DOE/PC/90057--T11

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THE SELECTIVE CATALYTIC CRACKING OF FISCHER-TROPSCH LIQUIDS TO HIGH VALUE TRANSPORTATION FUELS

REPORT NO. 41

QUARTERLY TECHNICAL STATUS REPORT

FOR

FIRST QUARTER FISCAL YEAR, 1994

(October 1, 1993 - December 31, 1993)

PROJECT MANAGER: R. D. HUGHES

PRINCIPAL INVESTIGATOR: M. M. SCHWARTZ

WORK PERFORMED UNDER CONTRACT NO. DE-AC22-91PC90057

FOR

U.S. DEPARTMENT OF ENERGY
PITTSBURGH ENERGY TECHNOLOGY CENTER
PITTSBURGH, PENNSYLVANIA

BY

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TABLE OF CONTENTS

DISCLAIMER

EXECUTIVE SUMMARY

Amoco Oil Company, under a contract with the United States Department of Energy, is investigating a selective catalytic cracking process to convert the Fischer-Tropsch gasoline and wax fractions to high value transportation fuels. This report describes the work in the First Quarter, Fiscal Year, 1994, the ninth quarter of the two year and six month project. The completion date of this contract was extended (on the basis of no additional cost to DOE) until March 31, 1994.

Task 1, Project Management Plan. The plan has been accepted by the Project Manager DOE/PETC. This report contains the most current and accurate information and projections of the scope of work, schedules, milestones, staffing/manpower plan and costs.

Task 2, Preparation of Feedstocks and Equipment Calibration. The work in this area is complete.

Task 3, Catalytic Cracking Catalyst Screening Program. The work in this area is complete.

Task 4, Pilot Plant Tests. Activities were performed under Task 4 during this reporting period. Characterization of the IBP-430, 430-650, and 650+ °F fractions of the three pilot plant runs that were made in August, 1993 was completed. Sasol wax was the feedstock for those runs. The catalysts used were 10% steamed USY, 10% steamed Beta, and standard equilibrium USY.

The 10% steamed USY catalyst produced naphtha having the lowest molecular weight, lowest density, highest olefin content, and highest octane number of the three catalysts. The standard equilibrium USY catalyst produced naphtha having the highest molecular weight, highest density, lowest olefin content, highest aromatic content, and lowest octane number of the three catalysts.

The 10% steamed Beta catalyst produced light catalytic cycle oil with the highest API gravity and cetane index. It also produced 650+ °F cycle oil with the highest API gravity and lowest weight percent C_A(NMR).

The work in this area is now complete.

Task 5, Preparation of C_5-C_8 Ethers. The work in this area is complete.

Task 6, Evaluation of Gasoline Blending Properties of Ethers and Alcohol Products. The work in this area is complete.

Task 7, Scoping Economic Evaluation of the Proposed Processes. Activities were performed under Task 7 during this reporting period. Task 7 activities were related to a comparison of the economics for using Fischer-Tropsch wax as feedstock for hydrocracking versus catalytic cracking processes. Hydrocracker values are similar to FCC product values for a simple refinery configuration (no Ether Unit). Hydrocracker values are less than FCC product values for a complex refinery configuration (contains Ether Unit). The work in this area is now complete.

BACKGROUND

Fischer-Tropsch (F-T) synthesis technology produces liquid hydrocarbons from synthesis gas (hydrogen and carbon monoxide) derived from the gasification of coal. Domestic supplies of both high- and low- rank coals are extensive and represent a strategic resource to supplement dwindling petroleum reserves. The Fischer-Tropsch technology has been practiced commercially at Sasol in South Africa since the mid-1950's. The F-T liquid product consists of a broad range of normal paraffins (C_5-C_{50}) and a small quantity of oxygenates and olefins. The gasoline range C_5-C_{12} product fraction consists of linear paraffins and olefins of low octane number. The distillate fraction, C_{12}-C_{18}, is an excellent quality fuel. The largest product fraction, C_{18}+, is primarily wax and is useless as a transportation fuel. There are many studies on the upgrading of these F-T liquids. These products are further treated by conventional petroleum processes, such as hydrotreating, reforming and catalytic cracking to produce conventional gasoline and distillate fuels. There are no reported studies of the catalytic cracking processing of F-T liquids to produce C_3-C_8 olefins as feedstocks for the synthesis of gasoline range ethers and alcohols. This is the primary focus of this project.

