A BASIC REFERENCE ON PETROLEUM REFINING COSTS AND REFINERY TYPES IN LOUISIANA

By

T. Michael French, P.E.

William J. Delmar, Jr., P.E.

DEPARTMENT OF NATURAL RESOURCES

Technology Assessment Section

Baton Rouge

April 2, 1987

TABLE OF CONTENTS

State of Louisiana

EDWIN EDWARDS
GOVERNOR

DEPARTMENT OF NATURAL RESOURCES

B. JIM PORTER
SECRETARY

April 2, 1987

[redacted]

Dear [redacted]:

I am pleased to transmit the attached refinery analysis that the Technology Assessment staff prepared in response to your request on March 19. I hope the information will be beneficial, and that your pursuits will result in a successful project.

Sincerely,

B. Jim Porter

BJP/pso

Attachment

P. O. BOX 94396 · BATON ROUGE, LA 70804-9396 · A/C 504-342-4500
NATURAL RESOURCES BUILDING

State of Louisiana

EDWIN W. EDWARDS
GOVERNOR

DEPARTMENT OF NATURAL RESOURCES

B. JIM PORTER
SECRETARY

March 31, 1987

[redacted]

Dear [redacted]

As an outcome of my meeting with you on March 19, Bill Delmar and I have examined the data we have on the four refineries you requested: Hill Petroleum Co., Placid Refining Co., Gulf Oil Corp. at Venice, and International Processors. The operable capacities and capacities of downstream processing facilities for these four refineries are provided in Table I, attached. The Gulf Oil refinery at Venice has been sold, disassembled, and moved out of the state. The International Processors refinery has been sold to Hill Petroleum and restarted.

Utilizing the DNR Louisiana Industrial Energy and Economics Model, which was developed by the Pace Consultants of Houston, we have prepared cost sheets to provide estimated economics of operating refineries based on current crude and processing costs. The cost sheets also show projected economics based on an assumed general rate of inflation of 2.5% per year and an annual crude oil cost increase equal to the general rate of inflation.

Since you may not wish to limit your consideration to only the four refineries discussed, we have taken the complexity factor approach to generating the attached refining cost sheets (Tables V to X). The complexity factor for each refinery is derived from the refinery's crude distillation capacity, the capacity of the refinery's downstream processing equipment relative to its crude capacity, and the capabilities of each of those downstream units. Long established correlations and studies have shown that refineries with similar complexity factors have similar economics whether or not the refineries have the same capacities or configurations; thus, the complexity factor criteria provides a generic and versatile initial approach for screening and evaluating refining options and for evaluating overall refining trends.

NATURAL RESOURCES BUILDING . P.O. BOX 94396 . BATON ROUGE, LOUISIANA 70804-9396 . PHONE 504/342-450?

The crude capacity, downstream processing capacity, and complexity factor are provided in Table II for each operating refinery in the state and in Table III for each shutdown refinery in the state. Table IV provides a list of these same refineries arranged by decreasing complexity factor along with a date of last operation and the number of years in operation for the shutdown refineries. Tables I through IV reflect data on these refineries as of January 1, 1986. In June, we should have all of the data updated to January 1, 1987. To aid in interpreting Tables I through III, Appendix A provides a brief summary of the purpose of different downsteam processes. Additionally, Appendix B is a general glossary of refining terminology.

Very generally, it may be stated that if a refinery has downstream capacity for thermal operation, then it can upgrade some heavy crude into lighter components; if it has downstream capacity for hydrocracking or hydrotreating, it can process some sour crude (crude containing sulfur); and if it has downstream capacity for catalytic cracking, reforming, alkylation, or isomerization, then it has some capability to upgrade easier-to-make and lower value products (e.g., residual fuel oil, medium distillate, naptha, sub-octane gasoline) into harder-to-make and higher value products (e.g., light distillates, high octane gasoline). Naturally, the higher the downstream capacity and the more diversity in that capacity, the more flexible is the refinery for competing in changing product markets. Appendix A contains additional information on refinery configuration and refined product slates, and Appendix C contains some example crude oil analyses.

To supplement the cost sheets provided in Tables V to X, gross refining margins and net refining margins are plotted in Figures 1 and 2, respectively, for each of five refining complexity factor ranges. These figures are based on the previously mentioned assumptions for inflation rate and crude price escalation and the assumption that future price ratios among the various different crude grades and among the different product types will remain the same as they presently are, which will not necessarily be the case.

There is no public base of information that provides cost sturctures for specific refineries. Also, different accounting procedures, treatments of financial interactions, and marketing arrangements all lead to differences in allocated cost bases and perceptions of net profit. The attached cost sheets minimize these differences by utilizing gross and net refining margins as the economic indexes for comparing various refining options on a common basis. Our estimated operating costs include all variable and fixed costs associated with refinery operations. Following standard industry practice, however, the refining margins do not include depreciation, capital charges, or income taxes, which are items often subject to great variations in treatment by the internal accounting practices of different companies.

The attached cost sheets are not intended to portray the actual process economics of any single or individual refinery in Louisiana. To generate the economics of an individual refinery, specific information must be known about the refinery in far greater detail then is publicly available. The type of information required includes the composition of the crude feed, operating severity of major processing equipment, the number of and composition of various recycle streams, the target product slate, various marketing data, etc. This information would then be used in a refinery linear program model specifically set up for that individual refinery. The linear program model would then be able to generate the actual economics for the individual refinery for a range of different crude feeds and product slates. Since refining is only one of about two dozen major energy sector areas we try to keep up with, we have never been able to develop this capability. There are a number of engineering consulting firms that have staff that work full time in the refining sector and do have this capability. We will be glad to assist you in locating the appropriate firms should you have a need to do so.

I hope the attached information will be helpful. If you have any questions, please do not hesitate to call.

Sincerely,

Mike French

T. Michael French, Manager
Technology Assessment

TMF/bmd

Attachment

Table I
Capacity of Selected Petroleum Refineries as of January 1, 1986 or last date of operation
(Barrels per Stream Day, Except Where Noted)

Refinery	Location	Crude Capacity: Barrels per Calendar Day	Crude Capacity: Barrels per Stream Day	Charge Capacity: Vacuum Distillation	Charge Capacity: Thermal Operation	Charge Capacity: Catalytic Cracking (Fresh)	Charge Capacity: Catalytic Cracking (Recycled)	Charge Capacity: Catalytic Reforming	Charge Capacity: Catalytic Hydro-cracking	Charge Capacity: Catalytic Hydro-treating	Production Capacity: Alkylation	Production Capacity: Asphalt	Production Capacity: Aromatics	Production Capacity: Isomerization	Production Capacity: Lubricating Oils	Production Capacity: Hydrogen (MMCFD)	Production Capacity: Petroleum Coke	Complexity Factor
Gulf Oil Corp.	Venice	28,700	29,100	0	0	0	0	18,000	11,500	16,800	0	0	0	0	0	0	0	7.00
Hill Petroleum Co	Krotz Springs	55,300	57,500	24,000	0	28,000	0	12,500	0	12,500	0	0	0	0	0	0	0	5.57
International Processors	St. Rose	28,356	35,000	14,000	0	0	0	0	0	0	0	0	0	0	0	0	0	1.80
Placid Refining Co.	Port Allen	45,000	48,000	18,000	0	18,000	2,000	7,000	0	7,000	4,200	0	0	0	0	0	0	5.54

TABLE II
Operable Capacity of Operating Petroleum Refineries and Capacity
Downstream as of January 1, 1986
(Barrels per Stream Day, Except Where Noted)

Refinery	Location	Crude Capacity: Barrels per Calendar Day Total	Crude Capacity: Barrels per Stream Day Total	Charge Capacity: Vacuum Distillation	Charge Capacity: Thermal Operation	Charge Capacity: Catalytic Cracking (Fresh)	Charge Capacity: Catalytic Cracking (Recycled)	Charge Capacity: Catalytic Reforming	Charge Capacity: Catalytic Hydro-cracking	Charge Capacity: Catalytic Hydro-treating	Production Capacity: Alkylation	Production Capacity: Asphalt	Production Capacity: Aromatics	Production Capacity: Isomerization	Production Capacity: Lubricating Oils	Production Capacity: Hydrogen (MMCFD)	Production Capacity: Petroleum Coke	Complexity Factor
Calcasieu Refining Co.	Lake Charles	14,000	14,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Calumet Refining Co.	Princeton	3,162	4,400	4,400	0	0	0	0	0	0	0	723	0	0	2,535	0	0	32.46
Cameron Resources	Gueydan	7,400	8,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Canal Refining	Church Point	8,000	8,000	0	0	0	0	1,900	0	0	0	0	0	0	0	0	0	1.86
Citgo Petroleum Corp	Lake Charles	320,000	330,000	83,000	63,000	150,000	0	91,000	37,000	145,000	20,200	0	2,300	0	9,000	0	15,000	10.11
Claiborne Gasoline Co.	Lisbon	6,500	6,700	0	0	0	0	2,000	0	0	0	0	0	2,000	0	0	0	3.09
Conoco Inc.	Westlake (Lake Charles)	156,500	164,000	63,000	60,800	30,600	0	27,400	0	134,500	6,000	0	0	0	0	28	15,800	6.93
Conoco Inc.	Egan	10,000	13,750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Exxon Co. U.S.A.	Baton Rouge	455,000	474,000	205,000	76,000	155,000	0	95,000	24,000	171,500	29,800	28,900	0	0	17,400	0	20,015	8.67
Hill Petroleum Co.	Krotz Springs	55,300	57,500	24,000	0	28,000	0	12,500	0	12,500	0	0	0	0	0	0	0	5.57
International Processors	St. Rose	28,356	35,000	14,000	0	0	0	0	0	0	0	0	0	0	0	0	0	1.80
Kerr-McGee Refining Corp	Dubach	10,000	11,000	0	0	0	0	2,200	0	2,200	0	0	0	0	0	2	0	2.20
Kerr-McGee Refining Corp	Cotton Valley	7,800	8,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Marathon Petroleum Co	Garyville	255,000	263,000	125,000	0	75,000	14,000	50,000	0	143,500	20,000	25,000	0	7,000	0	0	0	6.69
Murphy Oil U.S.A. Inc.	Meraux	92,500	95,000	40,000	0	35,300	3,000	23,000	0	44,000	10,300	12,000	0	0	0	0	0	8.39
Pennzoil Products Co.	Shreveport	46,200	50,000	24,300	0	0	0	10,000	0	20,100	0	600	0	0	8,500	6	0	12.12
Placid Refining Co.	Port Allen	45,000	48,000	18,000	0	18,000	2,000	7,000	0	7,000	4,200	0	0	0	0	0	0	5.54
Shell Oil Co.	Norco	218,000	225,000	78,000	124,500	100,000	2,000	30,000	27,700	127,000	13,500	0	0	0	0	70	5,200	8.69
Standard Oil Co.	Belle Chasse (Alliance)	198,500	205,000	73,000	21,000	89,000	2,300	40,000	0	88,000	28,400	0	22,500	0	0	0	3,400	11.62
Tenneco Oil Co.	Chalmette	137,000	144,000	62,000	27,000	45,000	0	45,000	18,000	55,000	19,000	0	7,000	0	0	24	7,280	10.13
Texaco Refining & Marketing	Convent	225,000	240,000	75,000	12,000	70,000	20,000	40,000	35,000	142,000	12,500	0	0	0	0	63	0	6.93

