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PILOT SCALE DISTILLATION AND CHARACTERIZATION OF DIESEL FUEL FRACTIONS OF STRATEGIC PETROLEUM RESERVE CRUDE OILS

INTERIM REPORT
BFLRF No. 224

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Little, beyond crude assay data, has been known about the properties of various fuel fractions, including diesel fuel, which might ensue in the event crude oils available at the Strategic Petroleum Reserve were actually to be refined. Accordingly, eight distinct crude oil streams were collected from the Reserve and subjected to distillation in a pilot-scale unit. Middle distillate fractions were prepared in an attempt to approximate production of diesel fuel, and the fractions were characterized by ASTM tests and evaluated according to the requirements of VV-F-800 and other criteria. VV-F-800 is the Federal Diesel Fuel Specification.

Results of the distillation effort were documented and indicate a successful effort over the range of operating conditions explored. The diesel fuels produced exhibit cetane numbers greater than specification requirements and can be expected to be stable. The data indicate that fuels conforming to VV-F-800 can be obtained from Strategic Petroleum Reserve crude oil, although a

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normal amount of additional upgrading may be required. Recommendations are made to examine such upgraded material, including full-scale engine testing, to demonstrate the power and performance of both treated and untreated fuels.

FOREWORD

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I. INTRODUCTION AND OBJECTIVES

The Energy Policy and Conservation Act (Public Law 94-163, 22 December 1975), as amended, authorizes the creation of a Strategic Petroleum Reserve (SPR) to store up to 1 billion barrels of oil for use in the event of an oil import disruption.(1)* Present plans are to achieve a 750-million-barrel goal by expanding three of five existing storage sites and by developing a new site at Big Hill, TX.

The SPR storage sites are connected by pipeline to three marine terminals for oil fill and to additional pipelines for oil drawdown and distribution during an oil-supply disruption:

- **Seaway complex:** The Bryan Mound storage site is connected to Phillips Petroleum Company's terminal (formerly the Seaway terminal) in Freeport, TX; to the Phillips refinery at Sweeney, TX; and to the ARCO marine terminal at Texas City, TX.

- **Texoma complex:** The West Hackberry and Sulphur Mines storage sites are connected, and the Big Hill storage site will be connected, to Sun Oil Company's marine terminal in Nederland, TX.

- **Capline complex:** The Weeks Island and Bayou Choctaw storage sites are connected to the government-owned St. James marine terminal on the Mississippi River; and to the LOCAP pipeline, also at St. James, LA.(1)

Responsibility for overall program management and planning lies with the Department of Energy's (DOE) SPR Program Office in Washington, DC.

The SPR is segregating the crude oil it purchases into four grades or qualities. These grades are light gravity-low sulfur, intermediate gravity-intermediate sulfur, intermediate gravity-high sulfur, and heavy gravity-high sulfur. As of 31 December 1986, 191 million barrels of light gravity-low sulfur crude were segregated in 19 caverns, with 234 million barrels of intermediate gravity-high sulfur crude segregated in 25 other caverns. A single cavern is dedicated to the storage of 11.2 million barrels of heavy gravity-high sulfur Maya crude, while Weeks Island mine contains the Reserve's entire 73-million-barrel stockpile of intermediate gravity-intermediate sulfur crude.

* Underscored numbers in parentheses refer to the list of references at the end of this report.

During a disruption of crude oil imports to the United States necessitating a drawdown of the SPR, it is probable that transportation fuels refined from SPR crude oil will be acquired by the U.S. military forces. These fuels may be used almost immediately, or they may become a component of prepositioned reserves subject to long-term storage or they may be added to tank farms for relatively short-term storage.

To date, no products have been commercially refined from the segregated SPR crude oil streams. The crude oil sold during a test sale and drawdown in December 1985 and January 1986 was commingled with other crude oil stocks at refineries prior to being processed. While the consensus among refiners is that they will be able to obtain products from the segregated SPR crude oil streams with little or no refining difficulty, no thought or study is known to have been given to additive treatment, storage stability, or upgrading response of these products.

The technical responsibility for research on mobility fuels within the Department of the Army resides at the U.S. Army Belvoir Research, Development and Engineering Center, one of two research centers under the U.S. Army Troop Support Command. The execution of this technology base program is supported by the Belvoir Fuels and Lubricants Research Facility (BFLRF), a Government-owned, contractor-operated laboratory located at the Southwest Research Institute (SwRI) in San Antonio, TX. A primary mission of both the Center and BFLRF is research on transportation fuels used by the U.S. military and NATO allies. BFLRF has performed research on storage of crude oils/finished fuels for DOE's Strategic Petroleum Reserve Office in the 1976-1979 time-frame (2-4), and has developed a computerized crude oil characterization program for the U.S. Army.(5)

Accordingly, the objective of this program was to investigate quality of diesel fuels distilled from the eight SPR crude oil streams. Each of the crude oil streams was actually a mixture of crude oils, with one exception.

This report details the methods used to produce diesel fuels, the results of tests on their characterization, and provides recommendations for follow-on studies, which should generate further valuable data of interest to the U.S. Army and the U.S. refining industry.

II. BACKGROUND

The Strategic Petroleum Reserve has been storing crude oil since 1977. Crude oil is separated into the rather broad categories of "sweet" and "sour", depending upon sulfur content. Nearly two-thirds of the reserve is high sulfur or "sour" crude, i.e., it contains in excess of one percent by weight of sulfur. Crude oil received through 1986 came from 20 different countries throughout the world. Because of the diversity of crudes purchased for the SPR, there has been concern about compatibility on mixing and stability during mixed storage. Crudes may be mixed through 1) commingling before storage, 2) turbulence during cavern "pump in", 3) diffusion, convection, and gravity during storage, and 4) drawdown exercises or when withdrawing crudes for sale. Partial assays of these crude mixes have been published but only recently has distillation and characterization of significant fuel fractions derived from SPR crudes been performed.

In a July 1985 letter of agreement to DOE from U.S. Army titled "Characterization of Diesel and Aircraft Turbine Fuels From SPR Crudes," it was stated:

- "Over the next 12 months, the SPR will provide BFLRF with 500-gallon (10-barrel) samples of each of the eight SPR crude oil segregations;
- "Using a pilot-plant still, BFLRF will refine these eight crude oil samples to obtain 100- to 200-gallon samples of the fuels of interest for detailed characterization;
- "The refined fuels will be used in limited full-scale engine evaluations and subjected to upgrading to DF-2 quality; and
- "Complete study results will be provided to SPR for review and comment prior to publication."

From December 1985 to January 1986, the Strategic Petroleum Reserve Office (SPRO) conducted a test sale and drawdown on four of the eight SPR crude oil streams. Concurrently, 10-drum samples of each of the eight SPR crude oil streams were collected for use in this work.

III. STATEMENT OF APPROACH

A. Approach

The crudes were to be distilled to provide naphtha, middle distillate, and bottoms fractions. Two of these fractions were simply to be set aside. The middle distillate cut was to be characterized and any difficulties/peculiarities in the distillation effort documented. This was to be a moderate-scale distillation effort rather than a laboratory-scale process. Key chemical properties were to be measured via standard laboratory testing, supplemented by bench testing and, possibly, limited full-scale engine testing.

B. Program Plan

Key activities in this effort included:

- Review and evaluation of present SPR crude inventory and assay relationship to refineability
- Acquisition of samples from the eight SPR crude streams
- Physical/chemical characterization of crude streams (crude assay data)
- Distillation into predetermined fractions and complete characterization of these fractions versus VV-F-800* (6) requirements or other specifications
- Comparison of SwRI distillation yields with crude assay data
- Interpretation of distillate characteristics in terms of refineability
- Interpretation of fuel characteristics in terms of field expedient fuel program requirements and fuel stability

* VV-F-800 is the Federal method which specifies three grades of diesel fuel.

IV. EQUIPMENT AND MATERIALS

A. Crude Oil Samples

Preliminary assay data published in the Federal Register (7) were used for scope and planning purposes and are included as Appendix A. These eight crude oil stream samples are:

1. SPR West Hackberry Sweet
2. SPR Bryan Mound Sweet
3. SPR Bayou Choctaw Sweet
4. SPR West Hackberry Sour
5. SPR Bayou Choctaw Sour
6. SPR Bryan Mound Sour
7. SPR Weeks Island Sour
8. SPR Maya

A complete crude oil assay of each SPR crude oil stream was performed by the National Institute for Petroleum and Energy Research (NIPER). These results are included as Appendix B, and it is noted that the NIPER samples were collected separately from those employed in this work.

Initial tests of the delivered crude samples (measurement of API gravity) indicated consistent quality of crude from drum to drum for each sample. Results are shown in TABLE 1. Comparison of these data to both the preliminary and NIPER assay data was excellent and indicated that all samples were properly labeled and identified.

TABLE 1. Gravity of SPR Crudes at BFLRF Compared to Other Gravity Data

Crude Oil Name	BFLRF No.	API Gravity: By Drum Number 1	5	10	BFLRF Avg.	NIPER Data	Federal Register
Bayou Choctaw Sour	1072C	33.3	33.3	33.3	33.3	33.6	31.0
Bayou Choctaw Sweet	1071C	36.3	36.3	36.3	36.3	36.5	36.2
Bryan Mound Maya	1058C	22.8	23.4	22.9	23.0	22.9	22.1
Bryan Mound Sour	1059C	32.7	32.6	32.6	32.6	31.5	33.2
Bryan Mound Sweet	1060C	36.5	36.6	36.7	36.6	36.0	36.2
Weeks Island Sour	1073C	28.9	28.9	28.9	28.9	28.9	29.7
W. Hackberry Sour	1064C	33.4	33.5	33.4	33.4	33.1	33.1
W. Hackberry Sweet	1065C	38.1	37.9	38.1	38.0	38.1	37.0

All crude charged to the system was prefiltered through a 40-micron sock filter to remove particulate matter and to provide some dewatering of the otherwise untreated crude oil. The crudes were not desalted as is the conventional practice for a normal refinery because the hardware capability was not available. The salt and water contents of crudes stored in the SPR were known to diminish with time as a result of settling out due to gravity; the concentrations of salt and water in the samples used in this program were not determined. The volume of filtered crude charged to the system feed tank was measured by a level gauge on the tank.

B. Pilot Plant Distillation Apparatus

A simplified flow diagram of the continuous pilot plant distillation apparatus used in this study is presented as Fig. 1. The design and construction of the apparatus have been described previously.(8) The distillation system modules are illustrated in Fig. 1, and the operating procedure is described below. The eight modules of the distillation system are:

- Feedstock storage and delivery
- Distillation column
- Inert gas delivery
- System pressure control
- Overhead distillate recovery
- Overhead product storage
- Bottoms product recovery
- Bottoms product storage

The feedstock storage and delivery module consists of a 350-gallon stainless steel tank, feed pump, flow meter, feed preheater, and associated piping and valving. The column module includes five separate feed port locations along the length of the column, a rectification furnace (top half of the column), a stripping furnace (bottom half of the column), a reboiler, and reboiler furnace. The column is 13 feet in height and is packed with Goodloe packing. Inert gas feed to the column is regulated, metered, and introduced to the column through the reboiler.

The overhead distillate recovery system consists of an overhead vapor condenser, a gas liquid separator, a reflux splitter which diverts condensed liquids either back to the

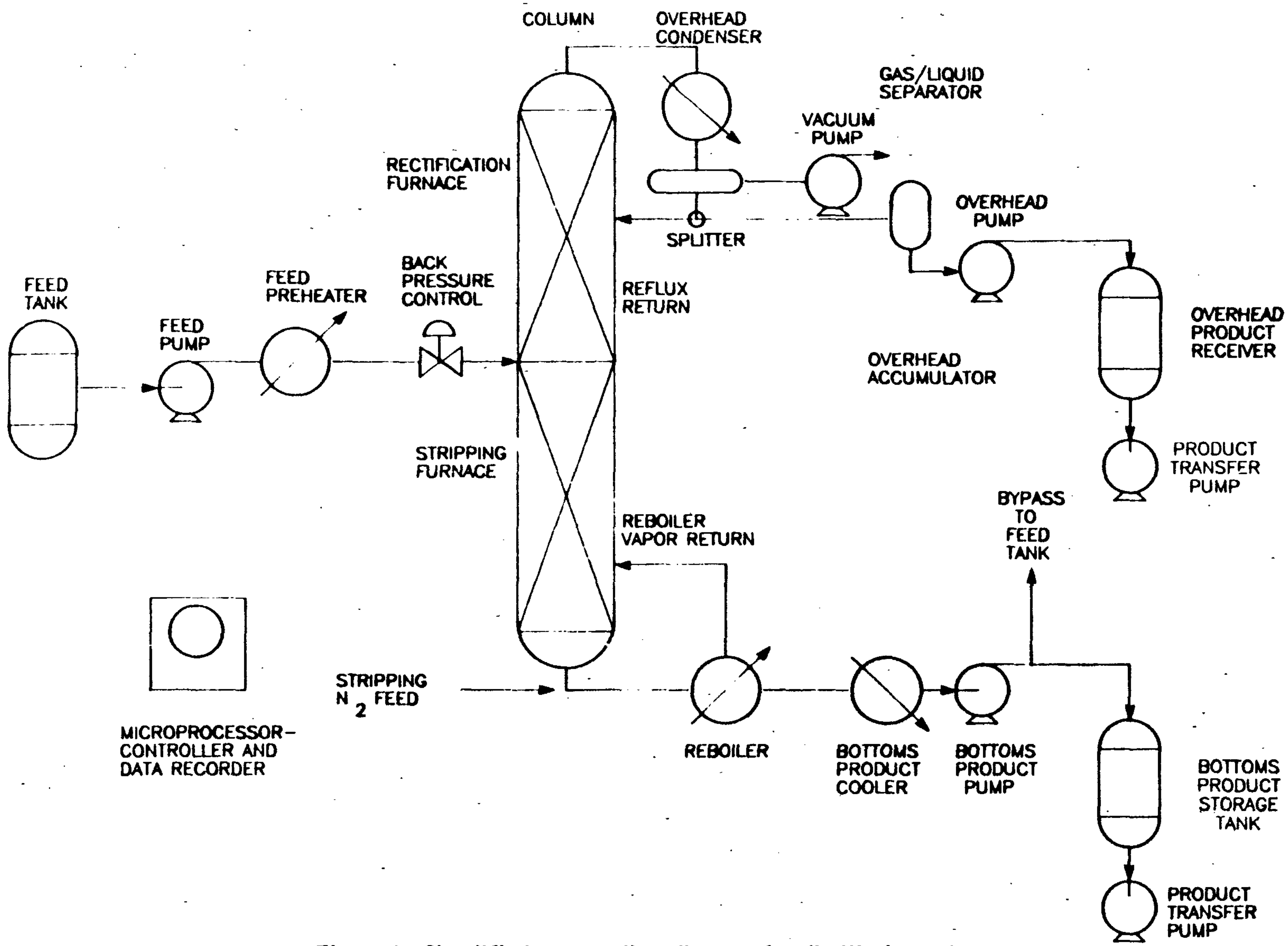

Figure 1. Simplified process flow diagram for distillation unit

column or to product collection, an overhead product receiver (5-gallon capacity), and an overhead product pump. The system pressure control is an extension of the overhead distillate recovery module that has a vent or vacuum port connected to the gas/liquid separator. Pressure is controlled with a vacuum pump and bypass control valve. The bottoms product recovery module consists of a bottoms product cooler, bottoms product pump, flow meter, and recycle line.

