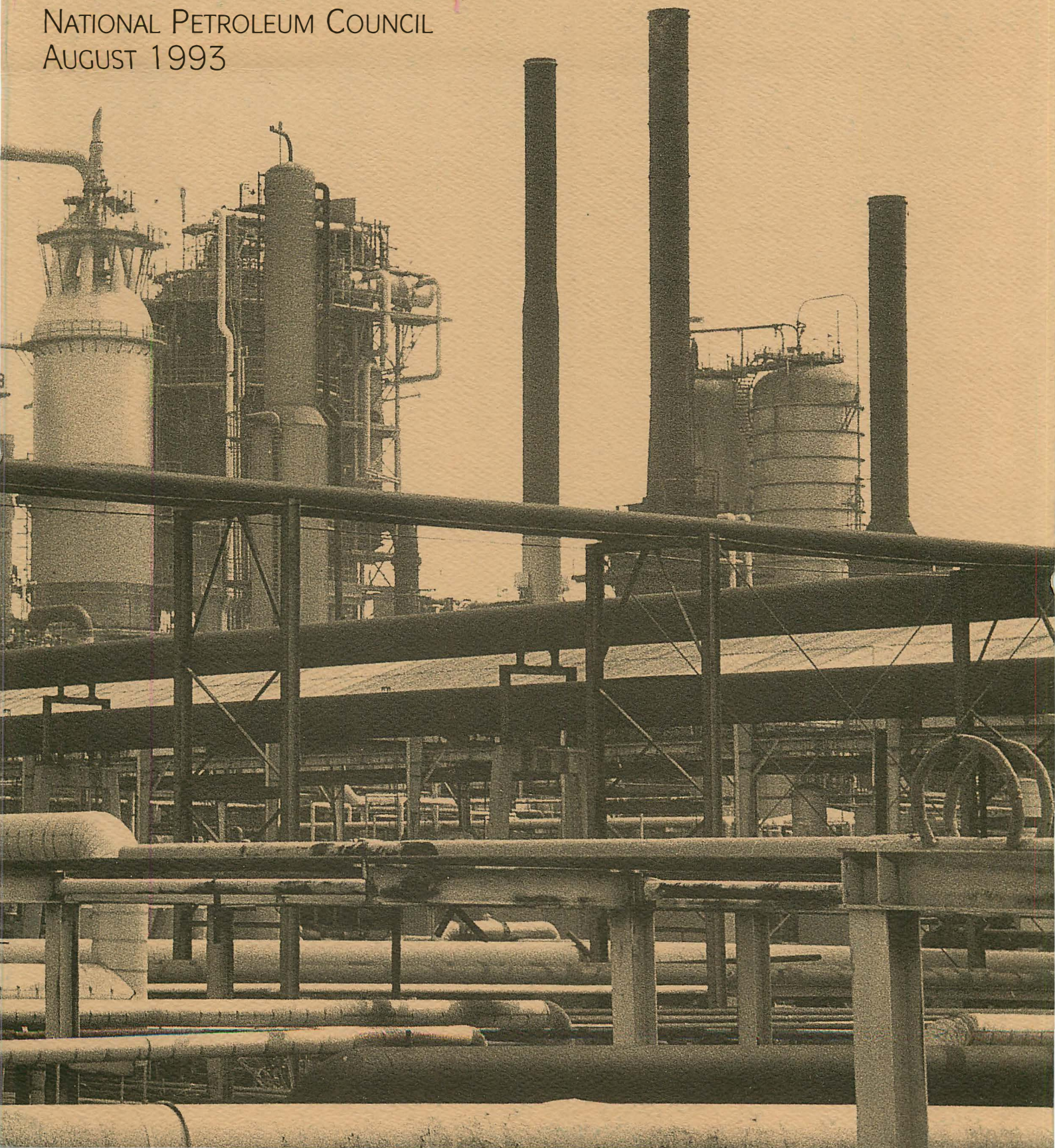


U.S. PETROLEUM REFINING

MEETING REQUIREMENTS FOR
CLEANER FUELS AND REFINERIES

VOLUME V—REFINING CAPABILITY APPENDIX

NATIONAL PETROLEUM COUNCIL
AUGUST 1993



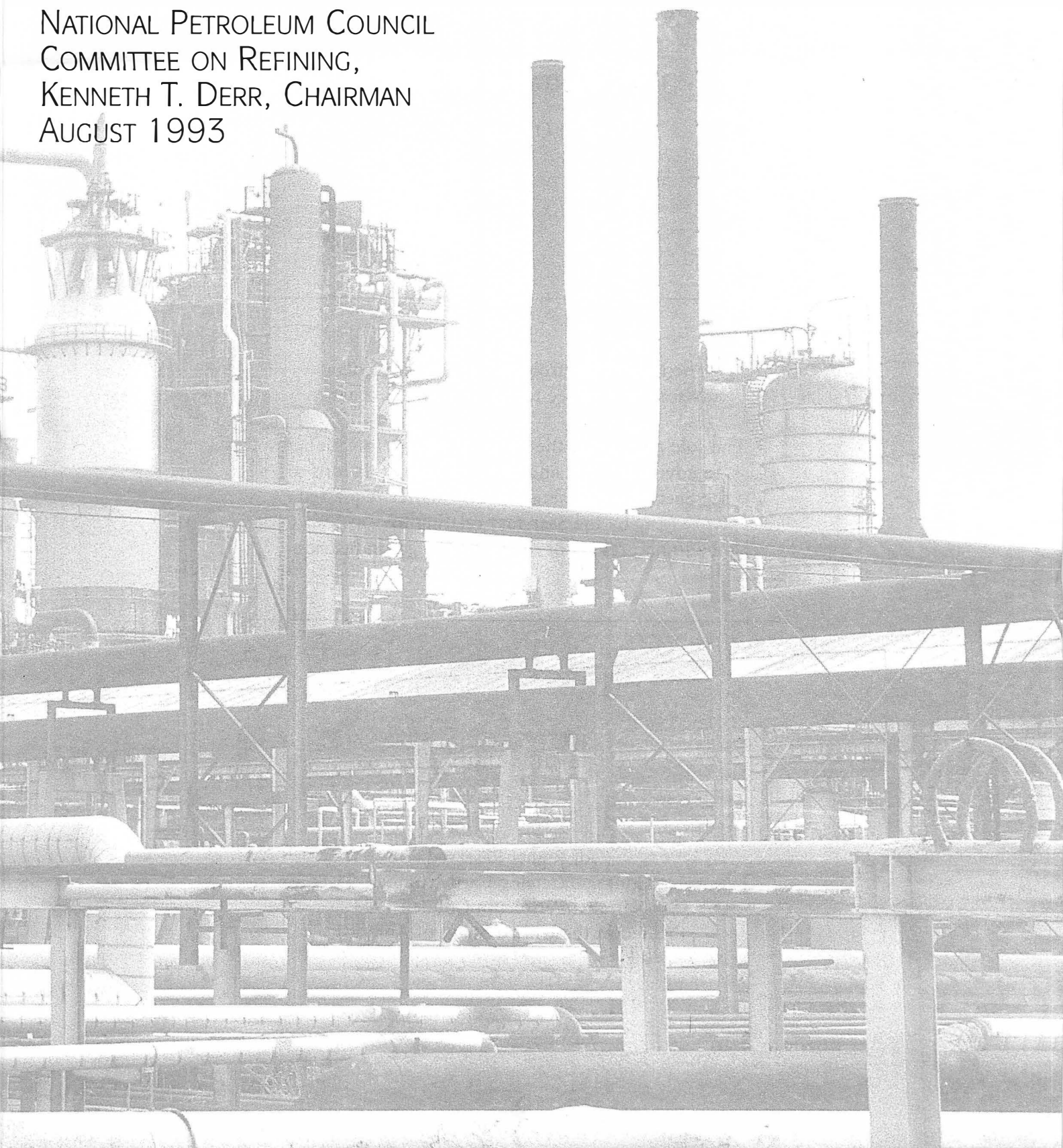
COVER PHOTOGRAPH: PASCAGOULA REFINERY, CHEVRON U.S.A. INC.

U.S. PETROLEUM REFINING

MEETING REQUIREMENTS FOR CLEANER FUELS AND REFINERIES

VOLUME V—REFINING CAPABILITY APPENDIX

NATIONAL PETROLEUM COUNCIL
COMMITTEE ON REFINING,
KENNETH T. DERR, CHAIRMAN
AUGUST 1993



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APPENDIX M

APPENDIX TO CHAPTER FOUR — U.S. REFINING CAPABILITY AND COSTS

SECTION I

COST EFFECTIVENESS TABLES

TABLE 1

**COST AND VOC & NO_x PERFORMANCE OF
VARIOUS REFORMULATIONS (PADD I, SUMMER)¹**

Year	% RFG	Case Description	Cost (¢/gal) ²		% VOC Reduction ³		% NO _x Reduction ³	
			Refin.	Total	4/92	2/93	4/92	2/93
1995	0%	conventional gasoline (Q9)	0.0	0.0	9%	1%	-3%	-22%
2000	100%	complex model base case (Q6)	8.2	10.2	41%	27%	-1%	-9%
2000	100%	low olefin RFG (QN2H)	10.3	12.4	41%	30%	2%	2%
2000	100%	low sulfur and olefin RFG (S10)	11.3	13.1	41%	27%	7%	5%
2000	100%	California Phase 2 (S21)	21.3	24.2	48%	36%	8%	18%

¹ Data taken from Exhibit 24 (4/16/93), Table E-2 (1/15/93), and Table E1-2 (1/13/93).

² Total cost includes consumer cost for extra gasoline used due to lower BTU content, relative to conventional gasoline under the pre-1990 Clean Air Act.

³ Percent change in emissions relative to the performance of the statutory baseline gasoline under the complex model proposed on 4/92 by EPA and the more recent 2/93 proposed model.

TABLE 2
AVERAGE COST EFFECTIVENESS OF
VARIOUS RFG FORMULATIONS (PADD I, SUMMER)

Case	Cost (¢/gal) ⁴	Model ⁵	Change in VOC Reduction ⁶	Change in NOx Reduction ⁶	C/E Dollars per Ton (summer)	
					VOC	VOC & NOx
RFG 2000 (Q6)	10.2	4/92 2/93	32% 26%	2% 13%	\$12K \$12K	\$10K \$8.1K
RFG 2000, low olefins (QN2H)	12.4	4/92 2/93	32% 29%	5% 24%	\$13K \$12K	\$12K \$10K
RFG 2000 low sulfur & olefins (S10)	13.1	4/92 2/93	32% 26%	10% 27%	\$13K \$15K	\$12K \$7.6K
California Phase 2 RFG (S21)	24.2	4/92 2/93	39% 35%	11% 40%	\$20K \$21K	\$18K \$9.9K

⁴ Total cost over conventional gasoline (Q9).

⁵ The two complex models also include different baseline emissions. For the 4/92 model, VOCs are about 1.25 g/mile; NOx 0.66 g/mile. For the 2/93 model, VOCs are about 1.35 g/mile and NOx is 1.34 g/mile. Average MPG of 22.1 for conventional gasoline was used.

⁶ Versus performance of conventional gasoline (Q9).

TABLE 3
INCREMENTAL COST EFFECTIVENESS OF
CALIFORNIA PHASE 2 RFG (PADD I, SUMMER)

Case	Cost (¢/gal) ⁷	Model ⁸	Incremental VOC Reduction	Incremental NOx Reduction	C/E Dollars per Ton (summer)	
					VOC	VOC & NOx
Tightening of 2000 spec with low olefins (Q6vs QN2H)	2.2	4/92 2/93	0% 3%	3% 11%	NA \$22K	\$47K \$4.8K
Tightening of 2000 spec with low olefin and low sulfur (Q6vs S10)	2.9	4/92 2/93	0% 0%	8% 14%	NA NA	\$23K \$6.3K
Tightening of 2000 spec to match Calif Phase 2 (Q6 vs S21)	14.0	4/92 2/93	7% 9%	9% 27%	\$66K \$47K	\$40K \$12K

⁷ Excludes 2¢/gallon attributed to investments specific to meeting the benzene specification.

⁸ The two complex models also include different baseline emissions. For the 4/92 model, VOCs are about 1.25 g/mile; NOx 0.66 g/mile. For the 2/93 model, VOCs are about 1.35 g/mile and NOx is 1.34 g/mile. Average MPG of 22.1 for conventional gasoline was used.

TABLE 4
COST AND VOC & NO_x PERFORMANCE OF
VARIOUS REFORMULATIONS (PADD II, SUMMER)⁹

Year	% RFG	Case Description	Cost (¢/gal) ¹⁰		% VOC Reduction ¹¹		% NO _x Reduction ¹¹	
			Refin.	Total	4/92	2/93	4/92	2/93
1995	0%	conventional gasoline only (Q9)	0.0	0.0	6%	0%	0%	-9%
1995	56%	full opt-in, simple model (S5)	5.3	7.5	25%	25%	-1%	-1%
2000	56%	complex model base case (Q6N)	8.9	10.5	41%	29%	0%	-4%
2000	100%	complex base case with 100% RFG (S6)	7.5	9.6	41%	27%	0%	-3%
2000	100%	formulation to accommodate ethanol (S13H)	11.9	18.0 ¹²	41%	29%	4%	4%

⁹ Data taken from Exhibit 25 (4/16/93), Exhibit 18 (5/20/93), and Table F-2 (5/11/93).

¹⁰ Total costs including need to buy extra gallons due to low BTU content vs. conventional gasoline.

¹¹ Reductions are relative to the statutory baseline gasoline's performance under the two models from EPA of 4/92 and 2/93.

¹² Cost includes effect of federal ethanol tax subsidy for ethanol.

TABLE 5
AVERAGE COST EFFECTIVENESS OF
VARIOUS RFG FORMULATIONS (PADD II, SUMMER)

Case	Cost (¢/gal)	Model ¹³	Change in VOC Reduction	Change in NOx Reduction	C/E Dollars per Ton (summer)	
					VOC	VOC & NOx
Simple model RFG (S5)	7.5	4/92 2/93	19% 25%	-1% 8%	\$13K \$9.1K	\$13K \$7K
2000 RFG (Q6N)	10.5	4/92 2/93	35% 29%	0% 5%	\$9.9K \$11K	\$9.9K \$9.4K
Use of ethanol for summer RFG in 2000 (S13H)	18.0	4/92 2/93	35% 29%	4% 13%	\$16K \$20K	\$16K \$14K

¹³ The two complex models used also have different baseline gasoline emissions. For the 4/92 model, VOCs are about 1.25 g/mile; NOx is 0.66 g/mile. For the 2/93 model, VOCs are about 1.35 g/mile and NOx is 1.34 g/mile. Average MPG of 22.1 for conventional gasoline was used.

TABLE 6
INCREMENTAL COST EFFECTIVENESS OF
VARIOUS RFG FORMULATIONS (PADD II, SUMMER)

Case	Cost (¢/gal)	Model ¹⁴	Incremental VOC Reduction	Incremental NOx Reduction	Incremental C/E Dollars per Ton (summer)	
					VOC	VOC & NOx
Tightening of specs between 1995 and 2000 (S5 vs. Q6N)	3.0	4/92 2/93	16% 4%	1% -3%	\$6.2K \$23K	\$6K \$91K
Use of ethanol for summer RFG in 2000 (Q6N vs. S13H)	7.5	4/92 2/93	0% 0%	4% 8%	NA NA	\$62K \$31K

¹⁴ The two complex models used also have different baseline gasoline emissions. For the 4/92 model, VOCs are about 1.25 g/mile; NOx is 0.66 g/mile. For the 2/93 model, VOCs are about 1.35 g/mile and NOx is 1.34 g/mile. Average MPG of 22.1 for conventional gasoline was used.

TABLE 7
COST AND VOC & NO_x PERFORMANCE OF
VARIOUS REFORMULATIONS (PADD IV, SUMMER)¹⁵

Year	% RFG	Case Description	Cost (¢/gal) ¹⁶		% VOC Reduction ¹⁷		% NO _x Reduction ¹⁷	
			Refin.	Total	4/92	2/93	4/92	2/93
1995	0%	conventional gasoline (Q9)	0.0	0.0	19%	5%	-1%	-9%
2000	63%	complex model base case (Q6)	7.8	9.3	45%	24%	6%	7%
2000	100%	complex base case with all RFG (S6)	10.4	12.8	45%	26%	1%	-2%
2000	100%	California Phase 2 RFG (S21)	25.3	28.5	51%	33%	7%	19%

¹⁵ Exhibit 26 (4/16/93) and Tables G1-2 (5/11/93), G-2 (1/15/93), and G-1 (9/18/92).

¹⁶ Total cost includes fuel economy effect, relative to conventional gasoline under the pre-1990 Clean Air Act.

¹⁷ Percent change in emissions relative to the performance of the statutory baseline gasoline under the complex model proposed in 4/92 by EPA and the more recent 2/93 proposed model.

TABLE 8
AVERAGE COST EFFECTIVENESS OF
VARIOUS RFG FORMULATIONS (PADD IV, SUMMER)

Case	Cost (¢/gal)	Model ¹⁸	Change in VOC Reduction	Change in NOx Reduction	C/E Dollars per Ton (summer)	
					VOC	VOC & NOx
RFG 2000 (Q6)	9.3	4/92 2/93	26% 19%	7% 16%	\$12K \$15K	\$10K \$8.1K
100% produc- tion of RFG in 2000 (S6)	12.8	4/92 2/93	26% 21%	2% 7%	\$15K \$18K	\$17K \$15K
Tightening of 2000 spec to match Calif Phase 2 (S21)	28.5	4/92 2/93	32% 28%	8% 28%	\$29K \$30K	\$26K \$16K

¹⁸ The two complex models also include different baseline emissions. For the 4/92 model, VOCs are about 1.25 g/mile; NOx is 0.66 g/mile. For the 1/93 model, VOCs are about 1.35 g/mile and NOx is 1.34 g/mile. Average MPG of 22.1 for conventional gasoline was used.

TABLE 9
INCREMENTAL COST EFFECTIVENESS OF VARIOUS
RFG FORMULATIONS (PADD IV, SUMMER)

Case	Change in Cost (¢/gal)	Model ¹⁹	Incremental VOC Reduction ²⁰	Incremental NOx Reduction ²⁰	C/E Dollars per Ton (summer)	
					VOC	VOC & NOx
Tightening of 2000 spec to match Calif Phase 2 (S6 vs. S21)	15.7	4/92 2/93	6% 7%	6% 21%	\$86K \$68K	\$56K \$17K

¹⁹ The two complex models also include different baseline emissions. For the 4/92 model, VOCs are about 1.25 g/mile; NOx is 0.66 g/mile. For the 2/93 model, VOCs are about 1.35 g/mile and NOx is 1.34 g/mile. Average MPG of conventional gasoline of 22.1 was used.

²⁰ Versus performance of conventional gasoline (O9).

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Detailed Issue and Sensitivity Case Results

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PADD I

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REC
5/6/93

EXHIBIT 1

PRELIMINARY RESULTS - 1995 SIMPLE FORMULA CASES

COMMENTS ON EXHIBITS 2 AND 3

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

- The preliminary cost results for reformulated gasoline (RFG), based on EPA's simple formula (SF) under the Federal Clean Air Act Amendments (FCAAA), are summarized in Exhibit 2. Similarly, the preliminary cost results for ultra low sulfur (ULS) and low aromatic (LA) diesel are summarized in Exhibit 3.
- These costs were corrected off-line to include required butane fractionation and the capital charge for summer RFG facilities which are not required nor used in the winter.
- Most of the added unit costs for FCAAA RFG are for ether and the fuel economy penalty associated with it.
- Over two-thirds of the total added investment for RFG, as defined by EPA's SF, is required for MTBE production. Most of the MTBE investment will be made in petrochemical plants outside of refineries.
- In the 100% California Air Resources Board Phase 2 (CARB 2) gasoline case, only about one-third of the much larger total investment is required for MTBE production.
- With constant product demands and required ether addition in RFG, the U.S. refining industry will have more surplus crude, cracking and reforming capacity than it has today. This surplus will be even greater in the winter due to oxygenated gasoline (OG) requirements of the FCAAA.
- Ether demand is significantly higher in the winter due to the OG requirements of the FCAAA in the winter.

REC
10/9/92

EXHIBIT 2

INCREASED COSTS OVER BASE CASES – GASOLINE RESULTS SUMMARY⁽¹⁾

TM&C SIMPLE FORMULA CASES FOR 1995 SUMMER – CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(1990 \$)

	PADDs						U.S. Total/ Average ⁽³⁾
	I	II	III	IV	VOC	VC ⁽²⁾	
<u>Q9 – No FCAAA Base</u>							
RFG, % of Pool	0	0	0	0	0	0	0
<u>Q6 – FCAAA</u>							
RFG, % of Pool	100	16	11	0	0	59	27
Refining Δ Investment, MMM\$	1 ⁽³⁾	0.5 ⁽³⁾	0.8			0.5	3
Added Costs, ¢/G RFG							
Refining	7 ⁽³⁾	3 ⁽³⁾	3.0			7.1	5.5
Fuel Economy	2 ⁽³⁾	2 ⁽³⁾	1.8			2.3	2
Total	9 ⁽³⁾	5 ⁽³⁾	4.8			9.4	7.5
<u>S17 – Permits Delayed</u>							
RFG, % of Pool	27	16	11	0	0	27	16
Refining Δ Investment, MMM\$	0	0	0	0	0	0	0
Added Costs, ¢/G RFG							
Refining	4.4		2.8				4.5
Fuel Economy	2.8		1.8				2
Total	7.2		4.6				6.5
<u>S5 – Full Opt-in</u>							
RFG, % of Pool	100	55	63	13	0	94	65
Refining Δ Investment, MMM\$		1.1	2.4			0.6	5
Added Costs, ¢/G RFG							
Refining		5.3	5.8			6.5	6
Fuel Economy		2.2	2.2			2.2	2
Total		7.5	8.0			8.7	8
<u>S21 – All CARB 2 RFG</u>							
CARB 2 RFG, % of Pool	100	100	100	100	100	100	100
Refining Δ Investment, MMM\$	3.7		10.2	1.2		3.5	24
Added Costs, ¢/G RFG							
Refining	21.3		14.3	25.3		15.1	17
Fuel Economy	2.9		2.8	3.2		3.3	3
Total	24.2		17.1	28.5		18.4	20

(1) Base cases are 1995 with no FCAAA – Q9 summer.

(2) From public WSPA study results, adjusted to NPC premises.

(3) Extrapolated.

REC – 2/17/93

EXHIBIT 3

INCREASED COSTS OVER BASE CASES - DIESEL RESULTS SUMMARY⁽¹⁾

TM&C SIMPLE FORMULA 1995 ANNUAL CASES - CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(1990 \$)

	PADDs						U.S. Total/Average ⁽²⁾	
	I	II	III	IV	VOC	VC ⁽³⁾	w/CARB	w/o CARB
<u>Q9¥ and F2 Base Cases</u>								
ULS Diesel, % of No. 2	81	83	70	67	77	100	74	73
<u>S7 - 1990 Prod. Props.⁽⁴⁾</u>								
ULS Diesel, % of No. 2	0	0	0	0	0	33	3	0
Refining Δ Investment, MMM\$	(0.6)		(3.2)	(0.6)			(7.5)	(6.5)
RFG Δ Investment, MMM\$	(0.1)		(0.9)	(0.1)			(1.5)	(1.5)
Diesel Δ Investment, MMM\$	(0.4)		(1.4)	(0.3)			(4.5)	(3.5)
Added Costs, ¢/G CG	(0.4)		(0.6)	(0.8)			(0.9)	(0.9)
Added Costs, ¢/G Δ ULS Diesel	(4.3)		(2.1)	(9.3)			(5)	(4)
Added Costs, MMM\$/Year	(0.2)		(0.6)	(0.1)			(2)	(1.5)
Added Diesel Costs, MMM\$/Year	(0.2)		(0.3)	(0.1)			(1.5)	(1.0)
<u>S12 - All ULS Diesel</u>								
ULS Diesel, % of No. 2	100	100	100	100	100	100	100	100
Refining Δ Investment, MMM\$			0.8	0.1			1.5	1.5
Added Costs, ¢/G Δ ULS Diesel			4.3	8.4			4.5	4.5
Added Costs, MM\$/Year			0.2	0.1			0.5	0.5
<u>S8 - All ULS, LA Diesel</u>								
ULS, LA Diesel, % of No. 2	100	100	100	100	100	100	100	100
Refining Δ Investment, MMM\$			4.5				13	14
Added Costs, ¢/G Δ ULS, LA Diesel			8.3				10	10
Added Costs, MMM\$/Year			1.6				4	4.5

⁽¹⁾ Base cases are as follows: 1995 Q9¥ with no FCAAA [for S7 and S12 (PADD IV)]; 1995 F2 with FCAAA [for S12 (PADD III)]; and S12 with all ULS diesel [for S8].

⁽²⁾ Extrapolated.

⁽³⁾ Includes 51% ULS, LA diesel in cases Q9¥ and S12 in VC for U.S. with CARB; not included in U.S. without CARB.

⁽⁴⁾ No RFG; however, part of refining Δ investment was for initial advertised premium "RFG" facilities, primarily MTBE. Indicated added cost split between CG and ULS diesel was estimated from other NPC case results.

REC
5/26/93

EXHIBIT 4

RESULTS – COMMENTS ON PLOTTED EXHIBITS 5 THROUGH 12

REFORMULATED GASOLINE COSTS, T.A.P. AND NO_x VS. V.O.C. REDUCTION

NPC 1991-92 STUDY OF U.S REFINING INDUSTRY

- Exhibit 5 graphically presents summer gasoline reformulation costs for PADD III plotted against V.O.C. reduction, based on the 4/92 complex formulas.
- Costs include fuel economy changes based on delta BTU contents, which raise RFG costs for added ether and reduce RFG costs for lower RVPs.
- The V.O.C. reduction was the primary controlling variable for all of the summer complex formula cases, which were all optimized using the 4/92 complex formulas.
- Any prescribed RVP floor will create the righthand break point, or knee, in the Δ V.O.C. cost curve for RFG Phase II (RFG II) at the premised RVP floor. NPC PQTG selected the 6.5 RVP floor used in our base case, and the 4/92 complex formula V.O.C. reduction target was set at this knee, which is the point of incipient high costs for further V.O.C. reduction. The 4/92 complex formula cases for 2000 show a 45% V.O.C. reduction as their target over the statutory base (SB), as indicated in Exhibit 5.
- The T.A.P. reduction was computed at the control V.O.C. reduction levels, as shown in Exhibit 6, using the 4/92 complex formula. T.A.P. reduction over SB was greater than required by the FCAAA; so, it was not controlling the LP case results for RFG.
- The NO_x reduction was computed at the control V.O.C. reduction levels as shown in Exhibit 7, using the 4/92 complex formula. NO_x reduction was not limiting the LP case results for RFG because it was greater than zero, as required in the FCAAA.
- The incremental cost-effectiveness for summer V.O.C. reduction control, using the 4/92 EPA complex formulas, is indicated in Exhibit 8. It shows that:
 - Reducing RVP down to its floor level is extremely cost-effective at \$1-5M/ton;
 - Reducing sulfur down to about 80 ppm is the next most cost-effective reformulation technique at about \$20M/ton (about half an order of magnitude higher cost than reducing RVP);
 - Reducing T90 down to about 320°F is also next most cost-effective at about \$20M/ton (similar to reducing sulfur); and

- Increasing oxygen and concomitant reducing aromatics and benzene are least cost-effective at about \$75M/ton (more than an order of magnitude higher cost than reducing RVP).
- If the FCAAA did not mandate the added oxygen and reduced benzene, the TM&C LP model with the 4/92 complex formulas would reduce primarily RVP at low costs to achieve the cost-effective V.O.C. reduction target. T.A.P. reduction would be only about 15%, instead of 34% (with the 4/92 complex formula). Meeting the greater T.A.P. minimum reduction of 20% required in the FCAAA would result in a benzene reduction. Further T.A.P. reductions would cause sulfur and T90 decreases.
- The difference in costs for lowering RVP alone was estimated between cases Q9 and S5 to show more accurate cost curves than a straight line between these points.
- The X axis of the V.O.C. reduction cost curve is subject to significant change with changes in the complex formulas, especially to the exhaust versus non-exhaust weighting (as presented in Exhibit 9). The Q6 target case for the Phase II economic V.O.C. reduction would also move with the X axis change. The RFG cost, target case properties and relative cost-effectiveness of various V.O.C. reduction strategies will remain about the same in spite of these changes with most complex formulas.
- EPA's 10/92 and 1/93 proposed reductions in non-exhaust and increases in exhaust weightings for Phase II will reduce RVP impact on Δ V.O.C., but lowering RVP is still more cost-effective than reducing sulfur. These changes and EPA's probable future revised complex formulas may further alter the X axis and shift the Δ V.O.C. cost curve to in between the 1/93 EPA and 1/93 API/EPA CFs, but may not change the composition of the most cost-effective RFG.
- Exhibit 9 shows significant discontinuities in the cost versus Δ V.O.C. curves between Phase I and Phase II for both of the 1/93 CFs. This discontinuity is due to shifting from Mobile 4.1 in Phase I with 65/35 non-exhaust/exhaust weighting to Mobile 5.0 in Phase II with its 35/65 non-exhaust/exhaust weighting. Phase II shows an 8 to 11% lower V.O.C. reduction for the same gasoline properties as Phase I RFG.
- Exhibit 9A shows that EPA's initial concept target Δ V.O.C. regulations would fit NPC target case Q6 without ethanol. However, the proposed use of ethanol would require a higher Δ V.O.C. at the Q40H level for RFG with MTBE (RFG-M).
- Exhibits 10 and 10A show that the incremental cost-effectiveness levels for Phase II V.O.C. control are fairly similar for 4/92, 10/92 and 1/93 API/EPA complex formulas. Incremental cost-effectiveness levels are significantly different for the 1/93 EPA

complex formulas with lower and acceptable incremental cost-effectiveness for reaching Q40H. The 1/93 EPA complex formulas indicate a significant flatter cost curve, which could shift the incremental cost-effective target up from the NPC Q6 target case to the Q40H case.

- Exhibits 11 and 11A indicate that all complex formulas should attain the 20% minimum T.A.P. reduction at either target V.O.C. reduction level. T.A.P. reduction could limit benzene with the 10/92 or 1/93 EPA complex formulas. EPA plans to specify the minimum legal 20% T.A.P. limit, not the optional 25% due to extremely high incremental cost-effectiveness for reducing T.A.P.
- Exhibits 12 and 12A show that the refining industry has big NO_x reduction problems if the 10/92 or 1/93 EPA complex formulas are used. To meet the no NO_x increase FCAAA requirement, almost all complex formula gasolines beginning in 1997 would require significant olefins reductions. This requirement does not occur with the 4/92 EPA or 1/93 API/EPA complex formulas; so, it may be eliminated by EPA's planned CF revision. In final rule-making in late 1993, EPA may require several % NO_x reduction to reduce ozone, which could also make the Q40H case required to meet EPA's reformulation regulations.
- The 1.1¢/gallon cost of the 1990 SB case at zero V.O.C. reduction is related to the NPC PQTG and TMWG's premise of zero cost for the NPC Q9 1995 base case with no FCAAA. NPC base case Q9 has a lower RVP (by 0.8), a higher MTBE content (by 2%) and a much higher olefin content (by 4.3%), saving about 1.1¢/gallon from the FCAAA 1990 baseline. Hence, 1990 statutory baseline (SB) gasoline costs are higher than Q9 (at zero costs). Further, 1989 actual summer gasoline has a 10-18% V.O.C. increase over SB with a negative cost of 0.9¢/gallon due to its higher RVP and lower MTBE content versus Q9 at zero cost. The cost difference between the 1989 base and the 1990 SB of 2¢/gallon is primarily due to meeting the low olefin content of the SB.
- The lower V.O.C. reduction cases Q9 and S5 were run using the simple formula (SF) whereas the higher V.O.C. reduction cases S19 and higher were run using initial 4/92 complex formula in the LP. The V.O.C. reductions for the simple formula cases were calculated using the CF off-line. The V.O.C. reductions as well as Δ T.A.P. and Δ NO_x results were calculated off-line for the more recent CFs.
- Some of the costs that are plotted were adjusted slightly from the tabulated costs shown on the detailed case results Tables -2 to put all plotted costs on a consistent basis with a constant 63% RFG.

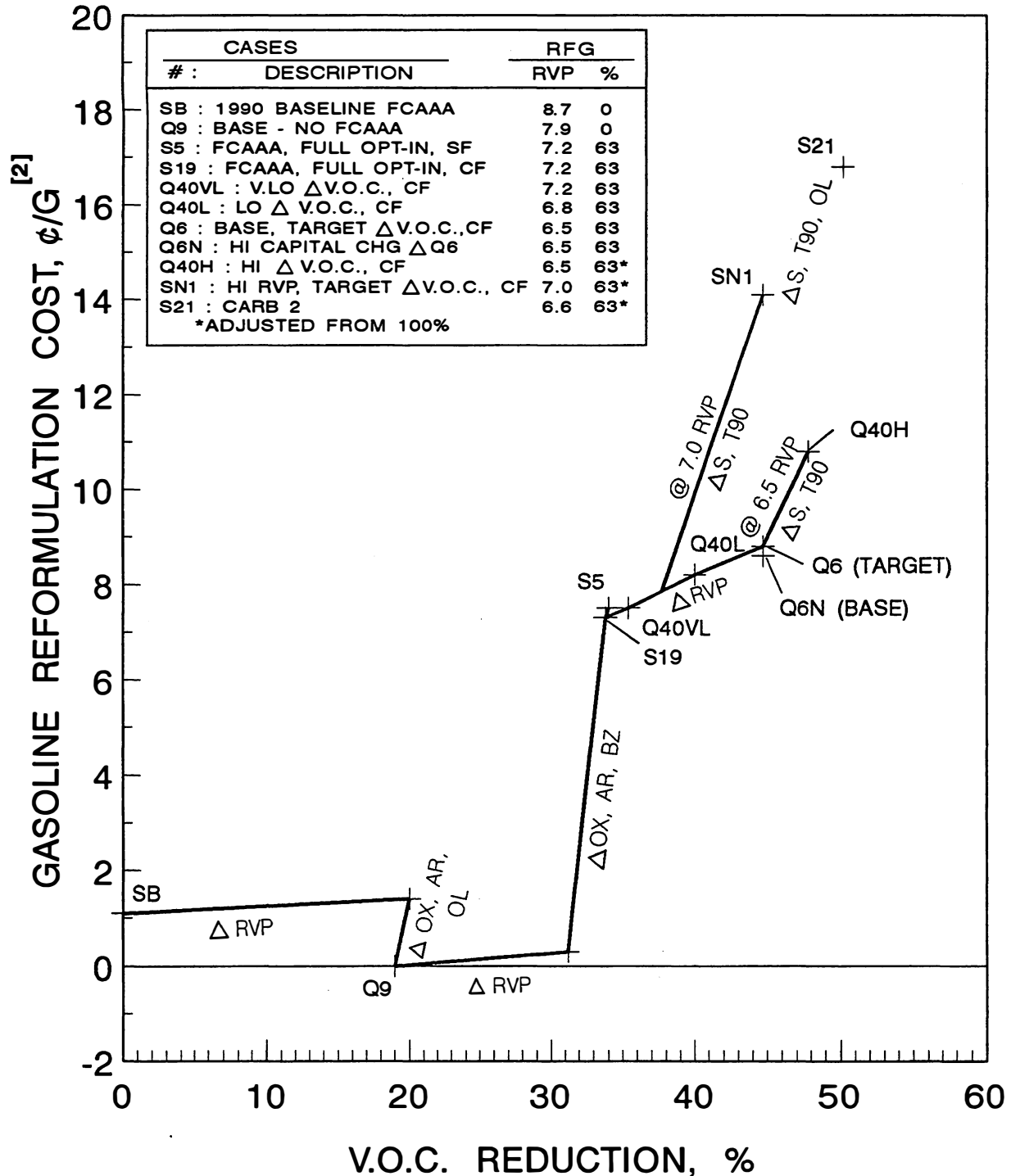
REC
2/12/93

EXHIBIT 5

GASOLINE REFORMULATION COST vs. V.O.C. REDUCTION

1995/2000 PADD III SUMMER RESULTS WITH 4/92 COMPLEX FORMULA ^[1]

NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY



[1] SEE EXHIBIT 6 FOR ABBREVIATIONS

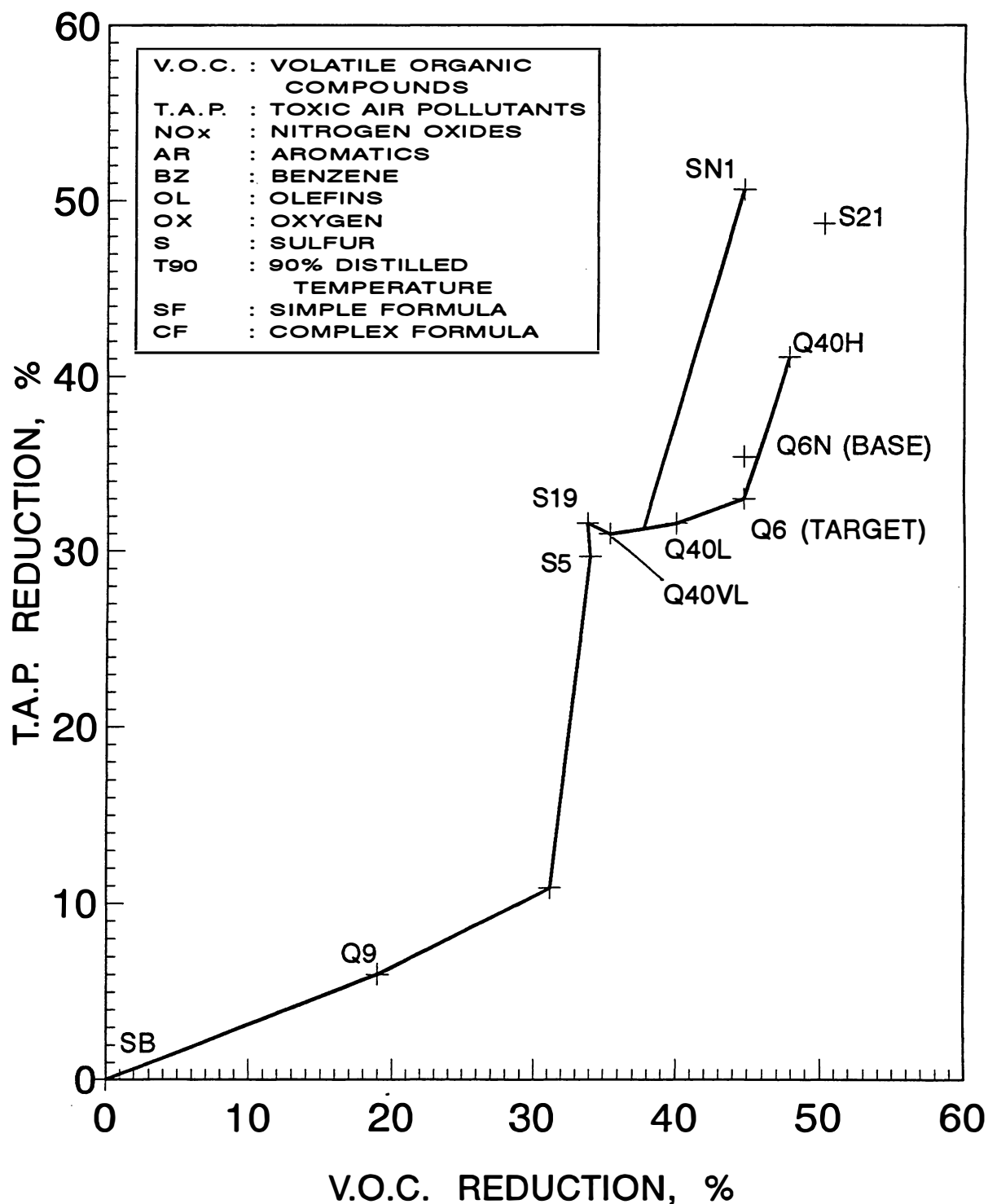
[2] CONSUMER COSTS OF CONVENTIONAL GASOLINE UPGRADED

EXHIBIT 6

T.A.P. REDUCTION vs. V.O.C. REDUCTION^[1]

1995/2000 PADD III SUMMER RESULTS WITH 4/92 COMPLEX FORMULA^[2]

NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY



[1] CONTROLLED BY V.O.C. REDUCTION LIMITS

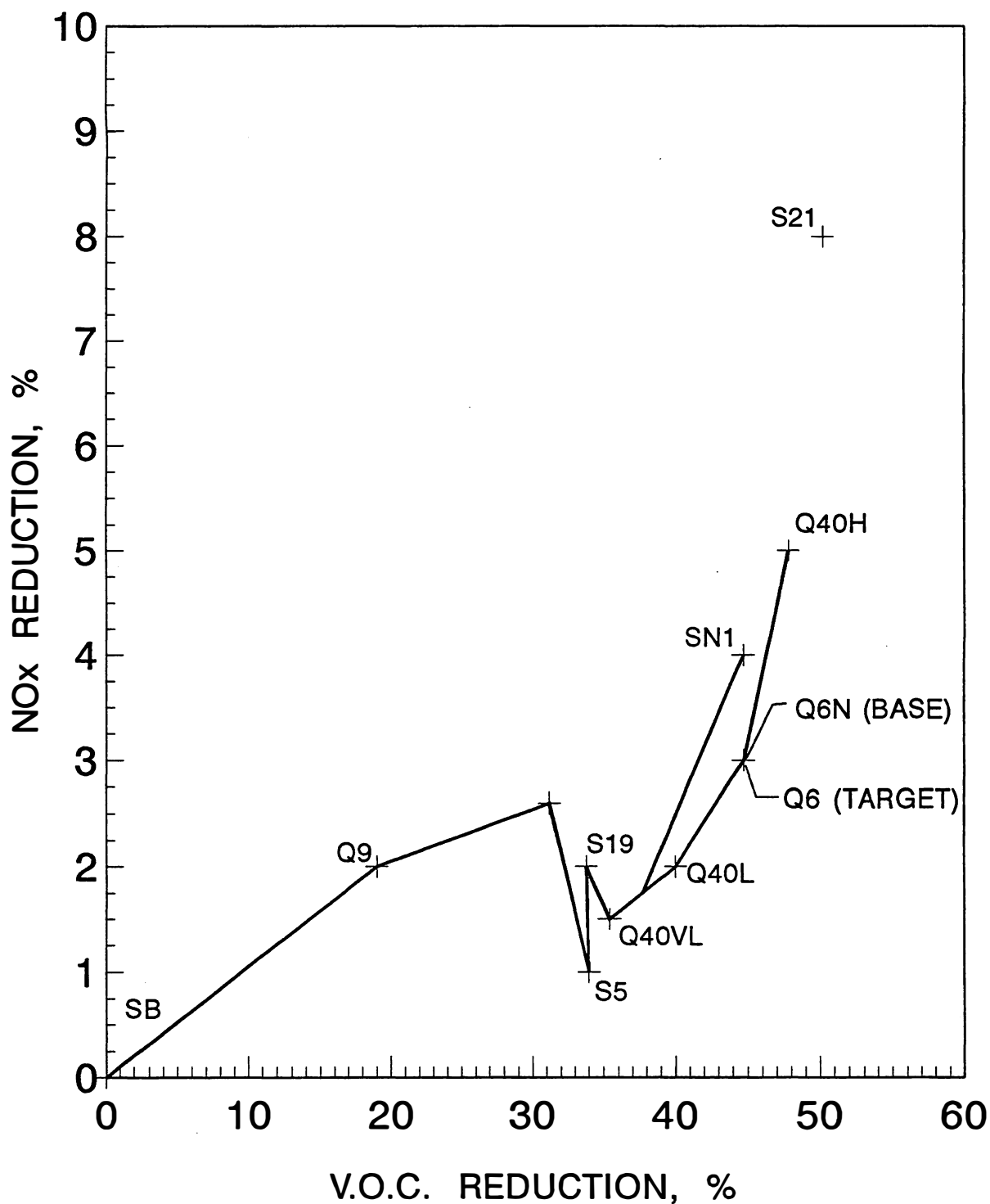
[2] REFER TO EXHIBIT 5 FOR DESCRIPTION OF CASES

EXHIBIT 7

NO_x REDUCTION vs. V.O.C. REDUCTION

1995/2000 PADD III SUMMER RESULTS WITH 4/92 COMPLEX FORMULA ^[1]

NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY



[1] SEE EXHIBIT 5 FOR DESCRIPTION OF CASES

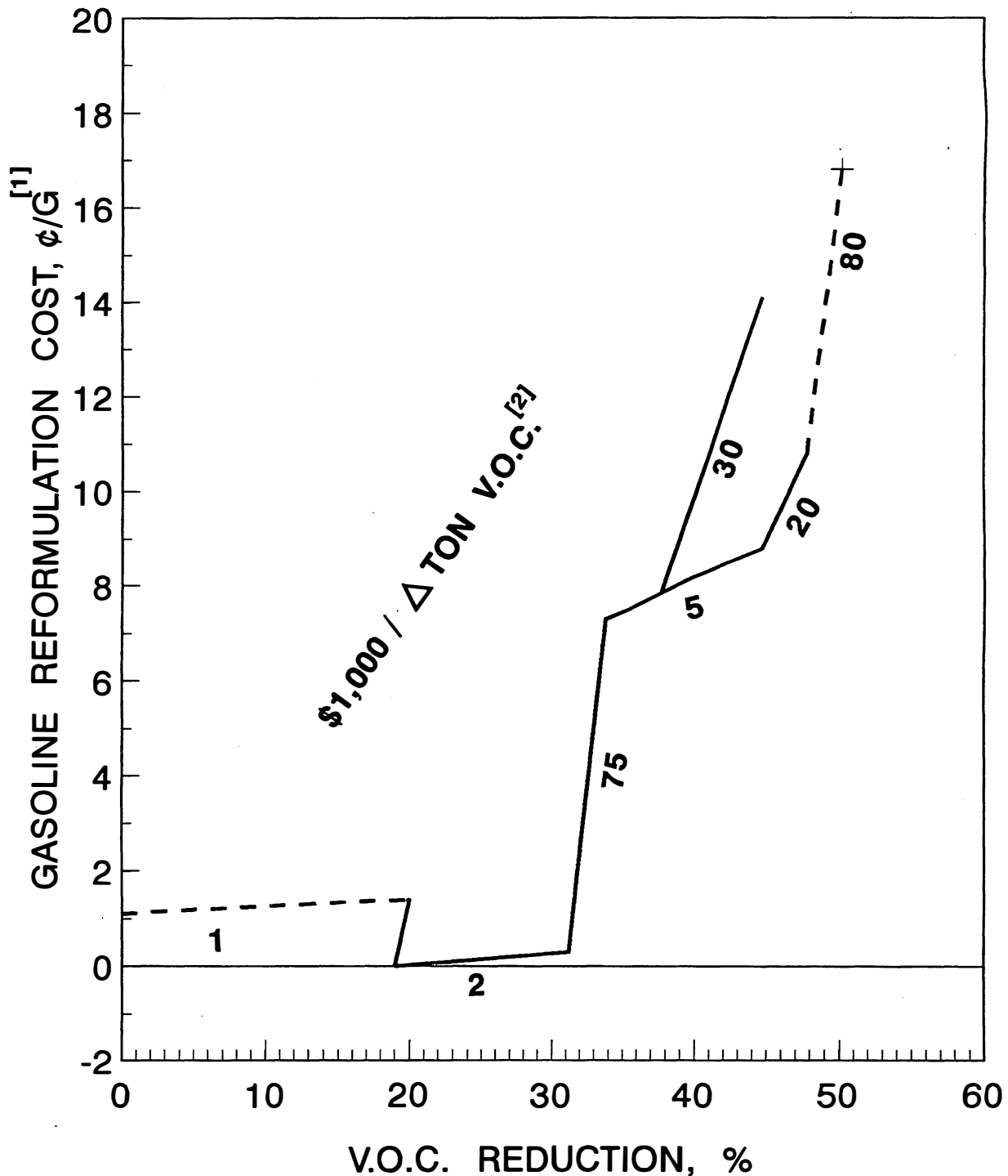
REC/MAH - 2/11/93

TURNER, MASON & COMPANY
Consulting Engineers

EXHIBIT 8

INCREMENTAL COST-EFFECTIVENESS vs. V.O.C. REDUCTION

1995/2000 PADD III SUMMER RESULTS WITH 4/92 COMPLEX FORMULA
NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY



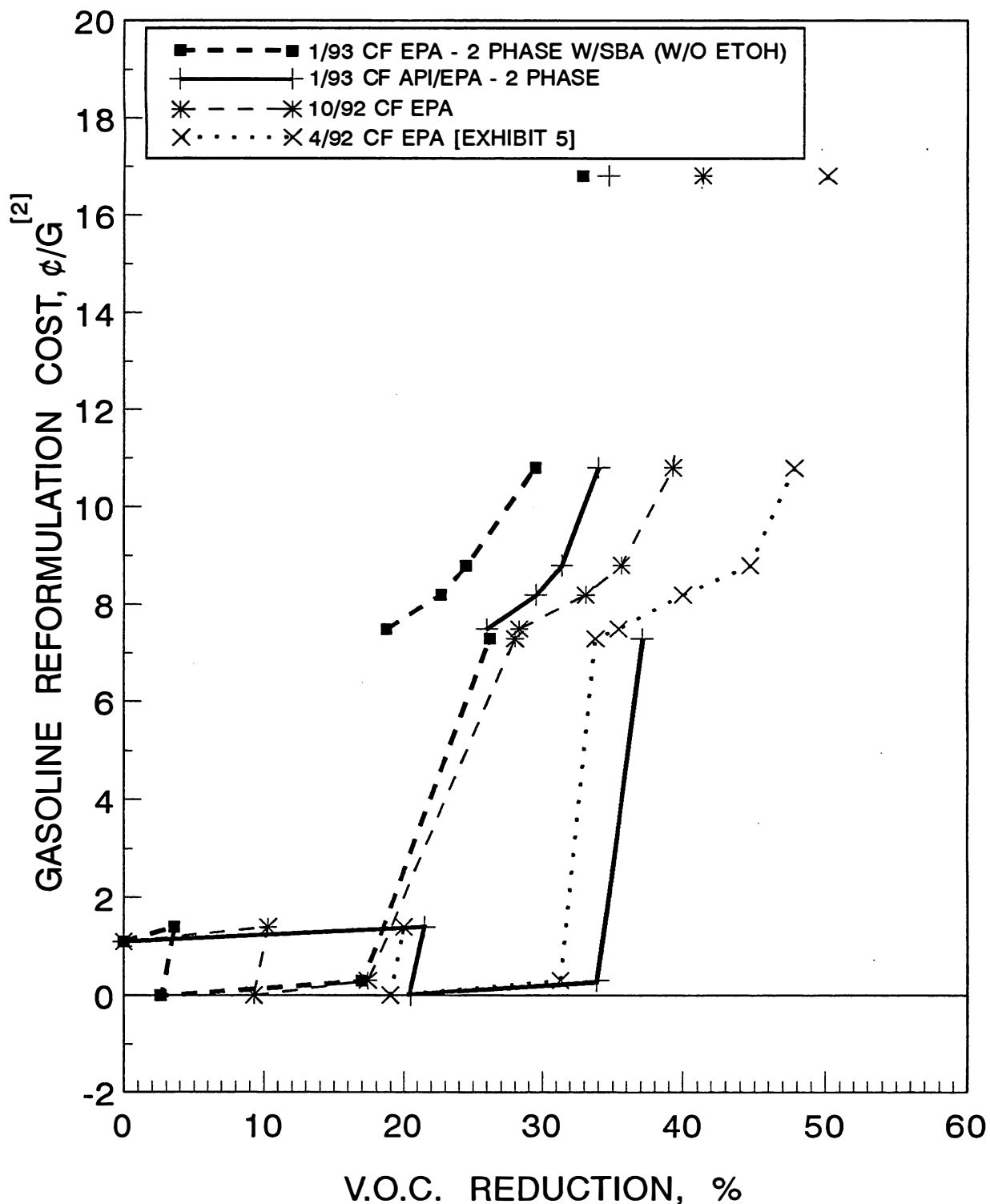
[1] CONSUMER COSTS OF CONVENTIONAL GASOLINE UPGRADED

[2] SUMMER INCREMENTAL COST-EFFECTIVENESS. DIVIDE BY 2 TO OBTAIN ANNUAL INCREMENTAL COST-EFFECTIVENESS

EXHIBIT 9

IMPACTS OF COMPLEX FORMULAS ON V.O.C. REDUCTIONS

1995/2000 PADD III SUMMER RESULTS WITH COMPLEX FORMULAS^[1]
NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY



[1] EXCLUDES CASES S5, SN1 AND Q6N (SHOWN ON EXHIBIT 5) TO SIMPLIFY COMPARISON

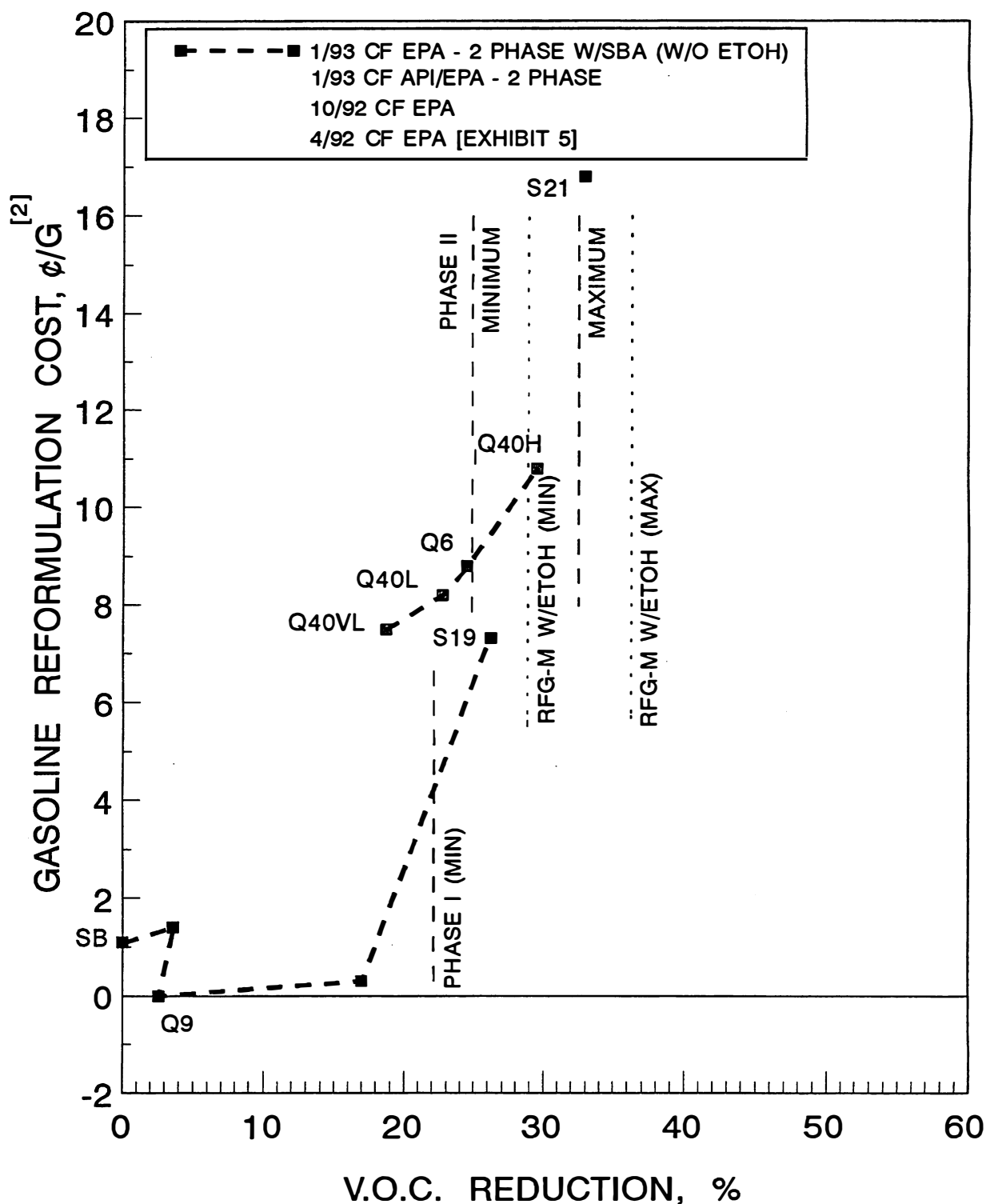
[2] CONSUMER COST OF CONVENTIONAL GASOLINE UPGRADED

TURNER, MASON & COMPANY
Consulting Engineers

EXHIBIT 9A

IMPACTS OF 1/93 EPA DRAFT NPRM ON V.O.C. REDUCTIONS

1995/2000 PADD III SUMMER RESULTS WITH COMPLEX FORMULAS^[1]
NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY



[1] EXCLUDES CASES S5, SN1 AND Q6N (SHOWN ON EXHIBIT 5) TO SIMPLIFY

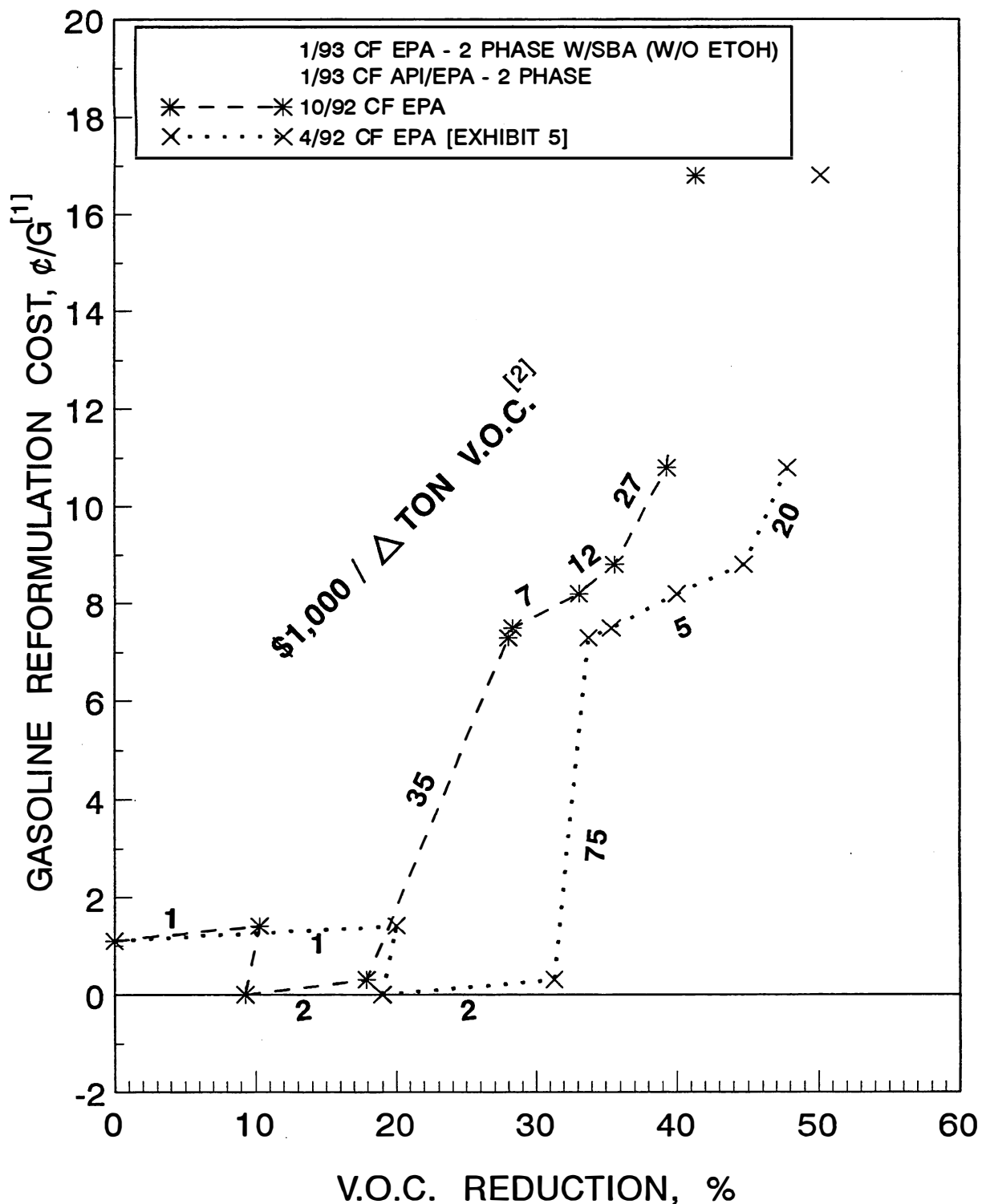
[2] CONSUMER COST OF CONVENTIONAL GASOLINE UPGRADED

TURNER, MASON & COMPANY
Consulting Engineers

EXHIBIT 10

INCREMENTAL COST-EFFECTIVENESS vs. V.O.C. REDUCTION

1995/2000 PADD III SUMMER RESULTS WITH COMPLEX FORMULAS
NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY



[1] CONSUMER COSTS OF CONVENTIONAL GASOLINE UPGRADED.

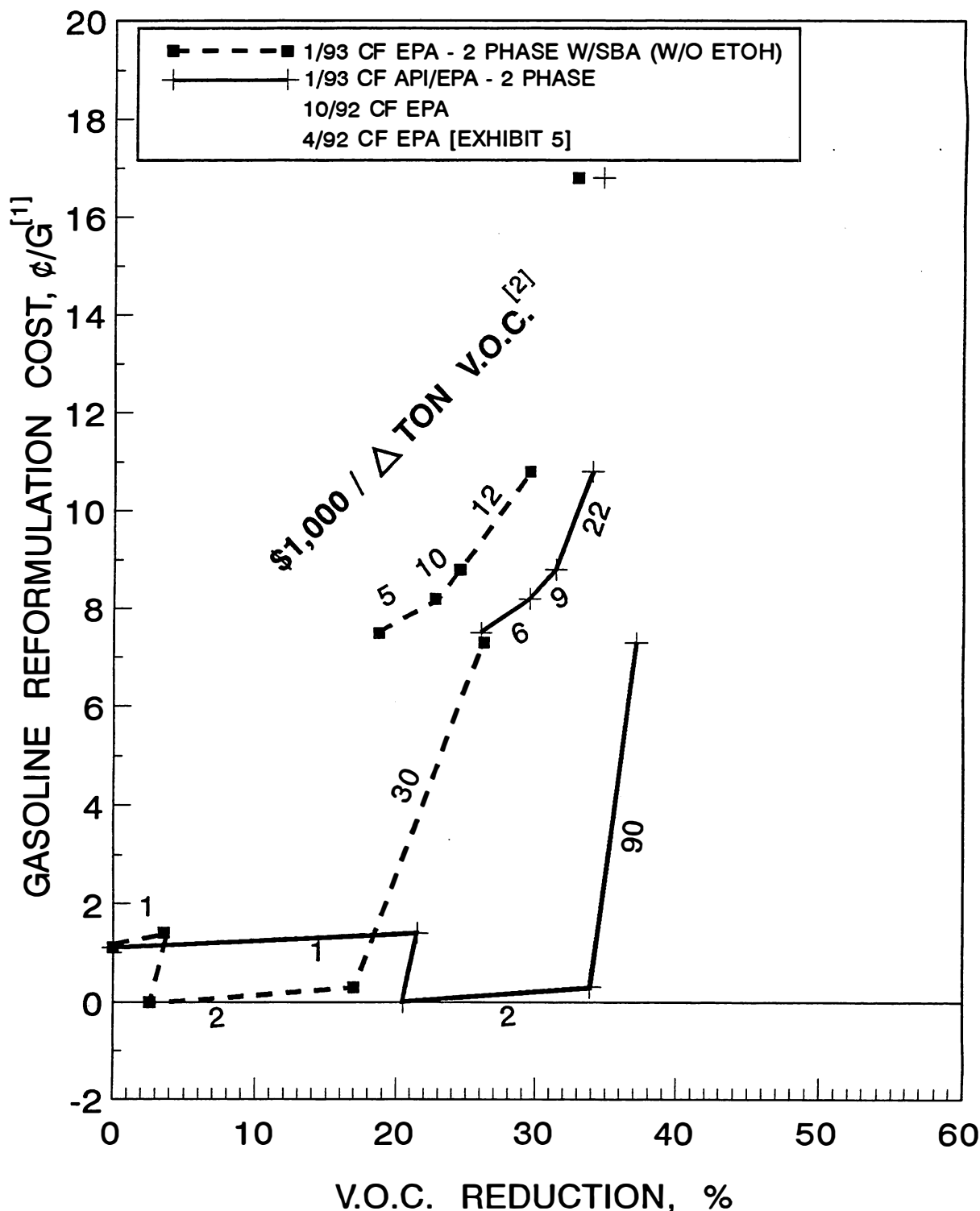
[2] SUMMER INCREMENTAL COST-EFFECTIVENESS. DIVIDE BY 2 TO OBTAIN ANNUAL INCREMENTAL COST EFFECTIVENESS.

TURNER, MASON & COMPANY
Consulting Engineers

EXHIBIT 10A

INCREMENTAL COST-EFFECTIVENESS vs. V.O.C. REDUCTION

1995/2000 PADD III SUMMER RESULTS WITH COMPLEX FORMULAS
NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY



[1] CONSUMER COSTS OF CONVENTIONAL GASOLINE UPGRADED

[2] SUMMER INCREMENTAL COST-EFFECTIVENESS. DIVIDE BY 2 TO OBTAIN ANNUAL INCREMENTAL COST EFFECTIVENESS.

TURNER, MASON & COMPANY
Consulting Engineers

EXHIBIT 11

IMPACTS OF COMPLEX FORMULAS ON T.A.P. REDUCTIONS

1995/2000 PADD III SUMMER RESULTS WITH COMPLEX FORMULAS
NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY

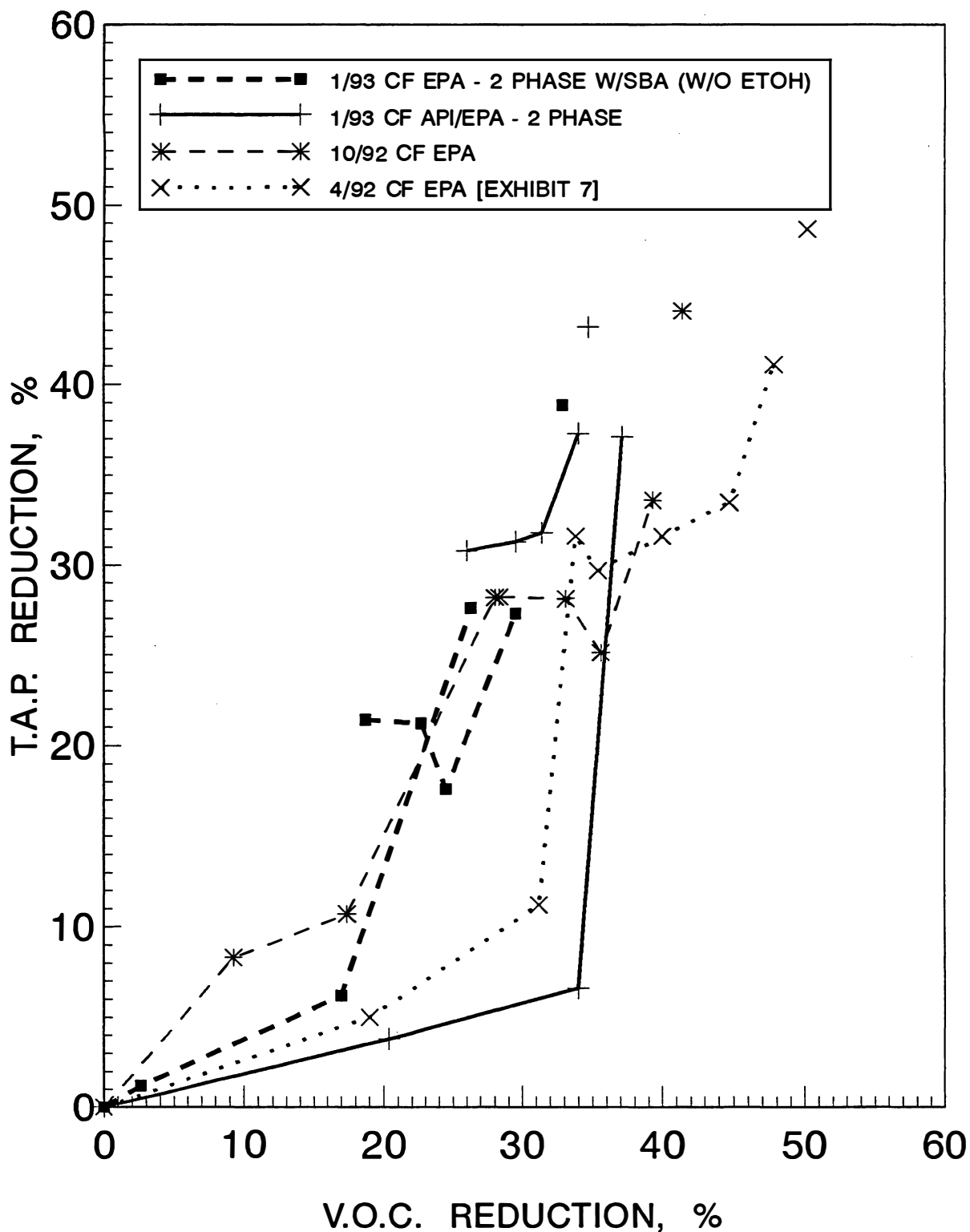


EXHIBIT 11A

IMPACTS OF 1/93 EPA DRAFT NPRM ON T.A.P. REDUCTIONS

1995/2000 PADD III SUMMER RESULTS WITH COMPLEX FORMULAS
NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY

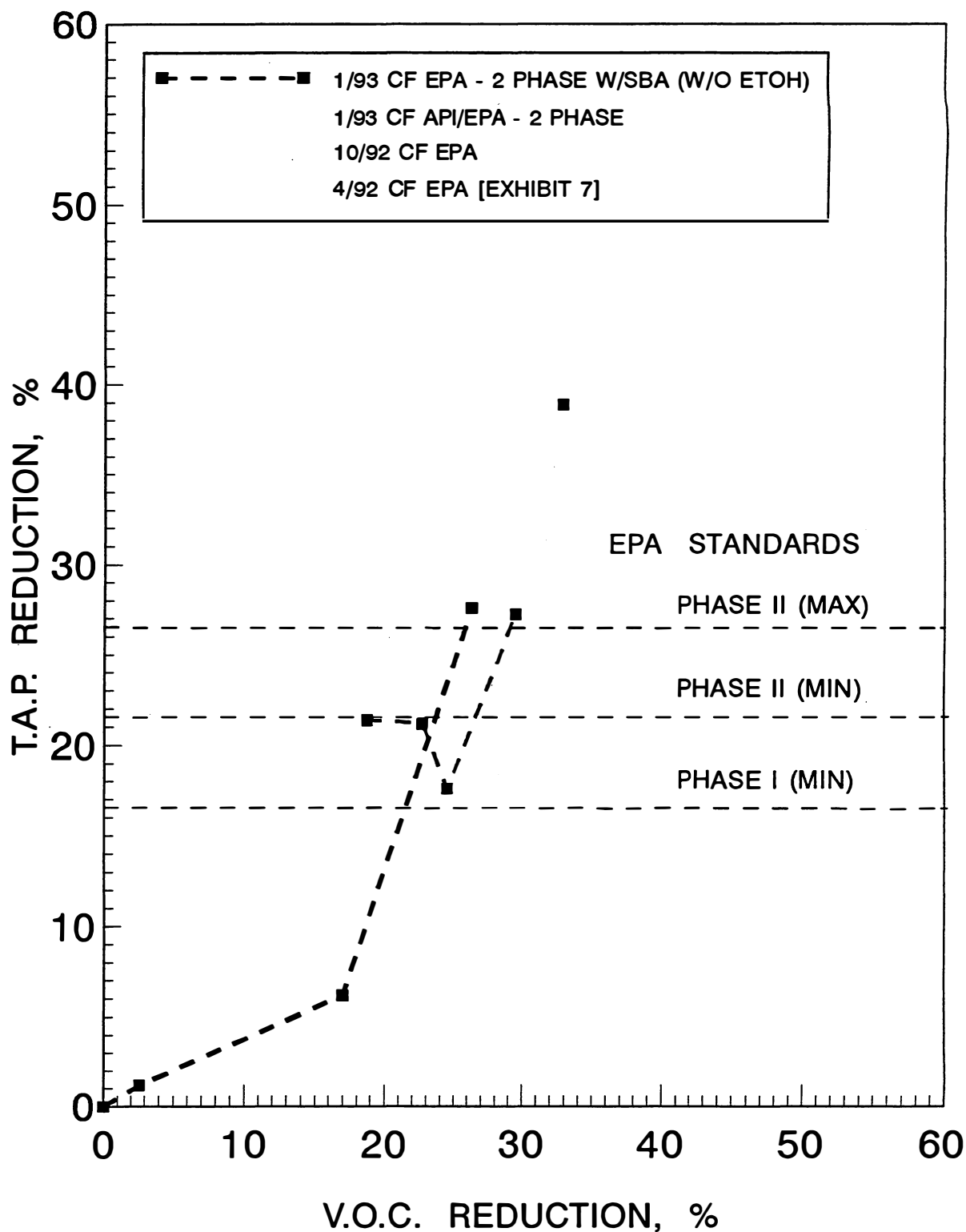


EXHIBIT 12

IMPACTS OF COMPLEX FORMULAS ON NO_x REDUCTIONS

1995/2000 PADD III SUMMER RESULTS WITH COMPLEX FORMULAS
NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY

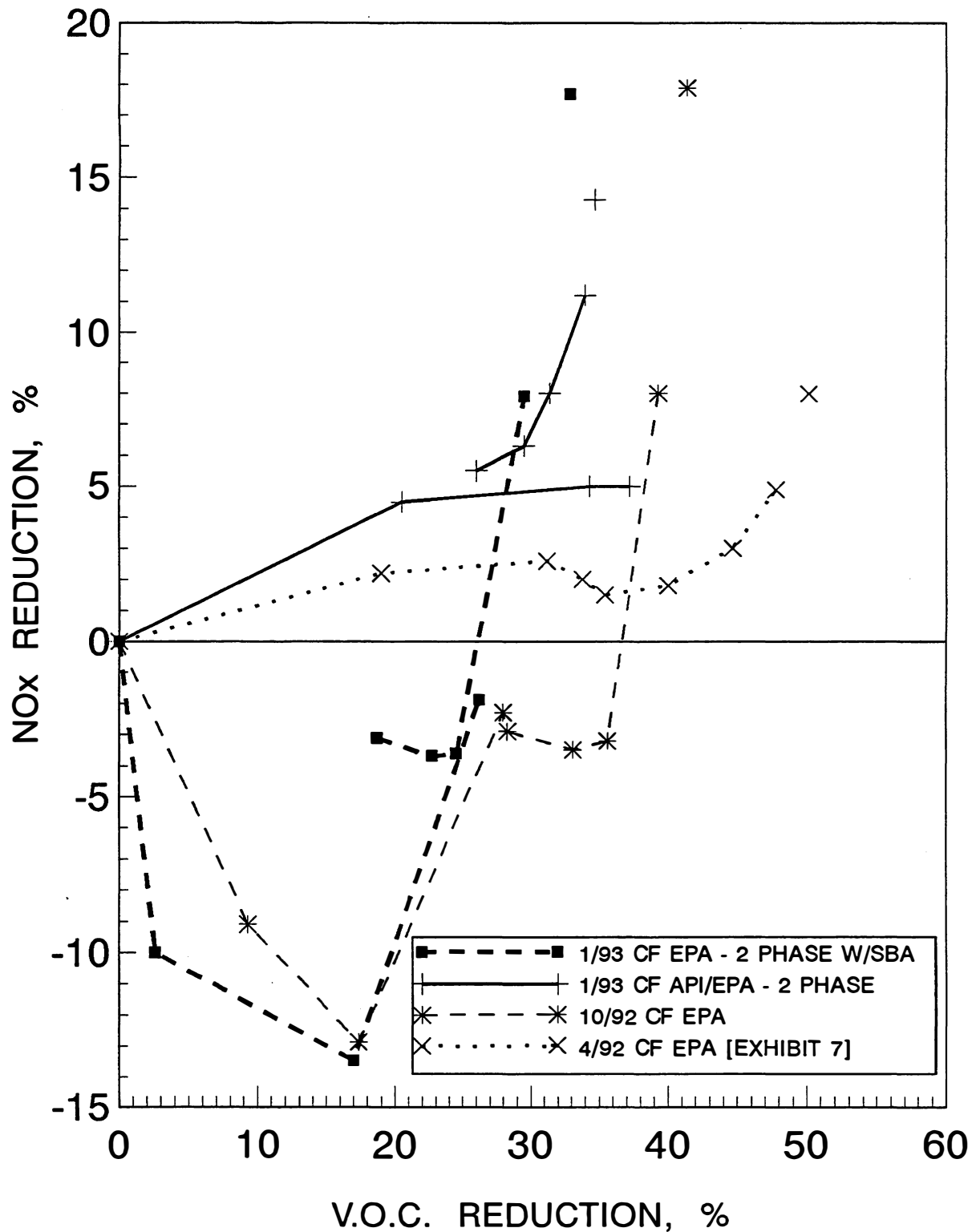


EXHIBIT 12A

IMPACTS OF COMPLEX FORMULAS ON NO_x REDUCTIONS

1995/2000 PADD III SUMMER RESULTS WITH COMPLEX FORMULAS
NPC 1991 - 92 STUDY OF U.S. REFINING INDUSTRY

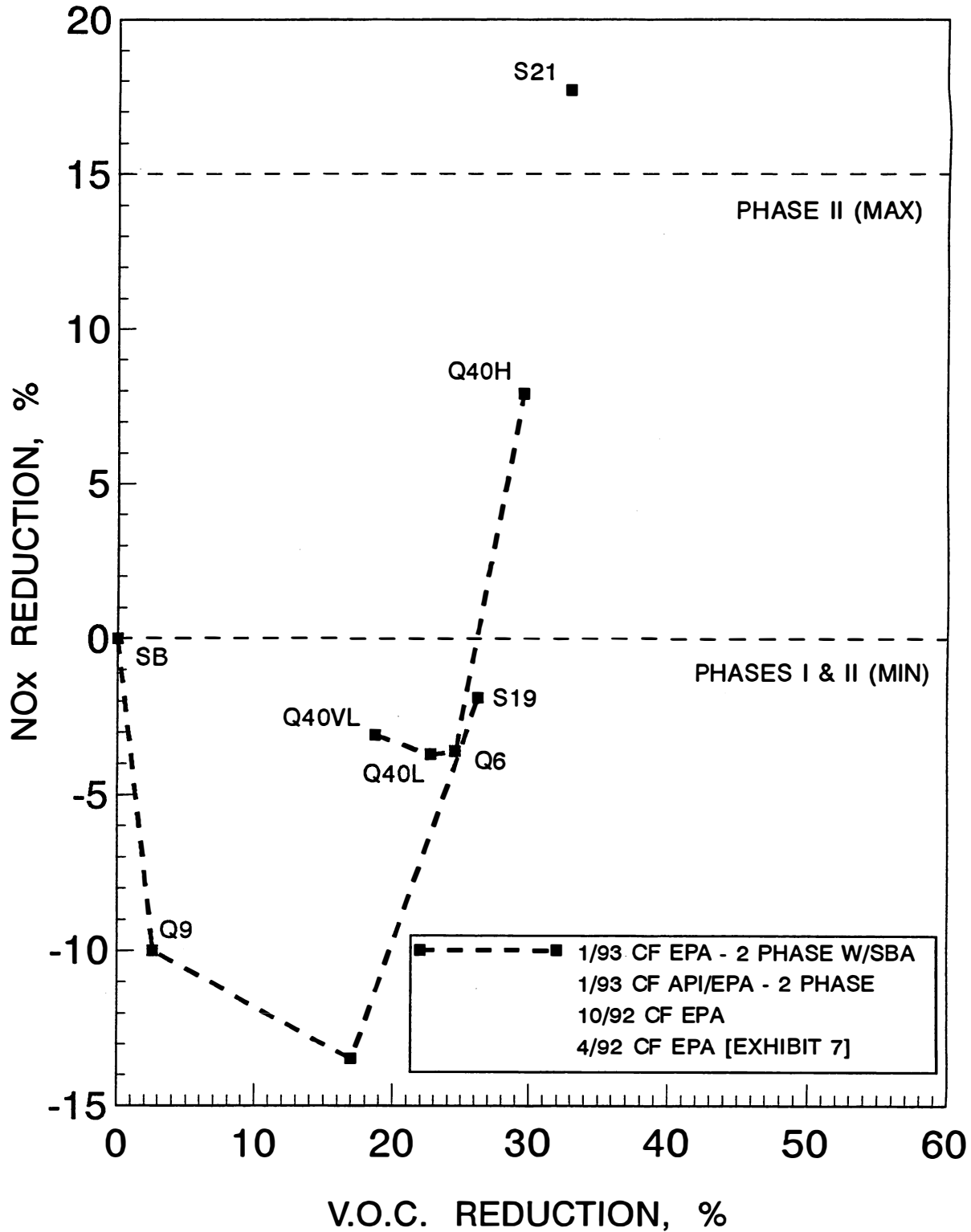


EXHIBIT 13

FCAAA REFORMULATED GASOLINE TIME AND PENETRATION PROGRESSION

PERCENT PRODUCTION, EMISSIONS REDUCTION AND INCREASED COSTS

PADD III SUMMER CASES - F2 CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(costs in 1990 \$)

Case	Conventional Gasoline Without FCAAA			Reformulated Gasoline With FCAAA				
	1989	1990	1994	1995	1995	1997	2000+	2000+
	Actual	SB	Q9 ⁽¹⁾	Q6	S5	S19	Q6N	S6
RFG, % of Total Pool	0	0	0	11	63	63	63	100
V.O.C. Reduction, % ⁽²⁾	(18)	0	19	34	34	34	45 ⁽³⁾	45
T.A.P. Reduction, % ⁽²⁾	(12)	0	6	29	30	32	34 ⁽³⁾	34
NO _x Reduction, % ⁽²⁾	(1)	0	2	(4)	1	2	3 ⁽³⁾	4
RVP ⁽⁴⁾	9.4	8.7	7.9	7.2	7.2	7.2	6.5	6.5
MTBE, %	1.2	0.0	2.0	11.7	11.7	11.7	11.7	11.7
Olefins, %	13.2	9.2	13.6	14.0	12.2	13.1	10.7	10.7
Refining Δ Investment, \$MMM	(0.3)	0.8	0.0	0.8	2.4	2.0	2.7	3.2
<u>Added Costs, ¢/G CG or RFG</u>								
Refining	(1.2)	1.2	0.0	2.4	5.8	5.3	6.9	7.2
Fuel Economy	<u>0.3</u>	<u>(0.1)</u>	<u>0.0</u>	<u>1.8</u>	<u>2.2</u>	<u>2.2</u>	<u>1.9</u>	<u>1.9</u>
Total	(0.9)	1.1	0.0	4.2	8.0	7.5	8.8	9.1

⁽¹⁾ 1995/2000 business-as-usual without FCAAA; includes EPA Phase 2 RVP reduction.