TABLE III A

Capacity of Louisiana's Shutdown Refineries as of Last Date of Operation

(Barrels per Stream Day, Except Where Noted)

Refinery	Location	Crude Capacity: Barrels per Calendar Day Total	Crude Capacity: Barrels per Stream Day Total	Charge Capacity: Vacuum Distillation	Charge Capacity: Thermal Operation	Charge Capacity: Catalytic Cracking (Fresh)	Charge Capacity: Catalytic Cracking (Recycled)	Charge Capacity: Catalytic Reforming	Charge Capacity: Catalytic Hydro-cracking	Charge Capacity: Catalytic Hydro-treating	Production Capacity: Alkylation	Production Capacity: Asphalt	Production Capacity: Aromatics	Production Capacity: Isomerization	Production Capacity: Lubricating Oils	Production Capacity: Hydrogen (MMCFD)	Production Capacity: Petroleum Coke	Complexity Factor
Bayou State Oil Corp.	Hosston	3,000	4,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Celeron Oil & Gas Corp.	Hermanteau	11,000	15,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Clark Oil & Refining	Mount Airy	23,000	23,000	11,000	16,000	0	0	0	0	0	0	0	0	0	0	0	0	4.04
Evangeline Refining Co.	Jennings	4,500	5,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
GHR Energy Corp.	Good Hope	300,000	300,000	200,000	120,000	110,000	0	3,000	0	0	12,000	0	0	0	0	0	0	5.77
Gulf Oil Corp.	Venice	28,700	29,100	0	0	0	0	18,000	11,500	16,800	0	0	0	0	0	0	0	7.00
Hansborough Energy	Crowley	0	0															-
Ida Gasoline	Belcher	0	0															-
Lake Charles Refining Co.	Lake Charles	28,000	30,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
McTan Refining Corp.	St. James	19,300	20,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Port Petroleum Inc.	Stonewall	3,200	4,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Schulze Processing Inc.	Tallulah	1,760	2,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Shepard Oil Co.	Jennings	10,000	10,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Sooner Refining Co.	Darrow	9,000	10,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
T & S Refining Co.	Jennings	10,500	13,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
Texas NAPCO Inc.	St. James	20,000	20,000	20,000	0	0	0	0	0	0	0	0	0	0	0	0	0	3.00
Total		471,960	485,600	231,000	136,000	110,000	0	21,000	11,500	16,800	12,000	0	0	0	0	0	0	

TABLE III B

Capacity of Louisiana's Shutdown Refineries as of Last Date of Operation

(Barrels per Stream Day, Except Where Noted)

Refinery	Location	Date of Last Operation	Date Shutdown	Years in Operation	Shut-down	Comments
Bayou State Oil Corp.	Hosston	1/81	3/82	25+	Y	
Celeron Oil & Gas Corp.	Hermanteau	2/83	8/84	6	Y	Formerly - Slapco
Clark Oil & Refining	Mount Airy	12/82			Y	Formerly - Mt. Airy Refining Co.
Evangeline Refining Co.	Jennings	12/82	12/82	25+	Y	
GHR Energy Corp.	Good Hope	12/82	9/83	15	Y	Recently Sold - ??
Gulf Oil Corp.	Venice	4/81	12/81	13		Disassembled and Moved
Hansborough Energy	Crowley	?	?	?	Y	Used as storage
Ida Gasoline	Belcher	?	?	?	Y	Used as storage
International Processors	St. Rose	9/82	2/85	6		Sold to Hill Petroleum & Restarted 1986
Lake Charles Refining Co.	Lake Charles	4/81	2/82	2	Y	
McTan Refining Corp.	St. James	7/81	8/83	6	Y	Formerly - Bruin Refining Inc.
Port Petroleum Inc.	Stonewall	12/83	2/84	4	Y	
Schulze Processing Inc.	Tallulah	5/81	8/82	4	Y	
Shepard Oil Co.	Jennings	5/81	2/82	4		Converted to Ethanol Production
Sooner Refining Co.	Darrow	1/82	2/82	2	Y	
T & S Refining Co.	Jennings	7/81	3/82	2	Y	
Texas NAPCO Inc.	St. James	12/83			Y	Formerly - LaJet Inc.

TABLE IV

Louisiana Refineries by Complexity

(Barrels per Stream Day, Except Where Noted)

Refinery	Location	Total Crude Capacity Barrels per Stream Day	Complexity Factor
Calumet Refining Co.	Princeton	4,400	32.46
Pennzoil Products Co.	Shreveport	50,000	12.12
Standard Oil Co.	Belle Chasse (Alliance)	205,000	11.62
Tenneco Oil Co.	Chalmette	144,000	10.13
Citgo Petroleum Corp.	Lake Charles	330,000	10.11
Shell Oil Co.	Norco	225,000	8.69
Exxon Co. U.S.A.	Baton Rouge	474,000	8.67
Murphy Oil U.S.A. Inc.	Meraux	95,000	8.39
Gulf Oil Corp.	Venice	29,100	7.00
Conoco Inc.	Westlake (Lake Charles)	164,000	6.93
Texaco Refining & Marketing	Convent	240,000	6.93
Marathon Petroleum Co.	Garyville	263,000	6.69
GHR Energy Corp.	Good Hope	300,000	5.77
Hill Petroleum Co.	Krotz Springs	57,500	5.57
Placid Refining Co.	Port Allen	48,000	5.54
Clark Oil & Refining	Mount Airy	23,000	4.04
Claiborne Gasoline Co.	Lisbon	6,700	3.09
Texas NAPCO Inc.	St. James	20,000	3.00
Kerr-McGee Refining Corp	Dubach	11,000	2.20
Canal Refining	Church Point	8,800	1.86
International Processors	St. Rose	35,000	1.80
T & S Refining Co.	Jennings	13,000	1.00
Calcasieu Refining Co.	Lake Charles	14,500	1.00
Sooner Refining Co.	Darrow	10,000	1.00
Evangeline Refining Co.	Jennings	5,000	1.00
McTan Refining Corp.	St. James	20,000	1.00
Kerr-McGee Refining Corp	Cotton Valley	8,500	1.00
Celeron Oil & Gas Corp.	Mermanteau	15,000	1.00
Bayou State Oil Corp.	Hosston	4,000	1.00
Cameron Resources	Gueydan	8,000	1.00
Port Petroleum Inc.	Stonewall	4,000	1.00
Conoco Inc.	Egan	13,750	1.00
Schulze Processing Inc.	Tallulah	2,000	1.00
Lake Charles Refining Co.	Lake Charles	30,000	1.00
Hansborough Energy	Crowley	0	-
Ida Gasoline	Belcher	0	-
Shepard Oil Co.	Jennings	(Converted to Ethanol)	

TABLE V
COST SHEET FOR REFINERY
COMPLEXITY FACTORS (1.0 - 2.50)

REFINERY 1 COMPLEXITY (1.0-2.50)	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GROSS MARGIN ($/BBL)	1.28	0.87	1.43	1.63	1.72	1.65	1.63	1.67	1.74	1.81	1.87	1.94	1.99	2.04	2.08	2.13	2.19
OPERATING COSTS																	
WAGES & BENEFITS	0.27	0.27	0.30	0.32	0.35	0.37	0.40	0.44	0.47	0.51	0.55	0.59	0.64	0.69	0.74	0.80	0.86
MAINTENANCE	0.12	0.13	0.14	0.15	0.16	0.17	0.19	0.20	0.22	0.24	0.25	0.27	0.30	0.32	0.34	0.37	0.40
G & A	0.16	0.15	0.10	0.11	0.12	0.12	0.13	0.13	0.14	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21
DEPRECIATION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER FIXED COSTS	0.08	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.20	0.21	0.23	0.25
CAT/CHEM	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.17	0.18	0.18	0.19
UTILITIES	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
TOTAL OPERATING COSTS	0.79	0.89	0.90	0.96	1.02	1.09	1.17	1.25	1.33	1.42	1.52	1.62	1.74	1.86	1.99	2.13	2.29
NET MARGIN ($/BBL)	0.49	-0.02	0.53	0.67	0.70	0.56	0.46	0.42	0.41	0.39	0.35	0.32	0.25	0.18	0.09	0.00	-0.10

TABLE VI
COST SHEET FOR REFINERY
COMPLEXITY FACTORS (2.51 - 4.50)

REFINERY 2 COMPLEXITY (2.51-4.50)																	
GROSS MARGIN ($/BBL)	1.78	1.50	2.00	2.17	2.47	2.38	2.38	2.40	2.50	2.58	2.65	2.72	2.79	2.85	2.91	2.98	3.05
OPERATING COSTS																	
WAGES & BENEFITS	0.44	0.43	0.48	0.52	0.56	0.61	0.65	0.71	0.76	0.82	0.89	0.96	1.03	1.11	1.20	1.30	1.40
MAINTENANCE	0.24	0.25	0.27	0.29	0.31	0.34	0.36	0.39	0.42	0.46	0.49	0.53	0.57	0.62	0.67	0.72	0.78
G & A	0.12	0.12	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.14	0.14	0.15	0.16
DEPRECIATION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER FIXED COSTS	0.20	0.20	0.22	0.24	0.25	0.27	0.30	0.32	0.34	0.37	0.40	0.43	0.47	0.50	0.54	0.59	0.63
CAT/CHEM	0.19	0.18	0.19	0.19	0.19	0.20	0.20	0.21	0.22	0.22	0.23	0.23	0.24	0.24	0.25	0.26	0.26
UTILITIES	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
TOTAL OPERATING COSTS	1.42	1.42	1.49	1.60	1.71	1.83	1.95	2.09	2.24	2.40	2.57	2.76	2.96	3.17	3.40	3.65	3.92
NET MARGIN ($/BBL)	0.36	0.08	0.51	0.57	0.76	0.56	0.42	0.34	0.26	0.18	0.08	-0.03	-0.17	-0.32	-0.49	-0.67	-0.87

TABLE VII
COST SHEET FOR REFINERY
COMPLEXITY FACTORS (4.51 -6.50)

REFINERY 3 COMPLEXITY (4.51-6.50)																	
GROSS MARGIN ($/BBL)	1.92	1.88	2.65	2.68	3.13	3.04	3.04	3.10	3.17	3.25	3.32	3.40	3.47	3.54	3.62	3.69	3.77
OPERATING COSTS																	
WAGES & BENEFITS	0.46	0.45	0.51	0.55	0.59	0.64	0.69	0.74	0.80	0.86	0.93	1.01	1.08	1.17	1.26	1.36	1.47
MAINTENANCE	0.35	0.36	0.39	0.42	0.45	0.49	0.53	0.57	0.62	0.66	0.72	0.77	0.83	0.90	0.97	1.05	1.13
G & A	0.10	0.09	0.06	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13
DEPRECIATION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER FIXED COSTS	0.33	0.34	0.37	0.40	0.43	0.47	0.50	0.54	0.59	0.63	0.68	0.74	0.80	0.86	0.93	1.00	1.08
CAT/CHEM	0.25	0.24	0.25	0.25	0.26	0.27	0.27	0.28	0.29	0.29	0.30	0.31	0.32	0.32	0.33	0.34	0.35
UTILITIES	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
TOTAL OPERATING COSTS	1.77	1.76	1.86	1.99	2.13	2.28	2.44	2.61	2.79	2.99	3.20	3.43	3.68	3.94	4.23	4.54	4.87
NET MARGIN ($/BBL)	0.16	0.12	0.79	0.69	1.00	0.76	0.61	0.50	0.38	0.26	0.12	-0.03	-0.21	-0.40	-0.61	-0.84	-1.10