The overhead product storage module (not shown in entirety) receives distillate product through the overhead product transfer pump. This module also includes a product transfer pump. The bottoms product storage module (not shown in entirety) receives product through the bottoms product pump directly from the column and includes its own transfer pump. The product storage tanks are 250-gallon capacity each.

System conditions are controlled by a computer which monitors system temperature, flow rates, and pressures. The computer software package provides interactive communication with the process, time event programming, and data logging features. Material balances were aided by volume level gauges on the feed tank, overhead product receiver, bottom product storage tank, and overhead product storage tank.

Operating conditions of record included feed rate, preheater temperature, rectification temperature, stripping temperature, and reboiler temperature. The feed rate (gallons per hour) was controlled by a meter setting on the feed pump. This was adjusted to provide maximum flow rate at desired preheater temperature without stressing the heat duty of the preheater beyond 90 percent. The rectification temperature is the control setting for the rectification furnace, which adds heat to the top half of the column. The stripping temperature is the control setting for the stripping furnace, which adds heat to the bottom half of the column. The reboiler temperature is the control setting for the reboiler furnace which adds heat to the reboiler pot. The reboiler is attached to the bottom of the column, and a liquid level is maintained in it to control flow to the bottoms product storage tank. Nitrogen stripping was used in each run to assist in removing light components from bottoms fractions. The overhead product reflux ratio was varied from 1:1 to 5:1 (reflux:product).

V. PRESENTATION OF RESULTS

A. Preoperation Shakedown

Because no crude oils had previously been distilled with the unit, the distillation apparatus was taken through a preoperation evaluation. Several minor repairs were required as preparation for operation. A special feed and filter system for handling crude oils was designed along with a heat-traced bottoms-handling system. The column was also equipped with a vacuum system to permit lower temperature distillation of crude oils. As a shakedown run of the modified unit, diesel fuel used in another BFLRF program was distilled in 25 vol% increments. Following this shakedown, and completion of other modifications to the column to allow operation with crude oil, West Hackberry Sweet crude oil was charged to the unit for the initial run.

B. Results of Preliminary Test Run

West Hackberry Sweet crude oil was chosen for the initial run because it represented the "lightest" (or lowest gravity) of the sweet crude oils. Accordingly, it was expected to be the easiest crude oil to process. Minor problems with the electrical, vaccum, and feed pump systems, piping, and computer control were encountered in this initial run. While these problems individually were not significant, together they resulted in an unsuccessful test run. The data in TABLE 2 resulted from the first attempt to distill crude oil using this system.

TABLE 2. Yield Data; Preliminary Distillation of West Hackberry Sweet Crude Oil

Description	Yield Data		D 86 Data		Gravity, °API
	gallons	vol%(1)	IBP, °F (°C)	EP, °F (°C)	
Naphtha	25	23.6	88 (31)	492-494 (255-257)	59.8-60.4
Topped Crude (unprocessed)	3	2.8	NA	NA	NA
Dist. No. 1	0.5	0.5	NA	NA	NA
Dist. No. 2	2	1.9	213 (100)	456 (236)	47.5
Dist. No. 3	1	0.9	274 (134)	501 (260)	41.7
Dist. No. 4	4	3.8	288 (142)	494 (257)	44.1
Dist. No. 5	4	3.8	423 (217)	590 (310)	37.7
Dist. No. 6	12	11.3	454 (234)	651 (344)	35.3
Bottoms	30	28.3	380 (193)	NA(2)	27.3
Unaccounted for(1)	24.5	23.1			
Total(1)	106.0	100.0			

(1) based on two drums charged to still at 53 gallons per drum.
(2) cracked at 720°F (382°C).

No attempt was made to reconstitute a 350° (177°C) to 650°F (343°C) fraction from distillate samples 1 through 6, nor was any VV-F-800-type analysis of a distillate oil or reconstituted blend attempted. This is because the wide range of D 86 data for the six samples, plus the large amount of material lost or unaccounted for (23.1 vol%), raised a serious question concerning the representativeness of these samples. The tabulated results thus indicated that a redistillation of West Hackberry Sweet would be necessary if project objectives were to be met.

Because the pilot distillation column is only capable of making a single fractionation per pass, it was necessary to collect a naphtha fraction in the first pass and then redistill the bottoms product from that run to obtain the desired boiling range product. In the case of two crude oils (Bryan Mound Sweet and Maya), this procedure was modified by removing both the naphtha and diesel fuel fraction in the first pass and then the naphtha was split from the diesel fuel fraction in the second pass.

C. Distillation of Eight SPR Crude Oil Streams

A total of 2.5 to 10 gallons of distillate product in the DF-2 boiling range were prepared from each of the eight SPR crude oil mixes. Characterization of these materials was conducted using standard ASTM methodology. All distillate samples were stored in a cold box, as were the naphtha fractions, in order to minimize deterioration of products prior to analysis. The one sample of middle distillate from West Hackberry Sweet originally prepared under less than optimal operating conditions was replaced by repeating the distillation of West Hackberry Sweet crude oil. The column operating conditions employed during distillation of the eight crude oils are presented in TABLE 3. TABLE 4 represents a comparison of actual to expected yields based on crude assay data. Analytical data for middle distillate fractions obtained are presented in TABLE 5. Arithmetic balances performed on certain chemical/physical oil properties are shown in TABLE 6. Trace element content of the crude oil mixes and filterable particulates from the middle distillate fractions are provided in Table 7. The 80°C storage stability test date are included in TABLE 8. Because of the relatively small quantities of middle distillate actually refined from each of the eight crude oil streams, it was not possible to perform any full-scale engine evaluations or to upgrade any of the samples to DF-2 quality. Despite this, conclusions based on the quality of straight-run middle distillate fuels refined from SPR crude oil streams are useful in evaluating the quality of fuels that can be produced by a refinery using the same feedstock.

TABLE 3. SPR Crude Distillation Operating Conditions

Crude Oil Name:	West Hackberry Sweet	Bryan Mound Sweet	Bayou Choctaw Sweet	West Hackberry Sour	Bayou Choctaw Sour	Bryan Mound Sour	Weeks Island Sour	Bryan Mound Maya
Sample No.:	FL-1065-C	FL-1060-C	FL-1071-C	FL-1064-C	FL-1072-C	FL-1059-C	FL-1073-C	FL-1058-C
• NAPHTHA RUN								
Feed Rate, gph	5.0	7.2	5.5	5.5	5.5	5.5	5.5	7.3
Preheater Temp., °F(°C)	400(204)	375(191)	400(204)	385(196)	385(196)	400(204)	400(204)	375(191)
Rectification, °F(°C)	425(218)	400(204)	400(204)	385(196)	400(204)	410(210)	425(218)	410(210)
Stripping, °F(°C)	425(218)	400(204)	410(210)	415(213)	400(204)	425(218)	425(218)	410(210)
Reboiler Temp., °F(°C)	450(232)	425(218)	425(218)	425(218)	425(218)	450(232)	450(232)	425(218)
Reflux Ratio	5:1	5:1	1:1	5:1	5:1	5:1	5:1	5:1
Pressure, psi	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
Nitrogen Stripping	Yes	Yes	Yes	Yes	Yes	Yes	High	Yes
Comments		(Run Second)						(Run Second)
• DISTILLATE RUN								
Feed Rate, gph	4.0	4.0	3.3	3.5	4.0	3.5	3.0	2.5
Preheater Temp., °F(°C)	550(288)	500(260)	515(268)	525(274)	525(274)	525(274)	550(288)	550(288)
Rectification, °F(°C)	580(304)	515(268)	525(274)	525(274)	580(304)	580(304)	580(304)	580(304)
Stripping, °F(°C)	590(310)	570(299)	550(288)	540(282)	590(310)	590(310)	590(310)	590(310)
Reboiler Temp., °F(°C)	625(329)	625(329)	600(316)	610(321)	620(327)	625(329)	625(329)	625(329)
Reflux Ratio	5:1	3:1	3:1	5:1	1:1	1:1	1:1	1:1
Pressure	14.7	7.0	7.0	9.0	14.7	14.7	14.7	14.7
Nitrogen Stripping	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Comments		(Run First)						(Run First)

TABLE 4. Expected and Actual Yields; Distillation of SPR Crudes

Crude Oil Name: / Sample No.:	West Hackberry Sweet FL-1065-C	Bryan Mound Sweet FL-1060-C	Bayou Choctaw Sweet FL-1071-C	West Hackberry Sour FL-1064-C	Bayou Choctaw Sour FL-1072-C	Bryan Mound Sour FL-1059-C	Weeks Island Sour FL-1073-C	Bryan Mound Maya FL-1058-C
• Expected Naphtha Yields[1], vol%								
C_5-175°F (79°C)	6.3	4.6	4.9	4.4	4.1	3.5	3.1	3.4
175°-250°F (79°-121°C)	9.4	8.3	8.3	7.4	7.4	7.0	5.9	5.3
250°-375°F (121°-191°C)	13.5	13.0	12.4	13.6	13.1	13.6	10.6	10.2
Subtotal Naphtha	29.2	25.9	25.6	25.4	24.6	24.1	19.6	18.9
• Expected Middle Distillate Yields, Vol%								
375°-530°F (191°-277°C)	16.4	16.8	15.6	16.3	16.4	16.5	15.0	11.4
530°-650°F (277°-343°C)	12.3	13.0	11.7	12.0	12.0	11.9	12.3	9.7
Subtotal Middle Distillate	28.7	29.8	27.3	28.3	28.4	28.4	27.3	21.1
• Actual Naphtha Yields[2], vol%								
Naphtha	33.1	27.3	26.6	25.8	26.4	25.6	24.7	19.8
Naphtha as % Expected	113.4	105.4	103.9	101.6	107.3	106.2	126.0	104.8
• Actual Middle Distillate Yields[2], vol%								
<375°F (<191°C) Component	0.0	0.0	0.3	0.9	0.0	0.3	0.0	0.2
375°-530°F (191°-277°C) Component	11.8	14.4	14.4	14.2	13.8	15.0	10.3	9.3
>530°F (>277°C) Component	5.1	1.6	1.3	0.5	2.3	4.5	5.0	1.7
Subtotal Middle Distillate	16.9	16.0	16.0	15.6	16.1	19.8	15.3	11.2
Distillate as % Expected[3]	99.0	94.5	99.0	89.7	95.9	100.5	111.5	89.9
• Middle Distillate, D 86, °F (°C)								
IBP	342 (172)	378 (192)	363 (184)	302 (150)	374 (190)	364 (184)	419 (215)	366 (186)
10%	435 (224)	403 (206)	396 (202)	389 (198)	402 (206)	400 (204)	452 (2[illegible])	404 (207)
30%	469 (243)	423 (217)	422 (217)	419 (215)	429 (221)	436 (224)	479 (248)	425 (218)
50%	499 (259)	448 (231)	446 (230)	442 (228)	454 (234)	468 (242)	505 (263)	451 (233)
70%	531 (277)	475 (246)	473 (245)	465 (241)	485 (252)	508 (264)	534 (279)	486 (252)
90%	589 (309)	529 (276)	519 (271)	497 (258)	548 (287)	585 (307)	606 (319)	558 (292)
EP	666 (352)	602 (317)	580 (304)	538 (281)	662 (350)	696 (369)	690 (366)	653 (345)

1 Analysis provided as current SPR data as of 19 September 1986.

2 Provision was made to intentionally produce "excess" naphtha in order to increase the initial boiling point of distillate product. The distillations of FL-1060-C and FL-1058-C were exceptional because they involved a combined naphtha-distillate overhead followed by redistillation. Every distillation was made on a single drum quantity of crude oil except FL-1060-C (2 drums).

3 Based only on 375°-530°F (191°-277°C) components compared to expected yield of a similar fraction, and restated to include distillate contained in the naphtha.

TABLE 5. Analytical Data for Middle Distillate Fractions From SPR Crudes

Crude Oil Name:	VV-F-800C Requirements		West Hackberry Sweet	Bryan Mound Sweet	Bayou Choctaw Sweet	West Hackberry Sour	Bayou Choctaw Sour	Bryan Mound Sour	Weeks Island Sour	Bryan Mound Maya
Sample No.:	DF-1	DF-2	FL-1065-C	FL-1060-C	FL-1071-C	FL-1064-C	FL-1072-C	FL-1059-C	FL-1073 C	FL-1058-C
Visual, D 4176	Clean/ Bright	Clean/ Bright	Sed/ Hazy	Dark	Sed/ Bright	Sed/ Bright	Clean/ Dark	Sed/ Dark	Sed/ Bright	Dark
Color, D 1500	NR	NR	1.5	7.0	4.0	0.5	5.0	3.5	1.0	>8.0
Particulate Contamination, D 2276, mg/L	10.0, max	10.0, max	65.7	29.7	5.8	8.8	59.3	225.8	11.3	237.2
Accelerated Stability, D 2274, Total Insolubles, mg/100 mL	1.5, max	1.5, max	0.2	1.7	0.5	0.3	0.6	0.6	0.4	0.4
Treated*, Total Insolubles, mg/100 mL	1.5, max	1.5, max	0.1	0.4	0.4	0.4	0.4	0.5	0.4	0.4
Flash Point, D 93, °C	38, min	52, min	74	73	67	20	68	67	82	64
Cloud Point, D 2500, °C	Local	Local	-16	-37	-32	-41	-20	-18	-10	Too Dark
Pour Point, D 97, °C	Report	Report	-22	-37	-34	-41	-27	-18	-15	-32
Kinematic Viscosity at 40°C, D 445, cSt	1.3-2.9	1.9-4.1	2.4	1.9	1.9	1.6	1.9	2.1	2.8	2.0
Kinematic Viscosity at 54°C, D 445, cSt	NR	NR	1.9	1.5	1.5	1.3	1.6	1.6	2.1	1.6
Carbon Residue, 10% Bottoms, D 524, mass%	0.15, max	0.35, max	0.11	0.15	0.10	0.08	0.19	0.15**	0.07	0.25**
Sulfur, X-Ray Fluorescence, mass%	0.50, max	0.50, max	0.09	0.12	0.10	0.27	0.34	0.46	0.52	0.56
Doctor Test, UOP 41-74	NR	NR	Sweet	Sweet	Sweet	Sour	Sweet	Sweet	Sweet	Sour
Mercaptan Sulfur, D 3227, mass%	NR	NR	0.0005	0.0034	0.0023	0.0030	0.0036	0.0043	0.0036	0.0039
Copper Corrosion at 50°C, D 130	3, max	3, max	1A	1A	1A	3A	1A	1A	1A	1A
Ash, D 482, mass%	0.01, max	0.01, max	<0.01	<0.01	<0.01	0.03	0.07	<0.01	0.01	0.01
Total Acid Number, D 974, g KOH/g sample	NR	NR	0.05	0.007	0.007	0.067	0.018	0.021	0.040	0.021
Cetane Number, D 613	40, min	40, min	55	51	50	51	53	55	52	52
Cetane Index, D 976-80	43, min	43, min	51	48	49	51	50	50	48	48
Distillation, D 86, °C										
50% evap.	Report	Report	259	231	230	228	234	242	263	233
90% evap.	288, max	338, max	309	276	271	258	287	307	319	292
End Point	330, max	370, max	352	317	304	281	350	369	366	345
Residue, vol%	3, max	3, max	2.0	1.0	1.0	1.0	1.5	1.0	1.0	1.0
Aniline Point, D 611, °C	NR	NR	68.2	66.4	66.0	64.2	66.5	66.7	65.5	65.0
Gravity, °API, D 1298	NR	NR	38.1	40.6	40.9	43.1	40.9	40.1	35.7	40.2
Density, D 1298, kg/L	Report	Report	0.834	0.822	0.820	0.810	0.820	0.824	0.846	0.824
Water and Sediment, D 2709, vol%	NR	NR	0.01	0.05	0.05	0.10	0.10	0.05	0.05	0.01
Karl Fischer Water, D 1744, ppm	NR	NR	22.5	8.5	<0.1	1.0	2.0	131	111.5	151
Salt, lb/1000 bbl***	NR	NR	1.4	9.8	5.6	0.9	2.4	5.0	3.2	120.0
Aromatics, D 1319, vol%	NR	NR	23.1	19.2	20.4	19.9	22.7	24.8	29.2	24.4
Olefins, D 1319, vol%	NR	NR	1.6	1.2	0.5	0.6	0.8	0.4	0.9	0.7
Saturates, D 1319, vol%	NR	NR	75.3	79.6	79.1	79.5	76.5	74.8	69.9	74.9
Aromatic Carbon, mass%										
Mono	NR	NR	4.95	5.07	5.10	10.17	10.59	7.73	7.25	7.65
Di	NR	NR	5.03	3.77	4.00	3.43	3.50	3.59	5.24	3.26
Tri	NR	NR	0.35	0.18	0.15	0.05	0.28	0.40	0.56	0.36

* Reference MIL-S-53021, multifunctional additive only.
** Sample filtered before testing.
*** NIPER data.
NR No Requirement.