⁽²⁾ From 1990 statutory baseline (SB) based on initial 4/92 complex formulas.

⁽³⁾ With 1/93 API/EPA alternate complex formulas emissions reductions would be 32% V.O.C., 33% T.A.P. and 8% NO_x.

⁽⁴⁾ Based on 40% Class B and 60% Class C.

REC - 4/15/93

EXHIBIT 13A

COMMENTS ON EXHIBIT 13 – TIME/PENETRATION PROGRESSION OF RFG

PADD III SUMMER CASES – F2 CONSTANT DEMAND

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

- Exhibit 13 shows cases for 1989 actual, 1990 statutory base, 1994 with no Federal Clean Air Act Amendments, 1995 with the nine cities, 1995 with full opt-in, 1997 with the initial complex formula with full opt-in, 2000 with more severe complex formula standards with full opt-in and 2000 at 100% RFG. RFG ranges from zero to 100%, with zero for the three base cases, 11% for the nine cities, 63% with full opt-in and 100% with full U.S. RFG.
- The 1994 no FCAAA base case was the basis for our NPC study, so it has a cost of zero. Assuming EPA Phase 2 RVP controls, it has a 19% V.O.C. reduction compared to zero for the 1990 statutory base, using the 4/92 complex formulas. The conventional gasoline produced in 1989 has a 0.9¢/gallon negative cost relative to the no FCAAA base, due to its higher vapor pressure and lower ether content. It has an 18% negative V.O.C. reduction. The statutory base for 1990 has a 0.0% V.O.C. reduction by definition; however, it has cost of 1.1¢/gallon, as the cost of reducing olefins to its 9.2% level exceeds the savings from its higher RVP and zero ether content relative to the no FCAAA base.
- For all of the reformulated gasoline cases, the fuel economy cost is about 2¢/gallon, ranging from 1.8 to 2.2¢/gallon of conventional gasoline upgraded to RFG.
- Refining costs for RFG range from a low of 2.4¢/gallon with the simple formula at 11% penetration to a high in the year 2000 with 100% RFG of 7.2¢/gallon with the complex formula and more stringent V.O.C. reduction.
- Calculated RFG refining costs with full opt-in with the simple formula are 5.8¢/gallon. This cost would drop to 5.3¢/gallon with the use of the 4/92 complex formula in 1997. The 1997 RFG refining cost would increase if the EPA 1/93 complex formula were used.
- RFG refining costs increase to 6.9¢/gallon in the year 2000 due to tighter standards using the 4/92 complex formula. They further increase to 7.2¢/gallon with 100% RFG. These costs would also be higher if the EPA 1/93 complex formula were required, which would force an olefins reduction for no NO_x increase.

REC
2/11/93

EXHIBIT 14
FCAAA REFORMULATED GASOLINE ALTERNATIVE SEVERITIES
INCREASED COSTS VS. EMISSIONS REDUCTIONS
2000 PADD III SUMMER CASES - F2 CONSTANT DEMANDS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	S19 SF Alt	Q40VL VL Δ VOC	Q40L L Δ VOC	Q6 T Δ VOC	Q6N Q6 + Cap Chg	QN2 Q6 + 10.7% OL	S10 Q6 + 30 S	S6 Q6 + 100% RFG	Q40H H Δ VOC	SN1 Q6 + 7 RVP	S21 CARB 2
RFG, % of Pool	63	63	63	63	63	63	63	100	100	100	100
<u>Δ Emissions, % from SB</u>											
4/92 CF - V.O.C.	34	35	40	45	45	45	45	45	48	45	50
- NO _x	2	1	2	3	3	4	9	4	5	4	8
- T.A.P.	32	30	32	34	35	34	37	34	41	51	49
10/92 CF - V.O.C.	28	28	33	36	37	37	40	36	39	36	41
- NO _x	(2)	(3)	(3)	(3)	0	(0)	14	0	8	16	18
- T.A.P.	28	28	28	25	28	28	39	27	34	43	44
1/93 API/EPA CF - V.O.C.	37	26	29	31	32	32	32	31	34	32	35
- NO _x	6	6	6	8	8	9	14	9	11	12	14
- T.A.P.	37	31	31	32	33	33	38	32	37	42	43
1/93 EPA CF ⁽¹⁾ - V.O.C.	26	19	23	24	26	26	31	26	30	28	33
- NO _x	(3)	(3)	(4)	(4)	0	(1)	14	0	8	16	18
- T.A.P.	28	21	21	18	22	21	33	20	27	37	39
<u>Properties, RFG</u>											
Aromatics, %	24.7	24.1	23.8	24.7	23.7	24.0	24.5	24.7	23.1	20.5	22.0
Olefins, %	13.1	13.0	12.3	11.6	10.7	10.7	5.2	10.7	9.7	8.9	4.0
Sulfur, ppm	151	171	173	144	141	137	30	125	76	58	30
RVP, psi	7.2	7.2	6.8	6.5	6.5	6.5	6.6	6.5	6.5	7.0	6.6
T90, °F	344	344	346	344	342	344	329	341	325	295	292
<u>Refining Δ Investment, \$MMM</u>	2.0	2.0	2.4	3.0	2.7	3.2	3.6	3.2	4.5	6.4	10.2
<u>Added Costs, c/G</u>											
Refining	5.3	5.5	6.3	7.1	6.9	7.7	8.2	7.2	8.9	11.3	14.3
Fuel Economy	<u>2.2</u>	<u>2.2</u>	<u>2.1</u>	<u>1.9</u>	<u>1.9</u>	<u>1.8</u>	<u>1.9</u>	<u>1.9</u>	<u>2.2</u>	<u>3.1</u>	<u>2.8</u>
Total	7.5	7.7	8.4	9.0	8.8	9.5	10.1	9.1	11.1	14.4	17.1

⁽¹⁾ From SBA with 7.8 RVP for Class B (8.2 RVP for PADD III).

REC - 4/15/93

EXHIBIT 14A

COMMENTS ON EXHIBIT 14 - RFG COSTS VERSUS EMISSIONS REDUCTIONS

2000 PADD III SUMMER CASES - COMPLEX FORMULA CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

- Exhibit 14 presents results of 11 cases covering the full range of potential RFG severities - from the low severity 1997 initial complex formula case under the FCAAA up to the stringent CARB 2 requirements.
- Exhibit 14 presents the emissions reductions from the statutory base for four different complex formulas - 4/92, 10/92, 1/93 API/EPA and 1/93 EPA. It also indicates the most pertinent gasoline properties, the incremental refining investment and the added cost for making RFG. These results have been plotted in Exhibits 9 through 12 and extensively commented on in Exhibit 4. Some additional comments are presented below.
- The only RFGs with significant NO_x reduction with all of the alternate complex formulas are the more severe reformulations in Cases Q40H, S10, SN1 and S21. The cheapest of these reformulations with significant NO_x reduction are Q40H and S10, which significantly reduce sulfur or reduce sulfur and olefins at RFG refining costs of about 8.2-8.9¢/gallon. The most expensive reformulations, SN1 and CARB 2 S21 at RFG refining costs of about 11.3-14.3¢/gallon, include substantial T90 reduction, which also further reduces T.A.P.
- For the cost-effective RVP-based V.O.C. reductions shown by Cases Q6, Q6N and S6, added refining investments for PADD III range from about \$2.7-3.2 billion. Additional refining investments increase to about \$3.6-4.5 billion for the lower cost NO_x reduction cases, S10 and Q40H. They further increase to about \$6.4-10.2 billion for the most severe reformulation cases SN1 and S21.
- Issue S14 addresses questions about property averaging. Our results are based on the premise of average limits for each type of gasoline. They assume that average emission limits are set at target incremental cost-effectiveness levels - i.e., the break point of the cost versus V.O.C. curve. Under this premise, every gallon standards would be set lower to account for compliance margins.

- EPA's draft 1/93 NPRM did not provide for compliance margins. It set every gallon standards at the target cost-effectiveness level and added 1.5% for averaged limits. This offset requires higher actual incremental cost-effectiveness to meet either averaged or every gallon limits.
- The cost difference between the uniform annual capital charge case Q6 and the higher summer capital charge (1.5 X annual) case Q6N was minor at about 0.2¢/gallon lower RFG cost. The higher capital charge case reduced refining investments by about 10%, or about \$0.3 billion in PADD III.
- Although the Q40 series of cases is based on Q6 (uniform annual capital charge), they were corrected for the higher summer capital charge in the tabulated costs and cost plots. Q6N is used for PADD III in the Q6 series of cases reported in the C-tables for consistency with the Q6 cases for the other PADDs, which were run with the higher summer capital charge.

REC
4/15/93

EXHIBIT 15

INCREASED COSTS OVER BASE CASES - GASOLINE RESULTS SUMMARY⁽¹⁾

TM&C COMPLEX FORMULA 2000 SUMMER CASES - CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(1990 \$)

	PADDs						U.S. Total/Average ⁽²⁾	
	I	II	III	IV	VOC	VC ⁽³⁾	w/CARB	w/o CARB
<u>Q9 - No FCAAA Base</u>								
RFG, % of Pool	0	0	0	0	0	0	0	0
<u>Q6 - FCAAA - Full Opt-in</u>								
RFG, % of Pool	100	56	63	13	0	91	65	65
Refining Δ Investment, MMM\$	0.9	1.6	2.7	0.2	0	3.2	8.6	6.0
Added Costs, ¢/G RFG								
Refining	8.2	8.9	6.9	7.8		15.1	9.2	7.6
Fuel Economy	<u>2.0</u>	<u>1.6</u>	<u>1.9</u>	<u>0.8</u>		<u>3.3</u>	<u>2.1</u>	<u>1.9</u>
Total	10.2	10.5	8.8	8.6		18.4	11.3	9.5
<u>S6 - 100% RFG</u>								
RFG, % of Pool	100	100	100	100	100	100	100	100
Refining Δ Investment, MMM\$	0.9	2.2	3.2	0.5		3.3	10.5	8
Added Costs, ¢/G RFG								
Refining	8.2	7.5	7.2	10.2		14.4	9	7.6
Fuel Economy	<u>2.0</u>	<u>2.1</u>	<u>1.9</u>	<u>2.2</u>		<u>3.2</u>	<u>2</u>	<u>2</u>
Total	10.2	9.6	9.1	12.4		17.6	11	9.6
<u>S10 - RFG with 30 PPM Sulfur</u>								
RFG, % of Pool	100		63	100			65	65
Refining Δ Investment, MMM\$	1.1		3.6	0.8			10.5	8
Added Costs, ¢/G RFG								
Refining	11.3		8.2	14.1			10.5	9
Fuel Economy	<u>1.8</u>		<u>1.9</u>	<u>2.4</u>			<u>2</u>	<u>2</u>
Total	13.1		10.1	16.5			12.5	11
<u>QN2 - RFG with Lower Olefins</u>								
RFG, % of Pool	100		63				65	65
Refining Δ Investment, \$MMM	1.4		3.2				10	7.5
Added Costs, ¢/G RFG								
Refining	10.3		7.7				10	8.5
Fuel Economy	<u>2.1</u>		<u>1.8</u>				<u>2</u>	<u>2</u>
Total	12.4		9.5				12	10.5

(1) Base cases are 2000 with no FCAAA, Q9 summer.

(2) Extrapolated.

(3) With CARB 2 gasoline from public WSPA results, adjusted to NPC premises of 91% CARB 2 in cases Q6 and S6. Remaining 9% is CG in case Q6 and FCAAA RFG in case S6.

EXHIBIT 15A

COMMENTS ON EXHIBIT 15

INCREASED COSTS USING COMPLEX FORMULA

2000 SUMMER CASES - CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

- Exhibit 15 shows results of four RFG cases, which were run for two to five PADDs. These cases are Q6 with full RFG opt-in, S6 with 100% RFG, S10 with 30 ppm sulfur and QN2 with lower olefins.
- The PADD results are combined or extrapolated for the U.S. total/average both without CARB regulations (the U.S. FCAA nationwide) and with the CARB regulations impacting the California gasoline and U.S. average RFG costs.
- The RFG fuel economy cost is about 2¢/gallon for all of the options studied except CARB 2, which costs about 3¢/gallon for fuel economy.
- Q6 full opt-in case shows that the U.S. RFG requirement is 65% of the gasoline pool with a refining total investment of about \$6 billion without CARB, which increases to about \$8.6 billion with the inclusion of CARB 2 in California. The added cost for RFG for the U.S. refining industry is about 7.6¢/gallon without CARB, which would increase to about 9.2¢/gallon if CARB 2 is included in California. The RFG refining cost ranges from about 6.9¢/gallon in PADD III to about 8.9¢/gallon in PADD II.
- In S6 with 100% RFG, the U.S. refining investment increases by about \$2 billion above Case Q6, but the U.S. average RFG refining cost without CARB is essentially unchanged at about 7.5¢/gallon. The RFG refining cost ranges from about 7.2 to 10.2¢/gallon for the PADDs studied.
- PADD IV RFG refining cost of about 10.2¢/gallon in the S6 case is a more realistic number than the 7.8¢/gallon with only 13% RFG calculated in Q6. All of the RFG in PADD IV is concentrated in Salt Lake City; hence, those refineries have to make more than half of their gasoline as RFG. The calculated lower cost at 13% RFG in PADD IV is unrealistic due to the localized concentration of RFG.
- Reducing RFG sulfur to 30 ppm in S10 increased refining investment in the U.S. by about \$2 billion and increased RFG cost by about 1.5¢/gallon, as shown by S10 less

Q6. The RFG cost increase for 30 ppm sulfur varied from about 1.3¢/gallon in PADD III to about 3.9¢/gallon in PADD IV.

- If sulfur is reduced in the summer only (to meet a more severe summer Δ NO_x requirement), the RFG Δ costs would be around 1¢/gallon higher than shown for the S10 cases. The S10 cases were computed assuming all-year sulfur reductions with no summer capital charge multipliers for summer only additional sulfur reduction facilities required.
- Reducing olefins to meet no NO_x increase with the 10/92 complex formulas in cases QN2 increased RFG U.S. refining investment by about \$1.5 billion over Q6 and increased RFG U.S. average refining cost by about 1¢/gallon over Q6. The RFG refining cost increase over Q6 for reduced olefins ranged from about 0.8¢/gallon in PADD III to about 2.1¢/gallon in PADD I.

REC
4/15/93

EXHIBIT 16

REFORMULATED GASOLINE RESULTS SUMMARY

ESTIMATED COSTS, SEVERITIES AND RATES

FOR U.S. (W/CARB) SUMMER CONSTANT DEMAND SCENARIO⁽¹⁾

(costs in mid-1990 \$)

Reformulated Demand EPA RFG Regulations Reformulated Model Formulas Year	NONE		9 CITIES	FULL OPT-IN		
	NONE			PHASE I	PHASE II	
	NONE			SIMPLE	COMPLEX	
	1989	1994	1995	1997	1997	2000
<u>Gasoline Rates, MBPCD</u>						
Conventional (CG)	7,043	6,990	5,146	2,498	2,498	2,498
Reformulated (RFG)	-	-	1,902	3,715	3,715	3,715
CARB 2	-	-	-	913	913	913
Total	7,043	6,990	7,048	7,126	7,126	7,126
MTBE Included	61	140	223	536	536	536
<u>Increased Costs of CG Upgraded⁽²⁾</u>						
Refining, ¢/G	(1.3)	0	5.5	8	8.5	11.5
Fuel Economy, ¢/G	0.3	0	2	2	2	2
Total, ¢/G	(1)	0	7.5	10	10.5	13.5
Total, Billion \$/Year	(1)	0	2	7	7.5	9.5
<u>Refining Investment, Billion \$</u>	(1)	0	3	7.5	8.5	11
<u>Emissions Reduction, %⁽²⁾⁽³⁾</u>						
V.O.C.	(39)	3	25	26	27	30
NO _x	(9)	(10)	(5)	1	2	9
T.A.P.	(21)	1	22	30	28	30

⁽¹⁾ Assuming California makes more severe CARB 2 gasoline instead of FCAAA RFG in 1997+.

⁽²⁾ U.S. costs and emissions reductions were estimated from calculated results for some of the five regional refinery models plus published results of prior TM&C studies. Added costs include olefin reduction in 1997 and sulfur, olefins and T90 reductions in 2000 to meet 1/93 EPA draft NPRM NO_x requirements with 1/93 complex formulas.

⁽³⁾ From 1990 adjusted statutory base (EPA Phase 2 RVP) using 1/93 EPA complex model formulas. Reductions are only illustrative and are highly dependent on whether base RVP is statutory or EPA Phase 2 and on complex formulas used. Note that with less stringent 1/93 API/EPA complex formulas and statutory base RVP, emission reductions in 2000 would be 34% V.O.C., 11% NO_x and 36% T.A.P.

REC
2/16/93

TURNER, MASON & COMPANY
Consulting Engineers

EXHIBIT 16A

REFORMULATED GASOLINE RESULTS SUMMARY

ESTIMATED COSTS, SEVERITIES AND RATES

FOR U.S. (W/O CARB) SUMMER CONSTANT DEMAND SCENARIO⁽¹⁾

(costs in mid-1990 \$)

Reformulated Demand EPA RFG Regulations Reformulated Model Formulas Year	NONE		9 CITIES	FULL OPT-IN		
	NONE			PHASE I	PHASE II	
	NONE			SIMPLE	COMPLEX	
	1989	1994	1995	1997	1997	2000
<u>Gasoline Rates, MBPCD</u>						
Conventional (CG)	7,043	6,990	5,146	2,498	2,498	2,498
Reformulated (RFG)	-	-	1,902	4,628	4,628	4,628
Total	7,043	6,990	7,048	7,126	7,126	7,126
MTBE Included	61	140	223	541	541	541
<u>Increased Costs of CG Upgraded⁽²⁾</u>						
Refining, ¢/G	(1.3)	0	5.5	6	6.5	10
Fuel Economy, ¢/G	0.3	0	2	2	2	2
Total, ¢/G	(1)	0	7.5	8	8.5	12
Total, Billion \$/Year	(1)	0	2	5.5	6	8.5
<u>Refining Investment, Billion \$</u>	(1)	0	3	5	6	9
<u>Emissions Reduction, %⁽²⁾⁽³⁾</u>						
V.O.C.	(39)	3	25	26	27	30
NO _x	(9)	(10)	(5)	(2)	0	8
T.A.P.	(21)	1	22	30	25	30

⁽¹⁾ Assuming California makes FCAAA instead of more severe CARB 2 gasoline in 1997+.

⁽²⁾ U.S. costs and emissions reductions were estimated from calculated results for some of the five regional refinery models plus published results of prior TM&C studies. Added costs include olefin reduction in 1997 and sulfur, olefins and T90 reductions in 2000 to meet 1/93 EPA draft NPRM NO_x requirements with 1/93 EPA complex formulas.

⁽³⁾ From 1990 adjusted statutory base (EPA Phase 2 RVP) using 1/93 EPA complex model formulas. Reductions are only illustrative and are highly dependent on whether base RVP is statutory or EPA Phase 2 and on complex formulas used. Note that with less stringent 1/93 API/EPA complex formulas and statutory base RVP, emission reductions in 2000 would be 34% V.O.C., 11% NO_x and 34% T.A.P.

REC/KEZ
2/17/93

TURNER, MASON & COMPANY
Consulting Engineers

EXHIBIT 16B

REFORMULATED GASOLINE RESULTS SUMMARY

ESTIMATED COSTS, SEVERITIES AND RATES

FOR U.S. EX. CALIFORNIA SUMMER CONSTANT DEMAND SCENARIO

(costs in mid-1990 \$)

Reformulated Demand EPA RFG Regulations Reformulated Model Formulas Year	NONE		9 CITIES	FULL OPT-IN		
	NONE			PHASE I	PHASE II	
	NONE			SIMPLE	COMPLEX	
	1989	1994	1995	1997	1997	2000
<u>Gasoline Rates, MBPCD</u>						
Conventional (CG)	6,051	6,016	4,719	2,407	2,403	2,406
Reformulated (RFG)	-	-	1,305	3,678	3,679	3,668
Total	6,051	6,016	6,024	6,085	6,082	6,074
MTBE Included	61	120	153	430	430	429
<u>Increased Costs of CG Upgraded⁽²⁾</u>						
Refining, ¢/G	(1.3)	0	5.5	6	6.5	10
Fuel Economy, ¢/G	0.3	0	2	2	2	2
Total, ¢/G	(1)	0	7.5	8	8.5	12
Total, Billion \$/Year	(1)	0	1.5	4.5	5	7
<u>Refining Investment, Billion \$</u>	(1)	0	2.5	4.5	5.5	8
<u>Emissions Reduction, %⁽¹⁾⁽²⁾</u>						
V.O.C.	(39)	3	25	26	27	30
NO _x	(9)	(10)	(5)	(2)	0	8
T.A.P.	(21)	1	22	30	25	30

(1) U.S. – ex. California costs and emissions reductions were estimated from calculated results for some of the five regional refinery models plus published results of prior TM&C studies. Added costs include olefin reduction in 1997 and sulfur, olefins and T90 reductions in 2000 to meet 1/93 EPA draft NPRM NO_x requirements with 1/93 EPA complex formulas.

(2) From 1990 adjusted statutory base (EPA Phase 2 RVP) using 1/93 EPA complex model formulas. Reductions are only illustrative and are highly dependent on whether base RVP is statutory or EPA Phase 2 and on complex formulas used. Note that with less stringent 1/93 API/EPA complex formulas and statutory base RVP, emission reductions in 2000 would be 34% V.O.C., 11% NO_x and 34% T.A.P.

REC/KEZ
2/17/93

EXHIBIT 17

INCREASED GASOLINE AND JET PRODUCTION CAPABILITY AND COSTS

OVER BASE RFG CASES FOR 2000 WITH CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(costs in 1990 \$)

	PADDs						Simple	U.S.
	I	II	III	IV	VOC	VC	Refineries	Total/ Average ⁽¹⁾
Summer								
<u>Q9 Base Cases – No FCAAA</u>								
Yields, MBPCD								
Gasoline	670	1,682	3,151	246	227		72	6,990
Jet (Kero)	86	205	686	34	102		54	1,401
Capability, MBPCD ⁽¹⁾								
Gasoline								7,400
Jet								1,580
Surplus Capacity, % of Yield ⁽¹⁾								
Gasoline								6
Jet								13
<u>Q6 Base Cases Yields, MBPCD</u>								
Gasoline	682	1,696	3,185	246	227	973	72	7,082
Jet	86	205	686	34	102	234	54	1,401
<u>Q3 Max Gaso Cases – No Invest</u>								
Gaso Capability, MBPCD	781		3,723					7,900
Surplus Capacity, MBPCD	99		538					820
% of Q6 Gaso Yield	14.5		16.9					12
Increased Cost, ¢/G Δ Gaso	(9.4)		(10.0)					(9.5)
<u>QN1 Max Gaso Case With Invest</u>								
Gaso Capability, MBPCD			3,925					8,200
Surplus Capacity, MBPCD			740					1,120
% of Q6 Gaso Yield			23.2					16
Increased Cost, ¢/G Δ Gaso			(9.3)					(8.5)
Δ Refining Investment, \$MMM			0.15					0.3
Summer/Winter/Annual⁽²⁾								
	<u>III-S</u>	<u>III-W</u>			<u>US-S</u>	<u>US-W</u>	<u>US-A</u>	
<u>Q5 Max Jet Cases – No Invest</u>								
Jet (Kero) Capability, MBPCD	775	847			1,580	1,700		1,640
Surplus Capacity, MBPCD	89	79			180	160		170
% of Q6 Jet Yield	13.0	10.3			13	10		12
Increased Costs, ¢/G Δ Jet	1.2	(7.2)			2	(6)		(2)

(1) Estimated from other results of this study and prior public studies, except for Q6 U.S. total yields.

(2) Summer: III-S, US-S; winter: III-W, US-W; annual: US-A.

EXHIBIT 17A

COMMENTS ON INCREASED GASOLINE AND JET CAPABILITY AND COSTS

OVER BASE CASES FOR 2000 WITH CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

- We determined the maximum gasoline and kerosene jet capabilities of PADD III and estimated it for the U.S. without and with added RFG investment for short- and long-term situations, respectively. Maximum summer gasoline capability extrapolations to the entire U.S. were based on surplus conversion capacity in each of the PADD models. Maximum jet capability extrapolations were based on surplus crude unit and hydrocracker jet capacity in each of the PADD models.
- We estimated surplus gasoline capacity for summer Q9 base cases with no FCAAA for comparison. We estimated maximum summer U.S. gasoline capability of about 7.4 MMBPCD, or 6% surplus capacity above the base U.S. demand of 7.0 MMBPCD.
- With 65% RFG make, we estimated maximum summer U.S. gasoline capability for short-term situations – without added RFG investment – at about 7.9 MMBPCD, or 12% above the base U.S. demand of 7.1 MMBPCD. This maximum summer U.S. gasoline capability would increase to about 8.2 MMBPCD, or 16% above the base demand, if additional RFG investment is allowed for long-term situations.
- The estimated U.S. percentage surplus gasoline capacity is less than that shown in PADDs I and III because a lower percent surplus conversion capacity exists in the other PADDs.
- The extrapolated incremental refining investment for added RFG facilities for the long-term situation was only \$0.5 billion for the U.S.
- We calculated that the incremental gasoline would cost about 8.5-9.5¢/gallon less than the historic wholesale gasoline pricing for CG used in this study. These low costs were attained even though 65% of the incremental gasoline would be produced as more valuable RFG.
- These incremental gasoline costs are low because there are no fixed costs nor capital charges associated with incremental barrel costs with no added investment. The added fixed costs and capital charges are small for the added RFG investment case because the added investment is low. Obviously, normal supply and demand

competition always keeps incremental refinery products from being sold at the average wholesale prices.

- The indicated recent surplus refining gasoline capability, even at the 6% level shown in the no FCAAA Q9 base cases, is too large in our no-gasoline-growth scenario; hence, it has limited refining margins. Probably less than 3% surplus gasoline refining capacity is required for stable, adequate refining margins.
- If economically viable surplus gasoline capacity is only about 3%, then about 13% of the existing refining capacity would be shut-down to fit the full opt-in RFG constant demand scenario. This would equal shut-down of about 2 MMBPCD of crude capacity. Hence, the RFG program will create a refining industry replay of the early 1980s, in which it took several years to rationalize a suddenly created large surplus of refining capacity.
- Significant alternate fuels penetration of gasoline markets or a significant decrease in gasoline demand would aggravate the large surplus gasoline refining capacity situation outlined above for the constant demand scenario.
- Surplus jet producing capability varied from about 10% of demand in the winter to 13% in the summer, for an annual average of about 12% of demand. This amounts to about 170 MBPCD surplus jet capability, or over 1.6 MMBPCD maximum annual jet capability.
- This jet increment could be produced at a 2¢/gallon annual cost savings relative to historic wholesale jet pricing. The cost savings in the winter would be about 6¢/gallon on the increment, whereas summer costs would increase by about 2¢/gallon on the increment.

REC
1/27/93

EXHIBIT 18**INCREASED ETHANOL USAGE IN RFG - IMPACTS SUMMARY****COSTS, RATES AND ENERGY INCREASES OVER****BASE Q9 AND 100% RFG CASE S6 SUMMER 2000 - CONSTANT DEMANDS****NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY**

(costs in 1990 \$)

Page 1 of 2

	<u>PADD II</u>	<u>U.S. Total/Average</u>	
		<u>w/CARB</u>	<u>w/o CARB</u>
<u>S6 100% RFG-M (MTBE) Over Q9</u>			
RFG, % of Gasoline	100	100	100
Δ V.O.C. Reduction - 4/92 CF, % Over SB	41	44	44
Added Refining Investment, MMM\$	2.1	10.5	8
Added Costs, ¢/G RFG			
Refining	7.5	9	7.6
Fuel Economy	<u>2.1</u>	<u>2</u>	<u>2</u>
Total	9.6	11	9.6
<u>High Ethanol Cases - 30% RFG-E Over S6⁽¹⁾</u>			
RFG, % of Gasoline	100	100	100
Added Ethanol in RFG, MBPCD	30	111	123
<u>S13H - Constant Δ V.O.C.⁽²⁾</u>			
Δ V.O.C. Reduction - 4/92 CF, % Over SB	41	44	44
Added Refining Investment, MMM\$	0.83	3	3
Added Costs Over CG, ¢/G RFG-E			
Refining	11.9	12	12
Fuel Economy	3.1	3	3
Ethanol Subsidy @ 54¢/G E	<u>3.0</u>	<u>3</u>	<u>3</u>
Total	18.0	18	18
<u>Added Energy Use Over S6, % E⁽³⁾</u>			
Products Less Raw Materials	28	30	30
Utilities	<u>147</u>	<u>145</u>	<u>145</u>
Total	175	175	175

EXHIBIT 18

INCREASED ETHANOL USAGE IN RFG - IMPACTS SUMMARY

COSTS, RATES AND ENERGY INCREASES OVER

BASE Q9 AND 100% RFG CASE S6 SUMMER 2000 - CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(costs in 1990 \$)

Page 2 of 2

	PADD II	<u>U.S. Total/Average</u>	
		<u>w/CARB</u>	<u>w/o CARB</u>
<u>S13 - Lower Δ V.O.C.</u> ⁽⁴⁾			
Δ V.O.C. Reduction - 4/92 CF, % Over SB	38	41	41
Added Refining Investment, MMM\$	0.19	0.7	0.7
Added Costs Over CG, ¢/G RFG-E			
Refining	3.9	4	4
Fuel Economy	2.1	2	2
Ethanol Subsidy @ 54¢/G E	<u>3.0</u>	<u>3</u>	<u>3</u>
Total	9.0	9	9
Added Energy Use Over S6, % E ⁽³⁾			
Products Less Raw Materials	14	15	15
Utilities	<u>54</u>	<u>55</u>	<u>55</u>
Total	68	70	70

(1) Based on 1 psi higher RVP (7.5 psi) for RFG-E (ethanol). Excludes combined Δ V.O.C. reduction loss of 3% from commingling RFG-E with RFG-M.

(2) Δ V.O.C. reduction for RFG-E is only 31%; so, Δ V.O.C. reduction for RFG-M increased from 41 to 45% to hold combined Δ V.O.C. reduction constant.

(3) Percent of ethanol energy content that is lost in overall refinery yields and used for increased utilities. Change inside of refineries with fuel economy adjustment.

(4) Δ V.O.C. reduction for RFG-E is only 29%; so, Δ V.O.C. reduction for RFG-M increased from 38 to 42% to limit combined decrease in Δ V.O.C. reduction to 3%.

REC

5/20/93

EXHIBIT 18A

COMMENTS ON INCREASED ETHANOL USAGE IN RFG

IMPACTS ON COSTS, RATES AND ENERGY

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

- We explored the impacts of high ethanol usage based on a requirement for 30% RFG-with-ethanol (RFG-E) and based on substitution of ETBE for MTBE in PADD II over 100% RFG case S6. In one high ethanol usage case, we assumed constant combined V.O.C. reduction excluding the RFG-E and RFG-with-MTBE (RFG-M) commingling effects (of about 3% lower V.O.C. reduction). This case is similar to EPA's 1/93 draft NPRM requirements for ethanol blending. In a second high ethanol usage case, we assumed a 3% lower combined V.O.C. reduction before considering commingling effects. We also computed the properties and costs of making RFG subgrades for terminal blending of oxygenates.
- These cases used 30 MBPCD more ethanol in PADD II and would use 111 MBPCD more for the U.S. with 100% RFG with 30% required RFG-E. U.S. added ethanol usage in summer RFG would drop to about 40 MBPCD with 65% U.S. RFG (full opt-in) and mandated 30% RFG-E in only the northern, Class C, areas, as indicated in the EPA 1/93 draft NPRM.

Constant Combined Δ V.O.C. Case

- To maintain constant combined V.O.C., the cost of RFG-E over CG was about 18¢/gallon, including 12¢ for refining, 3¢ fuel economy and 3¢ ethanol subsidy (54¢/gallon of ethanol).
- This cost of 18¢/gallon of CG upgraded to RFG-E is about double the cost of 9.6¢/gallon for CG upgraded to RFG-M in base case S6. Hence, mandated RFG-E is equivalent to a total subsidy of about \$1.53/gallon of ethanol.
- The added U.S. refining investment was about \$3 billion based on 111 MBPCD more U.S. ethanol. This would decrease to about \$1.1 billion for the 40 MBPCD more ethanol use NPRM basis discussed above.
- The added energy use over Case S6 was about 175% of the energy content of the additional ethanol used. Most of the added energy use was derived from increased crude rate and was consumed by increased refining utilities. These added utilities were used to more severely reformulate RFG-M to offset the higher V.O.C. emissions from RFG-E with its higher RVP.

Lower Combined Δ V.O.C. Case

- When the combined V.O.C. reduction was decreased by 3% (allow more increased overall V.O.C. emissions with ethanol usage), the RFG cost dropped to 9¢/gallon, or essentially the same costs for RFG-E and RFG-M. Refining only costs were actually lower at 4¢/gallon for RFG-E compared to 7.5¢/gallon for RFG-M.
- For the lower Δ V.O.C. case, the added energy use also dropped to 70% of the ethanol energy content.
- The U.S. investment cost in refining increased by less - only \$0.7 billion for the lower Δ V.O.C. case based on 111 MBPCD more U.S. ethanol use. U.S. investment would decrease to only \$0.3 billion based on the 40 MBPCD added U.S. ethanol use as discussed above.

Issue SI - RFG Subgrades (RBOBs) Option

- We computed the properties of RFG subgrades for terminal blending of oxygenates. We calculated RFG subgrade properties for use with both ethanol (RBOB-E) and MTBE (RBOB-M) for cases S13H and S13. Due to the difference in required oxygenate content (5.7% ethanol versus 11.7% MTBE), a single RBOB for both oxygenates would not be economic.
- For case S13H, which fits the EPA 1/93 draft NPRM ethanol blending concepts, increased refining costs for a common RBOB over separate RBOB-E and RBOB-M would be about 2.1¢/gallon of RFG.
- For case S13H, the increases in properties for RBOB-E over RBOB-M were: 1.3 octane, 5% aromatics, (21)°F T90, (16)°F T50, 0.1 psi RVP and 0.1% benzene. These increases are due to differences in concentration and impacts of the high octane oxygenates added to make RFG with balanced and cheapest incremental costs.

ETBE Substitution for MTBE

- We computed the economics of using ETBE instead of MTBE by hand for 100% RFG case S6 in PADD II. The ethanol subsidy would need to be increased by about 5-20¢/gallon (to 59-74¢/gallon) to make ETBE production and blending competitive with MTBE production and blending.
- This ETBE alternative for indirectly including ethanol in summer RFG would require less than half of the effective ethanol subsidy compared to RFG-E (59-74¢/gallon versus \$1.53/gallon) and increase potential summer ethanol usage. It would also eliminate the lack of fungibility, added grade handling, enforcement complications and increased emissions from commingling associated with RFG-E.

EXHIBIT 19

DEMAND LEVEL AND ALTERNATE FUEL PENETRATION IMPACTS SUMMARY

INCREASED COSTS AND RATES – 2010 SUMMER CASES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(1990 \$)

Page 1 of 2

	PADD III	<u>U.S. Total/Average</u>	
		<u>w/CARB</u>	<u>w/o CARB</u>
<u>Constant Demand, Q6⁽¹⁾</u>			
Rates, MBPCD			
Crudes	5,783	13,280	13,270
Gasolines	3,182	7,080	7,070
Kero Jet	686	1,400	1,400
Diesel/No. 2	1,229	2,870	2,870
Residual Fuels	122	520	520
Refinery Investment, \$MMM ⁽²⁾	2.69	8.6	6
<u>Δ High Demand F1 – Constant Demand Q6⁽¹⁾</u>			
Δ Rates, MBPCD			
Crudes	1,512	3,190	3,190
Gasolines	405	890	890
Kero Jet	356	700	700
Diesel/No. 2	329	720	720
Residual Fuels	143	300	300
Δ Refinery Investment, \$MMM	2.32	5.5	5
Δ Cost, \$/B Crude Increase	(1.60)	(1.80)	(1.80)
Δ Cost, ¢/G Gaso + Kero Jet + Diesel/No. 2	(5.3)	(6)	(6)
<u>Δ Low Demand F3 – Constant Demand Q6⁽¹⁾</u>			
Δ Rates, MBPCD			
Crudes	(811)	(1,760)	(1,760)
Gasolines	(398)	(870)	(870)
Kero Jet	(108)	(210)	(210)
Diesel/No. 2	(184)	(410)	(410)
Residual Fuels	(24)	(50)	(50)
Δ Refinery Investment, \$MMM	(0.33)	(1.0)	(0.7)
Δ Cost, \$/B Crude Reduction	2.48	2.70	2.70
Δ Cost, ¢/G Gaso + Kero Jet + Diesel/No. 2	6.9	7.5	7.5

EXHIBIT 19

DEMAND LEVEL AND ALTERNATE FUEL PENETRATION IMPACTS SUMMARY

INCREASED COSTS AND RATES – 2010 SUMMER CASES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(1990 \$)

Page 2 of 2

	<u>PADD III</u>	<u>U.S. Total/Average w/CARB</u>	<u>w/o CARB</u>
<i><u>High Demand, F1</u></i>			
Rates, MBPCD			
Gasoline	3,587	7,970	7,960
Refinery Investment, \$MMM ⁽²⁾	4.97	14	11
<i><u>Δ Med. Alternate Fuels S20M – High Demand F1</u></i>			
Δ Rates, MBPCD			
Gasoline	(403)	(890)	(890)
% of Base F1 Gasoline	(11.2)	(11)	(11)
Δ Refinery Investment, \$MMM	(0.88)	(2.5)	(2)
Δ Costs, ¢/G			
Based on Gasoline Production Decrement	12.0	12.5	12.5
Based on Remaining Gasoline Production	1.5	2	2
<i><u>Δ High Alternate Fuels S20H – High Demand F1</u></i>			
Δ Rates, MBPCD			
Gasoline	(802)	(1,760)	(1,760)
% of Base F1 Gasoline	(22.4)	(22)	(22)
Δ Refinery Investment, \$MMM	(1.25)	(3.5)	(3)
Δ Costs, ¢/G			
Based on Gasoline Production Decrement	14.3	15	15
Based on Remaining Gasoline Production	4.1	4.5	4.5

⁽¹⁾ PADD III results are based on Case Q6N instead of Q6.

⁽²⁾ Above investments for Q9 base cases, summer 2000 or 2010 with no FCAAA.

GWM/REC
2/17/93

TURNER, MASON & COMPANY
Consulting Engineers

EXHIBIT 19A

COMMENTS ON EXHIBIT 19

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

- Exhibit 19 indicates the impact of higher and lower demands and potential alternate fuels penetration displacing gasoline with PADD III summer cases for the year 2010. Based on the PADD III cases, the U.S. total and average were extrapolated for scenarios with and without CARB 2 gasoline in California. These cases are all based on full opt-in of RFG at target Δ V.O.C. based on Q6N case for 2000. The constant demand base Q6 cases require Δ refining investment of \$6 billion without CARB and \$8.6 billion with CARB.
- The NPC high demand F1 scenario compared to the constant demand F2 scenario was based on an increased crude run of 24% in 2010, or 1.4% per year growth, for fifteen years. It was based on annual demand growth rates of 0.8% gasoline, 2.8% kero jet and 1.5% diesel/No. 2.
- The NPC high demand over the constant demand case required additional refining investment in the U.S. of \$5 billion. Based on constant product pricing, refining costs would decrease by \$1.82/barrel of incremental crude run, or decrease by 6¢/gallon of incremental combined gasoline, kero jet and diesel. These cost decreases are based on the high demand F1 case less the constant demand Q6 case
- The NPC low demand F3 scenario compared to the constant demand F2 scenario premised a 13% decrease in crude run in 2010, or 0.8% per year decline from 1995 to 2010. Similar annual demand decreases were shown for gasoline, kero jet and diesel fuel of 0.8-0.9% per year.
- In comparing the economics of the low demand case to the constant demand case, the U.S. refinery investment would be \$0.7 billion less, and the increased costs were \$2.70/barrel of crude reduction, or 7.5¢/gallon of combined gasoline, kero jet and diesel reduction.
- Incremental barrel economics forced the cost up at lower crude rates and reduced costs at higher crude rates.
- The impact of alternate fuels penetration on the high demand F1 scenario is also shown in Exhibit 19 as the difference between Case F1 and Case S20M or Case S20H for medium or high alternate fuels penetration, respectively.

- For the medium fuels penetration case, gasoline demand was reduced by 11%, which reduced U.S. refining investment by \$2 billion out of the \$11 billion required for the high demand case F1. For this case, gasoline costs increased by 12.5¢/gallon of gasoline decrement replaced by alternate fuels. This is equivalent to a gasoline production cost increase of 2¢/gallon for the 89% of remaining gasoline.
- For the high alternate fuels penetration case, U.S. refining investment was reduced by \$3 billion out of the \$11 billion required for the high demand case F1. Gasoline cost increased by 15¢/gallon of gasoline decrement of 22% of F1 total replaced by alternate fuels. This is equivalent to a gasoline production cost increase cost of 4.5¢/gallon for the remaining 78% of the gasoline.
- For the high alternate fuels penetration case, middle distillate demand as a percent of crude run was significantly higher. Refinery operations were shifted to maximize jet and diesel yields and reduce gasoline yield, which reduced FCC and alky utilizations to only 61% and 46%, respectively.

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EXHIBIT 20

INCREASED COSTS OVER BASE CASES – REFORMULATED GASOLINE RESULTS⁽¹⁾ TM&C COMPLEX FORMULA FULL OPT-IN SUMMER CASES – CONSTANT DEMANDS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(1990 \$)

	PADD III	U.S. Total/Average ⁽²⁾ w/CARB	w/o CARB
<u>Q9 – No FCAAA Base</u>			
RFG, % of Pool	0	0	0
<u>Q19 – 1997 Phase I RFG CF</u>			
RFG, % of Pool	63	65	65
Refining Δ Investment, MMM\$	2.0	7 ⁽³⁾	4.5 ⁽³⁾
Added Costs, ¢/G RFG			
Refining	5.3	7.5 ⁽³⁾	5.5 ⁽³⁾
Fuel Economy	<u>2.2</u>	<u>2</u>	<u>2</u>
Total	7.5	9.5 ⁽³⁾	7.5 ⁽³⁾
<u>Q40L – 2000 Phase II CF RFG – Low Δ V.O.C.</u>			
Δ V.O.C., % from SBA (7.8 RVP), 1/93 EPA CF	23	23	23
Δ NO _x , % from SBA (7.8 RVP), 1/93 EPA CF	(4)	(1)	(4)
RFG, % of Pool	63	65	65
Refining Δ Investment, MMM\$	2.5	8 ⁽³⁾	5.5 ⁽³⁾
Added Costs, ¢/G RFG			
Refining	6.3	9 ⁽³⁾	7 ⁽³⁾
Fuel Economy	<u>2.1</u>	<u>2</u>	<u>2</u>
Total	8.4	11 ⁽³⁾	9 ⁽³⁾
<u>Q40H – 2000 Phase II CF RFG – High Δ V.O.C.⁽⁴⁾</u>			
Δ V.O.C., % from SBA (7.8 RVP), 1/93 EPA CF	30	30	30
Δ NO _x , % from SBA (7.8 RVP), 1/93 EPA CF	8	9	8
RFG, % of Pool	100	65	65
Refining Δ Investment, MMM\$	4.5	11	9
Added Costs, ¢/G RFG			
Refining	8.9	11.5	10
Fuel Economy	<u>2.2</u>	<u>2</u>	<u>2</u>
Total	11.1	13.5	12

(1) Base case is no FCAAA Q9 summer for 2000 (applies to 1997 also).

(2) Extrapolated.

(3) To meet no NO_x increase based on 1/93 EPA draft NPRM and 1/93 EPA CF would require olefins reduction and increase U.S. refining Δ investment by \$1.5 MMM and raise added refining costs and added total costs by 1¢/G.

(4) Fits 1/93 EPA draft NPRM preamble probable NO_x reduction.

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EXHIBIT 20A

COMMENTS ON EXHIBIT 20

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

- Exhibit 20 shows results for three RFG cases which were run for PADD III and extrapolated to the U.S. for scenarios with and without CARB 2 in California. These cases cover three alternate RFG severities not included in Exhibit 15.
- Q19 1997 Phase I complex formula results are presented. They indicate for full RFG opt-in for the entire United States, an added refining cost of 5.5¢/gallon with an additional refining investment of \$4.5 billion without CARB. This is about \$0.5 billion less and about 0.5¢/gallon less than the 1997 S5 case results based on the simple formula, which are summarized in Exhibit 2. Phase I of the complex formula must be used in 1997 through 1999. It may also be used in 1995 and 1996.
- Although this case as run makes an acceptable NO_x decrease with the 1/93 API/EPA complex formula, it does not meet the no NO_x increase requirements with the 1/93 EPA complex formula. Meeting the NO_x requirements with the 1/93 EPA CF would necessitate an olefin reduction, which would increase added costs by about 1¢/gallon and Δ refining investment by about \$1.5 billion.
- Case Q40L for 2000 makes a Phase II RFG with low V.O.C. reduction. The RVP was reduced to only 6.8, which gave a V.O.C. reduction of 23%, using the 1/93 EPA complex formula and the adjusted statutory base (SBA) in the 1/93 EPA draft NPRM. The SBA uses the 7.8 RVP in Class B areas per EPA Phase 2 RVP regulations. Added costs for this case are about 0.5¢/gallon below the NPC Q6 target RFG case, and Δ refining investment is about \$0.5 billion below the Q6 case.
- Case Q40L, using the 1/93 EPA complex formula, shows a NO_x increase of 4%. To eliminate this NO_x increase based on the minimum NO_x requirement in the 1/93 draft NPRM, olefins would have to be reduced. Olefins reduction would increase added costs by about 1¢/gallon and Δ refining investment by about \$1.5 billion.
- Case Q40H for 2000 Phase II CF RFG is NPC's high Δ V.O.C. case. It fits the 1/93 EPA draft NPRM preamble target based on attaining an 8% NO_x reduction. Attaining this NO_x reduction required a reduction in sulfur, olefins and T90 compared to the NPC Q6 target RFG case.
- Case Q40H would add refining cost of about 10¢/gallon of RFG, which is about 2.5¢/gallon more than NPC target Δ V.O.C. case Q6, shown in Exhibit 15. Increased

refining investment costs for Q40H are about \$9 billion, which is \$3 billion above case Q6.

- Shifting the U.S. total from a non-CARB scenario with only FCAAA RFG gasoline to a CARB 2 in California scenario raises costs. U.S. Δ refining investment would increase by about \$2-2.5 billion. U.S. added RFG costs would increase by 1.5-2¢/gallon, as shown in Exhibit 20.

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EXHIBIT 21
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
PHASE I REFORMULATED AND CONVENTIONAL GASOLINE
PADD III 1995/1997 SUMMER CASES - F2 CONSTANT DEMANDS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Reformulated				Conventional									
	1995 SF			1997	1995 SF									1997
	Base	S17	S5	S19	1989 Actual	RS	Base	1989	Base	Base	S17	S5	S19	
	Case Q6-1995	Permit Delay	Full Opt In	1995 CF Full Opt In			Case Q9	Actual	Case Q9	Case Q6-1995	Permit Delay	Full Opt In	1995 CF Full Opt In	
RFG, % of Pool	11.3	11.2	63	63	0	0	0	0	0	11.3	11.2	63	63	
Region 2, %	40	40	40	40	40	40	40	40	40	40	40	40	40	
Properties														
Aromatics, vol %	27.2	27.2	25.6	24.7	31.6	31.3	30.9	31.6	30.9	30.9	30.9	30.9	33.4	
Oxygen, wt %	2.1	2.1	2.1	2.1	0.2	0.4	0.4	0.2	0.4	0.0	0.0	0.0	0.0	
Olefins, vol %	14.0	14.0	12.2	13.1	13.2	13.8	13.6	13.2	13.6	13.8	13.8	14.2	12.5	
Benzene, vol %	0.7	0.7	0.7	0.7	1.6	1.8	1.8	1.6	1.8	1.7	1.7	1.7	1.6	
Sulfur, ppmw	305	305	186	151	305	210	206	305	206	278	261	245	242	
RVP, psi	7.2	7.2	7.2	7.2	9.4	7.2	7.9	9.4	7.9	7.9	7.9	7.9	7.9	
T50, deg F	207	202	201	198	212	213	211	212	211	209	211	211	210	
T90, deg F	326	325	339	344	341	349	347	341	347	350	350	351	341	
% Evap @ 200 deg F	48.4	50.0	50.2	50.9	45.0	44.1	46.6	45.0	46.6	46.9	45.9	45.8	43.6	
% Evap @ 300 deg F	86.8	87.1	83.0	82.0	82.3	80.8	81.1	82.3	81.1	80.7	80.5	80.0	82.0	
Emissions Reduction														
	From Statutory Base					From 1989 Base								
EPA 4/92 CF														
V.O.C., %	34	35	35	34	(18)	31	19	0	31	30	30	30	31	
NOx, %	(4)	(4)	1	2	(1)	2	2	0	3	1	2	2	3	
T.A.P., %	30	30	30	32	(12)	11	5	0	15	15	15	15	15	
EPA 10/92 CF														
V.O.C., %	27	27	28	28	(17)	17	9	0	22	21	21	21	21	
NOx, %	(5)	(3)	(2)	(2)	(8)	(13)	(9)	0	(1)	(3)	(3)	(5)	1	
T.A.P., %	22	24	28	28	(11)	11	8	0	17	20	20	20	21	
API 1/93 CF[1]														
V.O.C., %	37	37	37	37	(17)	34	20	0	32	31	31	31	31	
NOx, %	(1)	(1)	5	6	(1)	5	5	0	6	3	4	4	4	
T.A.P., %	33	34	36	37	(4)	7	4	0	8	7	7	7	8	
EPA 1/93 CF[2]														
V.O.C., %	25	25	26	26	(39)	17	3	0	30	29	29	29	29	
NOx, %	(5)	(4)	(2)	(3)	(9)	(14)	(10)	0	(1)	(3)	(3)	(5)	1	
T.A.P., %	22	23	28	28	(21)	6	1	0	18	21	21	21	22	

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995-1999) and Phase II (2000+).

[2] For RFG includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 21 (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
PHASE I REFORMULATED AND CONVENTIONAL GASOLINE
PADD III 1995/1997 SUMMER CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Reformulated				Conventional								
	1995 SF		1997		1995 SF								
	Base	S17	S5	S19	1989 Actual	RS	Base	1989	Base	Base	S17	S5	S19
	Case	Permit	Full	1995 CF			Case	Actual	Case	Case	Permit	Full	1995 CF
	Q6–1995	Delay	Opt In	Full Opt In			Q9		Q9	Q6–1995	Delay	Opt In	Full Opt In
Emissions													
EPA 4/92 CF													
V.O.C., gm/mi	0.850	0.840	0.840	0.850	1.513	0.883	1.040	1.513	1.040	1.060	1.060	1.060	1.050
NOx, gm/mi	0.686	0.686	0.653	0.647	0.664	0.646	0.647	0.664	0.647	0.660	0.653	0.653	0.647
T.A.P., mg/mi	37.00	37.00	37.00	36.00	58.78	46.74	50.00	58.78	50.00	50.00	50.00	50.00	50.00
EPA 10/92 CF													
V.O.C., gm/mi	0.620	0.616	0.610	0.609	0.988	0.699	0.767	0.988	0.767	0.778	0.777	0.783	0.778
NOx, gm/mi	0.694	0.683	0.670	0.675	0.711	0.745	0.720	0.711	0.720	0.734	0.735	0.745	0.704
T.A.P., mg/mi	30.49	29.92	28.20	28.21	43.68	35.12	36.05	43.68	36.05	34.81	35.06	35.03	34.71
API 1/93 CF[1]													
V.O.C., gm/mi	0.800	0.800	0.804	0.801	1.493	0.841	1.014	1.493	1.014	1.026	1.025	1.025	1.025
NOx, gm/mi	0.666	0.667	0.627	0.619	0.667	0.627	0.630	0.667	0.630	0.649	0.643	0.640	0.637
T.A.P., mg/mi	30.40	30.16	28.90	28.60	47.29	42.44	43.74	47.29	43.74	43.96	43.87	43.82	43.67
EPA 1/93 CF[2]													
V.O.C., gm/mi	0.829	0.827	0.818	0.817	1.538	0.920	1.080	1.538	1.080	1.093	1.092	1.098	1.093
NOx, gm/mi	0.694	0.683	0.671	0.676	0.715	0.748	0.725	0.715	0.725	0.739	0.740	0.750	0.706
T.A.P., mg/mi	32.86	32.28	30.48	30.50	50.97	39.53	41.63	50.97	41.63	40.20	40.48	40.42	39.88

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

[2] For RFG includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 22
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED GASOLINE – PHASE II
PADD III 2000 SUMMER CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	2000													
	Q40VL	Q40L	Q6	Q6N	QN2	S6	S10	SN1	Q40H	S21	Q3	QN1	Q5S	S3HH
	VL Delta	L Delta	Target	Q6 +	Q6N +	Q6 +	Q6 +	S6 +	H Delta	All	Q6N Units	Q6+ Max	Q6N Units	Q6N Units
	V.O.C.	V.O.C.	V.O.C.	Cap Chg	10.7% OL	All RFG	30 Sul	7 RVP	V.O.C.	CARB 2	Max Gaso	Gaso	Max K Jet	HH Crude
RFG, % of Pool	63	63	63	63	63	100	63	100	100	100	63	63	63	63
Region 2, %	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Properties														
Aromatics, vol %	24.1	23.8	24.7	23.7	24.0	24.7	24.5	20.5	23.1	22.0	24.1	24.2	23.6	24.1
Oxygen, wt %	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.1	2.1	2.1	2.1
Olefins, vol %	13.0	12.3	11.6	10.7	10.7	10.7	5.2	8.9	9.7	4.0	10.9	11.1	11.4	11.2
Benzene, vol %	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.7	0.7
Sulfur, ppmw	171	173	144	141	137	125	30 *	58	76	30 *	183	174	187	198
RVP, psi	7.2	6.8	6.5	6.5	6.5	6.5	6.6	7.0	6.5	6.6	6.5	6.5	6.5	6.5
T50, deg F	200	201	205	203	204	204	206	192	201	193	205	205	204	205
T90, deg F	344	346	344	342	344	341	329	295	325	292	343	337	344	342
% Evap @ 200 deg F	51.0	49.0	49.0	49.3	49.2	48.8	47.8	54.1	49.8	54.2	48.7	49.0	49.1	48.8
% Evap @ 300 deg F	82.2	82.2	82.2	82.7	82.0	81.9	84.8	91.3	86.5	92.3	82.0	83.1	82.2	82.2
Emissions Reduction From Statutory Base														
EPA 4/92 CF														
V.O.C., %	35	40	45	45	45	45	45	45	48	50	45	45	45	45
NOx, %	1	2	3	3	4	4	9	4	5	8	2	2	2	1
T.A.P., %	30	32	34	35	34	34	37	51	41	49	34	34	34	34
EPA 10/92 CF														
V.O.C., %	28	33	36	37	37	36	40	36	39	41	36	36	36	36
NOx, %	(3)	(3)	(3)	0	(0)	0	14	16	8	18	(3)	(2)	(3)	(3)
T.A.P., %	28	28	25	28	28	27	39	43	34	44	26	26	26	25
API 1/93 CF[1]														
V.O.C., %	26	29	31	32	32	31	32	32	34	35	31	31	31	31
NOx, %	6	6	8	8	9	9	14	12	11	14	7	7	6	6
T.A.P., %	31	31	32	33	33	32	38	42	37	43	32	32	32	31
EPA 1/93 CF[2]														
V.O.C., %	19	23	24	26	26	26	31	28	30	33	25	26	25	25
NOx, %	(3)	(4)	(4)	0	(1)	0	14	16	8	18	(3)	(2)	(4)	(4)
T.A.P., %	21	21	18	22	21	20	33	37	27	39	19	19	19	18

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

[2] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 22 (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED GASOLINE – PHASE II
PADD III 2000 SUMMER CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	2000													
	Q40VL	Q40L	Q6	Q6N	QN2	S6	S10	SN1	Q40H	S21	Q3	QN1	Q5S	S3HH
	VL Delta	L Delta	Target	Q6 +	Q6N +	Q6 +	Q6 +	S6 +	H Delta	All	Q6N Units	Q6+ Max	Q6N Units	Q6N Units
	V.O.C.	V.O.C.	V.O.C.	Cap Chg	10.7% OL	All RFG	30 Sul	7 RVP	V.O.C.	CARB 2	Max Gaso	Gaso	Max K Jet	HH Crude
Emissions														
EPA 4/92 CF														
V.O.C., gm/mi	0.830	0.770	0.710	0.710	0.710	0.710	0.710	0.710	0.870	0.840	0.710	0.710	0.710	0.710
NOx, gm/mi	0.653	0.647	0.640	0.639	0.636	0.634	0.601	0.634	0.827	0.607	0.647	0.646	0.650	0.651
T.A.P., mg/mi	37.00	36.00	35.00	34.00	35.00	35.00	33.00	26.00	31.00	27.00	35.00	35.00	35.00	35.00
EPA 10/92 CF														
V.O.C., gm/mi	0.606	0.566	0.544	0.533	0.535	0.537	0.510	0.541	0.514	0.496	0.540	0.538	0.539	0.541
NOx, gm/mi	0.679	0.683	0.681	0.658	0.663	0.657	0.567	0.552	0.607	0.542	0.677	0.670	0.683	0.683
T.A.P., mg/mi	28.23	28.26	29.45	28.12	28.42	28.53	23.87	22.47	26.09	21.96	29.05	28.96	29.11	29.35
API 1/93 CF[1]														
V.O.C., gm/mi	1.071	1.021	0.994	0.986	0.991	0.992	0.987	0.979	0.956	0.946	0.998	0.993	0.996	1.000
NOx, gm/mi	1.266	1.256	1.233	1.228	1.226	1.220	1.149	1.185	1.190	1.148	1.252	1.247	1.255	1.261
T.A.P., mg/mi	54.87	54.47	54.10	52.87	53.24	53.61	49.39	45.79	49.68	45.07	54.24	53.77	54.02	54.50
EPA 1/93 CF[2]														
V.O.C., gm/mi	1.098	1.043	1.020	0.993	0.999	1.003	0.937	0.974	0.952	0.907	1.009	1.005	1.006	1.012
NOx, gm/mi	1.380	1.388	1.386	1.336	1.346	1.334	1.151	1.120	1.233	1.101	1.374	1.361	1.387	1.386
T.A.P., mg/mi	58.98	59.16	61.81	58.83	59.46	59.70	49.94	46.99	54.58	45.84	60.78	60.59	60.89	61.40

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

[2] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 22A
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
CONVENTIONAL GASOLINE – PHASE II
PADD III 2000 SUMMER CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	1989 Actual	2000									
		Q40VL VL Delta V.O.C.	Q40L L Delta V.O.C.	Q6 Target V.O.C.	Q6N Q6 + Cap Chg	QN2 Q6N + 10.7% OL	S10 Q6 + 30 Sul	Q3 Q6N Units Max Gaso	QN1 Q6+ Max Gaso	Q5S Q6N Units Max K Jet	S3HH Q6N Units HH Crude
RFG, % of Pool	0	63	63	63	63	63	63	63	63	63	63
Region 2, %	40	40	40	40	40	40	40	40	40	40	40
Properties											
Aromatics, vol %	31.6	32.1	33.2	32.6	34.3	33.2	32.2	32.7	32.3	33.2	31.7
Oxygen, wt %	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Olefins, vol %	13.2	13.2	14.3	14.3	14.8	12.2	18.4	13.5	11.6	14.6	14.6
Benzene, vol %	1.6	1.7	1.6	1.6	1.7	1.7	1.6	1.7	1.4	1.7	1.7
Sulfur, ppmw	305	183	185	184	186	138	172	189	228	184	171
RVP, psi	9.4	8.7	8.7	8.7	7.9	8.6	8.7	8.6	8.7	8.7	8.7
T50, deg F	212	207	207	203	208	206	210	206	206	204	204
T90, deg F	341	342	341	343	351	344	356	346	352	343	347
% Evap @ 200 deg F	45.0	46.0	46.0	48.0	45.4	46.3	46.2	46.2	46.0	47.6	47.3
% Evap @ 300 deg F	82.3	82.0	81.8	81.5	80.0	81.6	76.5	81.2	79.2	82.1	81.5
Emissions Reduction From 1989 Base											
EPA 4/92 CF											
V.O.C., %	0	17	17	17	31	17	16	19	15	17	17
NOx, %	0	4	4	4	4	6	10	4	4	3	4
T.A.P., %	0	10	10	10	13	10	10	10	10	10	10
EPA 10/92 CF											
V.O.C., %	0	10	9	9	16	11	2	11	9	8	9
NOx, %	0	2	(1)	(1)	(8)	4	(21)	(1)	1	(2)	(2)
T.A.P., %	0	17	18	19	20	20	16	16	20	17	18
API 1/93 CF[1]											
V.O.C., %	0	10	10	10	19	11	9	11	8	10	11
NOx, %	0	6	5	5	6	8	5	6	5	5	6
T.A.P., %	0	4	4	5	1	5	1	3	7	3	5
EPA 1/93 CF											
V.O.C., %	0	7	5	5	8	8	(4)	7	6	4	5
NOx, %	0	2	(1)	(1)	(7)	4	(21)	(1)	1	(2)	(2)
T.A.P., %	0	16	16	18	18	18	14	16	18	16	17

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

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EXHIBIT 22A (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
CONVENTIONAL GASOLINE – PHASE II
PADD III 2000 SUMMER CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	2000										
		Q40VL	Q40L	Q6	Q6N	QN2	S10	Q3	QN1	Q5S	S3HH
	1989	VL Delta	L Delta	Target	Q6 +	Q6N +	Q6 +	Q6N Units	Q6+ Max	Q6N Units	Q6N Units
	Actual	V.O.C.	V.O.C.	V.O.C.	Cap Chg	10.7% OL	30 Sul	Max Gaso	Gaso	Max K Jet	HH Crude
Emissions											
EPA 4/92 CF											
V.O.C., gm/mi	1.513	1.260	1.260	1.260	1.050	1.250	1.270	1.230	1.280	1.260	1.260
NOx, gm/mi	0.664	0.640	0.640	0.640	0.640	0.627	0.601	0.640	0.640	0.647	0.640
T.A.P., mg/mi	58.78	53.00	53.00	53.00	51.00	53.00	53.00	53.00	53.00	53.00	53.00
EPA 10/92 CF											
V.O.C., gm/mi	0.988	0.885	0.902	0.902	0.829	0.876	0.971	0.882	0.895	0.909	0.902
NOx, gm/mi	0.711	0.698	0.718	0.720	0.765	0.682	0.859	0.717	0.706	0.727	0.726
T.A.P., mg/mi	43.68	36.33	35.98	35.28	34.76	35.16	36.90	36.53	34.89	36.07	35.69
API 1/93 CF[1]											
V.O.C., gm/mi	1.571	1.408	1.410	1.411	1.278	1.391	1.426	1.396	1.444	1.408	1.404
NOx, gm/mi	1.353	1.272	1.280	1.280	1.273	1.243	1.287	1.276	1.290	1.282	1.272
T.A.P., mg/mi	81.11	77.70	77.93	76.92	80.65	77.17	80.62	78.82	75.16	79.08	77.38
EPA 1/93 CF											
V.O.C., gm/mi	1.652	1.533	1.569	1.569	1.513	1.528	1.721	1.540	1.557	1.587	1.570
NOx, gm/mi	1.444	1.417	1.456	1.460	1.552	1.383	1.744	1.455	1.436	1.476	1.475
T.A.P., mg/mi	86.89	73.11	72.80	71.12	71.04	70.84	75.11	72.77	71.01	72.74	71.90

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

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EXHIBIT 23
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED GASOLINE
OTHER PADD III 1995/2000/2010 SUMMER CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Annual Cases – F2 Demand		Winter Cases – F2 Demand [2]		Summer 2010			
	Q6A	F2	Q6W	Q5W	F1	S20M	S20H	F3
	2000	1995	2000	Q6N Units	2010	Medium	High	2010
	Target[1]	Base	Target	Max K Jet	Base	Alt Fuels	Alt Fuels	Base
RFG, % of Pool	64	11	64	64	63	63	63	63
Region 2, %	40	40	40	40	40	40	40	40
Properties								
Aromatics, vol %	22.8	23.4	20.3	19.6 *	23.5	25.2	24.9	24.1
Oxygen, wt %	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Olefins, vol %	10.7	13.5	9.5	11.5	11.1	12.3	10.9	11.8
Benzene, vol %	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, ppmw	147	305	153	174	233	201	174	122
RVP, psi	9.2	8.8	11.9 *	11.9 *	6.5	6.5	6.6	6.5
T50, deg F	195	201	186	181	202	204	205	203
T90, deg F	339	325	334	334	333	342	325	345
% Evap @ 200 deg F	53.2		56.1	59.0	49.1	48.7	48.2	48.9
% Evap @ 300 deg F	83.7		85.1	85.2	84.5	83.2	86.5	82.0
Emissions Reduction From Statutory Base[3]								
EPA 4/92 CF								
V.O.C., %	45				45	45	45	45
NOx, %	4		4	3	0	1	2	3
T.A.P., %	28		20	21	34	32	35	35
EPA 10/92 CF								
V.O.C., %	38				37	35	36	36
NOx, %	4		12	9	(1)	(6)	1	(2)
T.A.P., %	23		22	18	27	23	28	28
API 1/93 CF[4]								
V.O.C., %	31				32	31	32	32
NOx, %	7		7	5	4	5	7	9
T.A.P., %	30		28	28	32	30	33	33
EPA 1/93 CF[5]								
V.O.C., %	24				26	23	25	25
NOx, %	3		10	9	(1)	(6)	1	(3)
T.A.P., %	19		22	18	20	15	21	19

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Weighted average of summer and winter cases.

[2] 10/1/92 and 1/93 EPA CF equations calculated at 8.7 psi RVP.

[3] VOC reduction is summer only.

[4] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

[5] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 23 (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED GASOLINE
OTHER PADD III 1995/2000/2010 SUMMER CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Annual Cases – F2 Demand		Winter Cases – F2 Demand[2]		Summer 2010			
	Q6A	F2	Q6W	Q5W	F1	S20M	S20H	F3
	2000	1995	2000	Q6N Units	2010	Medium	High	2010
	Target[1]	Base	Target	Max K Jet	Base	Alt Fuels	Alt Fuels	Base
Emissions								
EPA 4/92 CF								
V.O.C., gm/mi	0.710				0.710	0.710	0.710	0.710
NOx, gm/mi	0.640		0.640	0.650	0.660	0.653	0.647	0.640
T.A.P., mg/mi	33.64		31.91	31.61	35.00	36.00	34.00	34.00
EPA 10/92 CF								
V.O.C., gm/mi	0.544				0.534	0.552	0.542	0.540
NOx, gm/mi	0.635		0.583	0.601	0.667	0.700	0.653	0.676
T.A.P., mg/mi	26.84		23.82	24.91	28.64	30.44	28.22	29.01
API 1/93 CF[4]								
V.O.C., gm/mi	0.994				0.988	0.995	0.982	0.985
NOx, gm/mi	1.231		1.226	1.247	1.281	1.269	1.251	1.223
T.A.P., mg/mi	50.80		47.12	47.21	53.79	55.34	53.15	53.51
EPA 1/93 CF[5]								
V.O.C., gm/mi	1.020				0.995	1.035	1.006	1.009
NOx, gm/mi	1.291		1.184	1.198	1.353	1.421	1.326	1.373
T.A.P., mg/mi	56.72		50.79	53.03	59.90	63.69	59.02	60.69

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Weighted average of summer and winter cases.

[2] 10/1/92 and 1/93 EPA CF equations calculated at 8.7 psi RVP.

