

The liquid products from the first series flow hydrocracking run on EDS distillate feed (Plant 601, Run 777) were blended to provide a Platformer feedstock. Inspections of this hydrocracked naphtha (designated as EDS Hydrocrackate 3532-23) are given in Table 14.

EDS Hydrocrackate 3532-23 was reformed over a commercial Platforming catalyst in a bench scale continuous unit (Plant 636). Data were obtained at base pressure, 1.5 X base space velocity, and a range of temperaturess for the purpose of constructing a yield octane curve. Since gas data show very little hydrocracking to C_1-C_4, yields are relatively high. Analyses on these products are in progress.

Task 3

Work Forecast

Platforming of a second hydrocracked EDS naphtha from series flow hydrocracking operation will be carried out in early October (Figure 5) when sufficient amount of feedstock is available.

Table 1

Inspections of Hydrotreated EDS Liquid Product 3532-9

Sample No.	3532-9
°API @ 60°F	17.1
Sp.Gr. @ 60°F	0.9522
Distillation, ASTM D-1160	
IBP, °F	566
5%	410
10%	431
20%	457
30%	480
40%	509
50%	548
60%	586
70%	635
80%	700
90%	797
95%	849
EP	925
% Over	99.0
% Bottoms	1.0
Hydrogen, Wt-%	10.85
Carbon, Wt-%	88.58
Sulfur, Wt-ppm	266.8
Nitrogen, Wt-ppm	844.0
Oxygen, Wt-ppm	2982
Molecular Weight	238
FIA, Vol-%	
A	71.2
O	0.0
P&N	28.8

Table 2

Inspection of EDS Hydrocrackate 3532-17

Sample No.	3532-17
°API @ 60°F	44.4
Sp. Gr. @ 60°F	0.8044
Distillation, ASTM D-86	
IBP, °F	161
5%	187
10%	200
20%	222
30%	244
40%	270
50%	302
60%	341
70%	385
80%	432
90%	504
95%	540
EP	560
% Over	99.0
% Bottoms	1.0
Hydrogen, Wt-%	13.39
Carbon, Wt-%	86.03
Sulfur, Wt-ppm	
Nitrogen, Wt-ppm	0.2
Oxygen, Wt-ppm	226

Table 3

Hydrocracking Hydrotreated EDS Liquid Product 3532-8 to Fuel Oil
Product Distribution and Hydrogen Consumption
Plant 638H, Run 23A

Product Distribution, Wt-% of Feed	
C_1	0.0
C_2	0.3
C_3	3.8
C_4	12.7
C_5 (in Plant Gas)	6.8
C_6 (in Plant Gas)	3.6
Liquid Product[(a)]	75.5
H_2O	0.1
H_2S	trace
NH_3	trace
Total	102.8
Hydrogen Consumption, Wt-% of Feed	2.8
Hydrogen Consumption, SCF/bbl	1775

(a) Designated as EDS Hydrocrackate 3532-17.

Table 4

Vacuum Fractionation of EDS Hydrocrackate 3532-17

Cut Number	Boiling Range °F	Volume, ml	Vol-%	Weight, Grams	Wt-%
1[a]	IBP-375°	2160	69.2	1649	65.8
Botts.[b]	375°+	962	30.8	856	34.2
		3122	100.0	2505	100.0

(a) Designated as EDS Hydrocrackate 3532-19.

(b) Designated as EDS Fuel Oil 3532-20.

Table 5

Inspections of EDS Hydrocrackate 3532-19

Sample No.	3532-19
°API @ 60°F	53.6
Sp. Gr. @ 60°F	0.7645
Distillation, ASTM D-86	
IBP, °F	158
5%	171
10%	184
20%	200
30%	214
40%	226
50%	239
60%	254
70%	272
80%	290
90%	319
95%	329
EP	387
% Over	98.5
% Bottoms	1.5
Hydrogen, Wt-%	14.34
Carbon, Wt-%	85.50
Sulfur, Wt-ppm	
Nitrogen, Wt-ppm	
Oxygen, Wt-ppm	
Chloride, Wt-ppm	
FIA, Vol-%	
A	9.9
P&N	90.1
RON, Clear	72.5
Bromine Index	92.0
N_2 Jet Gum mg/100 ml	16