Fuel oxygenates, particularly alcohols and ethers, represent a potential solution to environmental concerns due to conventional automotive fuels. Governmental regulations, most recently in the Clean Air Act Amendments of November, 1990, have resulted in the phase-out of lead additives, lowering of the Reid vapor pressure of gasoline and in some geographical areas, the mandated use of oxygenates. Recent studies of methyl tertiary butyl ether (MTBE) and tertiary amyl methyl ether (TAME) suggest that these compounds may reduce automotive carbon monoxide emissions, have high blending gasoline octane ratings, R+M/2, (MTBE=108, TAME=102) and have low Reid vapor pressure. These ethers are produced commercially by the etherification of the appropriate olefin by methanol (MTBE, isobutylene; TAME, isoamylenes). These olefins are derived from conventional petroleum processes such as catalytic cracking or steam/thermal reforming.

There is a growing need for alternative sources of olefins for ethers and alcohols syntheses as demand for these materials escalates beyond the

capacity of conventional petroleum processes. This project addresses this requirement for an alternative olefin feedstock for oxygenate synthesis.

PROGRAM OBJECTIVES

The objective of this program is to prepare high-value transportation fuels, including gasoline, distillate, and gasoline range ethers and alcohols from non-petroleum resources. A selective catalytic cracking process of Fischer-Tropsch liquids is proposed. The C_4-C_8 product olefins would then be etherified with methanol to prepare the target ethers. Alcohols will be produced by direct hydration of C_3-C_8 product olefins. The gasoline and distillate products are also expected to be superior to conventional fuels because of the unique combination catalysts to be used in this process.

PROJECT DESCRIPTION

A two year, multi-task program will be used to accomplish the objective to develop a selective catalytic cracking process to produce premium transportation fuels, including ethers and alcohols from Fischer-Tropsch gasoline and wax products.

Task 1. -- Project Management Plan. A plan will be prepared which describes the work to be done, milestones, and manpower and cost requirements.

Task 2. -- Preparation of Feedstocks and Equipment Calibration. Suitable mixtures of Fischer-Tropsch waxes (C_{18}+) and light olefin components (C_5-C_{12}) will be prepared to simulate full range F-T liquids without the premium distillate products. The necessary analytical equipment will be calibrated for the detailed identification of C_4-C_8 olefins and ethers and other paraffin, aromatic and naphthene gasoline range components.

Task 3. -- Catalytic Cracking Catalyst Screening Program. Various zeolite catalysts and process variables will be studied with small scale test equipment.

Task 4. -- Pilot Plant Tests of the Optimized Catalyst and Process. The optimized process will be tested on a pilot plant scale. The target light olefin products, gasoline and distillate products will be produced in sufficient quantities for complete characterization.

Task 5. -- Preparation of C_5-C_8 Ethers and C_3-C_8 Alcohols. These products will be prepared from the pilot plant C_3-C_8 olefin products.

Task 6. -- Evaluation of Gasoline Blending Properties of Ethers and Alcohol Products. The gasoline blending properties of the product ethers and alcohols will be measured. The properties of the distillate products will also be evaluated.

Task 7. -- Scoping Economic Evaluation of the Proposed Processes. An economic analysis of the proposed process will be compared with conventional petroleum processes and ether and alcohol synthesis routes.

The DOE reporting requirements for this contract will be followed in all cases. This includes all project status, milestone schedule, and cost management reports. A final detailed project report will be submitted upon completion of the contract.

RESULTS AND DISCUSSION.

During this Quarter, project activities centered on Tasks 4 and 7 of the contract.

TASK 1. Project Management Plan.

Modification of the draft Project Management Plan has been accepted by the Program Manager at DOE/PETC. Task 1 of the contract is complete. This

document contains the most current and accurate information and projections of the scope of work, schedules, milestones, staffing/manpower plan and costs. This plan contains the following sections:

Management Plan
Technical Plan
Milestone Schedule/Manpower Plan
Cost Plan
Notice of Energy RD&D Project

The technical approach builds from small scale tests of the selective cracking concept to pilot plant scale verification of product yields. The screening test results will serve as a preliminary milestone of this process scheme. An assessment of project directions, scope of work and objectives after this milestone will be appropriate.

TASK 2. Feedstock Characterization. the work in this area is now complete.