TABLE VIII
COST SHEET FOR REFINERY
COMPLEXITY FACTORS (6.51 - 9.50)

REFINERY 4 (PACE) COMPLEXITY (6.51-9.50)	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GROSS MARGIN ($/BBL)	2.55	2.76	3.45	3.44	3.77	3.70	3.71	3.79	3.87	3.96	4.04	4.13	4.22	4.30	4.39	4.48	4.58
OPERATING COSTS																	
WAGES & BENEFITS	0.42	0.42	0.47	0.50	0.54	0.59	0.63	0.68	0.74	0.80	0.86	0.93	1.00	1.08	1.16	1.26	1.36
MAINTENANCE	0.46	0.47	0.51	0.55	0.60	0.64	0.69	0.75	0.81	0.87	0.94	1.01	1.09	1.18	1.27	1.37	1.48
G & A	0.18	0.18	0.12	0.13	0.14	0.14	0.15	0.16	0.16	0.17	0.18	0.19	0.20	0.21	0.22	0.23	0.25
DEPRECIATION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER FIXED COSTS	0.39	0.40	0.43	0.47	0.50	0.54	0.59	0.63	0.68	0.74	0.80	0.86	0.93	1.00	1.08	1.16	1.26
CAT/CHEM	0.30	0.29	0.30	0.31	0.32	0.32	0.33	0.34	0.35	0.36	0.37	0.37	0.38	0.39	0.40	0.41	0.42
UTILITIES	0.16	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
TOTAL OPERATING COSTS	2.18	2.16	2.24	2.40	2.55	2.73	2.91	3.11	3.32	3.55	3.80	4.06	4.35	4.66	4.99	5.34	5.73
NET MARGIN ($/BBL)	0.37	0.60	1.21	1.05	1.22	0.97	0.80	0.68	0.55	0.41	0.25	0.07	-0.13	-0.35	-0.60	-0.86	-1.15

TABLE IX
COST SHEET FOR REFINERY
COMPLEXITY FACTORS (9.50 +)

REFINERY 5 COMPLEXITY (9.50+)																	
GROSS MARGIN ($/BBL)	3.50	3.78	4.16	4.26	4.59	4.51	4.53	4.62	4.72	4.83	4.93	5.04	5.14	5.25	5.36	5.47	5.59
OPERATING COSTS																	
WAGES & BENEFITS	0.50	0.50	0.55	0.60	0.65	0.70	0.75	0.81	0.88	0.94	1.02	1.10	1.19	1.28	1.38	1.49	1.61
MAINTENANCE	0.45	0.46	0.50	0.54	0.59	0.63	0.68	0.73	0.79	0.86	0.92	1.00	1.07	1.16	1.25	1.35	1.46
G & A	0.20	0.19	0.13	0.14	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.21	0.22	0.24	0.25	0.26
DEPRECIATION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OTHER FIXED COSTS	0.21	0.22	0.24	0.26	0.28	0.30	0.32	0.35	0.37	0.40	0.44	0.47	0.51	0.55	0.59	0.64	0.69
CAT/CHEM	0.28	0.27	0.28	0.29	0.29	0.30	0.31	0.32	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.39
UTILITIES	0.16	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
TOTAL OPERATING COSTS	2.04	2.02	2.09	2.23	2.38	2.54	2.71	2.89	3.09	3.30	3.53	3.77	4.04	4.32	4.63	4.96	5.31
NET MARGIN ($/BBL)	1.45	1.76	2.07	2.03	2.21	1.98	1.83	1.73	1.64	1.53	1.40	1.27	1.11	0.93	0.73	0.52	0.28

TABLE X (A)
COST SHEET FOR REFINERY
STEAM SYSTEMS ($/MLB)

MFG COST OF STEAM ($/MLB)	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ROI (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SIZE: (MLB/DAY)	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
TOTAL INVESTMENT (M$/YEAR)	12,460	12,160	12,536	12,849	13,170	13,500	13,837	14,183	14,538	14,901	15,274	15,656	16,047	16,448	16,859	17,281	17,713
R.M.COST (NAT.GAS)	6.21	6.29	2.84	2.69	2.61	2.54	2.54	2.61	2.67	2.69	2.69	2.69	2.69	2.69	2.69	2.69	2.69
SALARIES & WAGES	0.15	0.14	0.15	0.15	0.16	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.20	0.20	0.21	0.21
UTILITIES & CAT.CHEM	-1.12	-0.84	-0.77	-0.79	-0.81	-0.83	-0.85	-0.87	-0.90	-0.92	-0.94	-0.97	-0.99	-1.02	-1.04	-1.07	-1.09
CAPITAL COSTS	0.50	0.49	0.51	0.52	0.53	0.55	0.56	0.57	0.59	0.60	0.62	0.63	0.65	0.67	0.68	0.70	0.72
BEFORE TAX PROFIT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STEAM COST ($/MLB)	5.75	6.07	2.72	2.57	2.49	2.41	2.41	2.48	2.55	2.55	2.54	2.54	2.54	2.53	2.53	2.52	2.52

TABLE X (B)
COST SHEET FOR REFINERY
POWER SYSTEMS ($/KWH)

MFG.COST OF POWER DISTR. ($/KWH)																	
ROI (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SIZE: (KWH/DAY)	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000
TOTAL INVESTMENT (M$/YEAR)	5,518	5,385	5,552	5,690	5,833	5,978	6,128	6,281	6,438	6,599	6,764	6,933	7,106	7,284	7,466	7,653	7,844
CAPITAL COSTS	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
POWER DIST. COST ($/KWH)	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

TABLE X(C)
COST SHEET FOR REFINERY
COOLING WATER SYSTEMS ($/MGAL)

MFG.COST OF CIRC.WATER ($/MGAL)																	
ROI (%)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SIZE: (MGAL/DAY)	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
TOTAL INVESTMENT (M$/YEAR)	5,162	5,038	5,193	5,323	5,456	5,593	5,733	5,876	6,023	6,173	6,328	6,486	6,648	6,814	6,985	7,159	7,338
SALARIES & WAGES	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
UTILITIES & CAT.CHEM	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06
CAPITAL COSTS	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
CIRC WATER COST ($/MGAL)	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11

FIGURE 1

GROSS MARGIN BY REFINERY COMPLEXITY

(PRODUCT REVENUE LESS FEEDSTOCK COST)

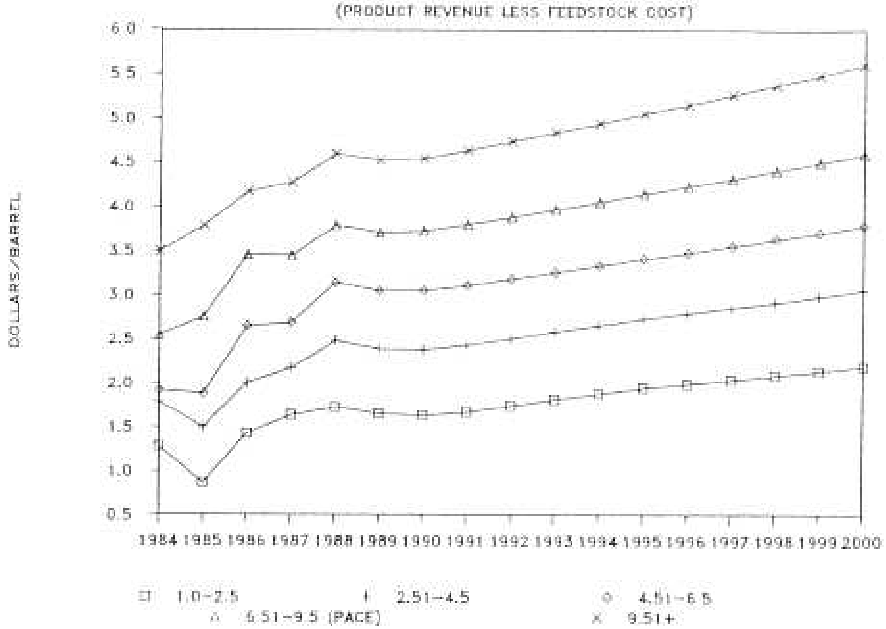


FIGURE 2

NET MARGIN BY REFINERY COMPLEXITY

(GROSS MARGIN LESS OP. COST)