[3] V.O.C. Reduction is summer only.

[4] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

[5] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 23A
IMPACT OF DIFFERENT COMPLEX FORMULA EQUATIONS
CONVENTIONAL GASOLINE
1995/2010 PADD III CASES
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Annual Cases – F2 Demand				Winter Cases – F2 Demand[1]				Summer 2010					
	Q9A	Q6A	F2	1989 Actual[2]	Q9W	Q6W	Q5W	1989 Actual	Q9	F1	S20M	S20H	F3	
	1989	2000	1995		2000	2000	Q6N Units		2000	2010	Medium	High	2010	
	Base[2]	Target[2]	Base		Base	Target	Max K Jet		Base	Base	Alt Fuels	Alt Fuels	Base	
RFQ, % of Pool	0	0	64	11	0	0	64	64	0	0	63	63	63	63
Region 2, %	40	40	40	40	40	40	40	40	40	40	40	40	40	40
<u>Properties</u>														
Aromatics, vol %	30.2	29.3	31.8	29.9	28.7	27.6	31.6	31.6	31.6	30.9	33.5	34.3	34.0	33.7
Oxygen, wt %	0.2	0.4	0.1	0.0	0.2	0.4	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0
Olefins, vol %	12.8	13	13.4	13.8	12.4	12.4	13.0	12.7	13.2	13.6	14.8	10.7	13.7	14.3
Benzene, vol %	1.6	1.7	1.6	1.7	1.5	1.6	1.7	1.7	1.6	1.8	1.7	1.7	1.7	1.6
Sulfur, ppmw	318	196	229	211	331	186	282	307	305	206	210	138	196	165
RVP, psi	11	9.9	10.2	9.7	12.6	11.9	11.9	11.9	9.4	7.9	8.3	8.7	8.6	8.6
T50, deg F	206	206	202	206	200	200	202	205	212	211	210	204	202	204
T90, deg F	338	343	341	348	335	339	341	337	341	347	351	339	336	344
% Evap @ 200 deg F	47.4	48.1	49.0		49.9	50.6	49.4	46.9	45.0	46.6	45.3	47.4	49.0	48.0
% Evap @ 300 deg F	81.5	81.9	81.9		80.7	82.7	81.8	83.3	82.3	81.1	79.6	82.1	83.5	81.7
<u>Emissions Reduction From 1989 Base[3]</u>														
<u>EPA 4/92 CF</u>														
V.O.C., %	0	31	17						0	31	24	17	19	19
NOx, %	0	3	3		0	4	2	1	0	3	3	7	4	4
T.A.P., %	0	11	4		0	5	(6)	(6)	0	15	12	10	10	12
<u>EPA 10/92 CF</u>														
V.O.C., %	0	22	9						0	22	12	10	11	9
NOx, %	0	1	(2)		0	2	(5)	(3)	0	(1)	(7)	7	1	(2)
T.A.P., %	0	10	4		0	6	(2)	(5)	0	17	17	20	18	20
<u>API 1/93 CF[4]</u>														
V.O.C., %	0	20	10						0	20	14	10	12	11
NOx, %	0	6	4		0	7	2	2	0	5	5	8	5	6
T.A.P., %	0	5	1		0	7	(6)	(7)	0	4	(1)	4	2	4
<u>EPA 1/93 CF</u>														
V.O.C., %	0	17	5						0	17	6	7	7	5
NOx, %	0	0	(3)		0	2	(5)	(4)	0	(2)	(7)	7	1	(2)
T.A.P., %	0	13	10		0	4	(3)	(5)	0	19	15	19	17	19

*Outside range of 10/1/92 and subsequent EPA equations.

[1] EPA 10/92 and 1/93 CF equations calculated at 8.7 psi RVP.

[2] Weighted average of summer and winter cases.

[3] VOC reduction is summer only.

[4] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995-1999) and Phase II (2000+).

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EXHIBIT 23A (CONTINUED)
IMPACT OF DIFFERENT COMPLEX FORMULA EQUATIONS
CONVENTIONAL GASOLINE
1995/2010 PADD III CASES
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Annual Cases – F2 Demand			Winter Cases – F2 Demand[1]				Summer 2010						
	Q9A	Q6A	F2	Q9W	Q6W	Q5W	Q6N Units Max K Jet	Q9	F1	S20M	S20H	F3		
	1989	2000	2000	1989	2000	2000		1989	2000	2010	Medium	High	2010	
	Actual[2]	Base[2]	Target[2]	Base	Actual	Base		Target	Actual	Base	Base	Alt Fuels	Alt Fuels	Base
EPA 4/92 CF														
V.O.C., gm/mi	1.513	1.040	1.260					1.513	1.040	1.150	1.260	1.230	1.230	
NOx, gm/mi	0.667	0.644	0.648		0.670	0.641	0.658	0.663	0.664	0.647	0.647	0.620	0.640	0.640
T.A.P., mg/mi	50.29	44.78	48.30		41.44	39.33	43.97	43.82	58.78	50.00	52.00	53.00	53.00	52.00
EPA 10/92 CF														
V.O.C., gm/mi	0.988	0.767	0.902						0.988	0.767	0.870	0.884	0.881	0.899
NOx, gm/mi	0.699	0.692	0.712		0.687	0.670	0.721	0.711	0.711	0.720	0.764	0.661	0.703	0.723
T.A.P., mg/mi	37.41	33.59	35.85		30.87	29.14	31.48	32.28	43.68	36.05	36.37	35.15	35.61	34.93
API 1/93 CF[4]														
V.O.C., gm/mi	1.571	1.255	1.411						1.571	1.255	1.352	1.419	1.389	1.391
NOx, gm/mi	1.341	1.259	1.287		1.329	1.238	1.296	1.307	1.353	1.280	1.290	1.241	1.287	1.270
T.A.P., mg/mi	74.44	70.37	73.68		67.49	62.89	71.53	72.14	80.44	77.54	81.34	77.59	78.89	77.34
EPA 1/93 CF														
V.O.C., gm/mi	1.652	1.379	1.569						1.652	1.379	1.555	1.532	1.539	1.577
NOx, gm/mi	1.402	1.400	1.440		1.359	1.334	1.431	1.411	1.444	1.469	1.551	1.341	1.428	1.468
T.A.P., mg/mi	76.48	66.64	69.13		65.62	63.09	67.29	68.85	86.89	70.05	73.86	70.67	71.80	70.77

*Outside range of 10/1/92 and subsequent EPA equations.

[1] EPA 10/92 and 1/93 CF equations calculated at 8.7 psi RVP.

[2] Weighted average of summer and winter cases.

[3] VOC reduction is summer only.

[4] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995-1999) and Phase II (2000+).

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EXHIBIT 23B
IMPACT OF DIFFERENT COMPLEX FORMULA EQUATIONS
OXYGENATED AND REFORMULATED – OXYGENATED GASOLINE
1995/2010 PADD III CASES
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Oxygenated					Reformulated–Oxygenated		
	Annual Cases – F2 Demand		Winter Cases – F2 Demand			Annual Case –	Winter Cases – F2 Demand	
	F2		F2 Demand			F2	F2 Demand	
	1989 Actual	1995 Base	1989 Actual	Q6W 2000 Base	Q5W Q6N Units Max K Jet	1995 Base	Q6W 2000 Base	Q5W Q6N Units Max K Jet
RFG, % of Pool	0	11		64	64	11	64	64
Region 2, %	40	40		40	40	40	40	40
Properties								
Aromatics, vol %	30.2	25.4	28.7	22.9	25.6	19.2 *	22.3	22.4
Oxygen, wt %	0.2	2.7	0.2	2.7	2.7	2.7	2.7	2.7
Olefins, vol %	12.8	8.5	12.4	5.8	13.7	13.6	10.6	13.7
Benzene, vol %	1.6	1.7	1.5	1.7	1.7	0.7	0.7	0.7
Sulfur, ppmw	318	305	331	224	234	305	142	174
RVP, psi	11	11.9 *	12.6 *	11.9 *	11.9 *	11.9 *	11.9 *	11.9 *
T50, deg F	206	188	200	185	184	180	180	176
T90, deg F	338	325	335	311	332	303	336	316
% Evap @ 200 deg F	47.4		49.9	57.5	58.6		59.0	60.5
% Evap @ 300 deg F	81.5		80.7	88.3	86.0		85.1	88.0
Emissions Reduction[1]		From 1989 Base					From Statutory Base	
EPA 4/92 CF								
V.O.C., %	0							
NOx, %	0		0	3	(0)		4	1
T.A.P., %	0		0	15	7		17	23
EPA 10/92 CF[2]								
V.O.C., %	0							
NOx, %	0		0	8	4	11	9	7
T.A.P., %	0		0	2	(3)	29	18	15
API 1/93 CF[3]								
V.O.C., %	0							
NOx, %	0		0	5	1		6	3
T.A.P., %	0		0	18	10		26	26
EPA 1/93 CF[2]								
V.O.C., %	0							
NOx, %	0		0	7	2		7	7
T.A.P., %	0		0	3	(2)		18	15

*Outside range of 10/1/92 and subsequent EPA equations.

[1] V.O.C. reduction is summer only.

[2] Winter calculated at 8.7 psi RVP.

[3] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

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EXHIBIT 23B (CONTINUED)
IMPACT OF DIFFERENT COMPLEX FORMULA EQUATIONS
OXYGENATED AND REFORMULATED – OXYGENATED GASOLINE
1995/2010 PADD III CASES
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Oxygenated					Reformulated–Oxygenated				
	Annual Cases – F2 Demand		Winter Cases – F2 Demand			Annual Cases – F2 Demand		Winter Cases – F2 Demand		
	F2					F2				
	1989 Actual	1995 Base	1989 Actual	2000 Base	Q5W Q6N Units Max K Jet	1995 Base		2000 Base	Q5W Q6N Units Max K Jet	
Emissions – Phase II[1]										
EPA 4/92 CF										
V.O.C., gm/mi	1.513									
NOx, gm/mi	0.667		0.670	0.651	0.671			0.643	0.668	
T.A.P., mg/mi	50.29		41.44	35.08	38.73			33.13	30.78	
EPA 10/92 CF[2]										
V.O.C., gm/mi	0.988									
NOx, gm/mi	0.699	0.650	0.687	0.635	0.658	0.590		0.601	0.611	
T.A.P., mg/mi	37.41	36.00	30.87	30.14	31.81	28.00		25.10	25.89	
API 1/93 CF[3]										
V.O.C., gm/mi	1.571									
NOx, gm/mi	1.341		1.329	1.264	1.310			1.239	1.272	
T.A.P., mg/mi	74.44		67.49	55.55	61.07			48.25	48.54	
EPA 1/93 CF[2]										
V.O.C., gm/mi	1.652									
NOx, gm/mi	1.402		1.359	1.263	1.336			1.220	1.221	
T.A.P., mg/mi	76.48		65.62	63.66	67.26			53.40	55.08	
Emissions – Phase I										
API 1/93 CF[3]										
V.O.C., gm/mi	1.493									
NOx, gm/mi	0.667		0.668							
T.A.P., mg/mi	40.39		33.19							
EPA 1/93 CF[2]										
V.O.C., gm/mi	1.538									
NOx, gm/mi	0.694		0.673							
T.A.P., mg/mi	41.85		32.34							

*Outside range of 10/1/92 and subsequent EPA equations.

[1] V.O.C. reduction is summer only.

[2] Winter calculated at 8.7 psi RVP.

[3] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

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EXHIBIT 24
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED AND CONVENTIONAL GASOLINE
PADD I 1995/2000 – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Reformulated							Conventional			
	1995 Summer	2000 Summer						1989 Actual	1995 Summer		Annual
	S17 Permit Delay	Q6 Target V.O.C.	Q3 Q6N Units Max Gaso	QN2M Q6N + 11.1% OL	QN2H Q6N + 8.6% OL	S10 Q6 + 30 Sul	S21 All CARB 2		Base Case Q9	S17 Permit Delay	Q9A 2000 Base
RFG, % of Pool	27	100	100	100	100	100	100	0	0	27	0
Region 2, %	80	90	90	90	90	90	80	80	80	80	80
<u>Properties</u>											
Aromatics, vol %	20.8	24.4	25.4	24.3	24.3	27.0	22.0	33.3	31.2	31.7	29.6
Oxygen, wt %	2.1	2.1	2.1	2.1	2.1	2.1	2.0	0.3	0.4	0.5	0.4
Olefins, vol %	15.6	13.1	14.2	11.1	8.6	10.2	4.0	16.0	15.9	14.8	16.1
Benzene, vol %	0.7	0.7	0.7	0.7	0.7	0.7	0.8	1.8	1.8	1.8	1.8
Sulfur, ppmw	305	233	247	239	214	30	29	407	341	344	341
RVP, psi	7.3	6.5	6.5	6.5	6.5	6.7	6.6	9.9	8.2	8.2	10.2
T50, deg F	199	206	209	205	205	205	193	206	212	212	208
T90, deg F	337	340	346	339	337	346	290	337	354	356	352
% Evap @ 200 deg F	52.4	48.4	47.0	48.5	48.0	48.7	54.6	47.5	46.1	46.1	
% Evap @ 300 deg F	83.7	82.0	80.8	82.7	83.1	81.5	92.3	83.5	80.1	79.6	
<u>Emissions Reduction</u>											
	From Statutory Base							From 1989 Base			
<u>EPA 4/92 CF</u>											
V.O.C., %	32	41	41	41	41	41	48	0	32	31	
NOx, %	(4)	(1)	(2)	0	2	7	8	0	2	3	
T.A.P., %	33	33	31	31	33	35	48	0	18	16	
<u>EPA 10/92 CF</u>											
V.O.C., %	26	31	28	32	33	30	38	0	22	23	
NOx, %	(5)	(9)	(16)	(3)	2	5	18	0	(6)	(5)	
T.A.P., %	25	19	13	24	29	28	43	0	26	25	
<u>API 1/93 CF[1]</u>											
V.O.C., %	34	30	29	30	30	29	34	0	34	34	
NOx, %	(1)	4	3	4	6	12	14	0	5	5	
T.A.P., %	36	29	26	30	32	32	43	0	11	10	
<u>EPA 1/93 CF[2]</u>											
V.O.C., %	31	27	24	28	30	27	36	0	32	32	
NOx, %	(6)	(9)	(16)	(4)	2	5	18	0	(7)	(5)	
T.A.P., %	28	17	10	21	26	26	41	0	26	26	

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995–1999) and Phase II (2000+).

[2] For RFG includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 24 (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED AND CONVENTIONAL GASOLINE
PADD I 1995/2000 – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Reformulated							Conventional		
	1995 Summer	2000 Summer						1995 Summer	Annual	
	S17	Q6	Q3	QN2M	QN2H	S10	S21	Base	S17	Q9A
	Permit Delay	Target V.O.C.	Q6N Units Max Gaso	Q6N + 11.1% OL	Q6N + 8.6% OL	Q6 + 30 Sul	All CARB 2	1989 Actual	Case Q9	Permit Delay
Emissions - Phase II										
EPA 4/92 CF										
V.O.C., gm/mi	0.850	0.730	0.730	0.730	0.730	0.730	0.650	1.661	1.130	1.140
NOx, gm/mi	0.686	0.667	0.673	0.660	0.647	0.614	0.607	0.694	0.680	0.673
T.A.P., mg/mi	35.00	35.00	36.00	36.00	35.00	34.00	27.00	65.66	54.00	55.00
EPA 10/92 CF										
V.O.C., gm/mi	0.595	0.553	0.571	0.544	0.536	0.558	0.496	1.038	0.804	0.804
NOx, gm/mi	0.696	0.719	0.767	0.683	0.649	0.629	0.543	0.751	0.797	0.785
T.A.P., mg/mi	29.20	31.25	33.58	29.64	27.68	27.80	21.96	50.71	37.75	38.13
API 1/93 CF[1]										
V.O.C., gm/mi		0.989	0.999	0.992	0.994	0.999	0.938			
NOx, gm/mi		1.290	1.302	1.285	1.260	1.174	1.147			
T.A.P., mg/mi		56.07	58.23	55.16	53.84	53.66	44.94			
EPA 1/93 CF[2]										
V.O.C., gm/mi		1.024	1.063	1.004	0.985	1.028	0.898			
NOx, gm/mi		1.460	1.557	1.387	1.317	1.277	1.101			
T.A.P., mg/mi		65.26	70.12	61.92	57.87	58.18	45.78			
Emissions - Phase I										
API 1/93 CF[1]										
V.O.C., gm/mi	0.809							1.641	1.079	1.082
NOx, gm/mi	0.666							0.712	0.676	0.676
T.A.P., mg/mi	28.60							52.74	47.20	47.42
EPA 1/93 CF[2]										
V.O.C., gm/mi	0.815							1.704	1.164	1.162
NOx, gm/mi	0.698							0.756	0.806	0.794
T.A.P., mg/mi	31.52							59.31	43.82	44.16

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995–1999) and Phase II (2000+).

[2] For RFG includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 25
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED GASOLINE
PADD II 1995/2000 – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	1995 Summer	2000					
		Summer				Winter[1]	Annual[2]
	S5	Q6	S6	S13	S13H		
	Full	Target	Q6 +	S6 +	S13 +	Q6W	Q6A
	Opt In	V.O.C.	All RFG	Hi EtOH	S6 VOC	Target	Target
RFG, % of Pool	56	56	100	100	100	55	
Region 2, %	80	80	80	80	80	80	80
Properties							
Aromatics, vol %	24.3	22.2	23.9	24.3	23.7	18.2	20.0
Oxygen, wt %	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Olefins, vol %	11.4	10.7	10.3	10.2	10.0	8.4	9.4
Benzene, vol %	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, ppmw	281	273	236	193	86	239	255
RVP, psi	7.6	6.5	6.6	6.8	6.8	12.5 *	9.5
T50, deg F	197	203	208	209	209	182	193
T90, deg F	340	348	342	334	327	336	342
% Evap @ 200 deg F	51.6	49.9	47.8	47.3	47.4	59.0	54.2
% Evap @ 300 deg F	82.2	81.0	81.5	82.2	84.8	84.2	82.7
<u>Emissions Reduction From Statutory Base</u>							
<u>EPA 4/92 CF</u>							
V.O.C., %	25	41	41	37	41		41
NOx, %	(1)	0	0	0	4	3	1
T.A.P., %	27	31	33	33	38	19	26
<u>EPA 10/92 CF</u>							
V.O.C., %	23	34	32	31	33		34
NOx, %	(0)	(4)	(3)	0	4	9	3
T.A.P., %	29	26	26	27	30	21	24
<u>API 1/93 CF[3]</u>							
V.O.C., %	28	29	29	28	31		29
NOx, %	1	3	5	6	11	3	3
T.A.P., %	34	31	30	30	34	28	30
<u>EPA 1/93 CF[4]</u>							
V.O.C., %	25	29	27	26	29		29
NOx, %	(1)	(4)	(3)	(0)	4	9	3
T.A.P., %	31	22	22	25	29	21	22

*Outside range of 10/1/92 and subsequent EPA equations.

[1] EPA CF equations calculated at 8.7 psi RVP.

[2] Weighted average of summer and winter cases. Δ VOC is summer only.

[3] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

[4] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 25 (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED GASOLINE
PADD II 1995/2000 – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

Emissions	1995	2000				2000	2000
	Summer	Summer				Winter[1]	Annual[2]
	S5	Q6	S6	S13	S13H		
	Full Opt In	Target V.O.C.	Q6 + All RFG	S6 + Hi EtOH	S13 + S6 VOC	Q6W Target	Q6A Target
<u>EPA 4/92 CF</u>							
V.O.C., gm/mi	0.940	0.740	0.740	0.785	0.734		0.740
NOx, gm/mi	0.667	0.660	0.660	0.660	0.634	0.653	0.656
T.A.P., mg/mi	38.00	36.00	35.00	35.00	32.20	32.32	34.05
<u>EPA 10/92 CF</u>							
V.O.C., gm/mi	0.625	0.533	0.548	0.561	0.544		0.533
NOx, gm/mi	0.662	0.684	0.680	0.660	0.635	0.598	0.641
T.A.P., mg/mi	27.70	28.95	28.86	28.30	27.06	23.91	26.35
<u>API 1/93 CF[3]</u>							
V.O.C., gm/mi	0.890	1.005	1.011	1.022	0.988		1.005
NOx, gm/mi	0.654	1.300	1.279	1.257	1.198	1.274	1.286
T.A.P., mg/mi	29.54	54.58	55.22	55.12	51.90	46.83	50.61
<u>EPA 1/93 CF[4]</u>							
V.O.C., gm/mi	0.882	0.983	1.011	1.030	0.990		0.983
NOx, gm/mi	0.664	1.388	1.381	1.340	1.280	1.190	1.291
T.A.P., mg/mi	30.20	60.46	60.32	57.80	54.78	50.92	55.67

* Outside range of 10/1/92 and subsequent EPA equations.

[1] EPA CF equations calculated at 8.7 psi RVP.

[2] Weighted average of summer and winter cases. Δ VOC is summer only.

[3] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

[4] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 25A
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
CONVENTIONAL GASOLINE
PADD II 1995/2000 CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	1995 Summer			2000 Summer		Winter[1]				Annual[2]			
	1989 Summer Actual	Base Case Q9	S5 Full Opt In	Base Case Q9	Q6 Target V.O.C.	1989 Actual	Q9W 1995 Base	Q9W 2000 Base	Q6W 2000 Target	1989 Actual	Q9A 1995 Base	Q9A 2000 Base	Q6A 2000 Target
RFG, % of Pool	0	0	56	0	56	0	0	0	55		0	0	56
Region 2, %	80	80	80	80	80	80	80	80	80	80	80	80	80
Properties													
Aromatics, vol %	29.7	31.8	31.8	31.8	35.6	26.9	27.3	27.3	31.8	28.3	29.6	29.6	33.0
Oxygen, wt %	0.0	0.4	0.0	0.4	0.0	0.0	0.4	0.4	0.0	0	0.4	0.4	0.2
Olefins, vol %	12.8	12.3	11.7	12.3	13.6	12.0	11.0	11.0	13.2	12.4	11.7	11.7	13.0
Benzene, vol %	1.6	2.1 *	2.1 *	2.1 *	2.1 *	1.5	1.9	1.9	2.0	1.6	2.0	2.0	2.0
Sulfur, ppmw	422	312	298	312	248	367	256	256	255	395	284	284	253
RVP, psi	9.9	8.4	8.4	8.4	7.8	13.2 *	12.5 *	12.5 *	12.5 *	11.5	10.4 *	10.4 *	10.2
T50, deg F	205	210	213	210	208	195	198	198	200	200	205	205	203
T90, deg F	334	345	345	345	338	334	339	339	329	334	342	342	334
% Evap @ 200 deg	48.0	46.4	44.3	46.4	46.0	51.8	50.7	50.7	50.0	49.9	48.7	48.7	48.4
% Evap @ 300 deg	84.0	80.9	81.0	80.9	82.3	81.6	83.0	83.0	84.2	82.8	81.9	81.9	83.3
Emissions Reduction From 1989 Base													
EPA 4/92 CF													
V.O.C., %	0	29	29	29	40					0	29	29	40
NOx, %	0	4	5	4	5	0	4	4	3	0	4	4	4
T.A.P., %	0	7	7	7	15	0	(2)	(2)	(5)	0	3	3	8
EPA 10/92 CF													
V.O.C., %	0	20	19	20	23					0	20	20	23
NOx, %	0	(3)	(1)	(3)	(4)	0	(1)	(1)	(5)	0	5	5	3
T.A.P., %	0	17	17	17	24	0	(6)	(6)	(7)	0	8	8	12
API 1/93 CF[3]													
V.O.C., %	0	31	31	19	25					0	31	19	25
NOx, %	0	6	7	6	9	0	5	5	5	0	6	6	7
T.A.P., %	0	(4)	(4)	(8)	(10)	0	(2)	(2)	(12)	0	(3)	(5)	(10)
EPA 1/93 CF[4]													
V.O.C., %	0	28	28	15	16					0	28	15	16
NOx, %	0	(3)	(1)	(3)	(5)	0	(0)	(0)	(5)	0	(2)	(2)	(4)
T.A.P., %	0	16	16	17	23	0	(6)	(6)	(8)	0	8	8	11

*Outside range of 10/1/92 and subsequent EPA equations.

[1] 10/92 and 1/93 EPA CF equations calculated at 8.7 psi RVP.

[2] Weighted average of summer and winter cases. Δ VOC is summer only.

[3] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995-1999) and Phase II (2000+).

[4] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 25A (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
CONVENTIONAL GASOLINE
PADD II 1995/2000 CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	1989 Summer Actual	1995 Summer		2000 Summer		Winter[1]				Annual[2]			
		Base Case Q9	S5 Full Opt In	Base Case Q9	Q6 Target V.O.C.	1989 Actual	Q9W 1995 Base	Q9W 2000 Base	Q6W 2000 Target	1989 Actual	Q9A 1995 Base	Q9A 2000 Base	Q6A 2000 Target
Emissions – Phase II													
EPA 4/92 CF													
V.O.C., gm/ml	1.658	1.170	1.170	1.170	0.990					1.658	1.170	1.170	0.990
NOx, gm/ml	0.687	0.660	0.653	0.660	0.653	0.675	0.650	0.650	0.657	0.681	0.655	0.655	0.655
T.A.P., mg/ml	61.44	57.00	57.00	57.00	52.00	40.75	41.64	41.64	42.70	51.17	49.38	49.38	47.09
EPA 10/92 CF													
V.O.C., gm/ml	0.994	0.798	0.800	0.798	0.765					0.994	0.798	0.798	0.765
NOx, gm/ml	0.690	0.711	0.700	0.711	0.720	0.665	0.669	0.669	0.697	0.726	0.690	0.690	0.705
T.A.P., mg/ml	48.68	40.64	40.41	40.64	37.21	29.86	31.78	31.78	32.03	39.34	36.24	36.24	34.54
API 1/93 CF[3]													
V.O.C., gm/ml	1.672			1.350	1.249					1.672		1.350	1.249
NOx, gm/ml	1.428			1.343	1.306	1.352		1.279	1.291	1.390		1.311	1.299
T.A.P., mg/ml	80.79			87.26	89.17	65.73		66.86	73.55	73.31		77.13	80.29
EPA 1/93 CF[4]													
V.O.C., gm/ml	1.680			1.432	1.413					1.680		1.432	1.413
NOx, gm/ml	1.400			1.441	1.463	1.324		1.329	1.386	1.362		1.385	1.417
T.A.P., mg/ml	97.80			81.60	75.55	63.45		67.25	68.31	80.75		74.48	71.73
Emissions – Phase I													
API 1/93 CF[3]													
V.O.C., gm/ml	1.643	1.137	1.141							1.643	1.137		
NOx, gm/ml	0.703	0.662	0.653			0.680	0.643			0.692	0.653		
T.A.P., mg/ml	48.23	50.32	50.40			32.17	32.84			40.260	41.640		
EPA 1/93 CF[4]													
V.O.C., gm/ml	1.652	1.182	1.184							1.652	1.182		
NOx, gm/ml	0.692	0.713	0.702			0.652	0.655			0.672	0.684		
T.A.P., mg/ml	56.65	47.63	47.53			31.22	33.23			44.03	40.48		

*Outside range of 10/1/92 and subsequent EPA equations.

[1] 10/92 and 1/93 EPA CF equations calculated at 8.7 psi RVP.

[2] Weighted average of summer and winter cases. Δ VOC is summer only.

[3] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

[4] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 25B
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
OG, RFG-OG, RFG-E AND RFG-M
PADD II 2000 CASES – F2 CONSTANT DEMANDS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 Winter[1]			2000 Summer			
	OG		RFG-OG	RFG-E		RFG-M	
	1989	Q6W		S13	S13H	S13	S13H
	Actual	2000 Target	2000 Target	S6 + Hi EtOH	S13 + S6 VOC	S6 + Hi EtOH	S13 + S6 VOC
RFG, % of Pool	0	55	55	30	30	70	70
Region 2, %	80	80	80	80	80	80	80
<u>Properties</u>							
Aromatics, vol %	26.9	21.3	14.4 *	20.3	28.0	26.0	21.8
Oxygen, wt %	0.0	2.7	2.7	2.1	2.1	2.1	2.1
Olefins, vol %	12.0	7.4	5.7	12.4	9.0	9.3	10.4
Benzene, vol %	1.5	1.7	0.7	0.7	0.7	0.7	0.7
Sulfur, ppmw	367	279	208	178	85	200	86
RVP, psi	13.2 *	12.5 *	12.5 *	7.5	7.5	6.5	6.5
T50, deg F	195	185	188	217	204	205	211
T90, deg F	334	339	329	341	320	331	330
% Evap @ 200 deg F	51.8	57.0	57.9	44.0	48.0	48.9	47.1
% Evap @ 300 deg F	81.6	84.5	85.3	79.0	88.4	83.5	83.2
<u>Emissions Reduction</u>	From 1989 Base			From Statutory Base			
<u>EPA 4/92 CF</u>							
V.O.C., %				29	31	41	45
NOx, %	0	2	4	1	5	2	4
T.A.P., %	0	5	26	33	33	31	41
<u>EPA 10/92 CF</u>							
V.O.C., %				25	25	33	36
NOx, %	0	4	12	(3)	9	2	2
T.A.P., %	0	(4)	29	29	34	27	29
<u>API 1/93 CF[2]</u>							
V.O.C., %				23	25	30	33
NOx, %	0	4	5	6	10	6	11
T.A.P., %	0	12	33	27	31	31	36
<u>EPA 1/93 CF[3]</u>							
V.O.C., %				22	22	28	32
NOx, %	0	4	12	(3)	9	1	2
T.A.P., %	0	(3)	29	26	30	23	26

*Outside range of 10/1/92 and subsequent EPA equations.

[1] 10/1/92 and 1/93 EPA CF equations calculated at 8.7 psi RVP.

[2] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995-1999) and Phase II (2000+).

[3] For RFG includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 25B (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
OG, RFG-OG, RFG-E AND RFG-M
PADD II 2000 CASES – F2 CONSTANT DEMANDS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 Winter[1]			2000 Summer			
	OG		RFG-OG	RFG-E		RFG-M	
	Q6W		Q6W	S13	S13H	S13	S13H
	1989 Actual	2000 Target	2000 Target	S6 + HI EtOH	S13 + S6 VOC	S6 + HI EtOH	S13 + S6 VOC
Emissions - Phase II							
<u>EPA 4/92 CF</u>							
V.O.C., gm/mi				0.890	0.860	0.730	0.680
NOx, gm/mi	0.675	0.659	0.645	0.653	0.627	0.647	0.634
T.A.P., mg/mi	40.75	38.87	29.53	35.00	35.00	36.00	31.00
<u>EPA 10/92 CF</u>							
V.O.C., gm/mi				0.607	0.604	0.541	0.518
NOx, gm/mi	0.665	0.639	0.579	0.680	0.599	0.650	0.645
T.A.P., mg/mi	29.86	30.98	21.71	27.67	25.84	28.57	27.58
<u>API 1/93 CF[2]</u>							
V.O.C., gm/mi				1.100	1.070	0.996	0.960
NOx, gm/mi	1.352	1.304	1.244	1.256	1.211	1.259	1.193
T.A.P., mg/mi	65.41	57.53	43.99	57.34	54.90	54.74	50.90
<u>EPA 1/93 CF[3]</u>							
V.O.C., gm/mi				1.090	1.084	1.001	0.951
NOx, gm/mi	1.324	1.273	1.150	1.380	1.215	1.320	1.310
T.A.P., mg/mi	63.45	65.37	46.26	57.74	53.99	59.74	57.55
Emissions - Phase I							
<u>API 1/93 CF[2]</u>							
V.O.C., gm/mi							
NOx, gm/mi	0.680						
T.A.P., mg/mi	32.17						
<u>EPA 1/93 CF[3]</u>							
V.O.C., gm/mi							
NOx, gm/mi	0.652						
T.A.P., mg/mi	31.22						

*Outside range of 10/1/92 and subsequent EPA equations.

[1] 10/1/92 and 1/93 EPA CF equations calculated at 8.7 psi RVP.

[2] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995-1999) and Phase II (2000+).

[3] For RFG includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 26
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED GASOLINE – PHASE II
PADD IV 2000 SUMMER – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Q6 Target V.O.C.	S3 Q6 Units HH Crude	S6 Q6 + All RFG	S10 S6 + 30 Sul	S21 All CARB 2
RFG, % of Pool	13	13	100	100	100
Region 2, %	40	40	40	40	40
<u>Properties</u>					
Aromatics, vol %	28.9	27.8	21.9	20.8	18.0 *
Oxygen, wt %	2.1	2.1	2.1	2.1	2.0
Olefins, vol %	7.1	8.2	11.3	10.4	4.0
Benzene, vol %	0.7	0.7	0.7	0.7	0.8
Sulfur, ppmw	100	199	196	30	30 *
RVP, psi	6.5	6.5	6.6	6.8	6.6
T50, deg F	205	214	205	206	193
T90, deg F	337	325	340	328	290
% Evap @ 200 deg F	49.9	47.0	49.3	48.9	54.5
% Evap @ 300 deg F	82.9	85.7	82.3	84.8	92.3
<u>Emissions Reduction From Statutory Base</u>					
<u>EPA 4/92 CF</u>					
V.O.C., %	45	45	45	45	51
NOx, %	6	2	1	6	7
T.A.P., %	30	32	35	43	53
<u>EPA 10/92 CF</u>					
V.O.C., %	35	36	37	38	42
NOx, %	7	1	(2)	9	19
T.A.P., %	29	22	29	37	48
<u>API 1/93 CF[1]</u>					
V.O.C., %	30	31	31	32	35
NOx, %	10	6	6	13	15
T.A.P., %	31	30	33	38	46
<u>EPA 1/93 CF[2]</u>					
V.O.C., %	24	25	26	29	33
NOx, %	7	1	(2)	9	19
T.A.P., %	22	15	22	32	43

* Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995–1999) and Phase II (2000+).

[2] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 26 (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
REFORMULATED GASOLINE – PHASE II
PADD IV 2000 SUMMER – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

<u>Emissions</u>	<u>Q6 Target V.O.C.</u>	<u>S3 Q6 Units HH Crude</u>	<u>S6 Q6 + All RFG</u>	<u>S10 S6 + 30 Sul</u>	<u>S21 All CARB 2</u>
<u>EPA 4/92 CF</u>					
V.O.C., gm/mi	0.710	0.710	0.710	0.710	0.630
NOx, gm/mi	0.620	0.647	0.653	0.620	0.614
T.A.P., mg/mi	37.00	36.00	34.00	30.00	25.00
<u>EPA 10/92 CF</u>					
V.O.C., gm/mi	0.546	0.544	0.536	0.528	0.493
NOx, gm/mi	0.612	0.653	0.675	0.601	0.532
T.A.P., mg/mi	27.83	30.55	27.89	24.57	20.52
<u>API 1/93 CF[1]</u>					
V.O.C., gm/mi	1.010	0.998	0.999	0.980	0.934
NOx, gm/mi	1.200	1.255	1.259	1.168	1.141
T.A.P., mg/mi	54.41	55.35	53.03	49.01	42.90
<u>EPA 1/93 CF[2]</u>					
V.O.C., gm/mi	1.022	1.018	0.993	0.961	0.900
NOx, gm/mi	1.242	1.326	1.370	1.219	1.082
T.A.P., mg/mi	58.34	63.86	58.32	51.34	42.90

* Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995–1999) and Phase II (2000+).

[2] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 26A
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
CONVENTIONAL GASOLINE
PADD IV 1995/2000 CASES – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	1989 Actual Summer	1995 Summer Base Case Q9	2000 Summer Q6 Target V.O.C.	S3 Q6 Units HH Crude	Annual Q9A 1995 Base
RFG, % of Pool	0	0	13	13	0
Region 2, %	40	40	40	40	40
<u>Properties</u>					
Aromatics, vol %	25.6	28.0	28.0	27.9	26.9
Oxygen, wt %	0.0	0.4	0.0	0.0	0.4
Olefins, vol %	15.7	14.6	15.4	15.6	14.1
Benzene, vol %	1.9	1.9	1.7	1.7	1.9
Sulfur, ppmw	371	287	284	310	248
RVP, psi	9.4	7.9	8.7	8.7	9.9
T50, deg F	202	206	205	207	203
T90, deg F	325	344	346	346	342
% Evap @ 200 deg F	49.0	48.0	48.0	47.5	
% Evap @ 300 deg F	86.0	81.6	81.5	80.8	
<u>Emissions Reduction From 1989 Base</u>					
<u>EPA 4/92 CF</u>					
V.O.C., %	0	30	14	14	
NOx, %	0	3	3	3	
T.A.P., %	0	13	8	8	
<u>EPA 10/92 CF</u>					
V.O.C., %	0	22	9	9	
NOx, %	0	(9)	(10)	(11)	
T.A.P., %	0	18	15	13	
<u>API 1/93 CF[1]</u>					
V.O.C., %	0	31	8	8	
NOx, %	0	5	4	3	
T.A.P., %	0	8	3	1	
<u>EPA 1/93 CF</u>					
V.O.C., %	0	30	5	5	
NOx, %	0	(9)	(10)	(11)	
T.A.P., %	0	20	13	11	

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995–1999) and Phase II (2000+).

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EXHIBIT 26A (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
CONVENTIONAL GASOLINE
PADD IV 1995/2000 CASES - F2 CONSTANT DEMANDS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1989	1995 Summer	2000 Summer		Annual
	Actual	Base	Q6	S3	Q9A
	Summer	Case	Target	Q6 Units	1995
		Q9	V.O.C.	HH Crude	Base
<u>Emissions - Phase II</u>					
<u>EPA 4/92 CF</u>					
V.O.C., gm/ml	1.476	1.040	1.270	1.270	
NOx, gm/ml	0.691	0.667	0.667	0.673	
T.A.P., mg/ml	56.52	49.00	52.00	52.00	
<u>EPA 10/92 CF</u>					
V.O.C., gm/ml	0.949	0.744	0.868	0.866	
NOx, gm/ml	0.659	0.716	0.727	0.730	
T.A.P., mg/ml	43.32	35.64	37.04	37.67	
<u>API 1/93 CF[1]</u>					
V.O.C., gm/ml	1.532		1.406	1.414	
NOx, gm/ml	1.397		1.335	1.350	
T.A.P., mg/ml	78.95		76.76	77.88	
<u>EPA 1/93 CF</u>					
V.O.C., gm/ml	1.567		1.496	1.493	
NOx, gm/ml	1.339		1.475	1.483	
T.A.P., mg/ml	85.43		74.40	75.67	
<u>Emissions - Phase I</u>					
<u>API 1/93 CF[1]</u>					
V.O.C., gm/ml	1.474	1.012			
NOx, gm/ml	0.688	0.654			
T.A.P., mg/ml	48.22	44.27			
<u>EPA 1/93 CF</u>					
V.O.C., gm/ml	1.496	1.053			
NOx, gm/ml	0.659	0.720			
T.A.P., mg/ml	51.47	41.29			

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995-1999) and Phase II (2000+).

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EXHIBIT 27
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
PADD V 2000 SUMMER - F2 CONSTANT DEMANDS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Reformulated Gasoline	Conventional Gasoline			
	VCC	VCOC			VCC
	Q6	Q6	Q6		Q6
	Target	Target	At	1989	Target
	V.O.C.	V.O.C.	8.7 RVP	Actual	V.O.C.
RFG, % of Pool	94	0	0	0	94
Region 2, %	0	100	100	0	0
<u>Properties</u>					
Aromatics, vol %	22.0	31.8	33.8	32.9	35.2
Oxygen, wt %	2.0	0	0.3	0.3	0
Olefins, vol %	4.0	10.5	12.2	11.9	9.5
Benzene, vol %	0.8	2.6	2.9 *	2.8 *	2.0
Sulfur, ppmw	30 *	389	249	243	161
RVP, psi	6.6	10.3	7.3	8.7	8.5
T50, deg F	196	207	208	206	217
T90, deg F	290	326	337	335	328
% Evap @ 200 deg F	50.8	46.3	45.8	46.8	42.0
% Evap @ 300 deg F	91.6	85	83.9	84.5	84.3
<u>Emissions Reduction</u>		<u>From 1989 Base</u>			
<u>EPA 4/92 CF</u>					
V.O.C., %	52	0	32	32	0
NOx, %	8	0	4	4	0
T.A.P., %	49	0	22	21	0
<u>EPA 10/92 CF</u>					
V.O.C., %	44	0	34	21	0
NOx, %	17	0	(2)	(0)	0
T.A.P., %	45	0	33	26	0
<u>API 1/93 CF[1]</u>					
V.O.C., %	35	0	35	23	0
NOx, %	15	0	8	7	0
T.A.P., %	42	0	2	4	17
<u>EPA 1/93 CF[2]</u>					
V.O.C., %	30	0	28	17	0
NOx, %	17	0	(2)	(1)	0
T.A.P., %	39	0	32	27	0

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995-1999) and Phase II (2000+).

[2] For RFG includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 27 (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
PADD V 2000 SUMMER – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Reformulated Gasoline	Conventional Gasoline				
		VCOC			VCC	
		Q6		Q6	Q6	
		Target	Target	At	1989	Target
	V.O.C.	Actual	V.O.C.	8.7 RVP	Actual	V.O.C.
<u>Emissions - Phase II</u>						
<u>EPA 4/92 CF</u>						
V.O.C., gm/mi	0.630	1.786	1.210	1.213	1.228	1.230
NOx, gm/mi	0.607	0.675	0.647	0.650	0.625	0.634
T.A.P., mg/mi	27.00	80.54	63.00	63.34	54.59	53.00
<u>EPA 10/92 CF</u>						
V.O.C., gm/mi	0.495	1.031	0.682	0.811	0.861	0.904
NOx, gm/mi	0.547	0.682	0.695	0.685	0.643	0.695
T.A.P., mg/mi	22.04	63.98	42.90	47.06	41.27	41.85
<u>API 1/93 CF[1]</u>						
V.O.C., gm/mi	0.956	1.762	1.149	1.364	1.395	1.359
NOx, gm/mi	1.144	1.404	1.295	1.308	1.244	1.265
T.A.P., mg/mi	45.85	101.15	99.08	97.55	84.35	78.84
<u>EPA 1/93 CF[2]</u>						
V.O.C., gm/mi	0.912	1.761	1.273	1.458	1.457	1.551
NOx, gm/mi	1.110	1.384	1.411	1.393	1.305	1.410
T.A.P., mg/mi	44.43	127.63	86.16	93.80	81.72	84.51
<u>Emissions - Phase I</u>						
<u>API 1/93 CF[1]</u>						
V.O.C., gm/mi		1.786			1.224	
NOx, gm/mi		0.691			0.613	
T.A.P., mg/mi		63.91			49.56	
<u>EPA 1/93 CF[2]</u>						
V.O.C., gm/mi		1.788			1.258	
NOx, gm/mi		0.682			0.643	
T.A.P., mg/mi		76.90			48.27	

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995–1999) and Phase II (2000+).

[2] For RFG includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 28

INCREASED COSTS OVER BASE CASES WINTER AND ANNUAL GASOLINE RESULTS SUMMARY TM&C 1995 AND 2000 CASES – CONSTANT DEMANDS NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(1990 \$)

	PADDs						U.S. Total/Average	
	I	II	III	IV	VOC	VC	w/CARB	w/o CARB
<u>Q9W⁽¹⁾/A⁽²⁾ – No FCAAA Base⁽³⁾</u>								
RFG + RFG-OG, % of Pool	0	0	0	0	0	0	0	0
<u>Q6W⁽¹⁾ – FCAAA – 2000 Full Opt-In</u>								
RFG + RFG-OG, % of Pool	100	54	63	12	0	93	65	65
Refining Δ Investment, MMM\$	-	0.9	1.6	-	-	-	6.4	3.8
Added Cost, ¢/G CG Upgraded								
Refining	-	4.4	5.1	-	-	-	7.2	5.5
Fuel Economy	-	<u>2.4</u>	<u>2.2</u>	-	-	-	<u>2.5</u>	<u>2.5</u>
Total	-	6.8	7.3	-	-	-	9.7	8.0
<u>Q6A⁽²⁾ – FCAAA 2000 – Full Opt-In⁽³⁾</u>								
RFG + RFG-OG, % of Pool	100	55	63	12	0	93	65	65
Refining Δ Investment, MMM\$	0.9	1.6	2.7	0.2	-	3.2	8.6	6.0
Added Cost, ¢/G CG Upgraded								
Refining	-	6.7	6.0	-	-	-	8.2	6.6
Fuel Economy	-	<u>2.0</u>	<u>2.1</u>	-	-	-	<u>2.3</u>	<u>2.2</u>
Total	-	8.7	8.1	-	-	-	10.5	8.8
<u>F2A⁽²⁾ – FCAAA – 1995</u>								
RFG + RFG-OG, % of Pool	100	16	11	0	0	59	N/A	27
Refining Δ Investment, MMM\$	-	-	0.8	-	-	-	-	3
Added Cost, ¢/G CG Upgraded								
Refining	-	-	0.8	-	-	-	-	4.5
Fuel Economy	-	-	<u>2.7</u>	-	-	-	-	<u>2.0</u>
Total	-	-	3.5	-	-	-	-	6.5

(1) Winter case.

(2) Annual case.

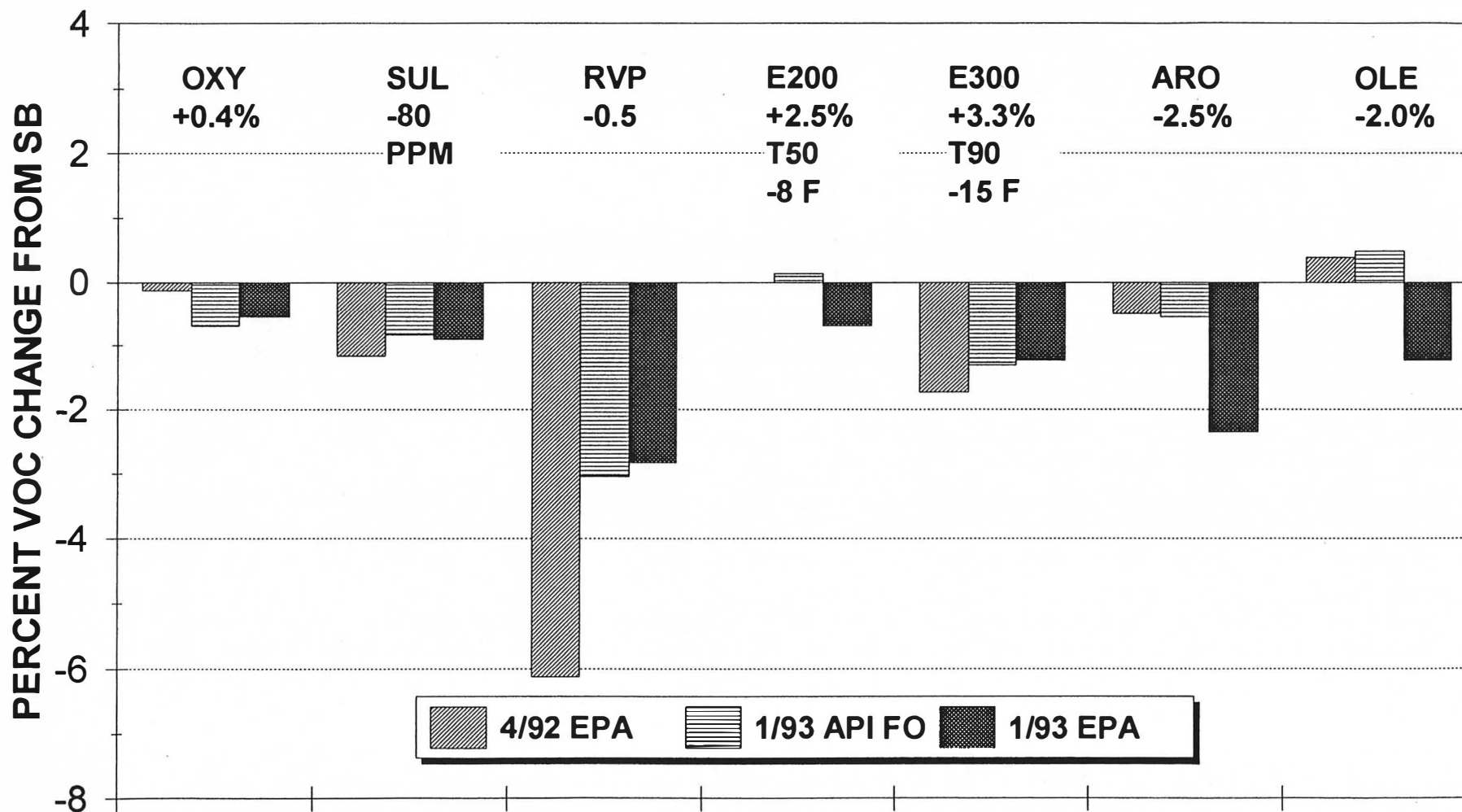
(3) Calculated by combining results of winter (49.4%) and summer (50.6%) cases. Summer results for Case Q6S are summarized on Exhibit 15.

REC – 4/27/93

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EXHIBIT 29

△ VOC IMPACTS OF GASOLINE PROPERTIES PERTURBATIONS * WITH 4/92 EPA, 1/93 API FO & 1/93 EPA PHASE II COMPLEX FORMULAS NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY



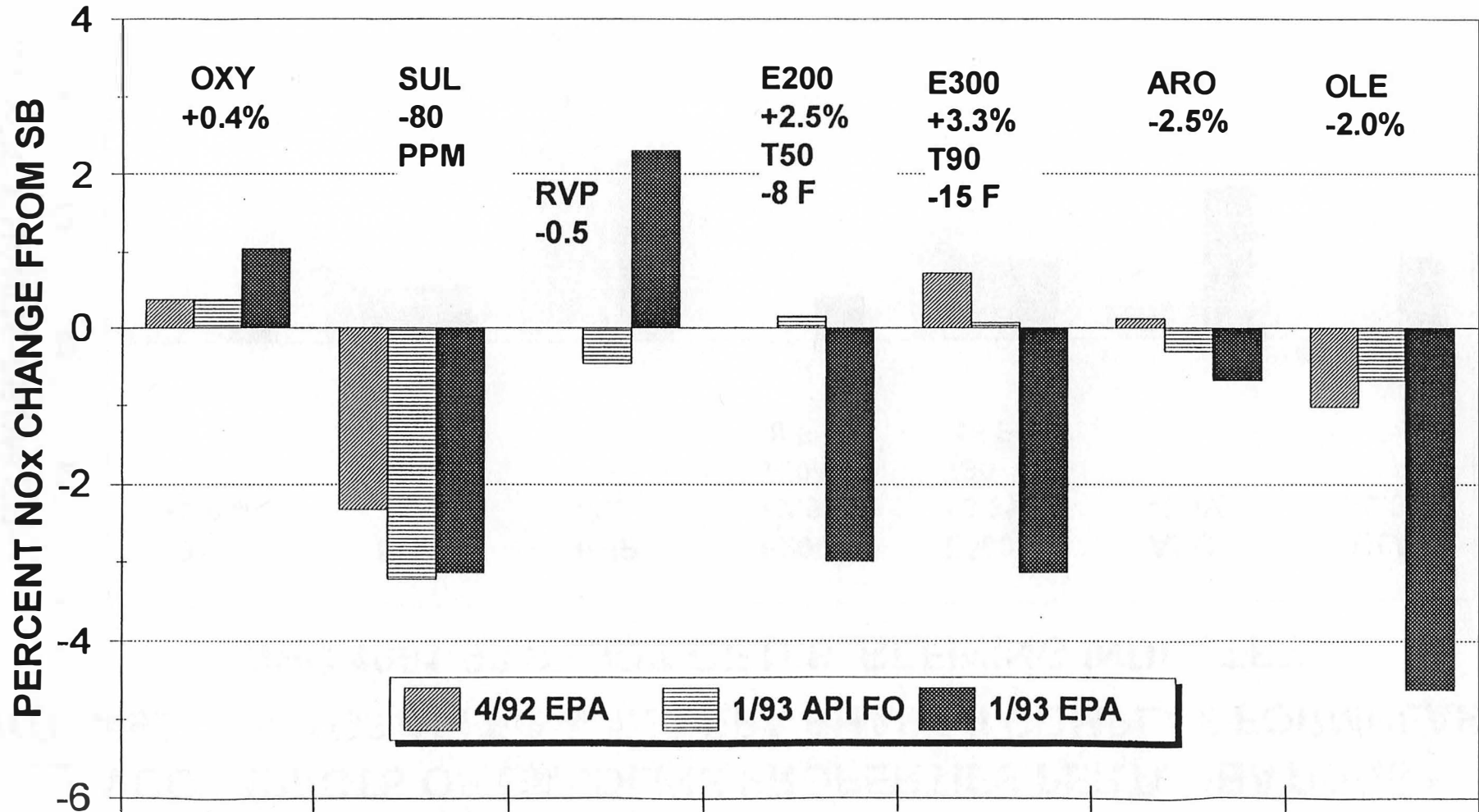
TRH/MAH 4/16/93

* FROM NPC PADD III CASE Q6

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EXHIBIT 30

△ NO_x IMPACTS OF GASOLINE PROPERTIES PERTURBATIONS * WITH 4/92 EPA, 1/93 API FO & 1/93 EPA PHASE II COMPLEX FORMULAS NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY



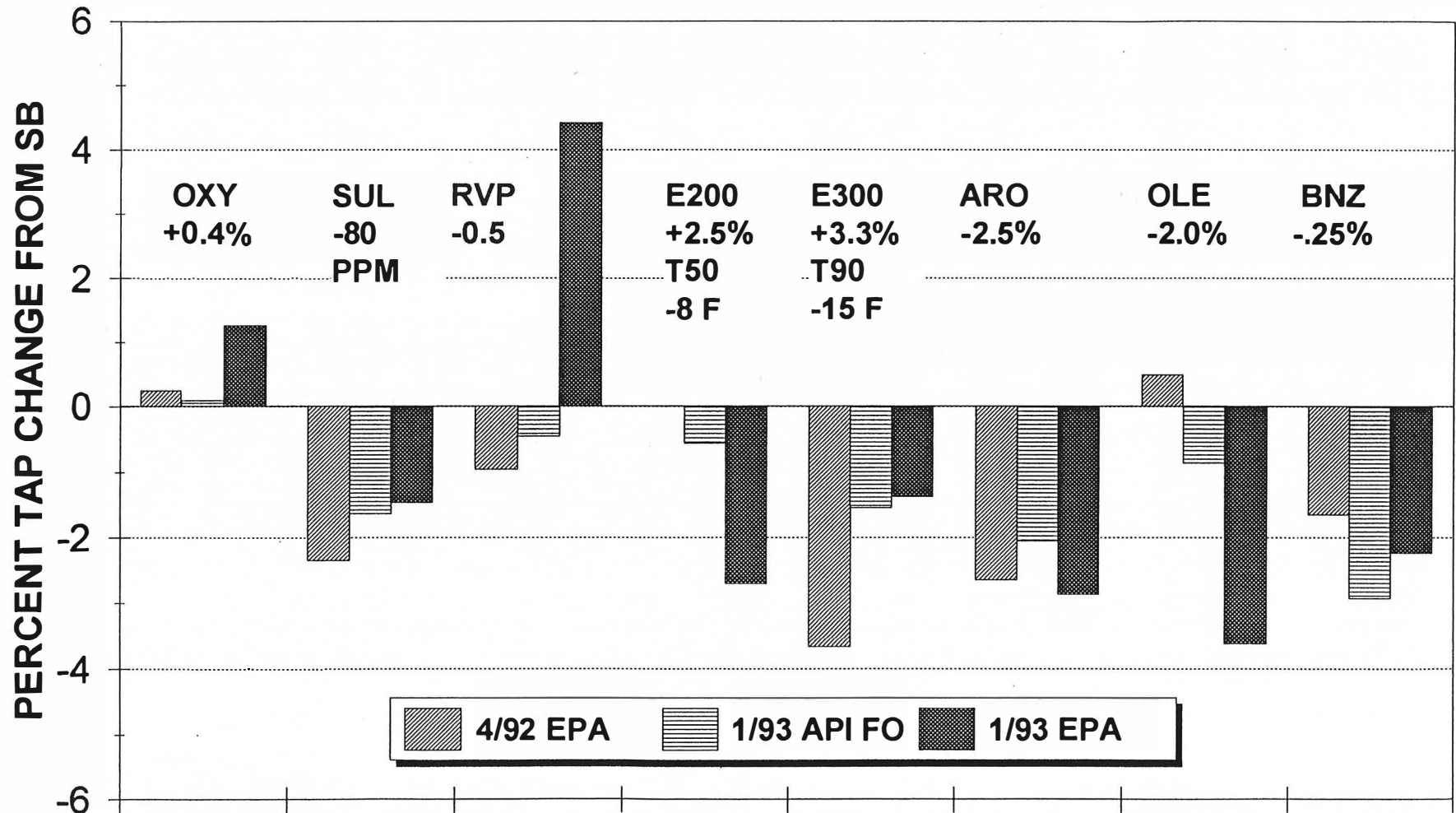
* FROM NPC PADD III CASE Q6

TRH /MAH 4/16/93

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EXHIBIT 31

△ TAP IMPACTS OF GASOLINE PROPERTIES PERTURBATIONS * WITH 4/92 EPA, 1/93 API FO & 1/93 EPA PHASE II COMPLEX FORMULAS NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY



*FROM NPC PADD III CASE QG, EXCEPT EPA RVP WAS REDUCED 0.5 FROM 7. IF IT WERE REDUCED FROM 6.5, TAP CHANGE WOULD BE 22.8%

TRH/MAH 4/16/93

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EXHIBIT 32
EMISSIONS WITH ALTERNATE COMPLEX FORMULAS
STATUTORY BASE – PHASES I & II
ALL PADDs 1995/2000 – SUMMER AND WINTER
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Phase I					Phase II						
	Summer				Winter All PADDs	Summer						Winter All PADDs
	PADD I	PADD II	PADD III	PADD IV		PADD I	PADD II	PADD III	PADD IV	PADD VCC	PADD VCOC	
Region 2, %	80	80	40	40		90	80	40	40	0	100	
Properties												
Aromatics, vol %	32.0	32.0	32.0	32.0	26.4	32.0	32.0	32.0	32.0	32.0	32.0	26.4
Oxygen, wt %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Olefins, vol %	9.2	9.2	9.2	9.2	11.9	9.2	9.2	9.2	9.2	9.2	9.2	11.9
Benzene, vol %	1.53	1.53	1.53	1.53	1.62	1.53	1.53	1.53	1.53	1.53	1.53	1.62
Sulfur, ppmw	339	339	339	339	338	339	339	339	339	339	339	338
RVP, psi	8.7	8.7	8.7	8.7	11.9	8.7	8.7	8.7	8.7	8.7	8.7	11.9
T50, deg F	218	218	218	218	199	218	218	218	218	218	218	199
T90, deg F	330	330	330	330	332	330	330	330	330	330	330	332
% Evap @ 200 deg F	41.9	41.9	41.9	41.9	50.3	41.9	41.9	41.9	41.9	41.9	41.9	50.3
% Evap @ 300 deg F	82.1	82.1	82.1	82.1	83.2	82.1	82.1	82.1	82.1	82.1	82.1	83.2
Emissions												
EPA 4/92 CF												
V.O.C., gm/mi	1.247	1.247	1.284	1.284		1.238	1.247	1.284	1.284	1.320	1.229	
NOx, gm/mi	0.660	0.660	0.660	0.660	0.670	0.660	0.660	0.660	0.660	0.660	0.660	0.670
T.A.P., mg/mi	52.29	52.29	52.65	52.65	40.11	52.20	52.29	52.65	52.65	53.01	52.11	40.11
EPA 10/92 CF												
V.O.C., gm/mi	0.808	0.808	0.846	0.846		0.799	0.808	0.846	0.846	0.883	0.789	
NOx, gm/mi	0.660	0.660	0.660	0.660	0.660	0.660	0.660	0.660	0.660	0.660	0.660	0.660
T.A.P., mg/mi	38.88	38.88	39.31	39.31	30.44	38.77	38.88	39.31	39.31	39.74	38.67	30.44
API 1/93 CF[1]												
V.O.C., gm/mi	1.234	1.234	1.274	1.274		1.416	1.423	1.448	1.448	1.472	1.410	
NOx, gm/mi	0.660	0.660	0.660	0.660	0.660	1.340	1.340	1.340	1.340	1.340	1.340	1.313
T.A.P., mg/mi	44.85	44.85	45.45	45.45	32.09	78.93	79.00	79.28	79.28	79.56	78.86	65.26
EPA 1/93 CF[2]												
V.O.C., gm/mi	1.180	1.180	1.109	1.109		1.400	1.390	1.350	1.350	1.311	1.410	
NOx, gm/mi	0.660	0.660	0.659	0.659	0.647	1.340	1.339	1.338	1.338	1.337	1.340	1.313
T.A.P., mg/mi	43.81	43.81	42.14	42.14	31.89	78.20	77.57	75.03	75.03	72.50	78.84	64.81

[1] Includes EPA 1/21/93 non-exhaust equations: Phase I (1995–1999) and Phase II (2000+).

[2] Includes SB RVP adjustment from 8.7 to 7.8 psi for Region 1.

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EXHIBIT 33
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
CONVENTIONAL GASOLINE - PHASE II
Q9 2000 CASE - F2 CONSTANT DEMANDS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer				Winter	
	PADD I	PADD II	PADD III	PADD IV	PADD II	PADD III
	Base	Base	Base	Base	Q9W	Q9W
	Case	Case	Case	Case	2000	2000
	Q9	Q9	Q9	Q9	Base	Base
RFG, % of Pool	0	0	0	0	0	0
Region 2, %	80	80	40	40	80	40
<u>Properties</u>						
Aromatics, vol %	31.2	31.8	30.9	28.0	27.3	27.6
Oxygen, wt %	0.4	0.4	0.4	0.4	0.4	0.4
Olefins, vol %	15.9	12.3	13.6	14.6	11.0	12.4
Benzene, vol %	1.8	2.1	1.8	1.9	1.9	1.6
Sulfur, ppmw	341	312	206	287	256	186
RVP, psi	8.2	8.4	7.9	7.9	12.5	11.9
T50, deg F	212	210	211	206	198	200
T90, deg F	354	345	347	344	339	339
% Evap @ 200 deg F	46.1	46.4	46.6	48.0	50.7	50.6
% Evap @ 300 deg F	80.1	80.9	81.1	81.6	83.0	82.7
<u>Emissions Reduction From Statutory Base</u>						
<u>EPA 4/92 CF</u>						
V.O.C., %	8.7	6.2	19.0	19.0		
NOx, %	(3.0)	0.0	2.0	(1.0)	3.0	4.3
T.A.P., %	(3.4)	(9.0)	5.0	6.9	(3.8)	1.9
<u>EPA 10/92 CF</u>						
V.O.C., %	(0.7)	1.2	9.3	12.1		
NOx, %	(20.8)	(7.7)	(9.1)	(8.5)	(1.4)	(1.5)
T.A.P., %	2.7	(4.5)	8.3	9.3	(4.4)	4.3
<u>API 1/93 CF[1]</u>						
V.O.C., %	7.6	5.1	13.3	13.5		
NOx, %	(2.5)	(0.2)	4.5	0.9	2.6	5.7
T.A.P., %	(6.2)	(10.5)	2.2	1.6	(2.5)	3.6
<u>EPA 1/93 CF [2]</u>						
V.O.C., %	(4.6)	(2.9)	(2.0)	1.8		
NOx, %	(20.8)	(7.6)	(9.5)	(8.7)	(1.2)	(1.6)
T.A.P., %	1.6	(5.4)	2.4	4.2	(3.8)	2.7

* Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995-1999) and Phase II (2000+).

[2] From SB adjusted to 7.8 RVP for Region 1.

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EXHIBIT 33 (CONTINUED)
EMISSIONS REDUCTION RESULTS WITH ALTERNATE COMPLEX FORMULAS
CONVENTIONAL GASOLINE – PHASE II
Q9 2000 CASE – F2 CONSTANT DEMANDS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Summer				Winter	
	PADD I	PADD II	PADD III	PADD IV	PADD II	PADD III
	Base	Base	Base	Base	Q9W	Q9W
	Case	Case	Case	Case	2000	2000
	Q9	Q9	Q9	Q9	Base	Base
Emissions						
<u>EPA 4/92 CF</u>						
V.O.C., gm/mi	1.130	1.170	1.040	1.040		
NOx, gm/mi	0.680	0.660	0.647	0.667	0.650	0.641
T.A.P., mg/mi	54.00	57.00	50.00	49.00	41.64	39.33
<u>EPA 10/92 CF</u>						
V.O.C., gm/mi	0.804	0.798	0.767	0.744		
NOx, gm/mi	0.797	0.711	0.720	0.716	0.669	0.670
T.A.P., mg/mi	37.75	40.64	36.05	35.64	31.78	29.14
<u>API 1/93 CF[1]</u>						
V.O.C., gm/mi	1.309	1.350	1.255	1.252		
NOx, gm/mi	1.373	1.343	1.280	1.328	1.279	1.238
T.A.P., mg/mi	83.85	87.26	77.54	77.99	66.86	62.89
<u>EPA 1/93 CF[2]</u>						
V.O.C., gm/mi	1.464	1.431	1.378	1.326		
NOx, gm/mi	1.618	1.441	1.465	1.455	1.329	1.334
T.A.P., mg/mi	76.93	81.77	73.23	71.91	67.25	63.09

*Outside range of 10/1/92 and subsequent EPA equations.

[1] Includes EPA 1/21/93 non-exhaust equations. Phase I (1995–1999) and Phase II (2000+).

[2] From SB adjusted to 7.8 RVP for Region 1.

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TABLE A-O

DEFINITION OF ABBREVIATIONS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 7

1) Names - Associations, Agencies, Groups, Locations and Companies

API	American Petroleum Institute
A/O or Auto/Oil	Joint automobile and oil industry "Air Quality Improvement Research Program"
CARB	California Air Resources Board
CO-Nonattainment	Regions of the U.S. which do not attain EPA air quality standards for carbon monoxide
9 Cities	Nine specific high ozone cities in which Federal Clean Air Act Amendments require use of reformulated gasoline
Full Opt-in	All ozone non-attainment areas, which may use RFG - 65% of U.S. gasoline consumption
DOE	Department of Energy
EIA	Energy Information Administration (of DOE)
EPA	Environmental Protection Agency
FCAAA or CAAA	Federal Clean Air Act Amendments
GM	General Motors
NIPER	National Institute for Petroleum and Energy Research (in Bartlesville, OK)
NPC	National Petroleum Council
FTG	Facilities Task Group
PQTG	Product Quality Task Group
SDLTG or SDL	Supply, Demand and Logistics Task Group
STG	Survey Task Group
TMCWG	Turner, Mason & Company work group
NPRA	National Petroleum Refiner's Association
PADD	Petroleum Administration for Defense District
TM&C	Turner, Mason & Company
U.K.	United Kingdom
U.S.	United States
WSPA	Western States Petroleum Association

2) Names and Types of Crudes

ANS	Alaskan North Slope
HH	Crude type with sulfur > 0.5% and 1050 °F + > 15%

TABLE A-O

DEFINITION OF ABBREVIATIONS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 7

2) Names and Types of Crudes (Continued)

HL	Crude type with sulfur > 0.5% and 1050 °F + < 15%
S or Sweet	Crude type with sulfur ≤ 0.5% and 1050+ ≤ 15%
WTI	West Texas Intermediate
WTS	West Texas Sour

3) Types of Finished Gasolines

Class B	ASTM volatility class - southern grade in summer
Class C	ASTM volatility class - northern grade in summer
GT	Gasoline type
Gaso or Mogas	Gasoline
Midgrade	Mid-octane grade unleaded gasoline
Premium	Premium octane grade unleaded gasoline
Regular	Regular octane grade unleaded gasoline
CG	Conventional gasoline
OG	Oxygenated gasoline
RFG	Reformulated gasoline
RFG I	RFG meeting Phase I regulations in 1995-1999
RFG II	RFG meeting Phase II regulations in 2000+
RFG-E	Reformulated gasoline with ethanol
RFG-M	Reformulated gasoline with MTBE
RFG-OG	Reformulated and oxygenated gasoline
CARB 2	CARB phase 2 gasoline regulations to be implemented in 1996
RBOB-E	Subgrade RFG-E prior to blending with ethanol
RBOB-M	Subgrade RFG-M prior to blending with MTBE
RVP II	EPA's phase II gasoline RVP regulations
Region 1	EPA more stringent summer RVP specifications must be met – southern grade Class B summer
Region 2	EPA less stringent summer RVP specifications allowed – northern grade Class C summer
CF	Complex Formula Regulations
SF	Simple Formula Regulations

TABLE A-O

DEFINITION OF ABBREVIATIONS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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4) Other Products

Alt. Fuels	Alternate fuels - substitutes for gasoline
C. Black	Carbon black
C ₂	Ethane
C ₂ =	Ethene
C ₃ S	Propane and propene
LPG	Liquefied petroleum gases
C ₄ S	Butanes and butenes
NC ₄	Normal butane
IC ₄	Isobutane
C ₅ S	Pentanes and pentenes
C ₆ S	Hexanes and hexenes
NGL	Natural gas liquids
LSR	Light straight run (gasoline)
Misc/HSR	Special, miscellaneous and heavy straight run naphthas
Major products	Gasolines, jet fuel, distillate fuels and No. 6 fuels
Major light products	Gasolines, jet fuel and distillate fuels
Minor products	All non-major refinery products
EtOH or E	Ethanol
MTBE	Methyl-tertiary-butyl-ether
ETBE	Ethyl-tertiary-butyl-ether
TAME	Methyl-tertiary-amyl-ether
P/C or P/Chem	Petrochemical
Kero Jet or K Jet or Jet A	Kerosene type jet fuel
ULSD or LSD	Ultra low sulfur (0.05%) diesel
ULSLAD	Ultra low sulfur (0.05%) low aromatic diesel
LAD	Low aromatic (7%) diesel

5) Names and types of Process Units

Alky	Alkylation
ARDS	Atmospheric residuum desulfurization unit
CCR	Continuous catalyst-regeneration (reforming unit)
FCC	Fluid catalytic cracker

TABLE A-O

DEFINITION OF ABBREVIATIONS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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5) Names and types of Process Units (Continued)

HDA	Hydrodealkylation
HDS	Hydrodesulfurization
Poly	Polymerization
TIP Pen-Hex Isom	Total isomerization process for pentane and hexane (recycle)

6) Model Names

C or Conv	Conversion
IC or I	Conversion refineries in PADD I (East Coast)
IIC or II	Conversion refineries in PADD II (mid-continent)
IIIC or III	Conversion refineries in PADD III (Gulf Coast)
IV	All refineries in PADD IV (Rocky Mountains)
VCC or VC	Conversion refineries in California
VCOC	Conversion refineries outside California in PADD V (West Coast)
IS	Simple (non-conversion) refineries in PADD I
IIS	Simple refineries in PADD II
IIIS	Simple refineries in PADD III
VS	Simple refineries in PADD V
LP	Linear program

7) Gasoline Properties

A or AR	Aromatics (vol. %)
BZ or B	Benzene (vol. %)
OL	Olefins (vol. %)
OX or O	Oxygen (wt. %)
(R+M)/2	Average of research and motor octanes
RONC	Research octane number clear
RVP	Reid vapor pressure
S or SUL	Sulfur (wt. %)
SG	Specific gravity
T or T90	Temperature at 90% distilled (°F)
T10 or T50	Temperature at 10% or 50% distilled (°F)
E200	% evaporated at 200°F using D-86 distillation
E300	% evaporated at 300°F using D-86 distillation

TABLE A-O

DEFINITION OF ABBREVIATIONS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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7) Gasoline Properties (Continued)

V/L @ 20	Temperature for vapor: liquid ratio of 20
CF model	Complex formulas for V.O.C., T.A.P. and NO _x
NOX or NO _x	Nitrogen oxides
V.O.C. or VOC	Volatile organic compounds
T.A.P. or TAP	Toxic air pollutants
Δ V.O.C.	Decrease in V.O.C. from SB as % of SB V.O.C.
Δ T.A.P.	Decrease in T.A.P. from SB at % of SB T.A.P.
Δ NO _x	Decrease in NO _x from SB at % of SB NO _x
SB	1990 statutory base in FCAAA
SBA	1990 statutory base adjusted to lower EPA Phase II RVP requirement of 7.8 for Class B areas

8) Units

\$/B	Dollars per barrel
¢/G	Cents per gallon
% S	Weight percent sulfur
#	Pound
400# B	400-pound barrel of coke (5 barrels/ton)
B	Barrels
BPD	Barrels per day
BPCD	Barrels per calendar day
BPSD	Barrels per stream day
BTU	British thermal unit
° or Deg	Degrees
°API	Degrees API gravity
°F	Degrees Fahrenheit
FOE	Fuel oil equivalent
FOE B	Fuel oil equivalent barrels
G or Gal	Gallons
Gm	Grams
KWH	Kilowatt hours
LTPD	Long tons per day
M	Thousand

TABLE A-O

DEFINITION OF ABBREVIATIONS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 6 of 7

8) Units (Continued)

MM	Million
MMM	Billion
MMGPY	Million gallons per year
MMSCFPD	Million standard cubic feet per day
ppm	Parts per million
PSI	Pounds per square inch
SCF	Standard cubic feet
SSF	Saybolt seconds furol (viscosity)
V % or Vol. %	Volume percent
W % or Wt. %	Weight percent

9) Other

/	<u>Per</u> (as in \$/B is dollars per barrel); <u>And</u> (as in asphalt/road oil is asphalt and road oil); <u>Or</u> (as in (gain)/loss is (gain) or loss)
<	Less than
>	Greater than
¥	To differential Q9 annual cases from Q9 summer cases
Ann or A	Annual
Avg	Average
BAU	Business as usual
Ex	Excluding
F1	NPC increasing demand foundation cases for the years 2000, 2010
F2	NPC constant demand foundation cases for the years 1995, 2000, 2010
F3	NPC decreasing demand foundation cases for the years 2000, 2010
GDP	Gross domestic product
Hvy	Heavy
Lt	Light
H	High
L	Low

TABLE A-O
DEFINITION OF ABBREVIATIONS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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9) Other (Continued)

VH	Very High
VL	Very low
Incl	Including
Incrmt	Increment
DCF	Discounted cash flow
IRR	Internal rate of return
ROI	Return on investment
Max	Maximum
Min	Minimum
RM	Rule-making (regulations)
NPRM	Notice of Proposed Rule-making
SNPRM	Supplemental Notice of Proposed Rule-making
PSA	<i>Petroleum Supply Annual</i>
S&D	Supply and demand
S or Sum or Summer	Second and third calendar quarters
W or Win or Winter	First and fourth calendar quarters
Unf	Unfinished
VLS	Very low sulfur
W/	With
W/o	Without

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TABLE A-1

INVESTMENT ASSUMPTIONS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

- The investments for facilities under construction, as derived in Table A-7, are sunk investments. Allow the LP models to add economic capacity as required, based on units sized to provide one unit for each refinery in the model group in the summer. Use fixed cost factors shown in Table A-6.
- Optimize investments using 15% risk-free hurdle rate for return on investments (ROI) in LP model runs. Low RVP complex formula runs based on multiplier of 2, or 48.4% capital charge for summer only facilities, and multipliers of 1.5, or 36.3% capital charge, to payout extra capacity in summer facilities that are not used in the winter due to its higher RVP. Adjust off-line to 10% actual annual internal rate of return (IRR) in calculating final costs.
- Investment costs for most refining processes determined by the NPC Facilities Task Group (FTG) are listed in Table A3-1. These mid-1991 USGC costs will be adjusted to mid-1990 \$, using the gross domestic product deflator calculated by NPC Supply, Demand and Logistics Task Group (SDLTG) and to other locations using the NPC FTG location factors shown in Table A-6.
- Allow existing units to be expanded by up to 20% of capacity based on the same percent of its replacement cost. For example, a 6 MBPSD alky unit could be expanded by 1.2 MBPSD for 20% of its replacement cost. This capacity would be much less costly than a small 1.2 MBPSD new unit. This approach keeps costs of new capacity more realistic.
- No capacity creep is assumed because most existing units have already been expanded to take advantage of low-cost debottlenecking. An offsetting assumption is that no allowance is made for probable unannounced future shutdowns.
- Minimum practical unit size for new process facilities is 2 MBPSD. The only exceptions are for new ether units and for downstream units in PADD IV, where unit sizes are allowed to drop to 0.5 MBPSD.
- Optional new facilities available to control gasoline properties are listed on Table A-4. Benzene recovery is not allowed in California due to environmental and permitting restrictions. Benzene saturation required in refineries without existing aromatics extraction units.
- Diesel sulfur is reduced to 0.05% weight by deep desulfurization in distillate HDS units. Diesel aromatics are reduced in high-pressure distillate aromatics saturation units, feeding desulfurized distillate.