TASK 4. Pilot Plant Tests. Task 4 activities were related to analysis of the characterization data from the fractions of the three pilot-plant runs using Sasol wax as feedstock that were reported last September. These were runs 943-1, 944-2, and 945-2, and the catalysts used were 10% steamed USY, 10% steamed Beta, and standard equilibrium USY, respectively. For the reader's convenience, Table I identifies the feedstocks, catalysts, process conditions used, and summarizes the conversions that were obtained. The conversion to 430- °F product is based on atmospheric distillation of the total liquid product. The conversions to 430-650 light catalytic cycle oil (LCCO) and 650+ °F cycle oil are based on vacuum distillation of the 430+ °F fraction.

Tables II-IV give the characterizations that have been obtained on the naphtha (IBP-430 °F), light catalytic cycle oil (LCCO; 430-650 °F), and 650+ °F cycle oil, respectively. These data are discussed next.

Properties of 430- °F Product (Naphtha)

Table II gives the API gravity, simulated distillation, research and motor octane numbers (RON and MON, respectively) that were measured in engine tests, and detailed PIANO analyses that were obtained for the three runs.

The PIANO analyses show that the *distribution of compound types* was significantly different for the three naphthas. The naphtha from the 10% steamed USY catalyst contained 9% naphthenes, 9% aromatics, 51% olefins, and had a 4.3 ratio of *i*- to *n*-paraffins. The naphtha from the standard equilibrium USY catalyst contained 16% naphthenes, 23% aromatics, 27% olefins and had a 4.5 ratio of *i*- to *n*-paraffins. The naphtha from the 10% steamed Beta catalyst contained 15% naphthenes, 9% aromatics, 47% olefins, and had a 2.2 ratio of *i*- to *n*-paraffins.

The PIANO analyses also show that the *carbon number distribution* within the compound types was significantly different for the three naphthas. Naphtha from the 10% steamed USY catalyst was much lighter (38% C_5-C_6s and 8% C_{10}-C_{13}s) than the naphtha made with either the standard equilibrium USY

catalyst (15% C_5-C_6s and 18% C_{10}-C_{13}s) or 10% steamed Beta catalyst (27% C_5-C_6s and 12% C_{10}-C_{13}s)).

These PIANO results show that the primary products from cracking over the mildly acidic 10% steamed USY catalyst are olefins distributed around C_6, but that they increasingly cyclize, aromatize, and disproportionate into higher molecular weight products over the much more strongly acidic standard equilibrium USY catalyst.

The PIANO analysis of the naphtha from the 10% steamed Beta was most noticeably different from that of either of the USY-based catalysts in its 50% lower ratio of *i*- to *n*-paraffins. The 10% steamed Beta catalyst also differed from the 10% steamed USY catalyst in that it produced almost twice the naphthenes but the same amount of aromatics.

The 10% steamed USY catalyst produced naphtha with an API gravity of 68.5, which was much higher than the gravity produced by either the 10% steamed Beta or standard equilibrium USY catalysts, which were 63.5 and 58, respectively. These gravities reflect the PIANO analyses which showed that the 10% steamed USY made low naphthenes and low aromatics, the 10% steamed Beta made high naphthenes and low aromatics, and that the standard equilibrium USY made high naphthenes and high aromatics.

The 10% steamed USY catalyst produced naphtha with an (R+M)/2 octane number of 84.8, which was much higher than the octane produced by either the 10% steamed Beta or standard equilibrium USY catalysts, which were 80.9 and 78.1, respectively. These results are also explained by the PIANO analyses. The high octane number of the naphtha from the 10% steamed USY catalyst is produced by its high content of low molecular weight olefins. The naphtha from the 10% steamed Beta catalyst was lower in octane number because it had lower total olefins, the olefins were of higher molecular weight, and it had a high naphthene content. The low octane number of the naphtha from the standard equilibrium USY catalyst was surprising because, although it had the lowest olefin content, it had the highest content of aromatics plus olefins. Apparently the increase in molecular weight of the olefins and aromatics over those made by the 10% steamed USY catalyst, and the high content on naphthenes, combined to lower the octane of the naphtha that was made with the standard equilibrium USY catalyst.

Properties of 430-650 °F Product (LCCO)

Table III gives the API gravity, simulated distillation, cetane index, weight percent C_A(NMR), and pour and cloud points for the three LCCOs. Cetane index, which is calculated from the API gravity and simulated distillation, is proportional to the paraffin content; it is a measurement of diesel fuel quality analogous to octane number for gasoline. Weight percent C_A(NMR) is usually used as the indicator of aromatic carbon content, but is really the amount of sp_2-hybridized carbon. Because these samples are expected to have high olefin contents, the C_A might not be proportional to the aromatic carbon content. Additional analysis would be required to distinguish the olefinic from the aromatic carbon.