TABLE 6. Arithmetic Balances for SPR Crude Oil Distillation Runs

Crude Oil Name: / Sample No.:	West Hackberry Sweet FL-1065-C	Bryan Mound Sweet FL-1060-C	Bayou Choctaw Sweet FL-1071-C	West Hackberry Sour FL-1064-C	Bayou Choctaw Sour FL-1072-C	Bryan Mound Sour FL-1059-C	Weeks Island Sour FL-1073-C	Bryan Mound Maya FL-1058-C
• Gravity, °API								
Observed Value	38.1	40.6	40.9	43.1	40.9	40.1	35.7	40.2
Calculated Value, <375°F	0	0	0.95	3.02	0	0.78	0	0.93
375°-530°F	27.9	36.0	36.27	38.05	35.5	31.44	26.25	33.21
530°-650°F	10.2	3.4	2.80	1.06	4.7	7.48	10.20	4.75
Total of Calculated Values	38.1	39.4	40.02	42.13	40.2	39.70	36.45	38.89
Difference, °API	-0-	+1.2	+0.9	+1.0	+0.7	+0.4	-0.75	+1.31
• Sulfur, XRF, mass%								
Observed Value	0.09	0.12	0.10	0.27	0.34	0.46	0.52	0.56
Calculated Value, <375°F	0	0	0.00	0.002	0	0.001	0	0.005
375°-530°F	0.03	0.072	0.054	0.291	0.27	0.318	0.195	0.789
530°-650°F	0.07	0.026	0.021	0.033	0.14	0.259	0.278	0.304
Total of Calculated Values	0.10	0.098	0.075	0.326	0.41	0.578	0.473	1.098
Difference, mass%	-0.01	+0.022	+0.025	-0.056	-0.07	-0.118	+0.047	-0.538
• Aniline Pt, °F								
Observed Value	154.8	151.5	150.8	147.8	151.7	152.1	149.9	149.0
Calculated Value, <375°F	0	0	2.4	7.4	0	1.9	0	2.3
375°-530°F	99.8	130.9	130.3	132.7	123.7	109.8	92.5	117.7
530°-650°F	49.6	16.6	13.6	5.2	22.9	36.5	50.0	23.1
Total of Calculated Values	149.4	147.5	146.3	145.3	146.6	148.2	142.5	143.1
Difference, °F	+5.4	+4.0	+4.5	+2.5	+5.1	+3.9	+7.4	+5.9
• Cetane Index								
Observed Value	51	48	49	51	50	50	48	48
Calculated Value, <375°F	0	0	NA	NA	0	NA	0	NA
375°-530°F	32.7	42.38	42.86	45.84	42.53	37.73	30.50	39.10
530°-650°F	15.8	5.27	4.31	1.64	7.26	11.51	15.68	7.31
Total of Calculated Values	48.5	47.65	47.17	47.48	49.79	49.24	46.18	46.41
Difference	+2.5	+0.35	+1.83	+3.52	+0.21	+0.76	+1.82	+1.59

NOTE: Difference = observed value - calculated value.

TABLE 7. D 2276 Filter Analysis and Trace Metals in Crude Oils

Crude Oil Name:	West Hackberry Sweet	Bryan Mound Sweet	Bayou Choctaw Sweet	West Hackberry Sour	Bayou Choctaw Sour	Bryan Mound Sour	Weeks Island Sour	Bryan Mound Maya
FL-Code:	1065-C	1060-C	1071-C	1064-C	1072-C	1059-C	1073-C	1058-C
D 2296 Filter Analysis*, Metals, X-Ray Fluorescence, mass%								
Iron	18.20	0.21	10.60	6.70	15.70	6.10	16.00	5.65
Sulfur	1.35	9.60	2.00	<0.01	0.80	<0.01	<0.01	0.19
Chlorine	4.04	<0.01	<0.01	9.20	0.29	0.10	2.10	0.04
Tin	0.11	<0.01	0.19	0.67	0.03	0.01	2.90	<0.01
Calcium	0.01	0.13	0.10	<0.01	<0.01	<0.01	0.31	<0.01
Vanadium	<0.01	0.16	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	0.03	<0.01	0.12	0.65	0.04	0.01	0.07	0.01
Manganese	0.01	<0.01	0.62	<0.01	0.37	0.13	0.64	0.07
Nickel	<0.01	<0.01	<0.01	0.35	<0.01	<0.01	<0.01	<0.01
Zinc	<0.01	<0.01	0.05	0.02	<0.01	<0.01	0.02	<0.01
Trace Metals in Crude Oil, X-Ray Fluorescence, ppm by mass								
Iron	0.46	3.05	1.69	1.83	1.56	<0.03	0.28	0.73
Copper	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc	0.08	<0.07	0.14	0.24	<0.10	0.01	0.09	0.19

* Filter obtained from D 2276 analysis of diesel distillate (TABLE 5).

TABLE 8. 80°C Storage Stability Test Results

Crude Oil Name:	West Hackberry Sweet		Bryan Mound Sweet		Bayou Choctaw Sweet		West Hackberry Sour		Bayou Choctaw Sour		Bryan Mound Sour		Weeks Island Sour	
FL-Code:	1065-C	1065-C	1060-C	1060-C	1071-C	1071-C	1064-C	1064-C	1072-C	1072-C	1059-C	1059-C	1073-C	1073-C
Run No.:	1B	1B	2C	2C	3C	3C	4B	4B	5C	5C	6C	6C	7B	7B
	Untreated	Treated*	Untreated	Treated*	Untreated	Treated*	Untreated	Treated*	Untreated	Treated*	Untreated	Treated*	Untreated	Treated*
0 Day														
Filterable Insolubles, mg/100 mL	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.3	0.4	0.2	0.2	0.1	0.1
Adherent Insolubles, mg/100 mL	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.1	0.1
Total Insolubles, mg/100 mL	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.5	0.7	0.4	0.4	0.2	0.2
Steam Jet Gum, D 381, mg/100 mL	6.1	2.4	29.4	27.6	14.7	15.0	0.4	1.2	24.0	23.8	12.1	12.0	1.5	1.6
Color, D 1500	1.5	1.5	5.0	6.0	3.5	4.0	0.5	0.5	5.0	5.0	3.5	4.0	2.0	2.0
3 Days														
Filterable Insolubles, mg/100 mL	0.1	0.1	1.5	0.6	0.2	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2
Adherent Insolubles, mg/100 mL	0.3	0.4	0.5	0.4	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.1
Total Insolubles, mg/100 mL	0.4	0.5	2.0	1.0	0.4	0.4	0.3	0.4	0.2	0.2	0.2	0.3	0.3	0.3
Steam Jet Gum, D 381, mg/100 mL	1.0	2.6	26.3	28.2	15.1	15.4	0.6	2.2	35.8	35.1	9.7	11.0	2.8	2.6
Color, D 1500	1.5	1.5	5.5	6.0	4.0	4.0	0.5	0.5	5.0	5.0	3.5	4.0	2.0	2.0
7 Days														
Filterable Insolubles, mg/100 mL	1.0	1.9	2.3	1.7	0.3	0.2	0.1	0.1	0.4	0.2	0.3	0.1	0.1	0.2
Adherent Insolubles, mg/100 mL	0.3	0.5	0.6	0.6	0.5	0.5	0.4	0.2	0.4	0.5	0.4	0.5	0.2	0.2
Total Insolubles, mg/100 mL	1.3	2.4	2.9	2.3	0.8	0.7	0.5	0.3	0.8	0.7	0.7	0.6	0.3	0.4
Steam Jet Gum, D 381, mg/100 mL	2.0	2.0	25.0	27.4	16.1	16.2	0.1	2.0	25.2	25.4	17.1	16.9	3.6	3.6
Color, D 1500	1.0	1.0	5.5	5.5	3.0	3.0	0.5	0.5	4.5	5.0	3.0	3.5	1.5	1.5
14 Days														
Filterable Insolubles, mg/100 mL	0.1	0.2	3.1	2.0	0.2	0.2	0.2	0.5	0.7	0.6	0.8	0.3	2.1	2.9
Adherent Insolubles, mg/100 mL	0.4	0.2	0.6	0.7	0.2	0.2	0.3	0.3	0.7	0.7	0.8	0.6	0.3	0.3
Total Insolubles, mg/100 mL	0.5	0.4	3.7	2.7	0.4	0.4	0.5	0.8	1.4	1.3	1.6	0.9	2.4	3.2
Steam Jet Gum, D 381, mg/100 mL	1.8	2.5	25.4	28.4	13.5	15.9	0.2	1.4	24.4	24.3	15.4	13.2	5.1	4.6
Color, D 1500	2.0	2.0	5.0	6.0	5.5	6.0	0.5	0.5	4.5	4.5	4.0	4.0	2.0	2.0

* Reference MIL-S-53021, multifunctional additive only.
NOTE: Bryan Mound Maya not stored due to insufficient sample volume.

VI. DISCUSSION

Expected yields as calculated from crude assays provided by NIPER are compared against actual yields in TABLE 4. The target product was the fraction of crude oil boiling from 375°F (190°C) to 650°F (343°C). Separation efficiencies were less than anticipated and, therefore, some of the material boiling above 375°F was collected in the naphtha fraction and not all material boiling up to 650°F was collected in the diesel fuel fraction. Recovery of all the 650°F material in commercial refining operations is also a problem unless the column is running at optimum conditions.

The eight middle distillate samples collected fall within a range of 302°F (150°C) to 419°F (215°C) initial boiling point and 538°F (281°C) to 696°F (369°C) end point as measured by ASTM D 86 distillation. Based on these results and the available crude assay data, data for the products obtained are in apparent agreement with expected values, with the exception of a poor sulfur balance for middle distillate derived from Maya crude (TABLE 6). Additional samples of the Maya middle distillate fraction were evaluated, but no satisfactory explanation for the discrepancy has been identified.

As a general check of distillation efficiency, a material balance was run on the 375°F (190°C) to 530°F (277°C) fraction reported in the crude assay, as complete recovery of this material should be evident in either the naphtha or the diesel fuel fraction. Material balance calculations were made from a combination of total product recovery from distillation operations and the ASTM D 86 distillation curves for the recovered products. The fraction recoveries for both the naphtha and middle distillate are presented in TABLE 4. Actual yields of naphtha were consistently higher than assay because some of the 375° to 530°F fraction was also collected in this cut. This is particularly true of the West Hackberry Sweet and Weeks Island Sour crudes in which the naphtha run temperatures were higher than other runs, based on data in TABLE 3.

The material balance for the middle distillate fractions (375° to 530°F) ranged from 90- to 112-percent recovery. Deviation of these recovery figures from the expected 100 percent can be attributed to measurement errors. Relatively small quantities of each diesel fuel fraction were collected, and the total feed was determined by difference of what remained in the feed tank and the column and the amount collected in the bottoms storage tank. This was compared against the quantity collected as product. The combination of losses in the column and the measurement of relatively small quantities in large tanks added error to the calculations. The other source of data for the material balances is the ASTM D 86 distillation. This method is a less efficient distillation than the ASTM D 2892 and D 1160 methods used for the crude assays and, therefore, is not directly comparable. Considering these error sources, and discounting measurement errors, recovery of the middle distillate fractions matched that documented in the crude assays. Based on the data presented in TABLES 4 and 5, both DF-1 and DF-2 can be refined from SPR crude oil streams. Some upgrading will likely be necessary, however, to ensure that products fully conform to VV-F-800 specifications.

All products exhibited good accelerated stability (D 2274 in Table 5) following treatment with a multifunctional additive. Even in the absence of the additive, seven of the eight products had good accelerated stability, and these trends were confirmed by 80°C storage stability test results (Table 8). The cetane numbers and cetane indexes of all products exceeded the minimum requirements for both DF-1 and DF-2.

While the flash point of West Hackberry Sour was unacceptably low, this product also had the lowest initial boiling point (IBP). Consequently, the flash point could be raised by taking a larger naphtha cut, effectively raising the IBP. The kinematic viscosity of West Hackberry Sour was also the lowest of the eight streams, but an upward adjustment of the naphtha cut-width to raise the flash point and IBP would also raise the viscosity. Copper strip corrosion for the West Hackberry Sour product exceeded the specification maximum, perhaps as a consequence of corrosive mercaptans being present in the lower boiling fraction of the product. This would be consistent with the makeup of the stream that is known to contain crude oil with a relatively high content of mercaptans. Once again, a higher IBP may mitigate this problem for DF-1 and DF-2 products.

All products met DF-2 requirements for carbon residue of the 10-percent bottoms, and only Bryan Mound Maya and Bayou Choctaw Sour products failed to meet the more stringent DF-1 requirements.

The ash content of West Hackberry Sour and Bayou Choctaw Sour products exceeded the DF-1 and DF-2 maximum of 0.01 mass%. The high ash content of these two samples does not appear to be related to the trace elements content of the samples (TABLE 7), as other product samples have higher trace elements but lower ash contents.

In TABLE 6, the deviation between observed and calculated values for aniline point is positive in all cases and represents an apparent bias. This bias results from an assumption of uniform distribution of aromatic compounds throughout the boiling point range of each fraction collected for analysis. In fact, there is no such even distribution across the fractions. Therefore, the calculated "contribution" of aniline point from each fraction whose sum comprises the observed value is directionally low. Thus, the difference between observed and calculated values is directionally high. A similar bias may account for the positive deviation between observed and calculated values for cetane index. As noted earlier, an unexplainably large difference exists between observed and calculated values for sulfur content of the Bryan Mound Maya product.

Iron and other trace elements were present in moderate amounts in the products from all eight SPR crude oil streams (TABLE 7). This is not an unexpected result but is typical of refinery experience wherein an overhead condensor for a distillation tower, or product rundown pipelines, are corroded through contact with hot corrosive vapor, resulting in the presence of scale in products. Certainly, the relatively high iron content of all but the Bryan Mound Sweet product would be expected from corrosion of steel. The high sulfur content of the Bryan Mound Sweet product, relative to other trace elements, may be a manifestation of the product's instability. Bryan Mound Sweet product had, by far, the greatest quantity of total insolubles in the accelerated stability test of untreated samples.