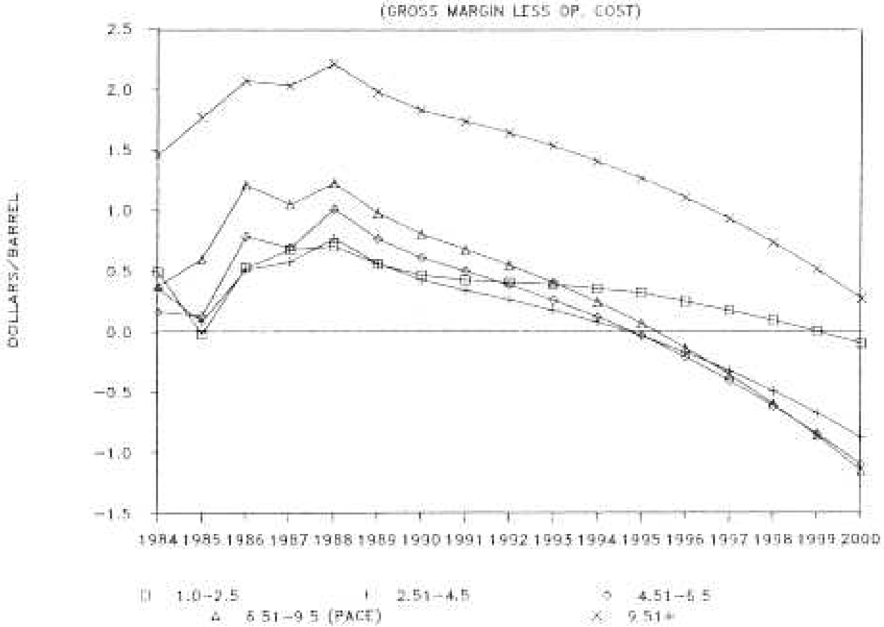
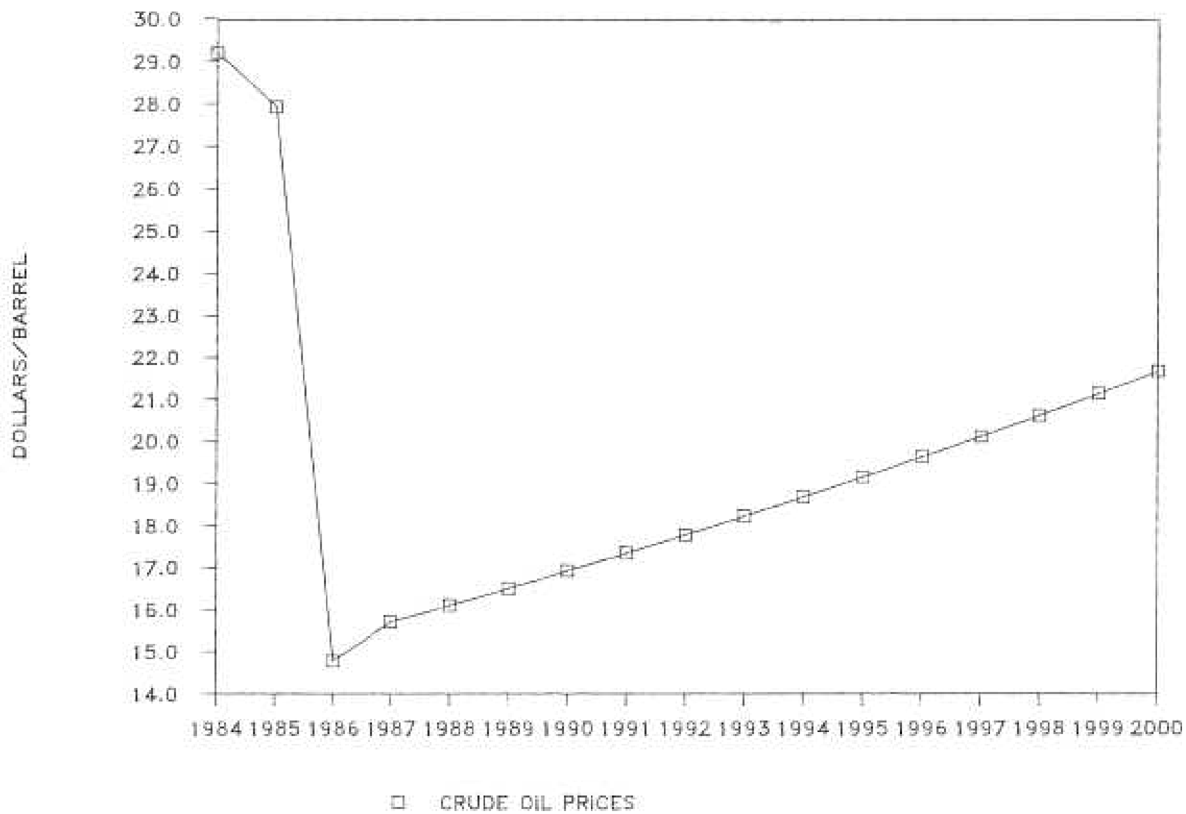


FIGURE 3

CRUDE OIL PRICES



APPENDIX A

REFINERY CONFIGURATIONS AND DOWNSTREAM PROCESSES

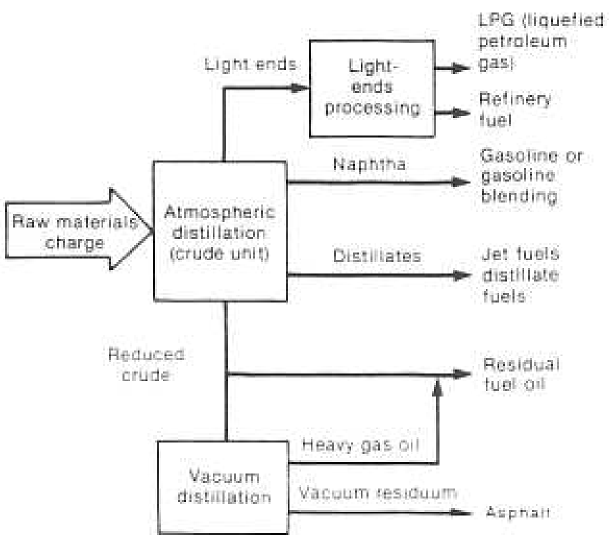
KINDS OF REFINERIES

Most refineries can be categorized as falling under one of three broad categories: topping, hydroskimming, or complex. There are, of course, a multitude of variations between these categories.

Topping Refineries

A topping refinery is usually small, often having less than 15,000 bbl/day (barrels per day) crude capacity. The only major refinery process it utilizes is distillation. The simplest topping refinery has only atmospheric distillation. Others employ both atmospheric and vacuum distillation units. (See Figure A-1.) In either case, since distillation is the only refining operation it performs, a topping refinery´s product slate is entirely dependent on the type of crude fed to the plant. It can only separate the crude into its original components, and it cannot alter the chemical composition of the crude components. (See example crude analyses in Appendix C.) To produce a product slate with light products, the refinery must be fed a light crude that contains a high proportion of naturally occuring components in the boiling range of distillate fuels, napthas, and gasolines, or they will not be produced. The heavy components(heavy ends, bottoms, or residuum) in the crude will come out of the bottom of the atmospheric distillation column and have to be sold as heavy fuel oil. If vacuum distillation is employed, some of the residuum could be recovered as asphalt.

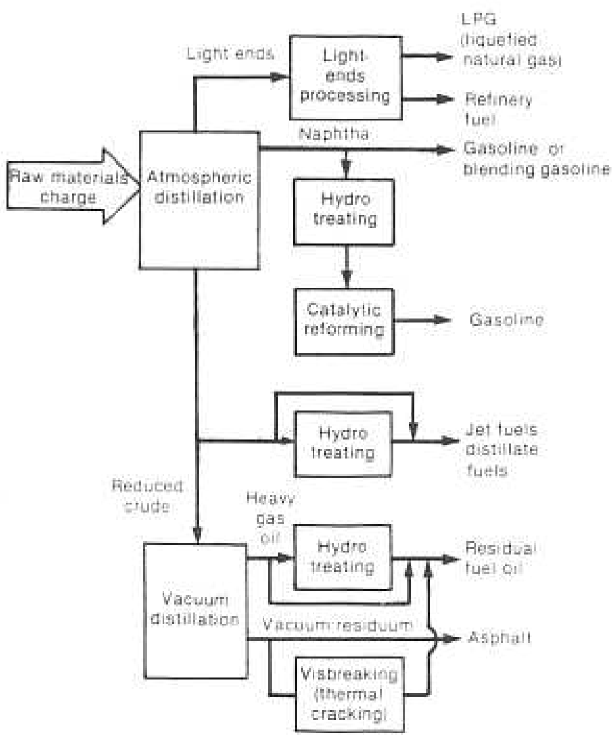
Figure A-1 - Topping Refinery



Hydroskimming Refineries

Hydroskimming refineries make extensive use of hydrogen treating processes such as hydrotreating and hydrocracking to clean up napthas and distillates by removing impurities such as sulfur, nitrogen and oxygen, to decolorize and stablize products, and to convert heavier components of the crude to lighter more valuable products such as gasoline, jet fuel, kerosene, and middle distillate fuels. (See Figure A-2.) A hydroskimming refinery is thus less dependent on the quality and type of crude feedstock, but its product slate is heavily weighted toward fuel oils, and it has limited ability to produce high octane unleaded gasoline. A hydroskimming refinery may have some ability to upgrade vacuum residuum to residual fuel oil and other heavy distillate fuels by using a thermal process such as Visbreaking, but would be unable to desulfurize these heavy fuels.

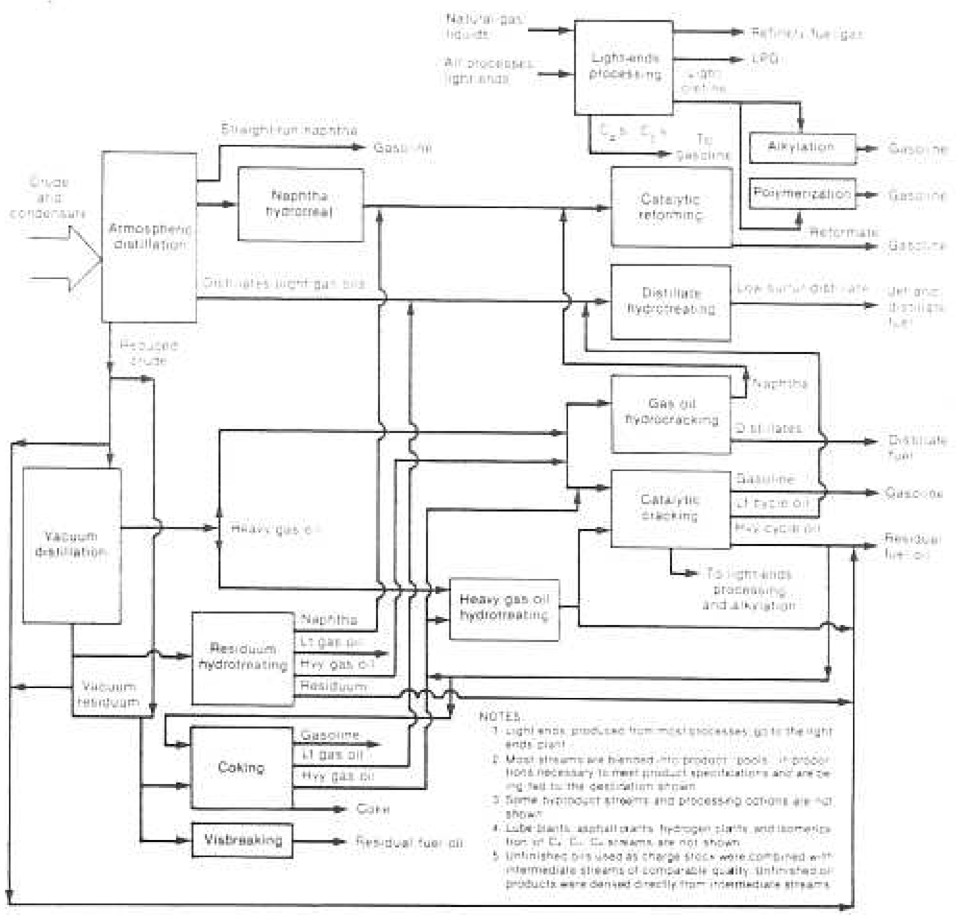
Figure A-2 - Hydroskimming Refinery



Complex Refineries

A typical complex refinery employs most of the major refinery processes described later in this Appendix. (See Figure A-3.) Through processes such as alkylation and polymerization, a complex refinery can take light ends and gaseous product from the refinery or from a natural gas processing plant and convert them into lower boiling compounds suitable for blending into gasoline. It can also crack residuum in various thermal processes to produce heavy distillate fuels which it can probably also desulfurize. Through various cracking processes it can convert heavy distillate fuels into medium and light distillates, and convert medium distillates into light distillates. Using processes such as catalytic reforming and isomerization, it can rearrange molecules and convert low octane gasoline components into high octane components. It uses hydrogen treating processes more extensively than the hydroskimming refinery. It may also have other processes to produce lubricating oils and petrochemical feedstocks. It is likely to have the capability to process some high sulfur crude such as Alaskan North Slope. A complex refinery, then, has the capability to use a wide range of crude feedstocks and to produce a wide range of products, and is capable of changing these to respond to changes in crude supply availability, product market demand, and economics.