Table III shows that the 10% Beta catalyst produced LCCO with the highest API gravity (42.2) and cetane index (60.9) and lowest weight percent C_A(NMR) (15) of the three catalysts. The standard equilibrium USY catalyst

produced LCCO with the lowest API gravity (36.9) and cetane index (50.8) and highest weight percent C_A(NMR) (24.8). LCCO from the 10% steamed USY catalyst had a 38.9 API gravity, 56.3 cetane index, and 19.4 wt % C_A(NMR). The observed trends in API gravity, cetane index, and C_A(NMR) are internally consistent. Although the 10% Beta made the highest cetane index product, the LCCOs from all three runs would be excellent stock for blending into diesel fuel.

The relative ranking of the LCCO from the standard equilibrium USY catalyst -- heaviest and most aromatic -- is consistent with the trends observed in the naphthas (discussed above). However, the relative ranking of the APIs of the LCCOs from the 10% steamed USY and 10% steamed Beta catalysts are reversed from those of the naphthas. This implies that the LCCO fraction is not simply partially converted paraffinic feed but that the LCCO contains products of condensation, cyclization, and aromatization. The lower API gravity and higher C_A(NMR) of the LCCO made with the 10% steamed USY catalyst versus the 10% steamed Beta catalyst is consistent with those processes.

The pour and cloud points of all three products were experimentally equivalent, 0 to -6 and -1 °F, respectively.

Properties of 650+ °F Cycle Oil

Table IV shows that the 10% steamed Beta catalyst produced the 650+ °F cycle oil with the highest API gravity (36.8) and lowest weight percent C_A(NMR) (10.6) of the three catalysts. The standard equilibrium USY catalyst produced 650+ °F cycle oil with the highest weight percent C_A(NMR) (24.1) and lowest API gravity (29.9). LCCO from the 10% steamed USY catalyst had 16 wt % C_A(NMR) and a 32.8 API gravity. The observed trends in API gravity and C_A(NMR) are consistent with those of the LCCOs from these three catalysts: more condensation, cyclization, and aromatization (high API and low C_A(NMR)) with either USY-based catalyst than the Beta-based catalyst, and more aromatization with the standard equilibrium USY catalyst than the 10% steamed USY catalyst.

This report concludes the work done under Task 4.

CONCLUSIONS

Task 1, the Project Management Plan, is complete.

Task 2, Preparation of Feedstocks and Equipment Calibration, is complete.

Task 3, Catalytic Cracking Catalyst Screening Program, is complete.

Task 4, Pilot Plant Tests. Activities were performed under Task 4 during this reporting period. Three pilot plant runs were completed using Sasol wax as feedstock. The catalysts used were 10% steamed USY, 10% steamed Beta, and standard equilibrium USY. Characterization of the IBP-430, 430-650, and 650+ °F fractions of these runs was completed.

There was no activity under Task 5, Preparation of C_5-C_8 Ethers, during this Quarter. Task 5 of the contract is complete.

Task 6, Evaluation of Gasoline Blending Properties of Ethers and Alcohol Products, is complete.

Task 7, Scoping Economic Evaluation of the Proposed Processes, Activities were performed under Task 7 during this reporting period. Task 7 activities were related to a comparison of the economics for using Fischer-Tropsch wax as feedstock for hydrocracking versus catalytic cracking processes. The conclusions were:

1. Hydrocracker values are similar to FCC product values for a simple refinery configuration (no Ether Unit).

2. Hydrocracker values are less than FCC product values for a complex refinery configuration (contains Ether Unit).

This analysis was performed by Dr. J. J. Nicholas of Amoco Oil Process Research, and his report to me of December 16, 1993 is attached.

ACKNOWLEDGEMENT

This work is supported by the United States Department of Energy under Contract No. DE-AC22-91PC90057.