TABLE A-2
ALLOCATION APPROACH AND FLEXIBILITY
BASE CASE 1995/2000/2010 LP MODEL RUNS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 3

- Start with: 1) 1989 and 1990 actual DOE detail U.S. refinery supply and demands that have been sorted into specific refinery model groupings by DOE at our request, and 2) the NPC Supply, Demand and Logistics Task Group's (SDLTG) three premised U.S. consumer supply and demand scenarios (foundation cases F1 increasing, F2 constant and F3 decreasing) for 1995, 2000 and 2010. Assume finished product imports are relatively constant at close to 1989 level to develop three significantly different refining supply and demand scenarios, as summarized on Table A-15. These three refining supply and demand scenarios can be used with interpolation, along with the final economic product import levels determined by NPC SDLTG to meet the three foundation cases consumer demand scenarios.
- Adjust product import rates for natural gas liquids to petrochemical feeds and oxygenates as required. Make changes in minor product import and export rates as required to maintain 1995 and 2000 refinery production constant in F2 scenario and minimize refinery minor product output changes in 2010 in F1 and F3 scenarios.
- The NPC SDLTG assumed all changes from 1989 rates in U.S. consumer demands for major products can be fully ratioed by population across all geographic areas. They plan to break down U.S. consumer demand into thirteen U.S. demand regions and into more products. We will develop even more detailed supply and demand forecasts for minor products and minor raw materials. We will ratio the U.S. refinery input and production scenario changes from 1989 to each PADD (using uniform ratios across all PADDs). Fairly constant finished product imports will cause some change in inter-PADD product transfers, but these transfer rates will also be held fairly constant for the F2 constant demand scenarios. We will further allocate refinery input and production to the specific model groupings within the PADDs, based on 1989 actual allocation data and calculated changes in simple refineries' product outputs.
- These actual DOE, premised NPC SDLTG and assumed TM&C consumer and refining demands are all derived from refineries, imports and exports. They do not include about 60 MBPCD of ethanol and resultant increased gasoline supply and

TABLE A-2
ALLOCATION APPROACH AND FLEXIBILITY
BASE CASE 1995/2000/2010 LP MODEL RUNS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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demand that is blended at terminals. NPC PQTG premises that this ethanol will continue to be blended (primarily into conventional gasoline) at terminals but will shift to more winter use. If ethanol use shifts some from historic PADD (primarily PADD II) use rates, inter-PADD transfer rates will shift to compensate for these changes.

- Meet these NPC and TM&C premised U.S., PADD and model refinery production rates for finished major light products (motor gasolines, kero jet and diesel/No. 2 fuel). Adjust refinery production rates between models as required for optimized residual fuel and variable minor product rates.
- The three foundation scenarios assume fairly constant 1989 actual crude qualities and types. NPC assumed constant domestic crude production for simplicity. Real declines in domestic production of crudes would need to be replaced by increased imports of the same types of crudes. Sensitivity cases will be used to explore probable heavier-higher-sulfur crude slates. Allocate the 1989 DOE domestic and foreign crude runs by type (sweet, light medium sulfur, heavy medium sulfur, light high sulfur and heavy high sulfur) to PADD and specific model group crude runs. Use the TM&C crude assay library and the 1989 detailed crude run type, property and import data by model groups supplied by DOE to develop this detailed crude run allocation. Reduce and increase total base 1989 crudes rates by types using about the same crude type ratios for the high and low demand scenarios (F1 and F3), respectively. Shift primarily imported swing crudes by types to attain latter objective of approximately constant total crude qualities (within 0.5°API and 0.1 weight % sulfur).
- Optimize crude rate and composition of limited swing crudes: Arabian (light, medium and heavy), Nigerian medium and U.K. Brent in models IC, IIC and IIIC; Canadian and Wyoming in models IIC and IV; and ANS, California Elk Hills and Arabian in models VCC, VCOC, IIIC and IIC. The incremental Arabian crudes are representative of other potential Middle East crude imports. The incremental Nigerian medium and Brent are representative of other potential sweet crude

TABLE A-2

ALLOCATION APPROACH AND FLEXIBILITY

BASE CASE 1995/2000/2010 LP MODEL RUNS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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imports. Allow adequate imported crude shifts to minimize the increase in surplus coker capacity in low demand scenario.

- Optimize marketable coke, catalytic coke, 1% sulfur and bunker residual fuel, toluene hydrodealkylation, MTBE, light petrochemical feed naphtha, C₅s, C₄s, C₃s, process gas and sulfur product rates in model runs.
- Optimize input rates for MTBE, methanol, IC₄, NC₄ and natural gas feed to hydrogen plants in model runs.
- Use the NPC SDLTG 1989 annual product pricing for all future time periods and regions (Platt's 1989 low spot actuals from 1989 and 1990 *Platt's Oil Price Handbook* and *Oilmanac*). Use TM&C developed annual crude and other raw material and product pricing, as well as summer and winter crude and product pricing from Platt's 1989 low spot actuals. Adjust 1989 pricing to mid-1990 using NPC SDLTG provided GDP inflator. Increase 1989 MTBE price by 10¢/G in 1995 and 2000, due to anticipated shortfall and high long-term contract prices. Provide TM&C pricing estimates for new products with improved properties to provide reasonable model run results (to avoid dumping unwanted components at zero value).
- Use seasonally weighted annual average pricing for highly seasonal products. These include gasoline types and asphalt.
- Use base 1995 unit capacities, as defined in Tables A-7 and A-8, in each model. Allow models to add economic capacity.

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TABLE A-3

PRODUCT GRADE RATIOS AND PROPERTIES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

- Use June 1991 API research study #058, *Meeting the Oxygenate Requirements of the 1990 Clean Air Act Amendments*, to develop consumer gasoline splits by types. Increase consumer RFG and OG by 10% for spillover, as directed by NPC PQTG. Adjust NPC SDLTG population-based consumer demand to fit actual consumer demands by PADDs in the 1989 DOE PSA. Use these PADD consumer demands and normal PADD imports, PADD exports and inter-PADD transfer rates to develop PADD refinery gasoline supply by types. (See Tables A-26 through A-32)
- Calculate all initial gasoline demands by types based on equivalent CG. Estimate incremental gasoline demand to maintain constant total vehicle miles traveled with lower BTU content, lower specific gravity (S.G.), higher oxygen content RFG and OG based on S.G./oxygen/mileage relationship developed in Auto/Oil. This relationship indicates that mileage change approximately equals BTU content change. (See Tables A-18 through A-21)
- Use NPC SDLTG premises for gasoline grade ratios. Split midgrade into regular and premium based on its octane to keep total number of gasoline grades more manageable in LP model with multiple types (CG, RFG, OG, RFG-OG). Use NPC PQTG premises for properties limits and NPRA survey octanes for refinery production. Model gasoline properties have already been calibrated in prior studies. Use estimated DOE complex model, or similar, equations for V.O.C., T.A.P., and NO_x for RFG and CG limits for 2000 and 2010 after public release, as directed by NPC PQTG.
- Use actual 1989 NPRA survey data published as part of Auto/Oil research project for most 1990 summer individual base gasoline properties (Table A-23). Use statutory industry base summer gasoline properties in FCAAA (including RVP of 8.7 psi) in determining summer RFG limits with complex formulas.
- Assume NPC SDLTG consumer demand for on-highway 0.05% sulfur No. 2 diesel and 0.25% sulfur No. 2 fuel plus off-highway diesel. Shift consumer demands using NPC PQTG on-highway diesel spillover of 50%. Calculate refining supply and demand based on normal inter-PADD supply rates. Assume simple refineries production, imports, exports and inventory swings are all 0.25% sulfur No. 2 fuel. Assume base 1990 level as aromatics limits (no increase in high aromatic

TABLE A-3
PRODUCT GRADE RATIOS AND PROPERTIES
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

components) on No. 2 diesels and No. 2 fuel. Use 10% aromatics limit for California on-highway diesel. (See Tables A-33 through A-35)

- Use NPC SDLTG premises for total consumer residual fuel. Use TM&C sulfur grade estimates for consumer demands and refining productions. Allow model runs to optimize 1% sulfur and bunker outputs for refinery grades. Vary import grades to close balance with future NPC SDLTG consumer demands by grades.
- Limit total U.S. aromatics production to premise levels. Allow increased refinery benzene production to displace refinery toluene production and shut down all non-refinery toluene HDA capacity.

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5/20/92

TABLE A-4

TM&C MODEL PROCESSING OPTIONS

FOR REDUCTIONS IN GASOLINE PROPERTIES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 3

Benzene

- Reformer feed to prefractionator to concentrate benzene precursors feed into separate reformer and reduce reformat splitting required
- Reformate to fractionator columns
 - Light reformate (C_5 -210°F) to benzene extraction and benzene to distillation and sales
 - Light reformate (C_5 -210°F) to benzene saturation unit or isomerization
- Use existing toluene and xylene extraction capacity for benzene extraction
- Light straight run (C_5 -150°F) to naphtha HDS, distillation and isomerization
- Light coker gasoline (C_5 -180°F) to naphtha HDS, distillation and isomerization
- Light hydrocrackate (C_5 -175°F) to benzene saturation
- Bypass reformer - benzene precursors
 - Increase cut point on light straight run gasoline to gasoline blending or isomerization
 - Increase cut point on light hydrocrackate to gasoline blending

Olefins

- FCC gasoline to multiple splitter columns
 - FCC C_5 olefins (C_5 -100°F) to TAME and/or alkylation
 - FCC C_6 olefins (100-180°F) to naphtha HDS, distillation and isomerization
 - Medium FCC gasoline (180-225°F) to naphtha HDS and cat reforming
 - Heartcut FCC gasoline (225-300°F) to naphtha HDS and cat reforming
 - Heavy-heavy FCC gasoline (375-430°F) to distillate HDS unit and distillate blending
 - Heavy-heavy FCC gasoline (375-430°F) to resid cutter and/or sales
 - Heavy and heavy-heavy FCC gasoline (300-430°F) to new gasoline hydrocracker to 300°F- or to C_4 s
- Reduce FCC octane catalyst, conversion level and feed rate
- Increase FCC feed (heavy gas oil) hydrotreating
- Reduce FCC resid cracking
- Shut down polymer and dimersol units and send C_3/C_4 olefins to alkylation
- Light coker gasoline (C_5 -180°F) to naphtha HDS, distillation and isomerization
- Light coker gasoline (C_5 -180°F) to extractive Merox desulfurizer (DS), splitter; C_5 olefins to TAME, alky; C_6 olefins to HDS, distillation and isomerization

TABLE A-4
TM&C MODEL PROCESSING OPTIONS
FOR REDUCTIONS IN GASOLINE PROPERTIES
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 3

Sulfur

- Same as olefin controls, except no shutdown of polymer and dimersol units
- High sulfur FCC feed to heavy gas oil HDS unit or to severe HDS (VLS product)
- High sulfur atmospheric resid to ARDS unit and FCC feed
- Medium BT naphtha to naphtha HDS and distillation
- Light straight run gasoline to naphtha HDS and distillation

Aromatics

- Reduce reformer severity
- Reformate to fractionator columns
 - Heavy reformate (300°F+) to resid cutter and/or sales
 - Heavy reformate (300°F+) to new gasoline hydrocracker to 300°F- or to C₄s
 - Heavy reformate (300°F+) to distillate blending
- FCC gasoline fractionation into heavy and light FCC gasoline; FCC heavy gasoline to splitter columns, light FCC gasoline to blending
 - Heavy-heavy FCC gasoline (375-430°F) to resid cutter and/or sales
 - Heavy and heavy-heavy FCC gasoline (300-430°F) to new gasoline hydrocracker to 300°F- or to C₄s
 - Heavy and heavy-heavy FCC gasoline (300-430°F) to distillate HDS and distillate blending
- Heavy naphtha to splitter column
 - Heavy-heavy naphtha (300-375°F) to distillate HDS and kero jet blending
 - Heavy-heavy naphtha (300-375°F) to new gasoline hydrocracker to 300°F- or to C₄s
- Reduce heavy hydrocrackate cut point to 300°F
 - Hydrocrack heavy hydrocrackate to 300°F- on gasoline operation
 - Switch to maximum jet operation
- Bypass reformer - higher cut point on light gasolines, lower cut point on kerosene
 - Medium (BT) naphtha (150-220°F) to gasoline blending
 - Medium hydrocrackate (175-225°F) to gasoline blending
 - Heavy-heavy naphtha (300-375°F) to distillate HDS and kero jet blending
 - Heavy-heavy naphtha (300-375°F) to new gasoline hydrocracker to 300°F- or to C₄s

TABLE A-4
TM&C MODEL PROCESSING OPTIONS
FOR REDUCTIONS IN GASOLINE PROPERTIES
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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Aromatics (Continued)

- Heavy coker naphtha to splitter column
 - Heavy-heavy coker naphtha (300-375°F) to distillate HDS and distillate blending
 - Heavy-heavy coker naphtha (300-375°F) to new gasoline hydrocracker to 300°F- or to C₄s

90% Distilled

- Same as aromatics reduction options except no reformer severity reduction, no medium naphtha or medium hydrocrackate to gasoline blending
- Alkylate fractionation
 - Heavy alkylate (300°F+) to kero jet blending
 - Heavy alkylate (300°F+) to distillate blending
 - Heavy alkylate (300°F+) to new gasoline hydrocracker to 300°F- or to C₄s

RVP

- Add gasoline debutanizer columns to better separate C₄s from C₅+
- Fractionate FCC gasoline into light and heavy FCC gasolines; blend heavy FCC gasoline and route light FCC gasoline to splitter columns
 - FCC C₅s olefins to TAME and/or alky
 - FCC pentanes sales for petrochemical feed
 - FCC C₆+ to gasoline blending
- Light coker gasoline to extractive Merox desulfurization, then to splitter; C₅ olefins to TAME and/or alky; C₆+ to gasoline blending
- Fractionate light hydrocrackate; sell pentanes for petrochemical feed; blend C₆+ to gasoline

REC/GWM
9/2/92

TURNER, MASON & COMPANY
Consulting Engineers

TABLE A-5
ASSUMED PETROCHEMICAL OXYGENATES INVESTMENT COSTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1991 \$)

	<u>Methanol</u>	<u>Field Butane Isomerization</u>	<u>Isobutane Dehydrogenation</u>	<u>MTBE</u>	<u>Combined MTBE Complex</u>
<u>Middle East</u> Standard Size	300 MMGPY (21.7 MBPSD) (2,750 TPSD) ⁽¹⁾	12.1 MBPSD	11.9 MBPSD	12.5 MBPSD	12.5 MBPSD
<u>TM&C Estimates - Used</u>					
Unit Investment, MM\$ ⁽²⁾	395	50	205	35	370 ⁽³⁾
Unit Cost, MM\$/MBPCD	20.2	4.1	17.5	2.9	32.3
<u>Other Estimates (For Comparison)</u>					
Unit Investment, MM\$ ⁽⁴⁾	375-400	45-55	195-215	35-40	350-390 ⁽²⁾

⁽¹⁾ Metric tons per stream day.

⁽²⁾ Includes 60% off-sites.

⁽³⁾ Includes one-fifth of a standard size methanol plant, or \$80 million.

⁽⁴⁾ Includes offsites.

REC/MAH
4/17/92

TABLE A-6
TM&C FIXED COSTS FACTORS
FOR ADDED PROCESS FACILITIES
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>% of Investment</u>	
	<u>Annual Cost</u>	<u>Initial</u>
<u>Initial Cost</u>		
Investment - Gulf Coast	-	100 ⁽¹⁾
Investment - Other Locations		
East Coast - PADD I	-	120
Midwest - PADD II	-	120
Rocky Mountain - PADD IV	-	120
California - Model VCC ⁽²⁾	-	140
Other West Coast - Model VCOC	-	120
Engineering and Start-Up	-	10
<u>Operating Costs</u>		
Capital Charge ⁽³⁾⁽⁴⁾	17.2	-
Maintenance - On-Site	4.0	-
- Off-Site	2.0	-
Taxes and Insurance	1.5	-
Miscellaneous Fixed Costs	0.6	-
Operator Wages Average <u>\$15.96/hour</u> ⁽¹⁾		
Salaries and Wages of All Other Refinery Personnel ⁽⁵⁾		
is <u>155%</u> of Process Operators' Wages		
Benefits @ <u>39%</u> of Salaries and Wages		

(1) Based on mid-1990 constant dollars.

(2) Includes extra 20% for environmental, permitting and other costs.

(3) Based on a constant dollar 10% after-tax rate of return on investment (ROI) with a fifteen-year project life, ten-year tax life, double declining balance tax depreciation (10% in first year), 39% income tax rate (including 5% state) and two-year construction time. [Model investment decisions use a capital charge factor of 24.2%, based on 15% DCF annual risk-free hurdle ROI.]

(4) Capital charge multipliers of 2 used to payout summer only facilities (used six months) and of 1.5 used to payout high summer capacity (low winter capacity) facilities. (See Tables A3-18 and A3-19 for detailed discussion and list of process units associated with each multiplier.)

(5) All refinery personnel except process operators and maintenance. Includes off-site operators, supervisory, administrative, technical, laboratory and clerical. This 155% of added process operators' wages for added facilities in existing refineries is two-thirds of average total refinery factor of 233%.

REC/GWM - 4/21/93

TABLE A-7
REFINERY PROCESS CAPACITIES BASIS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

- Start with all operable refineries as of January 1, 1991 reported by DOE in the 1990 PSA.
- Exclude refineries that reported no inputs to DOE in 1990. Delete refineries and partial refineries that have announced pending shutdowns. Deletion of some downstream equipment when indicated by announcement.
- Add refineries that have announced restarts and have actively begun the restart process.
- Add process unit capacity that is under construction and scheduled for completion before 1/1/95 or completed since 1/1/91 according to *Hydrocarbon Processing* and *Oil & Gas Journal*. Include units at partially operating refineries. Do not include in refinery count if crude unit is idle (except for Hess at Pt. Reading and Valero at Corpus Christi).
- Add some 1/1/90 unit capacities indicated in NPRA survey for Auto/Oil not shown by published data. These are the bases for Tables A-8, -9, -10 and -11 and the base capacities for our LP cases.
- Add to premised unit capacities in Tables A-8, -9, -10 and -11 the incremental capacities shown in 1991-92 NPC survey as the estimated capacities for 1/1/96 over the base capacities shown in these tables. Tables A-8A, -9A and -10A show these adjusted survey estimated 1/1/96 capacities for comparison to our issue cases LP calculated required capacities. Because most of the higher survey estimated capacities are not under construction, it was considered speculative. It will be used for comparisons, but not in our LP cases. NPC cases using the simple formula were mostly completed prior to receiving NPC survey results.
- Assume following maximum annual and seasonal utilizations of stream day capacities, based on actual utilizations for 1987-90 (shown in Table A-12) plus TM&C's estimates of under-utilizations due to excess capacity. Lower downstream utilizations in models IIC and IV reflect more second quarter turnarounds during gasoline season and lower winter gasoline demands, both due to colder weather in first and fourth quarters.

TABLE A-7

REFINERY PROCESS CAPACITIES BASIS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

	<u>II C, IV</u>	<u>I, III, VCC, VCOC</u>	<u>U.S. Average</u>
<u><i>Annual</i></u>			
Crude	94	95	95
FCC/Coking	85	91	89
Hydrocracking/Ether	80	84	83
Dependent Downstream ⁽¹⁾	82	87	86
Other Downstream	85	90	89
<u><i>Summer</i></u>			
Crude	96	97	97
FCC	87	94	92
Coking	86	92	91
Hydrocracking/Ether	83	87	86
Dependent Downstream ⁽¹⁾	84	89	88
Other Downstream	87	92	91
<u><i>Winter</i></u>			
Crude	92	93	93
FCC	83	88	87
Coking	84	90	89
Hydrocracking/Ether	77	81	80
Dependent Downstream ⁽¹⁾	80	85	84
Other Downstream	83	88	87

⁽¹⁾ Units for which operation is dependent on simultaneous operation of other downstream units, i.e., alkylation, polymerization, C₄ isomerization and hydrogen.

Sulfur recovery maximum utilization of stream day capacities is (%):

	<u>IC, VCC</u>	<u>II C, III C, VCOC</u>	<u>IV</u>
Annual	59	66	80
Summer	61	68	82
Winter	57	64	78

REC/CLM
8/11/92

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Consulting Engineers

TABLE A-8
REFINERY PROCESS UNIT CAPACITIES DETAIL
1995 BASE(1) BEFORE REQUIRED ADDITIONS
NPC 1991-1992 STUDY OF U. S. REFINING INDUSTRY
(MBPSD)

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>Combined</u>	<u>U.S.</u>
Number of Refineries	11	34	44	17	7	16	Simple	Total
							70	199
Feed Rate								
Crude - Atmospheric	1,299.0	3,455.4	6,882.1	541.3	726.5	1,978.6	1,368.4	16,251.3
- Vacuum	639.1 (2)	1,396.3	2,828.4	202.4	298.3	1,141.6	475.2	6,981.2
Catalytic Cracking	613.5	1,307.3	2,625.4	186.7	138.5	622.7 (2)		5,494.1
Hydrocracking	55.0	130.8	493.1	7.9	63.6	313.9		1,064.3
Hydrocracking(Low Conv)(3)	14.0	32.1	105.4	2.0	15.4	78.4		247.3
Total Hydrocracking	69.0	162.9	598.5	9.9	79.0	392.3 (2)	6.0	1,317.6
Coking - Delayed	35.0	306.0	678.3	34.7	78.0	374.9		1,506.9
- Fluid	45.0		36.5	7.7		94.5		183.7
Combined	80.0	306.0	714.8	42.4	78.0	469.4		1,690.6
Combined Coke, 400# B	19.7	72.5	172.9	8.6	20.0	91.2		384.9
Thermal Cracking/Visbreaking	10.0	25.6	73.5		13.0	24.8	15.0	161.9
Solvent Deasphalting		39.8	191.5	16.5	21.5	50.0		319.3
Catalytic Reforming - 100 PSI(3)(4)	118.0	338.5	836.6		69.5	65.5	6.0	1,434.1
- 200 PSI	37.2	98.8	323.2	40.4	69.0	143.2	38.8	750.6
- 400 PSI	178.8	606.7	676.8	76.0	24.0	319.3	59.7	1,941.2
Total	334.0	1,044.0	1,836.6	116.4	162.5	528.0	104.5	4,125.9
Hydrotreating - Naphtha(4)	393.5	1,046.2	1,887.8	125.6	126.5 (2)	466.2	110.9	4,156.7
- Distillate	410.3	825.3	1,658.3	89.0	188.6	393.2	23.3	3,588.1
- Heavy Gas Oil	116.0	362.8	827.7	60.2	7.5	565.5	32.2	1,971.9
- Resid		13.0	327.5			40.0	6.0	386.5
Reformate Fractionation(2)	159.8	173.0	505.2			3.5		841.5
Aromatics Extraction(3)	27.6	81.2	295.8	0.6			4.2	409.3
Toluene Hydrodealkylation	7.8	8.2	27.8 (2)					43.8
FCC Gasoline Fractionation(2)	227.3	191.7	628.2	38.6	54.0	360.7		1,500.5
IC4 Dehydrogenation			34.0					34.0
Product Rate								
Alkylation	95.0	276.0	541.3	33.5	31.5	114.2		1,091.5
Polymerization (Incl. Dimersol)	15.0	17.6	40.1	7.5	3.3	9.3	0.9	93.7
Isomerization - C5/C6	31.1	169.7 (2)	207.8	5.1	4.0	7.4	6.3	431.4
- C4	11.5	17.5	36.9	12.9	4.3	5.5	4.4	92.9
Hydrogen, MMSCFPD	109.0	295.1 (2)	1,139.2 (2)	27.0	129.0	1,294.0 (2)	13.0	3,006.3
Hydrogen, FOEB	5.5	15.0	57.9	1.4	6.6	65.8	0.7	152.9
Asphalt	71.0	285.0	147.7	51.3	1.8	43.8	248.8	849.4
Lubes	20.0	31.7	107.5			20.0	47.3	226.5
Aromatics	19.2	56.4	205.4	0.4			2.9	284.3
MTBE	6.0	12.2	66.5			5.5		90.2
TAME	5.5	7.7	23.1			3.4		39.7
Sulfur, MLTPD	1.8	3.9	11.1	0.1	0.3	4.9	0.1	22.2

(1) 1/1/91 existing(DOE-PSA 1990 and Oil & Gas Journal 3/18/91) plus under-construction (Hydrocarbon Processing and Oil & Gas Journal through 10/91) adjusted to reflect NPRA survey for Auto/Oil.

(2) Increased to reflect NPRA (Auto/Oil) survey results greater than the sum of available publicly reported capacities.

(3) Estimated.

(4) Subcategories include some estimates on the proper allocation.

TABLE A-8A
ALTERNATE REFINERY PROCESS UNIT CAPACITIES DETAIL
1995 BASE(1) BEFORE REQUIRED ADDITIONS – SURVEY
NPC 1991–1992 STUDY OF U. S. REFINING INDUSTRY
(MBPSD)

	IC	IIC	IIIC	IV	VCOC	VCC	Combined Simple	U.S. Total
Number of Refineries	11	34	44	17	7	16	70	199
Feed Rate								
Crude – Atmospheric	1,299.0	3,512.7 (3)	6,882.1	549.3 (3)	738.5 (3)	1,978.6	1,368.4	16,328.6
– Vacuum	639.1 (2)	1,483.1 (3)	2,872.7 (3)	222.6 (3)	328.0 (3)	1,141.6	475.2	7,162.3
Catalytic Cracking	616.5 (3)	1,336.4 (3)	2,625.4	200.7 (3)	143.0 (3)	630.8 (3)		5,552.8
Hydrocracking	55.0	130.8	493.1	7.9	65.6 (3)	317.7 (3)		1,070.1
Hydrocracking(Low Conv)(4)	14.0	32.1	113.7 (3)	2.0	15.4	91.8 (3)		269.0
Total Hydrocracking	69.0	162.9	606.8 (3)	9.9	81.0 (3)	409.5 (3)	6.0	1,345.1
Coking – Delayed	35.0	317.1 (3)	704.5 (3)	34.7	78.0	384.5 (3)		1,553.8
– Fluid	45.0		36.5	7.7		95.5 (3)		184.7
Combined	80.0	317.1 (3)	741.0 (3)	42.4	78.0	480.0 (3)		1,738.5
Combined Coke, 400# B	19.7	72.5	172.9	8.6	20.0	91.2		384.9
Thermal Cracking/Visbreaking	10.0	25.6	75.0 (3)		13.0	24.8	15.0	163.4
Solvent Deasphalting		39.8	191.5	16.5	21.5	50.0	8.2 (3)	327.5
Catalytic Reforming – 100 PSI(4)	118.0	338.5	836.6		69.5	65.5	6.0	1,434.1
– 200 PSI	37.2	98.8	323.2	40.4	69.0	143.2	38.8	750.6
– 400 PSI	178.8	606.7	676.8	80.5 (3)	24.0	319.3	59.7	1,945.8
Total(5)	334.0	1,044.0	1,836.6	120.9 (3)	162.5	528.0	104.5	4,130.5
Hydrotreating – Naphtha	393.5	1,062.3 (3)	1,887.8	132.2 (3)	145.3 (3)	466.2	127.8 (3)	4,215.1
– Distillate	410.3	884.7 (3)	1,866.6 (3)	151.8 (3)	188.6	393.2	52.1 (3)	3,947.3
– Heavy Gas Oil	116.0	386.0 (3)	955.7 (3)	60.2	7.5	621.5 (3)	32.2	2,179.1
– Resid		13.0	327.5			(3)	6.0	346.5
Reformate Fractionation(2)	159.8	173.0	505.2			3.5		841.5
Aromatics Extraction	42.0 (3)	125.7 (3)	452.3 (3)	0.6			4.2	624.8
Toluene Hydrodealkylation	7.8	8.2	27.8 (2)					43.8
FCC Gasoline Fractionation(2)	227.3	191.7	628.2	38.6	54.0	360.7		1,500.5
IC4 Dehydrogenation			34.0					34.0
Product Rate								
Alkylation	95.0	276.0	563.1 (3)	37.2 (3)	36.5 (3)	169.3 (3)		1,177.1
Polymerization (Incl. Dimersol)	16.8 (3)	20.0 (3)	40.1	10.7 (3)	4.9 (3)	16.2 (3)	0.9	109.6
Isomerization – C5/C6	31.1	191.3 (3)	207.8	5.1	4.0	107.9 (3)	23.0 (3)	570.2
– C4	11.5	17.5	46.2 (3)	12.9	4.3	23.2 (3)	4.4	119.9
Hydrogen, MMSCFPD	109.0	295.1 (2)	1,139.2 (2)	49.0 (3)	142.8 (3)	1,294.0 (2)	65.8 (3)	3,094.9
Hydrogen, FOEB	5.5	15.0	57.9	2.5	7.3	65.8	3.3	157.4
Asphalt	71.0	285.0	147.7	51.3	1.8	43.8	248.8	849.4
Lubes	20.0	31.7	107.5			20.0	47.3	226.5
Aromatics	19.2	56.4	205.4	0.4			2.9	284.3
MTBE(3)	11.2	28.5	105.7	1.7		29.7		176.8
TAME(3)	9.8	8.9	38.0			6.0		62.7
Sulfur, MLTPD	1.8	4.5 (3)	11.9 (3)	0.5 (3)	0.4 (3)	4.9	0.1	24.1

(1) 1/1/91 existing(DOE-PSA 1990 and Oil & Gas Journal 3/18/91) plus under-construction (Hydrocarbon Processing and Oil & Gas Journal through 10/91) increased to reflect NPRA survey for Auto/Oil and 1992 NPC survey for 1/1/96 capacity.

(2) Increased to reflect NPRA (Auto/Oil) survey results greater than the sum of available publicly reported capacities.

(3) Increased to reflect 1992 NPC survey results for 1/1/96 greater than the sum of available publicly reported capacities.

(4) Estimated.

(5) Subcategories include some estimates on the proper allocation.

TABLE A-9

REFINERY PROCESS DISTRIBUTION – COUNT(1)

1995 BASE BEFORE REQUIRED ADDITIONS

NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	Subtotal <u>Conversion</u>	Combined <u>Simple</u>	U.S. <u>Total</u>
Number of Refineries	11	34	44	17	7	16	129	70	199
Number of Refineries With(1)									
Crude – Atmospheric	10	34	44	17	7	16	128	66	194
– Vacuum	10	32	40	14	6	16	118	40	158
Catalytic Cracking	11	34	43	15	4	13	120		120
Hydrocracking	3	8	17	2	3	14	47	2	49
Coking – Delayed	2	15	19	4	2	9	51		51
– Fluid	1		2	1		3	7		7
Combined	3	15	21	5	2	12	58		58
Thermal Cracking/Visbreaking	1	3	6		1	2	13	2	15
Solvent Deasphalting		6	11	3	2	1	23		23
Catalytic Reforming – 100 PSI	3	10	23		4	3	43	1	44
– 200 PSI	2	9	12	5	2	5	35	10	45
– 400 PSI	6	24	28	12	1	13	84	11	95
Total	10	34	44	17	6	16	127	22	149
Hydrotreating – Naphtha	10	33	43	14	6	15	121	18	139
– Distillate	10	23	34	11	4	11	93	6	99
– Heavy Gas Oil	3	10	17	4	1	13	48	4	52
– Resid		1	5			1	7	2	9
Reformate Fractionation	6	9	17			1	33		33
Aromatics Extraction	4	9	17	1			31	2	33
Toluene Hydrodealkylation	3	2	4				9		9
FCC Gasoline Fractionation	7	9	20	3	4	10	53		53
IC4 Dehydrogenation			3				3		3
Alkylation	10	33	41	12	4	12	112		112
Polymerization (Incl. Dimersol)	4	8	9	5	2	4	32	1	33
Isomerization – C5/C6	3	21	20	3	1	1	49	7	56
– C4	2	5	7	7	2	2	25	4	29
Hydrogen	5	11	15	2	5	13	51	4	55
Asphalt	3	24	18	10	2	5	62	33	95
Lubes	2	7	8			3	20	10	30
Aromatics	4	9	17	1			31	2	33
MTBE	5	9	22			4	40		40
TAME	2	8	11			3	24		24
Sulfur	10	27	39	7	5	14	102	3	105

(1) Number of refineries having each process.

TABLE A-9A

ALTERNATE REFINERY PROCESS DISTRIBUTION – COUNT(1)

1995 BASE BEFORE REQUIRED ADDITIONS – SURVEY

NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>Subtotal Conversion</u>	<u>Combined Simple</u>	<u>U.S. Total</u>
Number of Refineries	11	34	44	17	7	16	129	70	199
Number of Refineries With(1)									
Crude – Atmospheric	10	34	44	17	7	16	128	66	194
– Vacuum	10	32	40	14	6	16	118	40	158
Catalytic Cracking	11	34	43	16	4	13	121		121
Hydrocracking	3	8	17	2	3	14	47	2	49
Coking – Delayed	2	15	20	4	2	10	53		53
– Fluid	1		2	1		3	7		7
Combined	3	15	22	5	2	12	59		59
Thermal Cracking/Visbreaking	1	3	6		1	2	13	2	15
Solvent Deasphalting		6	13	3	2	1	25	4	29
Catalytic Reforming – 100 PSI	3	10	23		4	3	43	1	44
– 200 PSI	2	9	12	5	2	5	35	10	45
– 400 PSI	6	24	28	12	1	13	84	11	95
Total	10	34	44	17	6	16	127	22	149
Hydrotreating – Naphtha	10	33	43	16	7	15	124	18	142
– Distillate	10	26	37	13	4	12	102	8	110
– Heavy Gas Oil	3	10	21	4	1	13	52	4	56
– Resid		1	5				6	2	8
Reformate Fractionation	6	9	17			1	33		33
Aromatics Extraction	4	9	17	1			31	2	33
Toluene Hydrodealkylation	3	2	4				9		9
FCC Gasoline Fractionation	7	9	20	3	4	10	53		53
IC4 Dehydrogenation			3				3		3
Alkylation	10	33	41	12	4	13	113		113
Polymerization (Incl. Dimersol)	5	10	9	6	3	5	38	1	39
Isomerization – C5/C6	3	21	20	3	1	10	58	10	68
– C4	2	7	7	7	2	6	31	4	35
Hydrogen	5	12	15	4	5	13	54	6	60
Asphalt	3	24	18	10	2	5	62	33	95
Lubes	2	7	8			3	20	10	30
Aromatics	4	9	17	1			31	2	33
MTBE	6	13	27	3		8	57		57
TAME	3	8	14			4	29		29
Sulfur	10	31	40	11	7	15	114	8	122

(1) Number of refineries having each process.

TABLE A-10

REFINERY PROCESS DISTRIBUTION – %(1)

1995 BASE BEFORE REQUIRED ADDITIONS

NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	Subtotal <u>Conversion</u>	Combined <u>Simple</u>	U.S. <u>Total</u>
Number of Refineries	11	34	44	17	7	16	129	70	199
Percent of Refineries With(1)									
Crude – Atmospheric	91	100	100	100	100	100	99	94	97
– Vacuum	91	94	91	82	86	100	91	57	79
Catalytic Cracking	100	100	98	88	57	81	93		60
Hydrocracking	27	24	39	12	43	88	36	3	25
Coking – Delayed	18	44	43	24	29	56	40		26
– Fluid	9		5	6		19	5		4
Combined	27	44	48	29	29	75	45		29
Thermal Cracking/Visbreaking	9	9	14		14	13	10	3	8
Solvent Deasphalting		18	25	18	29	6	18		12
Catalytic Reforming – 100 PSI	27	29	52		57	19	33	1	22
– 200 PSI	18	26	27	29	29	31	27	14	23
– 400 PSI	55	71	64	71	14	81	65	16	48
Total	91	100	100	100	86	100	98	31	75
Hydrotreating – Naphtha	91	97	98	82	86	94	94	26	70
– Distillate	91	68	77	65	57	69	72	9	50
– Heavy Gas Oil	27	29	39	24	14	81	37	6	26
– Resid		3	11			6	5	3	5
Reformate Fractionation	55	26	39			6	26		17
Aromatics Extraction	36	26	39	6			24	3	17
Toluene Hydrodealkylation	27	6	9				7		5
FCC Gasoline Fractionation	64	26	45	18	57	63	41		27
IC4 Dehydrogenation			7				2		2
Alkylation	91	97	93	71	57	75	87		56
Polymerization (Incl. Dimersol)	36	24	20	29	29	25	25	1	17
Isomerization – C5/C6	27	62	45	18	14	6	38	10	28
– C4	18	15	16	41	29	13	19	6	15
Hydrogen	45	32	34	12	71	81	40	6	28
Asphalt	27	71	41	59	29	31	48	47	48
Lubes	18	21	18			19	16	14	15
Aromatics	36	26	39	6			24	3	17
MTBE	45	26	50			25	31		20
TAME	27	24	25			19	19		12
Sulfur	91	79	89	41	71	88	79	4	53

(1) Percent of refineries having each process.

TABLE A-10A
ALTERNATE REFINERY PROCESS DISTRIBUTION – %(1)
1995 BASE BEFORE REQUIRED ADDITIONS – SURVEY
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>Subtotal</u> <u>Conversion</u>	<u>Combined</u> <u>Simple</u>	<u>U.S.</u> <u>Total</u>
Number of Refineries	11	34	44	17	7	16	129	70	199
Percent of Refineries With(1)									
Crude – Atmospheric	91	100	100	100	100	100	99	94	97
– Vacuum	91	94	91	82	86	100	91	57	79
Catalytic Cracking	100	100	98	94	57	81	94		61
Hydrocracking	27	24	39	12	43	88	36	3	25
Coking – Delayed	18	44	45	24	29	62	41		27
– Fluid	9		5	6		19	5		4
Combined	27	44	50	29	29	75	46		30
Thermal Cracking/Visbreaking	9	9	14		14	13	10	3	8
Solvent Deasphalting		18	30	18	29	6	19	6	15
Catalytic Reforming – 100 PSI	27	29	52		57	19	33	1	22
– 200 PSI	18	26	27	29	29	31	27	14	23
– 400 PSI	55	71	64	71	14	81	65	16	48
Total	91	100	100	100	86	100	98	31	75
Hydrotreating – Naphtha	91	97	98	94	100	94	96	26	71
– Distillate	91	76	84	76	57	75	79	11	55
– Heavy Gas Oil	27	29	48	24	14	81	40	6	28
– Resid		3	11				5	3	4
Reformate Fractionation	55	26	39			6	26		17
Aromatics Extraction	36	26	39	6			24	3	17
Toluene Hydrodealkylation	27	6	9				7		5
FCC Gasoline Fractionation	64	26	45	18	57	63	41		27
IC4 Dehydrogenation			7				2		2
Alkylation	91	97	93	71	57	81	88		57
Polymerization (Incl. Dimersol)	45	29	20	35	43	31	29	1	20
Isomerization – C5/C6	27	62	45	18	14	62	45	14	34
– C4	18	21	16	41	29	38	24	6	18
Hydrogen	45	35	34	24	71	81	42	9	30
Asphalt	27	71	41	59	29	31	48	47	48
Lubes	18	21	18			19	16	14	15
Aromatics	36	26	39	6			24	3	17
MTBE	55	38	61	18		50	44		29
TAME	27	24	32			25	22		15
Sulfur	91	91	91	65	100	94	88	11	61

(1) Percent of refineries having each process.

TABLE A-11
SIMPLE REFINERY PROCESS UNIT CAPACITIES DETAIL
1995 BASE(1)

NPC 1991-92 STUDY OF US REFINING INDUSTRY
(MBPSD)

	<u>IS</u>	<u>IIS</u>	<u>IIIS</u>	<u>VS</u>	<u>Combined Simple</u>	<u>Adjusted Combined Simple</u> (2)
	12	7	29	22	70	70
Number of Refineries						
<u>Feed Rate</u>						
Crude - Atmospheric	286.4	76.1	575.2	430.7	1368.4	1368.4
- Vacuum	127.0	18.3	162.7	167.3	475.2	475.2
Catalytic Cracking						
Hydrocracking			1.0	5.0	6.0	6.0
Coking - Delayed						
- Fluid						
Combined						
Thermal Cracking/Visbreaking			10.0	5.0	15.0	15.0
Solvent Deasphalting						8.2
Catalytic Reforming - 100 PSI			6.0		6.0	6.0
- 200 PSI	10.8		22.0	6.0	38.8	38.8
- 400 PSI	3.5	6.3	35.6	14.3	59.7	59.7
Total	14.3	6.3	63.6	20.3	104.5	104.5
Hydrotreating - Naphtha	11.8	8.8	67.8	22.5	110.9	127.8
- Distillate	1.8		13.9	7.6	23.3	52.1
- Heavy Gas Oil			18.2	14.0	32.2	32.2
- Resid			6.0		6.0	6.0
Reformate Fractionation						
Aromatics Extraction			0.6	3.6	4.2	4.2
Toluene Hydrodealkylation						
FCC Gasoline Fractionation						
<u>Product Rate</u>						
Alkylation						
Polymerization (Incl. Dimersol)				0.9	0.9	0.9
Isomerization - C5/C6	1.2	0.3	3.9	1.0	6.3	23.0
- C4			4.4		4.4	4.4
Hydrogen, MMSCFPD			4.0	9.0	13.0	65.8
Asphalt	95.4	5.8	43.3	104.2	248.8	248.8
Lubes	14.8		22.5	10.0	47.3	47.3
Aromatics			0.4	2.5	2.9	2.9
MTBE						
Sulfur, LTPD			73.0	7.0	80.0	80.0

(1) 1/1/91 existing (DOE-PSA 1990) plus under construction to be completed by 1/1/95 (Hydrocarbon Processing and Oil & Gas Journal through 10/91) adjusted to reflect shutdowns.

(2) Increased to reflect higher 1/1/96 capacity based on 1991-92 NPC survey. This reported added capacity was not distributed by PADDs.

RMA/CLM
1/15/93

TURNER, MASON & COMPANY
Consulting Engineers

TABLE A-12
ACTUAL AVERAGE UTILIZATION DATA FROM DOE
NPC 1991-1992 STUDY OF U.S. REFINING INDUSTRY
(% of stream day capacities)

	CAPACITY %	WINTER QUARTERS 1987	SUMMER QUARTERS 1988	WINTER QUARTERS 1988	SUMMER QUARTERS 1989	WINTER QUARTERS 1989	SUMMER QUARTERS 1990	WINTER QUARTERS 1990	SUMMER QUARTERS AVERAGE	WINTER QUARTERS AVERAGE	ANNUAL AVERAGE 1988-90
<u>FCC</u>											
U.S.	100	81.8	87.2	84.9	91.8	80.7	87.0	83.8	88.7	82.8	85.3
PADD I	11	91.5	90.8	90.7	95.5	88.0	82.5	84.6	89.6	88.7	88.7
PADD II	23	76.4	82.6	79.8	82.4	77.9	84.8	81.0	83.3	78.8	81.4
PADD III	48	82.6	89.5	88.0	95.9	80.9	88.3	83.3	91.2	83.7	86.9
PADD IV	4	75.5	84.2	77.4	84.5	74.6	86.8	77.1	85.2	76.2	80.8
PADD V	14	81.6	85.5	80.5	93.0	79.2	85.9	87.8	88.1	82.3	84.8
<u>Hydrocracker</u>											
U.S.	100	77.4	79.1	75.9	78.4	71.0	74.4	71.0	77.3	73.8	75.3
PADD I	7	74.3	78.9	62.9	88.3	57.6	70.6	66.0	79.3	65.2	70.7
PADD II	13	64.9	80.3	67.5	72.9	61.7	80.3	69.9	77.8	66.0	72.1
PADD III	42	77.9	71.8	71.4	80.9	66.4	70.4	68.3	74.4	71.0	72.4
PADD IV	1	79.7	57.5	62.3	74.1	55.6	36.6	46.1	56.1	60.9	55.4
PADD V	37	81.6	86.9	85.9	76.2	81.6	78.7	76.1	80.6	81.3	81.0
<u>Coker</u>											
U.S.	100	89.0	89.3	89.5	90.4	86.3	85.1	84.1	88.2	87.2	87.7
PADD I	5	89.9	85.0	88.1	74.5	90.7	91.3	86.3	83.6	88.7	86.0
PADD II	20	86.0	89.7	86.8	85.0	83.3	79.0	78.4	84.6	83.6	83.7
PADD III	40	95.2	90.9	93.5	95.8	90.9	86.9	85.2	91.2	91.2	91.2
PADD IV	1	58.4	52.5	71.4	64.8	65.2	81.4	70.5	66.2	66.4	67.6
PADD V	34	85.2	89.8	87.6	90.7	82.6	84.1	84.9	88.2	85.1	86.4
<u>Crude</u>											
U.S.	100	79.5	83.4	82.1	84.9	84.8	86.7	89.5	85.0	84.0	84.4
PADD I	9	81.8	85.0	84.1	81.8	82.4	81.4	78.1	82.7	81.6	82.1
PADD II	21	82.2	87.2	85.0	86.6	82.8	90.4	83.2	88.1	83.3	85.9
PADD III	46	80.0	81.5	81.2	84.5	82.7	87.9	83.4	84.7	81.8	83.0
PADD IV	4	76.5	85.0	75.4	83.8	79.0	84.0	75.2	84.3	76.5	80.4
PADD V	20	75.2	82.5	81.4	85.5	86.2	87.7	88.1	85.3	82.7	83.8

TABLE A-13

1989 AVERAGE SPOT LOW PRICING BY PADDs⁽¹⁾

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

	PADD					
	I	II	III	IV	VOC	VC
<u>Major Products, ¢/G</u>						
Unleaded Regular	57.3	59.1	55.7	61.6	60.9	60.7
Unleaded Premium	64.5	66.9	61.6	67.6	67.6	66.9
Jet/Kerosene	58.7	58.0	55.5	60.9	59.3	59.8
No. 2 Distillate Fuel (0.25% S)	55.4	54.1	52.1	57.7	57.2	56.0
No. 6/Bunker Fuel, \$/B	14.35	11.36	13.36	9.36	14.38	13.72
<u>Major Crudes, \$/B</u>						
Domestic - WTI	-	20.06	19.56	-	-	-
- WTS	-	18.63	18.13	-	-	-
- ANS	-	17.68	17.18	-	17.07	17.07
- CA Kern River	-	-	-	-	-	13.17
Foreign - U.K. Brent	18.84	19.59	19.09	-	-	-
- Nigeria Medium	18.80	19.30	18.80	-	-	-
- Dubai	17.56	18.31	17.81	-	-	-
- Arab Light	17.53	18.28	17.78	-	17.43	17.43
- Arab Medium	16.70	17.45	16.95	-	-	-
- Arab Heavy	16.25	17.00	16.50	-	16.15	16.15
- Mexican Maya	14.93	15.23	14.73	-	-	-
<u>Other, ¢/G</u>						
MTBE	86	88	86	98	86	86
Methanol	50	52	50	62	55	55
Ethanol	-	107	107	112	-	-
Propane	33	20.1	21.4	19	40.8	40.8
Isobutane	50	38.6	37.2	39	57.1	57.1
Normal Butane	29	29	29.8	27	36.2	36.2
Natural Gas, \$/MMBTU	2.60	2.30	2.00	2.30	3.30	3.30
Natural Gas, \$/FOE B	16.38	14.49	12.60	14.49	20.79	20.79
Coke <3% Sulfur, \$/400 #B	5.00	4.00	5.00	2.00	5.50	5.50

TABLE A-13

1989 AVERAGE SPOT LOW PRICING BY PADDs⁽¹⁾

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

⁽¹⁾ Notes:

- Gasoline, kero/jet and diesel/No. 2 pipeline actual and estimated lows based on SDLTG memo of 4/3/92 from Barnes. TM&C used the following simple averages of SDLTG pricing locations for its refining models:
 - I Boston spot cargo
New York spot cargo
Baltimore◄
Pittsburg◄
 - II Chicago◄
Minneapolis◄
Tulsa pipeline (Group 3)
 - III Gulf Coast pipeline
 - IV Rocky Mountains (Denver/Salt Lake City/Billings)◄
 - VOC Seattle pipeline
 - VC San Francisco pipeline
Los Angeles pipeline
- ◄ Estimated pipeline based on actual terminal pricing and typical pipeline vs. terminal differentials.
- Crude prices are delivered.
- Other 1989 prices from *Platt's Oil Price Handbook* 1990 and other sources.
- MTBE prices from DeWitt are adjusted up by 10¢/G for 1995 and 2000 based on recent spot and five-year contract prices; revert to 1989 prices in 2010.
- Ethanol price is 1989 average from *Octane Week* before tax credit.
- Summer and winter price differentials from annual average pricing used by TM&C to create Tables 13A and 13B. These are based on *Platt's Oil Price Handbook*, 1989 pricing for summer (second and third quarters) and winter (first and fourth quarters). They are also based on the following selected pricing locations for TM&C refining models:
 - I New York spot cargo
 - II Group 3 spot pipeline
 - III/IV Gulf Coast spot pipeline
 - VOC/VC Los Angeles spot pipeline

REC/GWM - 4/21/92

TABLE A-13A

1989 AVERAGE SUMMER SPOT LOW PRICING BY PADDs⁽¹⁾

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	PADD					
	I	II	III	IV	VOC	VC
<u>Major Products, c/G</u>						
Unleaded Regular	61.9	64.9	59.7	67.4	65.8	65.6
Unleaded Premium	68.9	73.2	65.4	73.9	72.4	71.7
Jet/Kerosene	54.3	56.5	51.9	59.4	56.6	57.1
No. 2 Distillate Fuel (0.25% S)	51.4	52.6	49.0	56.2	54.3	53.1
No. 6/Bunker Fuel, \$/B	14.55	11.97	13.97	9.97	14.70	14.04
<u>Major Crudes, \$/B</u>						
Domestic - WTI	-	20.30	19.80	-	-	-
- WTS	-	18.80	18.30	-	-	-
- ANS	-	17.70	17.20	-	17.17	17.17
- CA Kern River	-	-	-	-	-	13.75
Foreign - U.K. Brent	18.66	19.41	18.91	-	-	-
- Nigeria Medium	18.62	19.12	18.62	-	-	-
- Dubai	17.52	18.27	17.77	-	-	-
- Arab Light	17.49	18.24	17.74	-	17.39	17.39
- Arab Medium	16.66	17.41	16.91	-	-	-
- Arab Heavy	16.21	16.96	16.46	-	16.11	16.11
- Mexican Maya	15.59	15.89	15.39	-	-	-
<u>Other, c/G</u>						
MTBE	85	87	85	97	85	85
Methanol	51	53	51	63	56	56
Ethanol	-	114	114	119	-	-
Propane	31	18.1	19.7	17	38.8	38.8
Isobutane	50	38.6	37.2	39	57.1	57.1
Normal Butane	26.8	26.8	28.0	24.8	34.0	34.0
Natural Gas, \$/MMBTU	2.52	2.22	1.92	2.22	3.22	3.22
Natural Gas, \$/FOE B	15.88	13.99	12.10	13.99	20.29	20.29
Coke <3% Sulfur, \$/400 #B	5.00	4.00	5.00	2.00	5.50	5.50

⁽¹⁾ Table A-13 1989 annual prices adjusted to Platt's 1989 second and third quarters.

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TABLE A-13B

1989 AVERAGE WINTER SPOT LOW PRICING BY PADDs⁽¹⁾

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	PADD					
	I	II	III	IV	VOC	VC
<u>Major Products, ¢/G</u>						
Unleaded Regular	52.7	53.3	51.7	55.8	56.0	55.8
Unleaded Premium	60.1	60.6	57.8	61.3	62.8	62.1
Jet/Kerosene	63.1	59.5	59.1	62.4	62.0	62.5
No. 2 Distillate Fuel (0.25% S)	59.4	55.6	55.2	59.2	60.1	58.9
No. 6/Bunker Fuel, \$/B	14.15	10.75	12.75	8.75	14.06	13.40
<u>Major Crudes, \$/B</u>						
Domestic - WTI	-	19.82	19.32	-	-	-
- WTS	-	18.46	17.96	-	-	-
- ANS	-	17.66	17.16	-	16.97	16.97
- CA Kern River	-	-	-	-	-	12.59
Foreign - U.K. Brent	19.02	19.77	19.27	-	-	-
- Nigeria Medium	18.98	19.48	18.98	-	-	-
- Dubai	17.60	18.35	17.85	-	-	-
- Arab Light	17.57	18.32	17.82	-	17.47	17.47
- Arab Medium	16.74	17.49	16.99	-	-	-
- Arab Heavy	16.29	17.04	16.54	-	16.19	16.19
- Mexican Maya	14.27	14.57	14.07	-	-	-
<u>Other, ¢/G</u>						
MTBE	87	89	87	99	87	87
Methanol	49	51	49	61	54	54
Ethanol	-	100	100	105	-	-
Propane	35	22.1	23.1	21	42.8	42.8
Isobutane	50	38.6	37.2	39	57.1	57.1
Normal Butane	31.2	31.2	31.6	29.2	38.4	38.4
Natural Gas, \$/MMBTU	2.68	2.38	2.08	2.38	3.38	3.38
Natural Gas, \$/FOE B	16.88	14.99	13.10	14.99	21.29	21.29
Coke <3% Sulfur, \$/400 #B	5.00	4.00	5.00	2.00	5.50	5.50

⁽¹⁾ Table A-13 1989 annual prices adjusted to Platt's 1989 first and fourth quarters.

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4/21/92

TABLE A-14

PLANNED U.S. SUPPLY AND DEMAND SCENARIOS

FOUNDATION CASES DEFINITIONS AND RATES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Consumer Demand:	F2 Constant	F1 High	F3 Low
Consumer Demand Basis:	1989 Rates	<u>EIA Reference</u>	<u>Reduced Levels</u>
Product Imports Basis:⁽¹⁾	1989 Rates		
Crude Type Basis:⁽²⁾	1989 Rates/Qualities		
<u>1995</u>			
Consumer Demand, MMBPD	17.1	-	-
Crude Run, MMBPD	13.1	-	-
RFG	9 cities + 10%	-	-
Oxygenated Gasoline ⁽³⁾	CO-nonattainment + 10%	-	-
Low Sulfur Diesel ⁽³⁾	On-highway + 50%	-	-
Low Aromatics Diesel ⁽³⁾	California + 0%	-	-
<u>2000</u>			
Consumer Demand, MMBPD	17.2	18.6	16.2
Crude Run, MMBPD	12.9	14.1	12.1
RFG ⁽³⁾	Ozone nonattainment + 10%		
CARB Phase 2 Gasoline ⁽³⁾	California + 0%		
<u>2010</u>			
Consumer Demand, MMBPD	17.2	20.4	14.8
Crude Run, MMBPD	12.9	15.7	10.9

⁽¹⁾ Applies to all scenarios; fairly constant 1989 finished product imports and exports rates; estimated crude runs reflect changes in refining demand.

⁽²⁾ Applies to all scenarios; assumes constant 1989 domestic crude rates (ignores significant DOE projected decline); assumes import rate changes to attain fairly constant quality.

⁽³⁾ Applies to all 2000 and 2010 scenarios.

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TABLE A-15
U.S. CRUDE RUNS - ACTUAL AND SCENARIOS⁽¹⁾
TYPES OF DOMESTIC AND IMPORTED - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Actual ⁽³⁾				NPC Scenarios ⁽²⁾			
	1984 ⁽⁴⁾	1985	1988	1989 ⁽⁵⁾	F1		F3	
					2000	2010	2000	2010
Domestic - Sweet	4,728	4,663	3,740	3,908	3,908	3,908	3,908	3,908
- Light High Sulfur	818	812	731	517	517	517	517	517
- Heavy High Sulfur ⁽⁶⁾	<u>3,152</u>	<u>3,326</u>	<u>3,668</u>	<u>3,188</u>	<u>3,188</u>	<u>3,188</u>	<u>3,188</u>	<u>3,188</u>
Subtotal	8,698	8,801	8,139	7,613	7,613	7,613	7,613	7,613
Imported - Sweet	1,583	1,580	2,051	2,240	2,631	3,409	1,580	939
- Light High Sulfur	418	384	935	1,197	1,306	1,523	1,013	834
- Heavy High Sulfur	<u>1,345</u>	<u>1,237</u>	<u>2,121</u>	<u>2,394</u>	<u>2,750</u>	<u>3,455</u>	<u>1,794</u>	<u>1,214</u>
Subtotal	3,346	3,201	5,107	5,831	6,687	8,387	4,387	2,987
Combined - Sweet	6,311	6,243	5,791	6,148	6,539	7,317	5,488	4,847
- Light High Sulfur	1,236	1,196	1,666	1,714	1,823	2,040	1,530	1,351
- Heavy High Sulfur	<u>4,497</u>	<u>4,563</u>	<u>5,789</u>	<u>5,582</u>	<u>5,938</u>	<u>6,643</u>	<u>4,982</u>	<u>4,402</u>
Total	12,044	12,002	13,246	13,444	14,300	16,000	12,000	10,600

⁽¹⁾ Definition of crude types (NPC): Sweet $\leq 0.5\%$ sulfur; light $\leq 15\%$ vacuum resid at 1,050°F.

⁽²⁾ Final U.S. crude rates should be within 500 MBPCD of these preliminary estimates; constant 1989 quality and types; constant 1989 domestic crude rates; import rates adjusted by types to fit assumed combined refinery rates.

⁽³⁾ TM&C estimates from DOE data.

⁽⁴⁾ From NPC survey and report.

⁽⁵⁾ F2 (constant) NPC scenarios for 1995, 2000 and 2010 are within 500 MBPCD of 1989 actual U.S. crude rate.

⁽⁶⁾ Included ANS rates in MBPD are:

1,538	1,779	1,975	1,832	1,832	1,832	1,832	1,832

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TABLE A-16
REFINERY JET, NO. 2 AND NO. 6 FUELS SPECIFICATIONS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Jet A	No. 2 Fuel	Low Sulfur Diesel	No. 6 Fuel			
				<0.3% S	<1% S	<2% S	Bunker
Gravity, °API, Minimum	38.5	30.5	32	5.5	5.5	5.5	5.5
Maximum	47	38.5	38.5	-	-	-	-
Margin ⁽¹⁾	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sulfur, W %, Maximum	0.04 ⁽²⁾	0.25	0.042	0.25	0.84	1.68	2.94
Margin ⁽¹⁾	0.01 ⁽²⁾	0.05	0.008	0.05	0.16	0.32	0.56
Flash Point, °F, Minimum	112	139	144	160	160	160	160
Margin ⁽¹⁾	4	4	4	10	10	10	10
Freeze Point, °F, Maximum	-44	-	-	-	-	-	-
Margin ⁽¹⁾	4	-	-	-	-	-	-
Luminometer No., Minimum ⁽³⁾	45	-	-	-	-	-	-
Distillation, °F, Maximum							
10%	390	440	440	-	-	-	-
Margin ⁽¹⁾	10	35	20	-	-	-	-
90%	-	610	610	-	-	-	-
Margin ⁽¹⁾	-	20	10	-	-	-	-
Pour Point, °F, Maximum ⁽⁴⁾	-	-2	-5	-	-	-	-
Margin ⁽¹⁾	-	5	5	-	-	-	-
Cetane Index, Minimum	-	41	46	-	-	-	-
Margin ⁽¹⁾	-	1	1	-	-	-	-
Viscosity, SSF @ 122°F, Minimum	-	-	-	49	49	49	49
Margin ⁽¹⁾	-	-	-	4	4	4	4
Maximum	-	-	-	280	280	280	280
Margin ⁽¹⁾	-	-	-	20	20	20	20
Aromatics, %, Maximum ⁽⁵⁾	-	35	25	-	-	-	-
Margin ⁽¹⁾	-	3	3	-	-	-	-

⁽¹⁾ Compliance margin included in refinery specs normally equal to at least ASTM lab test reproducibility or average of repeatability and reproducibility. Margin increased on some specifications to make LP products with actual average properties.

⁽²⁾ Real Jet A sulfur maximum is 0.25 W% with 0.05 W% margin. Our LP hydrotreats all Jet A.

⁽³⁾ Equivalent to smoke of 22 mm.

⁽⁴⁾ Annual = -5 low sulfur, -2 No. 2 fuel; summer = 0; winter = -10 low sulfur, -5 No. 2 fuel.

⁽⁵⁾ Aromatics vary by model by up to 5% higher than shown for PADD III. Aromatics content increase over base levels was not allowed.

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TABLE A-17

U.S. 1989 ACTUAL DOE SUPPLY AND DEMAND - MBPCD(1)

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Supply				Demand		
	Field Produc- tion	Imports	From Inven- tory	Net Receipts	Refinery Produc- tion	Refinery Input	Exports Products Demand
<u>Crudes</u>							
Domestic	7,613					7,613	
Foreign		5,843	(86)	200		5,788	142
[Total Crudes]	7,613	5,843	(86)	200		13,401	142
<u>Products - NGL/Unfinished</u>							
Natural Gasoline	309	8	(5)			184	6
Ethane/Ethene	466	8	(16)		12	5	
Propane/Propene	471	111	52		392	11	24
Normal Butane/Butenes	151	48	12		137	148	11
Isobutane	149	14			13	151	
[Subtotal - NGL]	1,546	189	43		554	499	41
Unfinished Oils		348	(17)			511	
Mogas Components		66	6			42	
Oxygenates and Other	60		(1)			60	
[Subtotal - Unf. and Other]	60	414	(12)			613	
[Total - NGL/Unf. and Other]	1,606	603	31		554	1,112	41
<u>Products - Finished</u>							
Motor Gasolines		369	35		6,963		39
Aviation Gasolines					25		
Naphtha Jet		3	(1)		206		4
Kero Jet		102	9		1,197		23
Kerosene		7	6		74		2
Diesel/No. 2		306	49		2,899		97
Residual Fuels		629	2		954		215
Petrochem Naphtha		82			126		5
P/Chem Gas Oil + C. Black		62	(1)		216		21
Special Naphtha/Miscellaneous		10	3		129		14
Lubes and Waxes		13	(2)		185		21
Marketable Coke - 400 #B		1	(2)		330		233
Catalytic Coke - 400 #B					212		
Asphalt/Road Oil		31	1		424		3
Process Gas - FOE					681		
[Subtotal - Finished]		1,615	99		14,621		677
[Total Products]	1,606	2,218	130		15,175	1,112	718
Total Crudes and Products	9,219	8,061	44	200	15,175	14,513	860
(Gain)/Loss					(662)		

(1) Includes Puerto Rico, Virgin Islands and Guam.

Note: Rows and columns may not balance due to rounding.

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TABLE A-18

U.S. 1995 SUPPLY AND NPC CONSTANT DEMAND SCENARIO F2 – MBPCD

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Supply				Demand		
	Field Produc- tion	Imports	PChem MTBE	Refining Produc- tion	Refining Input	Exports	Products Demand
<u>Crudes</u>							
Domestic	7,613				7,613		
Foreign		5,694			5,525	142	27
[Total Crudes]	7,613	5,694			13,138	142	27
<u>Products - NGL/Unfinished</u>							
Natural Gasoline	309	4			184	6	123
Ethane/Ethene	466	8		12	5		481
Propane/Propene	471	128		392	11	24	956
Normal Butane/Butenes	151	138	(90)	137	135	11	190
Isobutane	149	39	(25)	13	151		25
[Subtotal - NGL]	1,546	317	(115)	554	486	41	1,775
Unfinished Oils		330			511		(181)
Mogas Components		72			42		30
Oxygenates and Other	85	74	75		235		(1)
[Subtotal - Unf. and Other]	85	476	75		788		(152)
[Total - NGL/Unf. and Other]	1,631	793	(40)	554	1,274	41	1,623
<u>Products - Finished</u>							
Motor Gasolines		369		6,888		39	7,218
RFG/OG Incrmt - BTU				70			70
Aviation Gasolines				25			25
Kero Jet		134		1,382		27	1,489
Kerosene/No. 1		7		95		2	100
Diesel/No. 2		294		2,899		97	3,096
Residual Fuels		629		875		215	1,289
Petrochem Naphtha		110		126		5	231
P/Chem Gas Oil + C. Black		98		216		21	293
Special Naphtha/Miscellaneous		9		129		14	124
Lubes and Waxes		6		185		21	170
Marketable Coke - 400 #B		1		330		238	93
Catalytic Coke - 400 #B				205			205
Asphalt/Road Oil		17		424		3	438
Process Gas - FOE				659			659
[Subtotal - Finished]		1,674		14,508		682	15,500
[Total Products]	1,631	2,467	(40)	15,062	1,274	723	17,123
Total Crudes and Products	9,244	8,161	(40)	15,062	14,412	865	17,150
(Gain)/Loss			40	(650)			

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TABLE A-19

U.S. 2000 SUPPLY AND NPC CONSTANT DEMAND SCENARIO F2 – MBPCD

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Supply				Demand		
	Field Produc- tion	Imports	PChem MTBE	Refining Produc- tion	Refining Input	Exports	Products Demand
<u>Crudes</u>							
Domestic	7,613				7,613		
Foreign		5,479			5,311	142	26
[Total Crudes]	7,613	5,479			12,924	142	26
<u>Products - NGL/Unfinished</u>							
Natural Gasoline	309	4			184	6	123
Ethane/Ethene	466	8		12	5		481
Propane/Propene	471	154		392	11	24	982
Normal Butane/Butenes	151	178	(130)	137	135	11	190
Isobutane	149	54	(40)	13	151		25
[Subtotal - NGL]	1,546	398	(170)	554	486	41	1,801
Unfinished Oils		330			511		(181)
Mogas Components		72			42		30
Oxygenates and Other	85	304	110		500		(1)
[Subtotal - Unf. and Other]	85	706	110		1,053		(152)
[Total - NGL/Unf. and Other]	1,631	1,104	(60)	554	1,539	41	1,649
<u>Products - Finished</u>							
Motor Gasolines		369		6,888		39	7,218
RFG/OG Incrmt - BTU				140			140
Aviation Gasolines				25		1	24
Kero Jet		116		1,400		27	1,489
Kerosene/No. 1		7		77		2	82
Diesel/No. 2		294		2,899		97	3,096
Residual Fuels		629		875		215	1,289
Petrochem Naphtha		131		126		5	252
P/Chem Gas Oil + C. Black		124		216		21	319
Special Naphtha/Miscellaneous		5		129		14	120
Lubes and Waxes				185		21	164
Marketable Coke - 400 #B		1		330		241	90
Catalytic Coke - 400 #B				198			198
Asphalt/Road Oil		2		424		3	423
Process Gas - FOE				637			637
[Subtotal - Finished]		1,678		14,549		686	15,541
[Total Products]	1,631	2,782	(60)	15,103	1,539	727	17,190
Total Crudes and Products	9,244	8,261	(60)	15,103	14,463	869	17,216
(Gain)/Loss			60	(640)			

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TABLE A-20

U.S. 2010 SUPPLY AND NPC HIGH DEMAND SCENARIO F1 – MBPCD

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Supply				Demand		
	Field Produc- tion	Imports	PChem MTBE	Refining Produc- tion	Refining Input	Exports	Products Demand
Crudes							
Domestic	7,613				7,613		
Foreign		8,255			8,084	142	29
[Total Crudes]	7,613	8,255			15,697	142	29
Products – NGL/Unfinished							
Natural Gasoline	309	8			188	6	123
Ethane/Ethene	466	8		12	5		481
Propane/Propene	471	440		440	10	24	1,317
Normal Butane/Butenes	151	178	(130)	137	135	11	190
Isobutane	149	54	(40)	13	151		25
[Subtotal – NGL]	1,546	688	(170)	602	489	41	2,136
Unfinished Oils		348			529		(181)
Mogas Components		66			36		30
Oxygenates and Other	85	354	110		550		(1)
[Subtotal – Unf. and Other]	85	768	110		1,115		(152)
[Total – NGL/Unf. and Other]	1,631	1,456	(60)	602	1,604	41	1,984
Products – Finished							
Motor Gasolines		369		7,748		39	8,078
RFG/OG Incrmt – BTU				159			159
Aviation Gasolines		2		25			27
Kero Jet		105		2,141		27	2,219
Kerosene/No. 1		7		63		2	68
Diesel/No. 2		306		3,621		97	3,830
Residual Fuels		629		1,055		215	1,469
Petrochem Naphtha		82		250		5	327
P/Chem Gas Oil + C. Black		62		373		21	414
Special Naphtha/Miscellaneous		16		129		14	131
Lubes and Waxes		16		185		21	180
Marketable Coke – 400 #B		1		330		233	98
Catalytic Coke – 400 #B				217			217
Asphalt/Road Oil		43		424		3	464
Process Gas – FOE				699			699
[Subtotal – Finished]		1,638		17,419		677	18,380
[Total Products]	1,631	3,094	(60)	18,021	1,604	718	20,364
Total Crudes and Products	9,244	11,349	(60)	18,021	17,301	860	20,393
(Gain)/Loss			60	(720)			

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TABLE A-21

U.S. 2010 SUPPLY AND NPC LOW DEMAND SCENARIO F3 – MBPCD

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Supply				Demand		
	Field Produc- tion	Imports	PChem MTBE	Refining Produc- tion	Refining Input	Exports	Products Demand
<u>Crudes</u>							
Domestic	7,613				7,613		
Foreign		3,453			3,291	142	20
[Total Crudes]	7,613	3,453			10,904	142	20
<u>Products - NGL/Unfinished</u>							
Natural Gasoline	309	8			188	6	123
Ethane/Ethene	466	8		12	5		481
Propane/Propene	471			342	10	53	750
Normal Butane/Butenes	151	178	(130)	137	135	11	190
Isobutane	149	54	(40)	13	151		25
[Subtotal - NGL]	1,546	248	(170)	504	489	70	1,569
Unfinished Oils		348			529		(181)
Mogas Components		66			36		30
Oxygenates and Other	85	244	110		440		(1)
[Subtotal - Unf. and Other]	85	658	110		1,005		(152)
[Total - NGL/Unf. and Other]	1,631	906	(60)	504	1,494	70	1,417
<u>Products - Finished</u>							
Motor Gasolines		369		6,028		39	6,358
RFG/OG Incrmt - BTU				123			123
Aviation Gasolines				19			19
Kero Jet		105		1,214		27	1,292
Kerosene/No. 1		7		44		2	49
Diesel/No. 2		306		2,483		97	2,692
Residual Fuels		629		635		215	1,049
Petrochem Naphtha		82		157		5	234
P/Chem Gas Oil + C. Black		62		255		21	296
Special Naphtha/Miscellaneous		10		98		14	94
Lubes and Waxes		13		137		21	129
Marketable Coke - 400 #B		1		302		233	70
Catalytic Coke - 400 #B				155			155
Asphalt/Road Oil		31		304		3	332
Process Gas - FOE				500			500
[Subtotal - Finished]		1,615		12,454		677	13,392
[Total Products]	1,631	2,521	(60)	12,958	1,494	747	14,809
Total Crudes and Products	9,244	5,974	(60)	12,958	12,398	889	14,829
(Gain)/Loss			60	(560)			

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TABLE A-22
GASOLINE GRADES - %
CONSUMER AND REFINERY OUTPUT - ACTUAL AND NPC SDLTG PREMISES
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Model						Combined Simple	U.S. Total
	IC	IIC	IIIC	IV	VCOC	VCC		
Consumer								
<u>1995/2000/2010 - NPC Premises⁽¹⁾</u>								
Unleaded Regular	58.1	76.2	72.4	74.9	79.5	71.7		68.6
Unleaded Midgrade	14.9	9.8	11.1	12.0	4.4	6.0		11.2
Unleaded Premium	<u>27.0</u>	<u>14.0</u>	<u>16.6</u>	<u>13.2</u>	<u>16.1</u>	<u>22.3</u>		<u>20.2</u>
Total Gasoline	100.0	100.0	100.0	100.0	100.0	100.0		100.0
Refinery								
<u>1989 - Actual⁽²⁾</u>								
Leaded Regular	2.5	8.8	8.1	30.8	27.9	19.7	22.2	10.8
Unleaded Regular	52.2	66.1	55.5	54.7	51.7	54.2	77.8	58.9
Unleaded Midgrade	10.5	8.0	9.0	1.5	0.1	1.5	-	6.8
Unleaded Premium	<u>34.8</u>	<u>17.1</u>	<u>27.4</u>	<u>13.0</u>	<u>20.3</u>	<u>24.6</u>	-	<u>23.5</u>
Total Gasoline	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>1995/2000/2010 - TM&C Scenario⁽³⁾</u>								
Unleaded Regular	71.3	81.4	74.0	82.6	82.4	75.6	100.0	75.9
Unleaded Premium	<u>28.7</u>	<u>18.6</u>	<u>26.0</u>	<u>17.4</u>	<u>17.6</u>	<u>24.4</u>	-	<u>24.1</u>
Total Gasoline	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(1) By PADDs not models; based on split of 1989/1990 leaded to unleaded regular and midgrade.

(2) DOE (leaded) and published NPRA survey for Auto/Oil (unleaded grades).

(3) Midgrade split into regular and premium to simplify LP model representation; total PADD and U.S. pool octane same as NPC premise.

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TABLE A-23
REFINING PRODUCTION GASOLINE PROPERTIES
ACTUAL AVERAGE 1989⁽¹⁾ AND FUTURE RVP
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>Total U.S.</u>
<u>Actual</u>							
● Pool - Summer							
RVP, psi	9.9	9.9	9.4	9.4	10.3	8.5	9.5
T10 Distilled, °F	120	118	120	119	117	128	120
T50 Distilled, °F	206	205	212	202	207	217	210
T90 Distilled, °F	337	334	341	325	326	328	336
Benzene, Vol. % ⁽²⁾	1.75	1.61	1.64	1.91	2.58	2.00	1.75
Aromatics, Vol. %	33.3	29.7	31.6	25.6	31.8	35.2	31.8
Olefins, Vol. %	16.0	12.8	13.2	15.7	10.5 ⁽³⁾	9.5	12.7
MTBE, Vol. %	1.6	0.1	1.2	0.1	0.0	0.0	0.9
Sulfur, wppm ⁽³⁾	407	422	305	371	389	161	314
Octane, (R+M)/2 Clear	89.4	88.1	88.9	86.5	87.7	88.5	88.6
● Pool - Winter							
RVP, psi ⁽²⁾⁽⁴⁾	13.0	13.4	12.7	12.9	13.0	11.8	12.8
T90 Distilled, °F ⁽⁴⁾	329	326	333	317	318	320	328
● Grade - Summer							
Octane, (R+M)/2 Clear							
Unleaded Regular	87.3	87.1	87.2	85.7	87.3	87.4	87.2
Unleaded Midgrade	89.3	88.9	89.1	N/A	89.2	N/A	89.0
Unleaded Premium	93.0	92.3	92.6	90.9	91.9	92.0	92.5
<u>Base and Future RVP, psi</u>							
● 1990 Base							
Summer - Statutory	8.7	8.7	8.7	8.7	8.7	8.7	8.7
Winter ⁽⁵⁾	12.2	12.5	11.9	12.0	12.3	10.1	11.9
Annual	10.4	10.6	10.3	10.3	10.5	9.4	10.3
● Future - Summer							
1995 CG (EPA II) ⁽⁶⁾	8.2	8.4	7.9	7.9	8.7	7.5	8.0
1995 RFG	7.4	7.6	7.2	7.2	8.0	6.9	7.3
2000/2010 CG ⁽⁷⁾	8.7	8.7	8.7	8.7	8.7	8.7	8.7
2000/2010 RFG ⁽⁸⁾	6.9	6.9	6.9	6.9	6.9	6.6	6.9

(1) Published NPRA survey for Auto/Oil; 1989 average second and third quarter properties.