The chlorine present in some samples may result from salt entrained in the crude oil and hydrolyzed during distillation. This commonly occurs in refinery distillation operations and is cause for extensive use of desalting equipment. The copper corrosion value of 3a for the West Hackberry Sour product, the highest of the eight, may have been caused by a combination of the presence of corrosive sulfur and chlorine compounds, such as mercaptans and hydrochloric acid, respectively. The presence of most of the other trace elements can be explained by the presence of scale, salt, and sediment entrained in the crude oil. The presence of tin in one product is inexplicable, but may be due to contamination of the crude during collection or contamination of product during handling.

Normally, salt and sediment are removed at a refinery prior to the crude being processed, which would lower the trace element content of products. Desalting equipment was not, however, available for this project.

Variation among certain fuel properties can be accounted for not only by differences in the crude oil makeup of each of the SPR streams, but also by the wide range of operating conditions employed. For example, middle distillate produced from W. Hackberry Sour crude is close to meeting DF-1 criteria, and examination of the operating conditions shows that the processing used to manufacture this material was indeed quite mild. In other cases, yield of material was nearly maximized, but at the expense of having to sacrifice fuel quality. Fig. 2 and Fig. 3 compare distillation cutpoints to the common specification limits of VV-F-800.

In summary, DF-1 and DF-2 can be made from SPR crude oils, but some upgrading will be necessary to ensure that products meet the requirements for sulfur and corrosion.

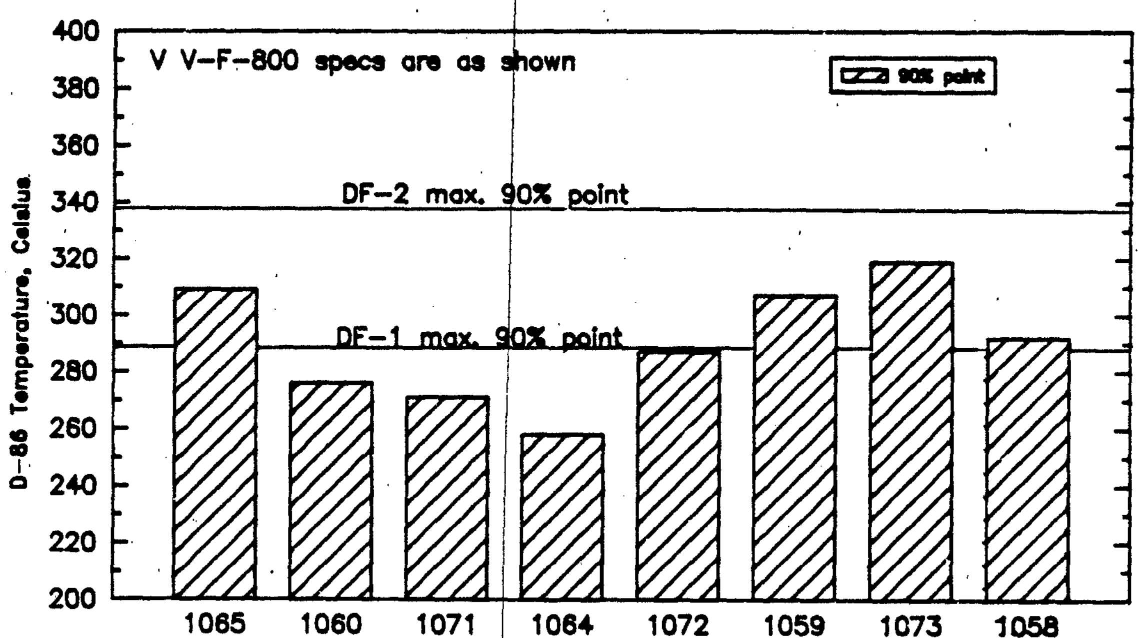

Figure 2. 90% point data for middle distillate fractions from SPR crude

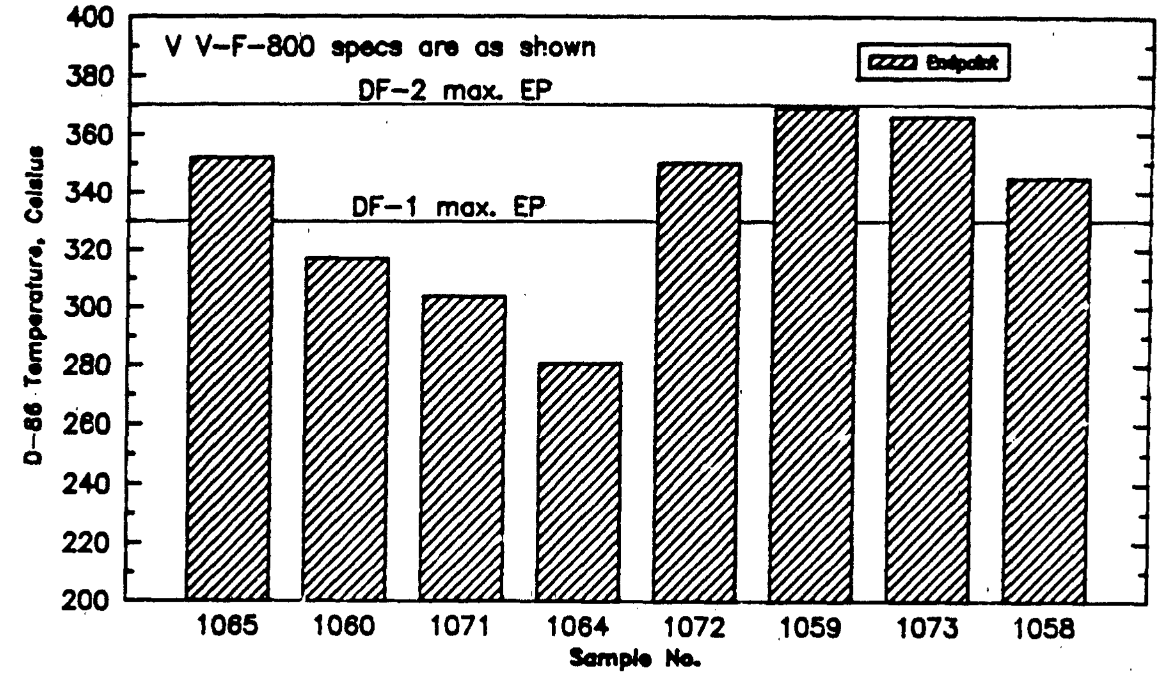

Figure 3. Endpoint data for middle distillate fractions from SPR crude

VII. SUMMARY AND CONCLUSIONS

Diesel fuel fractions were produced from each of the eight Strategic Petroleum Reserve crude oil streams using a pilot-scale distillation column. The usual trade-off between fuel quality and quantity (distillation range) was in evidence throughout the work and reflects the variable operating conditions. Operation over a range of conditions was explored successfully.

The distinction between the ASTM D 86 data (on distillates) as employed in this program and the D 2892 distillations (on crude oil) carried out at NIPER for fractions boiling up to approximately 650°F (343°C) influences the interpretation of data. The former test consists of a single-plate column operated without reflux, while the latter test encompasses 15 theoretical plates and 5:1 reflux ratio. A comparison of data from the two sets of work must be made with this major difference always in mind. Also, the crude oil samples analyzed at NIPER are from the same streams as those used at BFLRF, but the two sets of samples apparently were not collected at the same time. The effect of this difference is considered to be minor.

Overall, the data indicate that diesel fuel produced from these crude oil streams will have a high cetane number. In general, the middle distillates produced by distillation of SPR crude oil can be expected to be stable. Good stability was observed for seven of the eight untreated products. For the one product that exhibited poor stability, the addition of a multifunctional stabilizer additive proved beneficial in that no increase in the formation of deleterious products was observed following additive treatment. Results of fuel storage tests at 80°C were in agreement with the accelerated stability test results obtained by D 2274 and indicated good stability characteristics for the additive-treated products.

Because of operational problems, it was not possible to obtain fuel samples in the quantities originally hoped for and, consequently, it was not possible to perform any full-scale engine evaluations or to upgrade the fuels by hydrotreating.

Nonetheless, the data obtained on the straight-run untreated fuels indicate that transportation fuels conforming to VV-F-800 specifications can be obtained from the SPR crude oil streams. Fuels on the market today which meet VV-F-800 specifications have most likely undergone some upgrading. Therefore, the SPR crude streams and the fuels refined from them are essentially no different than other refinery feedstocks and unfinished product streams. Integrated U.S. refineries producing such fuels have the capability to perform the upgrading necessary to make these fuels fully conform to the specifications. It is likely that high particulates encountered in this work would be eliminated by crude pretreatment and product finishing.

In summary, DF-1 and DF-2 can be made from SPR crude oils. However, some upgrading (e.g., hydrotreating) will be necessary to ensure that products meet specification requirements for sulfur and corrosion that may not be demanded in a field expedient fuel.

VIII. RECOMMENDATIONS

To more fully evaluate the quality of middle distillate fuels (both diesel and jet) that can be obtained from SPR crude oil streams:

- More distillate should be refined from selected crudes
  - --Additional drums of each crude are available
  - --Operating experience gained from this study will allow more efficient distillation;
- Samples should be upgraded by hydrotreating at a variety of severities, especially if jet fuel production is anticipated; and
- Full-scale engine tests should be conducted on both treated and untreated fuels.

IX. LIST OF REFERENCES

1. Status of Strategic Petroleum Activities as of 30 September 1985. A report by the United States General Accounting Office GAO/RCED-86-37, 15 October 1985.
2. Bowden, J.N. and Stavinoha, L.L., "Final Report on Crude and Product Storage: State-of-the-Art Review and Assessment," Interim Report AFLRL No. 110, AD A066605, U.S. Army Fuels and Lubricants Research Laboratory, San Antonio, TX, Contract No. DAAK70-78-C-0001, November 1978.
3. Stavinoha, L.L., Bowden, J.N., Westbrook, S.R., and Giles, H.N., "Final Report on Assessment of Crude Oil and Refined Petroleum Product Quality During Long-Term Storage," Interim Report AFLRL No. 121, AD A082365, U.S. Army Fuels and Lubriants Research Laboratory, San Antonio, TX, Contract Nos. DAAK70-78-C-0001 and DAAK70-80-C-0001, December 1979.
4. Eichelberger, J.R., Stavinoha, L.L., and Giles, H.N., "Final Report on Strategic Petroleum Reserve Crude Oil Data Search File Documentation," Interim Report AFLRL No. 107, U.S. Army Fuels and Lubricants Research Laboratory, San Antonio, TX, Contract No. DAAK70-78-C-0001 and IA No. EL-78-A-01-2815, September 1979.
5. Frame, E.A., Owens, E.C., and Newman, F.M., "Crude Oil Characterization Data Program," Interim Report AFLRL No. 35, AD A005076, U.S. Army Fuels and Lubricants Research Laboratory, San Antonio, TX, Contract No. DAAK02-73-C-0221, July 1974.
6. VV-F-800C; Federal Specification, Fuel Oil, Diesel.
7. Federal Register, Vol. 49, No. 14, pp. 2721-2728, Friday, 20 January 1984.
8. Sefer, N.R. and Bailey, B.K. "Pilot Plant Preparation of High Freezing Point Navy Jet Fuels," Interim Report AFLRL No. 185, AD B094244L, U.S. Army Fuels and Lubricants Research Laboratory, San Antonio, TX, Contract No. DAAK70-85-C-0007, December 1984.

APPENDIX A

1983 ASSAY DATA FROM THE FEDERAL REGISTER

U. S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
CRUDE OIL ANALYSIS

Data current as of December 1, 1983,
but subject to change

STREAM SPR Bryan Mound Sour

TERMINAL Seaway Terminal, Freeport, Texas

WHOLE CRUDE:

Specific Gravity	0.859			RVP, psi	5.0 max.
API Gravity	33.2 ± 1.0			Neutralization No.	<0.15
Sulfur, Wt. %	1.71 ± 0.10	UOP "K" Factor	11.85	Mercaptans, ppm	43
Nitrogen, Wt. %	0.103	Org. Cl, ppm	TBD*	SUS Viscosity (cSt)	
Carbon Residue, Wt. %	4.74	O.D. Color	13,900	77 °F	51 (7.68)
Pour Point, °F	<5	H_2S, ppm	<1.0	100 °F	44 (5.51)

DISTILLATION TO 1000°F:

Fraction	1	2	3	4	5	6	7
Cut Temperature	C5-175°F	175°-250°F	250°-375°F	375°-530°F	530°-650°F	650°-1000°F	Residuum
Vol. %	5.2	8.0	15.8	13.5	13.0	26.1	18.3
Wt. %	4.0	6.7	14.1	12.8	12.9	28.0	21.4
Specific Gravity	0.656	0.718	0.771	0.818	0.855	0.920	1.003
API Gravity	84.2	65.6	52.0	41.5	34.0	22.3	9.6
Sulfur, Wt. %				0.29	1.01	2.23	3.88
Mercaptans, ppm	20	33	126	56			
Cetane Index				49.8	52.4		
Aniline Point, °F				147.0	158.0	175.5	
SUS Visc., °F: 77				34	-	-	
100				32	39	-	
130				-	35	88	
180				-	-	50	
Cloud Point, °F					18	94	
Freeze Point, °F				-31			
Nitrogen, Wt. %					0.034	0.090	0.399
Carbon Residue, Wt. %						0.52	22.20

* TO BE DETERMINED

Exhibit D—SPR Crude Oil Stream Characteristics

U. S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
CRUDE OIL ANALYSIS

Data current as of December 1, 1983,
but subject to change

STREAM SPR Bryan Mound Sweet

TERMINAL Seaway Terminal, Freeport, Texas

WHOLE CRUDE:

Specific Gravity 0.844
API Gravity 36.2 ± 1.0
Sulfur, Wt. % 0.32 ± 0.03
Nitrogen, Wt. % 0.099
Carbon Residue, Wt. % 2.6
Pour Point, °F 35

UOP "K" Factor 11.65
Org. Cl, ppm TBD*
O.D. Color 9100
H_2S, ppm <1.0

RVP, psi 7.8 max.
Neutralization No. <0.14
Mercaptans, ppm 8.4
SUS Viscosity (cSt)
77 °F 53 (8.28)
100 °F 42 (4.88)

DISTILLATION TO 1000°F:

Fraction	1	2	3	4	5	6	7
Cut Temperature	C5-175°F	175°-250°F	250°-375°F	375°-530°F	530°-650°F	650°-1000°F	Residuum
Vol. %	6.2	8.8	13.2*	14.8	14.0	26.2	14.3
Wt. %	4.9	7.8	12.4	14.8	14.5	28.8	16.9
Specific Gravity	0.662	0.733	0.789	0.826	0.856	0.908	0.979
API Gravity	82.4	61.5	47.9	39.3	33.8	24.3	13.1
Sulfur, Wt. %				0.06	0.23	0.45	1.07
Mercaptans, ppm	7.4	14	26	33			
Cetane Index				45.8	52.1		
Aniline Point, °F				143.0	165.8	192.6	
SUS Visc., °F: 77				36	-	-	
100				34	42	-	
130				-	38	130	
180				-	-	62	
Cloud Point, °F					30	100	
Freeze Point, °F				-35.0			
Nitrogen, Wt. %					0.008	0.093	0.461
Carbon Residue, Wt. %						-	16.56

* TO BE DETERMINED

U. S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
CRUDE OIL ANALYSIS

Data current as of December 1, 1983,
but subject to change

STREAM SPR Bryan Mound Maya

TERMINAL Seaway Terminal, Freeport, Texas

WHOLE CRUDE:

Specific Gravity	0.921			RVP, psi	3.[illegible]
API Gravity	22.1 + 0.5			Neutralization No.	0.21
Sulfur, Wt. %	3.25 + 0.22	UOP "K" Factor	11.71	Mercaptans, ppm	53
Nitrogen, Wt. %	0.357	Org. Cl, ppm	3.6	SUS Viscosity (cSt)	
Carbon Residue, Wt. %	10.5	O.D. Color	51,200	[illegible]00 °F	340 (73.6)
Pour Point, °F	<5	H_2S, ppm	<1.0	[illegible] °F	171 (36.55)

DISTILLATION TO 1000°F:

Fraction	1	2	3	4	5	6	7
Cut Temperature	C5-175°F	175°-250°F	250°-375°F	375°-530°F	530°-650°F	650°-1000°F	Residuum
Vol. %	4.7	4.2	10.7	9.7	11.7	22.1	35.8
Wt. %	3.4	3.2	9.0	8.7	[illegible].1	22.4	41.1
Specific Gravity	0.666	0.718	0.769	0.823	0.[illegible]	0.935	1.057
API Gravity	81.0	65.6	52.5	40.4	31.3	19.8	2.4
Sulfur, Wt. %	########	########	########	1.11	2.26	3.01	5.12
Mercaptans, ppm	15	203	352	3	########	########	########
Cetane Index	########	########	########	47.9	[illegible]8.1	########	########
Aniline Point, °F	########	########	########	144.7	152.6	174.2	########
SUS Visc., °F: 77	########	########	########	34	-	-	########
100	########	########	########	32	42	-	########
130	########	########	########	-	37	126	########
180	########	########	########	-	-	60	########
Cloud Point, °F	########	########	########	########	26	100	########
Freeze Point, °F	########	########	########	-29.2	########	########	########
Nitrogen, Wt. %	########	########	########	########	0.052	0.2[illegible]	0.789
Carbon Residue, Wt. %	########	########	########	########	########	0.17	23.6

U. S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
CRUDE OIL ANALYSIS

Data current as of December 1, 1983,
but subject to change

STREAM SPR West Hackberry Sweet

TERMINAL Sun Terminal, Nederland, Texas

WHOLE CRUDE:

Specific Gravity	0.840			RVP, psi	6.2
API Gravity	37.0 ± 0.5			Neutralization No.	0.14
Sulfur, Wt. %	0.34 ± 0.05	UOP "K" Factor	11.90	Mercaptans, ppm	7.4
Nitrogen, Wt. %	0.105	Org. Cl, ppm	TBD*	SUS Viscosity (cSt)	
Carbon Residue, Wt. %	2.19	O.D. Color	8100	77 °F	43 (5.82)
Pour Point, °F	25	H_2S, ppm	<1.0	100 °F	39 (3.94)

DISTILLATION TO 1000°F:

Fraction	1	2	3	4	5	6	7
Cut Temperature	C5-175°F	175°-250°F	250°-375°F	375°-530°F	530°-650°F	650°-1000°F	Residuum
Vol. %	6.9	9.2	14.6	15.2	17.0	25.5	11.5
Wt. %	5.5	8.1	13.8	15.3	17.7	25.9	13.7
Specific Gravity	0.663	0.733	0.779	0.829	0.859	0.913	0.985
API Gravity	82.1	61.5	50.2	39.1	33.3	23.5	12.2
Sulfur, Wt. %				0.09	0.26	0.46	1.13
Mercaptans, ppm	15	32	92	26			
Cetane Index				45.6	51.3		
Aniline Point, °F				146.9	167.1	192.2	
SUS Visc., °F: 77				36	-	-	
100				33	43	-	
130				-	38	117	
180				-	-	58	
Cloud Point, °F					36	115	
Freeze Point, °F				-31.3			
Nitrogen, Wt. %					0.010	0.109	0.548
Carbon Residue, Wt. %						-	16.27

* TO BE DETERMINED

U. S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
CRUDE OIL ANALYSIS

Data current as of December 1, 1983,
but subject to change

STREAM SPR West Hackberry Sour

TERMINAL Sun Terminal, Nederland, Texas

WHOLE CRUDE:

Specific Gravity	0.860			RVP, psi	5.3 max.
API Gravity	33.1 ± 1.0			Neutralization No.	<0.12
Sulfur, Wt. %	1.71 ± 0.10	UOP "K" Factor	12.02	Mercaptans, ppm	19
Nitrogen, Wt. %	0.105	Org. Cl, ppm	TBD*	SUS Viscosity (cSt)	
Carbon Residue, Wt. %	4.04	O.D. Color	TBD	77 °F 59	(10.05)
Pour Point, °F	<30	H_2S, ppm	<1.0	100 °F 53	(8.28)

DISTILLATION TO 1000°F:

Fraction	1	2	3	4	5	6	7
Cut Temperature	C5-175°F	175°-250°F	250°-375°F	375°-530°F	530°-650°F	650°-1000°F	Residuum
Vol. %	5.6	7.6	16.2	14.3	12.9	26.1	17.7
Wt. %	4.4	6.5	16.8	13.9	13.1	26.3	21.0
Specific Gravity	0.661	0.721	0.773	0.822	0.863	0.924	1.011
API Gravity	82.6	64.8	51.6	40.7	32.5	21.6	8.5
Sulfur, Wt. %	########	########	########	0.36	1.12	2.26	3.86
Mercaptans, ppm	20	45	83	65	########	########	########
Cetane Index	########	########	########	48.3	50.0	########	########
Aniline Point, °F	########	########	########	143.2	157.6	180.0	########
SUS Visc., °F: 77	########	########	########	34	-	-	########
100	########	########	########	33	42	-	########
130	########	########	########	-	37	124	########
180	########	########	########	-	-	60	########
Cloud Point, °F	########	########	########	########	21	86	########
Freeze Point, °F	########	########	########	-22.4	########	########	########
Nitrogen, Wt. %	########	########	########	########	0.015	0.104	0.362
Carbon Residue, Wt. %	########	########	########	########	########	TBD	20.29

* TO BE DETERMINED

U. S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
CRUDE OIL ANALYSIS

Data current as of December 1, 1983,
but subject to change

STREAM SPR Bayou Choctaw Sweet

TERMINAL SPR St. James Terminal, St. James, Lousiana

WHOLE CRUDE:

Specific Gravity	0.844			RVP, psi	5.6
API Gravity	36.2 ± 1.0			Neutralization No.	0.09
Sulfur, Wt. %	0.35 ± 0.05	UOP "K" Factor	12.19	Mercaptans, ppm	27
Nitrogen, Wt. %	0.098	Org. Cl, ppm	TBD*	SUS Viscosity (cSt)	
Carbon Residue, Wt. %	2.8	O.D. Color	TBD	77 °F	55 (8.91)
Pour Point, °F	35	H_2S, ppm	<1	100 °F	49 (7.06)

DISTILLATION TO 1000°F:

Fraction	1	2	3	4	5	6	7
Cut Temperature	C5-175°F	175°-250°F	250°-375°F	375°-530°F	530°-650°F	650°-1000°F	Residuum
Vol. %	5.6	9.0	13.6	13.5	14.1	26.6	16.7
Wt. %	4.8	8.0	12.8	13.5	14.5	27.0	19.6
Specific Gravity	0.661	0.734	0.781	0.825	0.851	0.903	0.976
API Gravity	82.5	61.4	49.8	40.0	34.8	25.2	13.5
Sulfur, Wt. %	########	########	########	0.08	0.22	0.46	1.05
Mercaptans, ppm	14.5	22	40	53	########	########	########
Cetane Index	########	########	########	47.1	53.7	########	########
Aniline Point, °F	########	########	########	146.5	167.5	190.3	########
SUS Visc., °F: 77	########	########	########	42	-	-	########
100	########	########	########	39	41	-	########
130	########	########	########	-	37	102	########
180	########	########	########	-	-	55	########
Cloud Point, °F	########	########	########	########	26	99	########
Freeze Point, °F	########	########	########	-35	########	########	########
Nitrogen, Wt. %	########	########	########	########	0.006	0.091	0.492
Carbon Residue, Wt. %	########	########	########	########	########	-	15.2

* TO BE DETERMINED

U. S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
CRUDE OIL ANALYSIS

Data current as of December 1, 1983,
but subject to change

STREAM SPR Bayou Choctaw Sour

TERMINAL SPR St. James Terminal, St. James, Lousiana

WHOLE CRUDE:

Specific Gravity	0.871			RVP, psi	5.30 max.
API Gravity	31.0 ± 1.0			Neutralization No.	<0.12
Sulfur, Wt. %	1.76 ± 0.10	UOP "K" Factor	11.84	Mercaptans, ppm	18
Nitrogen, Wt. %	0.138	Org. Cl, ppm	TBD*	SUS Viscosity (cSt)	
Carbon Residue, Wt. %	4.50	O.D. Color	TBD	77 °F	67 (12.28)
Pour Point, °F	5	H_2S, ppm	<1.0	100 °F	52 (8.10)

DISTILLATION TO 1000°F:

Fraction	1	2	3	4	5	6	7
Cut Temperature	C5-175°F	175°-250°F	250°-375°F	375°-530°F	530°-650°F	650°-1000°F	Residuum
Vol. %	6.0	6.9	15.8	15.4	12.2	24.9	17.7
Wt. %	4.6	5.8	14.3	14.9	12.4	27.0	20.9
Specific Gravity	0.66[illegible]	0.724	0.773	0.824	0.867	0.929	1.017
API Gravity	81.5	63.9	51.5	40.3	31.7	20.9	7.7
Sulfur, Wt. %				0.44	1.26	2.19	3.85
Mercaptans, ppm	TBD	TBD	TBD	TBD			
Cetane Index				47.6	48.8		
Aniline Point, °F				TBD	TBD	TBD	
SUS Visc., °F: 77				34	-	-	
100				32	43	-	
130				-	38	137	
180				-	-	63	
Cloud Point, °F					24	85	
Freeze Point, °F				TBD			
Nitrogen, Wt. %					0.025	0.133	0.478
Carbon Residue, Wt. %						0.15	21.5

* TO BE DETERMINED

U. S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE
CRUDE OIL ANALYSIS

Data current as of December 1, 1983,
but subject to change

STREAM SPR Weeks Island Sour

TERMINAL SPR St. James Terminal, St. James, Louisiana

WHOLE CRUDE:

Specific Gravity 0.878
API Gravity 29.7° ± 0.5°
Sulfur, Wt. % 1.39 ± 0.10
Nitrogen, Wt. % 0.173
Carbon Residue, Wt. % 5.17
Pour Point, °F <5

UOP "K" Factor 11.78
Org. Cl, ppm <1
O.D. Color 28,840
H_2S, ppm <1.0

RVP, psi 4.9
Neutralization No. 0.09
Mercaptans, ppm 16
SUS Viscosity (cSt)
77 °F 76 (14.65)
100 °F 58 (9.76)

DISTILLATION TO 1000°F:

Fraction	1	2	3	4	5	6	7
Cut Temperature	C5-175°F	175°-250°F	250°-375°F	375°-530°F	530°-650°F	650°-1000°F	Residuum
Vol. %	4.3	6.6	12.5	12.6	15.8	25.4	21.7
Wt. %	3.3	5.5	11.2	12.0	15.8	27.0	25.3
Specific Gravity	0.659	0.729	0.778	0.829	0.868	0.927	1.014
API Gravity	83.1	62.7	50.5	39.3	31.5	21.2	8.0
Sulfur, Wt. %				0.31	1.02	1.70	3.14
Mercaptans, ppm	18	23	50	8.1			
Cetane Index				45.9	48.5		
Aniline Point, °F				141.6	156.1	173.1	
SUS Visc., °F: 77				34	-	-	
100				32	44	-	
130				-	38	131	
180				-	-	61	
Cloud Point, °F					29	105	
Freeze Point, °F				-33.6			
Nitrogen, Wt. %					0.015	0.126	0.341
Carbon Residue, Wt. %						0.18	20.65

BILLING CODE 6450-01-C

APPENDIX B

1986 CRUDE ASSAY DATA

U. S. DEPARTMENT OF ENERGY, STRATEGIC PETROLEUM RESERVE

CRUDE OIL ANALYSIS

Stream SPR Bayou Choctaw Sour   Terminal DOE St. James Terminal, St. James, LA

Crude					
Specific Gravity	0.8573	Ni, ppm	8.0(7.5)*	ERVP, psia @ 100° F	5.80
API Gravity	33.6	V, ppm	27.7(27.6)*	Neutralization No.	0.15
Sulfur, Wt. %	1.41	Fe, ppm	Not Detectable (1.5)*	H_2S, ppm (c)*	5.1
Nitrogen, Wt. %	0.144	Org. Cl, ppm (c)*	0.4	Mercaptans, ppm (c)*	4.2
Con. Car. Res., Wt. % (c)*	3.64	O.D. Color	15,900	Viscosity: 77° F	8.38 cSt 53.2 SUS
Pour Point, °F	5	UOP "K"	11.90	100° F	5.88 cSt 45.2 SUS

Fraction		1	2	3	4	5	6	7
Cut Temp.	C[illegible]- C[illegible]	C5- 175° F	175°- 250° F	250°- 375° F	375°- 530° F	530°- 650° F	650°- 1055° F	Residuum
Vol. - mls	180.5	184.6	329.3	585.5	731.4	535.9	1311.8	611.0
Vol. %	4.0	4.1	7.4	13.1	16.4	12.0	29.4	13.7
Vol. Sum %	4.0	8.1	15.5	28.6	45.0	57.0	86.4	100.1
Wt. - grams	108.3	124.8	238.9	451.5	598.6	461.0	1213.4	626.9
Wt. %	2.8	3.3	6.2	11.8	15.6	12.0	31.7	16.4
Specific Gravity	0.6	0.6761	0.7255	0.7712	0.8184	0.8603	0.9250	1.026
API Gravity		77.8	63.5	52.0	41.4	33.0	21.5	8.2
Sulfur, Wt. %		0.010	0.010	0.039	0.32	1.01	2.10	3.57
Mercaptans, ppm		<1	50.3	<1	7.1			
H_2S, ppm		31.3	3.8	32.4	<1			
Organic Cl, ppm		1.7	1.7	2.1				
Aniline Point, °F				125.8	144.3	160.5	179.4	
Neutralization No.					0.04	0.07		
Cetane Index					49.62	50.79		
Naphthalenes, vol. %					4.06	11.37		
Smoke point					19.1	14.0		
Nitrogen, Wt. %					0.0006	0.013	0.154	0.582
Viscosity:								
cSt (SUS) 77° F					2.25(33.5)			
100° F					1.79 (<32.0)	4.85(41.9)		
130° F						3.32(37.1)	29.45(139.4)	
180° F							11.30(63.7)	
210° F								2864(13359)
250° F								665.9(3113)
Freezing Point, °F					-31.9			
Cloud Point, °F						22	106	
Pour Point, °F						20	90	
Ni, ppm							Not Detectable	45.6
V, ppm							Not Detectable	168
Fe, ppm							Not Detectable	8.9
Con. Car. Res., Wt. %							--	22.2

Data current as of September 19, 1986, but subject to change.

* (c), calculated from fraction results.

Whole crude lead content: 0.022 ppm.