Figure A-3 - Complex Refinery



TYPICAL REFINERY CONSTRUCTION COSTS
(Dollars per Barrel of Daily Crude Capacity)

	1982[1]	1987[2]
Topping Refineries	1,600	1,800
Hydroskimming Refineries	2,800	3,150
Complex Refineries	4,800	5,400

[1] Source: Industrial Energy Use, U.S. Congress, Office of Technology Assessment, Washington, D.C.; OTA-E-198, June 1983.
[2] Estimated using Nelson Construction Cost Index

LOUISIANA REFINERIES' PRODUCT DISTRIBUTIONS

As previously mentioned, simple refineries have refined product distributions that directly reflect the composition of the components contained in the crude feedstock. Two Louisiana refineries, Calumet and Pennzoil which are both located in North Louisiana, could basically be classified as lubricating oil refineries. The remainder of the hydroskimming and complex refineries in the state are essentially designed and operated to maximize gasoline production; this is reflected in the composite product yield distributions for all of the refineries in the state as shown in Table A-I. Approximately 97% of Louisiana's refining capacity is in South Louisiana (Louisiana Gulf Coast), and, as Table A-1 shows, 42.5% of that output is motor gasoline.

Table A-I
1985 Refining Product Yield Distributions*

Commodity	La. Gulf Coast	No. La., Ark.
Finished Motor Gasoline	42.5	26.0
Finished Aviation Gasoline	.2	.0
Liquefied Refinery Gases	5.1	1.5
Naphtha-Type Jet Fuel	1.1	3.5
Kerosene-Type Jet Fuel	12.3	.1
Kerosene	.8	.6
Distillate Fuel Oil	21.6	29.2
Residual Fuel Oil	5.2	5.1
Naphtha < 400 Deg. F. Petro. Feed. Use	.6	.0
Other Oils > 400 Deg. F. Petro. Feed. Use	3.1	.0
Special Naphthas	-.1	2.7
Lubricants	1.1	8.0
Waxes	.1	1.1
Petroleum Coke	4.6	1.4
Asphalt and Road Oil	1.7	18.3
Still Gas	3.9	2.9
Miscellaneous Products	1.0	.7
Processing Gain(-) or Loss(+)	-4.8	-1.1

* U.S. Department of Energy, Energy Information Administration

APPENDIX B

GLOSSORY OF
PETROLEUM AND REFINING TERMS

Taken From: Petroleum Supply Annual 1985, U.S. Department of Energy, Energy Information Administration, Washington, D.C.; DOE/EIA - 0340(85)1, May 1986.

Definitions of Petroleum Products and Other Terms

Alcohol. The family name of a group of organic chemical compounds composed of carbon, hydrogen, and oxygen. The series of molecules vary in chain length and are composed of a hydrocarbon plus a hydroxyl group: CH-(CH)n-OH. Alcohol includes methanol and ethanol.

Alkylation. A refinery process for chemically combining isoparaffin with olefin hydrocarbons. The product, alkylate, has high octane value and is blended with motor and aviation gasoline to improve the antiknock value of the fuel.

API Gravity. An arbitrary scale expressing the gravity or density of liquid petroleum products. The measuring scale is calibrated in terms of degrees API; it may be calculated in terms of the following formula:

$$\text{Deg API} = \frac{141.5}{\text{sp gr 60F/60F}} - 131.5$$

Aromatics. Hydrocarbons characterized by unsaturated ring structures of carbon atoms. Commercial petroleum aromatics are benzene, toluene, and xylene.

Asphalt. A dark-brown-to-black cement-like material containing bitumens as the predominant constituents, obtained by petroleum processing. The definition includes crude asphalt as well as the following finished products: cements, fluxes, the asphalt content of emulsions (exclusive of water), and petroleum distillates blended with asphalt to make cutback asphalts. The conversion factor for asphalt is 5.5 barrels of 42 U.S. gallons per short ton.

ASTM. The acronym for the American Society for Testing and Materials.

Aviation Gasoline Blending Components. Finished components in the gasoline range which will be used for blending or compounding into finished aviation gasoline.

Aviation Gasoline (Finished). All special grades of gasoline for use in aviation reciprocating engines, as given in ASTM Specification D910 and Military Specification MIL-G5572. Excludes blending components which will be used in blending or compounding into finished aviation gasoline.

Barrel. A volumetric unit of measure for crude oil and petroleum products equivalent to 42 U.S. gallons. This measure is used in most statistical reports. Factors for converting petroleum coke, asphalt and wax to barrels are given in the definitions for these products.

Barrels Per Calendar Day. See *Operable Capacity*.

Barrels Per Stream Day. See *Operable Capacity*.

Bi-Metallic. A term used to describe a type of catalyst. A catalytic process utilizing a catalyst comprised of two metals (e.g. platinum, rhenium).

Butane. A normally gaseous straight-chain or branch-chain hydrocarbon. (C4H10). It is extracted from natural gas or refinery gas streams. It includes isobutane and normal butane and is covered by ASTM Specification D1835 and Gas Processors Association Specifications for commercial butane.

> *Isobutane.* A normally gaseous branch-chain hydrocarbon, (C4H10). It is a colorless paraffinic gas that boils at a temperature of 10.9 degrees F. It is extracted from natural gas or refinery gas streams.
>
> *Normal Butane.* A normally gaseous straight-chain hydrocarbon, (C4H10). It is a colorless paraffinic gas that boils at a temperature of 31.1 degrees F. It is extracted from natural gas or refinery gas streams.

Butylene. An olefinic hydrocarbon, (C4H8), recovered from refinery processes.

Catalytic Cracking. The refining process of breaking down the larger, heavier, and more complex hydrocarbon molecules into simpler and lighter molecules. Catalytic cracking is accomplished by the use of a catalytic agent and is an effective process for increasing the yield of gasoline from crude oil.

Catalytic Hydrocracking. A refining process for converting middle boiling or residual material to high-octane gasoline, reformer charge stock, jet fuel and/or high grade fuel oil. Hydrocracking is an efficient, relatively low temperature process using hydrogen and a catalyst.

Catalytic Hydrotreating. A process for treating petroleum fractions (e.g. distillate fuel oil and residual oil) and unfinished oils (e.g. naphthas, reformer feeds and heavy gas oils) in the presence of catalysts and substantial quantities of hydrogen to upgrade their quality.

Catalytic Reforming. The use of controlled heat and pressure with catalysts to effect the rearrangement of certain hydrocarbon molecules without altering their composition appreciably; the conversion of low-octane gasoline fractions into higher octane stocks suitable for blending into finished gasoline; also the conversion of naphthas to obtain a more volatile product of higher octane number.

Conventional. A term used to describe a type of catalyst. A catalytic process utilizing a catalyst comprised of a metal and a non-metal (e.g. platinum, alumina).

Coal. A generic term applied to carbonaceous rocks that were formed by the partial or complete decomposition of vegetation. These stratifed carbonaceous rocks are either solid or brittle and are highly combustible. Includes lignite, bituminous coal, and anthracite which conform to ASTM Specification D388.

Crude Distillation. The refining process of separating crude oil components by heating and subsequent condensing of the fractions by cooling.

Crude Oil (including Lease Condensate). A mixture of hydrocarbons that existed in liquid phase in underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities. Included are lease condensate and liquid hydrocarbons produced from tar sands, gilsonite and oil shale. Drip gases are also included, but topped crude oil (residual) oil and other unfinished oils are excluded. Liquids produced at natural gas processing plants and mixed with crude oil are likewise excluded where identifiable. Crude oil is considered as either domestic or foreign according to the following:

Domestic. Crude oil produced in the United States or from its "outer continental shelf" as defined in 43 U.S.C. 1331.

Foreign. Crude oil produced outside the United States. Imported Athabasca hydrocarbons are included.

Delayed Coking. A process to produce low Conradson carbon gas oil for catalytic cracking feedstock and for gasoline.

Distillate Fuel Oil. A general classification for one of the petroleum fractions produced in conventional distillation operations. It is used primarily for space heating, on-and-off-highway diesel engine fuel (including railroad engine fuel and fuel for agricultural machinery), and electric power generation. Included are products known as No. 1, No. 2, and No. 4 fuel oils; No. 1, No. 2, and No. 4 diesel fuels.

No. 1 Fuel Oil. A light distillate fuel oil intended for use in vaporizing pot-type burners. ASTM Specification D396 specifies for this grade maximum distillation temperatures of 400 degrees F. at the 10-percent point and 550 degrees F. at the 90-percent point, and kinematic viscosities between 1.4 and 2.2 centistokes at 100 degrees F.

No. 2 Fuel Oil. A distillate fuel oil for use in atomizing-type burners for domestic heating or for moderate capacity commercial-industrial burner units. ASTM Specification D396 specifies for this grade distillation temperatures at the 90-percent point between 540 degrees and 640 degrees F., and kinematic viscosities between 2.0 and 3.6 centistokes at 100 degrees F.

No. 1 and No. 2 Diesel Fuel Oils. Distillate fuel oils used in compression-ignition engines, as given by ASTM Specification D975:

No. 1-D. A volatile distillate fuel oil with a boiling range between 300-575 degrees F. and used in high-speed diesel engines generally operated under variations in speed and load. Includes type C-B diesel fuel used for city buses and similar operations. Properties are defined in ASTM Specification D975.

No. 2-D. A gas oil type distillate of lower volatility with distillation temperatures at the 90-percent point between 540-640 degrees F. for use in high-speed diesel engines generally operated under uniform speed and load conditions. Includes Type R-R diesel fuel used for railroad locomotive engines, and Type T-T for diesel-engine trucks. Properties are defined in ASTM Specification D975.

No. 4 Fuel Oil. A fuel oil for commercial burner installations not equipped with preheating facilities. It is used extensively in industrial plants. This grade is a blend of distillate fuel oil and residual fuel oil stocks that conforms to ASTM Specification D396 or Federal Specification VV-F-815C; its kinematic viscosity is between 5.8 and 26.4 centistokes at 100 degrees F. Also included is No. 4-D, a fuel oil for low- and medium-speed diesel engines that conforms to ASTM Specification D975.

Eastern Hemisphere. That half of the earth east of the Atlantic Ocean which includes Europe, Asia, Africa and Australia. The Hawaiian Foreign Trade Zone is in this hemisphere.

Electric Energy (Purchased). Electricity purchased for refinery operations that is not produced within the refinery complex.

Ethane. A normally gaseous straight-chain hydrocarbon, (C2H6). It is a colorless paraffinic gas that boils at a temperature of − 127.48 degrees F. It is extracted from natural gas and refinery gas streams.

Ethylene. An olefinic hydrocarbon, (C2H4), recovered from refinery processes or petrochemical processes.

Field Production. Represents crude oil production on leases, natural gas liquids production at natural gas processing plants, and new supply of other hydrocarbons and alcohol.

Fluid Coking. A thermal process utilizing the fluidized-solids technique for continuous conversion of heavy, low-grade oils into lighter products.