(2) Adjusted NIPER - Bartlesville; not weight averaged by market share; adjusted from consumer to production basis.

(3) Corrected by NPRA in final publication.

(4) December-February NIPER data. T90 based on -8°F U.S. average Δ from summer.

(5) Estimated first and fourth quarter average which is lower than adjusted NIPER winter data due to lower spring/fall RVPs.

(6) EPA Phase II RVP; based on 11/87 TM&C published survey and study for API entitled *U.S. Gasoline RVP Reduction Capabilities and Costs*.

(7) With complex formula and full opt-in in 2000+, CG RVP could increase to statutory 8.7 because it supplies only attainment areas. Sensitivity issue.

(8) Estimated substitute for complex formula, if complex formula not used. VCC is CARB 2.

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TABLE A-24

PREMISED REFINERY REFORMULATED GASOLINE SPECIFICATIONS⁽¹⁾

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Compliance Margins Included ⁽³⁾	U.S. (Ex. VCC) ⁽²⁾		VCC CARB Phase 2 2000/2010 ⁽⁵⁾
		1995	2000/2010 ⁽⁴⁾	
RVP, psi, Maximum				
Summer - Class C	0.3	7.7	6.5	-
- Class B	0.3	6.9	6.5	-
- California	0.4	6.9	-	6.6
Winter, Avg.	-	B ⁽⁶⁾	B	B
T50 Distilled, °F, Max.	-	-	210	200
T90 Distilled, °F, Max.	-	B	345	290
Benzene, Vol. %, Max.	0.3	0.7	0.7	0.8
Aromatics, Vol. %, Max.	-	27.9	25	22
Olefins, Vol. %, Max.	-	B	12	4
Oxygen, Wt. %, Min.	0.1	2.1	2.1	-
Min./Max.	0.2	-	-	2.0
Sulfur, ppm, Max.	-	B	150	30
Octane, (R+M)/2, Min.	0.1	B	B	B

⁽¹⁾ Conventional gasoline (CG) must not exceed 125% of base 1990 levels for T90, olefins and sulfur nor 100% of 1990 benzene and aromatics in 1995. In 2000+, CG and OG must not exceed 100% of 1990 base level emissions of V.O.C., toxics (T.A.P.) and NO_x using complex model equations; however, NO_x increases in OG due to increased oxygenates are exempt. 1990 base levels are assumed equal to 1989 NPRA survey levels shown in Table A-23, adjusted for seasonality.

⁽²⁾ Premised refinery gasoline specifications, developed by NPC PQTG, excluding California in 2000 and 2010 when CARB 2 applies.

⁽³⁾ Flat limits have NPC PQTG estimated refining compliance margins as shown. Add to refinery specifications to get consumer required specifications.

⁽⁴⁾ Revised average properties estimate from modified published complex formula. Alternate plan for 2000 and 2010 is linearized complex model from modified published complex formula for V.O.C. and T.A.P. reductions regulations with about 44% V.O.C. and 32% T.A.P. below statutory 1990 base level. We assume no increase in NO_x.

⁽⁵⁾ All are average limits except RVP and oxygen, which are flat limits.

⁽⁶⁾ B = base 1990 level. Assumed to equal 1989 NPRA survey level on Table A-23.

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TABLE A-25
REFINING PRODUCTION RATIOS
SUMMER QUARTERS ÷ ANNUAL
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>Average</u>
<u>PADD I</u>					
Inputs					
Crude Oils	1.054	1.012	0.979	1.027	1.018
Products					
Propane/Propylene/LPG	0.998	0.986	0.966	0.973	0.981
Finished Motor Gasoline	0.990	1.008	1.004	0.981	0.996
Kero Jet	0.987	1.052	0.957	0.917	0.978
Distillate	0.966	0.982	0.946	1.003	0.974
Residual	0.965	0.915	0.860	0.873	0.903
Asphalt	1.418	1.303	1.297	1.323	1.335
Total (Incl. Other)	1.014	1.011	0.991	0.999	1.004
<u>PADD II</u>					
Inputs					
Crude Oils	1.023	1.023	1.020	1.038	1.026
Products					
Propane/Propylene/LPG	1.049	1.053	1.027	1.015	1.036
Finished Motor Gasoline	1.014	1.004	0.994	1.014	1.007
Kero Jet	0.980	1.007	1.012	0.928	0.982
Distillate	0.995	1.003	0.972	1.026	0.999
Residual	0.925	0.888	0.912	0.966	0.923
Asphalt	1.260	1.256	1.222	1.186	1.231
Total (Incl. Other)	1.016	1.012	0.999	1.020	1.012
<u>PADD III</u>					
Inputs					
Crude Oils	0.997	1.007	1.018	1.029	1.013
Products					
Propane/Propylene/LPG	1.010	1.026	1.035	0.998	1.017
Finished Motor Gasoline	1.023	1.010	1.034	1.017	1.021
Kero Jet	0.948	0.936	0.937	0.965	0.947
Distillate	0.948	0.983	0.975	1.010	0.979
Residual	0.986	0.993	0.940	0.970	0.972
Asphalt	1.202	1.202	1.176	1.185	1.191
Total (Incl. Other)	1.004	1.000	1.017	1.017	1.010

TABLE A-25
REFINING PRODUCTION RATIOS
SUMMER QUARTERS ÷ ANNUAL
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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	<u>1987</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>Average</u>
<u>PADD IV</u>					
Inputs					
Crude Oils	1.044	1.057	1.039	1.056	1.049
Products					
Propane/Propylene/LPG	1.156	1.259	0.857	1.070	1.086
Finished Motor Gasoline	1.039	1.027	1.014	1.056	1.034
Kero Jet	0.996	0.974	0.962	0.927	0.965
Distillate	1.051	1.053	1.032	1.039	1.044
Residual	0.954	0.962	1.051	0.864	0.958
Asphalt	1.244	1.269	1.187	1.195	1.224
Total (Incl. Other)	1.050	1.050	1.032	1.052	1.046
<u>PADD V</u>					
Inputs					
Crude Oils	1.029	1.018	1.024	1.003	1.019
Products					
Propane/Propylene/LPG	1.097	1.098	1.155	1.188	1.135
Finished Motor Gasoline	1.030	0.999	1.030	1.007	1.017
Kero Jet	1.008	0.976	0.976	0.955	0.979
Distillate	1.012	1.021	1.026	1.001	1.015
Residual	0.985	0.948	0.983	1.018	0.984
Asphalt	1.454	1.213	1.165	1.176	1.252
Total (Incl. Other)					
<u>TOTAL U.S.</u>					
Inputs					
Crude Oils	1.016	1.014	1.000	1.005	1.009
Products					
Propane/Propylene/LPG	1.028	1.040	1.028	1.025	1.030
Finished Motor Gasoline	1.019	1.008	1.017	1.013	1.014
Kero Jet	0.973	0.967	0.954	0.953	0.962
Distillate	0.974	0.997	0.975	1.013	0.990
Residual	0.977	0.957	0.922	0.973	0.957
Asphalt	1.285	1.248	1.201	1.212	1.237
Total (Incl. Other)					

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TABLE A-26

ASSUMPTIONS FOR GASOLINE ALLOCATIONS BY TYPES

CONSUMER AND REFINERY SUPPLY AND DEMAND

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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- Used API project #058 to determine consumer demand rates for four types of gasoline (CG, OG, RFG-OG and RFG) by PADDs with and without opt-in and with and without 10% spillover.
- API project #058 shows 1989 gasoline demands designated by five categories as: OG; OG possible opt-in RFG; OG and RFG; RFG; and possible opt-in RFG. We assumed a 10% spillover for all OG, RFG and RFG-OG.
- We adjusted NPC SDLTG estimated PADD consumer gasoline demands to fit 1989 DOE PSA "apparent consumer demands" by PADDs relative to total U.S. demand. Because NPC SDLTG used more accurate marketing gasoline demand, their premised demand did not fit 1989 DOE PSA data, which overstates PADD III "apparent gasoline demand". This discrepancy is about 200 MBPD, which results from sales at PADD III refineries that are transported by buyers to PADD I to meet real marketing demand. This adjustment by TM&C was necessary to fit the real refinery supply and keep all results correct.
- Based on API project #058, we determined PADD consumer demand for the above five categories of gasoline, calculating CG by difference, assuming no change in demand for reformulated and oxygenated gasolines from the 1989 base. Based on initial uniform winter and summer demand (for clarity), we allocated these PADD consumer gasoline demands by five categories plus CG into annual, winter and summer for 1995 and 2000, based on no opt-in in 1995 and full opt-in in 2000, as shown in Table A-27.
- Next, we allocated these PADD consumer demands by five categories into the four gasoline types for annual, winter and summer for 1995 and 2000+, as shown in Table A-28 on our initial uniform demand basis (no seasonality for clarity). Table A-28A presents final seasonally adjusted PADD consumer gasoline demand rates by type. These PADD annual and seasonal consumer gasoline rates by type are changed to percentages of total gasoline in Table A-29.

TABLE A-26

ASSUMPTIONS FOR GASOLINE ALLOCATIONS BY TYPES

CONSUMER AND REFINERY SUPPLY AND DEMAND

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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- We assumed no seasonal overlaps or underlaps for this analysis. All refinery OG production is made only in and continues throughout the winter. Similarly, all refinery RFG production (that is V.O.C. controlled) is made only in and continues throughout the summer, for our LP model cases to simplify economics and processing analysis. Thereby, we make overall 4- to 6-month season peak rates. We do not fully match required annual rates because each season is assumed to be 6 months.
- We calculated PADD refinery gasoline production rates from consumer demands less imports plus exports less transfers in plus transfers out. We adjusted actual PADD imports and exports by average seasonal factors. We used historic transfers to and from other PADDs, adjusted by average seasonal factors. These seasonal rates allowed calculation of refinery gasoline production, both annually and seasonally. PADD gasoline rates are shown in Tables A-30 for 1995 and A-31 for 2000+, for F2 constant consumer demand and for required refining production by type.
- We assumed that all imports, exports and simple refinery production is CG. Seasonality for consumer demands as well as inter-PADD transfers, imports and exports were based on the average of 1989 and 1990.
- We assumed that PADD I refinery production was 100% RFG and RFG-OG. We also assumed that PADD IV was self-sufficient in RFG for Salt Lake City demand in 2000+. We assumed no spillover (in 2000+) of CARB 2 gasoline, which is only consumed in and produced in California. We also assumed that PADD VC consumer demands included California, Arizona and Nevada, because PADD V supply to Arizona and Nevada comes from or through California.
- We calculated PADDs I, II, IV, VOC and VC and then determined PADD III by difference, because it provides gasoline to balance PADDs I, II, IV and VC. Where gasoline is transferred from one PADD to another, we assumed source refineries produce the types of gasoline required in the probable consuming area of the PADD, based on normal pipeline and waterborne supply routes.

TABLE A-26

ASSUMPTIONS FOR GASOLINE ALLOCATIONS BY TYPES

CONSUMER AND REFINERY SUPPLY AND DEMAND

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

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- Final refining gasoline production (including annual and seasonal) by types by PADDs are presented as percentages of total gasoline production in Table A-32. These percentages were then used to develop the F1 high and F3 low refining gasoline production rates by type.

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Table A-27
FCAAA 1995 and 2000+ F2 Consumer Gasoline Demand by Catagories by PADDs
API Research Study 058 Results
NPC 1991-92 Study of U.S. Refining Industry

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	Base - No Spillover			Initial Estimate - With 10% Spillover (MBPCD)							
	MMGPY	MBPCD	%	%	Basis	1995			2000+		
						ANNUAL	SUMMER	WINTER	ANNUAL	SUMMER	WINTER
<u>PADD I</u>											
CG	9589	625.5	25.72	18.29	444.9	534.8	550.5	519.2	445.6	446.4	444.9
OG (OG[W] and CG[S])	240	15.7	0.64	0.71	17.2	16.4	15.7	17.2	16.4	15.7	17.2
OG/Possible Opt-In RFG (OG[W] and CG[S] or RFG-OG[W] and RFG[S])	4569	298.0	12.26	13.48	327.8	312.9	298.0	327.8	327.8	327.8	327.8
OG and RFG (RFG - OG[W] and RFG[S])	11494	749.8	30.83	33.91	824.7	824.7	824.7	824.7	824.7	824.7	824.7
RFG (RFG[W,S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Possible Opt-In RFG (CG[W,S] or RFG[W,S])	11390	743.0	30.55	33.61	817.3	743.0	743.0	743.0	817.3	817.3	817.3
PADD I TOTAL	37282	2432.0	100.00	100.00	2432.0	2432.0	2432.0	2432.0	2432.0	2432.0	2432.0
<u>PADD II</u>											
CG	15198	991.4	46.52	41.18	877.4	954.0	963.0	945.0	881.9	886.4	877.4
OG (OG[W] and CG[S])	1380	90.0	4.22	4.65	99.0	94.5	90.0	99.0	94.5	90.0	99.0
OG/Possible Opt-In RFG (OG[W] and CG[S] or RFG-OG[W] and RFG[S])	1370	89.4	4.19	4.61	98.3	93.8	89.4	98.3	98.3	98.3	98.3
OG and RFG (RFG - OG[W] and RFG[S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RFG (RFG[W,S])	4357	284.2	13.34	14.67	312.6	312.6	312.6	312.6	312.6	312.6	312.6
Possible Opt-In RFG (CG[W,S] or RFG[W,S])	10363	676.0	31.72	34.89	743.6	676.0	676.0	676.0	743.6	743.6	743.6
PADD II TOTAL	32668	2131.0	100.00	100.00	2131.0	2131.0	2131.0	2131.0	2131.0	2131.0	2131.0
<u>PADD III</u>											
CG	12069	787.3	66.95	63.64	748.4	771.9	774.9	768.9	749.3	750.2	748.4
OG (OG[W] and CG[S])	268	17.5	1.49	1.64	19.2	18.4	17.5	19.2	18.4	17.5	19.2
OG/Possible Opt-In RFG (OG[W] and CG[S] or RFG-OG[W] and RFG[S])	646	42.1	3.58	3.94	46.4	44.2	42.1	46.4	46.4	46.4	46.4
OG and RFG (RFG - OG[W] and RFG[S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RFG (RFG[W,S])	1901	124.0	10.54	11.60	136.4	136.4	136.4	136.4	136.4	136.4	136.4
Possible Opt-In RFG (CG[W,S] or RFG[W,S])	3144	205.1	17.44	19.18	225.6	205.1	205.1	205.1	225.6	225.6	225.6
PADD III TOTAL	18028	1176.0	100.00	100.00	1176.0	1176.0	1176.0	1176.0	1176.0	1176.0	1176.0
<u>PADD IV</u>											
CG	1740	113.5	50.89	45.98	102.5	109.4	113.5	105.2	106.7	110.8	102.5
OG (OG[W] and CG[S])	1269	82.8	37.12	40.83	91.1	86.9	82.8	91.1	86.9	82.8	91.1
OG/Possible Opt-In RFG (OG[W] and CG[S] or RFG-OG[W] and RFG[S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG and RFG (RFG - OG[W] and RFG[S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RFG (RFG[W,S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Possible Opt-In RFG (CG[W,S] or RFG[W,S])	410	26.7	11.99	13.19	29.4	26.7	26.7	26.7	29.4	29.4	29.4
PADD IV TOTAL	3419	223.0	100.00	100.00	223.0	223.0	223.0	223.0	223.0	223.0	223.0

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Table A-27

FCAAA 1995 and 2000+ F2 Consumer Gasoline Demand by Categories by PADDs
API Research Study 058 Results
NPC 1991-92 Study of U.S. Refining Industry

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	Base - No Spillover			Initial Estimate - With 10% Spillover (MBPCD)							
	MMGPY	MBPCD	%	%	Basis	1995			2000+		
						ANNUAL	SUMMER	WINTER	ANNUAL	SUMMER	WINTER
<u>PADD V OC</u>											
CG	1749	114.1	42.41	36.65	98.6	106.4	114.1	98.6	106.4	114.1	98.6
OG (OG[W] and CG[S])	2375	154.9	57.59	63.35	170.4	162.7	154.9	170.4	162.7	154.9	170.4
OG/Possible Opt-In RFG (OG[W] and CG[S] or RFG-OG[W] and RFG[S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG and RFG (RFG - OG[W] and RFG[S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RFG (RFG[W,S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Possible Opt-In RFG (CG[W,S] or RFG[W,S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PADD V OC TOTAL	4124	269.0	100.00	100.00	269.0	269.0	269.0	269.0	269.0	269.0	269.0
<u>PADD V C</u>											
CG	1216	79.3	8.03	-1.16	-11.5	10.9	29.7	-7.9	-6.3	-1.0	-11.5
OG (OG[W] and CG[S])	1600	104.4	10.57	11.63	114.8	109.6	104.4	114.8	109.6	104.4	114.8
OG/Possible Opt-In RFG (OG[W] and CG[S] or RFG-OG[W] and RFG[S])	4164	271.6	27.52	30.27	298.8	285.2	271.6	298.8	298.8	298.8	298.8
OG and RFG (RFG - OG[W] and RFG[S])	7604	496.0	50.26	55.28	545.6	545.6	545.6	545.6	545.6	545.6	545.6
RFG (RFG[W,S])	0	0.0	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Possible Opt-In RFG (CG[W,S] or RFG[W,S])	547	35.7	3.62	3.98	39.2	35.7	35.7	35.7	39.2	39.2	39.2
PADD V C TOTAL	15131	987.0	100.00	100.00	987.0	987.0	987.0	987.0	987.0	987.0	987.0
<u>Total U.S.</u>											
CG	41561	2711	37.56	31.32	2260.4	2487.4	2545.7	2429.1	2283.7	2306.9	2260.4
OG (OG[W] and CG[S])	7132	465.2	6.45	7.09	511.8	488.5	465.2	511.8	488.5	465.2	511.8
OG/Possible Opt-In RFG (OG[W] and CG[S] or RFG-OG[W] and RFG[S])	10749	701.2	9.71	10.69	771.3	736.2	701.2	771.3	771.3	771.3	771.3
OG and RFG (RFG - OG[W] and RFG[S])	19098	1245.8	17.26	18.99	1370.4	1370.4	1370.4	1370.4	1370.4	1370.4	1370.4
RFG (RFG[W,S])	6258	408.2	5.66	6.22	449.0	449.0	449.0	449.0	449.0	449.0	449.0
Possible Opt-In RFG (CG[W,S] or RFG[W,S])	25854	1686.5	23.37	25.70	1855.1	1686.5	1686.5	1686.5	1855.1	1855.1	1855.1
U.S. TOTAL	110652	7218.0	100.00	100.00	7218.0	7218.0	7218.0	7218.0	7218.0	7218.0	7218.0

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Table A-28
F2 Initial PADD Consumer Gasoline Demands by Type – MBPCD
NPC 1991-92 Study of U.S. Refining Industry

GASOLINE TYPES	1995			2000+		
	<u>ANNUAL</u>	<u>SUMMER</u>	<u>WINTER</u>	<u>ANNUAL</u>	<u>SUMMER</u>	<u>WINTER</u>
<u>PADD I</u>						
CG	1434.7	1607.2	1262.1	453.5	462.1	444.9
OG	172.5	0.0	345.1	8.6	0.0	17.2
RFG-OG	412.4	0.0	824.7	576.3	0.0	1152.6
RFG	<u>412.4</u>	<u>824.7</u>	<u>0.0</u>	<u>1393.6</u>	<u>1969.9</u>	<u>817.3</u>
TOTAL	2432.0	2432.0	2432.0	2432.0	2432.0	2432.0
<u>PADD II</u>						
CG	1719.7	1818.4	1621.0	927.0	976.5	877.4
OG	98.7	0.0	197.3	49.5	0.0	99.0
RFG-OG	0.0	0.0	0.0	49.2	0.0	98.3
RFG	<u>312.6</u>	<u>312.6</u>	<u>312.6</u>	<u>1105.4</u>	<u>1154.5</u>	<u>1056.2</u>
TOTAL	2131.0	2131.0	2131.0	2131.0	2131.0	2131.0
<u>PADD III</u>						
CG	1006.8	1039.6	974.0	758.0	767.7	748.4
OG	32.8	0.0	65.6	9.6	0.0	19.2
RFG-OG	0.0	0.0	0.0	23.2	0.0	46.4
RFG	<u>136.4</u>	<u>136.4</u>	<u>136.4</u>	<u>385.2</u>	<u>408.4</u>	<u>362.0</u>
TOTAL	1176.0	1176.0	1176.0	1176.0	1176.0	1176.0
<u>PADD IV</u>						
CG	177.5	223.0	132.0	148.1	193.6	102.5
OG	45.5	0.0	91.1	45.5	0.0	91.1
RFG-OG	0.0	0.0	0.0	0.0	0.0	0.0
RFG	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>29.4</u>	<u>29.4</u>	<u>29.4</u>
TOTAL	223.0	223.0	223.0	223.0	223.0	223.0
<u>PADD V OC</u>						
CG	183.8	269.0	98.6	183.8	269.0	98.6
OG	85.2	0.0	170.4	85.2	0.0	170.4
RFG-OG	0.0	0.0	0.0	0.0	0.0	0.0
RFG	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>	<u>0.0</u>
TOTAL	269.0	269.0	269.0	269.0	269.0	269.0
<u>PADD V C</u>						
CG	234.6	441.4	27.8	45.9	103.3	-11.5
OG	206.8	0.0	413.6	57.4	0.0	114.8
RFG-OG	272.8	0.0	545.6	422.2	0.0	844.4
RFG	<u>272.8</u>	<u>545.6</u>	<u>0.0</u>	<u>461.5</u>	<u>883.7</u>	<u>39.2</u>
TOTAL	987.0	987.0	987.0	987.0	987.0	987.0
<u>U.S. TOTAL</u>						
CG	4757.1	5398.6	4115.6	2516.3	2772.2	2260.4
OG	641.5	0.0	1283.0	255.9	0.0	511.8
RFG-OG	685.2	0.0	1370.4	1070.8	0.0	2141.7
RFG	<u>1134.2</u>	<u>1819.4</u>	<u>449.0</u>	<u>3375.0</u>	<u>4445.9</u>	<u>2304.2</u>
TOTAL	7218.0	7218.0	7218.0	7218.0	7218.0	7218.0

Table A-28A
F2 Final PADD Consumer Gasoline Demands by Type – MBPCD
Seasonally Adjusted
NPC 1991–92 Study of U.S. Refining Industry

<u>Gasoline Types</u>	<u>1995</u>			<u>2000+</u>		
	<u>Annual</u>	<u>Summer</u>	<u>Winter</u>	<u>Annual</u>	<u>Summer</u>	<u>Winter</u>
<u>PADD I</u>						
CG	1435.9	1618.5	1253.3	453.5	465.3	441.7
OG	171.3		342.7	8.6		17.1
RFG-OG	409.5		819.0	572.3		1144.5
RFG	415.3	830.5		1397.6	1983.7	811.6
Total	2432.0	2449.0	2414.9	2432.0	2449.0	2414.9
<u>PADD II</u>						
CG	1721.3	1847.5	1595.1	927.7	992.1	863.4
OG	97.1		194.2	48.7		97.4
RFG-OG				48.4		96.7
RFG	312.6	317.6	307.6	1106.2	1173.0	1039.3
Total	2131.0	2165.1	2096.9	2131.0	2165.1	2096.9
<u>PADD III</u>						
CG	1007.5	1061.4	953.6	758.2	783.8	732.7
OG	32.1		64.2	9.4		18.8
RFG-OG				22.7		45.4
RFG	136.4	139.3	133.5	385.7	416.9	354.4
Total	1176.0	1200.7	1151.3	1176.0	1200.7	1151.3
<u>PADD IV</u>						
CG	180.2	236.2	124.2	150.8	205.0	96.5
OG	42.8		85.7	42.8		85.7
RFG-OG						
RFG				29.4	31.2	27.7
Total	223.0	236.2	209.9	223.0	236.2	209.9
<u>PADD V OC</u>						
CG	185.5	274.4	96.6	185.5	274.4	96.6
OG	83.5		167.0	83.5		167.0
RFG-OG						
RFG						
Total	269.0	274.4	263.6	269.0	274.4	263.6
<u>PADD V C</u>						
CG	238.7	450.2	27.2	47.1	105.4	-11.2
OG	202.7		405.3	56.3		112.5
RFG-OG	267.4		534.7	413.8		827.5
RFG	278.3	556.5		469.9	901.3	38.5
Total	987.0	1006.7	967.3	987.0	1006.7	967.3
<u>U.S. Total</u>						
CG	4769.1	5488.1	4050.0	2522.9	2826.0	2219.7
OG	629.5		1259.0	249.3		498.6
RFG-OG	676.8		1353.7	1057.1		2114.2
RFG	1142.6	1844.0	441.2	3388.8	4506.1	2271.4
Total	7218.0	7332.1	7103.9	7218.0	7332.1	7103.9

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Table A-29

F2 Final PADD Consumer Gasoline Demands by Type – %

NPC 1991–92 Study of U.S. Refining Industry

Gasoline Types	1995			2000+		
	Annual	Summer	Winter	Annual	Summer	Winter
<u>PADD I</u>						
CG	59.0	66.1	51.9	18.6	19.0	18.3
OG	7.0		14.2	0.4		0.7
RFG–OG	16.8		33.9	23.5		47.4
RFG	17.1	33.9		57.5	81.0	33.6
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD II</u>						
CG	80.8	85.3	76.1	43.5	45.8	41.2
OG	4.6		9.3	2.3		4.6
RFG–OG				2.3		4.6
RFG	14.7	14.7	14.7	51.9	54.2	49.6
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD III</u>						
CG	85.7	88.4	82.8	64.5	65.3	63.6
OG	2.7		5.6	0.8		1.6
RFG–OG				1.9		3.9
RFG	11.6	11.6	11.6	32.8	34.7	30.8
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD IV</u>						
CG	80.8	100.0	59.2	67.6	86.8	46.0
OG	19.2		40.8	19.2		40.8
RFG–OG						
RFG				13.2	13.2	13.2
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD V OC</u>						
CG	69.0	100.0	36.7	69.0	100.0	36.7
OG	31.0		63.3	31.0		63.3
RFG–OG						
RFG						
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD V C</u>						
CG	24.2	44.7	2.8	4.8	10.5	–1.2
OG	20.5		41.9	5.7		11.6
RFG–OG	27.1		55.3	41.9		85.6
RFG	28.2	55.3		47.6	89.5	4.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>U.S. Total</u>						
CG	66.1	74.9	57.0	35.0	38.5	31.2
OG	8.7		17.7	3.5		7.0
RFG–OG	9.4		19.1	14.6		29.8
RFG	15.8	25.1	6.2	46.9	61.5	32.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE A-30

**1995 F2 PADD REFINERY GASOLINE PRODUCTION BY TYPE – MBPCD
 BASED ON PADD CONSUMER GASOLINE DEMANDS BY TYPE
 NPC 1991-92 STUDY OF US REFINING INDUSTRY**

Page 1 of 2

	Total			Summer By Type		Winter By Type			
	<u>Annual</u>	<u>Summer</u>	<u>Winter</u>	<u>CG</u>	<u>RFG</u>	<u>CG</u>	<u>OG</u>	<u>RFG - OG</u>	<u>RFG</u>
<u>PADD I</u>									
Consumer Demand	2,432	2,449	2,415	1,619	830	1,253	343	819	
Imports	329	327	331	327		331			
Exports	3	2	4	2		4			
Trans Fr II	57	58	56	58		56			
To II	160	162	158	162		158			
Fr III	1,524	1,546	1,502	1,387	159	1,017	343	142	
Smpl Rfy Prod	11	11	11	11		11			
Conv Rfy Prod	674	671	677		671			677	
<u>PADD II</u>									
Consumer Demand	2,131	2,165	2,097	1,847	318	1,595	194		308
Imports	12	12	12	12		12			
Exports	1	1	1	1		1			
Trans To I	57	58	56	58		56			
Fr I	160	162	158	162		158			
To IV	30	35	25	35		5	20		
Fr IV	15	15	15	15		15			
To III	55	55	55	55		55			
Fr III	415	441	389	391	50	308	31		50
Smpl Rfy Prod	2	2	2	2		2			
Conv Rfy Prod	1,670	1,682	1,658	1,414	268	1,217	183		258
<u>PADD III</u>									
Consumer Demand	1,176	1,201	1,151	1,062	139	953	64		134
Imports	2	2	2	2		2			
Exports	28	27	29	27		29			
Trans To I	1,524	1,546	1,502	1,387	159	1,017	343	142	
To II	415	441	389	391	50	308	31		50
Fr II	55	55	55	55		55			
To VC	32	25	39	25		14	25		
Smpl Rfy Prod	32	32	32	32		32			
Conv Rfy Prod	3,086	3,151	3,021	2,803	348	2,232	463	142	184
<u>PADD IV</u>									
Consumer Demand	223	236	210	236		124	86		
Trans To II	15	15	15	15		15			
Fr II	30	35	25	35		5	20		
To VOC	29	29	29	29		16	13		
Rfy Production	237	245	229	245		150	79		

TABLE A-30

**1995 F2 PADD REFINERY GASOLINE PRODUCTION BY TYPE – MBPCD
 BASED ON PADD CONSUMER GASOLINE DEMANDS BY TYPE
 NPC 1991-92 STUDY OF US REFINING INDUSTRY**

Page 2 of 2

	<u>Total</u>			<u>Summer By Type</u>		<u>Winter By Type</u>			
	<u>Annual</u>	<u>Summer</u>	<u>Winter</u>	<u>CG</u>	<u>RFG</u>	<u>CG</u>	<u>OG</u>	<u>RFG</u> <u>- OG</u>	<u>RFG</u>
<u>PADD VOC</u>									
Consumer Demand	269	274	264	274		97	167		
Imports	5	7	3	7		3			
Exports	1	1	1	1		1			
Trans Fr IV	29	29	29	29		16	13		
Fr VC	18	17	19	17		19			
Conv Rfy Prod	218	222	214	222		60	154		
 <u>PADD VC</u>									
Consumer Demand	987	1,007	967	450	557	27	405	535	
Imports	21	29	13	29		13			
Exports	6	4	8	4		8			
Trans Fr III	32	25	39	25		14	25		
To VOC	18	17	19	17		19			
Smpl Rfy Prod	27	27	27	27		27			
Conv Rfy Prod	931	947	915	390	557		380	535	
 <u>U.S Total</u>									
Consumer Demand	7,218	7,332	7,104	5,488	1,844	4,049	1,259	1,354	442
Imports	369	377	361	377		361			
Exports	39	35	43	35		43			
Smpl Rfy Prod	72	72	72	72		72			
Conv Rfy Prod	6,816	6,918	6,714	5,074	1,844	3,659	1,259	1,354	442

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TABLE A-31

**2000+ F2 PADD REFINERY GASOLINE PRODUCTION BY TYPE – MBPCD
 BASED ON PADD CONSUMER GASOLINE DEMANDS BY TYPE
 NPC 1991-92 STUDY OF US REFINING INDUSTRY**

Page 1 of 2

	Total			Summer By Type			Winter By Type				
	Annual	Summer	Winter	CG	RFG	CARB 2	CG	OG	RFG - OG	RFG	CARB 2
<u>PADD I</u>											
Consumer Demand	2,432	2,449	2,415	465	1,984		442	17	1,144	812	
Imports	329	327	331	327			331				
Exports	3	2	4	2			4				
Trans Fr II	57	58	56	13	45		23				33
To II	160	162	158	80	82		78				80
Fr III	1,524	1,546	1,502	196	1,350		159	17	467	859	
Smpl Rfy Prod	11	11	11	11			11				
Conv Rfy Prod	674	671	677		671				677		
<u>PADD II</u>											
Consumer Demand	2,131	2,165	2,097	992	1,173		864	97	97	1,039	
Imports	12	12	12	12			12				
Exports	1	1	1	1			1				
Trans To I	57	58	56	13	45		23				33
Fr I	160	162	158	80	82		78				80
To IV	30	35	25	35			5	20			
Fr IV	15	15	15	15			15				
To III	55	55	55	37	18		40				15
Fr III	415	441	389	216	225		165	20	11	193	
Smpl Rfy Prod	2	2	2	2			2				
Conv Rfy Prod	1,670	1,682	1,658	753	929		661	97	86	814	
<u>PADD III</u>											
Consumer Demand	1,176	1,201	1,151	784	417		733	19	45	354	
Imports	2	2	2	2			2				
Exports	28	27	29	27			29				
Trans To I	1,524	1,546	1,502	196	1,350		159	17	467	859	
To II	415	441	389	216	225		165	20	11	193	
Fr II	55	55	55	37	18		40				15
To VC	32	25	39	25			14	25			
Smpl Rfy Prod	32	32	32	32			32				
Conv Rfy Prod	3,086	3,151	3,021	1,177	1,974		1,026	81	523	1,391	
<u>PADD IV</u>											
Consumer Demand	223	236	210	205	31		96	86		28	
Trans To II	15	15	15	15			15				
Fr II	30	35	25	35			5	20			
To VOC	29	29	29	29			16	13			
Rfy Production	237	245	229	214	31		122	79		28	

TABLE A-31

**2000+ F2 PADD REFINERY GASOLINE PRODUCTION BY TYPE – MBPCD
 BASED ON PADD CONSUMER GASOLINE DEMANDS BY TYPE
 NPC 1991-92 STUDY OF US REFINING INDUSTRY**

Page 2 of 2

	Total			Summer By Type			Winter By Type				
	Annual	Summer	Winter	CG	RFG	CARB 2	CG	OG	RFG - OG	RFG	CARB 2
<u>PADD VOC</u>											
Consumer Demand	269	274	264	274			97	167			
Imports	12	7	16	7			16				
Exports	1	1	1	1			1				
Trans Fr IV	29	29	27	29			16	13			
To VC			20					20			
Fr VC		17	26	17			26				
Conv Rfy Prod	218	222	214	222			40	174			
<u>PADD VC</u>											
Consumer Demand	987	1,007	967	120		887	7	107			853
Imports	14	29		29							
Exports	6	4	8	4			8				
Trans Fr III	32	25	39	25			14	25			
Fr VOC			20					20			
To VOC		17	26	17			26				
Smpl Rfy Prod	27	27	27	27			27				
Conv Rfy Prod	931	947	915	60		887		62			853
<u>U.S Total</u>											
Consumer Demand	7,218	7,332	7,104	2,840	3,605	887	2,239	493	1,286	2,233	853
Imports	369	377	361	377			361				
Exports	39	35	43	35			43				
Smpl Rfy Prod	72	72	72	72			72				
Conv Rfy Prod	6,816	6,918	6,714	2,426	3,605	887	1,849	493	1,286	2,233	853

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4/22/92

TABLE A-32

PADD CONVERSION REFINERY GASOLINE PRODUCTION BY TYPE - %
NPC 1991-92 STUDY OF US REFINING INDUSTRY

Gasoline Types	1995			2000+		
	<u>Annual</u>	<u>Summer</u>	<u>Winter</u>	<u>Annual</u>	<u>Summer</u>	<u>Winter</u>
<u>PADD I</u>						
CG						
OG						
RFG-OG	50.2		100.0	50.2		100.0
RFG	49.8	100.0		49.8	100.0	
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD II</u>						
CG	78.8	84.1	73.4	42.3	44.8	39.9
OG	5.5		11.0	2.9		5.9
RFG-OG	0.0		0.0	2.6		5.2
RFG	15.7	15.9	15.6	52.2	55.2	49.1
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD III</u>						
CG	81.6	89.0	73.9	35.7	37.4	34.0
OG	7.5		15.3	1.3		2.7
RFG-OG	2.3		4.7	8.5		17.3
RFG	8.6	11.0	6.1	54.5	62.6	46.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD IV</u>						
CG	83.3	100.0	65.5	70.9	87.3	53.3
OG	16.7		34.5	16.7		34.5
RFG-OG						
RFG				12.4	12.7	12.2
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD VOC</u>						
CG	64.7	100.0	28.0	60.1	100.0	18.7
OG	35.3		72.0	39.9		81.3
RFG-OG						
RFG						
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>PADD VC</u>						
CG	20.9	41.2		3.2	6.3	
OG	20.4		41.5	3.3		6.8
RFG-OG	28.7		58.5			
RFG	29.9	58.8				
CARB 2				93.4	93.7	93.2
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>U.S. Total</u>						
CG	64.1	73.3	54.5	31.4	35.1	27.5
OG	9.2		18.8	3.6		7.3
RFG-OG	9.9		20.2	9.4		19.2
RFG	16.8	26.7	6.6	42.8	52.1	33.3
CARB 2				12.8	12.8	12.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

TABLE A-33

ASSUMPTIONS FOR DIESEL/NO. 2 FUEL ALLOCATIONS BY TYPES

CONSUMER AND REFINERY SUPPLY AND DEMAND

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

- Used NPC SDLTG estimate by regions of 0.05 weight % sulfur on-highway diesel and total diesel/No. 2 fuel consumer demand rates for 1989 dated 5/4/92. We combined these regional data into PADDs and ratioed them to fit the F2 1995 and 2000 total diesel/No. 2 fuel consumer demands. We used NPC PQTG premised 50% spillover of all non-California on-highway diesel consumer demand into 0.25 Wt. % sulfur off-highway diesel and heating oil markets.
- TM&C used *NPN Factbook* to estimate California on-highway diesel consumer demand rate. This is premised by NPC PQTG to be 100% low aromatics/0.05 wt. % sulfur diesel with no spillover and assumed by TM&C to be manufactured in California refineries only. Other California diesel/No. 2 fuel consumer demand assumed by TM&C to be 90% low (0.05 weight %) sulfur.
- Imports, exports and transfers between PADDs are based on average 1989-90 rates. Imports, exports, inventory changes and simple refinery production rates are all assumed by TM&C to be 0.25 wt. % sulfur diesel/No. 2 fuel. This inventory change assumption minimizes the seasonal conversion refinery production swing between 0.05 and 0.25 weight % sulfur types.
- Seasonality of total diesel/No. 2 fuel consumer demand, imports, exports, inventory changes and transfers between PADDs was based on 1989-90 average seasonal rates. On-highway diesel summer consumer demands were assumed by TM&C to be 105% of annual averages, based on data from PADDs with mostly on-highway diesel.
- Transfers into each PADD are split between on-highway and other diesel/No. 2 fuel types according to the ratio in the receiving PADD between their respective consumer demands adjusted to account for spillover, imports, exports, inventory changes and simple refinery production.
- We calculated PADDs I, II, IV, VOC and VC refining annual and seasonal production rates of 0.05% sulfur diesel and 0.25% sulfur No. 2 fuel type for the F2 scenario and then determined PADD III by difference, as shown in Table A-34.

TABLE A-33

ASSUMPTIONS FOR DIESEL/NO. 2 FUEL ALLOCATIONS BY TYPES

CONSUMER AND REFINERY SUPPLY AND DEMAND

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

- We calculated percentage of total diesel/No. 2 fuel for both types for the F2 PADD rates, as shown in Table A-35. We then applied these diesel/No. 2 percentages by types to the F1 and F3 scenarios.

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TABLE A-34

**F2 PADD REFINERY DIESEL/NO. 2 FUEL PRODUCTION BY TYPE – MBPCD(1)
 BASED ON PADD CONSUMER DIESEL/NO. 2 FUEL DEMANDS BY TYPE
 NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY**

Page 1 of 2

	Total			Summer by Type			Winter by Type		
	Annual	Summer	Winter	CA	On Hwy	Other	CA	On Hwy	Other
<u>PADD I</u>									
Consumer Demand	1,204	973	1,435		691	282		625	810
Imports	279	256	302			256			302
Exports	4	4	4			4			4
From Inventory		(110)	110			(110)			110
Trans Fr II	19	16	22		15	1		13	9
III	612	526	698		450	76		417	281
To II	63	64	62		55	9		50	12
Smpl Rfy Prod	37	37	37			37			37
Conv Rfy Prod	324	316	332		281	35		245	87
<u>PADD II</u>									
Consumer Demand	849	859	839		734	125		664	175
Imports	5	5	5			5			5
From Inventory		(10)	10			(10)			10
Trans Fr I	63	64	62		55	9		50	12
III	122	145	99		125	20		79	20
IV	10	4	16		3	1		12	4
To I	19	16	22		15	1		13	9
III	15	16	14		11	5		9	5
IV	4	4	4		3	1		3	1
Smpl Rfy Prod	5	5	5			5			5
Conv Rfy Prod	682	682	682		580	102		548	134
<u>PADD III</u>									
Consumer Demand	518	540	496		369	171		333	163
Imports	5	5	5			5			5
Exports	65	48	82			48			82
From Inventory		(30)	30			(30)			30
Trans Fr II	15	16	14		11	5		9	5
To I	612	526	698		450	76		417	281
II	122	145	99		125	20		79	20
V	4	7	1		7			1	
Smpl Rfy Prod	46	46	46			46			46
Conv Rfy Prod	1,255	1,229	1,281		940	289		821	460

TABLE A-34

**F2 PADD REFINERY DIESEL/NO. 2 FUEL PRODUCTION BY TYPE – MBPCD(1)
 BASED ON PADD CONSUMER DIESEL/NO. 2 FUEL DEMANDS BY TYPE
 NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY**

Page 2 of 2

	Total			Summer by Type			Winter by Type		
	<u>Annual</u>	<u>Summer</u>	<u>Winter</u>	<u>CA</u>	<u>On Hwy</u>	<u>Other</u>	<u>CA</u>	<u>On Hwy</u>	<u>Other</u>
<u>PADD IV</u>									
Consumer Demand	108	113	103		76	37		68	35
Trans Fr II	4	4	4		3	1		3	1
To II	10	4	16		3	1		12	4
V	8	15	1		10	5		1	
Conv Rfy Prod	122	128	116		86	42		78	38
<u>PADD VCOC</u>									
Consumer Demand	147	154	140		88	66		80	60
Imports	2	2	2			2			2
Exports	9	6	12			6			12
Trans Fr IV	8	15	1		10	5		1	
VCC	19	23	15			23		6	9
To VCC	9	18			18				
Smpl Rfy Prod	26	26	26			26			26
Conv Rfy Prod	110	112	108		96	16		73	35
<u>PADD VCC(2)</u>									
Consumer Demand	270	282	258	140	142		126	132	
Imports	3	3	3			3			3
Exports	19	12	26			12			26
Trans Fr III	4	7	1		7			1	
VCOC	9	18			18				
To VCOC	19	23	15			23		6	9
Smpl Rfy Prod	32	32	32			32			32
Conv Rfy Prod	260	257	263	140	117		126	137	
<u>U.S. Total</u>									
Consumer Demand	3,096	2,921	3,271	140	2,100	681	126	1,902	1,243
Imports	294	271	317			271			317
Exports	97	70	124			70			124
From Inventory		(150)	150			(150)			150
Smpl Rfy Prod	146	146	146			146			146
Conv Rfy Prod	2,753	2,724	2,782	140	2,100	484	126	1,902	754

(1) For 1995, 2000 and 2010.

(2) On highway indicates other low sulfur demand in California.

TABLE A-35

PADD CONVERSION REFINERY DIESEL/NO. 2 FUEL PRODUCTION BY TYPE - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>U.S Total</u>
<u>Annual</u>							
Diesel, LA, 0.05%S						51.2	4.6
Diesel, 0.05%S	81.2	82.7	70.2	67.2	77.3	48.8	69.0
No. 2 Fuel, 0.25%S	18.8	17.3	29.8	32.8	22.7		26.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>Summer</u>							
Diesel, LA, 0.05%S						54.5	4.9
Diesel, 0.05%S	88.9	85.0	76.5	67.2	85.7	45.5	73.1
No. 2 Fuel, 0.25%S	11.1	15.0	23.5	32.8	14.3		22.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>Winter</u>							
Diesel, LA, 0.05%S						47.9	4.3
Diesel, 0.05%S	73.8	80.4	64.1	67.2	67.6	52.1	65.0
No. 2 Fuel, 0.25%S	26.2	19.6	35.9	32.8	32.4		30.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE A1-1
REFINING RAW MATERIAL INPUT RATES DETAIL
1995 F2 ANNUAL SCENARIO - MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	U.S. <u>TOTAL</u>
Domestic Crudes	43	44	1,820	17	2,827	192	386	472	1,578	234	7,613
Foreign Crudes	<u>1,057</u>	<u>89</u>	<u>1,025</u>	<u>7</u>	<u>2,977</u>	<u>43</u>	<u>60</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>5,525</u>
Subtotal Crudes	1,100	133	2,845	24	5,804	235	446	603	1,710	238	13,138
Natural Gasoline/LSR			38		134	2	5		5		184
Reformate 100 RONC	27	(3)	35	(1)	(17)	1	2	(21)	23	(4)	42
Naphtha	8			(1)	85		(1)	2	5	(1)	97
Vacuum Gas Oil	169	2	27		218	(29)	(5)	(8)	31	(4)	401
Vacuum Resid					13						13
Normal Butane	2		38		71		12	4	8		135
Iso-butane	2		45		93		3	2	6		151
MTBE	70		33		60		3	7	60	2	235
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>14</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>16</u>
Total Input	1,378	132	3,063	22	6,475	209	465	589	1,848	231	14,412

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TABLE A1-2
REFINING PRODUCT RATES DETAIL
1995 F2 ANNUAL SCENARIO- MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Motor Gasolines											
CG Regular		11	1,071	2	1,863	32	163	116	147	27	3,432
CG Premium			245		655		34	25	48		1,007
OG Regular			74		171		33	63	144		485
OG Premium			17		60		7	14	46		144
RFG-OG Regular	242				53				202		497
RFG-OG Premium	97				18				65		180
RFG Regular	239		214		197				211		861
RFG Premium	96		49		69				68		282
Subtotal-Base	674	11	1,670	2	3,086	32	237	218	931	27	6,888
RFG/OG BTU Incrmt	21		10		18		1	2	18		70
Aviation Gasolines			3		15		1		6		25
Kero Jet/Kero	88	2	209	2	727	22	35	125	239	28	1,477
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									133		133
Diesel, 0.05%S	263		564		881		82	85	127		2,002
No. 2 Fuel, 0.25%S	61	37	118	5	374	46	40	25		58	764
Subtotal	324	37	682	5	1,255	46	122	110	260	58	2,899
Residual Fuels											
<0.3% Sulfur	22	1	2		9	27	1	9	3	17	91
0.7-1.0% Sulfur	69	3	10	2	52	3	1	22	12	4	178
>1.0% Sulfur	26	3	52		239	(5)	7	72	182	30	606
Subtotal	117	7	64	2	300	25	9	103	197	51	875
Asphalt/Road Oil	44	44	136	5	84	20	28		19	44	424
Marketable Coke - 400 #B	12		70		146		5	11	86		330
Catalytic Coke - 400 #B	30		45		93		6	6	25		205
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	3	14	18	5	49	31	1		3	5	129
Petrochem Naphtha		1			3	6			4	2	16
Lubes/Wax	11	13	24		97	16	2		17	5	185
Petrochem Gas Oil			18		152	2	1		4	3	180
Carbon Black Feed			4		31				1		36
Propene	13		23		65				1		102
Butanes/Butenes	6		2		119	3		1	18	1	150
Propane	30		69		149	1	7	9	25		290
Process Gas/C2-FOE B	66	2	136	1	308	4	19	19	111	5	671
(Gain)/Loss	(69)	1	(136)		(308)	1	(9)	(15)	(117)	2	(650)
Total Products	1,378	132	3,063	22	6,475	209	465	589	1,848	231	14,412

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TABLE A1-3
REFINING CRUDE INPUT SUMMARY
1995 F2 ANNUAL SCENARIO
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Typ</u>	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
<u>RATES - MBPCD</u>												
<u>Domestic</u>												
Low Sulfur	S	14	34	1,223	13	1,984	186	255	31	42	25	3,807
High Sulfur Light	HL			371	4	174		69				618
High Sulfur Heavy	HH	29	10	226		669	6	62	441	1,536	209	3,188
Subtotal		43	44	1,820	17	2,827	192	386	472	1,578	234	7,613
<u>Foreign</u>												
Low Sulfur	S	612	13	364		902	29	5	125	106	0	2,156
High Sulfur Light	HL	172		223	1	697		35	5	14		1,146
High Sulfur Heavy	HH	273	76	438	6	1,378	14	20	2	13	4	2,223
Subtotal		1,057	89	1,025	7	2,977	43	60	131	132	4	5,525
<u>Combined</u>												
Low Sulfur	S	626	47	1,587	13	2,886	215	260	156	148	25	5,963
High Sulfur Light	HL	172		594	5	871		104	5	14		1,764
High Sulfur Heavy	HH	302	86	664	6	2,047	20	82	443	1,549	213	5,411
Subtotal		1,100	133	2,845	24	5,804	235	446	603	1,710	238	13,138
<u>% - Combined</u>												
Low Sulfur	S	56.9	35.5	55.8	54.4	49.7	91.6	58.3	25.8	8.6	10.6	45.4
High Sulfur Light	HL	15.6		20.9	18.8	15.0		23.3	0.8	0.8		13.4
High Sulfur Heavy	HH	27.5	64.5	23.3	26.8	35.3	8.4	18.4	73.4	90.6	89.4	41.2
Subtotal		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>												
Domestic Gravity, deg. API		30.1	35.4	35.9	39.9	34.4	41.9	36.0	27.9	22.9	24.3	31.7
Domestic Sulfur, % wt.		2.47	0.93	0.73	0.54	0.64	0.39	0.79	0.99	1.17	1.49	0.84
Foreign Gravity, deg. API		32.4	19.6	31.8	27.9	31.5	29.5	34.5	43.0	39.9	23.2	32.0
Foreign Sulfur, % wt.		0.93	2.80	1.42	2.00	1.55	1.04	1.22	0.14	0.25	2.62	1.36
Combined Gravity, deg. API		32.3	24.5	34.4	36.2	32.9	39.5	35.8	31.0	24.1	24.3	31.8
Combined Sulfur, % wt.		0.99	2.22	0.98	0.99	1.11	0.52	0.85	0.82	1.11	1.51	1.06

Note: TM&C Calculated
Crude Properties for 1989

Combined Gravity, deg. API	32.5	24.5	34.3	36.2	33.0	39.5	35.8	30.9	24.2	24.3	31.9
Combined Sulfur, % wt.	0.99	2.22	0.99	0.99	1.14	0.52	0.85	0.82	1.10	1.51	1.07

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TABLE A1-4
REFINING DOMESTIC CRUDE INPUT RATES DETAIL
1995 F2 ANNUAL SCENARIO – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

		LP											U.S.
Location/Name		Code	Type	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	TOTAL
AL	Heavy	ALH	HH			5		30					35
	Light	ALL	S						18				18
AK	Cook	AKC	S								31	11	42
	North Slope	ANS	HH	13		54		417			441	776	1,832
AZ	Sweet	AZS	S										0
AR	Heavy	ARH	HH					31					31
CA	Beta	CBT	HH									16	16
	Elk Hills	CEH	S			36		51				31	134
	Huntington Beach	CHB	HH									20	20
	Hondo	CAH	HH	16	5							11	60
	LA Basin Light	CLL	HH									26	31
	San Ardo	CSA	HH									63	63
	SJV Light	CJL	HH									95	95
	SJV Kern River	CJH	HH									76	121
	SJV Heavy	CVH	HH		5							268	273
	Ventura	CCV	HH									48	48
	Wilmington Heavy	CWH	HH									88	88
	Wilmington Light	CWL	HH									49	49
CO	Rangely	COR	S			7				77			84
DI	PADD I Lube	PAL	S		15								15
FL	Jay	FLJ	S	14	6								20
IL	Sweet	ILS	S			28							28
	Weeks	ILW	S			28							28
IN	Sweet	IDS	S			9							9
KS	Butler	KSB	S			13							13
	Common	KSC	S			24							24
	Light	KSL	S			115							115
KY	Sweet	KYS	S			17							17
LA	Condensate	LAC	S					87	24				111
	Light Sweet	LLS	S			100		219					319
	North Mix	LAM	S					31	33				64
	Heavy Sweet	LAO	S		8	80		552					640
MI	Sweet	MIS	S			59							59
MS	Baxterville	MSB	HH					34	6				40
	Light Hey	MSH	HL				4	19					23
	Sweet	MSS	S					12					12
MT	Sour	MTS	HH			1				11			12
	Rebeki	MTR	S			10				35			45
NE	Light Sour	NES	HL			18							18
NV	Sweet	NVS	S									9	9
NM	Intermediate	NMI	S			114			24				138
	Sour	NMS	HL					49					49
ND	Light Sour	NDS	HL			32				69			101
OH/M	Light	OHL	S		5	23							28
OK	Cement	OKM	S			88		28					116
	Condensate	OKC	S			12							12
	Garber	OKG	S			126							126
	Velma	OKV	HH			66							66
SD	Sweet	SDS	S			6							6
TX	Condensate	TXC	S					69	15				84
	East	TXE	S			100		78					178
	Hawkins	TEH	HH					157					157
	Gulf Refugio	TGR	S					466	22				488
	West Intermed	TWI	S			111	13	391	50				565
	West Scurry	TWY	S			38							38
	West Sour	TWS	HL			321		106					427
UT	Altamont	UTA	S							27			27
	Mix	UTM	S							51			51
WY	Platte/Sour	WYP	HH			100				51			151
	Sweet	WYS	S			79				65			144
Total Volume				43	44	1,820	17	2,827	192	386	472	1,578	7,613

TABLE A1-5
REFINING FOREIGN CRUDE INPUT RATES DETAIL
1995 F2 ANNUAL SCENARIO - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>COUNTRY</u>	<u>NAME</u>	<u>TYPE</u>	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Abu Dhabi/Dubai/Oman/UAE		HL					25				13		38
Algeria	Cond.	S	1		11		37	2					51
Angola	Angolan	S	57	1	5		129	2					193
	Light	S	37	2	3		39						80
Cameroon	Kole	S	14		3		20						37
Canada	Heavy	HH	1		150				7			4	162
	Lloydmin	HH			135	6			13				154
	Intrprvn.	S	1		59		8		5			0	72
	Intermed.	HL	57		2	0	2		2				63
	Feder.	S			31								31
	Rangeland	HL			56	0			33	5			94
China	Daqing	S	20				23	12		7	14		76
Colombia	Cano Lim.	HH	21		9		104	1					136
Congo	Djeno	S					9	5					14
Ecuador	Oriente	HH	29	1	17		19	2		2	13		82
Gabon	Mandji	HH	2				13						15
	Gamba	S	8				27	1					37
Indonesia	Minas	S		2	1		28			24	36		91
	Attika	S					1			25	15		40
	Cond.	S			6		2			38	29		75
Iraq	Kirkuk	HL	37		55		341				1		434
Kuwait		HH	7		4		144						155
Mexico	Maya	HH	29	24	47		336	0					437
	Isthmus	HL	29				101						130
	Sweet	S	5		37		94						135
Nigeria	Heavy	S	30		14		29						72
	Forcados	S	84	0	26		93						204
	Medium	S	226	5	93		102						425
	Light	S	22		18		51						91
Norway	Heavy	S	55		3		4						61
	Medium	S	6		3		11	1					21
	Ekofisk	S	31				14						45
Saudi Arabia	Heavy	HH	67				134	0					201
	Medium	HH	63				273						336
	Light	HL	43		102		148						293
	Berri	HL	2		8		79						89
Trinidad	Light	S	1		20		53						74
United Kingdom	Brent	S			9		72						82
Venezuela	Boscan	HH		14				2					16
	Mlones	HH		17			14	3					34
	Bach Q17	HH	34	12			63						108
	TJ Med	HH					116						116
	Lago Med	HH	4	1	58		152						215
Yemen		S			20		14						34
Zaire		S	8	1	3		14	1					26
Misc. Low Sulfur		S	9	2	3		30	5		31	12	0	92
Misc. High Sul. Lt.		HL	4				2						6
Misc. High Sul. Hvy.		HH	16	8	18		10	5					56
Total			1,057	89	1,025	7	2,977	43	60	131	132	4	5,525

TABLE A1-6
REFINING RAW MATERIAL INPUT RATES DETAIL
2000 F2 ANNUAL SCENARIO - MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	U.S. <u>TOTAL</u>
Domestic Crudes	43	44	1,820	17	2,851	192	386	472	1,554	234	7,613
Foreign Crudes	<u>1,050</u>	<u>89</u>	<u>972</u>	<u>7</u>	<u>2,826</u>	<u>43</u>	<u>57</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>5,311</u>
Subtotal Crudes	1,093	133	2,792	24	5,677	235	443	603	1,686	238	12,924
Natural Gasoline/LSR			38		134	2	5		5		184
Reformat 100 RONC	27	(3)	35	(1)	(17)	1	2	(21)	23	(4)	42
Naphtha	8			(1)	85		(1)	2	5	(1)	97
Vacuum Gas Oil	169	2	27		218	(29)	(5)	(8)	31	(4)	401
Vacuum Resid					13						13
Normal Butane	2		38		71		12	4	8		135
Iso-butane	2		45		93		3	2	6		151
MTBE	75		103		217		7	7	89	2	500
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>14</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>16</u>
Total Input	1,376	132	3,080	22	6,505	209	466	589	1,853	231	14,463

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TABLE A1-7
REFINING PRODUCT RATES DETAIL
2000 F2 ANNUAL SCENARIO - MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Motor Gasolines											
CG Regular		11	575	2	815	32	139	108	22	27	1,731
CG Premium			132		286		29	23	8		478
OG Regular			40		30		33	72	23		198
OG Premium			9		11		6	15	8		49
RFG-OG Regular	241		35		194						470
RFG-OG Premium	97		8		68						173
RFG Regular	239		710		1,245		25				2,219
RFG Premium	97		161		437		5				700
CARB 2 Regular									658		658
CARB 2 Premium									212		212
Subtotal-Base	674	11	1,670	2	3,086	32	237	218	931	27	6,888
RFG/OG BTU Incrmt	21		29		61		2	2	25		140
Aviation Gasolines			3		15		1		6		25
Kero Jet/Kero	88	2	209	2	727	22	35	125	239	28	1,477
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									133		133
Diesel, 0.05%S	263		564		881		82	85	127		2,002
No. 2 Fuel, 0.25%S	61	37	118	5	374	46	40	25		58	764
Subtotal	324	37	682	5	1,255	46	122	110	260	58	2,899
Residual Fuels											
<0.3% Sulfur	22	1	2		9	27	1	9	3	17	91
0.7-1.0% Sulfur	69	3	10	2	52	3	1	22	12	4	178
>2.0% Sulfur	26	3	52		239	(5)	7	72	182	30	606
Subtotal	117	7	64	2	300	25	9	103	197	51	875
Asphalt/Road Oil	44	44	136	5	84	20	28		19	44	424
Marketable Coke - 400 #B	12		70		146		5	11	86		330
Catalytic Coke - 400 #B	29		44		89		6	6	24		198
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	3	14	18	5	49	31	1		3	5	129
Petrochem Naphtha		1			3	6			4	2	16
Lubes/Wax	11	13	24		97	16	2		17	5	185
Petrochem Gas Oil			18		152	2	1		4	3	180
Carbon Black Feed			4		31				1		36
Propene	13		23		65				1		102
Butanes/Butenes	6		2		119	3		1	18	1	150
Propane	30		69		149	1	7	9	25		290
Process Gas/C2-FOE B	64	2	132	1	295	4	19	19	108	5	649
(Gain)/Loss	(68)	1	(133)		(304)	1	(9)	(15)	(115)	2	(640)
Total Products	1,376	132	3,080	22	6,505	209	466	589	1,853	231	14,463

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TABLE A1-8
REFINING CRUDE INPUT SUMMARY
2000 F2 ANNUAL SCENARIO
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Type	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	VS	U.S. TOTAL
<u>RATES - MBPCD</u>												
<u>Domestic</u>												
Low Sulfur	S	14	34	1,223	13	1,985	186	255	31	41	25	3,807
High Sulfur Light	HL			371	4	174		69				618
High Sulfur Heavy	HH	29	10	226		692	6	62	441	1,513	209	3,188
Subtotal		43	44	1,820	17	2,851	192	386	472	1,554	234	7,613
<u>Foreign</u>												
Low Sulfur	S	608	13	345		864	29	5	125	106	0	2,095
High Sulfur Light	HL	171		212	1	668		33	5	14		1,103
High Sulfur Heavy	HH	271	76	415	6	1,294	14	19	2	13	4	2,113
Subtotal		1,050	89	972	7	2,826	43	57	131	132	4	5,311
<u>Combined</u>												
Low Sulfur	S	622	47	1,568	13	2,849	215	260	156	147	25	5,902
High Sulfur Light	HL	171		583	5	842		102	5	14		1,721
High Sulfur Heavy	HH	300	86	641	6	1,986	20	81	443	1,526	213	5,301
Subtotal		1,093	133	2,792	24	5,677	235	443	603	1,686	238	12,924
<u>% - Combined</u>												
Low Sulfur	S	56.9	35.5	56.2	54.4	50.2	91.6	58.7	25.8	8.7	10.6	45.7
High Sulfur Light	HL	15.6	0.0	20.9	18.8	14.8	0.0	23.0	0.8	0.8	0.0	13.3
High Sulfur Heavy	HH	27.4	64.5	23.0	26.8	35.0	8.4	18.3	73.4	90.5	89.4	41.0
Subtotal		100.0	100.0	100.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>												
Domestic Gravity, deg. API		30.1	35.4	35.9	39.9	34.4	41.9	36.0	27.9	22.8	24.3	31.7
Domestic Sulfur, % wt.		2.47	0.93	0.73	0.54	0.64	0.39	0.79	0.99	1.17	1.49	0.84
Foreign Gravity, deg. API		32.4	19.6	31.8	27.9	31.5	29.5	34.4	43.0	39.9	23.2	32.0
Foreign Sulfur, % wt.		0.93	2.80	1.42	2.00	1.54	1.04	1.22	0.14	0.25	2.62	1.35
Combined Gravity, deg. API		32.3	24.5	34.4	36.2	32.9	39.5	35.8	31.0	24.0	24.3	31.8
Combined Sulfur, % wt.		0.99	2.22	0.97	0.99	1.09	0.52	0.85	0.82	1.11	1.51	1.05

Note: TM&C Calculated

Crude Properties for 1989

Combined Gravity, deg. API	32.5	24.5	34.3	36.2	33.0	39.5	35.8	30.9	24.2	24.3	31.9
Combined Sulfur, % wt.	0.99	2.22	0.99	0.99	1.14	0.52	0.85	0.82	1.10	1.51	1.07

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TABLE A1-9
REFINING DOMESTIC CRUDE INPUT RATES DETAIL
2000 F2 ANNUAL SCENARIO – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Location/Name</u>		<u>LP</u>	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u>
		<u>Code</u> <u>Type</u>											<u>TOTAL</u>
AL	Heavy	ALH HH			5		30						35
	Light	ALL S						18					18
AK	Cook	AKC S								31	11		42
	North Slope	ANS HH	13		54		440			441	753	131	1,832
AZ	Sweet	AZS S											
AR	Heavy	ARH HH					31						31
CA	Beta	CBT HH									16		16
	Elk Hills	CEH S			36		52				30	16	134
	Huntington Beach	CHB HH									20		20
	Hondo	CAH HH	16	5							11	28	60
	LA Basin Light	CLL HH									26	5	31
	San Ardo	CSA HH									63		63
	SJV Light	CJL HH									95		95
	SJV Kern River	CJH HH									76	45	121
	SJV Heavy	CVH HH		5							268		273
	Ventura	CCV HH									48		48
	Wilmington Heavy	CWH HH									88		88
	Wilmington Light	CWL HH									49		49
CO	Rangely	COR S			7				77				84
DI	PADD I Lube	PAL S		15									15
FL	Jay	FLJ S	14	6									20
IL	Sweet	ILS S			28								28
	Weeks	ILW S			28								28
IN	Sweet	IDS S			9								9
KS	Butler	KSB S			13								13
	Common	KSC S			24								24
	Light	KSL S			115								115
KY	Sweet	KYS S			17								17
LA	Condensate	LAC S					87	24					111
	Light Sweet	LLS S			100		219						319
	North Mix	LAM S					31	33					64
	Heavy Sweet	LAO S		8	80		552						640
MI	Sweet	MIS S			59								59
MS	Baxterville	MSB HH					34	6					40
	Light Hey	MSH HL				4	19						23
	Sweet	MSS S					12						12
MT	Sour	MTS HH			1				11				12
	Rebeki	MTR S			10				35				45
NE	Light Sour	NES HL			18								18
NV	Sweet	NVS S										9	9
NM	Intermediate	NMI S			114			24					138
	Sour	NMS HL					49						49
ND	Light Sour	NDS HL			32				69				101
OH/M	Light	OHL S		5	23								28
OK	Cement	OKM S			88		28						116
	Condensate	OKC S			12								12
	Garber	OKG S			126								126
	Velma	OKV HH			66								66
SD	Sweet	SDS S			6								6
TX	Condensate	TXC S					69	15					84
	East	TXE S			100		78						178
	Hawkins	TEH HH					157						157
	Gulf Refugio	TGR S					466	22					488
	West Intermed	TWI S			111	13	391	50					565
	West Scurry	TWY S			38								38
	West Sour	TWS HL			321		106						427
UT	Altamont	UTA S							27				27
	Mix	UTM S							51				51
WY	Platte/Sour	WYP HH			100				51				151
	Sweet	WYS S			79				65				144
Total Volume			43	44	1,820	17	2,851	192	386	472	1,554	234	7,613

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TABLE A1-10
REFINING FOREIGN CRUDE INPUT RATES DETAIL
2000 F2 ANNUAL SCENARIO - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

COUNTRY	NAME	TYPE	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	VS	TOTAL
Abu Dhabi/Dubai/Oman/UAE		HL					25				13		38
Algeria	Cond.	S	1		11		37	2					51
Angola	Angolan	S	57	1	5		129	2					193
	Light	S	37	2	3		39						80
Cameroon	Kole	S	14		3		20						37
Canada	Heavy	HH	1		150				7			4	162
	Lloydmin	HH			112	6			12				130
	Intrprvn.	S	1		49		8		5			0	62
	Intermed.	HL	57		2	0	2		2				63
	Feder.	S			31								31
	Rangeland	HL			56	0			31	5			92
China	Daqing	S	20				23	12		7	14		76
Colombia	Cano Lim.	HH	21		9		104	1					136
Congo	Djeno	S					9	5					14
Ecuador	Oriente	HH	29	1	17		19	2		2	13		82
Gabon	Mandji	HH	2				13						15
	Gamba	S	8				27	1					37
Indonesia	Minas	S		2	1		28			24	36		91
	Attika	S					1			25	15		40
	Cond.	S			6		2			38	29		75
Iraq	Kirkuk	HL	37		55		341				1		434
Kuwait		HH	7		4		144						155
Mexico	Maya	HH	29	24	47		336	0					437
	Isthmus	HL	29				101						130
	Sweet	S	5		37		94						135
Nigeria	Heavy	S	30		14		29						72
	Forcados	S	84	0	26		93						204
	Medium	S	222	5	93		102						422
	Light	S	22		18		51						91
Norway	Heavy	S	55		3		4						61
	Medium	S	6		3		11	1					21
	Ekofisk	S	31				14						45
Saudi Arabia	Heavy	HH	67				134	0					201
	Medium	HH	61				189						250
	Light	HL	42		91		119						252
	Berri	HL	2		8		79						89
Trinidad	Light	S	1		20		53						74
United Kingdom	Brent	S					34						34
Venezuela	Boscan	HH		14				2					16
	Mlones	HH		17			14	3					34
	Bach Q17	HH	34	12			63						108
	TJ Med	HH					116						116
	Lago Med	HH	4	1	58		152						215
Yemen		S			20		14						34
Zaire		S	8	1	3		14	1					26
Misc. Low Sulfur		S	9	2	3		30	5		31	12	0	92
Misc. High Sul. Lt.		HL	4				2						6
Misc. High Sul. Hvy.		HH	16	8	18		10	5					56
Total			1,050	89	972	7	2,826	43	57	131	132	4	5,311

TABLE A1-11
REFINING RAW MATERIAL INPUT RATES DETAIL
2010 F1 (HIGH) ANNUAL SCENARIO - MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Domestic Crudes	43	44	1,774	17	2,391	192	386	618	1,914	234	7,613
Foreign Crudes	<u>1,264</u>	<u>89</u>	<u>1,570</u>	<u>7</u>	<u>4,705</u>	<u>43</u>	<u>139</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>8,084</u>
Subtotal Crudes	1,307	133	3,344	24	7,096	235	525	749	2,046	238	15,697
Natural Gasoline/LSR			39		137	2	5		5		188
Reformate 100 RONC	27	(3)	35	(1)	(21)	1	2	(23)	23	(4)	36
Naphtha	8			(1)	88		(1)	2	5	(1)	100
Vacuum Gas Oil	176	2	27		224	(29)	(5)	(8)	32	(4)	415
Vacuum Resid	0				14						14
Normal Butane	2		38		71		12	4	8		135
Iso-butane	2		45		93		3	2	6		151
MTBE	83		114		237		10	7	97	2	550
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>13</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>15</u>
Total Input	1,605	132	3,644	22	7,952	209	551	733	2,222	231	17,301

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4/20/92

TABLE A1-12
REFINING PRODUCT RATES DETAIL
2010 F1 (HIGH) ANNUAL SCENARIO - MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Motor Gasolines											
CG Regular		11	647	2	917	32	156	121	25	27	1,938
CG Premium			148		323		33	26	8		538
OG Regular			45		34		37	81	27		224
OG Premium			10		12		8	17	9		56
RFG-OG Regular	271		40		218						529
RFG-OG Premium	110		9		77						196
RFG Regular	269		798		1,402		27				2,496
RFG Premium	109		184		493		6				792
CARB 2 Regular									740		740
CARB 2 Premium									239		239
Subtotal-Base	759	11	1,881	2	3,476	32	267	245	1,048	27	7,748
RFG/OG BTU Incrmt	24		33		69		3	2	28		159
Aviation Gasolines			3		15		1		6		25
Kero Jet/Kero	132	2	317	2	1,102	22	51	189	359	28	2,204
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									166		166
Diesel, 0.05%S	331		712		1,115		104	107	159		2,528
No. 2 Fuel, 0.25%S	77	37	149	5	473	46	51	31		58	927
Subtotal	408	37	861	5	1,588	46	155	138	325	58	3,621
Residual Fuels											
<0.3% Sulfur	22	1	2		9	27	1	9	3	17	91
0.7-1.0% Sulfur	69	3	10	2	52	3	1	22	12	4	178
>2.0% Sulfur	33	3	68		314	(5)	9	95	239	30	786
Subtotal	124	7	80	2	375	25	11	126	254	51	1,055
Asphalt/Road Oil	44	44	136	5	84	20	28		19	44	424
Marketable Coke - 400 #B	12		70		146		5	11	86		330
Catalytic Coke - 400 #B	32		48		98		6	6	27		217
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	3	14	18	5	49	31	1		3	5	129
Petrochem Naphtha		1	19		108	6			4	2	140
Lubes/Wax	11	13	24		97	16	2		17	5	185
Petrochem Gas Oil			34		288	2	2		8	3	337
Carbon Black Feed			4		31				1		36
Propene	13		23		65				1		102
Butanes/Butenes	6		2		119	3		1	18	1	150
Propane	35		80		175	1	8	10	29		338
Process Gas/C2-FOE B	70	2	145	1	324	4	21	21	118	5	711
(Gain)/Loss	(76)	1	(150)		(343)	1	(10)	(16)	(129)	2	(720)
Total Products	1,605	132	3,644	22	7,952	209	551	733	2,222	231	17,301

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5/8/92

TURNER, MASON & COMPANY
Consulting Engineers

TABLE A1-13
REFINING CRUDE INPUT SUMMARY
2010 F1 (HIGH) ANNUAL SCENARIO
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Type	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	VS	U.S. TOTAL
<u>RATES - MBPCD</u>												
<u>Domestic</u>												
Low Sulfur	S	14	34	1,223	13	1,965	186	255	41	51	25	3,807
High Sulfur Light	HL			371	4	174		69				618
High Sulfur Heavy	HH	29	10	180		252	6	62	577	1,863	209	3,188
Subtotal		43	44	1,774	17	2,391	192	386	618	1,914	234	7,613
<u>Foreign</u>												
Low Sulfur	S	732	13	541		1,304	29	12	125	106	0	2,862
High Sulfur Light	HL	206		332	1	1,391		81	5	14		2,029
High Sulfur Heavy	HH	326	76	697	6	2,010	14	46	2	13	4	3,193
Subtotal		1,264	89	1,570	7	4,705	43	139	131	132	4	8,084
<u>Combined</u>												
Low Sulfur	S	746	47	1,764	13	3,269	215	267	166	157	25	6,669
High Sulfur Light	HL	206		703	5	1,565		150	5	14		2,647
High Sulfur Heavy	HH	355	86	877	6	2,262	20	108	579	1,876	213	6,381
Subtotal		1,307	133	3,344	24	7,096	235	525	749	2,046	238	15,697
<u>% - Combined</u>												
Low Sulfur	S	57.1	35.5	52.8	54.4	46.1	91.6	50.8	22.1	7.7	10.6	42.5
High Sulfur Light	HL	15.7		21.0	18.8	22.0		28.6	0.7	0.7		16.9
High Sulfur Heavy	HH	27.2	64.5	26.2	26.8	31.9	8.4	20.6	77.2	91.7	89.4	40.6
Subtotal		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>												
Domestic Gravity, deg. API		30.1	35.4	36.1	39.9	35.7	41.9	36.0	27.9	23.7	24.3	31.7
Domestic Sulfur, % wt.		2.47	0.93	0.72	0.54	0.57	0.39	0.79	0.99	1.15	1.49	0.84
Foreign Gravity, deg. API		32.8	19.6	32.2	27.9	32.2	29.5	34.9	43.0	39.9	23.2	32.5
Foreign Sulfur, % wt.		0.95	2.80	1.48	2.00	1.58	1.04	1.15	0.14	0.25	2.62	1.43
Combined Gravity, deg. API		32.7	24.5	34.2	36.2	33.4	39.5	35.7	30.4	24.7	24.3	32.1
Combined Sulfur, % wt.		1.00	2.22	1.08	0.99	1.24	0.52	0.89	0.85	1.10	1.51	1.14

Note: TM&C Calculated
Crude Properties for 1989

Combined Gravity, deg. API	32.5	24.5	34.3	36.2	33.0	39.5	35.8	30.9	24.2	24.3	31.9
Combined Sulfur, % wt.	0.99	2.22	0.99	0.99	1.14	0.52	0.85	0.82	1.10	1.51	1.07