	C_5-175°F	C_5-375°F
Research Octane Number:	63.5	44.6
Motor Octane Number:	59.4	42.5

Gas Chromatographic Analysis

SPR BAYOU CHOCTAW SOUR

	Distillate fractions, ASTM D 2892			
	C_5-175° F Vol. %	175-250° F Vol. %	250-375° F Vol. %	375-420° F Vol. %
* Total Paraffins	46.0	33.4	TBD+	TBD
Total Iso-paraffins	40.3	33.5		
Total Aromatics	2.5	7.6		
Total Naphthenes	12.2	25.5		
Total Olefins	0.0	0.0		
Total Unknowns	0.0	0.0		
Paraffins: C1	0.0	0.0		
C2	0.0	0.0		
C3	0.0	0.0		
C4	0.4	0.0		
C5	15.0	0.4		
C6	28.6	5.6		
C7	1.0	19.4		
C8	0.0	7.9		
C9	0.0	0.0		
C10	0.0	0.0		
C11	0.0	0.0		
C12	0.0	0.0		
Iso-paraffins: C4	0.0	0.0		
C5	5.7	0.1		
C6	29.8	2.7		
C7	4.8	16.0		
C8	0.0	13.7		
C9	0.0	1.1		
C10	0.0	0.0		
C11	0.0	0.0		
Aromatics: C6	2.0	0.7		
C7	0.5	5.5		
C8	0.0	1.4		
C9	0.0	0.0		
C10	0.0	0.0		
C11	0.0	0.0		
C12	0.0	0.0		
Naphthenes: C5	2.0	0.1		
C6	9.0	4.6		
C7	1.2	13.4		
C8	0.0	7.1		
C9	0.0	0.0		
C10	0.0	0.0		
C11	0.0	0.0		
C12	0.0	0.0		
Olefins: C4	0.0	0.0		
C5	0.0	0.0		
C6	0.0	0.0		
C7	0.0	0.0		
C8	0.0	0.0		

Debutanization Fraction	
Component	Vol. %
Methane	–
Ethane	0.1
Propane	10.8
i-Butane	7.7
n-Butane	31.5
i-Pentane	19.8
n-Pentane	24.2
C_6+	5.9

Whole Crude B-T-X

Component	Vol.%
Benzene	0.134
Toluene	0.428
Ethylbenzene	0.037
Xylenes	0.064

* The gas chromatographic PIANO method used provides for elution and identification of compc ients up to a nominal n-C_{12} (420° F)

+To be determined.

U. S. DEPARTMENT OF ENERGY, STRATEGIC PETROLEUM RESERVE

CRUDE OIL ANALYSIS

Stream SPR Bayou Choctaw Sweet Terminal DOE St. James Terminal, St. James, LA

Crude

Specific Gravity	0.8424	Ni, ppm	4.4(4.4)*	ERVP, psia @ 100° F	8.10
API Gravity	36.5	V, ppm	7.0(7.4)*	Neutralization No.	0.12
Sulfur, Wt. %	0.40	Fe, ppm	2.1(3.3)*	H_2S, ppm (c)*	2.2
Nitrogen, Wt. %	0.127	Org. Cl, ppm (c)*	0.4	Mercaptans, ppm (c)*	3.8
Con. Car. Res., Wt. % (c)*	2.53	O.D. Color	14,000	Viscosity: 77° F	6.86 cSt 48.2 SUS
Pour Point, °F	30	UOP "K"	12.05	100° F	4.90 cSt 42.1 SUS

Fraction		1	2	3	4	5	6	7
Cut Temp.	C_4-C_5	C5-175° F	175°-250° F	250°-375° F	375°-530° F	530°-650° F	650°-1051 °F	Residuum
Vol. - mls	259.0	236.7	403.7	600.9	755.8	565.4	1456.9	570.0
Vol. %	5.3	4.9	8.3	12.4	15.6	11.7	30.1	11.8
Vol. Sum %	5.3	10.2	18.5	30.9	46.5	58.2	88.3	100.1
Wt. - grams	155.4	161.6	298.0	466.2	622.4	482.2	1322.0	568.9
Wt. %	3.8	4.0	7.3	11.4	15.3	11.8	32.4	13.9
Specific Gravity	0.6	0.6826	0.7382	0.7759	0.8235	0.8528	0.9074	0.998
API Gravity		75.8	60.2	50.9	40.3	34.4	24.4	10.3
Sulfur, Wt. %		0.004	0.002	0.011	0.06	0.26	0.54	1.26
Mercaptans, ppm		8.0	<1	<1	23.0			
H_2S, ppm		<1	6.3	15.4	<1			
Organic Cl, ppm		2.9	1.8	1.3				
Aniline Point, °F				126.0	144.8	167.3	195.4	
Neutralization No.					0.04	0.08		
Cetane Index					47.62	53.05		
Naphthalenes, vol. %					4.40	9.12		
Smoke point					18.6	16.6		
Nitrogen, Wt. %					0.0003	0.006	0.136	0.630
Viscosity:								
cSt (SUS) 77° F					2.33(33.7)			
100° F					1.85(32.1)	4.89(42.0)		
130° F						3.33(37.1)	25.93(123.6)	
180° F							10.42(60.6)	
210° F								1227.9([illegible])
250° F								326.4 (1526)
Freezing Point, °F					-31.9			
Cloud Point, °F						28	114	
Pour Point, °F						25	100	
Ni, ppm							Not Detectable	31.9
V, ppm							Not Detectable	53.3
Fe, ppm							Not Detectable	23.6
Con. Car. Res., Wt. %							--	18.2

Data current as of September 19, 1986, but subject to change.

* (c), calculated from fraction results.

Whole crude lead content: 0.006 ppm.

	C_5-175°F	C_5-375°F
Research Octane Number:	68.4	51.7
Motor Octane Number:	64.1	48.2

Gas Chromatographic Analysis

SPR BAYOU CHOCTAW SWEET

		Distillate fractions, ASTM D 2892			
		C_6-175° F Vol. %	175-250° F Vol. %	250-375° F Vol. %	375-420° F Vol. %
* Total Paraffins		41.6	25.4	TBD+	TBD
Total Iso-paraffins		36.4	24.7		
Total Aromatics		3.1	7.7		
Total Naphthenes		18.9	42.0		
Total Olefins		0.0	0.0		
Total Unknowns		0.0	0.1		
Paraffins:	C1	0.0	0.0		
	C2	0.0	0.0		
	C3	0.0	0.0		
	C4	1.2	0.0		
	C5	17.3	0.3		
	C6	22.4	4.1		
	C7	0.7	14.6		
	C8	0.0	6.4		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Iso-paraffins:	C4	0.1	0.0		
	C5	8.1	0.1		
	C6	24.5	2.0		
	C7	3.6	12.2		
	C8	0.0	9.4		
	C9	0.0	0.9		
	C10	0.0	0.0		
	C11	0.0	0.0		
Aromatics:	C6	2.6	0.9		
	C7	0.6	5.6		
	C8	0.0	1.2		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Naphthenes:	C5	2.7	0.2		
	C6	14.2	8.3		
	C7	2.0	23.0		
	C8	0.0	10.5		
	C9	0.0	0.1		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Olefins:	C4	0.0	0.0		
	C5	0.0	0.0		
	C6	0.0	0.0		
	C7	0.0	0.0		
	C8	0.0	0.0		

Debutanization Fraction	
Component	Vol. %
Methane	–
Ethane	0.0
Propane	11.6
i-Butane	8.8
n-Butane	36.5
i-Pentane	18.1
n-Pentane	20.3
C_6+	4.6

Whole Crude B-T-X

Component	Vol.%
Benzene	0.202
Toluene	0.494
Ethylbenzene	0.033
Xylenes	0.064

* The gas chromatographic PIANO method used provides for elution and identification of components up to a nominal n-C_{12} (420° F)
+To be determined.

U. S. DEPARTMENT OF ENERGY, STRATEGIC PETROLEUM RESERVE

CRUDE OIL ANALYSIS

Stream SPR Bryan Mound Maya Terminal Phillips Terminal, Freeport, TX

Crude					
Specific Gravity	0.9166	Ni, ppm	58.4(62.4)*	ERVP, psia @ 100° F	5.15
API Gravity	22.9	V, ppm	263 (263)*	Neutralization No.	0.22
Sulfur, Wt. %	3.13	Fe, ppm	2.9 (0.9)*	H_2S, ppm (c)*	1.1
Nitrogen, Wt. %	0.356	Org. Cl, ppm (c)*	0.3	Mercaptans, ppm (c)*	17.7
Con. Car. Res., Wt. % (c)*	11.19	O.D. Color	69.450	Viscosity: 77° F 128.11 cSt	593 SUS
Pour Point, °F	0	UOP "K"	11.75	100° F 61.78 cSt	287 SUS

Fraction		1	2	3	4	5	6	7
Cut Temp.	C_4-C_4	C5-175° F	175°-250° F	250°-375° F	375°-530° F	530°-650° F	650°-1014° F	Residuum
Vol. - mls	71.0	140.3	220.2	421.6	473.8	404.2	1104.7	1317.2
Vol. %	1.7	3.4	5.3	10.2	11.4	9.7	26.6	31.7
Vol. Sum %	1.7	5.1	10.4	20.6	32.0	41.7	68.3	100.0
Wt. - grams	42.6	94.8	159.9	325.4	390.9	351.4	1034.7	1405.5
Wt. %	1.1	2.5	4.2	8.5	10.3	9.2	27.2	36.9
Specific Gravity	0.6	0.6755	0.7263	0.7719	0.8251	0.8693	0.9366	1.067
API Gravity		78.0	63.3	51.8	40.0	31.3	19.6	1.1
Sulfur, Wt. %		0.010	0.018	0.291	0.95	2.00	2.97	5.52
Mercaptans, ppm		82.0	113.6	127.6	<1			
H_2S, ppm		2.9	2.4	5.3	5.0			
Organic Cl, ppm		1.8	1.9	1.8				
Aniline Point, °F				128.7	141.7	151.9	163.4	
Neutralization No.					0.03	0.06		
Cetane Index					47.09	48.14		
Naphthalenes, vol. %					4.16	10.98		
Smoke point					16.0	13.3		
Nitrogen, Wt. %					0.0016	0.030	0.232	0.7[illegible]
Viscosity:								
cSt (SUS) 77° F					2.33(33.7)			
100° F					1.86(32.1)	4.92(42.1)		
130° F						3.32(37.1)	33.89(159.3)	
180° F							12.23(67.1)	
210° F								495874(2.31x10^6)
250° F								42772 (1999[illegible])
Freezing Point, °F					-31.9			
Cloud Point, °F						24	106	
Pour Point, °F						20	90	
Ni, ppm							Not Detectable	169
V, ppm							Not Detectable	711
Fe, ppm							Not Detectable	2.4
Con. Car. Res., Wt. %							0.45	30.[illegible]

Data current as of September 19, 1986, but subject to change.

* (c), calculated from fraction results.

Whole crude lead content: 0.008 ppm.

	C_5-175°F	C_5-375°F
Research Octane Number:	64.4	41.5
Motor Octane Number:	60.7	41.3

Gas Chromatographic Analysis

SPR BRYAN MOUND MAYA

		Distillate fractions, ASTM D 2892			
		C_5-175° F Vol. %	175-250° F Vol. %	250-375° F Vol. %	375-420° F Vol. %
* Total Paraffins		48.0	33.5	TBD+	TBD
Total Iso-paraffins		37.2	31.3		
Total Aromatics		3.1	7.8		
Total Naphthenes		11.7	27.0		
Total Olefins		0.0	0.0		
Total Unknowns		0.0	0.0		
Paraffins:	C1	0.0	0.0		
	C2	0.0	0.0		
	C3	0.1	0.0		
	C4	1.1	0.0		
	C5	20.2	0.7		
	C6	25.4	4.5		
	C7	1.3	19.0		
	C8	0.0	9.1		
	C9	0.0	0.1		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Iso-paraffins:	C4	0.2	0.0		
	C5	8.5	0.3		
	C6	24.0	2.5		
	C7	4.5	14.2		
	C8	0.0	13.5		
	C9	0.0	1.4		
	C10	0.0	0.0		
	C11	0.0	0.0		
Aromatics:	C6	2.0	0.8		
	C7	1.1	5.2		
	C8	0.0	1.8		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Naphthenes:	C5	2.0	0.2		
	C6	8.4	4.3		
	C7	1.4	13.1		
	C8	0.0	9.4		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Olefins:	C4	0.0	0.0		
	C5	0.0	0.0		
	C6	0.0	0.0		
	C7	0.0	0.0		
	C8	0.0	0.0		

Debutanization Fraction	
Component	Vol. %
Methane	–
Ethane	0.1
Propane	13.0
i-Butane	8.9
n-Butane	40.8
i-Pentane	15.0
n-Pentane	16.6
C_6+	5.6

Whole Crude B-T-X

Component	Vol. %
Benzene	0.110
Toluene	0.313
Ethylbenzene	0.029
Xylenes	0.057

* The gas chromatographic PIANO method used provides for elution and identification of components up to a nominal n-C_{12} (420° F)

+To be determined.

U. S. DEPARTMENT OF ENERGY, STRATEGIC PETROLEUM RESERVE

CRUDE OIL ANALYSIS

Stream SPR Bryan Mound Sour Terminal Phillips Terminal, Freeport, TX

Crude					
Specific Gravity	0.8683	Ni, ppm	11.3(15.4)*	ERVP, psia @ 100° F	3.40
API Gravity	31.5	V, ppm	50.9(60.6)*	Neutralization No.	0.08
Sulfur, Wt. %	1.60	Fe, ppm	Not Detectable	H_2S, ppm (c)*	0.8
Nitrogen, Wt. %	0.149	Org. Cl, ppm (c)*	1.1	Mercaptans, ppm (c)*	12.1
Con. Car. Res., Wt. % (c)*	4.81	O.D. Color	25,540	Viscosity: 77° F 11.4 cSt	63.7 SUS
Pour Point, °F	0	UOP "K"	11.85	100° F 7.44 cSt	50.2 SUS

Fraction		1	2	3	4	5	6	7
Cut Temp.	C_4-C_4	C5-175° F	175°-250° F	250°-375° F	375°-530° F	530°-650° F	650°-1061 °F	Residuum
Vol. - mls	23.8	133.6	271.6	522.8	634.3	459.2	1160.7	597.4
Vol. %	0.6	3.5	7.0	13.6	16.5	11.9	30.1	15.5
Vol. Sum %	0.6	4.[illegible]	11.[illegible]	24.7	41.2	53.1	83.2	98.7
Wt. - grams	14.3	90.1	197.0	403.6	518.8	395.1	1074.0	618.9
Wt. %	0.4	2.7	5.9	12.1	15.3	11.8	32.1	18.5
Specific Gravity	0.6	0.6743	0.7254	0.7720	0.8179	0.8605	0.9253	1.036
API Gravity		78.4	63.6	51.8	41.5	32.9	21.4	5.1
Sulfur, Wt. %		0.002	0.005	0.046	0.42	1.14	2.08	3.88
Mercaptans, ppm		24.4	41.3	74.2	<1			
H_2S, ppm		2.1	2.3	5.4	10.9			
Organic Cl, ppm		1.6	4.7	6.2				
Aniline Point, °F				126.7	144.9	160.4	178.9	
Neutralization No.					0.02	0.01		
Cetane Index					49.81	50.63		
Naphthalenes, vol. %					3.95	11.02		
Smoke point					16.6	14.2		
Nitrogen, Wt. %					0.0009	0.017	0.166	0.[illegible]
Viscosity:								
cSt (SUS) 77° F					2.26(33.4)			
100° F					1.79 (<32.0)	4.80(41.8)		
130° F						3.20(37.0)	29.30(138.7)	
180° F							11.05(62.9)	
210° F								9002([illegible])
250° F								1737([illegible])
Freezing Point, °F					-31.0			
Cloud Point, °F						24	112	
Pour Point, °F						20	95	
Ni, ppm							Not Detectable	83.[illegible]
V, ppm							Not Detectable	32[illegible]
Fe, ppm							Not Detectable	Not Detectable
Con. Car. Res., Wt. %							--	2[illegible]

Data current as of September 19, 1986 but subject to change.