Table 6

Inspections of EDS Fuel Oil 3532-20

Sample No.	3532-20
°API @ 60°F	27.4
Sp. Gr. @ 60°F	0.8905
Distillation, ASTM D-86	
IBP, °F	397
5%	408
10%	416
20%	423
30%	430
40%	439
50%	450
60%	464
70%	486
80%	512
90%	539
95%	560
EP	585
% Over	99.0
% Bottoms	1.0
Hydrogen, Wt-%	12.17
Carbon, Wt-%	86.93
Sulfur, Wt-ppm	
Nitrogen, Wt-ppm	
Oxygen, Wt-ppm	
Viscosity, 100°F	
cSt	2.278
SUS	33.6

Table 7

Inspections of EDS Hydrocrackate 3532-18

Sample No.	3532-18
°API @ 60°F	45.8
Sp. Gr. @ 60°F	0.7981
Distillation, ASTM D-86	
IBP, °F	164
5%	184
10%	196
20%	215
30%	234
40%	256
50%	282
60%	317
70%	360
80%	407
90%	474
95%	514
EP	540
% Over	98.5
% Bottoms	1.5
Hydrogen, Wt-%	13.34
Carbon, Wt-%	86.72
Sulfur, Wt-ppm	
Nitrogen, Wt-ppm	0.2
Oxygen, Wt-ppm	197

Table 8

Hydrocracking Hydrotreated EDS Liquid Product 3532-8 to Fuel Oil
Product Distribution and Hydrogen Consumption
Plant 638H, Run 23B

Product Distribution, Wt-% of Feed	
C_1	0.0
C_2	0.4
C_3	3.9
C_4	11.5
C_5 (in Plant Gas)	8.3
C_6 (in Plant Gas)	2.0
Liquid Product[(a)]	76.6
H_2O	0.1
H_2S	trace
NH_3	trace
Total	102.8
Hydrogen Consumption, Wt-% of Feed	2.8
Hydrogen Consumption, SCF/bbl	1775

(a) Designated as EDS Hydrocrackate 3532-18.

Table 9

Vacuum Fractionation of EDS Hydrocrackate 3532-18

Cut Number	Boiling Range, °F	Volume, ml	Vol-%	Weight, Grams	Wt-%
1 (a)	IBP-375°	2775	74.5	2119	71.5
Botts. (b)	375°+	950	25.5	843	28.5
		3725	100.0	2962	100.0

(a) Designated as EDS Hydrocrackate 3537-21.

(b) Designated as EDS Fuel Oil 3537-22.

Table 10

Inspections of EDS Hydrocrackate 3532-21

Sample No.	3532-21
°API @ 60°F	53.5
Sp. Gr. @ 60°F	0.7649
Distillation, ASTM D-86	
IBP, °F	154
5%	175
10%	185
20%	202
30%	214
40%	225
50%	239
60%	260
70%	278
80%	301
90%	325
95%	344
EP	365
% Over	98.5
% Bottoms	1.5
Hydrogen, Wt-%	14.20
Carbon, Wt-%	85.84
Sulfur, Wt-ppm	
Nitrogen, Wt-ppm	
Oxygen, Wt-ppm	
Chloride, Wt-ppm	
FIA, Vol-%	
A	11.6
P&N	88.4
RON, Clear	74.4
Bromine Index	57.0
N_2 Jet Gum, mg/100 ml	10

Table 11

Inspections of EDS Fuel Oil 3532-22

Sample No.	3532-22
°API @ 60°F	27.9
Sp. Gr. @ 60°F	0.8877
Distillation, ASTM D-86	
IBP, °F	400
5%	404
10%	406
20%	411
30%	419
40%	423
50%	433
60%	448
70%	464
80%	503
90%	540
95%	563
EP	583
% Over	98.5
% Bottoms	1.5
Hydrogen, Wt-%	12.20
Carbon, Wt-%	87.93
Sulfur, Wt-ppm	
Nitrogen, Wt-ppm	
Oxygen, Wt-ppm	
Viscosity, 100°F	
cSt	2.060
SUS	32.8

Table 12

Inspections of Rerun EDS Liquid Product 3532-10

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

Table 13

Inspections of Hydrotreated EDS Liquid Product 3532-15

Sample No.	3532-15
°API @ 60°F	21.0
Sp. Gr. @ 60°F	0.9279
Distillation, ASTM D-1160	
IBP, °F	419
5%	449
10%	462
20%	471
30%	487
40%	507
50%	526
60%	555
70%	585
80%	621
90%	676
95%	717
EP	801
% Over	99.0
% Bottoms	1.0
Hydrogen, Wt-%	10.87
Carbon, Wt-%	88.89
Sulfur, Wt-ppm	10.9
Nitrogen, Wt-ppm	
Oxygen, Wt-ppm	367
Con. Carbon, Wt-%	<0.01
Heptane Insolubles, Wt-%	<0.01
Molecular Weight, Average	225
FIA, Vol-%	
A	52.5
O	0.0
P&N	47.5