NOTICE

Prepared by
Amoco Oil Company (Amoco Corporation)
Naperville, Illinois

Table I

AUGUST, 1993 PILOT PLANT (AU-2L) RUNS: RUN CONDITIONS & CONVERSIONS

Run ID:	943-1	944-2	945-2
Feedstock ID:	1428	1428	1428
Feedstock Type:	Sasol Wax	Sasol Wax	Sasol Wax
Catalyst ID:	2062	2063	1397
Catalyst Type:	10 % Stm'd USY	10 % Stm'd Beta	USY Ref.
Reaction Temp., F	890	897	888
c/o Ratio	3.1	3	2.6
WHSV, 1/hr	35.8	31.5	34.2
Vol % Conversion	89.3	89.7	84.9
Wt % Recovery	93.9	55.2	63
Wt % Yields, Normalized			
H2S	0	0	0
Hydrogen	0.01	0.01	0.03
Methane	0.11	0.13	0.23
Ethylene	0.22	0.31	0.33
Ethane	0.11	0.16	0.2
Propylene	6.63	10.94	8.57
Propane	0.93	1.27	1.48
Butylenes	11.16	15.55	10.24
Isobutane	3.97	4.14	5.59
n-Butane	0.99	1.16	1.17
Pentenes	11.45	9.65	4.83
Isopentane	3.66	1.93	3.18
n-Pentane	1.56	1.11	0.54
C6-430 Naphtha	48.53	43.59	47.15
430-650 LCCO	7.44	6.61	11.1
650+ Cycle Oil	2.68	3.01	3.52
430+ Cycle Oils	10.12	9.63	14.65
Coke	0.55	0.43	1.81

Table II

Analysis of IBP-430 F Products from AU-2L Pilot Plant Runs

Run ID:	943-1	944-2	945-2
Feedstock ID:	1428	1428	1428
Feedstock Type:	Sasol Wax	Sasol Wax	Sasol Wax
Catalyst ID:	2062	2063	1397
Catalyst Type:	10 % Stm'd USY	10 % Stm'd Beta	USY Ref.
API	68.5	63.5	58
RON	90.3	85.4	81.3
MON	79.4	76.4	74.9
(RON+MON)/2	84.8	80.9	78.1
Sim Dist., F			
IBP	72	-25	-22
5 %	104	91	136
10 %	136	133	159
20 %	151	162	196
30 %	162	203	216
40 %	189	223	245
50 %	206	253	274
60 %	235	279	292
70 %	268	302	326
80 %	307	337	350
90 %	362	384	387
95 %	394	413	409
FBP	446	475	455
PIANO, Distribution of Compound Types, wt %			
n-Paraffins	5.41	7.18	5.56
i-Paraffins	23.23	16.02	24.88
i/n	4.3	2.2	4.5
Naphthenes	8.97	15.49	15.98
Aromatics	8.86	8.9	22.57
Olefins	51.17	46.87	26.95
Oxygenates	0.24	0.46	0.26
Unknowns	2.08	5.08	3.8

Table II. cont.

Analysis of IBP-430 F Products from AU-2L Pilot Plant Runs

Run ID:	943-1	944-2	945-2
Feedstock ID:	1428	1428	1428
Feedstock Type:	Sasol Wax	Sasol Wax	Sasol Wax
Catalyst ID:	2062	2063	1397
Catalyst Type:	10 % Stm'd USY	10 % Stm'd Beta	USY Ref.
PIANO, Distribution by Carbon Number, wt %			
Propane	0.02	0.03	0.02
Butanes	1.78	2.83	1.43
Pentanes	17.87	11.06	4.13
Hexanes	30.07	15.62	10.68
Heptanes	20.98	21.34	23.08
Octanes	11.79	19.08	22.27
Nonanes	7.7	12.52	17.02
Decanes	5.31	8.84	11.82
C11's	2.04	3.01	4.68
C12's	0.37	0.59	1.06
C13's	0	0	0
Unknowns	2.08	5.08	3.8
PIANO, Compound Types by Carbon Number, wt %			
Paraffins:			
C4	0.12	0.19	0.012
C5	0.9	0.63	0.22
C6	1.92	1.39	0.79
C7	0.7	1.16	1.02
C8	0.78	1.74	1.4
C9	0.35	0.81	0.69
C10	0.24	0.53	0.54
C11	0.23	0.44	0.45
C12	0.18	0.3	0.32
Isoparaffins:			
C4	0.25	0.29	0.3
C5	3	1.29	1.24
C6	8.06	2	3.31
C7	6.06	3.06	7.21
C8	2.85	3.18	5.94
C9	1.06	2.12	2.12
C10	1.28	2.77	3.08
C11	0.68	1.25	1.61
C12	0	0.06	0.06
Aromatics:			
C6	0	0	0.14
C7	0.39	0.25	0.97
C8	1.92	1.7	5.28
C9	2.63	2.53	6.84
C10	2.79	3.18	6.54
C11	0.94	1.03	2.14
C12	0.2	0.21	0.64

Table II. concl.