* (c), calculated from fraction results.

Whole crude lead content: 0.002 ppm.

	C_5-175°F	C_5-375°F
Research Octane Number:	64.6	41.3
Motor Octane Number:	60.7	40.5

Gas Chromatographic Analysis

SPR BRYAN MOUND SOUR

		Distillate fractions, ASTM D 2892			
		C_5-175° F Vol. %	175-250° F Vol. %	250-375° F Vol. %	375-420° F Vol. %
* Total Paraffins		46.9	34.3	TBD+	TBD
Total Iso-paraffins		38.4	31.6		
Total Aromatics		2.7	7.9		
Total Naphthenes		12.0	26.2		
Total Olefins		0.0	0.0		
Total Unknowns		0.0	0.0		
Paraffins:	C1	0.0	0.0		
	C2	0.0	0.0		
	C3	0.0	0.0		
	C4	0.3	0.0		
	C5	17.2	0.4		
	C6	28.9	5.8		
	C7	1.4	19.5		
	C8	0.0	8.6		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Iso-paraffins:	C4	0.0	0.0		
	C5	6.7	0.2		
	C6	27.6	2.6		
	C7	5.1	15.2		
	C8	0.0	13.3		
	C9	0.0	0.4		
	C10	0.0	0.0		
	C11	0.0	0.0		
Aromatics:	C3	1.9	0.8		
	C7	0.8	5.6		
	C8	0.0	1.5		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Naphthenes:	C5	2.0	0.1		
	C6	8.5	4.8		
	C7	1.5	13.2		
	C8	0.0	8.1		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Olefins:	C4	0.0	0.0		
	C5	0.0	0.0		
	C6	0.0	0.0		
	C7	0.0	0.0		
	C8	0.0	0.0		

Debutanization Fraction	
Component	Vol. %
Methane	–
Ethane	0.0
Propane	6.8
i-Butane	7.8
n-Butane	32.7
i-Pentane	22.6
n-Pentane	24.0
C_6+	6.0

Whole Crude B-T-X

Component	Vol.%
Benzene	0.123
Toluene	0.420
Ethylbenzene	0.035
Xylenes	0.071

* The gas chromatographic PIANO method used provides for elution and identification of components up to a nominal n-C_{12} (420° F)

+To be determined.

U. S. DEPARTMENT OF ENERGY, STRATEGIC PETROLEUM RESERVE

CRUDE OIL ANALYSIS

Stream SPR Bryan Mound Sweet   Terminal Phillips Terminal, Freeport, TX

Crude

Specific Gravity	0.8449	Ni, ppm	5.1(5.3)*	ERVP, psia @ 100° F	5.60
API Gravity	36.0	V, ppm	2.4(3.2)*	Neutralization No.	0.06
Sulfur, Wt. %	0.32	Fe, ppm	4.3(4.1)*	H_2S, ppm (c)*	8.4
Nitrogen, Wt. %	0.122	Org. Cl, ppm (c)*	0.7	Mercaptans, ppm (c)*	0.4
Con. Car. Res., Wt. % (c)*	2.20	O.D. Color	11,450	Viscosity: 77° F	7.93 cSt 51.7 SUS
Pour Point, °F	40	UOP "K"	12.00	100° F	4.89 cSt 42.0 SUS

Fraction		1	2	3	4	5	6	7
Cut Temp.	C_3-C_4	C5-175° F	175°-250° F	250°-375° F	375°-530° F	530°-650° F	650°-1035 °F	Residuum
Vol. - mls	106.2	159.2	291.0	452.7	586.6	455.5	1020.1	416.2
Vol. %	3.0	4.6	8.3	13.0	16.8	13.0	29.2	11.9
Vol. Sum %	3.0	7.6	15.9	28.9	45.7	58.7	87.9	99.8
Wt. - grams	63.7	108.8	214.2	350.9	484.0	389.0	927.4	412.0
Wt. %	2.2	3.7	7.3	11.9	16.4	13.2	31.4	14.0
Specific Gravity	0.6	0.6835	0.7362	0.7752	0.8251	0.8540	0.9091	0.990
API Gravity		75.5	60.7	51.0	40.0	34.2	24.1	11.4
Sulfur, Wt. %		0.003	0.002	0.016	0.08	0.26	0.54	1.02
Mercaptans, ppm		9.9	<1	<1	<1			
H_2S, ppm		<1	10.6	27.1	26.9			
Organic Cl, ppm		2.2	3.8	3.2				
Aniline Point, °F				127.4	145.4	166.4	192.9	
Neutralization No.					0.04	0.09		
Cetane Index					47.09	52.72		
Naphthalenes, vol. %					4.51	8.74		
Smoke point					16.8	14.7		
Nitrogen, Wt. %					0.0004	0.007	0.142	[illegible]
Viscosity:								
cSt (SUS) 77° F					7.40(50.0)			
100° F					1.85(32.1)	4.93(42.2)		
130° F						3.37(37.3)	25.07(119.9)	
180° F							10.03(59.3)	
210° F								884.6([illegible]
250° F								247.3([illegible]
Freezing Point, °F					-31.0			
Cloud Point, °F						26	118	
Pour Point, °F						25	100	
Ni, ppm							Not Detectable	[illegible]
V, ppm							Not Detectable	[illegible]
Fe, ppm							Not Detectable	[illegible]
Con. Car. Res., Wt. %							--	[illegible]

Data current as of September 19, 1986, but subject to change.

* (c), calculated from fraction results.

Whole crude lead content: 0.006 ppm.

	C_5-175°F	C_5-375°F
Research Octane Number:	70.9	52.6
Motor Octane Number:	67.2	48.6

Gas Chromatographic Analysis

SPR BRYAN MOUND SWEET

		Distillate fractions, ASTM D 2892			
		C_6-175° F Vol. %	175-250° F Vol. %	250-375° F Vol. %	375-420° F Vol. %
* Total Paraffins		43.1	23.8	TBD+	TBD
Total Iso-paraffins		36.0	25.5		
Total Aromatics		2.4	5.6		
Total Naphthenes		18.5	45.1		
Total Olefins		0.0	0.0		
Total Unknowns		0.0	0.0		
Paraffins:	C1	0.0	0.0		
	C2	0.0	0.0		
	C3	0.0	0.0		
	C4	1.4	0.1		
	C5	18.5	0.4		
	C6	22.4	4.2		
	C7	0.8	14.4		
	C8	0.0	4.8		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Iso-paraffins:	C4	0.0	0.0		
	C5	8.9	0.2		
	C6	24.2	2.1		
	C7	2.9	12.7		
	C8	0.0	10.5		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
Aromatics:	C6	2.0	0.7		
	C7	0.4	4.3		
	C8	0.0	0.7		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Naphthenes:	C5	2.1	0.1		
	C6	14.3	8.2		
	C7	2.1	24.7		
	C8	0.0	12.0		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Olefins:	C4	0.0	0.0		
	C5	0.0	0.0		
	C6	0.0	0.0		
	C7	0.0	0.0		
	C8	0.0	0.0		

Debutanization Fraction	
Component	Vol. %
Methane	–
Ethane	0.0
Propane	13.8
i-Butane	11.9
n-Butane	39.4
i-Pentane	18.0
n-Pentane	15.1
C_6+	1.8

Whole Crude B-T-X

Component	Vol. %
Benzene	0.150
Toluene	0.375
Ethylbenzene	0.020
Xylenes	0.034

* The gas chromatographic PIANO method used provides for elution and identification of components up to a nominal n-C_{12} (420° F).

+To be determined.

U. S. DEPARTMENT OF ENERGY, STRATEGIC PETROLEUM RESERVE

CRUDE OIL ANALYSIS

Stream SPR Weeks Island Sour Terminal DOE St. James Terminal, St. James, LA

Crude					
Specific Gravity	0.8821	Ni, ppm	14.0(15.6)*	ERVP, psia @ 100° F	4.85
API Gravity	28.9	V, ppm	39.2(42.5)*	Neutralization No.	0.19
Sulfur, Wt. %	1.32	Fe, ppm	0.7 (1.5)*	H_2S, ppm (c)*	0.3
Nitrogen, Wt. %	0.216	Org. Cl, ppm (c)*	0.3	Mercaptans, ppm (c)*	6.3
Con. Car. Res., Wt. % (c)*	4.97	O.D. Color	25,150	Viscosity: 77° F	18.02 cSt 89.5 SUS
Pour Point, °F	15	UOP "K"	11.85	100° F	11.43 cSt 63.9 SUS

Fraction		1	2	3	4	5	6	7
Cut Temp.	C_4-C_4	C5-175° F	175°-250° F	250°-375° F	375°-530° F	530°-650° F	650°-1029° F	Residuum
Vol. - mls	117.7	132.0	252.0	455.6	642.3	526.7	1330.0	835.3
Vol. %	2.7	3.1	5.9	10.6	15.0	12.3	31.0	19.5
Vol. Sum %	2.7	5.8	11.7	22.3	37.3	49.6	80.6	100.1
Wt. - grams	70.6	91.3	185.7	354.3	533.0	458.2	1233.7	855.3
Wt. %	1.9	2.4	4.9	9.3	14.1	12.1	32.6	22.6
Specific Gravity	0.6	0.6918	0.7370	0.7777	0.8298	0.8699	0.9276	1.024
API Gravity		73.0	60.5	50.4	39.0	31.2	21.0	6.7
Sulfur, Wt. %		0.054	0.004	0.043	0.29	0.85	1.58	3.00
Mercaptans, ppm		10.2	17.4	41.8	9.0			
H_2S, ppm		<1	2.5	2.3	<1			
Organic Cl, ppm		2.8	2.1	1.7				
Aniline Point, °F				119.6	137.4	152.9	173.3	
Neutralization No.					0.06	0.07		
Cetane Index					45.31	47.98		
Naphthalenes, vol. %					4.75	11.77		
Smoke point					15.5	12.7		
Nitrogen, Wt. %					0.0006	0.013	0.173	0.59[illegible]
Viscosity:								
cSt (SUS) 77° F					2.31(33.7)			
100° F					1.85(32.1)	5.17(42.9)		
130° F						3.48(37.6)	30.96(146.1)	
180° F							11.58(64.8)	
210° F								4201([illegible])
250° F								935.8(4375)
Freezing Point, °F					-33.7			
Cloud Point, °F						20	104	
Pour Point, °F						20	90	
Ni, ppm							Not Detectable	69.3
V, ppm							Not Detectable	133
Fe, ppm							Not Detectable	6.5
Con. Car. Res., Wt. %							0.34	[illegible]

Data current as of September 19, 1986, but subject to change.

* (c), calculated from fraction results.

Whole crude lead content: 0.014 ppm.

	C_5-175°F	C_5-375°F
Research Octane Number:	65.8	50.0
Motor Octane Number:	62.4	47.3

Gas Chromatographic Analysis

SPR WEEKS ISLAND SOUR

		Distillate fractions, ASTM D 2892			
		C_5-175° F Vol. %	175-250° F Vol. %	250-375° F Vol. %	375-420° F Vol. %
* Total Paraffins		41.0	27.7	TBD+	TBD
Total Iso-paraffins		36.6	27.5		
Total Aromatics		4.4	10.0		
Total Naphthenes		18.0	34.7		
Total Olefins		0.0	0.0		
Total Unknowns		0.0	0.0		
Paraffins:	C1	0.0	0.0		
	C2	0.0	0.0		
	C3	0.0	0.0		
	C4	0.2	0.0		
	C5	14.4	0.3		
	C6	25.4	4.7		
	C7	1.1	16.3		
	C8	0.0	6.4		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Iso-paraffins:	C4	0.0	0.0		
	C5	5.0	0.1		
	C6	26.9	2.0		
	C7	4.6	13.3		
	C8	0.0	11.2		
	C9	0.0	0.9		
	C10	0.0	0.0		
	C11	0.0	0.0		
Aromatics:	C6	3.7	1.4		
	C7	0.7	7.4		
	C8	0.0	1.2		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Naphthenes:	C5	2.9	0.1		
	C6	13.1	7.3		
	C7	2.0	18.8		
	C8	0.0	8.5		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Olefins:	C4	0.0	0.0		
	C5	0.0	0.0		
	C6	0.0	0.0		
	C7	0.0	0.0		
	C8	0.0	0.0		

Debutanization Fraction	
Component	Vol. %
Methane	–
Ethane	0.2
Propane	13.2
i-Butane	8.0
n-Butane	32.4
i-Pentane	17.9
n-Pentane	21.6
C_6+	6.6

Whole Crude B-T-X

Component	Vol.%
Benzene	0.197
Toluene	0.458
Ethylbenzene	0.025
Xylenes	0.048

* The gas chromatographic PIANO method used provides for elution and identification of components up to a nominal n-C_{12} (420° F)

+To be determined.

U. S. DEPARTMENT OF ENERGY, STRATEGIC PETROLEUM RESERVE

CRUDE OIL ANALYSIS

Stream SPR West Hackberry Sour Terminal Sun Marine Terminal, Nederland, TX

Crude

Specific Gravity	0.8599	Ni, ppm	6.5(6.6)*	ERVP, psia @ 100° F	4.10
API Gravity	33.1	V, ppm	25.9(24.7)*	Neutralization No.	0.12
Sulfur, Wt. %	1.40	Fe, ppm	5.8(6.1)*	H_2S, ppm (c)*	1.2
Nitrogen, Wt. %	0.140	Org. Cl, ppm (c)*	0.4	Mercaptans, ppm (c)*	23.7
Con. Car. Res., Wt. % (c)*	3.75	O.D. Color	18,300	Viscosity: 77° F	8.88 cSt 54.9 SUS
Pour Point, °F	<-5	UOP "K"	11.90	100° F	6.27 cSt 46.4 SUS

Fraction		1	2	3	4	5	6	7
Cut Temp.	C_4-C_5	C5-175° F	175°-250° F	250°-375° F	375°-530° F	530°-650° F	650°-1050° F	Residuum
Vol. - mls	128.5	192.7	324.5	591.7	709.0	523.3	1265.3	635.9
Vol. %	2.9	4.4	7.4	13.6	16.3	12.0	29.0	14.6
Vol. Sum %	2.9	7.3	14.7	28.3	44.6	56.6	85.6	100.2
Wt. - grams	77.1	130.4	235.2	455.4	579.0	449.6	1166.5	646.7
Wt. %	2.1	3.5	6.3	12.1	15.4	12.0	31.1	17.2
Specific Gravity	0.6	0.6766	0.7249	0.7696	0.8167	0.8591	0.9219	1.017
API Gravity		77.6	63.7	52.4	41.8	33.2	22.0	7.6
Sulfur, Wt. %		0.020	0.010	0.040	0.32	1.02	1.96	[illegible]
Mercaptans, ppm		<1	43.1	120.4	41.4			
H_2S, ppm		16.8	3.7	3.2	<1			
Organic Cl, ppm		1.9	1.6	1.7				
Aniline Point, °F				128.0	145.8	162.5	180.5	
Neutralization No.					0.04	0.07		
Cetane Index					50.36	51.11		
Naphthalenes, vol. %					3.97	11.49		
Smoke point					20.1	15.3		
Nitrogen, Wt. %					0.0005	0.013	0.146	[illegible]
Viscosity:								
cSt (SUS) 77° F					2.24(33.4)			
100° F					1.78 (<32.0)	4.87(42.0)		
130° F						3.32(37.1)	27.65(131.3)	
180° F							10.82(62.0)	
210° F								2210([illegible])
250° F								529.6([illegible])
Freezing Point, °F					-31.9			
Cloud Point, °F						22	104	
Pour Point, °F						20	50	
Ni, ppm							Not Detectable	[illegible]
V, ppm							Not Detectable	[illegible]
Fe, ppm							Not Detectable	[illegible]
Con. Car. Res., Wt. %							--	[illegible]

Data current as of September 19, 1986, but subject to change.