Table 14

Inspections of EDS Hydrocrackate 3532-23

Sample No.	3532-23
°API @ 60°F	52.3
Sp. Gr. @ 60°F	0.7699
Distillation, ASTM D-86	
IBP, °F	148
5%	170
10%	181
20%	200
30%	215
40%	229
50%	224
60%	260
70%	280
80%	302
90%	324
95%	338
EP	372
% Over	98.5
% Bottoms	1.5
Hydrogen, Wt-%	13.74
Carbon, Wt-%	85.63
Sulfur, Wt-ppm	
Nitrogen, Wt-ppm	
Oxygen, Wt-ppm	
FIA, Vol-%	
A	14.2
P&N	85.8
RON, Clear	75.2
Bromine Index	369
Molecular Weight	102

Figure 1

Temperature vs. Time

Series Flow Hydrocracking of EDS Liquid Product 3532-9 to Gasoline

Plant 601, Run 777, First Reactor

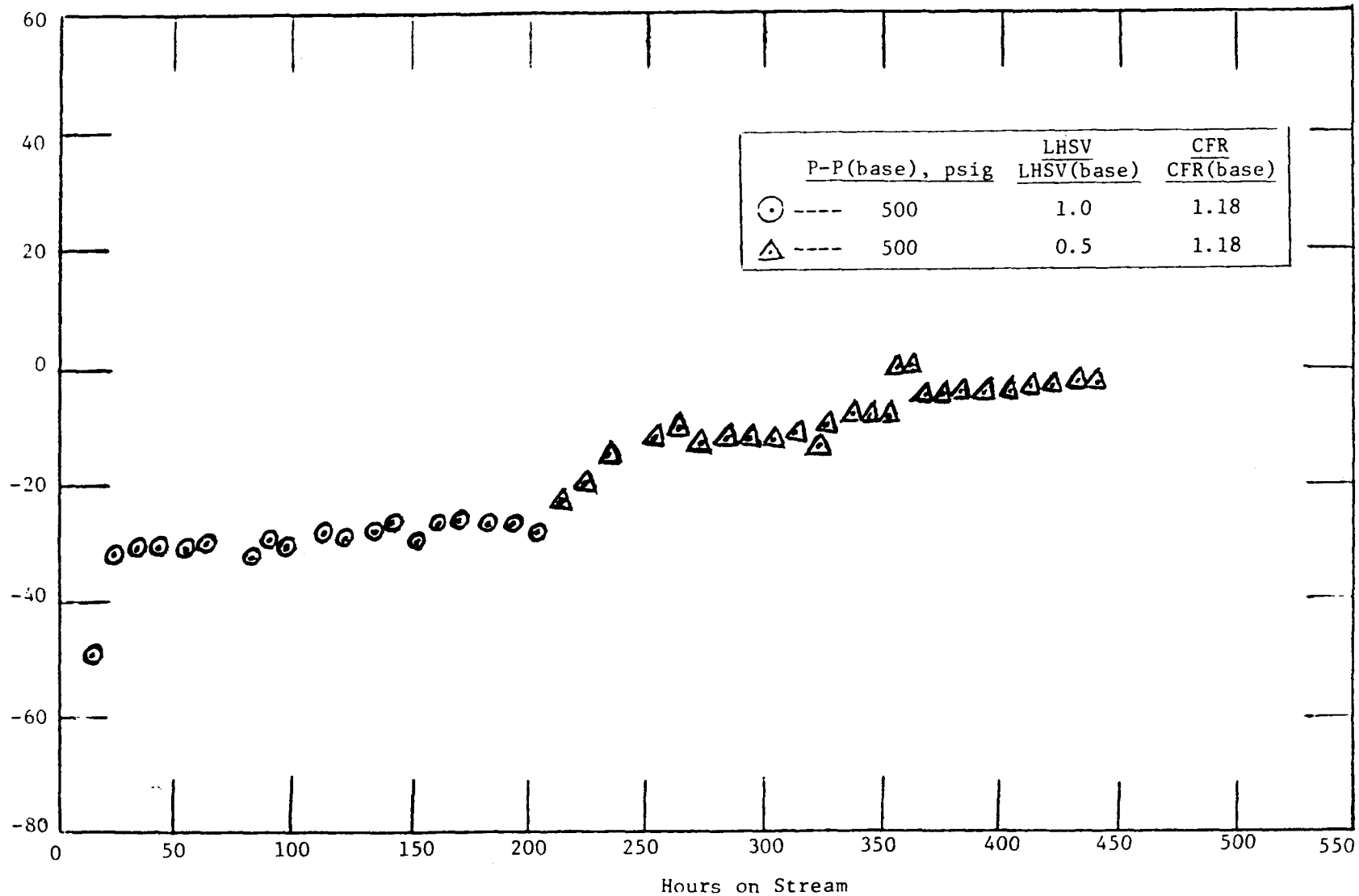


Figure 2