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TABLE A1-14
REFINING DOMESTIC CRUDE INPUT RATES DETAIL
2010 F1 (HIGH) ANNUAL SCENARIO - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Location/Name		LP	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	VS	U.S.
		Code Type											TOTAL
AL	Heavy	ALH HH			5		30						35
	Light	ALL S						18					18
AK	Cook	AKC S								41	1		42
	North Slope	ANS HH	13		8					577	1,103	131	1,832
AZ	Sweet	AZS S											
AR	Heavy	ARH HH					31						31
CA	Beta	CBT HH									16		16
	Elk Hills	CEH S			36		32				50	16	134
	Huntington Beach	CHB HH									20		20
	Hondo	CAH HH	16	5							11	28	60
	LA Basin Light	CLL HH									26	5	31
	San Ardo	CSA HH									63		63
	SJV Light	CJL HH									95		95
	SJV Kern River	CJH HH									76	45	121
	SJV Heavy	CVH HH		5							268		273
	Ventura	CCV HH									48		48
	Wilmington Heavy	CWH HH									88		88
	Wilmington Light	CWL HH									49		49
CO	Rangely	COR S			7				77				84
DI	PADD I Lube	PAL S		15									15
FL	Jay	FLJ S	14	6									20
IL	Sweet	ILS S			28								28
	Weeks	ILW S			28								28
IN	Sweet	IDS S			9								9
KS	Butler	KSB S			13								13
	Common	KSC S			24								24
	Light	KSL S			115								115
KY	Sweet	KYS S			17								17
LA	Condensate	LAC S					87	24					111
	Light Sweet	LLS S			100		219						319
	North Mix	LAM S					31	33					64
	Heavy Sweet	LAO S		8	80		552						840
MI	Sweet	MIS S			59								59
MS	Baxterville	MSB HH					34	6					40
	Light Hey	MSH HL				4	19						23
	Sweet	MSS S					12						12
MT	Sour	MTS HH			1				11				12
	Rebeki	MTR S			10				35				45
NE	Light Sour	NES HL			18								18
NV	Sweet	NVS S										9	9
NM	Intermediate	NMI S			114			24					138
	Sour	NMS HL					49						49
ND	Light Sour	NDS HL			32				69				101
OH/M	Light	OHL S		5	23								28
OK	Cement	OKM S			88		28						116
	Condensate	OKC S			12								12
	Garber	OKG S			126								126
	Velma	OKV HH			66								66
SD	Sweet	SDS S			6								6
TX	Condensate	TXC S					69	15					84
	East	TXE S			100		78						178
	Hawkins	TEH HH					157						157
	Gulf Refugio	TGR S					466	22					488
	West Intermed	TWI S			111	13	391	50					565
	West Scurry	TWY S			38								38
	West Sour	TWS HL			321		106						427
UT	Altamont	UTA S							27				27
	Mix	UTM S							51				51
WY	Platte/Sour	WYP HH			100				51				151
	Sweet	WYS S			79				65				144
Total Volume			43	44	1,774	17	2,391	192	386	618	1,914	234	7,613

TABLE A1-15
REFINING FOREIGN CRUDE INPUT RATES DETAIL
2010 F1 (HIGH) ANNUAL SCENARIO – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>COUNTRY</u>	<u>NAME</u>	<u>TYPE</u>	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>TOTAL</u>	<u>U.S.</u>
Abu Dhabi/Dubai/Oman/UAE		HL					25				13		38	
Algeria	Cond.	S	1		11		37	2					51	
Angola	Angolan	S	57	1	5		129	2					193	
	Light	S	37	2	3		39						80	
Cameroon	Kole	S	14		3		20						37	
Canada	Heavy	HH	1		150				7			4	162	
	Lloydmin	HH			147	6			39				192	
	Intrprvn.	S	1		59		8		12			0	79	
	Intermed.	HL	57		2	0	2		2				63	
	Feder.	S			31								31	
	Rangeland	HL			56	0			79	5			140	
China	Daqing	S	20				23	12		7	14		76	
Colombia	Cano Lim.	HH	21		9		104	1					136	
Congo	Djeno	S					9	5					14	
Ecuador	Oriente	HH	29	1	17		19	2		2	13		82	
Gabon	Mandji	HH	2				13						15	
	Gamba	S	8				27	1					37	
Indonesia	Minas	S		2	1		28			24	36		91	
	Attika	S					1			25	15		40	
	Cond.	S			6		2			38	29		75	
Iraq	Kirkuk	HL	37		55		341				1		434	
Kuwait		HH	7		4		144						155	
Mexico	Maya	HH	29	24	47		336	0					437	
	Isthmus	HL	29				101						130	
	Sweet	S	5		37		94						135	
Nigeria	Heavy	S	30		14		29						72	
	Forcados	S	84	0	26		93						204	
	Medium	S	236	5	93		102						436	
	Light	S	22		18		51						91	
Norway	Heavy	S	55		3		4						61	
	Medium	S	6		3		11	1					21	
	Ekofisk	S	31				14						45	
Saudi Arabia	Heavy	HH	67		2		134	0					203	
	Medium	HH	116		245		905						1,266	
	Light	HL	77		211		842						1,130	
	Berri	HL	2		8		79						89	
Trinidad	Light	S	1		20		53						74	
United Kingdom	Brent	S	110		186		474						770	
Venezuela	Boscan	HH		14				2					16	
	Mlones	HH		17			14	3					34	
	Bach Q17	HH	34	12			63						108	
	TJ Med	HH					116						116	
	Lago Med	HH	4	1	58		152						215	
Yemen		S			20		14						34	
Zaire		S	8	1	3		14	1					26	
Misc. Low Sulfur		S	9	2	3		30	5		31	12	0	92	
Misc. High Sul. Lt.		HL	4				2						6	
Misc. High Sul. Hvy.		HH	16	8	18		10	5					56	
Total			1,264	89	1,570	7	4,705	43	139	131	132	4	8,084	

TABLE A1-16
REFINING RAW MATERIAL INPUT RATES DETAIL
2010 F3 (LOW) ANNUAL SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	U.S. <u>TOTAL</u>
Domestic Crudes	43	44	1,837	17	3,250	192	369	373	1,254	234	7,613
Foreign Crudes	<u>854</u>	<u>89</u>	<u>488</u>	<u>7</u>	<u>1,543</u>	<u>43</u>		<u>131</u>	<u>132</u>	<u>4</u>	<u>3,291</u>
Subtotal Crudes	897	133	2,325	24	4,793	235	369	504	1,386	238	10,904
Natural Gasoline/LSR			39		137	2	5		5		188
Reformate 100 RONC	27	(3)	35	(1)	(21)	1	2	(23)	23	(4)	36
Naphtha	8			(1)	88		(1)	2	5	(1)	100
Vacuum Gas Oil	176	2	27		224	(29)	(5)	(8)	32	(4)	415
Vacuum Resid					14						14
Normal Butane	2		38		71		12	4	8		135
Iso-butane	2		45		93		3	2	6		151
MTBE	64		89		193		7	7	78	2	440
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>13</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>15</u>
Total Input	1,176	132	2,600	22	5,605	209	392	488	1,543	231	12,398

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4/20/92

TABLE A1-17
REFINING PRODUCT RATES DETAIL
2010 F3 (LOW) ANNUAL SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Motor Gasolines											
CG Regular		11	502	2	713	32	121	94	20	27	1,522
CG Premium			115		250		26	20	7		418
OG Regular			35		26		28	63	20		172
OG Premium			8		9		6	13	7		43
RFG-OG Regular	210		31		169						410
RFG-OG Premium	85		7		60						152
RFG Regular	210		620		1,088		21				1,939
RFG Premium	84		141		383		5				613
CARB 2 Regular									574		574
CARB 2 Premium									185		185
Subtotal-Base	589	11	1,459	2	2,698	32	207	190	813	27	6,028
RFG/OG BTU Incrmt	18		25		54		2	2	22		123
Aviation Gasolines			2		11		1		5		19
Kero Jet/Kero	75	2	176	2	614	22	30	106	203	28	1,258
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									114		114
Diesel, 0.05%S	222		477		748		70	72	109		1,698
No. 2 Fuel, 0.25%S	52	37	100	5	318	46	34	21		58	671
Subtotal	274	37	577	5	1,066	46	104	93	223	58	2,483
Residual Fuels											
<0.3% Sulfur	22	1	2		9	27	1	9	3	17	91
0.7-1.0% Sulfur	69	3	10	2	52	3	1	22	12	4	178
>2.0% Sulfur	15	3	30		141	(5)	4	42	106	30	366
Subtotal	106	7	42	2	202	25	6	73	121	51	635
Asphalt/Road Oil	27	44	84	5	51	20	17		12	44	304
Marketable Coke - 400 #B	11		64		133		5	10	79		302
Catalytic Coke - 400 #B	23		34		71		4	4	19		155
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	2	14	10	5	28	31	1		2	5	98
Petrochem Naphtha		1			34	6			4	2	47
Lubes/Wax	8	13	16		66	16	1		12	5	137
Petrochem Gas Oil			22		187	2	1		4	3	219
Carbon Black Feed			4		31				1		36
Propene	13		23		65				1		102
Butanes/Butenes	6		2		119	3		1	18	1	150
Propane	25		57		123	1	6	7	21		240
Process Gas/C2-FOE B	50	2	104	1	232	4	15	15	84	5	512
(Gain)/Loss	(59)	1	(117)		(266)	1	(8)	(13)	(101)	2	(560)
Total Products	1,176	132	2,600	22	5,605	209	392	488	1,543	231	12,398

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5/8/92

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TABLE A1-18
REFINING CRUDE INPUT SUMMARY
2010 F3 (LOW) ANNUAL SCENARIO
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Type	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	VS	U.S. TOTAL
RATES - MBPCD												
<u>Domestic</u>												
Low Sulfur	S	14	34	1,224	13	1,999	186	254	25	33	25	3,807
High Sulfur Light	HL			371	4	174		69				618
High Sulfur Heavy	HH	29	10	242		1,077	6	46	348	1,221	209	3,188
Subtotal		43	44	1,837	17	3,250	192	369	373	1,254	234	7,613
<u>Foreign</u>												
Low Sulfur	S	494	13	178		589	29		125	106	0	1,534
High Sulfur Light	HL	90		(0)	1	3	0	0	5	14		112
High Sulfur Heavy	HH	270	76	310	6	951	14	0	2	13	4	1,645
Subtotal		854	89	488	7	1,543	43	0	131	132	4	3,291
<u>Combined</u>												
Low Sulfur	S	508	47	1,402	13	2,588	215	254	150	139	25	5,341
High Sulfur Light	HL	90		371	5	177		69	5	14		730
High Sulfur Heavy	HH	299	86	552	6	2,028	20	46	350	1,234	213	4,833
Subtotal		897	133	2,325	24	4,793	235	369	504	1,386	238	10,904
<u>% - Combined</u>												
Low Sulfur	S	56.7	35.5	60.3	54.4	54.0	91.6	68.8	29.7	10.0	10.6	49.0
High Sulfur Light	HL	10.0		16.0	18.8	3.7		18.7	1.0	1.0		6.7
High Sulfur Heavy	HH	33.3	64.5	23.7	26.8	42.3	8.4	12.5	69.3	89.0	89.4	44.3
Subtotal		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>												
Domestic Gravity, deg. API		30.1	35.4	35.7	39.9	33.5	41.9	36.7	27.9	21.6	24.3	31.7
Domestic Sulfur, % wt.		2.47	0.93	0.75	0.54	0.69	0.39	0.70	0.99	1.21	1.49	0.84
Foreign Gravity, deg. API		31.7	19.6	29.2	27.9	29.6	29.5	26.5	43.0	39.9	23.2	30.7
Foreign Sulfur, % wt.		0.95	2.80	1.64	2.00	1.48	1.04	2.26	0.14	0.25	2.62	1.31
Combined Gravity, deg. API		31.6	24.5	34.3	36.2	32.2	39.5	36.7	31.6	23.2	24.3	31.4
Combined Sulfur, % wt.		1.03	2.22	0.94	0.99	0.95	0.52	0.70	0.78	1.12	1.51	0.98
 Note: TM&C Calculated Crude Properties for 1989												
Combined Gravity, deg. API		32.5	24.5	34.3	36.2	33.0	39.5	35.8	30.9	24.2	24.3	31.9
Combined Sulfur, % wt.		0.99	2.22	0.99	0.99	1.14	0.52	0.85	0.82	1.10	1.51	1.07

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6/22/92

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Consulting Engineers

TABLE A1-19
REFINING DOMESTIC CRUDE INPUT RATES DETAIL
2010 F3 (LOW) ANNUAL SCENARIO – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Location/Name		LP	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	VS	U.S.
		Code Type											TOTAL
AL	Heavy	ALH HH			5		30						35
	Light	ALL S						18					18
AK	Cook	AKC S								25	17		42
	North Slope	ANS HH	13		54		825			348	461	131	1,832
AZ	Sweet	AZS S											
AR	Heavy	ARH HH					31						31
CA	Beta	CBT HH									16		16
	Elk Hills	CEH S			36		66				16	16	134
	Huntington Beach	CHB HH									20		20
	Hondo	CAH HH	16	5							11	28	60
	LA Basin Light	CLL HH									28	5	31
	San Ardo	CSA HH									63		63
	SJV Light	CJL HH									95		95
	SJV Kern River	CJH HH									76	45	121
	SJV Heavy	CVH HH		5							268		273
	Ventura	CCV HH									48		48
	Wilmington Heavy	CWH HH									88		88
	Wilmington Light	CWL HH									49		49
CO	Rangely	COR S			7				77				84
DI	PADD I Lube	PAL S		15									15
FL	Jay	FLJ S	14	6									20
IL	Sweet	ILS S			28								28
	Weeks	ILW S			28								28
IN	Sweet	IDS S			9								9
KS	Butler	KSB S			13								13
	Common	KSC S			24								24
	Light	KSL S			115								115
KY	Sweet	KYS S			17								17
LA	Condensate	LAC S					87	24					111
	Light Sweet	LLS S			100		219						319
	North Mix	LAM S					31	33					64
	Heavy Sweet	LAO S		8	80		552						640
MI	Sweet	MIS S			59								59
MS	Baxterville	MSB HH					34	6					40
	Light Hey	MSH HL				4	19						23
	Sweet	MSS S					12						12
MT	Sour	MTS HH			1				11				12
	Rebeki	MTR S			10				35				45
NE	Light Sour	NES HL			18								18
NV	Sweet	NVS S										9	9
NM	Intermediate	NMI S			114			24					138
	Sour	NMS HL					49						49
ND	Light Sour	NDS HL			32				69				101
OH/M	Light	OHL S		5	23								28
OK	Cement	OKM S			88		28						116
	Condensate	OKC S			12								12
	Garber	OKG S			126								126
	Velma	OKV HH			66								66
SD	Sweet	SDS S			6								6
TX	Condensate	TXC S					69	15					84
	East	TXE S			100		78						178
	Hawkins	TEH HH					157						157
	Gulf Refugio	TGR S					466	22					488
	West Intermed	TWI S			111	13	391	50					565
	West Scurry	TWY S			38								38
	West Sour	TWS HL			321		106						427
UT	Altamont	UTA S							27				27
	Mix	UTM S							51				51
WY	Platte/Sour	WYP HH			116				35				151
	Sweet	WYS S			80				64				144
Total Volume			43	44	1,837	17	3,250	192	369	373	1,254	234	7,613

TABLE A1-20
REFINING FOREIGN CRUDE INPUT RATES DETAIL
2010 F3 (LOW) ANNUAL SCENARIO - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

COUNTRY	NAME	TYPE	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	VS	U.S. TOTAL
Abu Dhabi/Dubai/Oman/UAE		HL					(0)				13		13
Algeria	Cond.	S	1		11		37	2					51
Angola	Angolan	S	57	1	5		129	2					193
	Light	S	37	2	3		39						80
Cameroon	Kole	S	14		3		20						37
Canada	Heavy	HH	1		150				0			4	155
	Lloydmin	HH			7	6			(0)				13
	Intrprvn.	S	1		(0)		8					0	8
	Intermed.	HL	57		0	0	2		0				59
	Feder.	S			(0)								(0)
	Rangeland	HL				0				5			5
China	Daqing	S	20				23	12		7	14		76
Colombia	Cano Lim.	HH	21		9		104	1					136
Congo	Djeno	S					9	5					14
Ecuador	Oriente	HH	29	1	17		19	2		2	13		82
Gabon	Mandji	HH	2				13						15
	Gamba	S	8				27	1					37
Indonesia	Minas	S		2	1		28			24	36		91
	Attika	S					1			25	15		40
	Cond.	S			6		2			38	29		75
Iraq	Kirkuk	HL	0		(0)		(0)				1		1
Kuwait		HH	7		4		124						135
Mexico	Maya	HH	29	24	47		336	0					437
	Isthmus	HL	29										29
	Sweet	S	5		37		94						135
Nigeria	Heavy	S	30		14		29						72
	Forcados	S	84	0	26		5						116
	Medium	S	108	5	6								118
	Light	S	22		18								40
Norway	Heavy	S	55		3		4						61
	Medium	S	6		3		11	1					21
	Ekofisk	S	31				14						45
Saudi Arabia	Heavy	HH	67					0					67
	Medium	HH	60				(0)						60
	Light	HL	(0)										(0)
	Berri	HL	0		(0)		(0)						(0)
Trinidad	Light	S	1		20		53						74
United Kingdom	Brent	S			0		0						1
Venezuela	Boscan	HH		14				2					16
	Mlones	HH		17			14	3					34
	Bach Q17	HH	34	12			63						108
	TJ Med	HH					116						116
	Lago Med	HH	4	1	58		152						215
Yemen		S			20		14						34
Zaire		S	8	1	3		14	1					26
Misc. Low Sulfur		S	9	2	3		30	5		31	12	0	92
Misc. High Sul. Lt.		HL	4				2						6
Misc. High Sul. Hvy.		HH	16	8	18		10	5					56
Total			854	89	488	7	1,543	43	0	131	132	4	3,291

TABLE A1-21
REFINING RAW MATERIALS INPUT RATES DETAIL
1995 F2 SUMMER SCENARIO - MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Domestic Crudes	43	44	1,820	17	2,750	192	386	492	1,635	234	7,613
Foreign Crudes	<u>1,068</u>	<u>89</u>	<u>1,148</u>	<u>7</u>	<u>3,207</u>	<u>43</u>	<u>94</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>5,923</u>
Subtotal Crudes	1,111	133	2,968	24	5,957	235	480	623	1,767	238	13,536
Natural Gasoline/LSR			38		134	2	5		5		184
Reformate 100 RONC	27	(3)	35	(1)	(17)	1	2	(21)	23	(4)	42
Naphtha	8			(1)	85		(1)	2	5	(1)	97
Vacuum Gas Oil	169	2	27		218	(29)	(5)	(8)	31	(4)	401
Vacuum Resid					13						13
Normal Butane					5						5
Iso-butane	2		45		93		3	2	6		151
MTBE	70		25		54				44	2	195
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>14</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>16</u>
Total Input	1,387	132	3,140	22	6,556	209	484	598	1,881	231	14,640

REC/CLM
5/4/92

TABLE A1-22
REFINING PRODUCT RATES DETAIL
1995 F2 SUMMER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Motor Gasolines											
CG Regular		11	1,151	2	2,074	32	202	183	295	27	3,977
CG Premium			263		729		43	39	95		1,169
OG Regular											
OG Premium											
RFG-OG Regular											
RFG-OG Premium											
RFG Regular	478		218		258				421		1,375
RFG Premium	193		50		90				136		469
Subtotal-Base	671	11	1,682	2	3,151	32	245	222	947	27	6,990
RFG/OG BTU Incrmt	21		8		16				13		58
Aviation Gasolines			3		15		1		6		25
Kero Jet/Kero	86	2	205	2	686	22	34	122	234	28	1,421
Diesel/ No. 2 Fuels											
Diesel, LA, 0.05% S									140		140
Diesel, 0.05%S	281		580		940		86	96	117		2,100
No. 2 Fuel, 0.25%S	35	37	102	5	289	46	42	16		58	630
Subtotal	316	37	682	5	1,229	46	128	112	257	58	2,870
Residual Fuels											
<0.3% Sulfur	20	1	2		8	27	1	9	3	17	88
0.7-1.0% Sulfur	62	3	9	2	53	3	1	22	12	4	171
>2.0% Sulfur	23	3	48		228	(5)	7	71	179	30	584
Subtotal	105	7	59	2	289	25	9	102	194	51	843
Asphalt/Road Oil	73	44	169	5	102	20	34		35	44	526
Marketable Coke - 400 #B	12		71		146		5	11	88		333
Catalytic Coke - 400 #B	30		46		98		6	6	26		212
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	3	14	18	5	49	31	1		3	5	129
Petrochem Naphtha		1			3	6			4	2	16
Lubes/Wax	11	13	24		97	16	2		17	5	185
Petrochem Gas Oil			18		152	2	1		4	3	180
Carbon Black Feed			4		33				1		38
Propene	13		24		67				1		105
Butanes/Butenes	12		40		185	3		9	29	1	279
Propane	29		71		152	1	8	10	28		299
Process Gas/C2-FOE B	66	2	137	1	312	4	19	19	113	5	678
(Gain)/Loss	(69)	1	(137)		(312)	1	(9)	(15)	(119)	2	(657)
Total Products	1,387	132	3,140	22	6,556	209	484	598	1,881	231	14,640

CLM/GWM
5/8/92

TURNER, MASON & COMPANY
Consulting Engineers

TABLE A1-23
REFINING RAW MATERIALS INPUT RATES DETAIL
1995 F2 WINTER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Domestic Crudes	43	44	1,820	17	2,904	192	386	452	1,521	234	7,613
Foreign Crudes	<u>1,046</u>	<u>89</u>	<u>902</u>	<u>7</u>	<u>2,747</u>	<u>43</u>	<u>26</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>5,127</u>
Subtotal Crudes	1,089	133	2,722	24	5,651	235	412	583	1,653	238	12,740
Natural Gasoline/LSR			38		134	2	5		5		184
Reformate 100 RONC	27	(3)	35	(1)	(17)	1	2	(21)	23	(4)	42
Naphtha	8			(1)	85		(1)	2	5	(1)	97
Vacuum Gas Oil	169	2	27		218	(29)	(5)	(8)	31	(4)	401
Vacuum Resid					13						13
Normal Butane	4		112		137		24	15	16		308
Iso-butane	2		45		93		3	2	6		151
MTBE	70		41		66		6	14	76	2	275
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>14</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>16</u>
Total Input	1,369	132	3,022	22	6,394	209	446	587	1,815	231	14,227

REC/CLM
5/4/92

TABLE A1-24
REFINING PRODUCT RATES DETAIL
1995 F2 WINTER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>TOTAL</u>	U.S.
Motor Gasolines												
CG Regular		11	991	2	1,652	32	124	49		27	2,888	
CG Premium			226		580		26	11			843	
OG Regular			149		343		65	127	287		971	
OG Premium			34		120		14	27	93		288	
RFG-OG Regular	483				105				404		992	
RFG-OG Premium	194				37				131		362	
RFG Regular			210		136						346	
RFG Premium			48		48						96	
Subtotal-Base	677	11	1,658	2	3,021	32	229	214	915	27	6,786	
RFG/OG BTU Incrmt	21		12		20		2	4	23		82	
Aviation Gasolines			3		15		1		6		25	
Kero Jet/Kero	90	2	213	2	768	22	36	128	244	28	1,533	
Diesel/No. 2 Fuels												
Diesel, LA, 0.05% S									126		126	
Diesel, 0.05%S	245		548		821		78	73	137		1,902	
No. 2 Fuel, 0.25%S	87	37	134	5	460	46	38	35		58	900	
Subtotal	332	37	682	5	1,281	46	116	108	263	58	2,928	
Residual Fuels												
<0.3% Sulfur	24	1	2		10	27	1	9	3	17	94	
0.7-1.0% Sulfur	76	3	11	2	51	3	1	22	12	4	185	
>2.0% Sulfur	29	3	56		250	(5)	7	73	185	30	628	
Subtotal	129	7	69	2	311	25	9	104	200	51	907	
Asphalt/Road Oil	15	44	103	5	66	20	22		3	44	322	
Marketable Coke - 400 #B	12		69		146		5	11	84		327	
Catalytic Coke - 400 #B	30		44		88		6	6	24		198	
Benzene	2		2		21						25	
Toluene	6		5		25						36	
Xylene			9		40						49	
Spcl. Naph./Misc./HSR	3	14	18	5	49	31	1		3	5	129	
Petrochem Naphtha		1			3	6			4	2	16	
Lubes/Wax	11	13	24		97	16	2		17	5	185	
Petrochem Gas Oil			18		152	2	1		4	3	180	
Carbon Black Feed			4		29				1		34	
Propene	13		22		63				1		99	
Butanes/Butenes					53	3			7	1	64	
Propane	31		67		146	1	6	8	22		281	
Process Gas/C2-FOE B	66	2	135	1	304	4	19	19	109	5	664	
(Gain)/Loss	(69)	1	(135)		(304)	1	(9)	(15)	(115)	2	(643)	
Total Products	1,369	132	3,022	22	6,394	209	446	587	1,815	231	14,227	

CLM/GWM
4/30/92

TURNER, MASON & COMPANY
Consulting Engineers

TABLE A1-25
REFINING RAW MATERIALS INPUT RATES DETAIL
2000 F2 SUMMER SCENARIO - MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Domestic Crudes	43	44	1,820	17	2,785	192	386	492	1,600	234	7,613
Foreign Crudes	<u>1,060</u>	<u>89</u>	<u>1,092</u>	<u>7</u>	<u>3,040</u>	<u>43</u>	<u>92</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>5,690</u>
Subtotal Crudes	1,103	133	2,912	24	5,825	235	478	623	1,732	238	13,303
Natural Gasoline/LSR			38		134	2	5		5		184
Reformate 100 RONC	27	(3)	35	(1)	(17)	1	2	(21)	23	(4)	42
Naphtha	8			(1)	85		(1)	2	5	(1)	97
Vacuum Gas Oil	169	2	27		218	(29)	(5)	(8)	31	(4)	401
Vacuum Resid					13						13
Normal Butane					5						5
Iso-butane	2		45		93		3	2	6		151
MTBE	76		100		216		3		89	2	486
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>14</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>16</u>
Total Input	1,385	132	3,159	22	6,586	209	485	598	1,891	231	14,698

REC/CLM
4/20/92

TABLE A1-26
REFINING PRODUCT RATES DETAIL
2000 F2 SUMMER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Motor Gasolines											
CG Regular		11	613	2	871	32	177	183	45	27	1,961
CG Premium			140		306		37	39	15		537
OG Regular											
OG Premium											
RFG-OG Regular											
RFG-OG Premium											
RFG Regular	478		756		1,461		26				2,721
RFG Premium	193		173		513		5				884
CARB 2 Regular									671		671
CARB 2 Premium									216		216
Subtotal-Base	671	11	1,682	2	3,151	32	245	222	947	27	6,990
RFG/OG BTU Incrmt	21		28		61		1		25		136
Aviation Gasolines			3		15		1		6		25
Kero Jet/Kero	86	2	205	2	686	22	34	122	234	28	1,421
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									140		140
Diesel, 0.05%S	281		580		940		86	96	117		2,100
No. 2 Fuel, 0.25%S	35	37	102	5	289	46	42	16		58	630
Subtotal	316	37	682	5	1,229	46	128	112	257	58	2,870
Residual Fuels											
<0.3% Sulfur	20	1	2		8	27	1	9	3	17	88
0.7-1.0% Sulfur	62	3	9	2	53	3	1	22	12	4	171
>2.0% Sulfur	23	3	48		228	(5)	7	71	179	30	584
Subtotal	105	7	59	2	289	25	9	102	194	51	843
Asphalt/Road Oil	73	44	169	5	102	20	34		35	44	526
Marketable Coke - 400 #B	12		71		146		5	11	88		333
Catalytic Coke - 400 #B	29		45		93		6	6	25		204
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	3	14	18	5	49	31	1		3	5	129
Petrochem Naphtha		1			3	6			4	2	16
Lubes/Wax	11	13	24		97	16	2		17	5	185
Petrochem Gas Oil			18		152	2	1		4	3	180
Carbon Black Feed			4		33				1		38
Propene	13		24		67				1		105
Butanes/Butenes	12		40		185	3		9	29	1	279
Propane	29		71		152	1	8	10	28		299
Process Gas/C2-FOE B	64	2	133	1	298	4	19	19	110	5	655
(Gain)/Loss	(68)	1	(133)		(308)	1	(9)	(15)	(117)	2	(646)
Total Products	1,385	132	3,159	22	6,586	209	485	598	1,891	231	14,698

CLM
5/8/92

TURNER, MASON & COMPANY
Consulting Engineers

TABLE A1-27
REFINING RAW MATERIALS INPUT RATES DETAIL
2000 F2 WINTER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Domestic Crudes	43	44	1,820	17	2,917	192	386	452	1,508	234	7,613
Foreign Crudes	<u>1,039</u>	<u>89</u>	<u>852</u>	<u>7</u>	<u>2,612</u>	<u>43</u>	<u>22</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>4,931</u>
Subtotal Crudes	1,082	133	2,672	24	5,529	235	408	583	1,640	238	12,544
Natural Gasoline/LSR			38		134	2	5		5		184
Reformate 100 RONC	27	(3)	35	(1)	(17)	1	2	(21)	23	(4)	42
Naphtha	8			(1)	85		(1)	2	5	(1)	97
Vacuum Gas Oil	169	2	27		218	(29)	(5)	(8)	31	(4)	401
Vacuum Resid					13						13
Normal Butane	4		112		137		24	15	16		308
Iso-butane	2		45		93		3	2	6		151
MTBE	75		107		217		11	14	89	2	515
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>14</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>16</u>
Total Input	1,367	132	3,038	22	6,423	209	447	587	1,815	231	14,271

REC/CLM
4/21/92

TABLE A1-28
REFINING PRODUCT RATES DETAIL
2000 F2 WINTER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Motor Gasolines											
CG Regular		11	538	2	759	32	101	33		27	1,503
CG Premium			123		267		21	7			418
OG Regular			79		60		65	144	47		395
OG Premium			18		21		14	30	15		98
RFG-OG Regular	483		70		387						940
RFG-OG Premium	194		16		136						346
RFG Regular			663		1,029		23				1,715
RFG Premium			151		362		5				518
CARB 2 Regular									645		645
CARB 2 Premium									208		208
Subtotal-Base	677	11	1,658	2	3,021	32	229	214	915	27	6,786
RFG/OG BTU Incrmt	21		30		61		3	4	25		144
Aviation Gasolines			3		15		1		6		25
Kero Jet/Kero	90	2	213	2	768	22	36	128	244	28	1,533
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									126		126
Diesel, 0.05%S	245		548		821		78	73	137		1,902
No. 2 Fuel, 0.25%S	87	37	134	5	460	46	38	35		58	900
Subtotal	332	37	682	5	1,281	46	116	108	263	58	2,928
Residual Fuels											
<0.3% Sulfur	24	1	2		10	27	1	9	3	17	94
0.7-1.0% Sulfur	76	3	11	2	51	3	1	22	12	4	185
>2.0% Sulfur	29	3	56		250	(5)	7	73	185	30	628
Subtotal	129	7	69	2	311	25	9	104	200	51	907
Asphalt/Road Oil	15	44	103	5	66	20	22		3	44	322
Marketable Coke - 400 #B	12		69		146		5	11	84		327
Catalytic Coke - 400 #B	29		43		85		6	6	23		192
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	3	14	18	5	49	31	1		3	5	129
Petrochem Naphtha		1			3	6			4	2	16
Lubes/Wax	11	13	24		97	16	2		17	5	185
Petrochem Gas Oil			18		152	2	1		4	3	180
Carbon Black Feed			4		29				1		34
Propene	13		22		63				1		99
Butanes/Butenes					53	3			7	1	64
Propane	31		67		146	1	6	8	22		281
Process Gas/C2-FOE B	64	2	131	1	292	4	19	19	106	5	643
(Gain)/Loss	(68)	1	(132)		(301)	1	(9)	(15)	(113)	2	(634)
Total Products	1,367	132	3,038	22	6,423	209	447	587	1,815	231	14,271

CLM
5/8/92

TABLE A1-29
REFINING RAW MATERIALS INPUT RATES DETAIL
2010 F1 (HIGH) SUMMER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Domestic Crudes	43	44	1,774	17	2,327	192	386	636	1,960	234	7,613
Foreign Crudes	<u>1,270</u>	<u>89</u>	<u>1,690</u>	<u>7</u>	<u>4,895</u>	<u>43</u>	<u>176</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>8,437</u>
Subtotal Crudes	1,313	133	3,464	24	7,222	235	562	767	2,092	238	16,050
Natural Gasoline/LSR			39		137	2	5		5		188
Reformate 100 RONC	27	(3)	35	(1)	(21)	1	2	(23)	23	(4)	36
Naphtha	8			(1)	88		(1)	2	5	(1)	100
Vacuum Gas Oil	176	2	27		224	(29)	(5)	(8)	32	(4)	415
Vacuum Resid					14						14
Normal Butane					5						5
Iso-butane	2		45		93		3	2	6		151
MTBE	83		110		239		4		96	2	534
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>13</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>15</u>
Total Input	1,609	132	3,722	22	8,014	209	570	740	2,259	231	17,508

REC/CLM
4/21/92

TABLE A1-30
REFINING PRODUCT RATES DETAIL
2010 F1 (HIGH) SUMMER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Motor Gasolines											
CG Regular		11	690	2	981	32	199	205	51	27	2,198
CG Premium			158		345		42	44	16		605
OG Regular											
OG Premium											
RFG-OG Regular											
RFG-OG Premium											
RFG Regular	539		851		1,645		29				3,064
RFG Premium	217		195		578		6				996
CARB 2 Regular									755		755
CARB 2 Premium									244		244
Subtotal-Base	756	11	1,894	2	3,549	32	276	249	1,066	27	7,862
RFG/OG BTU Incrmt	24		32		69		1		28		154
Aviation Gasolines			3		15		1		6		25
Kero Jet/Kero	129	2	311	2	1,042	22	49	185	351	28	2,121
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									175		175
Diesel, 0.05%S	353		731		1,192		109	120	147		2,652
No. 2 Fuel, 0.25%S	44	37	129	5	366	46	53	20		58	758
Subtotal	397	37	860	5	1,558	46	162	140	322	58	3,585
Residual Fuels											
<0.3% Sulfur	20	1	2		8	27	1	9	3	17	88
0.7-1.0% Sulfur	62	3	9	2	53	3	1	22	12	4	171
>2.0% Sulfur	29	3	63		300	(5)	9	93	235	30	757
Subtotal	111	7	74	2	361	25	11	124	250	51	1,016
Asphalt/Road Oil	73	44	169	5	102	20	34		35	44	526
Marketable Coke - 400 #B	12		71		146		5	11	88		333
Catalytic Coke - 400 #B	32		49		103		6	6	28		224
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	3	14	18	5	49	31	1		3	5	129
Petrochem Naphtha		1	19		108	6			4	2	140
Lubes/Wax	11	13	24		97	16	2		17	5	185
Petrochem Gas Oil			34		288	2	2		8	3	337
Carbon Black Feed			4		33				1		38
Propene	13		24		67				1		105
Butanes/Butenes	12		40		185	3		9	29	1	279
Propane	34		83		177	1	9	11	33		348
Process Gas/C2-FOE B	70	2	146	1	328	4	21	21	120	5	718
(Gain)/Loss	(76)	1	(150)		(348)	1	(10)	(16)	(131)	2	(727)
Total Products	1,609	132	3,721	22	8,015	209	570	740	2,259	231	17,508

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TABLE A1-31
REFINING RAW MATERIALS INPUT RATES DETAIL
2010 F1 (HIGH) WINTER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Domestic Crudes	43	44	1,774	17	2,454	192	386	600	1,869	234	7,613
Foreign Crudes	<u>1,258</u>	<u>89</u>	<u>1,451</u>	<u>7</u>	<u>4,516</u>	<u>43</u>	<u>102</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>7,733</u>
Subtotal Crudes	1,301	133	3,225	24	6,970	235	488	731	2,001	238	15,346
Natural Gasoline/LSR			39		137	2	5		5		188
Reformate 100 RONC	27	(3)	35	(1)	(21)	1	2	(23)	23	(4)	36
Naphtha	8			(1)	88		(1)	2	5	(1)	100
Vacuum Gas Oil	176	2	27		224	(29)	(5)	(8)	32	(4)	415
Vacuum Resid					14						14
Normal Butane	4		112		137		24	15	16		308
Iso-butane	2		45		93		3	2	6		151
MTBE	83		118		235		16	14	98	2	566
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>13</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>15</u>
Total Input	1,601	132	3,603	22	7,890	209	532	733	2,186	231	17,139

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TABLE A1-32
REFINING PRODUCT RATES DETAIL
2010 F1 (HIGH) WINTER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Motor Gasolines											
CG Regular		11	605	2	855	32	114	37		27	1,683
CG Premium			139		300		24	8			471
OG Regular			89		68		74	162	53		446
OG Premium			20		24		15	34	17		110
RFG-OG Regular	543		79		436						1,058
RFG-OG Premium	219		18		153						390
RFG Regular			746		1,160		26				1,932
RFG Premium			172		407		5				584
CARB 2 Regular									726		726
CARB 2 Premium									234		234
Subtotal-Base	762	11	1,868	2	3,403	32	258	241	1,030	27	7,634
RFG/OG BTU Incrmt	24		34		69		5	4	28		164
Aviation Gasolines			3		15		1		6		25
Kero Jet/Kero	135	2	323	2	1,163	22	53	193	367	28	2,288
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									158		158
Diesel, 0.05%S	309		692		1,038		99	92	171		2,401
No. 2 Fuel, 0.25%S	110	37	169	5	581	46	49	44		58	1,099
Subtotal	419	37	861	5	1,619	46	148	136	329	58	3,658
Residual Fuels											
<0.3% Sulfur	24	1	2		10	27	1	9	3	17	94
0.7-1.0% Sulfur	76	3	11	2	51	3	1	22	12	4	185
>2.0% Sulfur	37	3	73		328	(5)	9	97	243	30	815
Subtotal	137	7	86	2	389	25	11	128	258	51	1,094
Asphalt/Road Oil	15	44	103	5	66	20	22		3	44	322
Marketable Coke - 400 #B	12		69		146		5	11	84		327
Catalytic Coke - 400 #B	32		47		93		6	6	26		210
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	3	14	18	5	49	31	1		3	5	129
Petrochem Naphtha		1	19		108	6			4	2	140
Lubes/Wax	11	13	24		97	16	2		17	5	185
Petrochem Gas Oil			34		288	2	2		8	3	337
Carbon Black Feed			4		29				1		34
Propene	13		22		63				1		99
Butanes/Butenes					53	3			7	1	64
Propane	36		77		173	1	7	9	25		328
Process Gas/C2-FOE B	70	2	144	1	320	4	21	21	116	5	704
(Gain)/Loss	(76)	1	(149)		(339)	1	(10)	(16)	(127)	2	(713)
Total Products	1,601	132	3,603	22	7,890	209	532	733	2,186	231	17,139

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TABLE A1-33
REFINING RAW MATERIALS INPUT RATES DETAIL
2010 F3 (LOW) SUMMER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Domestic Crudes	43	44	1,807	17	3,187	192	399	393	1,297	234	7,613
Foreign Crudes	<u>864</u>	<u>89</u>	<u>627</u>	<u>7</u>	<u>1,748</u>	<u>43</u>	<u>—</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>3,645</u>
Subtotal Crudes	907	133	2,434	24	4,935	235	399	524	1,429	238	11,258
Natural Gasoline/LSR			39		137	2	5		5		188
Reformate 100 RONC	27	(3)	35	(1)	(21)	1	2	(23)	23	(4)	36
Naphtha	8			(1)	88		(1)	2	5	(1)	100
Vacuum Gas Oil	176	2	27		224	(29)	(5)	(8)	32	(4)	415
Vacuum Resid					14						14
Normal Butane					5						5
Iso-butane	2		45		93		3	2	6		151
MTBE	64		86		195		3		77	2	427
Propane	<u>—</u>	<u>—</u>	<u>2</u>	<u>—</u>	<u>13</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>15</u>
Total Input	1,184	132	2,668	22	5,683	209	406	497	1,577	231	12,609

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TABLE A1-34
REFINING PRODUCT RATES DETAIL
2010 F3 (LOW) SUMMER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Motor Gasolines											
OG Regular		11	535	2	762	32	154	159	40	27	1,722
OG Premium			122		268		33	34	13		470
OG Regular											
OG Premium											
RFG-OG Regular											
RFG-OG Premium											
RFG Regular	419		661		1,276		22				2,378
RFG Premium	168		151		449		5				773
CARB 2 Regular									585		585
CARB 2 Premium									189		189
Subtotal-Base	587	11	1,469	2	2,755	32	214	193	827	27	6,117
RFG/OG BTU Incrmt	18		24		54		1		22		119
Aviation Gasolines			2		11		1		5		19
Kero Jet/Kero	73	2	173	2	578	22	29	104	199	28	1,210
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									120		120
Diesel, 0.05%S	237		490		799		73	81	101		1,781
No. 2 Fuel, 0.25%S	30	37	87	5	246	46	35	14		58	558
Subtotal	267	37	577	5	1,045	46	108	95	221	58	2,459
Residual Fuels											
<0.3% Sulfur	20	1	2		8	27	1	9	3	17	88
0.7-1.0% Sulfur	62	3	9	2	53	3	1	22	12	4	171
>2.0% Sulfur	13	3	28		134	(5)	4	41	104	30	352
Subtotal	95	7	39	2	195	25	6	72	119	51	611
Asphalt/Road Oil	51	44	105	5	63	20	21		24	44	377
Marketable Coke - 400 #B	11		65		133		5	10	81		305
Catalytic Coke - 400 #B	23		35		75		4	4	20		161
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	2	14	10	5	28	31	1		2	5	98
Petrochem Naphtha		1			34	6			4	2	47
Lubes/Wax	8	13	16		66	16	1		12	5	137
Petrochem Gas Oil			22		187	2	1		4	3	219
Carbon Black Feed			4		33				1		38
Propene	13		24		67				1		105
Butanes/Butenes	12		40		185	3		9	29	1	279
Propane	25		59		123	1	7	8	24		247
Process Gas/C2-FOE B	50	2	105	1	235	4	15	15	85	5	517
(Gain)/Loss	(59)	1	(117)		(270)	1	(8)	(13)	(103)	2	(566)
Total Products	1,184	132	2,668	22	5,683	209	406	497	1,577	231	12,609

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TABLE A1-35
REFINING RAW MATERIALS INPUT RATES DETAIL
2010 F3 (LOW) WINTER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	U.S. <u>TOTAL</u>
Domestic Crudes	43	44	1,867	17	3,312	192	339	353	1,212	234	7,613
Foreign Crudes	<u>844</u>	<u>89</u>	<u>350</u>	<u>7</u>	<u>1,338</u>	<u>43</u>	<u>—</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>2,938</u>
Subtotal Crudes	887	133	2,217	24	4,650	235	339	484	1,344	238	10,551
Natural Gasoline/LSR			39		137	2	5		5		188
Reformate 100 RONC	27	(3)	35	(1)	(21)	1	2	(23)	23	(4)	36
Naphtha	8			(1)	88		(1)	2	5	(1)	100
Vacuum Gas Oil	176	2	27		224	(29)	(5)	(8)	32	(4)	415
Vacuum Resid					14						14
Normal Butane	4		112		137		24	15	16		308
Iso-butane	2		45		93		3	2	6		151
MTBE	64		92		191		11	14	79	2	453
Propane	<u>—</u>	<u>—</u>	<u>2</u>	<u>—</u>	<u>13</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>15</u>
Total Input	1,168	132	2,569	22	5,526	209	378	486	1,510	231	12,231

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TABLE A1-36
REFINING PRODUCT RATES DETAIL
2010 F3 (LOW) WINTER SCENARIO – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Motor Gasolines											
CG Regular		11	470	2	664	32	88	29		27	1,323
CG Premium			107		233		19	6			365
OG Regular			69		52		57	126	41		345
OG Premium			16		18		12	26	13		85
RFG-OG Regular	421		61		338						820
RFG-OG Premium	170		14		119						303
RFG Regular			580		901		20				1,501
RFG Premium			132		316		4				452
CARB 2 Regular									563		563
CARB 2 Premium									182		182
Subtotal-Base	591	11	1,449	2	2,641	32	200	187	799	27	5,939
RFG/OG BTU Incrmt	18		26		54		3	4	22		127
Aviation Gasolines			2		11		1		5		19
Kero Jet/Kero	77	2	179	2	650	22	31	108	207	28	1,306
Diesel/No. 2 Fuels											
Diesel, LA, 0.05% S									108		108
Diesel, 0.05% S	207		464		697		67	62	118		1,615
No. 2 Fuel, 0.25% S	74	37	113	5	390	46	33	29		58	785
Subtotal	281	37	577	5	1,087	46	100	91	226	58	2,508
Residual Fuels											
<0.3% Sulfur	24	1	2		10	27	1	9	3	17	94
0.7-1.0% Sulfur	76	3	11	2	51	3	1	22	12	4	185
>2.0% Sulfur	17	3	32		148	(5)	4	43	108	30	380
Subtotal	117	7	45	2	209	25	6	74	123	51	659
Asphalt/Road Oil	3	44	63	5	39	20	13			44	231
Marketable Coke - 400 #B	11		63		133		5	10	77		299
Catalytic Coke - 400 #B	23		33		67		4	4	18		149
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph./Misc./HSR	2	14	10	5	28	31	1		2	5	98
Petrochem Naphtha		1			34	6			4	2	47
Lubes/Wax	8	13	16		66	16	1		12	5	137
Petrochem Gas Oil			22		187	2	1		4	3	219
Carbon Black Feed			4		29				1		34
Propene	13		22		63				1		99
Butanes/Butenes					53	3			7	1	64
Propane	25		55		123	1	5	6	18		233
Process Gas/C2-FOE B	50	2	103	1	229	4	15	15	83	5	507
(Gain)/Loss	(59)	1	(116)		(263)	1	(8)	(13)	(99)	2	(554)
Total Products	1,168	132	2,569	22	5,526	209	378	486	1,510	231	12,231

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TABLE A1-37
REFINING SEASONALLY WEIGHTED GASOLINE AVERAGES BY TYPE
1995 F2 ANNUAL SCENARIO
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>U.S. TOTAL</u>
% SUMMER PRODUCTION(1)							
<u>Motor Gasolines</u>							
CG Regular		53.8	55.7	62.2	78.4	100.0	58.0
CG Premium		53.8	55.7	62.2	78.4	100.0	58.0
OG Regular							
OG Premium							
RFG-OG Regular							
RFG-OG Premium							
RFG Regular	100.0	51.0	65.4			100.0	81.4
RFG Premium	100.0	51.0	65.4			100.0	81.4
Average	49.8	50.4	51.1	51.7	50.9	50.9	50.7
Asphalt / Road Oil(2)	83.0	62.1	60.7	60.7		92.1	62.0
<u>PRICING(3)</u>							
<u>Motor Gasolines, ¢/G</u>							
CG Regular		59.5	56.2	63.0	63.7	65.6	
CG Premium		67.4	62.0	69.2	70.3	71.7	
OG Regular		58.3	56.7	60.8	61.0	60.8	
OG Premium		65.6	62.8	66.3	67.8	67.1	
RFG-OG Regular	57.7		56.7			60.8	
RFG-OG Premium	65.1		62.8			67.1	
RFG Regular	66.9	64.2	61.9			70.6	
RFG Premium	73.9	72.0	67.8			76.7	
Asphalt / Road Oil, ¢/B	17.62	14.65	16.63	12.63		17.13	
<u>PROPERTIES</u>							
<u>Motor Gasolines, RVP, PSI</u>							
CG Regular		10.3	9.7	9.5	9.5	7.5	
CG Premium		10.3	9.7	9.5	9.5	7.5	
OG Regular		12.5	11.9	12.0	12.3	10.1	
OG Premium		12.5	11.9	12.0	12.3	10.1	
RFG-OG Regular	12.2		11.9			10.1	
RFG-OG Premium	12.2		11.9			10.1	
RFG Regular	7.4	10.0	8.8			6.9	
RFG Premium	7.4	10.0	8.8			6.9	
Average	9.8	10.4	9.8	9.9	10.5	8.6	
<u>Motor Gasolines, T-90, °F</u>							
CG Regular(4)		330	337	322	324	328	
CG Premium(4)		330	337	322	324	328	
OG Regular		326	333	317	318	320	
OG Premium		326	333	317	318	320	
RFG-OG Regular	324		333			320	
RFG-OG Premium	324		333			320	
RFG Regular	337	330	338			328	
RFG Premium	337	330	338			328	
Average	330	330	337	321	322	324	

(1) Simple refineries assumed equal to 50% summer production for CG regular and asphalt.

(2) Asphalt for PADD (combined conversion and simple) as follows (%):

I = 66.5, II = 61.7, III = 58.6, IV = 60.7, V = 62.7.

(3) OG, RFG-OG, RFG assumed pricing is 5¢/G above CG shown on Tables A-13, 13A and 13B.

(4) Times 125% or 356° F.

TABLE A1-38
REFINING SEASONALLY WEIGHTED GASOLINE AVERAGES BY TYPE
2000 F2 ANNUAL SCENARIO
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	IC	IIC	IIIC	IV	VCOC	VCC	U.S. TOTAL
% SUMMER PRODUCTION(1)							
Motor Gasolines							
CG Regular		53.2	53.4	63.7	84.7	100.0	56.5
CG Premium		53.2	53.4	63.7	84.7	100.0	56.5
OG Regular							
OG Premium							
RFG-OG Regular							
RFG-OG Premium							
RFG Regular	100.0	53.4	58.7	52.5			61.8
RFG Premium	100.0	53.4	58.7	52.5			61.8
CARB 2 Regular						50.9	50.9
CARB 2 Premium						50.9	50.9
Average	49.8	50.4	51.1	51.7	50.9	50.9	50.7
Asphalt / Road Oil(2)	83.0	62.1	60.7	60.7		92.1	62.0
PRICING(3)							
Motor Gasolines, ¢/G							
CG Regular		59.5	56.0	63.2	64.3	65.6	
CG Premium		67.3	61.9	69.3	70.9	71.7	
OG Regular		58.3	56.7	60.8	61.0	60.8	
OG Premium		65.6	62.8	66.3	67.8	67.1	
RFG-OG Regular	57.7	58.3	56.7				
RFG-OG Premium	65.1	65.6	62.8				
RFG Regular	71.9	67.1	64.3	69.6			
RFG Premium	78.9	75.0	70.2	75.1			
CARB 2 Regular						73.2	
CARB 2 Premium						79.4	
Asphalt / Road Oil, \$/B	17.62	14.65	16.63	12.63		17.13	
PROPERTIES(4)							
Motor Gasolines, RVP, PSI							
CG Regular		10.3	9.8	9.4	9.3	7.5	
CG Premium		10.3	9.8	9.4	9.2	7.5	
OG Regular		12.5	11.9	12.0	12.3	10.1	
OG Premium		12.5	11.9	12.0	12.3	10.1	
RFG-OG Regular	12.2	12.5	11.9				
RFG-OG Premium	12.2	12.5	11.9				
RFG Regular	7.3	9.8	9.1	9.4			
RFG Premium	7.3	9.8	9.1	9.6			
CARB 2 Regular						8.3	
CARB 2 Premium						8.3	
Average	9.8	10.2	9.6	9.8	10.5	8.3	
Motor Gasolines, T-90, °F							
CG Regular		330	337	322	325	328	
CG Premium		330	337	322	325	328	
OG Regular		326	333	317	318	320	
OG Premium		326	333	317	318	320	
RFG-OG Regular	295	295	295				
RFG-OG Premium	295	295	295				
RFG Regular	295	295	295	295			
RFG Premium	295	295	295	295			
CARB 2 Regular						290	
CARB 2 Premium						290	
Average	295	311	311	318	322	292	

(1) Simple refineries assumed equal to 50% summer production for CG regular and asphalt.

(2) Asphalt for PADD (combined conversion and simple) as follows (%):

I = 66.5, II = 61.7, III = 58.6, IV = 60.7, V = 62.7.

(3) Assumed pricing above CG shown in Tables A-13, 13A and 13B is as follows:

OG, RFG-OG = +5 ¢/G; CARB 2, RFG summer = +10 ¢/G.

(4) Based on alternate to complex formula shown in Tables A-23 and A-24.

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TABLE A2-1
REFINING RAW MATERIALS INPUT RATES DETAIL
1989 ACTUAL - MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
Domestic Crudes	43	44	1,820	17	2,743	192	386	485	1,649	234	7,613
Foreign Crudes	<u>1,112</u>	<u>89</u>	<u>1,060</u>	<u>7</u>	<u>3,181</u>	<u>43</u>	<u>72</u>	<u>131</u>	<u>132</u>	<u>4</u>	<u>5,831</u>
Subtotal Crudes	1,155	133	2,880	24	5,924	235	458	616	1,781	238	13,444
Natural Gasoline/LSR			34		104	2	5		5		150
Reformate 100 RONC	27	(3)	35	(1)	(41)	1	2	(24)	23	(4)	15
Naphtha	8			(1)	84		(1)	2	5	(1)	96
Vacuum Gas Oil	169	2	26		214	(29)	(5)	(8)	31	(4)	396
Vacuum Resid					13						13
Normal Butane	2		38		71		12	4	8		135
Iso-butane	2		44		90		3	2	6		147
MTBE	4		6		31		1		14	2	58
Propane	<u> </u>	<u> </u>	<u>2</u>	<u> </u>	<u>14</u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>16</u>
Total Input	1,367	132	3,065	22	6,504	209	475	592	1,873	231	14,470

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TABLE A2-2
REFINING PRODUCT RATES DETAIL
1989 ACTUAL – MBPCD
NPC 1991-92 STUDY OF US REFINING INDUSTRY

	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S. TOTAL</u>
<u>Motor Gasoline</u>											
Low Lead Regular	17	4	148	1	252	4	73	61	184	7	751
Unleaded Regular	354	7	1,110	1	1,722	28	130	113	508	20	3,993
Unleaded Intermediate	71		134		279		4		14		502
Unleaded Premium	236		287		850		31	45	230		1,679
Sub Total	678	11	1,679	2	3,103	32	238	219	936	27	6,925
Aviation Gasolines			3		15		1		6		25
Naphtha Jet	14	3	12	7	66	35	15	10	40	4	206
Kero Jet / Kerosene	75	1	183		633	12	27	109	203	27	1,270
Distillate Fuels - 0.05% S									88		88
Distillate Fuels - 0.25% S	322	37	679	5	1,252	46	122	109	177	58	2,807
<u>Residual Fuels</u>											
< 0.3% Sulfur	22	1	2		9	27	1	9	3	17	91
0.7 - 1.0% Sulfur	69	3	10	2	52	3	1	22	12	4	178
> 1.0% Sulfur	29	3	59		272	(5)	8	82	207	30	685
Sub Total	120	7	71	2	333	25	10	113	222	51	954
Asphalt / Road Oil	44	44	136	5	84	20	28		19	44	424
Marketable Coke - 400#	12		70		146		5	11	86		330
Catalytic Coke - 400#	31		47		96		6	6	26		212
Benzene	2		2		21						25
Toluene	6		5		25						36
Xylene			9		40						49
Spcl. Naph. / Misc.	4	12	26		73	6	2		4	2	129
Petrochem Naphtha		1			2	6			4	2	15
Lubes	11	10	23		90	14	1		14	5	168
Wax		3	1		7	2	1		3		17
Petrochem Gas Oil			18		152	2	1		4	3	180
Carbon Black Feed			4		31				1		36
Propane	13		23		65				1		102
Butanes / Butenes	6		2		119	3		1	18	1	150
Propane	30		69		149	1	7	9	25		290
Process Gas / C2 / C2=	68	2	141	1	317	4	20	20	115	5	693
(Gain) / Loss	(70)	1	(138)		(315)	1	(9)	(15)	(119)	2	(662)
Total Products	1,367	132	3,065	22	6,504	209	475	592	1,873	231	14,470

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TABLE A2-3
REFINING CRUDE INPUT SUMMARY
1989 ACTUAL
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Type	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	VS	U.S. TOTAL
<u>RATES - MBPCD</u>												
<u>Domestic</u>												
Low Sulfur	S	14	34	1,223	13	1,981	186	255	32	44	25	3,807
High Sulfur Light	HL			371	4	174		69				618
High Sulfur Heavy	HH	29	10	226		588	6	62	453	1,605	209	3,188
Subtotal		43	44	1,820	17	2,743	192	386	485	1,649	234	7,613
<u>Foreign</u>												
Low Sulfur	S	644	13	376		941	29	6	125	106	0	2,240
High Sulfur Light	HL	181		231	1	724		42	5	14		1,197
High Sulfur Heavy	HH	287	76	453	6	1,516	14	24	2	13	4	2,394
Subtotal		1,112	89	1,060	7	3,181	43	72	131	133	4	5,831
<u>Combined</u>												
Low Sulfur	S	658	47	1,599	13	2,922	215	261	157	150	25	6,047
High Sulfur Light	HL	181		602	5	898		111	5	14		1,815
High Sulfur Heavy	HH	316	86	679	6	2,104	20	86	455	1,618	213	5,582
Subtotal		1,155	133	2,880	24	5,924	235	458	616	1,782	238	13,444
<u>% - Combined</u>												
Low Sulfur	S	57.0	35.5	55.5	54.4	49.3	91.6	56.9	25.4	8.4	10.6	45.0
High Sulfur Light	HL	15.6		20.9	18.8	15.2		24.3	0.8	0.8		13.5
High Sulfur Heavy	HH	27.4	64.5	23.6	26.8	35.5	8.4	18.8	73.8	90.8	89.4	41.5
Subtotal		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>												
Domestic Gravity, deg. API		30.1	35.4	35.9	39.9	34.6	41.9	36.0	27.9	23.1	24.3	31.7
Domestic Sulfur, % wt.		2.47	0.93	0.73	0.54	0.63	0.39	0.79	0.99	1.17	1.49	0.84
Foreign Gravity, deg. API		32.5	19.6	31.8	27.9	31.6	29.5	34.6	43.0	39.9	23.2	32.0
Foreign Sulfur, % wt.		0.93	2.80	1.42	2.00	1.57	1.04	1.20	0.14	0.25	2.62	1.38
Combined Gravity, deg. API		32.5	24.5	34.3	36.2	33.0	39.5	35.8	30.9	24.2	24.3	31.9
Combined Sulfur, % wt.		0.99	2.22	0.99	0.99	1.14	0.52	0.85	0.82	1.10	1.51	1.07
Note: DOE Reported												
<u>Crude Properties</u>												
Combined Gravity, deg. API		32.3	24.7	34.7	36.4	33.2	39.7	36.0	30.7	24.4	24.5	32.1
Combined Sulfur, % wt.		0.97	2.25	1.00	0.98	1.10	0.52	0.85	0.80	1.15	1.51	1.06

TABLE A2-4
REFINING DOMESTIC CRUDE INPUT RATES DETAIL
1989 ACTUAL - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Location/Name		LP	IC	IS	IIC	IIS	IIIC	IIIS	IV	VCOC	VCC	VS	U.S.
		Code Type											TOTAL
AL	Heavy	ALH HH			5		30						35
	Light	ALL S						18					18
AK	Cook	AKC S								32	10		42
	North Slope	ANS HH	13		54		336			453	845	131	1,832
AZ	Sweet	AZS S											0
AR	Heavy	ARH HH					31						31
CA	Beta	CBT HH									16		16
	Elk Hills	CEH S			36		48				34	16	134
	Huntington Beach	CHB HH									20		20
	Hondo	CAH HH	16	5							11	28	60
	LA Basin Light	CLL HH									26	5	31
	San Ardo	CSA HH									63		63
	SJV Light	CJL HH									95		95
	SJV Kern River	CJH HH									76	45	121
	SJV Heavy	CVH HH		5							268		273
	Ventura	CCV HH									48		48
	Wilmington Heavy	CWH HH									88		88
	Wilmington Light	CWL HH									49		49
CO	Rangely	COR S			7				77				84
DI	PADD I Lube	PAL S		15									15
FL	Jay	FLJ S	14	6									20
IL	Sweet	ILS S			28								28
	Weeks	ILW S			28								28
IN	Sweet	IDS S			9								9
KS	Butler	KSB S			13								13
	Common	KSC S			24								24
	Light	KSL S			115								115
KY	Sweet	KYS S			17								17
LA	Condensate	LAC S					87	24					111
	Light Sweet	LLS S			100		219						319
	North Mix	LAM S					31	33					64
	Heavy Sweet	LAO S		8	80		552						640
MI	Sweet	MIS S			59								59
MS	Baxterville	MSB HH					34	6					40
	Light Hey	MSH HL				4	19						23
	Sweet	MSS S					12						12
MT	Sour	MTS HH			1				11				12
	Rebeki	MTR S			10				35				45
NE	Light Sour	NES HL			18								18
NV	Sweet	NVS S										9	9
NM	Intermediate	NMI S			114			24					138
	Sour	NMS HL					49						49
ND	Light Sour	NDS HL			32				69				101
OH/M	Light	OHL S		5	23								28
OK	Cement	OKM S			88		28						116
	Condensate	OKC S			12								12
	Garber	OKG S			126								126
	Velma	OKV HH			66								66
SD	Sweet	SDS S			6								6
TX	Condensate	TXC S					69	15					84
	East	TXE S			100		78						178
	Hawkins	TEH HH					157						157
	Gulf Refugio	TGR S					466	22					488
	West Intermed	TWI S			111	13	391	50					565
	West Scurry	TWY S			38								38
	West Sour	TWS HL			321		106						427
UT	Altamont	UTA S							27				27
	Mix	UTM S							51				51
WY	Platte/Sour	WYP HH			100				51				151
	Sweet	WYS S			79				65				144
Total Volume			43	44	1,820	17	2,743	192	386	485	1,649	234	7,613

TABLE A2-5
REFINING FOREIGN CRUDE INPUT RATES DETAIL
1989 ACTUAL - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>COUNTRY</u>	<u>NAME</u>	<u>TYPE</u>	<u>IC</u>	<u>IS</u>	<u>IIC</u>	<u>IIS</u>	<u>IIIC</u>	<u>IIIS</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VS</u>	<u>U.S.</u> <u>TOTAL</u>
Abu Dhabi/Dubai/Oman/UAE		HL					25				13		38
Algeria	Cond.	S	1		11		37	2					51
Angola	Angolan	S	57	1	5		129	2					193
	Light	S	37	2	3		39						80
Cameroon	Kole	S	14		3		20						37
Canada	Heavy	HH	1		150				7			4	162
	Lloydmin	HH			147	6			17				170
	Intrprvn.	S	1		59	0	8		6		0	0	73
	Intermed.	HL	57		2	0	2		2				63
	Feder.	S			31	0							31
	Rangeland	HL			56	0			40	5			101
China	Daqing	S	20				23	12		7	14		76
Colombia	Cano Lim.	HH	21		9		104	1					136
Congo	Djeno	S					9	5					14
Ecuador	Oriente	HH	29	1	17		19	2		2	13		82
Gabon	Mandji	HH	2				13						15
	Gamba	S	8				27	1					37
Indonesia	Minas	S		2	1		28			24	36		91
	Attika	S					1			25	15		40
	Cond.	S			6		2			38	29		75
Iraq	Kirkuk	HL	37		55		341				1		434
Kuwait		HH	7		4		144						155
Mexico	Maya	HH	29	24	47		336	0					437
	Isthmus	HL	29				101						130
	Sweet	S	5		37		94						135
Nigeria	Heavy	S	30		14		29						72
	Forcados	S	84		26		93						204
	Medium	S	236	5	93		102						436
	Light	S	22		18		51						91
Norway	Heavy	S	55		3		4						61
	Medium	S	6		3		11	1					21
	Ekofisk	S	31				14						45
Saudi Arabia	Heavy	HH	67		2		134	0					203
	Medium	HH	77		1		411						489
	Light	HL	52		110		175						337
	Berri	HL	2		8		79						89
Trinidad	Light	S	1		20		53						74
United Kingdom	Brent	S	22		21		111						154
Venezuela	Boscan	HH		14				2					16
	Mlones	HH		17			14	3					34
	Bach Q17	HH	34	12			63						108
	TJ Med	HH					116						116
	Lago Med	HH	4	1	58		152						215
Yemen		S			20		14						34
Zaire		S	8	1	3		14	1					26
Misc. Low Sulfur		S	9	2	3		30	5		31	12	0	91
Misc. High Sul. Lt.		HL	4				2						6
Misc. High Sul. Hvy.		HH	16	8	18		10	5					56
Total			1,112	89	1,060	7	3,181	43	72	131	133	4	5,831

TABLE A3-1
ESTIMATED INVESTMENT COSTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(mid-1991 dollars)⁽¹⁾

Investment	Capacity MB/SD	USGC Capital Costs, \$Million ⁽²⁾					Offsites ⁽³⁾	Scaling Factors ⁽⁴⁾
		On-Site	Catalyst	Royalty	Offsites ⁽³⁾	Total	% of On-Site	
Crude (w/o Gas Plant)	150	50	-	-	25	75	50	0.7
Vacuum	40	25	-	-	12	37	50	0.7
Coker (Delayed w/Gas Plant)	25	110	-	-	66	176	60	0.65
Distillate HDS (800 psi)	30	25	-	-	12	37	50	0.65
Reformer (CCR @ 100 psi)	35	50	3	2	25	80	50	0.65
Fluid Cat Cracker (FCC w/Gas Plant)	70	150	1	7	60	218	40	0.65
FCC Feed Hydrotreater (1,000 psi)	35	40	1	-	16	57	40	0.65
Hydrocracker (2-Stage @ 2,000 psi)	30	110	5	5	55	175	50	0.65
Alkylation (Sulfuric)	19	55	-	-	22	77	40	0.65
MTBE Unit	2	10	0	1	4	15	40	0.6
C ₅ /C ₆ Isomerization (Recycle)	15	25	1	3	10	39	40	0.65
Hydrogen Plant, MMSCF/D	60	50	1	-	20	71	40	0.65
Sulfur/Amine (w/Tail Gas), LT/D	200	20	-	-	8	28	40	0.6

(1) To be adjusted by gross domestic product deflator ratio (1990/1991) to obtain mid-1990 investment costs.

(2) NPC FTG determined these U.S. Gulf Coast on-site (or battery limit) investment costs and the alternate location factors shown in Table A-6. TM&C factor for permits, site preparation, owner engineering and startup is 14% of total costs (NPC FTG recommended equivalent factor of 20% of on-site costs).

(3) For grassroots refinery, offsites increase to about 100% of on-sites, compared to 40 to 50% shown for most new units in existing refinery.

(4) Exponential scaling factors for alternate unit sizes.

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TABLE A3-2
ESTIMATED OPERATING COSTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(USGC with mid-1991 dollars)

	Capacity MBPSD	Variable, \$/B		Fixed (Ex. Capital) ⁽¹⁾	
		<u>\$2.20/MSCF⁽²⁾</u>	<u>\$3.00/MSCF</u>	<u>\$/BPSD</u>	<u>\$MM/Yr.⁽³⁾</u>
Crude (w/o Gas Plant)	150	0.12	0.16	0.10	5.3
Vacuum	40	0.11	0.14	0.13	1.9
Coker (Delayed w/Gas Plant)	25	0.77	1.06	1.19	10.8
Distillate HDS (800 psi)	30	0.33	0.45	0.25	2.7
Reformer (CCR @ 100 psi) - 100 RONC	35	1.11 ⁽⁴⁾	1.48 ⁽⁴⁾	0.40	5.2
Fluid Cat Cracker (FCC w/Gas Plant)	70	0.92	1.15	0.55	14.1
FCC Ex. Coke	-	0.11	0.05	-	-
FCC Feed Hydrotreater (1,000 psi)	35	0.44	0.59	0.33	4.3
Hydrocracker (2-Stage @ 2,000 psi)	30	0.47	0.61	0.87	9.5
Alkylation (Sulfuric)	19	1.91	2.46	0.66	4.6
MTBE Unit	2	1.22	1.66	1.16	0.8
Isomerization (TIP, Pen/Hex)	15	0.80	1.08	0.85	4.7
Hydrogen Plant (H ₂), MMSCF/D	60	0.69 ⁽⁵⁾	0.92 ⁽⁵⁾	0.21 ⁽⁵⁾	4.7
H ₂ Including Feed	-	1.37 ⁽⁵⁾	1.84 ⁽⁵⁾	-	-
Sulfur/Amine (w/Tail Gas), LT/D	200	58 ⁽⁶⁾	82 ⁽⁶⁾	34 ⁽⁶⁾	2.5

(1) Fixed costs include offsite (total refinery) costs associated with each unit, except capital charge.

(2) Alternate natural gas cost shown because \$3.00 is much too high.

(3) Alternate annual cost shown because unit fixed costs are highly dependent on unit size.

(4) Variable costs @ 90 RONC would be \$0.07 and 0.09/B lower.

(5) Per MSCF.

(6) Per LTon.

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TABLE A3-3
EVALUATE MODEL RECALIBRATION
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

- NPC has tentatively decided that TM&C models do not require further calibration. The final NPC survey questionnaire does not request sufficient data for a complete and thorough gasoline property recalibration.
- Recalibration costs for all six models would be about \$70,000.
- The current TM&C models were extensively calibrated to actual 1984 data in the 1985 NPC study of U.S. refining industry capabilities. Calibration criteria and NPC results are shown in Tables A3-4 and A3-5.
- Finished gasoline RVP versus butane content was extensively calibrated against a 1987 TM&C survey for API. This was part of our study *U.S. Gasoline RVP Reduction Capabilities and Costs* for API.
- Component and finished gasoline distillation data were adjusted to match NIPER data on finished gasoline distillation in a 1989 subscription study, *U.S. Gasoline Outlook: 1989-94*. Results are shown in Table A3-6.
- TM&C's LP model 90% distilled prediction method was verified against Auto/Oil actual blend results, as shown in Table A3-7.
- As shown in Table A3-8, TM&C LP base cases for Auto/Oil matched 1989 NPRA survey aromatics and olefins data within less than test accuracy after adjustments for octane, MTBE content and RVP.
- TM&C model base cases for Auto/Oil, which were not constrained for benzene and sulfur, compared well to survey levels. They were off by less than lab reproducibility on the larger models, as shown in Table A-9. Component sulfur data were further calibrated for very low sulfur levels, based on results of an informal letter survey of participating oil companies.
- Our LP model very closely predicted physical test fuel properties of six blends created for WSPA in 1991 as part of our study *Future Reformulated Gasolines, WSPA/CARB/GM RVP/Driveability Index Emissions Testing Program*. Results are summarized in Table A3-10.

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TABLE A3-4

1984 NPC CALIBRATION CRITERIA

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Maximum Variance</u>
● Match Material Balance from DOE Allow Residual Fuels, C ₄ - and Gain to Vary	± 0.3% of Total Input
● Match Utilities from DOE Usage Fuel Composition	± 3% of Target ± 4% of Total Fuel
● Match Major Product Primary Qualities ⁽¹⁾ Mogas Octanes: (R+M)/2 Mogas Lead, gms./Gal. Mogas RVP, psi Distillate Fuels Sulfur, Wt. %	+ 0.1 - 0.1 - 0.5 - 0.2 ⁽²⁾
● Match Unit Utilizations ⁽¹⁾ Conversion Units by Type Composite of Conversion Units Catalytic Reformers	± 8% ± 5% ± 15%
● Match Unit Severities ⁽¹⁾ Cat Cracking Conversion, % Reformat Octane, RONC	± 5 ± 0.5
● Judgment Review of Shadow Values None Constraining Severely	± 20%

⁽¹⁾ From 1984 NPC survey data.

⁽²⁾ Adjusted to zero on future runs by allowing high sulfur diesel to bypass distillate HDS unit.

TABLE A3-5
1984 NPC CALIBRATION RUN RESULTS
ACTUAL VARIANCES⁽¹⁾ COMPARED TO ACCEPTABLE VARIANCES
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

	Maximum Acceptable Variance	IC	IIDC	IILC	IIIDC	IIILC	IV	VCOC	VCC	VCLA
<u>Material Balance, % Total Input</u>										
Residual Fuels	± 0.3	0.05	-0.01	0.04	0.26	0.18	0.01	0.1	-0.1	0.05
Propane	± 0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Produced Fuels, FOE	± 0.3	-0.08	0.03	-0.02	-0.11	-0.25	-0.27	-0.12	0.07	-0.03
Gain	± 0.2	-0.01	0.01	0.03	0.15	-0.16	0.0	0.01	0.0	0.08
<u>Utilities Usage, % Target</u>										
Total Fuels, FOE	± 2%	-0.1	0.4	0.3	-0.9	0.1	-1.1	-0.3	-0.7	-0.9
Purchased Fuels, FOE ⁽²⁾	± 4%	0.9	0.0	0.6	0.4	3.6	2.6	1.5	-1.4	-0.5
Produced Fuels, FOE ⁽²⁾	± 4%	-1.0	0.4	-0.3	-1.3	-3.5	-3.7	-1.8	0.7	-0.4
Power, KWH	± 3%	0.4	0.2	0.5	-2.5	-0.2	-1.4	-0.2	0.0	-1.0
<u>Product Qualities</u>										
Motor Gasolines										
Octane – (R+M)/2										
Grade	+0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pool	+0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lead, gms./Gal.										
Regular Leaded	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Premium Leaded	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RVP, psi										
Grade	-0.5	-0.46	-0.4	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
Pool	-0.2	-0.14	-0.17	-0.04	0.0	0.0	0.0	0.0	0.0	0.0
Distillate Fuels, % Sulfur ⁽³⁾	-0.2	-0.01	-0.17	-0.17	0.0	-0.15	0.0	0.0	-0.25	0.0

TABLE A3-5
1984 NPC CALIBRATION RUN RESULTS
ACTUAL VARIANCES⁽¹⁾ COMPARED TO ACCEPTABLE VARIANCES
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

	Maximum Acceptable Variance	<u>IC</u>	<u>IIDC</u>	<u>IIIC</u>	<u>IIIDC</u>	<u>IIILC</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>VCLA</u>
<u>Capacity Utilization, %⁽⁴⁾</u>										
Cat Cracking	± 8	1.8	4.9	2.5	-2.5	-6.7	4.9	7.7	-5.0	-0.5
Hydrocracking	± 8	2.2	7.3	*	8.3	*	*	*	4.0	0.4
Coking Combined	± 8	*	-1.1	-	7.1	-	*	*	-5.3	-5.2
Composite Conversion ⁽⁵⁾	± 5	*	3.9	*	0.6	*	*	*	-1.8	-1.7
Cat Reforming Combined	± 15	-14.8	2.7	-5.4	-0.3	-1.3	-4.7	5.0	-6.2	3.4
<u>Unit Severities</u>										
Cat Cracking Conversion, %	± 5	3.2	-1.5	-4.3	0.0	1.3	-2.2	-1.9	3.1	-1.7
Reformate Octane, RONC	± 0.5	-0.1	0.1	0.2	-0.3	-0.3	0.1	0.0	0.0	-0.1

(1) LP run results minus target (from DOE or survey data).

(2) Variance expressed as % of total fuel.

(3) Forecast case runs changed to allow bypassing distillate HDS with high-sulfur distillate; hence, forecast case runs variance from distillate fuels sulfur target is zero.

(4) Utilizations based on calendar day capacities and actual feed rates, ignoring severity effects.

(5) Utilizations for cat cracking, hydrocracking and coking combined on an actual feed basis, ignoring severity effects.

* Survey data excluded by NPC.