Gasohol. See ***Motor Gasoline (Finished).***

Gas Oil. A liquid petroleum distillate having a viscosity intermediate between that of kerosene and lubricating oil. Derives its name from having originally been used in the manufacture of illuminating gas. Now supplies distillate-type fuel oils and diesel fuel, also cracked to produce gasoline.

Gasoline Blending Components. Finished components in the gasoline range which will be used for blending or compounding into finished aviation or motor gasoline.

Idle Capacity. The component of operable capacity that is not in operation and not under active repairs, but capable of being placed in operation within 30 days; and capacity not in operation but under active repairs that can be completed within 90 days.

Imported Crude Oil Burned As Fuel. The amount of foreign crude oil burned as a fuel oil, usually as residual fuel oil, without being processed as such. Imported crude oil burned as fuel includes lease condensate and liquid hydrocarbons produced from tar sand oil, gilsonite, and shale oil.

Isobutane. See ***Butane.***

Isomerization. A refining process which alters the fundamental arrangement of atoms in the molecule. Used to convert normal butane into isobutane, an alyklation process feedstock, and normal pentane and hexane into isopentane and isohexane, high-octane gasoline components.

Kerosene. A petroleum distillate that boils at a temperature between 300-550 degrees F., that has a flash point higher than 100 degrees F. by ASTM Method D56, that has a gravity range from 40-46 degrees API, and that has a burning point in the range of 150-175 degrees F. Included are the two classifications recognized by ASTM D3699: No. 1-K and No. 2-K, and all grades of kerosene called range or stove oil which have properties similar to No. 1 fuel oil, but with a gravity of about 43 degrees API and a maximum end-point of 625 degrees F. Kerosene is used in space heaters, cook stoves, and water heaters and is suitable for use as an illuminant when burned in wick lamps.

Kerosene-Type Jet Fuel. A quality kerosene product with an average gravity of 40.7 degrees API, and a 10 percent distillation temperature of 400 degrees F. It is covered by ASTM Specification D1655 and Military Specification MIL-T-5624L (Grades JP-5 and JP-8). A relatively low-freezing point distillate of the kerosene type; it is used primarily for commercial turbojet and turboprop aircraft engines.

Lease Condensate. A natural gas liquid recovered from gas well gas (associated and nonassociated) in lease separators or natural gas field facilities. Lease condensate consists primarily of pentanes and heavier hydrocarbons.

Liquefied Petroleum Gases (LPG). Ethane, Ethylene, propane, propylene, normal butane, butylene, and isobutane produced at refineries or natural gas processing plants, including plants that fractionate raw natural gas plant liquids.

Liquefied Refinery Gases (LRG). Liquefied petroleum gases fractionated from refinery or still gases. Through compression and/ or refrigeration they are retained in the liquid state. The reported categories are ethane/ethylene, propane/propylene, normal butane/butylene, and isobutane. Excludes still gas used for chemical or rubber manufacture which is reported as a petrochemical feedstock and also excludes liquefied petroleum gases intended for blending into gasoline which are reported as gasoline blending components. Liquefied refinery gases are reported for use as petrochemical feedstock or other uses.

Lubricating Oils. A substance used to reduce friction between bearing surfaces. Petroleum lubricants may be produced either from distillates or residues. Other substances may be added to impart or improve certain required properties. "Lubricants" includes all grades of lubricating oils from spindle oil to cylinder oil and those used in greases. The three categories include:

Bright Stock. A refined, high viscosity lubricating oil base stock that is usually made from a residuum by a treatment such as deasphalting, acid treatment, or solvent extraction.

Neutral. A distillate lubricating oil base stock with a viscosity that is usually not above 550 Saybolt Universal Seconds (SUS) at 100 degrees F. It is prepared by a treatment such as hydrofining, acid treatment, or solvent extraction.

Other. A lubricating oil base stock used in finished lubricating oils and greases, including black, coastal, and red oils.

Middle Distillates. A general classification that includes distillate fuel oil and kerosene.

Miscellaneous Products. Includes all finished products not classified elsewhere, e.g., petrolatum, absorption oils, ram-jet fuel, petroleum rocket fuels, synthetic natural gas feedstocks, speciality oils and medicinal oils.

Motor Gasoline Blending Components. Finished components in the gasoline range which will be used for blending or compounding into finished motor gasoline. Pool gasoline is included in this category.

Motor Gasoline (Finished). A complex mixture of relatively volatile hydrocarbons, with or without small quantities of additives, that have been blended to form a fuel suitable for use in spark-ignition engines. Specifications for motor gasoline, as given in ASTM Specification D439 or Federal Specification VV-G-1690B, include a boiling range of 122-158 degrees F. at the 10-percent point to 365-374 degrees F. at the 90-percent point and a Reid vapor pressure range from 9 to 15 psi. "Motor gasoline" includes finished leaded gasoline, finished unleaded gasoline, and gasohol. Blendstock is excluded until blending has been completed. Alcohol that is to be used in the blending of gasohol is also excluded.

Finished Leaded Gasoline. Contains more than 0.05 gram of lead per gallon or more than 0.005 gram of phosphorus per gallon. The actual lead content of any given gallon, however, may vary as a function of the size of the producer and company according to specific Environmental Protection Agency waiver provisions. Premium and regular grades are included, depending on the octane rating. Includes leaded gasohol. Blendstock is excluded until blending has been completed. Alcohol that is to be used in the blending of gasohol is also excluded.

Finished Unleaded Gasoline. Contains not more than 0.05 gram of lead per gallon and not more than 0.005 gram of phosphorus per gallon. Premium and regular grades are included, depending on the octane rating. Includes unleaded gasohol. Blend stock is excluded until blending has been completed. Alcohol that is to be used in the blending of gasohol is also excluded.

Gasohol. A blend of finished motor gasoline (leaded or unleaded) and alcohol (generally ethanol but sometimes methanol) in which 10 percent or more of the product is alcohol.

Naphtha-Type Jet Fuel. A fuel in the heavy naphtha boiling range with an average gravity of 52.8 degrees API and 20 to 90 percent distillation temperatures of 290 degrees to 470 degrees F, meeting Military Specification MIL-T-5624L (Grade JP-4). JP-4 is used for turbojet and turboprop aircraft engines, primarily by the military. Excludes ram-jet and petroleum rocket fuels.

Natural Gas. A mixture of hydrocarbons and small quantities of various nonhydrocarbons existing in the gaseous phase or in solution with crude oil in underground reservoirs.

Natural Gas Field Facility. A field facility designed to process natural gas produced from more than one lease for the purpose of recovering condensate from a stream of natural gas; however, some field facilities are designed to recover propane, normal butane, pentanes plus, etc., and to control the quality of natural gas to be marketed.

Natural Gas Plant Liquids. Natural gas liquids recovered from natural gas in gas processing plants, and in some situations, from natural gas field facilities. Natural gas liquids extracted by fractionators are also included. These liquids are defined according to the published specification of the Gas Processors Association and the American Society for Testing and Materials and are classified as follows: Ethane, propane, normal butane, isobutane, pentanes plus, and other products from natural gas processing plants (i.e. products meeting the standards for finished petroleum products produced at natural gas processing plants, such as finished motor gasoline, finished aviation gasoline, special naphthas, kerosene, distillate fuel oil, and miscellaneous products).

Natural Gasoline and Isopentane. A mixture of hydrocarbons, mostly pentanes and heavier, extracted from natural gas, that meets vapor pressure, end-point, and other specifications for natural gasoline set by the Gas Processors Association. Includes isopentane which is a saturated branch-chain hydrocarbon, (C_5H_{12}), obtained by fractionation of natural gasoline or isomerization of normal pentane.

Normal Butane. See ***Butane.***

OPEC. The acronym for the Organization of Petroleum Exporting Countries, oil-producing and exporting countries that have organized for the purpose of negotiating with oil companies on matters of oil production, prices and future concession rights. Current members are Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.

Operable Capacity. The amount of capacity that, at the beginning of the period, is in operation; not in operation, and not under active repairs but capable of being placed in operation within 30 days; or not in operation but under active repairs that can be completed within 90 days. Operable capacity is the sum of the operating and idle capacity and is measured in barrels per calendar day or barrels per stream day.

Barrels Per Calendar Day. The maximum number of barrels of input that can be processed in an atmospheric distillation facility during a twenty-four hour period after making allowances for the following limitations:

The capability of downstream facilities to absorb the output of crude oil processing facilities of a given refinery. No reduction is made when a planned distribution of intermediate streams through other than downstream facilities is part of a refinery's normal operation.

The types and grades of inputs to be processed.

The types and grades of products expected to be manufactured.

The environmental constraints associated with refinery operations.

The reduction of capacity for scheduled downtime such as routine inspection, mechanical problems, maintenance, repairs and turnaround.

The reduction of capacity for unscheduled downtime such as mechanical problems, repairs, and slowdowns.

Barrels Per Stream Day. The amount a unit can process running at full capacity under optimal crude and product slate conditions.

Operating Capacity. The component of operable capacity that is in operation at the beginning of the period.

Other Hydrocarbons. Materials received by a refinery and consumed as raw materials. Includes hydrogen, coal tar derivatives, gilsonite, and natural gas received by the refinery for reforming into hydrogen. Natural gas to be used as fuel is excluded.

Pentanes Plus. A mixture of hydrocarbons, mostly pentanes and heavier, extracted from natural gas. Includes isopentane, natural gasoline and plant condensate.

Petrochemical Feedstock Use. Chemical feedstocks derived from petroleum, principally for the manufacture of chemicals, synthetic rubber and a variety of plastics. The categories reported are "Naphtha-Less than 400 degrees F. end-point" and "Other oils over 400 degrees F. end point."

Naphtha-Less Than 400 Degrees F. End-Point. A naphtha with an end point of less than 400 degrees F. that is intended for use as a petrochemical feedstock.

Other Oils-Over 400 Degrees F. End-Point. Oils with an end point over 400 degrees F. that is intended for use as a petrochemical feedstock.

Petroleum Coke. A residue, the final product of the condensation process in cracking. This product is reported as marketable coke or catalyst coke. The conversion factor is 5 barrels of 42 U.S. gallons per short ton.

Marketable Coke. Those grades of coke produced in delayed or fluid cokers which may be recovered as relatively pure carbon. This "green" coke may be sold as is or further purified by calcining.

Catalyst Coke. In many catalytic operations (i.e., catalytic cracking) carbon is deposited on the catalyst thus, deactivating the catalyst. The catalyst is reactivated by burning off the carbon, which is used as a fuel in the refinery process. This carbon or coke is not recoverable in a concentrated form.

Petroleum Products. Petroleum products are obtained from the processing of crude oil (including lease condensate), natural gas and other hydrocarbon compounds. Petroleum products include unfinished oils, liquefied petroleum gases, pentanes plus, aviation gasoline, motor gasoline, naphtha-type jet fuel, kerosene-type jet fuel, kerosene, distillate fuel oil, residual fuel oil, naphtha less than 400 F. end-point, other oils over 400 F. end-point, special naphthas, lubricants, waxes, petroleum coke, asphalt, road oil, still gas, and miscellaneous products.