Analysis of IBP-430 F Products from AU-2L Pilot Plant Runs

Run ID:	943-1	944-2	945-2
Feedstock ID:	1428	1428	1428
Feedstock Type:	Sasol Wax	Sasol Wax	Sasol Wax
Catalyst ID:	2062	2063	1397
Catalyst Type:	10 % Stm'd USY	10 % Stm'd Beta	USY Ref.
PIANO, Compound Types by Carbon Number, wt %			
Naphthenes:			
C6	0.45	0.18	0.3
C7	0.84	0.59	1.38
C8	3	5.46	5.06
C9	3.57	6.86	7.3
C10	0.98	2.31	1.62
C11	0.1	0.1	0.33
C12	0	0	0
Olefins:			
C4	1.33	2.29	0.97
C5	13.94	9.09	2.67
C6	19.63	12.06	6.15
C7	12.82	15.92	12.27
C8	3.24	7	4.6
C9	0.09	0.2	0.06
C10	0.02	0.06	0.03
C11	0.09	0.2	0.15
C12	0	0.02	0.03

Table III

Analysis of 430-650 F Products from AU-2L Pilot Plant Runs

Run ID:	943-1	944-2	945-2
Feedstock ID:	1428	1428	1428
Feedstock Type:	Sasol Wax	Sasol Wax	Sasol Wax
Catalyst ID:	2062	2063	1397
Catalyst Type:	10 % Stm'd USY	10 % Stm'd Beta	USY Ref.
API	38.9	42.2	36.9
Pour Pt, F	0	-6	-6
Cloud Pt, F	1	-1	-1
Cetane Index	56.3	60.9	50.8
C-sub-A (NMR), wt %	19.4	15	24.8
Sim Dist, F			
IBP	403	393	400
5 %	434	431	428
10 %	443	444	440
20 %	466	467	455
30 %	486	485	475
40 %	511	503	489
50 %	534	521	515
60 %	559	542	532
70 %	585	562	553
80 %	613	586	576
90 %	642	624	615
95 %	651	649	647
FBP	691	741	733

Table IV

Analysis of 650+ F Products from AU-2L Pilot Plant Runs

Run ID:	943-1	944-2	945-2
Feedstock ID:	1428	1428	1428
Feedstock Type:	Sasol Wax	Sasol Wax	Sasol Wax
Catalyst ID:	2062	2063	1397
Catalyst Type:	10 % Stm'd USY	10 % Stm'd Beta	USY Ref.
API	32.8	36.8	29.6
C-sub-A (NMR), wt %	16	10.6	24.1
Sim Dist, F			
IBP	236	224	233
5 %	670	600	604
10 %	690	624	625
20 %	704	649	649
30 %	717	674	672
40 %	730	697	695
50 %	741	715	712
60 %	759	734	730
70 %	781	762	752
80 %	808	794	786
90 %	856	844	838
95 %	910	892	895
FBP	1189	1155	1132

QUARTERLY MANPOWER REPORT

For FIRST QUARTER FISCAL YEAR, 1994

(October 1, 1993 - December 31, 1993)

TITLE: THE SELECTIVE CATALYTIC CRACKING OF FISCHER-TROPSCH LIQUIDS TO HIGH VALUE TRANSPORTATION FUELS

IDENTIFICATION NUMBER: DE-AC22-91PC90057

START DATE: June 1, 1991
COMPLETION DATE: March 31, 1994

PARTICIPANT NAME AND ADDRESS:

AMOCO OIL COMPANY
P. O. BOX 3011
NAPERVILLE, ILLINOIS 60566

	Manpower In Hours by Task							
Name	1	2	3	4	5	6	7	Total
W. J. Reagan	0	0	0	0	0	48	0	48
M. M. Schwartz	0	30	7	38	0	116	55	246
R. D. Hughes	0	0	7	8	0	54	0	69
J. J Nicholas	0	0	0	0	0	0	18	18
Technical Support	0	2	0	0	0	0	0	2
Secretarial	0	0	0	0	0	0	0	0
Total Hours	0	32	14	46	0	218	73	383