Temperature vs. Time

Series Flow Hydrocracking of EDS Liquid Product 3532-9 to Gasoline

Plant 601, Run 777, Second Reactor

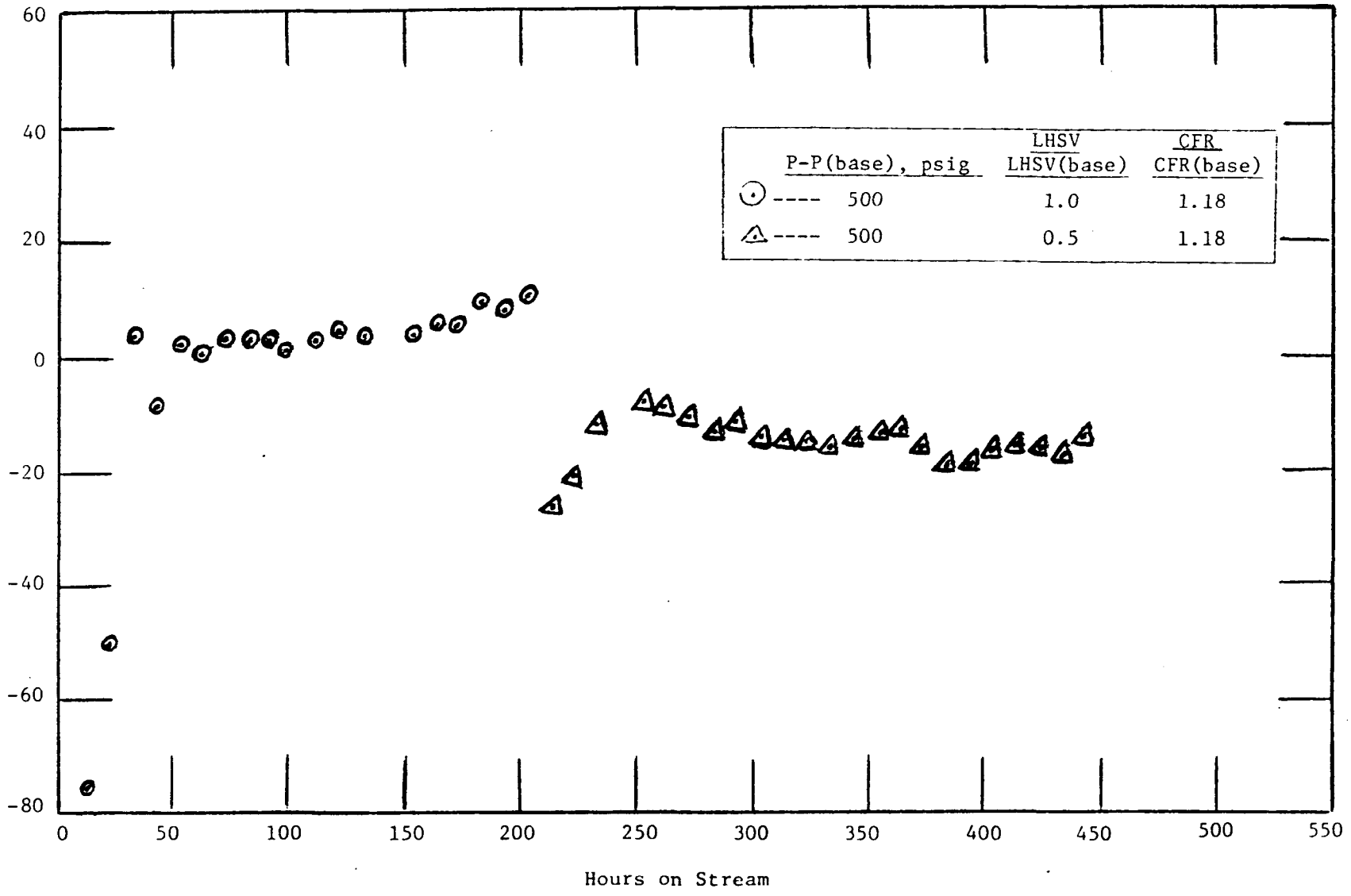


Figure 3

Temperature vs. Time

Series Flow Hydrocracking of EDS Liquid Product 3532-9 to Gasoline

Plant 601, Run 778, First Reactor

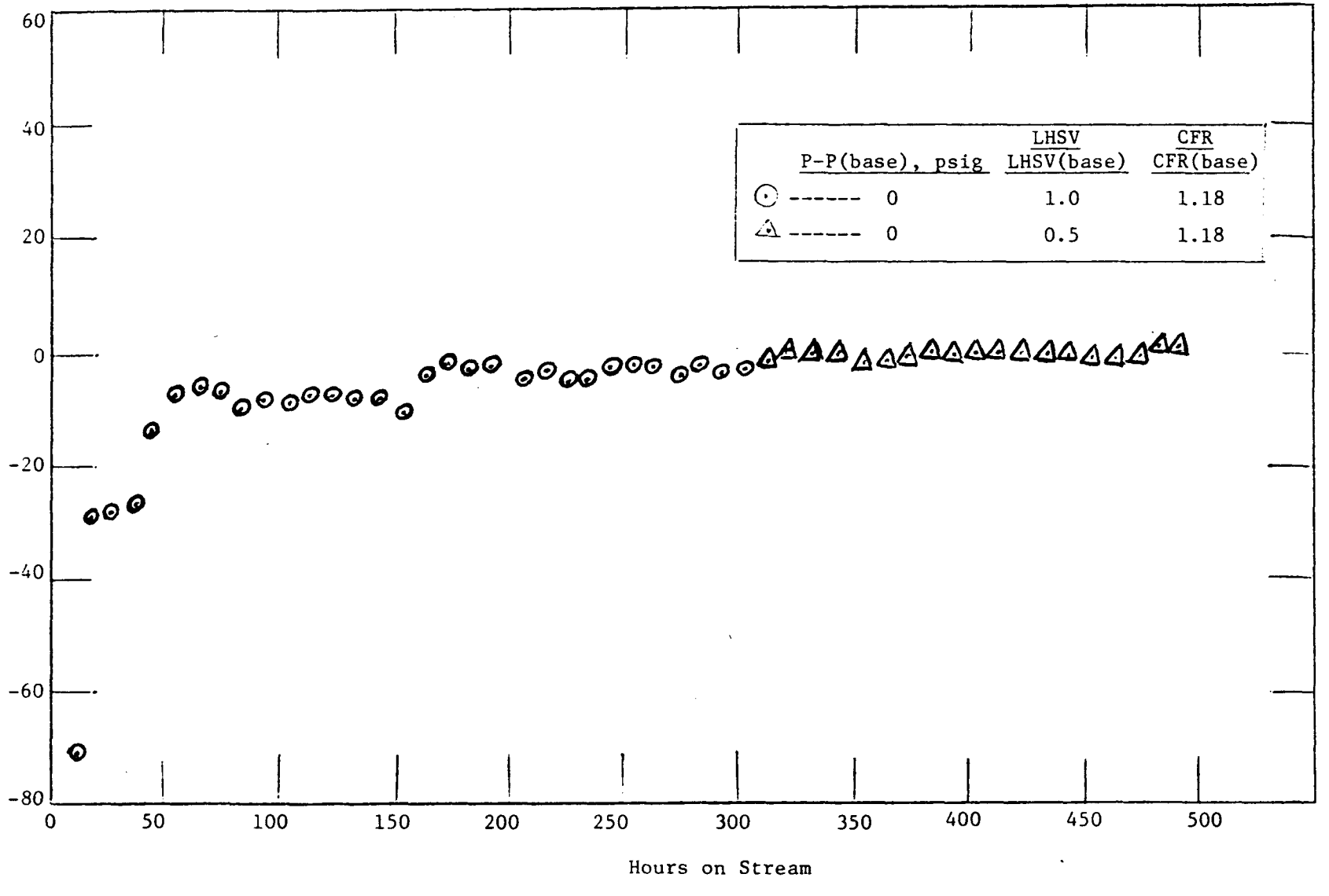