Petroleum Refinery. An installation that manufacturers finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and alcohol.

Plant Condensate. One of the natural gas liquids, mostly pentanes and heavier hydrocarbons, recovered and separated as liquids at gas inlet separators or scrubbers in processing plants.

Primary Stocks. Stocks of crude oil or petroleum products held in storage at (or in) leases, refineries, natural gas processing plants, pipelines, tankfarms, and bulk terminals that can store at least 50,000 barrels of petroleum products or that can receive petroleum products by tanker, barge, or pipeline. Crude oil that is in transit from Alaska, or that is stored on Federal leases or in the Strategic Petroleum Reserve is included. Primary Stocks excludes stocks of foreign origin that are held in bonded warehouse storage.

Propane. A normally gaseous straight-chain hydrocarbon, (C_3H_8). It is a colorless paraffinic gas that boils at a temperature of -43.67 degrees F. It is extracted from natural gas or refinery gas streams. It includes all products covered by Gas Processors Association Specifications for commercial propane and HD-5 propane and ASTM Specification D1835.

Propylene. An olefinic hydrocarbon, (C_3H_6), recovered from refinery processes or petrochemical processes.

Residual Fuel Oil. The topped crude of refinery operations which includes No. 5 and No. 6 fuel oils as defined in ASTM Specification D396 and Federal Specification VV-F-815C, Navy Special fuel oil as defined in Military Specification MIL-F-859E including Amendment 2 (NATO Symbol F-77), and Bunker C fuel oil. Residual fuel oil is used for the production of electric power, space heating, vessel bunkering, and various industrial purposes. Imports of residual fuel oil include "Imported Crude Oil Burned as Fuel."

Road Oil. Any heavy petroleum oil, including residual asphaltic oil used as a dust pallative and surface treatment on roads and highways. It is generally produced in six grades from 0, the most liquid, to 5, the most viscous.

Special Naphthas. All finished products within the gasoline range that are used as paint thinners, cleaners, or solvents. These products are refined to a specified flash point and have a boiling range of 90 degrees to 220 degrees F. "Special naphthas" includes all commercial hexane and cleaning solvents conforming to ASTM Specification D1836 and D484, respectively. Naphthas to be blended or marketed as motor gasoline or aviation gasoline or that are to be used as petrochemical and synthetic natural gas (SNG) feedstocks are excluded.

Steam (Purchased). Steam, purchased for use by a refinery, that was not generated from within the refinery complex.

Still Gas (Refinery Gas). Any form or mixture of gas produced in refineries by distillation, cracking, reforming, and other processes. The principal constituents are methane, ethane, ethylene, normal butane, butylene, propane, propylene, etc. Still gas is reported for petrochemical feedstock use and/or refinery fuel use.

Petrochemical Feedstock Use. Includes all refinery streams which are used by chemical or rubber manufacturing operations for further processing, less the amount of such streams returned to the source refinery. Finished petrochemical products are not included. For example, polyethylene, butadiene, etc. are considered petrochemical products; therefore, only their feedstock equivalents are included.

Fuel Use. All other still gas.

Strategic Petroleum Reserve (SPR). Petroleum stocks maintained by the Federal Government for use during periods of major supply interruption.

Thermal Cracking. A refining process in which heat and pressure are used to break down, rearrange, or combine hydrocarbon molecules. Thermal cracking is used to increase the yield of gasoline obtainable from crude oil.

Unfinished Oils. Includes all oils requiring further processing, except those requiring only mechanical blending.

Unfractionated Streams. Mixtures of unsegregated natural gas liquid components excluding those in plant condensate. This product is extracted from natural gas.

Vacuum Distillation. Distillation under reduced pressure (less the atmospheric) which lowers the boiling temperature of the liquid-being distilled. This technique with its relatively low temperatures prevents cracking or decomposition of the charge stock.

Visbreaking. A thermal cracking process in which heavy vacuum-still bottoms produced on the primary distillation unit are cracked to increase production of distillate products.

Wax. A solid or semi-solid material derived from petroleum distillates or residues by such treatments as chilling, precipitating with a solvent, or de-oiling. It is light-colored, more-or-less translucent crystalline mass, slightly greasy to the touch, consisting of a mixture of solid hydrocarbons in which the paraffin series predominates. Includes all marketable wax whether crude scale or fully refined. The three grades included are microcrystalline, crystalline-fully refined, and crystalline-other. The conversion factor is 280 pounds per 42-U.S. gallon barrel.

Microcrystalline Wax. Wax extracted from certain petroleum residues having a finer and less apparent crystalline structure than paraffin wax and having the following physical characteristics:

> Penetration at 77 degrees F. (D1321)-60 maximum. Viscosity at 210 degrees F. in Saybolt Universal Seconds (SUS). (D88)-60 SUS (10.22 centistokes) minimum to 150 SUS (31.8 centistokes) maximum. Oil content (D721)-5 percent minimum.

Crystalline-Fully Refined Wax. A light-colored paraffin wax having the following characteristics:

> Viscosity at 210 degrees F. (D88)-59.9 SUS (10.18 centistokes) maximum. Oil Content (D721)-0.5 percent maximum. Other +20 color, Saybolt minimum.

Crystalline-Other Wax. A paraffin wax having the following characteristics:

> Viscosity at 210 degrees F. (D88)-59.9 SUS (10.18 centistokes) maximum. Oil Content (D721)-0.51 percent minimum to 15 percent maximum.

Western Hemisphere. That half of the earth that includes North and South America and adjacent islands.

*U.S. GOVERNMENT PRINTING OFFICE: 1986-491-160:20007

APPENDIX C

EXAMPLE CRUDE OIL ANALYSES

Sources: [1] Gary, James H. and Glenn E. Handwerk, Petroleum Refining - Technology and Economics, 2nd Edition, Marcel Dekker, Inc., New York, N.Y; 1984.

[2] Gaines, L.L. and A.M. Wolsky, Energy and Materials Flows in Petroleum Refining, Argonne National Laboratory, Argonne, IL, ANL/CHSV - 10; 1981.

[3] Considine, Douglas M., editor-in-chief, Energy Technology Handbook, McGraw-Hill Book Co., New York, NY; 1977.

CRUDE PETROLEUM ANALYSIS[1]

Bureau of Mines Bartlesville Laboratory
Sample 54060

IDENTIFICATION

Bayou des Allemands field
Miocene

Louisiana
Lafourche Parish

GENERAL CHARACTERISTICS

Gravity, specific, 0.845 Gravity, ° API, 36.0 Pour point, ° F., 35
Sulfur, percent, 0.20 Color, brownish green
Viscosity, Saybolt Universal at 100°F, 49 sec. Nitrogen, percent, 0.040

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 743 mm. Hg
First drop, 86 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum, percent	Sp. gr., 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. visc., 100° F.	Cloud test, ° F.
1	122	0.5	0.5	0.670	79.7					
2	167	1.2	1.7	.675	78.1	11				
3	212	1.6	3.3	.722	64.5	23	1.39163	137.0		
4	257	2.7	6.0	.748	57.7	26	1.41725	141.7		
5	302	3.1	9.1	.765	53.5	26	1.42648	142.3		
6	347	3.9	13.0	.778	50.4	25	1.43374	140.7		
7	392	4.7	17.7	.789	47.8	24	1.43962	138.0		
8	437	5.7	23.4	.801	45.2	24	1.44529	137.6		
9	482	8.0	31.4	.814	42.3	25	1.45193	137.4		
10	527	10.7	42.1	.825	40.0	26	1.45884	142.9		
STAGE 2—Distillation continued at 40 mm. Hg										
11	392	5.0	47.1	0.845	36.0	31	1.46614	142.6	40	15
12	437	10.0	57.1	.854	32	32	1.46870	139.9	45	30
13	482	7.8	64.9	.863	32.5	33	1.47403	140.4	56	50
14	527	7.0	71.9	.874	30.4	35			81	65
15	572	6.5	78.4	.889	27.7	39			145	85
Residuum		20.8	99.2	.931	20.5					

Carbon residue, Conradson: Residuum, 3.7 percent; crude, 0.8 percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	3.3	0.697	71.5	
Total gasoline and naphtha	17.7	0.759	54.9	
Kerosine distillate	24.4	.816	41.9	
Gas oil	14.2	.850	35.0	
Nonviscous lubricating distillate	14.1	.858-.878	33.4-29.7	50-100
Medium lubricating distillate	6.0	.878-.895	29.7-26.6	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	20.8	.931	20.5	
Distillation loss	.8			

U.S. GOVERNMENT PRINTING OFFICE [illegible]

CRUDE PETROLEUM ANALYSIS[1]

Bureau of Mines Bartlesville Laboratory
Sample 60052

IDENTIFICATION

Black Bay, West field
9200', Miocene
9,178-9,185 feet

Louisiana
Plaquemines Parish

GENERAL CHARACTERISTICS

Gravity, specific, 0.853 Gravity, ° API, 34.4 Pour point, ° F., below 5
Sulfur, percent, 0.19 Color, brownish green
Viscosity, Saybolt Universal at 100°F., 46 sec. Nitrogen, percent,

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure, 758 mm. Hg
First drop, 113 ° F.

Fraction No.	Cut temp. ° F.	Percent	Sum percent	Sp. gr., 60/60° F.	° API, 60° F.	C. I.	Refractive index, n_D at 20° C.	Specific dispersion	S. U. visc., 100° F.	Cloud test, ° F.
1	122									
2	167									
3	212	2.6	2.6	0.706	68.9	-	1.39971	129.4		
4	257	3.1	5.7	.739	60.0	21	1.41235	132.0		
5	302	3.7	9.4	.762	54.2	25	1.42308	135.4		
6	347	4.2	13.6	.780	49.9	26	1.43298	137.1		
7	392	5.8	19.4	.796	46.3	28	1.44076	138.4		
8	437	4.9	24.3	.807	43.8	27	1.44701	139.1		
9	482	7.6	31.9	.820	41.1	28	1.45389	140.8		
10	527	9.1	41.0	.834	38.2	30	1.46161	143.0		
Stage 2—Distillation continued at 40 mm. Hg										
11	392	6.0	47.0	0.846	35.8	32	1.46906	148.8	40	below 5
12	437	8.3	55.3	.854	34.2	32	1.47238	147.4	46	20
13	482	6.8	62.1	.866	31.9	34	1.47868	144.0	58	50
14	527	5.8	67.9	.881	29.1	38	1.48434	-	81	60
15	572	6.1	74.0	.892	27.1	40			135	70
Residuum		24.5	98.5	.940	19.0					

Carbon residue, Conradson: Residuum, percent; crude, percent.