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Consulting Engineers

TABLE A3-6

GASOLINE DISTILLATION CALIBRATION

1988 ANNUAL DATA FOR PADD III

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	TM&C LP Results ⁽¹⁾⁽²⁾ <u>IIIC</u>	NIPER Data Actual <u>Production⁽³⁾</u>	<u>Difference</u>	<u>Reproduc- ibility</u>
Distillation, % at				
170°F	38	38	-	-
212°F	53	53	-	-
257°F	69	69	-	-
300°F	82	82	-	-
356°F	93	93	-	-
50% Point, °F	203	203	-	15
90% Point, °F	336	336	-	16
Temperature @ V/L = 20, °F	122	122	-	2

⁽¹⁾ Based on weighted average model IIIC gasoline pool component composition from 1988 calibration runs for models IIILC and IIIDC in 1989 subscription study *U.S. Gasoline Outlook, 1989-94*.

⁽²⁾ Based on adjusted LP model component gasoline distillations calibrated to match NIPER data on finished gasoline distillation.

⁽³⁾ Calculated weighted average of summer and winter NIPER data for PADD III production based on PADD III plus shipments to PADDs I and II.

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TABLE A3-7

COMPARISON OF MEASURED VS. PREDICTED GASOLINE DISTILLATION

90% DISTILLED TEMPERATURE FOR TEST FUELS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(°F)

	<u>Measured Average</u>	<u>Predicted</u>		<u>Predicted – Measured</u>	
		<u>TBP Method</u>	<u>LP Model Method</u>	<u>TBP Method</u>	<u>LP Model Method</u>
<u>Fuel</u>					
1	330	329	329	(1)	(1)
2	286	284	286	(2)	0
3	356	355	359	(1)	3
4	356	354	360	(2)	4
5	292	287	285	(5)	(7)
6	328	332	326	4	(2)
7	326	333	328	7	2
Average					
Net (Bias)				0	0
Absolute				3	3
Reproducibility				16	16

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TABLE A3-8

GASOLINE AROMATICS AND OLEFINS CALIBRATION

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

	NPRA Survey		TM&C Base Cases			Difference ⁽¹⁾
	Finished Gasoline	Pool	1995	2005	Adjusted to 1989	
		Hydrocarbon Type				
<u>PADD I</u>						
Aromatics, %	32.5	33.3	33.6	32.4	32.0	(1.3)
Olefins, %	17.8	16.0	15.7	15.8	15.6	(0.4)
(R+M)/2 (Clear)	89.4	-	89.6	89.3	89.4	-
MTBE, %	-	1.6	2.0	2.4	1.6	-
RVP, psi	9.9	-	8.6	8.6	9.9	-
<u>PADD II</u>						
Aromatics, %	29.4	29.7	-	31.8	30.9	1.2
Olefins, %	12.0	12.8	-	12.9	12.7	(0.1)
(R+M)/2 (Clear)	88.1	-	-	88.7	88.1	-
MTBE, %	-	0.1	-	2.0	0.1	-
RVP, psi	9.9	-	-	8.6	9.9	-
<u>PADD III</u>						
Aromatics, %	31.5	31.6	31.3	31.2	30.9	(0.7)
Olefins, %	12.2	13.2	14.7	14.2	14.1	0.9
(R+M)/2 (Clear)	88.9	-	89.2	89.0	88.9	-
MTBE, %	-	1.2	2.0	2.0	1.2	-
RVP, psi	9.4	-	8.6	8.6	9.4	-
<u>PADD IV</u>						
Aromatics, %	25.3	25.6	-	27.2	26.8	1.2
Olefins, %	15.2	15.7	-	14.8	14.8	(0.9)
(R+M)/2 (Clear)	86.5	-	-	87.0	86.4	-
MTBE, %	0.1	-	-	2.0	0.1	-
RVP, psi	9.4	-	-	8.6	9.4	-

⁽¹⁾ Adjusted TM&C minus survey pool hydrocarbon type.

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TABLE A3-8
GASOLINE AROMATICS AND OLEFINS CALIBRATION
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

	NPRA Survey		TM&C Base Cases			Difference ⁽¹⁾
	Finished Gasoline	Pool	1995	2005	Adjusted to 1989	
		Hydrocarbon Type				
<u>PADD V (California)</u>						
Aromatics, %	35.8	35.2	34.0	34.6	33.8	(1.4)
Olefins, %	9.5	9.5	10.9	10.2	10.9	1.4
(R+M)/2 (Clear)	88.5	-	89.0	89.0	88.5	-
MTBE, %	-(2)	-	2.0	2.1	0	-
RVP, psi	8.5	-	7.7	7.7	8.5	-
<u>PADD V (Ex. California)</u>						
Aromatics, %	31.4	31.8	31.4 ⁽³⁾	33.7	32.4 ⁽³⁾	0.6
Olefins, %	10.6	8.8 ⁽⁴⁾	10.6 ⁽³⁾	10.0	11.2 ⁽³⁾	2.4 ⁽⁴⁾
(R+M)/2 (Clear)	87.7	-	89.2 ⁽³⁾	88.7	87.7	-
MTBE, %	0.0	-	3.0 ⁽³⁾	3.9	-	-
RVP, psi	10.3	-	12.0 ⁽³⁾	8.6	10.3	-
<u>Total U.S.</u>						
Aromatics, %	31.6	31.8	-	32.0	31.6	(0.2)
Olefins, %	12.3	12.7	-	13.5	13.4	0.7
(R+M)/2 (Clear)	88.6	-	-	88.9	88.6	-
MTBE, %	0.9	0.8	-	2.2	0.8	-
RVP, psi	9.5	-	-	8.5	9.5	-

(1) Adjusted TM&C minus survey pool hydrocarbon type.

(2) Deleted by NPRA.

(3) TM&C 1992 base case for API study of RVP reduction.

(4) Includes soft data of 20.5% olefins on "other" component (mostly FCC gasoline). Assuming a typical value of 34.5% olefins for 93.5 RON FCC gasoline results in a calculated pool of 10.5% olefins.

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TABLE A3-9

GASOLINE BENZENE AND SULFUR COMPARISON⁽¹⁾

AS PRODUCED BY PADDs

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

	NPC ⁽²⁾	Actual			TM&C Model		Difference
	1984	NIPER	NIPER	NPRA	Base Cases	Base Cases	Model Less
		1988	1989	1989	1995	2005	Actual
<u>PADD I</u>							
Benzene, %	1.72	1.52	1.75	-	1.85	1.89	0.10-0.37
Sulfur, ppm	-	280	280	452	357	356	(95)-77
(R+M)/2, Clear	87.0	89.2	89.2	89.4	89.6	89.3	-
RVP, psi	12.6	11.4	9.4	9.9	8.6	8.6	-
<u>PADD II</u>							
Benzene, %	1.39	1.55	1.61	-	-	2.23	0.62-0.84
Sulfur, ppm	-	300	360	422	-	308	(114)-8
(R+M)/2, Clear	85.9	88.2	88.2	88.1	-	88.7	-
RVP, psi	12.4	11.0	9.6	9.9	-	8.6	-
<u>PADD III</u>							
Benzene, %	2.24	1.49	1.64	-	1.77	1.77	(0.47)-0.28
Sulfur, ppm	-	290	320	305	307	340	(13)-17
(R+M)/2, Clear	86.1	88.5	88.5	88.9	89.2	89.0	-
RVP, psi	11.5	10.9	9.2	9.4	8.6	8.6	-
<u>PADD IV</u>							
Benzene, %	1.37	1.74	1.91	-	-	2.09	0.18-0.72
Sulfur, ppm	-	420	450	371	-	298	(152)-(73)
(R+M)/2, Clear	83.0	86.9	86.7	86.5	-	87.0	-
RVP, psi	11.6	10.3	9.4	9.4	-	8.6	-

TABLE A3-9

GASOLINE BENZENE AND SULFUR COMPARISON⁽¹⁾

AS PRODUCED BY PADDs

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

	Actual				TM&C Model		Difference Model Less Actual
	NPC ⁽²⁾	NIPER		NPRA	Base Cases		
	1984	1988	1989	1989	1995	2005	
<u>PADD V (California)</u>							
Benzene, %	2.46	1.79	2.00	-	2.26	2.25	(0.20)-0.47
Sulfur, ppm	-	130	130	161	183	174	22-53
(R+M)/2, Clear	86.4	88.6	88.5	88.5	89.0	89.0	-
RVP, psi	10.0	8.7	8.5	8.5	7.7	7.7	-
<u>PADD V (Ex. California)</u>							
Benzene, %	1.67	2.13	2.58	-	-	2.84	0.26-1.17
Sulfur, ppm	-	470	370	389	-	284	(186)-(86)
(R+M)/2, Clear	86.3	88.1	87.9	87.7	-	88.7	-
RVP, psi	12.8	11.3	10.0	10.3	-	8.6	-
<u>Total U.S.</u>							
Benzene, %	1.96	1.58	1.75	-	-	2.02	0.06-0.44
Sulfur, ppm	-	290	310	321	-	306	(15)-16
(R+M)/2, Clear	86.2	88.4	88.4	88.6	-	88.9	-
RVP, psi	11.7	10.7	9.3	9.5	-	8.5	-
<u>Test Reproducibility</u>							
Benzene	-	-	-	-	-	-	0.20
Sulfur	-	-	-	-	-	-	90

- (1) Model runs were not restricted on benzene and sulfur levels; therefore, differences are greater.
- (2) Annual data.

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TABLE A3-10

DIFFERENCE: AVERAGE LAB LESS VCC REFINERY LP PREDICTED GASOLINE PROPERTIES

WSPA-CARB-GM RVP/DI EMISSIONS TESTING PROGRAM

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Test Fuel Number	RVP psi	DI	Distillation, °F			Octane (R+M)/2	MTBE %	Benzene %	Aromatics %	Olefins %
			10%	50%	90%					
0HO	0.0	13	6	0	3	(0.3)	0	(0.9) ⁽¹⁾	0	(2)
1HO	0.0	(26)	6	(8)	(9)	(0.1)	(1)	0.3	(1)	0
2LO	(0.2)	(44)	(1)	(12)	(10)	0.0	(1)	0.1	(1)	(1)
3HL	(0.1)	(20)	2	(11)	9	0.0	(1)	0.1	(3) ⁽²⁾	(1) ⁽²⁾
4LL	(0.1)	(24)	1	(8)	1	(0.8) ⁽²⁾	(1)	0.2	(3) ⁽²⁾	(2) ⁽²⁾
Average										
Absolute	0.1	25	3	8	6	0.2	1	0.3	2	1
Adjusted ⁽³⁾		-	-	-	-	0.1	-	0.2	1	1
Reproducibility	0.7	85	16	15	16	0.6	3	0.4	3	5

⁽¹⁾ Misleading LP result because LP had no incentive to minimize benzene.

⁽²⁾ Misleading due to inadequate number of lab tests.

⁽³⁾ If misleading differences are excluded from absolute average.

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TABLE A3-11
CHANGES IN V.O.C. REDUCTION TARGETS
USING MODIFIED PUBLISHED COMPLEX FORMULAS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Reasons for increase in NPC PQTG premised V.O.C. reduction in 2000+ from statutory 25% to target 44%:

- Revised evaporation equations published in April 1992.
- Increased evaporation versus exhaust contribution to V.O.C. published in April 1992.
- Initial results of refinery LP model calculations using modified complex formula published in April 1992.
- Simple formula results in 31% V.O.C. reduction using modified complex formula.
- Use of statutory 8.7 RVP 1990 baseline fuel.
- Move to probable cost-effective levels somewhat more restrictive than 1995 EPA simple formula regulations for Class B RFG with 39% V.O.C. reduction using modified complex formula.
- Eliminate compliance margins for benzene and RVP by allowed averaging of property limits for 2000+ RFG.

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TABLE A3-12

**FCAAA EMISSION REDUCTION TARGETS FOR RFG
USING MODIFIED PUBLISHED COMPLEX FORMULAS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(% of base)**

	RVP ⁽¹⁾ psi	1995		2000+	
		<u>V.O.C.</u>	<u>T.A.P.</u>	<u>V.O.C.</u>	<u>T.A.P.</u>
<u>FCAAA</u>					
Baseline	8.7	0	0	0	0
Target ⁽²⁾	-	15	15	25	25
Minimum	-	-	-	20	20
Maximum	-	-	-	35+	35+
<u>EPA Simple Formula⁽³⁾</u>					
Class C (North)	7.7	23	23	-	-
Class B (South)	6.9	39	26	-	-
U.S. Average	7.3	31	25	-	-
<u>NPC Revised Premise⁽⁴⁾</u>					
Class C (North)	6.5	-	-	41	32
Class B (South)	6.5	-	-	47	33
U.S. Average	6.5	-	-	44	32

- (1) After compliance margin (comply) of 0.3 for 1995 simple formula (SF) regulations.
- (2) To be set by EPA regulations at cost-effective levels.
- (3) Requires ≤ 0.7 V% benzene (0.7% benzene is a level refineries might elect to meet the FCAAA T.A.P. reduction requirements with lesser impact on gasoline aromatics); ≥ 2.1 W% oxygen (2.0 + 0.1 comply), ≤ 28 V% aromatics and $\leq$ base: sulfur, olefins and T90.
- (4) Where a fixed recipe is needed to represent 2000 RFG in an industry aggregate model, the NPC has used the following limits on the RFG pool in the model: ≤ 0.7 V% benzene, ≥ 2.1 W% oxygen, ≤ 25 V% aromatics, ≤ 150 wppm sulfur, $\leq 345^\circ\text{F}$ T90, $\leq 210^\circ\text{F}$ T50 and ≤ 12 V% olefins.

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TABLE A3-13

SUMMER V.O.C. EMISSIONS

MODIFIED PUBLISHED COMPLEX FORMULA EQUATIONS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(grams/mile)

Total V.O.C. Emissions =

Exhaust + Evaporative + Running + Refueling

Exhaust V.O.C. =

$$\begin{aligned} &0.46 * A_f * O_f * OI_f * T90_f * S_f \\ &A_f = 1 - 0.006 * (A_b - A_a) \\ &O_f = 1 - 0.01 * O_a \\ &OI_f = 1 + 0.0058 * (OI_b - OI_a) \\ &T90_f = 1 - 0.0038 * (T90_b - T90_a) \\ &S_f = 1 - 0.00042 * (S_b - S_a) \end{aligned}$$

Evaporative V.O.C.

$$\begin{aligned} \text{Area "B"} &= 0.7952 - 0.2461 * RVP_a + 0.02293 * RVP_a * RVP_a \\ \text{Area "C"} &= 0.813 - 0.2393 * RVP_a + 0.021239 * RVP_a * RVP_a \end{aligned}$$

Running Loss

$$\begin{aligned} \text{Area "B"} &= -0.734 + 0.1096 * RVP_a + 0.002791 * RVP_a * RVP_a \\ \text{Area "C"} &= 0.2963 - 0.1306 * RVP_a + 0.016255 * RVP_a * RVP_a \end{aligned}$$

Refueling Loss =

$$0.04 * (-0.45 + 0.1667 * RVP_a)$$

Abbreviation Definitions:

V.O.C. = Volatile Organic Compounds
A = Aromatics content in volume percent
O = Oxygen content in weight percent
OI = Olefin content in volume percent
T90 = 90% distilled temperature in degrees F
S = Sulfur content in parts per million
RVP = Reid vapor pressure in PSI
_a = Current fuel being evaluated
_b = Statutory baseline gasoline
_f = factor

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TABLE A3-14
SUMMER T.A.P. EMISSIONS
MODIFIED PUBLISHED COMPLEX FORMULA EQUATIONS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(milligrams/mile)

Total Toxics Emissions =

Benzene (Exhaust, Evaporative, Running and Refueling) + Exhaust (Butadiene + Formaldehyde + Acetaldehyde + Polycyclic Organic Material)

Benzene Emissions

Exhaust = Exhaust (Exh) V.O.C. * (1.65 + 0.9441 * B_a + 0.1133 * (A_a - B_a)) * 10

Evaporative

Area "B" = B_a/1.53 * (2.0268 - 1.6914 * RVP_a + 0.2244 * RVP_a * RVP_a)

Area "C" = B_a/1.53 * (1.5268 - 1.6914 * RVP_a + 0.2244 * RVP_a * RVP_a)

Running Loss

Area "B" = B_a/1.53 * (12.5734 - 5.232 * RVP_a + 0.5 * RVP_a * RVP_a)

Area "C" = B_a/1.53 * (12.1734 - 5.232 * RVP_a + 0.5 * RVP_a * RVP_a)

Refueling Loss = B_a/1.53 * (0.055 * RVP_a - 0.0785)

Butadiene Emissions

Exhaust = Exh V.O.C. * (0.5435 - 0.005573 * (A_a - A_b) + 0.01766 * (Ol_a - Ol_b) + 0.001822 * (T90_a - T90_b)) * 10

Formaldehyde Emissions

Exhaust = Exh V.O.C. * (1.196 - 0.01585 * (A_a - A_b) + 0.0292 * 5.5 * O_a) * 10

Acetaldehyde Emissions

Exhaust = Exh V.O.C. * (0.8478 - 0.006793 * (A_a - A_b)) * 10

Polycyclic Organic Material Emissions (POM)

Exhaust = 1.4

Abbreviation Definitions:

T.A.P. = Toxic Air Pollutants

A = Aromatics content in volume percent

B = Benzene content in volume percent

O = Oxygen content in weight percent

Ol = Olefin content in volume percent

T90 = 90% distilled temperature in degrees F

RVP = Reid vapor pressure in PSI

_a = Current fuel being evaluated

_b = Statutory baseline gasoline

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TABLE A3-15
WINTER T.A.P. EMISSIONS
MODIFIED PUBLISHED COMPLEX FORMULA EQUATIONS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(milligrams/mile)

Total Toxics Emissions =

Benzene + Butadiene + Formaldehyde + Acetaldehyde + Polycyclic Organic Material

To calculate toxics emissions in the winter, the exhaust Volatile Organic Compounds (Exh V.O.C.) must be calculated. There is no winter V.O.C. emission limit for reformulated gasoline.

$$\text{Exh V.O.C.}_s, \text{ grams/mile} = 0.46 * (1 - 0.127 * O_a/2.7)$$

$$\text{Exh V.O.C.}_w, \text{ grams/mile} = 0.68 * (1 - 0.127 * O_a/2.7)$$

Benzene Emissions =

$$(1.818 + (0.9154 * B_a) + (0.109 * (A_a - B_a)))/100 * 1000 * \text{Exh V.O.C.}_w$$

1,3 Butadiene Emissions =

$$0.00539 * 1000 * \text{Exh V.O.C.}_w$$

Formaldehyde⁽¹⁾⁽²⁾ =

$$0.01199 * \text{Exh V.O.C.}_s * 1000 * (1 + (0.42/2.7) * O_a)$$

Acetaldehyde⁽¹⁾⁽²⁾ =

$$0.00854 * \text{Exh V.O.C.}_s * 1000 * (1 + (0.078/2.7) * O_a)$$

Polycyclic Organic Material⁽²⁾ =

$$0.00304 * \text{Exh V.O.C.}_s * 1000$$

Abbreviation Definitions:

T.A.P. = Toxic Air Pollutants

A = Aromatics content volume percent

B = Benzene content in volume percent

O = Oxygen content in weight percent

_a = Current fuel being evaluated

_b = Statutory baseline gasoline

_s = Summer

_w = Winter

⁽¹⁾ Assumes MTBE is the oxygenate used.

⁽²⁾ The mass of formaldehyde, acetaldehyde and Polycyclic Organic Material is the same in the winter as in the summer. Therefore, the summertime Exh V.O.C. is used to calculate wintertime emissions of these toxics.

TABLE A3-16

SUMMER AND WINTER NO_x EMISSIONS INDEX MODIFIED PUBLISHED COMPLEX FORMULA EQUATIONS NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

NO_x Emissions Index⁽¹⁾ =

$$\begin{aligned} A_f &= 1 - 0.00047 * (A_b - A_a) \\ O_f &= 1 - 0.0088 * (O_a - O_b) \\ Ol_f &= 1 + 0.0049 * (Ol_b - Ol_a) \\ T90_f &= 1 - 0.00047 * (T90_b - T90_a) \\ S_f &= 1 + 0.0003 * (S_b - S_a) \end{aligned}$$

An emission index greater than 1 indicates overall NO_x emissions are less than the emissions from the baseline gasoline.

Abbreviation Definitions:

NO_x = Oxides of nitrogen
A = Aromatics content volume percent
O = Oxygen content in weight percent
Ol = Olefin content in volume percent
T90 = 90% distilled temperature in degrees F
S = Sulfur content in parts per million
a = Current fuel being evaluated
b = Statutory baseline gasoline
f = Factor

⁽¹⁾ Assumes MTBE as the oxygenate.

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TABLE A3-17

PUBLISHED MODIFIED COMPLEX FORMULA EQUATIONS

NPC 1991-92 STUDY OF U.S. REFINING CAPACITY

- The summer exhaust Volatile Organic Compounds (V.O.C.) equations are based on the Lieder equations published in the June 1991 *Federal Register*, initialized to correspond with the statutory baseline gasoline properties published in the April 1992 *Federal Register* Supplemental Notice of Proposed Rule Making (SNPRM).
- The summer evaporative V.O.C. equations are directly from the April 1992 SNPRM.
- The summer Toxic Air Pollutants (T.A.P.) equations are based on the equations from June 1991, adjusted to give the same properties as the statutory baseline gasoline as published in the April 1992 SNPRM.
- The winter T.A.P. equations are directly from the April 1992 SNPRM.
- The winter and summer Nitrogen Oxides (NO_x) equations are essentially the same as that published in the July 1991 *Federal Register* Notice of Proposed Rule Making.
- No V.O.C. limits are required on winter gasoline.
- Minor errors in the published equations were corrected.
- Results from using these modified published equations are similar to (within 5% of) those from using proprietary equations.

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8/11/92

TABLE A3-18

CALIBRATION TO FULL CAPITAL CHARGE ON SUMMER FACILITIES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

- Based on our public 1987 API lower RVP and 1991 WSPA CARB 2 gasoline studies plus initial NPC summer and winter LP cases, facilities required to lower RVP and to meet very low T90 for reformulated summer gasoline are neither required nor used in the winter. These facilities include improved gasoline debutanizers, depentanizers, TAME, C₅ alkylation, butane isomerization and heavy gasoline hydrocracking. Required capacities of another group of units for initial T90 reductions and for benzene reduction are significantly larger in the summer than in the winter. The other added units are required at close to uniform capacity year round.
- The full capital recovery costs for these summer only units were not reflected in our original RFG costs calculations based on our assumed uniform daily portion of the annual capital charge of 24.2% (15% ROI) in the refinery LP and 17.2% (10% ROI) in the tabulated costs.
- On back-to-back summer and winter cases for WSPA and NPC, total winter refinery investment was only about half of total summer refinery investment for both a high investment, severe CARB 2 RFG and a low investment, mild FCAAA RFG.
- To fully include facilities capital charges for the extra (about one-fourth of) summer only units investment, a capital charge multiplier of about 2 is needed for them. We determined which units are used in summer only (capital charge multiplier of 2), which units require more summer capacity (capital charge multiplier of 1.5) and the remaining units which are required almost uniformly year round (normal capital charge multiplier of 1). These units with the three-tier capital charge multipliers are listed in Table A3-19.
- Similarly, we used a capital charge multiplier of 1.5, 1.25 and 1 for these groups of units, respectively, in all annual cases with significant RFG investment.
- About half of all planned NPC cases and about 35% of all NPC RFG cases were completed prior to discovering this understatement of calculated summer RFG facilities capital charge. Two cases were completed on a trial basis with a simplified uniform summer capital charge multiplier of 1.5. This trial approach proved to be unsatisfactory in several sensitivity issue cases; so, it was improved to the three-tier capital charge multiplier approach outlined above.

TABLE A3-18

CALIBRATION TO FULL CAPITAL CHARGE ON SUMMER FACILITIES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

- RFG costs for completed cases will be adjusted off-line, without LP reoptimization. Future cases will be optimized with our three-tier summer capital charge multipliers.
- Although the LP would reoptimize with higher facilities capital charges, overall costs impacts would be essentially the same as those recalculated without LP cases reoptimization, based on sensitivity cases in our published 1990-91 Auto/Oil RFG economics study.
- Most of these completed cases have small refinery investments, so facilities costs adjustments are only 0.6 to 1.1¢/G of upgraded CG. Only four cases – the S21 (CARB 2) and SN1 (7.0 minimum RVP with 45% V.O.C. reduction) – have large refinery investment costs adjustments of 1.5 to 3.6¢/G of upgraded CG.

REC
9/4/92

TABLE A3-19

CALCULATED SUMMER CAPITAL CHARGE MULTIPLIERS⁽¹⁾

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Facilities Required for Summer RFG Only - Capital Charge Multiplier = 2

- C₅s reduction for RVP
 - Alkylation - pentenes
 - TAME
 - C₄ isomerization (for C₅ alky)
 - Light hydrocrackate depentanizer
- Large T90 reduction
 - Heavy gasoline hydrocracker
 - Gasoline aromatic saturation

Facilities With Much Higher Summer Capacity Required for RFG - Capital Charge Multiplier = 1.5

- Initial T90 reduction
 - Heavy naphtha splitter
 - FCC gasoline fractionator
 - FCC gasoline splitters
 - Alky splitter
- Benzene reduction
 - Reformate fractionation (also for T90 reduction)
 - Benzene saturation
 - Aromatics extraction
 - C₅/C₆ isomerization
- Support for extra summer facilities
 - Hydrogen plant

Year Round Facilities - Capital Charge Multiplier = 1.0

- All other refining units

⁽¹⁾ By groups of units required to recover capital on the extra refining facilities required to make summer RFG.

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TABLE A4-2

CASE REQUIREMENTS FOR TM&C MODELS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

Issue #	Rank	Description	Comment	Year/Model ⁽¹⁾			Completed Cases		
				1995	2000	2010	Summer	Winter	Annual
		<u>Base</u>							
F1	1	F1 Demand Growth	Complete			III	1	-	-
F2	1	F2 Demand Constant	Complete	III			-	-	1
F3	1	F3 Demand Decrease	Complete			III	1	-	-
Q6S	1	F2 Summer Flexibility/Base ⁽²⁾		III	I, II, III, IV, VC, VOC		7	-	-
Q6W	1	F2 Winter Flexibility/Base	Delete I, IV		I, II, III, IV		-	2	-
		Total F/Base ⁽³⁾		2	8	2	9	2	1
		<u>Sensitivity Issues⁽⁴⁾</u>							
S1	2	Refineries Make Subgrade [S13 Result]	Delete		II		-	-	-
S3	2	Crude Heavier/Lighter, Higher S	Delete Light		III, III, IV		2	-	-
S5	1	RFG Demand, Full Opt-In	Complete	II, III			2	-	-
S6	1	RFG Demand, 100%	Complete		II, III, IV		3	-	-
S7	1	No Added Product Regs (1990)	Complete		I, III, IV		-	-	3
S8	2	California 10% A, 0.05% S Diesel, 100%	Complete	III			-	-	1
S10	2	30 ppm RFG Sulfur	Complete		I, III, IV		3	-	-
S11	1	0.05% S Diesel, 100% [Interpolate]	Delete		III		-	-	-
S12	2	0.05% S Diesel/No. 2 Fuel, 100%	Complete	III, IV			-	-	2
S13	2	High Ethanol Use	Complete		II		2	-	-
S14	2	RFG Properties Avg./Credit Trade [Q40 Result]	Delete		III		-	-	-
S17	2	Permit Delays Beyond 1995	Complete	I, III			2	-	-
S19	2	RFG Simple to Complex Formula	Complete	III			1	-	-
S20	2	Alternative Fuels Penetration ⁽⁵⁾	Complete			III	2	-	-
S21	2	California CARB 2 Gaso, 100%	Complete		I, III, IV		3	-	-
SN1		7.0 psi RVP Floor on CF RFG	Complete		III		1	-	-
SN2		Delete Minimum Oxygen in FCAAA	Delete		III		-	-	-

TABLE A4-2

CASE REQUIREMENTS FOR TM&C MODELS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

Issue #	Rank	Description	Comment	Year/Model ⁽¹⁾			Completed Cases		
				1995	2000	2010	Summer	Winter	Annual
		<u>Other Issues⁽⁴⁾</u>							
Q3	1	Maximum Gaso Capability, No Investment	Delete II		I, II, ///		2	-	-
Q5	1	Maximum Kero Jet Capability, No Investment	Complete		///		1	1	-
Q7	1	Investment Required	Cases result				-	-	-
Q8	1	Change in Operating Costs	Cases result				-	-	-
Q9S	1	Cost of RFG, No RFG w/ULSD	Complete		I, II, III, IV		4	-	-
Q9F		Cost of OG/RFG, No OG/RFG w/ULSD	Complete		I, II, III, IV		-	-	4
Q9W		Cost of OG/RFG, No OG/RFG W/ULSD	Complete		II, III		-	2	-
Q15	1	Change in Facilities	Cases result				-	-	-
Q20	2	Source of Ethers	Cases result				-	-	-
Q25	2	Crude Mix Flexibility Loss — Regs	Delete		I		-	-	-
Q26	1	U.S. vs. Foreign Refining Added/Closure SDL	Delete		I, II, III, IV		-	-	-
Q27	2	Geographic Impacts Implied	Interpolate				-	-	-
Q40	1	RFG Specs — 35/40/49% V.O.C.	Complete		///		3	-	-
QN1		Maximum Gaso Capability w/Investment	Complete		///		1	-	-
QN2		Reduced Olefins, Reduced NO _x	Complete		I, III		3	-	-
Q6N		Q6 with 150% of Base Capital Charge	Complete		///		1	-	-
		Contingency Cases	Delete		III		-	-	-
		Total Issues ⁽³⁾					36	3	10

(1) The 25 cases shown **bolded** are initial group which do not require complex formula equations. The first 20 complex formula cases are shown in *italics*. The final 11 complex formula cases with low priority (scheduled for November/December) are underlined.

(2) Base cases for many RFG issues: S5, S6, S10, S13, S17, S19, S21, Q3, Q9 and Q40.

(3) Totals do not include deleted cases.

(4) All to F2 unless noted.

(5) F1 for all but mogas at F2 and F3.

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Consulting Engineers

TABLE A4-3

TM&C WORK PLANS AND SCHEDULE

NPC 1991-92 STUDY OF U.S. INDUSTRY

	Refinery LP Number of Cases	Month(s) Scheduled in 1992
<u>Overall</u>		
Develop Assumptions		[1991], 1-8
Survey Assistance/Review		[1991], 5-6
Coordination/Planning		All
Meetings		All
<u>Allocations - Refining Supply and Demand</u>		
F2: 1995, 2000; F1: 2010; F3: 2010		1-5
<u>Refinery LP Model Enhancement</u>		
Increase Gaso Grades to 8; Other Improve		3
V.O.C., T.A.P. and NO _x		
Initial Equations, Testing (by and for API)		3-5
Modeled Equations (modified, public - 4/92)		7, 8
<u>Initial Base and Issue Cases SF⁽¹⁾</u>		
Base Cases - 1995	2	5-6
Issue Cases - 1995, 2000	23	5-9
<u>Initial Base and Issue Cases CF⁽²⁾</u>		
Base Cases - 2000	5	7-9
Issue Cases - 1995, 2000	15	7-9
<u>Final Base Cases CF⁽²⁾</u> - 2000 and 2010	5	9-11
<u>Issue Cases CF⁽²⁾</u>		
Planned - 1995, 2000, 2010	17	9-11
Total Cases - Base	12	5-11
- Issue	55	5-11

(1) Simple formula - without complex formula equations.

(2) With complex formula equations.

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8/31/92

TABLE A4-4

INITIAL TM&C CASE RESULTS SCHEDULE

NPC CASES - SIMPLE FORMULA

1995 AND 2000 CONSTANT DEMAND

PADD VCOC Season	III		I		IV		II		VCC	
	<u>S</u>	<u>A</u>	<u>S</u>	<u>A</u>	<u>S</u>	<u>A</u>	<u>S</u>	<u>A</u>	<u>A</u>	<u>A</u>
No FCAAA	Q9 ¹	Q9¥ ¹	Q9 ²	Q9¥ ⁴	Q9 ³	Q9¥ ⁴	Q9 ⁴	Q9¥ ⁵	-	-
FCAAA	Q6 ¹	-	-	-	-	-	-	-	-	-
FCAAA	-	F2 ¹	-	-	-	-	-	-	F2 ⁵	-
CARB 2	S21 ¹	-	S21 ³	-	S21 ⁴	-	-	-	-	-
High RFG	S5 ²	-	-	-	-	-	S5 ⁴	-	-	-
1990 Specs	-	S7 ³	-	S7 ⁵	-	S7 ⁴	-	-	-	-
No Permit	S17 ²	-	S17 ³	-	-	-	-	-	-	-
LSLAD	-	S8 ³	-	-	-	-	-	-	-	-
LSD	-	S12 ²	-	-	-	S12 ⁴	-	-	-	-

<u>Priority</u>	<u>Total Cases</u>	<u>Completion Date</u>	<u>Tabulated Date</u>
¹ =	5	6/1	6/6
² =	4	6/10	6/15
³ =	5	6/22	6/26
⁴ =	6	7/2	7/9
⁵ =	<u>4</u>	7/13	7/17
	24		

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6/29/92

TABLE A4-5

INITIAL INDEX TO COMPLETED TM&C CASE RESULTS TABLES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Tables</u>	<u>Model(s)</u>	<u># of Cases</u>	<u>Cases and Description</u>
<u>Base Cases</u>			
B-	I, II, III, IV	4	Summer – Q9S – No FCAAA/BAU – F2 1995/2000
B1-	I, II, III, IV	4	Annual – Q9Y – No FCAAA/BAU – F2 1995/2000
	II, III	2	Winter – Q9W – No FCAAA/BAU – F2 1995/2000
C-	All	6	Summer – Q6S – F2 2000 CF
C1-	III	4	Other – 1995 SF: F2 Annual, Q6S Summer; F1, F3 2010 CF Summer
	II, III	2	Q6W – F2 2000 Winter CF
<u>Sensitivity Cases</u>			
D-	III	3	Summer 1995/2000 F2 SF: S17, S5, S21
D1-	III	5	Summer 2000 F2 CF: Q6N, Q40VL, Q40L, Q40H, QN2
D2-	III	5	Summer 2000 F2 CF: S6, SN1, QN1, S10, S19
D3-	III	5	Summer 2000 F2 CF: S3HH, Q3, Q5S Summer 2010 CF: F1, F3
D4-	III	3	Annual 1995/2000 F2 SF: S7, S12, S8
D5-	III	3	Winter 2000 F2 CF: Q5W; Summer 2010 F1 CF: S20M, S20H
E-	I	3	Summer 1995/2000 F2 SF: S17, S21; Annual 2000 F2 SF: S7
E1-	I	4	Summer 2000 F2 CF: Q3, S10, QN2M, QN2H
F-	II	4	Summer 1995/2000 F2 SF: S5; CF: S6, S13, S13H
F1-	II	1	Winter 2000 F2 CF: Q6
G-	IV	3	Summer 2000 F2 SF: S21; Annual 1995/2000 F2 SF: S7, S12
G1-	IV	3	Summer 2000 F2 CF: S3, S6, S10

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TABLE A4-6

BASIS FOR SELECTING TM&C MODEL CASES

TURNER-MASON WORK GROUP OF NPC PQTG

Page 1 of 2

The following guidelines were used by the Turner-Mason Work Group to select the computer cases for TM&C models to analyze the various issues defined in the refining industry study. The scope and budget for the selected cases are provided in Tables A4-1 and A4-2. A review of a parallel API study will be made when it becomes publicly available. The API results may complement and extend those of this NPC study, as the bases and assumptions for it are similar.

- The constant demand case (F2) was chosen as a basis for comparison for most of the issues since it is the mid-demand case of the three being studied. The use of this case for most of the analysis provides for consistency throughout the study and ease of comparison between various cases. The other demand cases (F1, F3) will be used for specific cases in which they are the most representative base case for comparison.
- The year 2000 was chosen as the basis for most comparisons since the bulk of currently projected environmental regulations will be in place by that time. The year 1995 is also covered by some of the 2000 cases as refinery production is the same for 1995 and 2000 F2 cases, except for the level of RFG and OG and deeper V.O.C. reduction with use of the complex formula. There are few 1995 cases because it was felt that 1995 would be too soon for refiners to have the added facilities operating to meet undefined Phase 2 RFG requirements, while 2010 was felt to be too distant to be of much analytical use to either refiners or DOE.
- The PADD III conversion refinery grouping will be used as a surrogate for the entire U.S. and for larger than average complex refineries in the U.S. The average PADD III refinery has a capacity of 156 MBPSD versus 115 MBPSD average for the entire U.S. PADD III conversion refineries make about 45% of total U.S. gasoline production and have about 45% of U.S. conversion refineries total process unit capacities. Finally, PADD III refineries also supply substantial rates of gasoline to both PADDs I and II, along with smaller rates of gasoline to PADDs IV and V. Therefore, PADD III operations will be impacted by the reformulation gasoline strategies in the other parts of the country, particularly in PADD I.

TABLE A4-6

BASIS FOR SELECTING TM&C MODEL CASES

TURNER-MASON WORK GROUP OF NPC PQTG

Page 2 of 2

- The PADD IV refinery grouping will be used as a surrogate for small refineries. The average PADD IV refinery has a capacity of 32 MBPSD versus 115 MBPSD for the U.S. average conversion refinery.
- Use of the surrogates listed above, along with PADDs I, II and some V in given cases, will allow the extrapolation of the study results to the entire U.S. refining population while keeping computer cases to a minimum. This will be done for both budget and ease of analysis constraints.
- Seasonal cases will be used for specific issues where pertinent. Summer cases, which will account for almost half of the planned issue cases, will be used to calculate RFG results with reduced V.O.C. emissions required.

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TABLE A4-7

INITIAL CASES WITH PRELIMINARY COMPLEX FORMULA

PADD III 2000 CONSTANT DEMAND – F2⁽¹⁾

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

Case		% Reductions – RFG			Results	Costs
<u>Number</u>	<u>Description</u>	<u>V.O.C.⁽²⁾</u>	<u>T.A.P.</u>	<u>Priority</u>	<u>Date</u>	<u>M\$</u>
<u>Initial Cost Curve and Base – Summer</u>						
Q6S	Base – Seasonal Flexibility	45	30	1	7/16	10
Q6S	Base – Seasonal Flexibility – <u>PADD I</u>	40	30	2	8/7	10
Q6S	Base – Seasonal Flexibility – <u>PADD II</u>	41	30	4	8/28	10
Q6S	Base – Seasonal Flexibility – <u>PADD IV</u>	44	30	4	9/11	10
Q6SN	With 150% of Base Capital Charge	45	30	4	8/28	4
Q40VL	RFG: Δ V.O.C. Costs	35	30	1	7/16	5
Q40L	RFG: Δ V.O.C. Costs	40	30	1	7/16	5
Q40H	RFG: Δ V.O.C. Costs, 100% RFG	48	30	2	8/14	5
<u>Sensitivity Cases – Summer</u>						
S3HH	Crude: Δ Heavy, High Sulfur	45	30	4	9/11	5
S6	100% RFG	45	30	2	8/7	5
S10	RFG: 30 ppm Sulfur	45	30	3	8/14	5
S19	RFG: SF to CF – 1997	34	25	3	8/14	5
SN1	RFG: 7.0 RVP, 100% RFG	45	30	2	8/12	5
Q3	Maximum Gasoline Capability, No Investment	45	30	3	9/4	5
Q5S	Maximum Kero Jet Capability	45	30	4	9/18	5
QN1	Maximum Gasoline Capability, Investment	45	30	2	8/7	<u>5</u>
Subtotal Summer – 16 Cases						99

TABLE A4-7

INITIAL CASES WITH PRELIMINARY COMPLEX FORMULA

PADD III 2000 CONSTANT DEMAND – F2⁽¹⁾

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

Case		% Reductions – RFG		Results	Costs	
<u>Number</u>	<u>Description</u>	<u>V.O.C.⁽²⁾</u>	<u>T.A.P.</u>	<u>Date</u>	<u>M\$</u>	
<u>Base and Sensitivity – Winter</u>						
Q6W	Base – <u>PADD II</u>		30	5	9/18	12
Q6W	Base		30	5	9/11	12
Q9W	Cost OG/RFG, Base – SF			5	9/11	3
Q9W	Cost OG/RFG, Base – SF – <u>PADD II</u>			5	9/18	3
S1	Refineries Make Subgrade – <u>PADD II</u>		30	5	9/30	5
S13W	High Ethanol Use – <u>PADD II</u>		30	5	9/30	5
Q5W	Maximum Kero Jet Capability		30	5	9/18	<u>5</u>
Subtotal Winter – 6 Cases						45
Total – 23 Cases						144

⁽¹⁾ PADD III, except as noted under description.

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9/14/92

TABLE A4-8

FINAL CASES WITH PRELIMINARY COMPLEX FORMULA⁽¹⁾

2000 CASES BASED ON F2 UNLESS NOTED

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Case Number</u>	<u>Description</u>	<u>PADDs</u>	<u>Season</u>	<u>Priority</u>	<u>Results Month</u>	<u># of Cases</u>	<u>Costs M\$</u>
<u>Base Cases</u>							
F1	Demand Growth – 2010	III	S	3	10	1	10
F3	Demand Decrease – 2010	III	S	3	10	1	10
Q6S	Summer Base F2	VC, VOC	S	4	11	<u>2</u>	<u>20</u>
	Total					4	40
<u>Issue Cases</u>							
S3HH	Heavier, Higher Sulfur Crude	IV	S	3	10	1	5
S6	100% RFG	II, IV	S	3	10	2	8
S10	30 ppm Sulfur RFG	I, IV	S	3, 4	10, 11	2	9
S13	High Ethanol Use	II	S	4	10	2	10
S20	Alternate Fuels Penalty – 2010	III	S	3	10	2	10
Q3	Maximum Gasoline, No Investment	I	S	3	10	1	5
QN2	Reduce Olefins and EPA NO _x	I, III	S	4	12	<u>3</u>	<u>15</u>
	Total					<u>14</u>	<u>67</u>
Final Cases Total						18	107

⁽¹⁾ About 8 cases planned for each month (August through December) with monthly budget costs of about \$40-45M for cases. (Most August and September cases are listed on Table A4-7.)

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TABLE A4-9

INDEX BY ISSUE TO CASE RESULTS TABLES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 1 of 2

Issue # ⁽¹⁾	Description	Tables Where Issue Case Results Reported						
		1995/2000						2010
		I	II	III	IV	VC	VOC	III
Q9S	Base – Cost of RFG, No RFG w/ULSD**	B	B	B	B			
Q9¥	Base – Cost of OG and RFG, No OG and RFG w/ULSD*	B1	B1	B1	B1			
Q9W	Base – Cost of OG and RFG, No OG and RFG W/ULSD**		B1	B1				
F1S	F1 Demand Growth							C1
F2A	F2 Demand Constant*			C1				
F3S	F3 Demand Decrease							C1
Q6S	F2 Summer Base – Target RFG	C	C	C/C1*	C	C	C	
Q6W	F2 Winter Base/Flexibility		C1	C1				
S3S	Heavier, Higher Sulfur Crude			D3	G1			
S5S	Higher RFG Demand, Full Opt-In*		F	D				
S6S	Maximum RFG Demand, 100%		F	D2	G1			
S7A	No Added Product Regulations (1990 Specs) ^{(2)*}	E		D4	G			
S8A	California 10% A, 0.05% Sulfur Diesel, 100%			D4				
S10S	30 ppm Sulfur in RFG	E1		D2	G1			
S12A	0.05% S Diesel/No. 2 Fuel, 100%*			D4	G			
S13S	High Ethanol Use, Same and Lower Δ V.O.C.		F					
S17S	Permit Delays Beyond 1995 Limit RFG*	E		D				
S19S	RFG Simple to Complex Formula – 1997			D2				
S20S	Alternative Fuels Penetration – Medium/High							D5

TABLE A4-9

INDEX BY ISSUE TO CASE RESULTS TABLES

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Page 2 of 2

Issue # ⁽¹⁾	Description	Tables Where Issue Case Results Reported						
		1995/2000						2010
		<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>VC</u>	<u>VOC</u>	<u>III</u>
S21S	California CARB 2 Gasoline, 100%	E		D	G			
SN1S	7.0 psi RVP Floor on CF RFG – Target Δ V.O.C.			D2				
Q3S	Maximum Gasoline Capability, No Δ Investment	E1		D3				
Q5S	Maximum Kerosene Jet Capability, No Δ Investment			D3				
Q5W	Maximum Kerosene Jet Capability, No Δ Investment			D5				
Q7	Investment Required							
Q8	Change in Operating Costs							
Q15	Change in Facilities							
Q20	Source of Ethers							
Q27	Geographic Impacts Implied							
Q40S	RFG Reg Severity – VL/Low/High Δ V.O.C.			D1				
QN1S	Maximum Gasoline Capability w/ Δ Investment			D2				
QN2S	Reduced Olefins, Reduced NO _x in RFG – Medium/High	E1		D1				
Q6NS	Q6S with 150% of Base Capital Charge			D1				

** 1995/2000 cases.

* 1995 cases.

(1) Final letter refers to time period: S = Summer, $\forall$ or A = Annual and W = Winter.

(2) Cost basis for base VLS diesel.

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TABLE B-1

REFINING RAW MATERIALS INPUT RATES DETAIL

Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS - MBPCD

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>
Domestic Crudes	43	1,820	2,851	430
Foreign Crudes	<u>1,096</u>	<u>1,177</u>	<u>3,049</u>	<u>57</u>
Sub Total Crudes	1,139	2,997	5,900	487
MTBE	8	10	3	4
Natural Gasoline		38	134	5
Reformate, 100 RONC	27	35	(17)	2
Naphtha	8		85	(1)
Vacuum Gas Oil	169	27	218	(5)
Vac Resid			13	
Normal Butane	4	17		7
Iso-Butane	1	22	54	1
Propane		2	14	
Nat. Gas Fd to H2, FOE	2	5	20	1
Methanol	<u>2</u>	<u>8</u>	<u>21</u>	<u>0</u>
Total Input	1,360	3,161	6,445	501

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TABLE B-2
REFINING PRODUCT RATES DETAIL
Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Motor Gasolines</u>	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>
Regular – CG	478	1,369	2,332	203
Premium – CG	192	313	819	43
Regular – OG				
Premium – OG				
Regular – RFG – OG				
Premium – RFG – OG				
Regular – RFG				
Premium – RFG				
Regular – CARB 2				
Premium – CARB 2				
Sub Total	<u>670</u>	<u>1,682</u>	<u>3,151</u>	<u>246</u>
Aviation Gasolines		3	15	1
Kero Jet / Kerosene	86	205	686	34
<u>No. 2 Fuels</u>				
Diesel – LA, ULS				
Diesel – 0.05% S	281	580	940	86
No. 2 Fuel – 0.25% S	<u>35</u>	<u>102</u>	<u>289</u>	<u>42</u>
Sub Total	<u>316</u>	<u>682</u>	<u>1,229</u>	<u>128</u>
<u>Residual Fuels</u>				
< 0.3% Sulfur	20	2	12	1
0.7 – 1.0% Sulfur	62	14	53	2
> 1.0% Sulfur	<u>6</u>	<u>11</u>	<u>57</u>	<u>1</u>
Sub Total	<u>88</u>	<u>27</u>	<u>122</u>	<u>4</u>
Asphalt / Road Oil	73	169	102	34
Marketable Coke – 400#	18	60	180	9
Catalytic Coke – 400#	26	52	97	8
Benzene	2	2	21	
Toluene	6	5	25	
Xylene		9	40	
Heavy Aromatic Gaso				
MTBE				
Pentanes to P/C				
Nat Gaso to P/C		38	134	5
PC/Spcl/Misc Naphtha	3	18	52	1
Petrochem Gas Oil		18	152	1
Carbon Black Feed		4	33	
Lubes / Wax	11	24	97	2
Butanes / Butene	3		44	6
Propene	16	24	67	
Propane	28	98	151	9
Process Gas / C2 / C2=, FOE	70	162	365	26
(Gain) / Loss	<u>(56)</u>	<u>(121)</u>	<u>(318)</u>	<u>(13)</u>
Total Products	<u>1,360</u>	<u>3,161</u>	<u>6,445</u>	<u>501</u>

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TABLE B-3
REFINING CRUDE INPUT SUMMARY
Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Type</u>	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>
<u>RATES – MBPD</u>					
<u>Domestic</u>					
Low Sulfur	S	14	1,223	1,985	230
High Sulfur Light	HL	0	371	174	69
High Sulfur Heavy	HH	29	226	692	131
Subtotal		43	1,820	2,851	430
<u>Foreign</u>					
Low Sulfur	S	515	259	732	5
High Sulfur Light	HL	171	166	669	33
High Sulfur Heavy	HH	410	752	1,648	19
Subtotal		1,096	1,177	3,049	57
<u>Combined</u>					
Low Sulfur	S	529	1,482	2,717	235
High Sulfur Light	HL	171	537	843	102
High Sulfur Heavy	HH	439	978	2,340	150
Total		1,139	2,997	5,900	487
<u>PROPERTIES – Calculated</u>					
Domestic Gravity, Deg. API		30.0	35.9	34.3	33.5
Domestic Sulfur, % wt.		2.50	0.76	0.66	1.14
Foreign Gravity, Deg. API		31.9	31.0	31.4	34.4
Foreign Sulfur, % wt.		1.26	1.81	1.70	1.24
Combined Gravity, Deg. API		31.8	33.9	32.8	33.6
Combined Sulfur, % wt.		1.31	1.18	1.20	1.15

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TABLE B-4
REFINING DOMESTIC CRUDE INPUT RATES DETAIL
Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>LOCATION / NAME</u>		<u>Type</u>	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>
AL	Heavy	HH		5	30	
	Light	S				
AK	Cook	S				
	North Slope	HH	13	54	440	
AZ	Sweet	S				
AR	Heavy	HH			31	
CA	Beta	HH				
	Elk Hills	S		36	52	
	Huntington	HH				
	Hondo	HH	16			
	LA Basin	HH				
	San Ardo	HH				
	SJV Light	HH				
	SJV Kern	HH				
	SJV Heavy	HH				
	Ventura	HH				
	Wilmington Heavy	HH				
	Wilmington Light	HH				
CO	Rangely	S		7		77
DI	Padd I Lube	S				
FL	Jay	S	14			
IL	Sweet	S		28		
	Weeks	S		28		
IN	Sweet	S		9		
KS	Butler	S		13		
	Common	S		24		
	Light	S		115		
KY	Sweet	S		17		
LA	Condensate	S			87	
	Light Sweet	S		100	219	
	North Mix	S			31	
	Heavy Sweet	S		80	552	
MI	Sweet	S		59		
MS	Baxterville	HH			34	
	Light Hey	HL			19	
	Sweet	S			12	
MT	Sour	HH		1		11
	Rebeki	S		10		35
NE	Light Sour	HL		18		
NV	Sweet	S				
NM	Intermediate	S		114		
	Sour	HL		32	49	
ND	Light Sour	HL				69
OH/MO	Light	S		23		
OK	Cement	S		88	28	
	Condensate	S		12		
	Garber	S		126		
	Velma	HH		66		
SD	Sweet	S		6		
TX	Condensate	S			69	
	East	S		100	78	
	Hawkins	HH			157	
	Gulf Refugio	S			466	
	West Intermediate	S		111	391	
	West Scurry	S		38		
	West Sour	HL		321	106	
UT	Altamont	S				27
	Mix	S				51
WY	Platte/Sour	HH		100		120
	Sweet	S		79		40
	Total		43	1,820	2,851	430

TABLE B-5
REFINING FOREIGN CRUDE INPUT RATES DETAIL
Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>COUNTRY</u>	<u>NAME</u>	<u>TYPE</u>	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>
Abu Dhabi/Dubai/Oman/UAE		HL			25	
Algeria	Cond.	S	1	11	37	
Angola	Angolan	S	57	5	129	
	Light	S	46	26	83	
Cameroon	Kole	S	14	3	20	
Canada	Heavy	HH	1	150		7
	Lloydmin	HH		112		12
	Intrprvn.	S	1	49	8	5
	Intermed.	HL	57	2	2	2
	Feder.	S		31		
	Rangeland	HL		56		31
China	Daqing	S	20		23	
Colombia	Cano Lim.	HH	21	9	104	
Congo	Djeno	S			9	
Ecuador	Oriente	HH	29	17	19	
Gabon	Mandji	HH	2		13	
	Gamba	S	8		27	
Indonesia	Minas	S		1	28	
	Attika	S			1	
	Cond.	S		6	2	
Iraq	Kirkuk	HL	37	55	341	
Kuwait		HH	7	4	144	
Mexico	Maya	HH	29	47	336	
	Isthmus	HL	29		101	
	Sweet	S	5	37	94	
Nigeria	Forcados	S	114	40	122	
	Medium	S	126	3	1	
	Light	S	22	18	51	
Norway	Heavy	S	55			
	Medium	S	6	6	15	
	Ekofisk	S	31		14	
Saudi Arabia	Heavy	HH	241	18	144	
	Medium	HH	42	337	543	
	Light	HL	46	45	121	
	Berri	HL	2	8	79	
Trinidad	Light	S	1	20	53	
United Kingdom	Brent	S			1	
Venezuela	Boscan	HH				
	Mlones	HH			14	
	Bach Q17	HH	34		63	
	TJ Med	HH			116	
	Lago Med	HH	4	58	152	
Zaire		S	8	3	14	
Total			1,096	1,177	3,049	57

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6/30/92

TABLE B-6
NEW PROCESS CAPACITY AND INVESTMENT REQUIRED OVER 1991 BASE[1]
Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>
<u>New Capacity, MBPSD</u>				
Crude – Atmospheric				
Catalytic Cracking				2 [2]
FCC Gasoline Splitters				
Coking, Delayed		11 [2]		
Coker Lt Gasoline DS/Splitter				
Distillate HDS		59 [2]		55 [2]
Reformer Feed Fractionation				
Reformate Fractionation				
Benzene Saturation				
Diesel Aromatics Saturation				
Alkylation				1 [2]
MTBE		18 [2]		
TAME				
Isomerization – C4				
Hydrogen, MMSCFPSD				17 [2]
Sulfur, STPSD				228 [2]
C4 Rerun – Saturates				
– Unsaturates				
<u>Improvements, MBPSD</u>				
Cat Reformers – Reduce Pressure	54	184	205	23
<u>Investment, MM\$ (In Constant Mid 1990 \$)[3]</u>				
New Capacity		434		352
MTBE Storage & Blending				
C4 Fractionation Upgrades				
Improve Cat Reformers – C5+ Yield	30	71	64	17
	<u>30</u>	<u>71</u>	<u>64</u>	<u>17</u>
Total Refinery	30	505	64	369

[1] 1/1/91 capacities plus under construction plus auto/oil survey.

[2] NPC survey based.

[3] This is not the complete industry investment required. It does not include capital for environmental restrictions other than diesel sulfur restrictions. It also excludes sustaining capital.

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TABLE B-7
PROCESS UNIT RATES PER REFINERY
Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC	IV
Crude – Atmospheric	103.5	88.1	134.1	28.6
Heavy Naphtha Splitter				
Catalytic Cracking(1)	47.9	32.4	50.2	9.7
Catalytic Cracking(2)	44.7	29.7	46.7	8.9
Conversion, %	78.6	78.1	77.5	79.4
Octane Catalyst, %	79.8	72.3	68.5	76.9
FCC Gasoline Splitters				
FCC Gasoline Fractionation	17.5	4.3	11.7	1.8
Hydrocracking – High Conversion	4.4	3.2	9.8	0.4
Jet Yield, % of Maximum	94.4	62.4	64.4	100.0
300 – Gasoline Operation, %				
Hydrocracking – Low Conversion	1.0	0.6	1.5	0.1
– Heavy Gasoline				
– Combined (2)	5.4	3.7	11.3	0.5
Hydrocrackate Fractionation				
Coking – Delayed	2.7	8.0	13.3	1.3
– Fluid	3.5		0.7	0.4
Coker Lt Gasoline DS/Splitter				
Thermal Cracking, Visbreaking	0.8	0.7	1.5	
Solvent Deasphalting		0.6	1.8	0.3
Catalytic Reforming – 100 PSI(1)	8.6	8.2	16.0	
– 200 PSI(1)	7.6	7.2	11.1	3.2
– 450 PSI(1)	6.5	6.7	7.1	1.9
– Combined(2)	20.6	20.8	33.0	4.9
– RONC	99.3	97.5	96.9	96.6
Hydrotreating – Naphtha	21.2	22.5	31.5	5.0
– FCC/Coker C6s				
– Distillate	31.2	22.6	33.3	7.4
– Heavy Gas Oil	8.8	8.7	16.3	2.8
– Residuum – Atm		0.3	6.9	
Reformer Feed Fractionation				
Reformate Fractionation	2.7	1.4	7.7	
Aromatics Extraction	2.1	0.9	4.1	
Benzene Saturation				
FCC Gasoline HDS				
Diesel Aromatics Saturation				
Alkylation	7.3	5.9	8.4	1.7
Alkylate Splitter				
Polymerization	0.8	0.2	0.4	0.3
Dehydrogenation – IC4			0.7	
MTBE	0.5	0.7	1.4	0.1
TAME				
Hydrodealkylation – Toluene				
Lubes	1.0	0.7	2.2	0.1
Isomerization – C5/C6	2.6	3.1	2.2	0.3
– C5/C6, Recycle		0.1	2.2	
– C4	0.9	0.4	0.8	0.6
Hydrogen, MMSCFPCD	7.9	6.1	19.7	2.2
Sulfur, STPCD	91	66	134	16

(1) Include effects of nonunitary capacity for some feedstocks and severities.

(2) Based on actual feed rates, ignoring severity effects.

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TABLE B-8
PROCESS UNIT UTILIZATIONS[1]
Q9 2000 SUMMER F2 NO FCAA BASE CASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC	IV
Crude Distillation – Atmospheric	87.7	86.7	85.7	90.0
Heavy Naphtha Splitter				
Catalytic Cracking[2]	85.9	84.2	84.2	87.0 *
Catalytic Cracking[3]	80.1	77.3	78.3	80.0
FCC Gasoline Splitters				
FCC Gasoline Fractionation	84.6	75.7	81.9	77.8
Hydrocracking – High Conversion	87.0 *	83.0 *	87.0 *	83.0 *
Hydrocracking – 2 Stage Distillate				
– Low Conversion	78.4	58.5	58.5	66.4
– Heavy Gasoline				
– Combined[3]	85.2	78.2	81.7	79.6
Hydrocrackate Fractionation				
Coking – Delayed	84.8	86.0 *	86.1	65.2
– Fluid	84.7		85.9	77.2
Coker Lt Gasoline DS/Splitter				
Thermal Cracking, Visbreaking	92.0 *	87.0 *	92.0 *	
Solvent Deasphalting		51.0	40.3	27.8
Catalytic Reforming – 100 PSI[2]	80.3	82.8	84.4	
– 200 PSI[2]	92.0 *	87.0 *	92.0 *	87.0 *
– 450 PSI[2]	60.0	56.3	69.3	60.2
– Combined[3]	69.0	69.0	79.8	71.6
Hydrotreating – Naphtha	59.2	73.2	73.5	68.3
– FCC/Coker C6s				
– Distillate	83.6	87.0 *	92.0 *	87.0 *
– Heavy Gas Oil	83.5	81.1	86.6	79.1
– Residuum, Atmospheric		87.0 *	92.0 *	
Reformer Feed Fractionation				
Reformate Fractionation	92.0 *	87.0 *	85.0	
Aromatics Extraction	87.3	87.0 *	92.0 *	
Benzene Saturation				
FCC Gasoline HDS				
Diesel Aromatics Saturation				
Alkylation	84.3	72.1	69.5	84.0 *
Alkylate Splitter				
Polymerization	58.5	47.9	45.0	77.2
Dehydrogenation – IC4			86.4	
MTBE	87.0 *	83.0 *	91.0 *	83.0
TAME	0.0	0.0	0.0	
Hydrodealkylation – Toluene	0.0	0.0	0.0	
Lubes	82.0	82.0	82.0	82.0
Isomerization – C5/C6	92.0 *	87.0 *	92.0 *	87.0 *
– C5/C6, Recycle		6.6	92.0 *	
– C4	89.0 *	84.0 *	89.0 *	84.0 *
Hydrogen	80.0	70.4	76.1	84.0 *
Sulfur	55.5	50.4	53.0	82.0 *
C4 Rerun – Saturates				
– Unsaturation				

*Unit Maximum

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

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5/4/93

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TABLE B-9
GASOLINE POOL COMPOSITONS
Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC	IV
FCC Gasoline	13.3	25.1	20.8	22.9
Lt FCC 255-	16.9	5.1	9.5	7.2
Hvy FCC 255+	11.8	3.5	6.8	5.0
Hvy FCC 255+ Desul.				
FCC Gaso (100-180)				
FCC Gaso (180-225)				
FCC Gaso (225-300)				
FCC Gaso (300-375)				
Total FCC Gasoline	42.0	33.7	37.1	35.1
Butenes				
Pentenenes				
Poly Gasoline	1.3	0.5	0.6	2.3
Lt Coker Gasoline (C5-180)	0.6	0.8	1.3	0.7
Total Olefinic	1.9	1.3	1.9	3.0
Reformate (220-350 Feed)	18.2	25.5	16.7	21.8
Reformate (220-300 Feed)	2.8	1.1	4.5	0.6
BT Reformate (150-220 Feed)	4.9	7.0	5.0	6.0
HC Reformate (210-300)			2.3	
Hvy Reformate (300+)	0.5	0.5	1.5	
Toluene/Xylenes	0.8	0.1	0.1	
Total Reformate(1)	27.2	34.2	30.1	28.4
Lt Reformate (C5-210)	0.5	0.5	1.3	
Lt Raffinate (C5-210)	0.9	0.4	2.4	
Alkylate/Lt Alkylate (C3/C4)	12.4	11.8	11.7	11.7
Alkylate/Lt Alkylate (C5)				
Butanes	4.4	5.2	3.7	4.0
Natural/LSR Gasoline	2.2		0.1	6.7
BT Naphtha (150-220)		1.9		6.3
Pentanes (I/N)				
Isomerate (C5-C6)	4.2	6.3	6.0	1.8
Isomerate (C6)				
Lt Hydrocrackate (C5-180)	1.4	1.3	2.6	0.4
Medium Hydrocrackate (180-225)	0.9	1.4	1.1	0.6
MTBE	2.0	2.0	2.0	2.0
TAME				
Total Low Aromatics, Saturated	28.9	30.8	30.9	33.5
Total	100.0	100.0	100.0	100.0

(1) Excluding Lt Reformate and Lt Raffinate.

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8/5/92

TABLE B-10
GASOLINE POOL PROPERTIES AND INCREMENTAL COSTS
Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC	IV
<u>Average Properties</u>				
(R+M)/2 Octane, Clear*	88.9	88.1	88.6	86.6
Aromatics, V%	31.2	31.8	30.9	28.0
Ethers, V%*	2.0	2.0	2.0	2.0
Oxygen, W%*	0.4	0.4	0.4	0.4
Olefins, V%	15.9	12.3	13.6	14.6
Benzene, V%	1.8 *	2.1	1.8	1.9 *
Sulfur, WPPM	341	312	206	287
Reid Vapor Pressure, PSI*	8.2	8.4	7.9	7.9
Temperature at V/L = 20, °F	141	140	142	142
<u>Distillation</u>				
T10, °F	116	113	117	122
T50, °F	212	210	211	206
T90, °F	354	345	347	344
Specific Gravity	0.7479	0.7479	0.7469	0.7431
Heat Content, MBTU/G	114.1	114.1	114.0	113.7
V.O.C., gm/mile	1.13	1.17	1.04	1.04
- % Reduction	9	6	19	19
NOx, index	1.03	1.00	0.98	1.01
- % Reduction	(3)	0	2	(1)
T.A.P., mg/mile	54	57	50	49
- % Reduction	(4)	(9)	6	7
% Class C, Fixed	80	80	40	40
<u>Incremental Costs for Property Decrease, ¢/G Per Unit(1)</u>				
(R+M)/2 Octane, Clear	(0.8)	(0.5)	(0.5)	(0.4)
Aromatics, V%				
Ethers, V%				
Olefins, V%				
Benzene, V%	0.2			0.1
Sulfur, 100 WPPM				
Reid Vapor Pressure, PSI	0.5	0.5	0.4	0.4
T90, 10 °F				
Butanes, V%				
V.O.C., 10%				
NOx, 10%				
T.A.P., 10%				

* Input limit.

(1) Shadow costs for very small changes.

Not applicable for significant changes.

CLM/GWM/REC
8/10/92

TABLE B-11
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
Q9 2000 SUMMER F2 NO FCAAA BASE CASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC</u>	<u>IV</u>
<u>No. 2 Diesel Compositions</u>				
Hvy Reformate (300+) 90 RON				
Hvy Reformate (300+) 100 RON				
FCC Heavy Gaso Tr(300-375)				
FCC Heavy Gaso Tr(375-430)				
Lt Cycle Oil - Treated	12.9	17.1	5.5	14.5
Coker Dist - Treated	<u>3.1</u>	<u>7.3</u>	<u>4.4</u>	<u>3.3</u>
Total High Aromatic	16.0	24.4	9.9	17.8
Heavy Alkylate (300+)				
Lt Kero - Treated (300-375)	4.0	2.0	4.0	6.1
Kero (375-500)	2.1	4.6	15.6	19.7
Kero - Treated (375-500)	30.0	32.0	23.4	11.6
Kero - Low Aromatics (375-500)				
Diesel Base	8.6	7.4	8.3	6.4
Diesel Base - Treated	39.3	29.6	38.8	38.4
Diesel Base - Low Aromatics				
Lt Cycle Oil - Low Aromatics				
Coker Dist - Low Aromatics				
Total Low Aromatic	<u>84.0</u>	<u>75.6</u>	<u>90.1</u>	<u>82.2</u>
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
<u>Properties</u>				
Diesel Ignition Improver				
Pour Point Depressant				
Aromatics	30.0	30.5	25.4	30.1
<u>Jet A Compositions</u>				
Heavy Alkylate (300+)				
Lt Kero - Treated (300-375)	34.0	22.0	36.2	40.0
Kero - Treated (375-500)	37.0	60.7	41.7	49.4
Hydrocracked Jet (295-525)	<u>29.0</u>	<u>17.3</u>	<u>22.1</u>	<u>10.6</u>
Total	100.0	100.0	100.0	100.0

CLM/GWM
6/30/92

TABLE B1-1
REFINING RAW MATERIALS INPUT RATES DETAIL
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Q9Y Annual IC	Q9Y Annual IIC	Q9Y Annual IIIC	Q9Y Annual IV	Q9W Winter IIC	Q9W Winter IIIC
Domestic Crudes	43	1,820	2,851	401	1,820	2,851
Foreign Crudes	1,042	1,036	2,897	57	887	2,758
Sub Total Crudes	1,085	2,856	5,748	458	2,707	5,609
MTBE	8	24	4	3	24	4
Natural Gasoline		38	134	5	38	134
Reformate, 100 RONC	27	35	(17)	2	35	(17)
Naphtha	8		85	(1)		85
Vacuum Gas Oil	169	27	218	(5)	27	218
Vac Resid			13			13
Normal Butane	25	82	109	16	143	210
Iso-Butane	1	34	46	1	29	46
Propane		2	14		2	14
Nat. Gas Fd to H2, FOE	2	5	20	0	5	21
Methanol	2	3	20	0	3	19
Total Input	1,327	3,107	6,394	480	3,013	6,356

CLM/GWM
9/29/92

TABLE B1-2
REFINING PRODUCT RATES DETAIL
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Q9Y Annual IC	Q9Y Annual IIC	Q9Y Annual IIIC	Q9Y Annual IV	Q9W Winter IIC	Q9W Winter IIIC
<u>Motor Gasolines</u>						
Regular – CG	480	1,360	2,284	197	1,350	2,235
Premium – CG	193	311	802	41	308	785
Regular – OG						
Premium – OG						
Regular – RFG – OG						
Premium – RFG – OG						
Regular – RFG						
Premium – RFG						
Regular – CARB 2						
Premium – CARB 2						
Sub Total	673	1,671	3,086	238	1,658	3,020
<u>Aviation Gasolines</u>		3	15	1	3	15
Kero Jet / Kerosene	88	209	727	35	213	768
<u>No. 2 Fuels</u>						
Diesel – LA, ULS						
Diesel – 0.05% S	263	564	881	82	548	821
No. 2 Fuel – 0.25% S	61	118	374	40	134	460
Sub Total	324	682	1,255	122	682	1,281
<u>Residual Fuels</u>						
< 0.3% Sulfur	22	2	13	1	2	10
0.7 – 1.0% Sulfur	49	14	52	2	14	55
> 1.0% Sulfur	7	12	60	1	13	63
Sub Total	78	28	125	4	29	128
Asphalt / Road Oil	44	136	84	28	103	66
Marketable Coke – 400#	21	65	177	8	65	174
Catalytic Coke – 400#	26	49	92	7	45	86
Benzene	2	2	21		2	21
Toluene	6	5	25		5	25
Xylene		9	40		9	40
Heavy Aromatic Gaso						
MTBE						
Pentanes to P/C						
Nat Gaso to P/C		37	134	5		134
PC/Spcl/Misc Naphtha	3	18	52	1	18	52
Petrochem Gas Oil		18	152	1	18	152
Carbon Black Feed		4	31		4	29
Lubes / Wax	11	24	97	2	24	97
Butanes / Butene	3		34	8		33
Propene	16	23	65		22	65
Propane	27	92	143	8	86	137
Process Gas / C2 / C2=, FOE	67	146	344	23	136	325
(Gain) / Loss	(61)	(113)	(305)	(12)	(109)	(292)
Total Products	1,327	3,107	6,394	480	3,013	6,356

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TABLE B1-3
REFINING CRUDE INPUT SUMMARY
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Type	Q9Y Annual IC	Q9Y Annual IIC	Q9Y Annual IIIC	Q9Y Annual IV	Q9W Winter IIC	Q9W Winter IIIC
<u>RATES – MBPD</u>							
<u>Domestic</u>							
Low Sulfur	S	14	1,223	1,985	230	1,223	1,985
High Sulfur Light	HL	0	371	174	69	371	174
High Sulfur Heavy	HH	29	226	692	102	226	692
Subtotal		43	1,820	2,851	401	1,820	2,851
<u>Foreign</u>							
Low Sulfur	S	515	269	732	5	298	732
High Sulfur Light	HL	171	166	669	33	166	669
High Sulfur Heavy	HH	356	601	1,496	19	423	1,357
Subtotal		1,042	1,036	2,897	57	887	2,758
<u>Combined</u>							
Low Sulfur	S	529	1,492	2,717	235	1,521	2,717
High Sulfur Light	HL	171	537	843	102	537	843
High Sulfur Heavy	HH	385	827	2,188	121	649	2,049
Total		1,085	2,856	5,748	458	2,707	5,609
<u>PROPERTIES – Calculated</u>							
Domestic Gravity, Deg. API		30.0	36.1	34.3	34.4	36.1	34.3
Domestic Sulfur, % wt.		2.50	0.74	0.66	1.02	0.74	0.66
Foreign Gravity, Deg. API		32.3	31.2	31.5	34.4	31.6	31.6
Foreign Sulfur, % wt.		1.13	1.71	1.66	1.24	1.52	1.62
Combined Gravity, Deg. API		32.2	34.3	32.9	34.4	34.6	33.0
Combined Sulfur, % wt.		1.18	1.10	1.17	1.05	1.00	1.14

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9/29/92

TABLE B1-4
REFINING DOMESTIC CRUDE INPUT RATES DETAIL
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>LOCATION/NAME</u>		<u>Type</u>	<u>Q9Y Annual IC</u>	<u>Q9Y Annual IIC</u>	<u>Q9Y Annual IIIC</u>	<u>Q9Y Annual IV</u>	<u>Q9W Winter IIC</u>	<u>Q9W Winter IIIC</u>
AL	Heavy	HH		5	30		5	30
	Light	S						
AK	Cook	S						
	North Slope	HH	13	54	440		54	440
AZ	Sweet	S						
AR	Heavy	HH			31			31
CA	Beta	HH						
	Elk Hills	S		36	52		36	52
	Huntington	HH						
	Hondo	HH	16					
	LA Basin	HH						
	San Ardo	HH						
	SJV Light	HH						
	SJV Kern	HH						
	SJV Heavy	HH						
	Ventura	HH						
	Wilmington Heavy	HH						
	Wilmington Light	HH						
CO	Rangely	S		7		77	7	
DI	Padd I Lube	S						
FL	Jay	S	14					
IL	Sweet	S		28			28	
	Weeks	S		28			28	
IN	Sweet	S		9			9	
KS	Butler	S		13			13	
	Common	S		24			24	
	Light	S		115			115	
KY	Sweet	S		17			17	
LA	Condensate	S			87			87
	Light Sweet	S		100	219		100	219
	North Mix	S			31			31
	Heavy Sweet	S		80	552		80	552
MI	Sweet	S		59			59	
MS	Baxterville	HH			34			34
	Light Hey	HL			19			19
	Sweet	S			12			12
MT	Sour	HH		1		11	1	
	Rebeki	S		10		35	10	
NE	Light Sour	HL		18			18	
NV	Sweet	S						
NM	Intermediate	S		114			114	
	Sour	HL			49			49
ND	Light Sour	HL		32		69	32	
OH/MO	Light	S		23			23	
OK	Cement	S		88	28		88	28
	Condensate	S		12			12	
	Garber	S		126			126	
	Velma	HH		66			66	
SD	Sweet	S		6			6	
TX	Condensate	S			69			69
	East	S		100	78		100	78
	Hawkins	HH			157			157
	Gulf Refugio	S			466			466
	West Intermediate	S		111	391		111	391
	West Scurry	S		38			38	
	West Sour	HL		321	106		321	106
UT	Altamont	S				27		
	Mix	S				51		
WY	Platte/Sour	HH		100		91	100	
	Sweet	S		79		40	79	
Total			43	1,820	2,851	401	1,820	2,851

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TABLE B1-5
REFINING FOREIGN CRUDE INPUT RATES DETAIL
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>COUNTRY</u>	<u>NAME</u>	<u>TYPE</u>	<u>Q9Y</u> <u>Annual</u> <u>IC</u>	<u>Q9Y</u> <u>Annual</u> <u>IIC</u>	<u>Q9Y</u> <u>Annual</u> <u>IIIC</u>	<u>Q9Y</u> <u>Annual</u> <u>IV</u>	<u>Q9W</u> <u>Winter</u> <u>IIC</u>	<u>Q9W</u> <u>Winter</u> <u>IIIC</u>
Abu Dhabi/Dubai/Oman/UAE		HL			25			25
Algeria	Cond.	S	1	11	37		11	37
Angola	Angolan	S	57	5	129		5	129
	Light	S	46	26	83		26	83
Cameroon	Kole	S	14	3	20		3	20
Canada	Heavy	HH	1	150		7	150	
	Lloydmin	HH		112		12	112	
	Intrprvn.	S	1	49	8	5	49	8
	Intermed.	HL	57	2	2	2	2	2
	Feder.	S		31			31	
	Rangeland	HL		56		31	56	
China	Daqing	S	20		23			23
Colombia	Cano Lim.	HH	21	9	104		9	104
Congo	Djeno	S			9			9
Ecuador	Oriente	HH	29	17	19		17	19
Gabon	Mandji	HH	2		13			13
	Gamba	S	8		27			27
Indonesia	Minas	S		1	28		1	28
	Attaka	S			1			1
	Cond.	S		6	2		6	2
Iraq	Kirkuk	HL	37	55	341		55	341
Kuwait		HH	7	4	144		4	144
Mexico	Maya	HH	29	47	336		47	336
	Isthmus	HL	29		101			101
	Sweet	S	5	37	94		37	94
Nigeria	Forcados	S	114	40	122		40	122
	Medium	S	126	13	1		42	1
	Light	S	22	18	51		18	51
Norway	Heavy	S	55					
	Medium	S	6	6	15		6	15
	Ekofisk	S	31		14			14
Saudi Arabia	Heavy	HH	83	18	144		18	144
	Medium	HH	146	186	391		8	252
	Light	HL	46	45	121		45	121
	Berri	HL	2	8	79		8	79
Trinidad	Light	S	1	20	53		20	53
United Kingdom	Brent	S			1			1
Venezuela	Boscan	HH						
	Mlones	HH			14			14
	Bach Q17	HH	34		63			63
	TJ Med	HH			116			116
	Lago Med	HH	4	58	152		58	152
Zaire		S	8	3	14		3	14
Total			1,042	1,036	2,897	57	887	2,758

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9/29/92

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TABLE B1-6
NEW PROCESS CAPACITY AND INVESTMENT REQUIRED OVER 1991 BASE[1]
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Q9Y Annual IC</u>	<u>Q9Y Annual IIC</u>	<u>Q9Y Annual IIIC</u>	<u>Q9Y Annual IV</u>	<u>Q9W Winter IIC</u>	<u>Q9W Winter IIIC</u>
<u>New Capacity, MBPSD</u>						
Crude – Atmospheric						
Catalytic Cracking						
FCC Gasoline Splitters						
Coking, Delayed						
Coker Lt Gasoline DS/Splitter						
Distillate HDS		15		56	20	
Reformer Feed Fractionation						
Reformate Fractionation						
Benzene Saturation						
Diesel Aromatics Saturation						
Alkylation						
MTBE						
TAME						
Isomerization – C4						
Hydrogen, MMSCFPSD						
Sulfur, STPSD				228		
C4 Rerun – Saturates						
– Unsaturates						
<u>Improvements, MBPSD</u>						
Cat Reformers – Reduce Pressure	54	184	205	23	184	205
<u>Investment, MM\$ (In Constant Mid 1990 \$)[2]</u>						
New Capacity		26		263	39	
MTBE Storage & Blending						
C4 Fractionation Upgrades						
Improve Cat Reformers – C5+ Yield	<u>30</u>	<u>71</u>	<u>64</u>	<u>17</u>	<u>71</u>	<u>64</u>
Total Refinery	30	97	64	280	110	64

[1] 1/1/91 capacities plus under construction plus auto/oil survey.