* (c), calculated from fraction results.

Whole crude lead content: 0.025 ppm.

	C_5-175°F	C_5-375°F
Research Octane Number:	62.9	43.6
Motor Octane Number:	59.6	40.9

Gas Chromatographic Analysis

SPR WEST HACKBERRY SOUR

		Distillate fractions, ASTM D 2892			
		C_5-175° F Vol. %	175-250° F Vol. %	250-375° F Vol. %	375-420° F Vol. %
* Total Paraffins		46.7	34.0	TBD+	TBD
Total Iso-paraffins		38.1	32.5		
Total Aromatics		2.9	7.5		
Total Naphthenes		11.3	25.9		
Total Olefins		0.0	0.0		
Total Unknowns		0.0	0.1		
Paraffins:	C1	0.0	0.0		
	C2	0.0	0.0		
	C3	0.0	0.0		
	C4	0.5	0.0		
	C5	17.2	0.3		
	C6	28.0	5.4		
	C7	0.9	20.5		
	C8	0.0	7.8		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Iso-paraffins:	C4	0.0	0.0		
	C5	6.4	0.1		
	C6	28.3	2.4		
	C7	4.3	16.1		
	C8	0.0	13.2		
	C9	0.0	0.8		
	C10	0.0	0.0		
	C11	0.0	0.0		
Aromatics:	C6	2.0	0.8		
	C7	0.9	5.6		
	C8	0.0	1.1		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Naphthenes:	C5	2.0	0.1		
	C6	8.3	4.7		
	C7	1.1	13.2		
	C8	0.0	7.9		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Olefins:	C4	0.0	0.0		
	C5	0.0	0.0		
	C6	0.0	0.0		
	C7	0.0	0.0		
	C8	0.0	0.0		

Debutanization Fraction	
Component	Vol. %
Methane	--
Ethane	0.2
Propane	9.0
i-Butane	7.6
n-Butane	34.6
i-Pentane	20.6
n-Pentane	24.6
C_6+	3.4

Whole Crude B-T-X

Component	Vol.%
Benzene	0.147
Toluene	0.454
Ethylbenzene	0.034
Xylenes	0.051

* The gas chromatographic PIANO method used provides for elution and identification of components up to a nominal n-C_{12} (420° F)

+To be determined.

U. S. DEPARTMENT OF ENERGY, STRATEGIC PETROLEUM RESERVE

CRUDE OIL ANALYSIS

Stream SPR West Hackberry Sweet   Terminal Sun Marine Terminal, Nederland, TX

Crude

Specific Gravity	0.8343	Ni, ppm	1.6(1.8)*	ERVP, psia @ 100° F	4.15
API Gravity	38.1	V, ppm	2.7(3.4)*	Neutralization No.	0.14
Sulfur, Wt. %	0.28	Fe, ppm	2.6(3.4)*	H_2S, ppm (c)*	0.5
Nitrogen, Wt. %	0.090	Org. Cl, ppm (c)*	0.9	Mercaptans, ppm (c)*	0.7
Con. Car. Res., Wt. % (c)*	1.81	O.D. Color	8,240	Viscosity: 77° F	4.88 cSt 41.9 SUS
Pour Point, °F	25	UOP "K"	12.00	100° F	3.60 cSt 37.9 SUS

Fraction		1	2	3	4	5	6	7
Cut Temp.	C_4-C_4	C5-175° F	175°-250° F	250°-375° F	375°-530° F	530°-650° F	650°-1050° F	Residuum
Vol. - mls	191.8	253.7	379.5	546.8	664.2	499.5	1131.5	382.1
Vol. %	4.7	6.3	9.4	13.5	16.4	12.3	27.9	9.4
Vol. Sum %	4.7	11.0	20.4	33.9	50.3	62.6	90.5	99.9
Wt. - grams	115.1	173.0	280.8	424.9	548.4	427.4	1028.5	378.7
Wt. %	3.4	5.1	8.3	12.6	16.2	12.6	30.4	11.2
Specific Gravity	0.6	0.6819	0.7400	0.7770	0.8256	0.8556	0.9090	0.991
API Gravity		76.0	59.7	50.6	39.9	33.9	24.2	11.3
Sulfur, Wt. %		0.020	0.001	0.004	0.04	0.23	0.53	1.09
Mercaptans, ppm		<1	<1	<1	4.5			
H_2S, ppm		<1	2.4	2.4	<1			
Organic Cl, ppm		1.5	4.0	4.1				
Aniline Point, °F				122.9	142.9	164.5	192.4	
Neutralization No.					0.05	0.10		
Cetane Index					46.91	52.23		
Naphthalenes, vol. %					4.96	9.52		
Smoke point					16.8	15.8		
Nitrogen, Wt. %					0.0005	0.007	0.130	[illegible]
Viscosity:								
cSt (SUS) 77° F					2.33(33.6)			
100° F					1.85(32.1)	4.95(42.2)		
130° F						3.37(37.3)	25.96(123.7)	
180° F							10.38(60.5)	
210° F								701.9(3[illegible])
250° F								204.96(95[illegible]
Freezing Point, °F					-32.8			
Cloud Point, °F						22	120	
Pour Point, °F						20	100	
Ni, ppm							Not Detectable	16.[illegible]
V, ppm							Not Detectable	30.3
Fe, ppm							Not Detectable	30.[illegible]
Con. Car. Res., Wt. %							--	[illegible]

Data current as of September 19, 1986, but subject to change.

* (c), calculated from fraction results.

Whole crude lead content: 0.004 ppm.

	C_5-175°F	C_5-375°F
Research Octane Number:	68.5	53.3
Motor Octane Number:	63.9	30.8

Gas Chromatographic Analysis

SPR WEST HACKBERRY SWEET

		Distillate fractions, ASTM D 2892			
		C_5-175° F Vol. %	175-250° F Vol. %	250-375° F Vol. %	375-420° F Vol. %
* Total Paraffins		43.9	24.9	TBD+	TBD
Total Iso-paraffins		35.1	24.4		
Total Aromatics		3.8	8.9		
Total Naphthenes		17.5	41.8		
Total Olefins		0.0	0.0		
Total Unknowns		0.0	0.0		
Paraffins:	C1	0.0	0.0		
	C2	0.0	0.0		
	C3	0.0	0.0		
	C4	1.7	0.0		
	C5	20.3	0.3		
	C6	21.3	4.1		
	C7	0.6	14.9		
	C8	0.0	5.6		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Iso-paraffins:	C4	0.2	0.0		
	C5	9.5	0.1		
	C6	22.5	1.7		
	C7	2.9	12.3		
	C8	0.0	9.4		
	C9	0.0	0.8		
	C10	0.0	0.0		
	C11	0.0	0.0		
Aromatics:	C6	3.1	1.2		
	C7	0.5	6.6		
	C8	0.0	1.0		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Naphthenes:	C5	2.9	0.1		
	C6	13.1	8.8		
	C7	1.5	22.8		
	C8	0.0	10.0		
	C9	0.0	0.0		
	C10	0.0	0.0		
	C11	0.0	0.0		
	C12	0.0	0.0		
Olefins:	C4	0.0	0.0		
	C5	0.0	0.0		
	C6	0.0	0.0		
	C7	0.0	0.0		
	C8	0.0	0.0		

Debutanization Fraction	
Component	Vol. %
Methane	–
Ethane	0.0
Propane	9.7
i-Butane	7.8
n-Butane	35.4
i-Pentane	17.4
n-Pentane	21.5
C_6+	8.2

Whole Crude B-T-X

Component	Vol.%
Benzene	0.308
Toluene	0.652
Ethylbenzene	0.025
Xylenes	0.051

* The gas chromatographic PIANO method used provides for elution and identification of components up to a nominal n-C_{12} (420° F)

+To be determined.

DEPARTMENT OF DEFENSE

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DEPARTMENT OF THE ARMY

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ATTN: AMSTA-RG (MR WHEELOCK) 1
AMSTA-TSL (MR BURG) 1
AMSTA-MTC (MR GAGLIO), AMSTA-MC, AMSTA-MV 1
AMSTA-RGP (MR RAGGIO/ MR McCARTNEY) 1
AMSTA-MLF (MR KELLER) 1
WARREN MI 48397-5000

DIRECTOR
US ARMY AVIATION RESEARCH & TECHNOLOGY ACTIVITIES (AVSCOM)
ATTN: SAURT-R (MR ANDRE) 1
AMES RESEARCH CENTER (MAIL STOP 207-5)
MOFFETT FIELD CA 94035-1099

CDR
US READINESS COMMAND
ATTN: J4-E 1
MACDILL AIR FORCE BASE FL 33608

DIRECTOR
US ARMY MATERIEL CMD
MATERIEL SUPPORT ACTIVITY
ATTN: AMXTB-T (MR STOLARICK) 1
FORT LEWIS WA 98433

CDR
US ARMY GENERAL MATERIAL & PETROLEUM ACTIVITY
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STRGP-FE, BLDG 85-3 (MR GARY SMITH) 1
STRGP-FT (MR FOSTER) 1
NEW CUMBERLAND PA 17070-5008

HQ, DEPT. OF ARMY
ATTN: DAEN-DRM 1
WASHINGTON DC 20310

CDR
US ARMY LABORATORY COMMAND
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AMSLC-TP-AL (LTC SCHRADER) 1
ADELPHI MD 20783-1145

CDR
US ARMY FORCES COMMAND
ATTN: AFLG-REG 1
AFLG-POP 1
FORT MCPHERSON GA 30330

CDR
US ARMY RES & STDZN GROUP
(EUROPE)
ATTN: AMXSN-UK-RA (DR OERTEL) 1
AMXSN-UK-SE 1
BOX 65
FPO NEW YORK 09510

CDR
US CENTRAL COMMAND
ATTN: CINCCEN/CC J4-L 1
MACDILL AIR FORCE BASE FL 33608

CDR
US ARMY YUMA PROVING GROUND
ATTN: STEYP-MT-TL-M
(MR DOEBBLER) 1
YUMA AZ 85364-9103

PROJ MGR, BRADLEY FIGHTING
VEHICLE SYS
ATTN: AMCPM-FVS-M 1
WARREN MI 48397

CDR
US ARMY DEVELOPMENT AND
EMPLOYMENT AGENCY
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(MAJ GROSSMAN) 1
FT LEWIS VA 98433-5000

PROJ MGR, MOBILE ELECTRIC POWER
ATTN: AMCPM-MEP-TM 1
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SPRINGFIELD VA 22150

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US ARMY EUROPE & SEVENTH ARMY
ATTN: AEAGG-FMD 1
AEAGD-TE 1
APO NY 09403

CDR
THEATER ARMY MATERIAL MGMT
CENTER (200TH)-DPGM
DIRECTORATE FOR PETROL MGMT
ATTN: AEAGD-MMC-PT-Q
(MR CARLONE) 1
APO NY 09052

HQ, EUROPEAN COMMAND
ATTN: J4/7-LJPO (LTC McCURRY) 1
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CDR
US ARMY RESEARCH OFC
ATTN: SLCRO-EG (DR MANN) 1
SLCRO-CB 1
P O BOX 12211
RSCH TRIANGLE PARK NC 27709-2211

CDR
US ARMY LEA
ATTN: DALO-LEP 1
NEW CUMBERLAND ARMY DEPOT
NEW CUMBERLAND PA 17070

CDR
US ARMY GENERAL MATERIAL &
PETROLEUM ACTIVITY
ATTN: STRGP-PW (MR PRICE) 1
BLDG 247, DEFENSE DEPOT TRACY
TRACY CA 95376-5051

CDR
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CENTER
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AIAST-MT-1 1
FEDERAL BLDG
CHARLOTTESVILLE VA 22901

HQ, US ARMY T&E COMMAND
ATTN: AMSTE-TO-O 1
AMSTE-CM-R-O 1
AMSTE-TE-T (MR RITONDO) 1
ABERDEEN PROVING GROUND MD
21005-5006

CDR, US ARMY TROOP SUPPORT
COMMAND
ATTN: AMSTR-ME 1
AMSTR-S 1
AMSTR-E 1
AMSTR-WL (MR BRADLEY) 1
4300 GOODFELLOW BLVD
ST LOUIS MO 63120-1798

TRADOC LIAISON OFFICE
ATTN: ATFE-LO-AV 1
4300 GOODFELLOW BLVD
ST LOUIS MO 63120-1798

HQ
US ARMY TRAINING & DOCTRINE CMD
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FORT MONROE VA 23651-5000

CDR
CONSTRUCTION ENG RSCH LAB
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CERL-EH 1
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CHAMPAIGN IL 61820

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ATSM-TD 1
ATSM-PFS (MR ELLIOTT) 1
FORT LEE VA 23801

CDR
US ARMY TRANSPORTATION SCHOOL
ATTN: ATSP-CD-MS (MR HARNET) 1
FORT EUSTIS VA 23604-5000

CDR
US ARMY WESTERN COMMAND
ATTN: APLG-TR 1
FORT SCHAFTER HI 96858

CDR
US ARMY LOGISTICS CTR
ATTN: ATCL-MS (MR A MARSHALL) 1
ATCL-C 1
FORT LEE VA 23801-6000

PROJECT MANAGER
PETROLEUM & WATER LOGISTICS
ATTN: AMCPM-PWL 1
4300 GOODFELLOW BLVD
ST LOUIS MO 63120-1798

CDR
US ARMY ENGINEER SCHOOL
ATTN: ATZA-TSM-G 1
ATZA-CD 1
FORT BELVOIR VA 22060-5606

CDR
MILITARY TRAFFIC MANAGEMENT
COMMAND
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CHIEF, U.S. ARMY LOGISTICS
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DEPARTMENT OF THE NAVY

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CDR
NAVAL SEA SYSTEMS CMD
ATTN: CODE 05M4 (MR R LAYNE) 1
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CDR
DAVID TAYLOR NAVAL SHIP R&D CTR
ATTN: CODE 2759 (MR STRUCKO) 1
CODE 2831 1
ANNAPOLIS MD 21402-5067

CDR
NAVAL SHIP ENGINEERING CENTER
ATTN: CODE 6764 1
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CDR
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CDR
NAVY PETROLEUM OFC
ATTN: CODE 43 (MR LONG) 1
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DEPARTMENT OF THE AIR FORCE

HQ, USAF
ATTN: LEYSF (COL LEE) 1
WASHINGTON DC 20330

HQ
AIR FORCE SYSTEMS CMD
ATTN: AFSC/DLF 1
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CDR
US AIR FORCE WRIGHT AERONAUTICAL LAB
ATTN: AFWAL/POSF (MR CHURCHILL) 1
WRIGHT-PATTERSON AFB OH 45433-6563

CDR
SAN ANTONIO AIR LOGISTICS CTR
ATTN: SAALC/SFT (MR MAKRIS) 1
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OTHER GOVERNMENT AGENCIES

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LEWIS RESEARCH CENTER
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DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
ATTN: AWS-110 1
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US DEPARTMENT OF ENERGY
ATTN: MR ECKLUND (CE-151) 1
MR H N GILES (EP-531) 10
FORRESTAL BLDG.
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