APPROXIMATE SUMMARY

	Percent	Sp. gr.	° API	Viscosity
Light gasoline	2.6	0.706	68.9	
Total gasoline and naphtha	19.4	0.765	53.5	
Kerosine distillate	12.5	.815	42.1	
Gas oil	21.9	.843	36.4	
Nonviscous lubricating distillate	12.9	.858-.884	33.4-28.6	50-100
Medium lubricating distillate	7.3	.884-.898	28.6-26.1	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	24.5	.940	19.0	
Distillation loss	1.5			

U. S. GOVERNMENT PRINTING OFFICE 16—57625-3

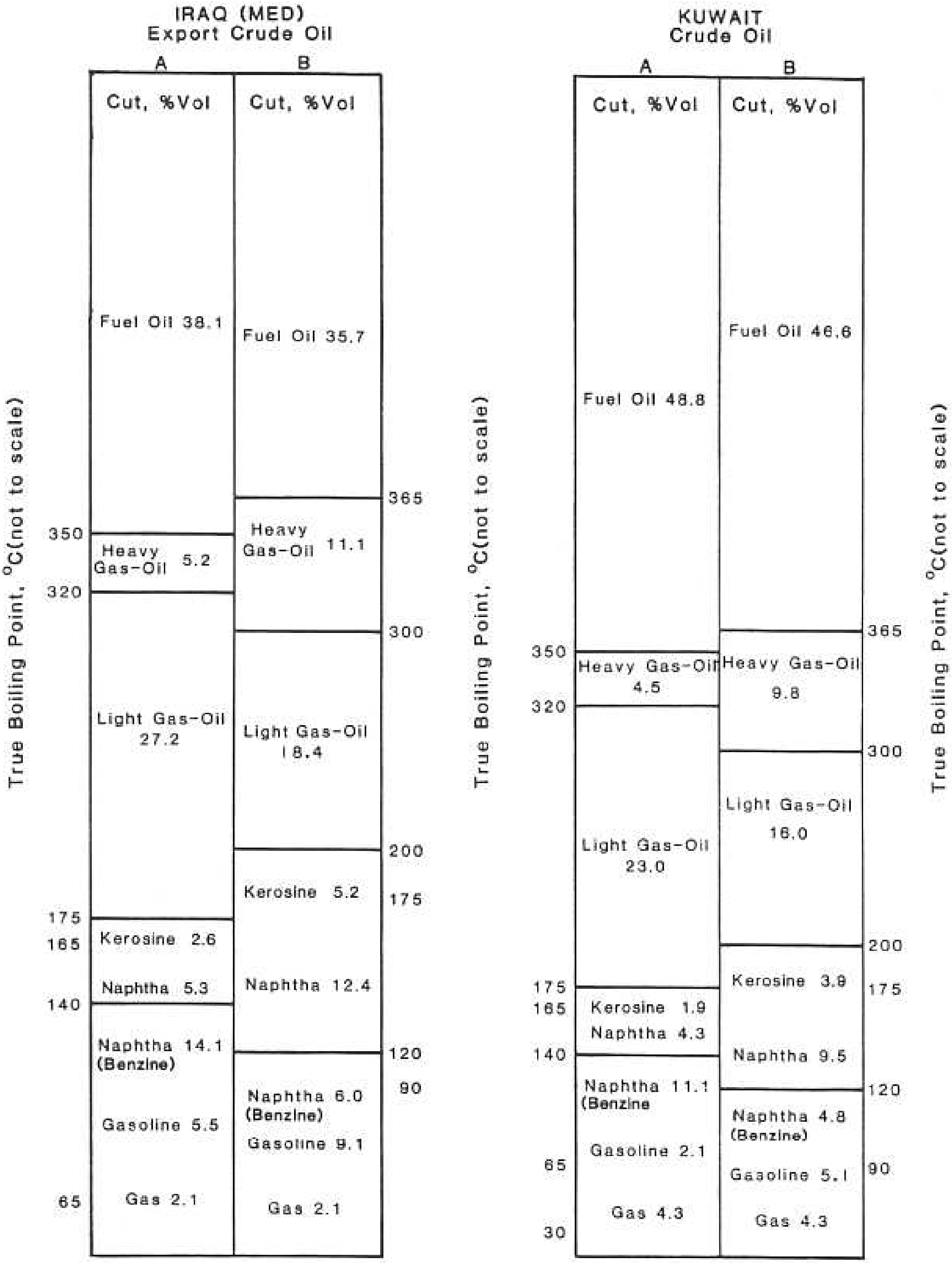


Diagram Showing Flexibility in Producing Crude Oil Cuts[2]

Analyses of United States Crude Oils[3]

	McComb, Mississippi		Southwest Texas		East Texas	Wyoming (Sour)	New Mexico	N. Kenai Penin., Alaska	San Ardo, California	Ospelousas, Lousiana		Velma, Oklahoma
Gravity, °API	40.7		36.5		39.1	17.9	37.5	25.9	13.3*	38.2		29.1
Distillation, °F:												
Type	D 86¶	UOP 76§	D 86	UOP 76	D 86	D 86	D 86	D 86	UOP	D 86	UOP 76	D 86
IBP (initial boiling point)	152	152	158	158	125	306	118	160	IBP 180 0.3†	127	127	145
5% over	192	192	208	208	191	408	162	196	180– 380 1.6†	206	206	224
10	224	224	244	244	211	476	224	220	380– 550 16.1†	256	256	482
30	344	344	461	461	355	633	354	514	550– 650 10.6†	438	438	659
50	504	506	700	770	539	675	530	660	650– 900 17.3†	545	575	712
70	655	703	760+	1075	702	710	626	690	900–1000 6.0†	672	720	748
90	760+	977	...	...	760	732‡	728	710‡	1000+ 48.1†	760+	905	748+
EP (end point)	...	1062	...	...	760+	732+	734+	710+	....	...	978	
% recovered	98.5	95.5	98.5	90.5	97.0	89.0	93.0	80.0	....	98.5	96.0	95.5
% bottoms	...	4.5	...	9.5	...	...	...	...	....	...	4.0	
% coke, wt.	1.6	...	1.8	...	2.8	11.0	5.6	...	....	0.7		
% recovered												
At 400°F	37.0	...	32.0	...	34.5	4.5	35.0	...	1.9*	26.5		22.5
525°F	53.0	...	48.0	...	54.0	15.0	55.0	...	17.9*	46.0		33.5
572°F	60.0	...	54.0	...	...	20.0	...	...	....	54.0		39.0

	McComb, Mississippi	Southwest Texas	East Texas	Wyoming (Sour)	New Mexico	N. Kenai Penin., Alaska	San Ardo, California	Ospelousas, Lousiana	Velma, Oklahoma
Total sulfur, wt %	0.07	0.45	0.2	3.33	1.0	1.036	1.93*	0.08	1.13
Reid vapor pressure, psi	4.6	3.4	...	0.2	8.8	4.2	...	8.4	4.0
Pour point, °F	60	30	55	−5	25	...	...	40	<−30
Bottom sediment and water, vol %	0.10	0.10	0.1	0.3	0.3	2.5	...	0.15	0.2
Conradson carbon residue, wt %	0.79	1.74	...	...	...	...	...	0.52	
Salt (as NaCl) lb/1,000 bbl	4	<0.5	31	0.6	14.0	76.0	...	5.0	78.0
Gasoline, vol%	35.5	32.0	29.0	6.3	37.8	14.4	1.9	26.1	22.3
Kerosine, vol %	18.1	12.1	10.1	9.1	...	18.0	16.1	18.9	17.3
Diesel fuel, vol %	14.6	38.0	13.8	14.0	...	18.4	10.6	22.9	8.5
Gas oil, vol %	28.1	12.6	...	30.7	41.2	22.3	23.3	27.9	31.9
Asphalt (bottoms), vol %	3.7	5.3	(47.1)	39.9	20.8	25.7	48.1	4.1	20.0
Metals (in gas oils), ppm:									
Nickel	0.06	...	...	...	...	...	0.15	...	...
Vanadium	0.08	...	...	...	...	...	<0.1	...	...

From Douglas M. Considine (ed.), "Chemical and Process Technology Encyclopedia," McGraw-Hill Book Company, New York, 1974.
*Calculated.
†% over in indicated boiling range.
‡Cracked at 80% over.
¶ Designates data from Method of Test D 86, Committee D-2 on Petroleum Products and Lubricants, ASTM.
§ Designates data from UOP Laboratory Test Methods for Petroleum and Its Products, No. 76, Universal Oil Products Company.

Analysis of World Crude Oils[3]

	Arabian	Minas, Central Sumatra, Topped		Putomayo, Colombia		Gulf Nigeria		Zulia, Venezuela		Iran		Kuwait	
Gravity, °API	30.0	35.3		35.0		34.7		25.2		36.6		31.5	
Distillation, °F: Type	D 86	D 86*	UOP 76†	°F	Vol %	°F	Vol %	Hempel‡	Vol %	Hempel‡	Vol %	Hempel‡	Vol %
IBP (initial boiling point)	77	173	594	IBP 400	34.1	IBP 140	6.3	IBP 122	0.1	IBP 122	1.5	IBP 122	2.8
5%	160	216	662	400–500	9.3	140–170	1.8	122–167	1.2	122–167	2.8	122–167	2.5
10	231	246	699	500–650	20.3	170–310	16.8	167–212	2.3	167–212	4.5	167–212	3.2
20	287	295	750	650–750	9.0	310–520	26.5	212–257	3.7	212–257	6.3	212–257	4.2
30	...	341	792	750–900	11.4	520–680	19.3	257–302	3.9	257–302	7.1	257–302	4.3
50	330	427	890	900+	17.2	680+	30.9	302–347	4.1	302–347	5.6	302–347	4.5
70	435	497	1042	...	...	...	...	347–392	3.6	347–392	5.4	347–392	4.0
90	452	575	Cracked	...	...	...	...	392–437	3.4	392–437	5.4	392–437	4.0
95	526	619	...	...	...	...	...	437–482	4.7	437–482	5.5	437–482	4.2
EP (end point)	526	639	1042+	...	...	...	...	482–527	6.0	482–527	7.4	482–527	5.5
								527–583	2.2	527–583	2.6	527–583	2.6
								583–633	5.1	583–633	6.6	583–633	7.0
								633–687	4.9	633–687	5.6	633–687	4.4
								687–738	5.2	687–738	5.1	687–738	4.8
								738–790	7.3	738–790	5.9	738–790	5.3
% recovered	...	99.0	72.5	101.3		101.6		57.7		77.3		63.3	
% residue	...	1.0	27.5	...		...		42.1		22.5		34.8	
Total sulfur, wt %	3.05	0.2		0.49		0.16		1.69		1.12		2.62	
Reid vapor pressure, psig	3.8												
Pour point, °F	−33	40		45		20		<5		5		<5	
Gasoline, vol %	29.1	11¶		34.1		24.9		18.9		32.2		25.5	
Kerosine, vol %	16.0	16¶		9.3		26.5		14.1		18.3		13.7	
Gas oils, vol %	12.5	14¶		40.7		19.3							
Residuum, vol %	42.4	59¶		17.2		30.9							
Metals in gas oils, ppm:													
Vanadium	0	...		25§		0.7§							
Nickel	0	...		11		5.1§							
Iron	3												
Salt, lb/1,000 bbl	12	...		Trace		5							

From Douglas M. Considine (ed.), "Chemical and Process Technology Encyclopedia," McGraw-Hill Book Company, New York, 1974.
*IBP to 650°F.
†On 650°F+ bottoms.
‡Bureau of Mines Hempel, vol % at stated cut points.
¶Estimated.
§In crude oil.