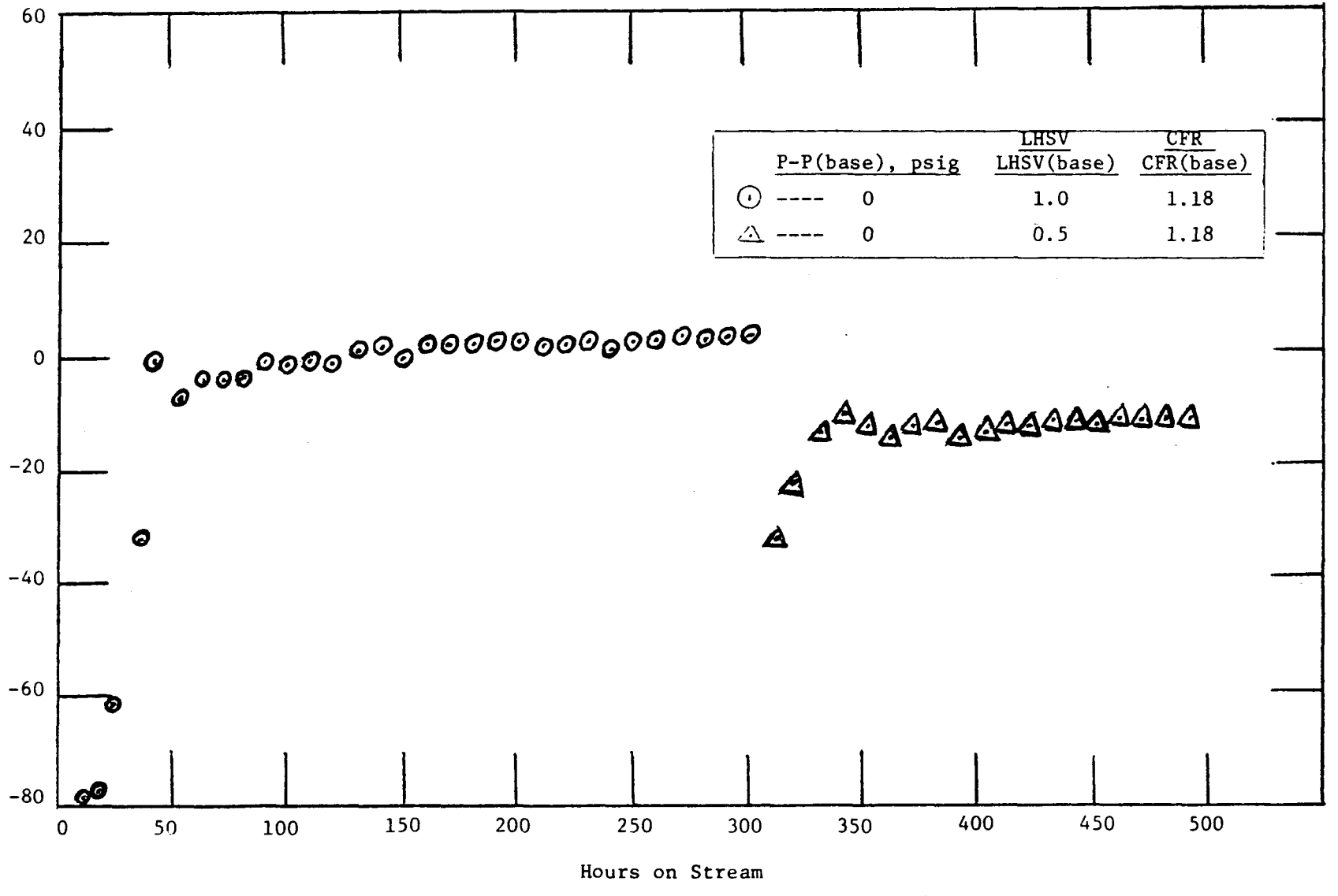


Figure 4

Temperature vs. Time

Series Flow Hydrocracking of EDS Liquid Product 3532-9 to Gasoline

Plant 601, Run 778, Second Reactor



R----Rerunning
U----Unifining

Figure 5
Work Plan and Progress

Legend
H-Coal Liquids
EDS Liquids
Scheduled
Completed