[2] This is not the complete industry investment required. It does not include capital for environmental restrictions other than diesel sulfur restrictions. It also excludes sustaining capital.

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5/19/93

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TABLE B1-7
PROCESS UNIT RATES PER REFINERY
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Q9Y Annual IC	Q9Y Annual IIC	Q9Y Annual IIIC	Q9Y Annual IV	Q9W Winter IIC	Q9W Winter IIIC
Crude – Atmospheric	98.6	84.0	130.6	27.0	79.6	127.5
Heavy Naphtha Splitter						
Catalytic Cracking(1)	47.2	30.6	46.5	8.8	28.0	42.8
Catalytic Cracking(2)	44.1	27.9	43.1	8.2	26.1	39.7
Conversion, %	78.6	78.7	78.1	78.3	77.8	79.0
Octane Catalyst, %	79.7	72.9	69.8	76.2	73.0	71.5
FCC Gasoline Splitters						
FCC Gasoline Fractionation	16.9	4.2	11.7	1.7	4.3	11.3
Hydrocracking – High Conversion	4.2	3.1	9.4	0.4	3.0	9.1
Jet Yield, % of Maximum	100.0	100.0	81.9	100.0	100.0	100.0
300 – Gasoline Operation, %						
Hydrocracking – Low Conversion	1.0	0.8	1.5	0.1	0.7	1.5
– Heavy Gasoline						
– Combined (2)	5.2	3.8	10.9	0.4	3.7	10.5
Hydrocrackate Fractionation						
Coking – Delayed	2.9	7.7	13.0	1.2	7.6	12.8
– Fluid	3.7		0.7	0.3		0.7
Coker Lt Gasoline DS/Splitter						
Thermal Cracking, Visbreaking	0.8	0.6	1.5		0.6	1.5
Solvent Deasphalting		0.9	1.8	0.2	1.0	2.0
Catalytic Reforming – 100 PSI(1)	7.8	7.0	15.5		6.6	13.7
– 200 PSI(1)	6.9	7.1	10.8	3.2	6.9	10.6
– 450 PSI(1)	6.4	6.0	5.5	1.6	5.4	5.5
– Combined(2)	19.4	19.5	31.3	4.6	18.4	29.3
– RONC	98.4	95.1	96.0	96.0	94.7	95.6
Hydrotreating – Naphtha	19.9	21.6	30.8	4.8	20.6	30.2
– FCC/Coker C6s						
– Distillate	31.4	21.0	32.1	7.3	20.6	31.0
– Heavy Gas Oil	8.5	8.2	15.9	2.7	8.0	15.6
– Residuum – Atm		0.3	6.7		0.3	6.6
Reformer Feed Fractionation						
Reformate Fractionation	2.6	1.3	8.0		1.3	8.0
Aromatics Extraction	2.1	0.7	4.0		0.8	4.0
Benzene Saturation						
FCC Gasoline HDS						
Diesel Aromatics Saturation						
Alkylation	7.3	6.0	7.7	1.4	5.5	6.9
Alkylate Splitter						
Polymerization	0.6	0.2	0.4	0.3	0.2	0.4
Dehydrogenation – IC4			0.7			0.6
MTBE	0.5	0.3	1.3	0.1	0.3	1.3
TAME						
Hydrodealkylation – Toluene						
Lubes	1.0	0.7	2.2	0.1	0.7	2.2
Isomerization – C5/C6	2.5	2.7	2.1	0.3	2.6	2.1
– C5/C6, Recycle		0.4	2.1		0.4	2.1
– C4	0.9	0.4	0.7	0.6	0.4	0.7
Hydrogen, MMSCFPCD	7.9	5.9	19.7	1.2	5.7	20.3
Sulfur, STPCD	89	62	128	15	56	123
C4 Rerun – Saturates						
– Unsaturation						

(1) Include effects of nonunitary capacity for some feedstocks and severities.

(2) Based on actual feed rates, ignoring severity effects.

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TABLE B1-8
PROCESS UNIT UTILIZATIONS (1)
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Q9Y Annual IC	Q9Y Annual IIC	Q9Y Annual IIIC	Q9Y Annual IV	Q9W Winter IIC	Q9W Winter IIIC
Crude Distillation - Atmospheric	83.5	82.7	83.5	84.7	78.3	81.5
Heavy Naphtha Splitter						
Catalytic Cracking (2)	84.7	79.6	77.9	75.9	72.8	71.7
Catalytic Cracking (3)	79.0	72.7	72.3	71.2	67.9	66.5
FCC Gasoline Splitters						
FCC Gasoline Fractionation	81.9	74.0	81.9	75.8	76.3	79.2
Hydrocracking - High Conversion	84.0 *	80.0 *	84.0 *	80.0 *	77.0 *	81.0 *
- Low Conversion	75.4	80.0 *	62.7	62.2	77.0 *	60.5
- Heavy Gasoline						
- Combined(3)	82.2	80.0	80.1	76.5	77.0 *	77.4
Hydrocrackate Fractionation						
Coking - Delayed	91.0 *	85.0 *	84.5	56.3	84.0 *	83.1
- Fluid	89.6		86.1	76.1		85.2
Coker Lt Gasoline DS/Splitter						
Thermal Cracking, Visbreaking	90.0 *	85.0 *	90.0 *		83.0 *	88.0 *
Solvent Deasphalting		77.8	42.3	23.9	82.3	44.9
Catalytic Reforming - 100 PSI (2)	72.7	70.5	81.3		66.4	72.1
- 200 PSI (2)	82.5	85.0 *	90.0 *	85.0 *	83.0 *	88.0 *
- 450 PSI (2)	59.1	50.4	53.6	51.0	45.4	53.7
- Combined (3)	65.0	64.7	75.9	67.8	61.1	71.0
Hydrotreating - Naphtha	55.7	70.3	71.7	68.9	66.9	70.3
- FCC/Coker C6S						
- Distillate	84.1	85.0 *	88.7	85.0 *	83.0 *	85.5
- Heavy Gas Oil	80.8	76.5	84.5	76.2	74.8	82.7
- Residuum, Atmospheric		85.0 *	90.0 *		83.0 *	88.0 *
Reformer Feed Fractionation						
Reformate Fractionation	87.9	85.0 *	69.3		83.0 *	69.3
Aromatics Extraction	88.1	72.2	60.0		73.7	59.9
Benzene Saturation						
FCC gasoline HDS						
Diesel Aromatics Saturation						
Alkylation	84.6	74.5	63.4	72.9	67.6	56.9
Alkylate Splitter						
Polymerization	43.9	41.0	44.1	77.1	40.0	43.1
Dehydrogenation - IC4			84.4			82.4
MTBE	84.0 *	80.0 *	88.0 *	81.0	80.0 *	84.0 *
TAME	0.0	0.0	0.0		0.0	0.0
Hydrodealkylation - Toluene	0.0	0.0	0.0		0.0	0.0
Lubes	82.0	82.0	82.0	82.0	82.0	82.0
Isomerization - C5/C6	90.0 *	85.0 *	90.0 *	85.0 *	83.0 *	88.0 *
- C5/C6, Recycle		19.9	90.0 *		23.7	88.0 *
- C4	87.0 *	82.0 *	87.0 *	82.0 *	80.0 *	85.0 *
Hydrogen	79.5	68.3	76.3	75.7	66.3	78.2
Sulfur	54.1	53.8	50.6	80.0 *	49.1	48.9
C4 Rerun - Saturates						
- Unsaturation						

*Unit Maximum

(1) Calendar day rates divided by stream day capacity.

(2) Include effects of nonunitary capacity factors for some feedstocks and severities.

(3) Based on actual feed rates, ignoring severity effects.

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TABLE B1-9
GASOLINE POOL COMPOSITIONS
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Q9Y Annual IC	Q9Y Annual IIC	Q9Y Annual IIIC	Q9Y Annual IV	Q9W Winter IIC	Q9W Winter IIIC
FCC Gasoline	13.5	23.6	18.6	21.3	21.5	17.0
Lt FCC 255-	16.3	5.0	9.8	7.2	5.2	9.7
Hvy FCC 255+	11.4	3.4	6.8	4.9	3.6	6.7
Hvy FCC 255+ Desul.						
FCC Gaso (100-180)						
FCC Gaso (180-225)						
FCC Gaso (225-300)						
FCC Gaso (300-375)						
FCC Gaso (375-430)						
Total FCC Gasoline	41.2	32.1	35.2	33.4	30.3	33.4
Butenes	0.7					
Pentenenes						
Poly Gasoline	1.0	0.4	0.6	2.5	0.4	0.6
Lt Coker Gasoline (C5-180)	0.6	0.8	1.3	0.7	0.8	1.3
Total Olefinic	2.3	1.3	1.9	3.2	1.2	1.9
Reformate (220-350 Feed)	18.6	24.2	15.2	21.4	22.4	13.8
Reformate (220-300 Feed)	0.9	0.2	5.1	0.6	0.2	5.7
BT Reformate (150-220 Feed)	5.3	8.0	4.7	6.0	8.4	3.8
HC Reformate (210-300)		0.5	2.6		0.4	2.6
Hvy Reformate (300+)	0.2	0.2	1.6		0.2	1.7
Toluene/Xylenes	1.0	0.0			0.0	
Total Reformate(1)	26.0	33.1	29.2	28.0	31.6	27.6
Lt Reformate (C5-210)	0.6	0.5	1.4		0.5	1.4
Lt Raffinate (C5-210)	0.8	0.4	2.5		0.4	2.5
Alkylate/Lt Alkylate (C3/C4)	12.1	12.4	10.9	9.9	11.4	10.0
Alkylate/Lt Alkylate (C5)						
Butanes	7.2	8.9	7.3	7.5	12.3	11.0
Natural/LSR Gasoline	1.9		0.1	6.9	1.9	
BT Naphtha (150-220)		0.9		6.4		
Pentanenes (I/N)						
Isomerase (C5-C6)	4.1	6.1	6.0	1.8	6.1	6.0
Isomerase (C6)						
Lt Hydrocrackate (C5-180)	1.3	1.1	2.4	0.4	1.1	2.2
Medium Hydrocrackate (180-225)	0.5	1.2	1.1	0.5	1.2	2.0
MTBE	2.0	2.0	2.0	2.0	2.0	2.0
TAME						
Total Low Aromatics, Saturated	30.5	33.5	33.7	35.4	36.9	37.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

(1) Excluding Lt Reformate and Lt Raffinate.

TABLE B1-10
GASOLINE POOL PROPERTIES AND INCREMENTAL COSTS
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Q9Y Annual IC	Q9Y Annual IIC	Q9Y Annual IIIC	Q9Y Annual IV	Q9W Winter IIC	Q9W Winter IIIC
Average Properties						
(R+M)/2 Octane, Clear*	88.9	88.1	88.6	86.6	88.1	88.6
Aromatics, V%	29.6	29.1	29.2	26.9	27.3	27.6
Ethers, V%*	2.0	2.0	2.0	2.0	2.0	2.0
Oxygen, W%*	0.4	0.4	0.4	0.4	0.4	0.4
Olefins, V%	16.1	11.7	13.0	14.1	11.0	12.4
Benzene, V%	1.8	1.9	1.7	1.9	1.9	1.6
Sulfur, WPPM	341	286	199	248	256	186
Reid Vapor Pressure, PSI*	10.2	10.4	9.9	9.9	12.5	11.9
Temperature at V/L = 20, °F	130	128	131	131	116	120
Distillation						
T10, °F	101	96	102	107	80	80
T50, °F	208	206	206	203	199	200
T90, °F	352	342	343	342	339	339
Specific Gravity	0.741	0.739	0.740	0.737	0.731	0.733
Heat Content, MBTU/G	113.3	113.2	113.2	112.9	112.2	112.4
V.O.C., gm/mile						
– % Reduction						
NOx, index					0.97	0.96
– % Reduction					3	4
T.A.P., mg/mile					42	39
– % Reduction					(4)	2
% Class C, Fixed	80	80	40	40	80	40
Incremental Costs for Property						
Decrease, ¢/G Per Unit[1]						
(R+M)/2 Octane, Clear	(0.3)	(0.4)	(0.4)	(0.3)	(0.4)	(0.3)
Aromatics, V%						
Ethers, V%						
Ethanol, %						
Olefins, V%						
Benzene, V%						
Sulfur, 100 WPPM						
Reid Vapor Pressure, PSI	0.4	0.5	0.4	0.4	0.4	0.3
T90, 10 °F						
Butanes, V%						
V.O.C., 10%						
NOx, 10%						
T.A.P., 10%						

* Input limit.

[1] Shadow costs for very small changes.

Not applicable for significant changes.

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TABLE B1-11
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
2000 ANNUAL/WINTER F2 NO FCAAA BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Q9Y</u> <u>Annual</u> <u>IC</u>	<u>Q9Y</u> <u>Annual</u> <u>IIC</u>	<u>Q9Y</u> <u>Annual</u> <u>IIIC</u>	<u>Q9Y</u> <u>Annual</u> <u>IV</u>	<u>Q9W</u> <u>Winter</u> <u>IIC</u>	<u>Q9W</u> <u>Winter</u> <u>IIIC</u>
No. 2 Diesel Compositions						
Hvy Reformate (300+) 90 RON						
Hvy Reformate (300+) 100 RON						
FCC Heavy Gaso Tr(300-375)						
FCC Heavy Gaso Tr(375-430)						
Lt Cycle Oil – Treated	15.0	12.6	3.8	15.0	13.7	2.6
Coker Dist – Treated	3.4	8.0	3.3	3.1	6.8	1.9
Total High Aromatic	18.4	20.6	7.1	18.1	20.5	4.5
Heavy Alkylate (300+)		0.0			0.0	
Lt Kero – Treated (300-375)	6.3	1.3	3.3	6.6	3.5	2.2
Kero (375-500)	9.3	6.8	13.2	15.6	13.1	25.0
Kero – Treated (375-500)	20.6	33.0	23.5	14.4	24.6	9.6
Kero – Low Aromatics (375-500)						
Diesel Base	3.4	10.7	17.0	9.2	7.2	32.1
Diesel Base – Treated	42.0	27.5	35.9	36.1	31.1	26.7
Diesel Base – Low Aromatics						
Lt Cycle Oil – Low Aromatics						
Coker Dist – Low Aromatics						
Total Low Aromatic	81.6	79.4	92.9	81.9	79.5	95.5
Total	100.0	100.0	100.0	100.0	100.0	100.0
Properties						
Diesel Ignition Improver						
Pour Point Depressant	Yes	Yes		Yes	Yes	
Aromatics	30.7	28.3	25.1	30.3	28.7	26.6
Jet A Compositions						
Heavy Alkylate (300+)						
Lt Kero – Treated (300-375)	34.0	32.1	35.1	40.3	35.2	34.0
Kero – Treated (375-500)	37.1	40.9	39.4	49.9	39.4	37.6
Hydrocracked Jet (295-525)	28.9	26.9	25.5	9.8	25.4	28.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE C-1
REFINING RAW MATERIALS INPUT RATES DETAIL
Q6 2000 SUMMER COMPLEX FORMULA BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC[1]</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	<u>Total U.S.C.</u>
Domestic Crudes	43	1,819	2,851	430	468	1,550	7,161
Foreign Crudes	<u>1,037</u>	<u>1,112</u>	<u>2,932</u>	<u>57</u>	<u>132</u>	<u>133</u>	<u>5,403</u>
Sub Total Crudes	1,080	2,931	5,783	487	600	1,683	12,564
MTBE	63	100	141	2	1	96	402
Natural Gasoline		38	134	5		5	182
Reformate, 100 RONC	27	35	(17)	2	(21)	23	49
Naphtha	8		85	(1)	2	5	99
Vacuum Gas Oil	169	27	218	(5)	(8)	31	432
Vac Resid			13				13
Normal Butane				10	6		16
Iso-Butane	1	36	46	1	1	3	88
Propane		2	14				16
Nat. Gas Fd to H2, FOE	2	5	24	0	2	25	58
Methanol	<u>6</u>	<u>4</u>	<u>32</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>47</u>
Total Input	1,356	3,179	6,473	502	584	1,874	13,967

[1] Case Q6N instead of Case Q6 because the assumptions in Q6N more closely match those for other PADDs.

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1/14/93

TABLE C-2
REFINING PRODUCT RATES DETAIL
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC[1]	IV	VCOC	VCC	Total U.S.C.
Motor Gasolines							
Regular – CG		612	868	177	187	45	1,889
Premium – CG		140	305	37	40	15	537
Regular – OG							
Premium – OG							
Regular – RFG – OG							
Premium – RFG – OG							
Regular – RFG	486	769	1,487	26			2,768
Premium – RFG	196	176	522	6			899
Regular – CARB 2						690	690
Premium – CARB 2						223	223
Sub Total	682	1,696	3,182	246	227	973	7,007
Aviation Gasolines		3	15	1		6	25
Kero Jet / Kerosene	86	205	686	34	102	234	1,347
No. 2 Fuels							0
Diesel – LA, ULS						140	140
Diesel – 0.05% S	281	580	940	86	96	117	2,100
No. 2 Fuel – 0.25% S	35	102	289	42	16		484
Sub Total	316	682	1,229	128	112	257	2,724
Residual Fuels							
< 0.3% Sulfur	20	2	8	1	4	1	36
0.7 – 1.0% Sulfur	62	14	57	2	28	14	176
> 1.0% Sulfur	6	11	57	1	30	120	225
Sub Total	88	27	122	4	61	135	437
Asphalt / Road Oil	73	169	102	34		35	413
Marketable Coke – 400#	14	59	174	9	21	108	385
Catalytic Coke – 400#	24	50	94	8	5	24	206
Benzene	4	2	21				27
Toluene	4	5	25				34
Xylene		9	40				49
Heavy Aromatic Gaso							0
MTBE							0
Pentanes to P/C							0
Nat Gaso to P/C	1	38	134	5	17		195
PC/Spcl/Misc Naphtha	3	18	52	1		7	81
Petrochem Gas Oil		18	152	1	12	4	187
Carbon Black Feed		4	33			1	38
Lubes / Wax	11	24	97	2		17	151
Butanes / Butene	6	24	78	7	14	31	160
Propene	16	24	67		2	17	125
Propane	24	94	144	9	8	41	320
Process Gas / C2 / C2=, FOE	57	144	337	26	26	110	699
(Gain) / Loss	(51)	(117)	(311)	(13)	(23)	(126)	(641)
Total Products	1,356	3,179	6,473	502	584	1,874	13,968

[1] Case Q6N.

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TABLE C-3
REFINING CRUDE INPUT SUMMARY
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Type	IC	IIC	IIIC[1]	IV	VCOC	VCC	Total U.S.C.
<u>RATES – MBPD</u>								
<u>Domestic</u>								
Low Sulfur	S	14	1,222	1,985	230	31	41	3,524
High Sulfur Light	HL	0	370	174	69	0	0	614
High Sulfur Heavy	HH	29	226	692	131	437	1,509	3,024
Subtotal		43	1,819	2,851	430	468	1,550	7,161
<u>Foreign</u>								
Low Sulfur	S	519	259	732	5	125	106	1,746
High Sulfur Light	HL	171	166	669	33	5	14	1,058
High Sulfur Heavy	HH	348	687	1,531	19	2	13	2,600
Subtotal		1,037	1,112	2,932	57	132	133	5,404
<u>Combined</u>								
Low Sulfur	S	533	1,481	2,717	235	156	147	5,269
High Sulfur Light	HL	171	537	843	102	5	14	1,671
High Sulfur Heavy	HH	377	913	2,223	150	439	1,522	5,624
Total		1,080	2,931	5,783	487	600	1,683	12,564
<u>PROPERTIES – Calculated</u>								
Domestic Gravity, Deg. API		30.0	36.1	34.3	33.5	28.1	22.7	31.6
Domestic Sulfur, % wt.		2.50	0.74	0.66	1.14	1.11	1.22	0.88
Foreign Gravity, Deg. API		32.3	31.1	31.5	34.4	44.0	40.3	32.1
Foreign Sulfur, % wt.		1.11	1.78	1.67	1.24	0.15	0.25	1.51
Combined Gravity, Deg. API		32.2	34.1	32.9	33.6	31.4	24.0	31.8
Combined Sulfur, % wt.		1.17	1.14	1.18	1.15	0.91	1.15	1.15

[1] Case Q6N.

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1/14/93

TABLE C-4
REFINING DOMESTIC CRUDE INPUT RATES DETAIL
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

LOCATION / NAME		Type	IC	IIC	IIIC[1]	IV	VCOC	VCC	Total U.S.C.
AL	Heavy	HH		5	30				35
	Light	S							0
AK	Cook	S					31	11	42
	North Slope	HH	13	54	440		437	749	1,692
AZ	Sweet	S							0
AR	Heavy	HH			31				31
CA	Beta	HH						16	16
	Elk Hills	S		36	52			30	118
	Huntington	HH						20	20
	Hondo	HH	16					11	27
	LA Basin	HH						26	26
	San Ardo	HH						63	63
	SJV Light	HH						95	95
	SJV Kern	HH						76	76
	SJV Heavy	HH						268	268
	Ventura	HH						48	48
	Wilmington Heavy	HH						88	88
	Wilmington Light	HH						49	49
CO	Rangely	S		7		77			84
DI	Padd I Lube	S							0
FL	Jay	S	14						14
IL	Sweet	S		28					28
	Weeks	S		28					28
IN	Sweet	S		9					9
KS	Butler	S		13					13
	Common	S		24					24
	Light	S		115					115
KY	Sweet	S		17					17
LA	Condensate	S			87				87
	Light Sweet	S		100	219				319
	North Mix	S			31				31
	Heavy Sweet	S		80	552				632
MI	Sweet	S		59					59
MS	Baxterville	HH			34				34
	Light Hey	HL			19				19
	Sweet	S			12				12
MT	Sour	HH		1		11			12
	Rebeki	S		10		35			45
NE	Light Sour	HL		18					18
NV	Sweet	S							0
NM	Intermediate	S		114					114
	Sour	HL			49				49
ND	Light Sour	HL		32		69			101
OH/MO	Light	S		23					23
OK	Cement	S		88	28				116
	Condensate	S		12					12
	Garber	S		126					126
	Velma	HH		66					66
SD	Sweet	S		6					6
TX	Condensate	S			69				69
	East	S		100	78				178
	Hawkins	HH			157				157
	Gulf Refugio	S			466				466
	West Intermediate	S		111	391				501
	West Scurry	S		38					38
	West Sour	HL		321	106				426
UT	Altamont	S				27			27
	Mix	S				51			51
WY	Platte/Sour	HH		100		120			220
	Sweet	S		79		40			119
	Total		43	1,819	2,851	430	468	1,550	7,161

[1] Case Q6N.

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TABLE C-5
REFINING FOREIGN CRUDE INPUT RATES DETAIL
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>COUNTRY</u>	<u>NAME</u>	<u>TYPE</u>	<u>IC</u>	<u>IIC</u>	<u>IIIC[1]</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>	Total U.S.C.
Abu Dhabi/Dubai/Oman/UAE		HL			25			13	38
Algeria	Cond.	S	1	11	37				49
Angola	Angolan	S	57	5	129				191
	Light	S	46	26	83				155
Australia		S					31	12	43
Cameroon	Kole	S	14	3	20				37
Canada	Heavy	HH	1	150		7			158
	Lloydmin	HH		112		12			124
	Intrprvn.	S	1	49	8	5			63
	Intermed.	HL	57	2	2	2			63
	Feder.	S		31					31
	Rangeland	HL		56		31	5		92
China	Daqing	S	20		23		7	14	64
Colombia	Cano Lim.	HH	21	9	104				134
Congo	Djeno	S			9				9
Ecuador	Oriente	HH	29	17	19		2	13	80
Gabon	Mandji	HH	2		13				15
	Gamba	S	8		27				35
Indonesia	Minas	S		1	28		24	36	89
	Attaka	S			1		25	15	41
	Cond.	S		6	2		38	29	75
Iraq	Kirkuk	HL	37	55	341			1	434
Kuwait		HH	7	4	144				155
Mexico	Maya	HH	29	47	336				412
	Isthmus	HL	29		101				130
	Sweet	S	5	37	94				136
Nigeria	Forcados	S	114	40	122				276
	Medium	S	130	3	1				134
	Light	S	22	18	51				91
Norway	Heavy	S	55						55
	Medium	S	6	6	15				27
	Ekofisk	S	31		14				45
Saudi Arabia	Heavy	HH	83	18	144				245
	Medium	HH	138	272	426				836
	Light	HL	46	45	121				212
	Berri	HL	2	8	79				89
Trinidad	Light	S	1	20	53				74
United Kingdom	Brent	S			1				1
Venezuela	Boscan	HH							0
	Mlones	HH			14				14
	Bach Q17	HH	34		63				97
	TJ Med	HH			116				116
	Lago Med	HH	4	58	152				214
Zaire		S	8	3	14				25
Total			1,037	1,112	2,932	57	132	133	5,404

[1] Case Q6N.

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1/14/93

TABLE C-6
NEW PROCESS CAPACITY AND INVESTMENT REQUIRED OVER 1991 BASE[1]
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC[2]	IV	VCOC	VCC	Total U.S.C.
<u>New Capacity, MBPSD</u>							
Crude – Atmospheric							
Heavy Naphtha Splitter						93	93
Catalytic Cracking				2			2
FCC Gasoline Splitters	96		135	10		333	574
Coking, Delayed		11					11
Coker Lt Gasoline DS/Splitter	2	15	24		5		46
Hydrotreating – Naphtha							
– FCC/Coker C6s					0	29	29
– Distillate		59		55		64	178
Reformer Feed Fractionation	250	756	1,463	103		344	2,916
Reformate Fractionation	80	71	255	7		177	590
Benzene Saturation	27	34	62	4		60	186
FCC Gasoline HDS						14	14
Diesel Aromatics Saturation	4				5	148	157
Alkylation				1		17	18
MTBE	8	18	26	2	4		57
TAME						3	3
Isomerization – C5/C6						57	57
– C5/C6, Recycle						32	32
– C4	5				7	4	16
Hydrogen, MMSCFPSD				17			17
Sulfur, STPSD				228	124		352
C4 Rerun – Saturates	36	101	203	4		78	422
– Unsaturation	115	260	501	10			886
<u>Improvements, MBPSD</u>							
Cat Reformers – Reduce Pressure	54	184	205	23	7	97	570
<u>Investment, MM\$ (In Constant Mid 1990 \$)[3]</u>							
New Capacity	812	1,862	2,446	483	180	3,371	9,154
MTBE Storage & Blending	45	64	111	7		40	267
C4 Fractionation Upgrades	57	113	162	8	26	71	437
Improve Cat Reformers – C5+ Yield	30	71	64	17	4	58	244
Total Refinery	944	2,110	2,783	515	210	3,540	10,102

[1] 1/1/91 capacities plus under construction plus auto/oil survey.

[2] Case Q6N.

[3] This is not the complete industry investment required. It does not include capital for environmental restrictions other than diesel sulfur restrictions. It also excludes sustaining capital.

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TABLE C-7
PROCESS UNIT RATES PER REFINERY
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC[1]	IV	VCOC	VCC
Crude - Atmospheric	98.2	86.2	131.4	28.7	85.7	105.2
Heavy Naphtha Splitter						5.7
Catalytic Cracking[1]	47.3	32.7	48.7	9.6	18.6	34.1
Catalytic Cracking[2]	43.0	29.9	45.3	8.8	16.9	34.2
Conversion, %	80.0	77.0	77.7	79.5	80.0	73.0
Octane Catalyst, %	79.0	70.6	68.9	76.7	85.0	15.0
FCC Gasoline Splitters	8.2		2.9	0.5		19.6
FCC Gasoline Fractionation	7.8	4.5	11.7	1.8	6.5	
Hydrocracking - High Conversion	3.0	3.2	9.3	0.4	7.9	17.1
Jet Yield, % of Maximum	93.5	40.5	72.8	100.0	100.0	34.5
300 - Gasoline Operation, %						37.8
Hydrocracking - 2 Stage Distillate						
Hydrocracking - Low Conversion	1.1	0.8	1.5	0.1	1.9	4.3
- Heavy Gasoline						
- Combined[3]	4.1	4.0	10.8	0.5	9.8	20.3
Hydrocrackate Fractionation						
Coking - Delayed	2.9	6.9	12.8	1.3	10.3	21.6
- Fluid	2.3		0.7	0.4		2.7
Coker Lt Gasoline DS/Splitter	0.2	0.4	0.5		0.7	
Thermal Cracking, Visbreaking	0.8	0.7	1.5		1.7	1.4
Solvent Deasphalting		0.7	1.7	0.2		2.9
Catalytic Reforming - 100 PSI[2]	6.0	6.5	14.0		7.8	2.8
- 200 PSI[2]	6.7	6.8	11.1	3.2	10.0	13.2
- 450 PSI[2]	5.0	5.7	5.7	2.2	2.1	6.7
- Combined[3]	18.4	18.0	30.0	5.1	18.9	22.6
- RONC	91.0	96.5	95.2	96.2	99.4	92.5
Hydrotreating - Naphtha	20.9	19.3	30.6	5.2	16.6	19.8
- FCC/Coker C6s					0.0	1.6
- Distillate	32.6	22.2	33.3	7.2	23.7	26.3
- Heavy Gas Oil	9.7	9.3	16.3	2.8	0.9	32.0
- Residuum - Atm		0.3	6.9			
- Residuum - Vac						0.3
Reformer Feed Fractionation	20.9	19.3	30.6	5.2		19.8
Reformate Fractionation	9.4	3.2	13.5	0.4		10.4
Aromatics Extraction	2.2	0.9	4.1			
Benzene Saturation	2.2	0.9	1.3	0.2		3.5
FCC Gasoline HDS						0.8
Diesel Aromatics Saturation	0.3				0.6	8.5
Alkylation	7.7	6.3	8.0	1.7	3.3	7.3
Alkylate Splitter						
Polymerization	0.3	0.2	0.4	0.4	0.2	
Dehydrogenation - IC4			0.7			
MTBE	1.1	0.3	1.9	0.1	0.5	0.3
TAME	0.4	0.0	0.3			0.4
Hydrodealkylation - Toluene						
Lubes	1.0	0.7	2.2	0.1		1.1
Isomerization - C5/C6	2.6	1.5	2.2	0.3	0.5	3.7
- C5/C6, Recycle		1.6	2.2			1.9
- C4	1.3	0.4	0.8	0.6	1.4	0.6
Hydrogen, MMSCFPCD	8.8	6.1	22.7	1.2	13.8	66.1
Sulfur, STPCD	81	64	130	16	55	109
C4 Rerun - Saturates	3.0	2.6	4.2			4.5
- Unsaturates	9.6	6.6	10.5			

[1] Case Q6N.

[2] Include effects of nonunitary capacity for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

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TABLE C-8
PROCESS UNIT UTILIZATIONS[1]
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC[2]	IV	VCOC	VCC
Crude Distillation - Atmospheric	83.2	84.8	84.0	90.0	82.5	85.1
Heavy Naphtha Splitter						97.0 *
Catalytic Cracking[3]	84.7	85.0	81.7	87.0 *	94.0 *	87.5
Catalytic Cracking[4]	77.0	77.9	75.9	79.8	85.5	87.8
FCC Gasoline Splitters	94.0 *		94.0 *	87.0 *		94.0 *
FCC Gasoline Fractionation	37.8	79.7	81.9	77.8	84.5	
Hydrocracking - High Conversion	59.7	83.0 *	82.9	83.0 *	87.0 *	87.0 *
Hydrocracking - 2 Stage Distillate						
- Low Conversion	87.0 *	83.0 *	58.5	83.0 *	87.0 *	87.0 *
- Heavy Gasoline						
- Combined[4]	65.3	83.0 *	78.3	83.0 *	87.0 *	82.6
Hydrocrackate Fractionation						
Coking - Delayed	92.0 *	76.9	82.9	65.9	92.0 *	92.0 *
- Fluid	56.3		85.9	77.2		46.1
Coker Lt Gasoline DS/Splitter	92.0 *	86.0 *	92.0 *		92.0 *	
Thermal Cracking, Visbreaking	92.0 *	87.0 *	92.0 *		92.0 *	92.0 *
Solvent Deasphalting		60.4	40.0	18.4	0.0	92.0 *
Catalytic Reforming - 100 PSI[3]	55.9	65.3	73.6		78.2	68.3
- 200 PSI[3]	80.2	81.3	92.0	87.0 *	92.0 *	87.7
- 450 PSI[3]	46.1	47.9	55.6	75.3	92.0 *	50.4
- Combined[4]	61.5	59.6	72.7	76.1	81.8	69.7
Hydrotreating - Naphtha	58.6	62.8	71.3	71.0	92.0 *	67.9
- FCC/Coker C6s					92.0 *	92.0 *
- Distillate	87.5	87.0 *	92.0 *	87.0 *	88.0	92.0 *
- Heavy Gas Oil	92.0 *	87.0 *	86.6	79.1	87.4	90.5
- Residuum, Atmospheric		87.0 *	92.0 *			
- Residuum, Vacuum						15.0
Reformer Feed Fractionation	92.0 *	87.0 *	92.0 *	87.0 *		92.0 *
Reformate Fractionation	92.0 *	87.0 *	92.0 *	87.0 *		92.0 *
Aromatics Extraction	92.0 *	87.0 *	92.0 *			
Benzene Saturation	92.0 *	87.0 *	92.0 *	87.0 *		92.0 *
FCC Gasoline HDS						92.0 *
Diesel Aromatics Saturation	92.0 *				92.0 *	92.0 *
Alkylation	89.0 *	77.4	65.9	84.0 *	74.1	89.0 *
Alkylate Splitter						
Polymerization	22.1	42.0	45.0	84.0 *	44.5	0.0
Dehydrogenation - IC4			89.0 *			
MTBE	87.0 *	84.0 *	90.0 *	84.0 *	90.0 *	87.0 *
TAME	87.0 *	7.8	50.1			87.0 *
Hydrodealkylation - Toluene	0.0	0.0	0.0			
Lubes	82.0	82.0	82.0	82.0		82.0
Isomerization - C5/C6	92.0 *	47.5	92.0 *	87.0 *	92.0 *	92.0 *
- C5/C6, Recycle		87.0 *	92.0 *			92.0 *
- C4	89.0 *	84.0 *	89.0 *	84.0 *	89.0 *	89.0 *
Hydrogen	89.0 *	70.4	87.9	72.0	75.1	81.8
Sulfur	49.4	55.8	51.4	82.0 *	68.0 *	36.7
C4 Rerun - Saturates	92.0 *	87.0 *	92.0 *			92.0 *
- Unsaturation	92.0 *	87.0 *	92.0 *			

*Unit Maximum

[1] Calendar day rates divided by stream day capacity.

[2] Case Q6N.

[3] Include effects of nonunitary capacity factors for some feedstocks and severities.

[4] Based on actual feed rates, ignoring severity effects.

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TABLE C-9
COMBINED GASOLINE POOL COMPOSITONS
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC[1]	IV	VCOC	VCC
FCC Gasoline	14.6	24.3	19.7	22.4	10.3	
Lt FCC 255-	7.4	5.4	5.5	3.7	11.9	
Hvy FCC 255+	5.1	3.7	6.6	5.0	7.5	
Hvy FCC 255+ Desulf.						1.4
FCC Gaso (100-180)	2.7		1.4	1.2		3.7
FCC Gaso (180-225)	1.4		0.8	0.8		3.9
FCC Gaso (225-300)	2.9		0.6	0.5	0.3	6.6
FCC Gaso (300-375)	1.9				0.2	0.8
FCC Gaso (375-430)	0.0					
Total FCC Gasoline	36.2	33.3	34.6	33.6	30.2	16.3
Butenes						
Pentenes	0.3			0.4	0.3	0.6
Poly Gasoline	0.5	0.4	0.6	2.6	0.6	
Lt Coker Gasoline (C5-180)	0.2	0.5	0.5	0.3	1.3	
Total Olefinic	1.0	0.9	1.1	3.2	2.2	0.6
Reformate (220-350 Feed)	13.3	24.6	20.7	22.1	18.3	1.3
Reformate (220-300 Feed)	0.5	0.1	1.2	0.6	6.2	14.8
BT Reformate (150-220 Feed)		2.1	0.1	4.3	11.9	0.5
HC Reformate (210-300)	5.9	1.0	3.6	1.2		7.7
Hvy Reformate (300+)	2.0	0.1	0.3			3.7
Toluene/Xylenes	0.6	0.2	0.1			
Total Reformate[2]	22.4	28.2	26.0	28.2	36.5	28.0
Lt Reformate (C5-210)		0.2	0.6			
Lt Raffinate (C5-210)	5.1	2.1	4.5	1.4		5.9
Alkylate/Lt Alkylate (C3/C4)	11.8	12.6	10.1	10.9	10.6	9.2
Alkylate/Lt Alkylate (C5)	0.9	0.1	0.7	0.3		2.6
Butanes	1.9	2.5	2.3	4.9	5.2	1.7 *
Natural/LSR Gasoline	1.7		0.4	7.1	3.7	
BT Naphtha (150-220)		4.3	0.5	5.6		
Pentanes (I/N)	1.1	0.1	0.7	0.5	0.4	2.9
Isomate (C5-C6)	4.1	6.1	5.9	1.8	1.6	6.3
Isomate (C6)					0.1	2.7
Lt Hydrocrackate (C5-180)	1.0	1.4	2.4	0.4	4.6	6.4
Medium Hydrocrackate (180-225)	1.1	1.5	2.8	0.6	3.3	6.4
MTBE	11.1	6.5	7.0	1.5	1.7	10.3
TAME	0.7	0.0	0.4			0.6
Alcohol						
Total Low Aromatics, Saturated	40.5	37.6	38.3	35.0	31.1	55.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

[1] Case Q6N.

[2] Excluding Lt Reformate and Lt Raffinate.

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TABLE C-9A
REFORMULATED GASOLINE POOL COMPOSITONS
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC[1]	IV	VCC
FCC Gasoline	14.6	26.3	22.4	8.3	
Lt FCC 255-	7.4				
Hvy FCC 255+	5.1	6.3	6.1	6.5	
Hvy FCC 255+ Desulf.					1.4
FCC Gaso (100-180)	2.7		1.2		4.0
FCC Gaso (180-225)	1.4		0.8		4.1
FCC Gaso (225-300)	2.9		0.6	0.6	5.5
FCC Gaso (300-375)	1.9				
FCC Gaso (375-430)	0.0				
Total FCC Gasoline	36.2	32.5	31.2	15.4	15.0
Butenes					
Pentenenes	0.3			3.2	0.2
Poly Gasoline	0.5	0.8	0.9		
Lt Coker Gasoline (C5-180)	0.2		0.7		
Total Olefinic	1.0	0.8	1.6	3.2	0.2
Reformate (220-350 Feed)	13.3	15.2	14.3	30.5	0.2
Reformate (220-300 Feed)	0.5	0.2	1.9		15.7
BT Reformate (150-220 Feed)					
HC Reformate (210-300)	5.9	1.9	5.8	9.0	8.2
Hvy Reformate (300+)	2.0	0.1	0.0		4.0
Toluene/Xylenes	0.6	0.4	0.1		
Total Reformate[2]	22.4	17.8	22.1	39.5	28.0
Lt Reformate (C5-210)					
Lt Raffinate (C5-210)	5.1	3.8	7.1	11.1	6.3
Alkylate/Lt Alkylate (C3/C4)	11.8	18.5	13.0	0.6	9.8
Alkylate/Lt Alkylate (C5)	0.9	0.2	1.2	2.1	2.8
Butanes	1.9	2.0 *	2.0 *	1.9 *	1.7 *
Natural/LSR Gasoline	1.7		0.6	1.9	
BT Naphtha (150-220)		6.3	0.7	4.8	
Pentanes (I/N)	1.1		0.0	0.1	1.9
Isomate (C5-C6)	4.1	6.1	5.8	7.8	6.7
Isomate (C6)					2.9
Lt Hydrocrackate (C5-180)	1.0	0.2	1.3		6.8
Medium Hydrocrackate (180-225)	1.1	0.2	1.6		6.8
MTBE	11.1	11.6	11.2	11.6	10.5
TAME	0.7	0.1	0.6		0.6
Alcohol					
Total Low Aromatics, Saturated	40.5	48.9	45.0	42.0	56.8
* Total Minimum.	100.0	100.0	100.0	100.0	100.0

[1] Case Q6N.

[2] Excluding Lt Reformate and Lt Raffinate.

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TABLE C-9B
CONVENTIONAL GASOLINE POOL COMPOSITONS
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC[1]</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>
FCC Gasoline		21.8	15.0	24.6	10.3	
Lt FCC 255-		12.1	15.1	4.3	11.9	
Hvy FCC 255+		0.5	7.4	4.8	7.5	
Hvy FCC 255+ Desulf.						
FCC Gaso (100-180)			1.7	1.3		
FCC Gaso (180-225)			0.8	0.8		
FCC Gaso (225-300)			0.5	0.5	0.3	23.8
FCC Gaso (300-375)					0.2	12.4
FCC Gaso (375-430)						
Total FCC Gasoline		<u>34.3</u>	<u>40.5</u>	<u>36.4</u>	<u>30.2</u>	<u>36.2</u>
Butenes						
Pentenenes					0.3	7.1
Poly Gasoline				2.9	0.6	
Lt Coker Gasoline (C5-180)		<u>1.2</u>	<u>0.2</u>	<u>0.3</u>	<u>1.3</u>	
Total Olefinic		<u>1.2</u>	<u>0.2</u>	<u>3.2</u>	<u>2.2</u>	<u>7.1</u>
Reformate (220-350 Feed)		36.4	31.6	20.8	18.3	19.1
Reformate (220-300 Feed)				0.7	6.2	
BT Reformate (150-220 Feed)		4.7	0.3	4.9	11.9	8.0
HC Reformate (210-300)						
Hvy Reformate (300+)		0.1	0.8			
Toluene/Xylenes						
Total Reformate[2]		<u>41.2</u>	<u>32.7</u>	<u>26.4</u>	<u>36.5</u>	<u>27.1</u>
Lt Reformate (C5-210)		0.5	1.7			
Lt Raffinate (C5-210)						
Alkylate/Lt Alkylate (C3/C4)		5.2	5.3	12.5	10.6	
Alkylate/Lt Alkylate (C5)						
Butanes		3.2	2.9	5.4	5.2	2.0 *
Natural/LSR Gasoline				7.9	3.7	
BT Naphtha (150-220)		1.9		5.8		
Pentanenes (I/N)		0.3	1.8	0.6	0.4	20.1
Isomate (C5-C6)		6.0	6.1	0.9	1.6	
Isomate (C6)					0.1	
Lt Hydrocrackate (C5-180)		3.0	4.2	0.5	4.6	
Medium Hydrocrackate (180-225)		3.1	4.8	0.7	3.3	
MTBE					1.7	7.4
TAME						
Alcohol						
Total Low Aromatics, Saturated		<u>23.3</u>	<u>26.7</u>	<u>34.0</u>	<u>31.1</u>	<u>29.5</u>
Total		<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

[1] Case Q6N.

[2] Excluding Lt Reformate and Lt Raffinate.

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TABLE C-10
COMBINED GASOLINE POOL PROPERTIES AND INCREMENTAL COSTS
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC[1]	IV	VCOC	VCC
<u>Average Properties</u>						
(R+M)/2 Octane, Clear*	88.9	88.1	88.6	86.6	88.3	88.5
Aromatics, V%	24.4	28.1	27.6	28.1	32.9 *	22.9 *
Ethers, V%	11.7 *	6.5 *	7.4 *	1.5 *	1.7	10.9 *
Oxygen, W%	2.1 *	1.2 *	1.3 *	0.3 *	0.3	2.0 *
Olefins, V%	13.1 *	12.0	12.2	14.3	11.9	4.5 *
Benzene, V%*	0.7	1.3	1.1	1.6	2.8	0.8
Sulfur, WPPM	233 *	262	157	260 *	243	37 *
Reid Vapor Pressure, PSI*	6.5	7.1	7.0	8.4	8.7	6.7
Temperature at V/L = 20, °	148	146	146	139	137	146
<u>Distillation</u>						
T10, °F	132	125	125	118	118	133
T50, °F	206	205	205	205	206	198
T90, °F	338	344	345	345	335	294 *
Specific Gravity	0.7443	0.7472	0.7461	0.7415	0.7475	0.7368
Heat Content, MBTU/G	112.1	113.2	112.9	113.6	113.9	111.3
V.O.C., gm/mile*	0.73	0.85	0.83	1.20	1.21	0.67
- % Reduction*	41	32	35	7	8	46
NOx, index	1.01	1.00	0.97	1.00	0.98	0.93
- % Reduction	(1)		3		2	7
T.A.P., mg/mile	35	43 *	40	51 *	63 *	29 *
- % Reduction	32	18 *	24	4 *	(19) *	45 *
% Class C, Fixed*	90	80	40	40	100	0

Incremental Costs for Property

Decrease, ¢/G Per Unit[2]

(R+M)/2 Octane, Clear	(0.6)	(0.8)	(0.6)	(0.5)	(1.8)	(1.8)
Aromatics, V%					0.1	0.4
Ethers, V%	(0.3)	(0.1)	(0.2)	(0.4)		0.3
Ethanol, %						
Olefins, V%	0.0					0.4
Benzene, V%	3.5	1.4	1.6	0.1	1.2	2.6
Sulfur, 100 WPPM	0.8			(0.0)		5.4
Reid Vapor Pressure, PSI	(0.1)	(1.0)	0.3 [3]	0.2 [3]	0.2	2.7
T90, 10 °F						0.8
Butanes, V%		0.0	(0.1)	(0.0)		(0.8)
V.O.C., 10%	1.2	1.0	0.4	0.1		0.0
NOx, 10%						
T.A.P., 10%		0.2		0.2	0.3	0.0

* Input limit.

[1] Case Q6N.

[2] Shadow costs for very small changes. Not applicable for significant changes.

[3] Average of absolute values. RFG is at minimum RVP (negative cost) while CG is at maximum (positive cost).

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TABLE C-10A
REFORMULATED GASOLINE POOL PROPERTIES AND INCREMENTAL COSTS
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC[1]	IV	VCC[2]
Average Properties					
(R+M)/2 Octane, Clear*	88.9	88.1	88.6	86.6	88.5
Aromatics, V%	24.4	22.2	23.7	28.9	22.0 *
Ethers, V%*	11.7	11.7	11.7	11.7	11.1
Oxygen, W%*	2.1	2.1	2.1	2.1	2.0
Olefins, V%	13.1 *	10.7	10.7	7.1	4.0 *
Benzene, V%*	0.7	0.7	0.7	0.7	0.8
Sulfur, WPPM	233 *	273	141	100 *	30 *
Reid Vapor Pressure, PSI*	6.5	6.5	6.5	6.5	6.6
Temperature at V/L = 20, °F	148	149	149	147	146
Distillation					
T10, °F	132	134	134	131	135
T50, °F	206	203	203	205	196
T90, °F	338	348	342	337	290 *
Specific Gravity	0.7443	0.7439	0.7444	0.7502	0.7359
Heat Content, MBTU/G	112.1	112.0	112.0	112.4	111.2
V.O.C., gm/mile*	0.73	0.74	0.71	0.71	0.63
- % Reduction*	41	41	45	45	49
NOx, index	1.01	1.00	0.97	0.94	0.92
- % Reduction	(1)		3	6	8
T.A.P., mg/mile	35	36 *	34	37 *	27
- % Reduction	32	32 *	35	31 *	48
% Class C, Fixed	90	80	40	40	0
Incremental Costs for Property					
Decrease, ¢/G Per Unit[3]					
(R+M)/2 Octane, Clear	(0.6)	(0.7)	(0.5)	(0.5)	(1.9)
Aromatics, V%					0.5
Ethers, V%	(0.3)	(0.1)	(0.4)	(0.4)	0.4
Ethanol, %					
Olefins, V%	0.0				0.4
Benzene, V%	3.5	2.1	2.1	0.5	2.8
Sulfur, 100 WPPM	0.8			(0.0)	5.8
Reid Vapor Pressure, PSI	(0.1)	(1.7)	(0.2)	(0.3)	2.9
T90, 10 °F					0.8
Butanes, V%		0.0	(0.2)	(0.0)	(0.8)
V.O.C., 10%	1.2	1.7	0.6	0.6	
NOx, 10%					
T.A.P., 10%		0.0		0.0	

* Input limit.

[1] Case Q6N.

[2] CARB-2 gasoline.

[3] Shadow costs for very small changes. Not applicable for significant changes.

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TABLE C-10B
CONVENTIONAL GASOLINE POOL PROPERTIES AND INCREMENTAL COSTS
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	IC	IIC	IIIC[1]	IV	VCOC	VCC
Average Properties						
(R+M)/2 Octane, Clear*		88.1	88.6	86.6	88.3	88.5
Aromatics, V%		35.6	34.3	28.0	32.9 *	35.8 *
Ethers, V%					1.7	7.4
Oxygen, W%					0.3	1.3
Olefins, V%		13.6	14.8	15.4	11.9	12.9 *
Benzene, V%		2.1 *	1.7 *	1.7	2.8 *	1.6
Sulfur, WPPM		248	186	284	243	136
Reid Vapor Pressure, PSI		7.8	7.9 *	8.7 *	8.7 *	8.5
Temperature at V/L = 20, °F		142	143	138	137	139
Distillation						
T10, °F		113	109	116	118	104
T50, °F		208	208	205	206	223
T90, °F		338	351	346	335	342 *
Specific Gravity		0.7512	0.7491	0.7402	0.7475	0.7503
Heat Content, MBTU/G		114.8	114.5	113.7	113.9	113.4
V.O.C., gm/mile		0.99	1.05	1.27	1.21	1.23 *
- % Reduction		21	18	1	8	*
NOx, index		0.99	0.97	1.01	0.98	0.96
- % Reduction		1	3	(1)	2	4
T.A.P., mg/mile*		52	51	53	63	53
- % Reduction*		0	4	0	(19)	(2)
% Class C, Fixed		80	40	40	100	0
Incremental Costs for Property						
Decrease, ¢/G Per Unit[2]						
(R+M)/2 Octane, Clear		(0.8)	(0.8)	(0.5)	(1.8)	(1.4)
Aromatics, V%					0.1	0.1
Ethers, V%				(0.4)		
Ethanol, %						
Olefins, V%						0.4
Benzene, V%		0.4	0.9		1.2	
Sulfur, 100 WPPM						
Reid Vapor Pressure, PSI			0.5	0.2	0.2	
T90, 10 °F						0.8
Butanes, V%						(0.2)
V.O.C., 10%						0.4
NOx, 10%						
T.A.P., 10%		0.5		0.2	0.3	0.2

* Input limit.

[1] Case Q6N.

[2] Shadow costs for very small changes. Not applicable for significant changes.

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TABLE C-11
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
Q6 2000 SUMMER 4/92 COMPLEX FORMULA BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>IC</u>	<u>IIC</u>	<u>IIIC[1]</u>	<u>IV</u>	<u>VCOC</u>	<u>VCC</u>
<u>No. 2 Diesel Compositions</u>						
Hvy Reformate (300+) 90 RON						
Hvy Reformate (300+) 100 RON						
FCC Heavy Gaso Tr(300-375)						8.3
FCC Heavy Gaso Tr(375-430)						
Lt Cycle Oil - Treated	14.3	17.5	6.5	13.9		
Coker Dist - Treated	<u>2.5</u>	<u> </u>	<u>3.3</u>	<u>4.0</u>	<u>8.1</u>	<u> </u>
Total High Aromatic	16.8	17.5	9.8	17.9	8.1	8.3
Heavy Alkylate (300+)				0.0		0.1
Lt Kero - Treated (300-375)	6.3	4.0	4.3	4.8	8.3	0.1
Kero - (375-500)	5.6	9.9	15.5	13.9	2.1	
Kero - Treated (375-500)	23.5	29.3	23.0	17.5	10.5	1.3
Kero - Low Aromatics (375-500)						24.1
Hydrocracked Jet (295-525)						
Diesel Base	2.3	5.5	7.6	14.7	12.8	0.8
Diesel Base - Treated	44.3	33.8	39.8	31.1	54.1	35.0
Diesel Base - Low Aromatics						23.2
Lt Cycle Oil - Low Aromatics	1.2					
Coker Dist - Low Aromatics	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u>4.1</u>	<u>7.1</u>
Total Low Aromatic	83.2	82.5	90.2	82.1	91.9	91.7
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
<u>Properties</u>						
Diesel Ignition Improver						
Pour Point Depressant		Yes			Yes	
Aromatics	30.1	28.8	25.9	30.3	26.4	19.7
<u>Jet A Compositions</u>						
Heavy Alkylate (300+)						
Lt Kero - Treated (300-375)	36.8	39.5	35.7	40.0	16.0	31.4
Kero - Treated (375-500)	42.9	48.3	40.6	49.2	54.4	44.1
Hydrocracked Jet (295-525)	<u>20.3</u>	<u>12.3</u>	<u>23.7</u>	<u>10.9</u>	<u>29.6</u>	<u>24.5</u>
Total	100.0	100.0	100.0	100.0	100.0	100.0

[1] Case Q6N.

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TABLE C1-1
REFINING RAW MATERIALS INPUT RATES DETAIL
1995/2000 FLEXIBILITY/2010 BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>1995 IIIC F2 Annual</u>	<u>1995 IIIC Q6 Summer</u>	<u>2010 IIIC F1 Summer</u>	<u>2010 IIIC F3 Summer</u>	<u>2000 IIIC Q6 Winter</u>	<u>2000 IIC Q6 Winter</u>
Domestic Crudes	2,827	2,827	2,391	3,250	2,851	1,820
Foreign Crudes	<u>2,948</u>	<u>3,142</u>	<u>4,904</u>	<u>1,722</u>	<u>2,578</u>	<u>789</u>
Sub Total Crudes	5,775	5,969	7,295	4,972	5,429	2,609
MTBE	(4)	(31)	163	119	171	117
Natural Gasoline	134	134	137	137	134	38
Reformate, 100 RONC	(17)	(17)	(21)	(21)	(17)	35
Naphtha	85	85	88	88	85	
Vacuum Gas Oil	218	218	224	224	218	27
Vac Resid	13	13	14	14	13	
Normal Butane	102				234	148
Iso-Butane	46	74	68	46	46	23
Propane	14	14	13	13	14	2
Nat. Gas Fd to H2, FOE	21	20	48	21	23	5
Methanol	<u>28</u>	<u>25</u>	<u>35</u>	<u>29</u>	<u>30</u>	<u>3</u>
Total Input	6,415	6,505	8,063	5,643	6,379	3,006

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TABLE C1-2
REFINING PRODUCT RATES DETAIL
1995/2000 FLEXIBILITY/2010 BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
<u>Motor Gasolines</u>						
Regular – CG	1,857	2,067	978	762	752	535
Premium – CG	652	726	344	268	264	122
Regular – OG	175				62	81
Premium – OG	61				22	18
Regular – RFG – OG	55				396	72
Premium – RFG – OG	19				139	16
Regular – RFG	200	263	1,676	1,298	1,056	681
Premium – RFG	70	92	589	456	371	155
Regular – CARB 2						
Premium – CARB 2						
Sub Total	3,089	3,148	3,587	2,784	3,063	1,681
Aviation Gasolines	15	15	15	11	15	3
Kero Jet / Kerosene	727	686	1,042	578	768	213
<u>No. 2 Fuels</u>						
Diesel – LA, ULS						
Diesel – 0.05% S	881	940	1,192	799	821	548
No. 2 Fuel – 0.25% S	374	289	366	246	460	134
Sub Total	1,255	1,229	1,558	1,045	1,281	682
<u>Residual Fuels</u>						
< 0.3% Sulfur	9	12	8	8	10	2
0.7 – 1.0% Sulfur	56	53	182	57	55	14
> 1.0% Sulfur	60	57	75	33	63	13
Sub Total	125	122	265	98	128	29
Asphalt / Road Oil	84	102	102	63	66	103
Marketable Coke – 400#	178	183	192	170	167	57
Catalytic Coke – 400#	98	117	119	79	82	43
Benzene	21	21	24	21	21	2
Toluene	25	25	22	25	25	5
Xylene	40	40	40	40	40	9
Heavy Aromatic Gaso						
MTBE						
Pentanes to P/C						
Nat Gaso to P/C	134	134	116	86	134	
PC/Spcl/Misc Naphtha	52	52	157	62	52	18
Petrochem Gas Oil	152	152	288	187	152	18
Carbon Black Feed	31	33	33	33	29	4
Lubes / Wax	97	97	97	66	97	24
Butanes / Butene	44	56	86	94	62	
Propene	65	67	67	67	63	22
Propane	147	163	168	126	126	81
Process Gas / C2 / C2=, FOE	349	388	421	301	294	118
(Gain) / Loss	(314)	(325)	(335)	(293)	(286)	(106)
Total Products	6,415	6,505	8,063	5,643	6,379	3,006

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TABLE C1-3
REFINING CRUDE INPUT SUMMARY
1995/2000 FLEXIBILITY/2010 BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

		1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIIC Q6 Winter
<u>RATES – MBPD</u>							
<u>Domestic</u>							
Low Sulfur	S	1,984	1,984	1,965	1,999	1,985	1,223
High Sulfur Light	HL	174	174	174	174	174	371
High Sulfur Heavy	HH	669	669	252	1,077	692	226
Subtotal		2,827	2,827	2,391	3,250	2,851	1,820
<u>Foreign</u>							
Low Sulfur	S	732	732	1,248	331	678	259
High Sulfur Light	HL	698	698	1,110	4	528	121
High Sulfur Heavy	HH	1,518	1,712	2,546	1,386	1,372	409
Subtotal		2,948	3,142	4,904	1,722	2,578	789
<u>Combined</u>							
Low Sulfur	S	2,716	2,716	3,213	2,330	2,663	1,482
High Sulfur Light	HL	872	872	1,284	178	702	492
High Sulfur Heavy	HH	2,187	2,381	2,798	2,464	2,064	635
Total		5,775	5,969	7,295	4,972	5,429	2,609
<u>PROPERTIES – Calculated</u>							
Domestic Gravity, Deg. API		34.4	34.4	35.7	33.5	34.3	36.0
Domestic Sulfur, % wt.		0.65	0.65	0.57	0.71	0.66	0.74
Foreign Gravity, Deg. API		31.5	31.4	32.0	29.3	31.3	31.3
Foreign Sulfur, % wt.		1.67	1.71	1.68	1.89	1.64	1.55
Combined Gravity, Deg. API		32.9	32.8	33.2	32.0	32.9	34.6
Combined Sulfur, % wt.		1.18	1.22	1.32	1.13	1.13	0.99

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TABLE C1-4
REFINING DOMESTIC CRUDE INPUT RATES DETAIL
1995/2000 FLEXIBILITY/2010 BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

LOCATION / NAME		Type	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIIC Q6 Winter
AL	Heavy	HH	30	30	30	30	30	5
	Light	S						
AK	Cook	S						
	North Slope	HH	417	417		825	440	54
AZ	Sweet	S						
AR	Heavy	HH	31	31	31	31	31	
CA	Beta	HH						
	Elk Hills	S	51	51	32	66	52	36
	Huntington	HH						
	Hondo	HH						
	LA Basin	HH						
	San Ardo	HH						
	SJV Light	HH						
	SJV Kern	HH						
	SJV Heavy	HH						
	Ventura	HH						
	Wilmington Heavy	HH						
	Wilmington Light	HH						
CO	Rangely	S						7
DI	Padd I Lube	S						
FL	Jay	S						
IL	Sweet	S						28
	Weeks	S						28
IN	Sweet	S						9
KS	Butler	S						13
	Common	S						24
	Light	S						115
KY	Sweet	S						17
LA	Condensate	S	87	87	87	87	87	
	Light Sweet	S	219	219	219	219	219	100
	North Mix	S	31	31	31	31	31	
	Heavy Sweet	S	552	552	552	552	552	80
MI	Sweet	S						59
MS	Baxterville	HH	34	34	34	34	34	
	Light Hey	HL	19	19	19	19	19	
	Sweet	S	12	12	12	12	12	
MT	Sour	HH						1
	Rebeki	S						10
NE	Light Sour	HL						18
NV	Sweet	S						
NM	Intermediate	S						114
	Sour	HL	49	49	49	49	49	
ND	Light Sour	HL						32
OH/MO	Light	S						23
OK	Cement	S	28	28	28	28	28	88
	Condensate	S						12
	Garber	S						126
	Velma	HH						66
SD	Sweet	S						6
TX	Condensate	S	69	69	69	69	69	
	East	S	78	78	78	78	78	100
	Hawkins	HH	157	157	157	157	157	
	Gulf Refugio	S	466	466	466	466	466	
	West Intermediate	S	391	391	391	391	391	111
	West Scurry	S						38
	West Sour	HL	106	106	106	106	106	321
UT	Altamont	S						
	Mix	S						
WY	Platte/Sour	HH						100
	Sweet	S						79
	Total		2,827	2,827	2,391	3,250	2,851	1,820

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TABLE C1-5
REFINING FOREIGN CRUDE INPUT RATES DETAIL
1995/2000 FLEXIBILITY/2010 BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>COUNTRY</u>	<u>NAME</u>	<u>TYPE</u>	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
Abu Dhabi/Dubai/Oman/UAE		HL	25	25	25		25	
Algeria	Cond.	S	37	37	37	37	37	11
Angola	Angolan	S	129	129	129	19	75	5
	Light	S	83	83	83	13	83	26
Cameroon	Kole	S	20	20	20	20	20	3
Canada	Heavy	HH						150
	Lloydmin	HH						112
	Intrprvn.	S	8	8	8	8	8	49
	Intermed.	HL	2	2	2	2	2	2
	Feder.	S						31
	Rangeland	HL						56
China	Daqing	S	23	23	23	23	23	
Colombia	Cano Lim.	HH	104	104	104	104	104	9
Congo	Djeno	S	9	9	9	9	9	
Ecuador	Oriente	HH	19	19	19	19	19	17
Gabon	Mandji	HH	13	13	13	13	13	
	Gamba	S	27	27	27	27	27	
Indonesia	Minas	S	28	28	28	28	28	1
	Attika	S	1	1	1	1	1	
	Cond.	S	2	2	2	2	2	6
Iraq	Kirkuk	HL	341	341	341		200	55
Kuwait		HH	144	144	144	124	144	4
Mexico	Maya	HH	336	336	336	336	336	47
	Isthmus	HL	101	101	101		101	
	Sweet	S	94	94	94	14	94	37
Nigeria	Forcados	S	122	122	122	34	122	40
	Medium	S	1	1	102		1	3
	Light	S	51	51	51		51	18
Norway	Heavy	S						
	Medium	S	15	15	15	15	15	6
	Ekofisk	S	14	14	14	14	14	
Saudi Arabia	Heavy	HH	144	144	144	10	144	
	Medium	HH	413	607	1,441	436	267	12
	Light	HL	150	150	562	2	121	
	Berri	HL	79	79	79		79	8
Trinidad	Light	S	53	53	53	53	53	20
United Kingdom	Brent	S	1	1	416		1	
Venezuela	Boscan	HH						
	Mlones	HH	14	14	14	14	14	
	Bach Q17	HH	63	63	63	63	63	
	TJ Med	HH	116	116	116	116	116	
	Lago Med	HH	152	152	152	152	152	58
Zaire		S	14	14	14	14	14	3
Total			2,948	3,142	4,904	1,722	2,578	789

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TABLE C1-6
NEW PROCESS CAPACITY AND INVESTMENT REQUIRED OVER 1991 BASE[1]
1995/2000 FLEXIBILITY/2010 BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 <u>Annual</u>	1995 IIIC Q6 <u>Summer</u>	2010 IIIC F1 <u>Summer</u>	2010 IIIC F3 <u>Summer</u>	2000 IIC Q6 <u>Winter</u>	2000 IIIC Q6 <u>Winter</u>
<u>New Capacity, MBPSD</u>						
Crude - Atmospheric			639			
Catalytic Cracking						
FCC Gasoline Splitters			229	117		248
Coking, Delayed						
Coker Lt Gasoline DS/Splitter			30	2	8	
Distillate HDS			582		18	
Reformer Feed Fractionation	589	608	1,727	1,313	726	1,359
Reformate Fractionation		237	300	237	39	247
Benzene Saturation		12	77	48	18	33
Diesel Aromatics Saturation						
Alkylation						
MTBE	29	15	34	18		18
TAME	8	4				
Isomerization - C4						
Hydrogen, MMSCFPSD						
Sulfur, STPSD						
C4 Rerun - Saturates			218	164		
- Unsaturation			555	427		
<u>Improvements, MBPSD</u>						
Cat Reformers - Reduce Pressure	205	205	205	205	184	205
<u>Investment, MM\$ (In Constant Mid 1990 \$)[2]</u>						
New Capacity	628	825	4,782	2,160	842	1,598
MTBE Storage & Blending			127	99	64	111
C4 Fractionation Upgrades			162	162		
Improve Cat Reformers - C5+ Yield	64	64	64	64	71	64
Total Refinery	692	889	5,135	2,485	977	1,773

[1] 1/1/91 capacities plus under construction plus auto/oil survey.

[2] This is not the complete industry investment required. It does not include capital for environmental restrictions other than diesel sulfur restrictions. It also excludes sustaining capital.

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TABLE C1-7
PROCESS UNIT RATES PER REFINERY
1995/2000 FLEXIBILITY/2010 BASE RESULTS – MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
Crude – Atmospheric	131.3	135.7	165.8	113.0	123.4	76.7
Heavy Naphtha Splitter						
Catalytic Cracking[1]	48.0	54.1	54.9	42.5	38.6	25.7
Catalytic Cracking[2]	44.5	49.6	50.8	39.4	37.5	24.0
Conversion, %	78.3	77.6	79.0	77.8	76.4	78.1
Octane Catalyst, %	70.6	67.3	74.1	67.7	70.8	73.4
FCC Gasoline Splitters			4.9	2.5	5.0	
FCC Gasoline Fractionation	11.7	11.7	11.7	9.9	11.3	4.3
Hydrocracking – High Conversion	9.4	9.3	9.8	8.6	8.9	3.0
Jet Yield, % of Maximum	97.4	100.0	100.0	66.1	100.0	100.0
300 – Gasoline Operation, %						
Hydrocracking – 2 Stage Distillate						
Hydrocracking – Low Conversion	1.5	1.5	1.5	1.3	1.5	0.7
– Heavy Gasoline						
– Combined[2]	10.9	10.8	11.3	9.9	10.3	3.7
Hydrocrackate Fractionation						
Coking – Delayed	13.1	13.5	14.2	12.6	12.2	7.6
– Fluid	0.7	0.7	0.8	0.6	0.7	
Coker Lt Gasoline DS/Splitter			0.6	0.0		0.2
Thermal Cracking, Visbreaking	1.5	0.6	1.5	1.5	1.5	0.6
Solvent Deasphalting	1.8	2.6	4.0	1.2	1.9	0.6
Catalytic Reforming – 100 PSI[1]	13.9	15.6	17.4	12.0	11.9	5.0
– 200 PSI[1]	10.8	11.1	11.0	10.6	10.6	5.5
– 450 PSI[1]	6.0	6.9	6.6	4.7	4.5	4.9
– Combined[2]	29.6	31.2	34.6	26.8	26.8	15.1
– RONC	96.8	98.3	94.7	95.2	94.6	94.9
Hydrotreating – Naphtha	30.9	32.6	36.1	27.4	27.2	17.7
– FCC/Coker C6s						
– Distillate	31.4	33.1	45.5	28.0	31.1	20.6
– Heavy Gas Oil	15.9	16.3	16.3	16.3	15.6	8.0
– Residuum – Atm	6.7	6.9	6.9	6.9	6.6	0.3
Reformer Feed Fractionation	12.0	12.7	36.1	27.4	27.2	17.7
Reformat Fractionation	8.0	13.1	14.4	13.1	12.7	2.2
Aromatics Extraction	4.0	4.1	4.1	4.1	3.9	0.9
Benzene Saturation		0.2	1.6	1.0	0.7	0.4
FCC Gasoline HDS						
Diesel Aromatics Saturation						
Alkylation	7.6	9.5	9.6	6.0	5.4	4.9
Alkylate Splitter						
Polymerization	0.4	0.4	0.4	0.4	0.4	0.2
Dehydrogenation – IC4	0.7	0.7	0.7	0.7	0.7	
MTBE	1.9	1.7	2.1	0.7	1.6	0.3
TAME			0.3	0.2	0.4	
Hydrodealkylation – Toluene						
Lubes	2.2	2.2	2.2	1.5	2.2	0.7
Isomerization – C5/C6	2.1	2.2	2.2	2.2	2.1	2.6
– C5/C6, Recycle	2.1	2.2	2.2	2.2	1.0	1.0
– C4	0.7	0.8	0.8	0.8	0.7	0.4
Hydrogen, MMSCFPCD	20.1	19.7	23.0	20.7	22.0	5.7
Sulfur, STPCD	128	134	166	112	119	52
C4 Rerun – Saturates			4.6	3.4		
– Unsaturation			11.6	8.9		

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

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TABLE C1-8
PROCESS UNIT UTILIZATIONS[1]
1995/2000 FLEXIBILITY/2010 BASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
Crude Distillation – Atmospheric	83.9	86.7	97.0 *	72.2	78.9	75.5
Heavy Naphtha Splitter						
Catalytic Cracking[2]	80.5	90.7	92.0	71.2	64.7	66.9
Catalytic Cracking[3]	74.6	83.1	85.2	66.1	62.9	62.3
FCC Gasoline Splitters			94.0 *	94.0 *	88.0 *	
FCC Gasoline Fractionation	81.9	81.9	81.9	69.3	79.2	76.3
Hydrocracking – High Conversion	84.0 *	83.3	87.0 *	76.7	79.0	77.0 *
– Low Conversion	62.7	58.5	58.5	50.7	60.5	77.0 *
– Heavy Gasoline						
– Combined[3]	80.1	79.4	81.7	71.8	75.8	77.0 *
Hydrocrackate Fractionation						
Coking – Delayed	85.2	87.7	92.0 *	81.6	79.3	84.0 *
– Fluid	86.1	85.9	92.0 *	72.6	85.2	
Coker Lt Gasoline DS/Splitter			92.0 *	92.0 *		84.0 *
Thermal Cracking, Visbreaking	90.0 *	38.8	92.0 *	88.1	88.0 *	83.0 *
Solvent Deasphalting	41.3	60.4	92.0 *	28.3	44.2	54.2
Catalytic Reforming – 100 PSI[2]	73.0	82.2	91.3	63.1	62.7	49.8
– 200 PSI[2]	90.0 *	92.0 *	91.6	88.6	88.0 *	66.5
– 450 PSI[2]	58.5	67.3	64.4	45.9	43.9	41.5
– Combined[3]	71.7	75.5	83.7	65.0	65.0	50.1
Hydrotreating – Naphtha	72.0	76.0	84.2	64.0	63.4	57.6
– FCC/Coker C6s						
– Distillate	86.6	91.4	92.0 *	77.2	85.9	83.0 *
– Heavy Gas Oil	84.5	86.6	86.6	86.6	82.7	74.8
– Residuum, Atmospheric	90.0 *	92.0 *	92.0 *	92.0 *	88.0 *	83.0 *
Reformer Feed Fractionation	90.0 *	92.0 *	92.0 *	92.0 *	88.0 *	83.0 *
Reformate Fractionation	90.0 *	92.0 *	92.0 *	92.0 *	88.0 *	83.0 *
Aromatics Extraction	90.0 *	92.0 *	92.0 *	92.0 *	88.0 *	83.0 *
Benzene Saturation		92.0 *	92.0 *	92.0 *	88.0 *	83.0 *
FCC Gasoline HDS						
Diesel Aromatics Saturation						
Alkylation	62.3	78.1	78.8	49.8	44.8	60.9
Alkylate Splitter						
Polymerization	44.1	45.0	45.0	45.0	43.1	40.0
Dehydrogenation – IC4	87.0 *	89.0 *	89.0 *	89.0 *	85.0 *	
MTBE	88.0 *	91.0 *	90.0 *	90.0 *	85.0 *	80.0 *
TAME	0.0	0.0	51.4	40.3	81.0 *	0.0
Hydrodealkylation – Toluene	0.0	0.0	0.0	0.0	0.0	0.0
Lubes	82.0	82.0	82.0	56.0	82.0	82.0
Isomerization – C5/C6	90.0 *	92.0 *	92.0 *	92.0 *	88.0 *	83.0 *
– C5/C6, Recycle	90.0 *	92.0 *	92.0 *	92.0 *	41.9	51.6
– C4	87.0 *	89.0 *	89.0 *	89.0 *	85.0 *	80.0 *
Hydrogen	78.1	76.1	89.0 *	80.3	85.0 *	66.3
Sulfur	50.6	53.0	65.6	44.3	47.3	45.6
C4 Rerun – Saturates			92.0 *	92.0 *		
– Unsaturation			92.0 *	92.0 *		

*Unit Maximum

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

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TABLE C1-9
GASOLINE POOL COMPOSITONS
1995/2000 FLEXIBILITY/2010 BASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
FCC Gasoline	19.4	21.9	15.3	20.3	14.5	18.7
Lt FCC 255-	9.8	9.7	8.4	5.2	2.5	5.1
Hvy FCC 255+	6.9	6.6	5.9	6.4	6.6	3.6
Hvy FCC 255+ Desulf.						
FCC Gaso (100-180)			1.2	1.4	2.4	
FCC Gaso (180-225)			0.8	0.8	1.5	
FCC Gaso (225-300)			1.4	0.6	1.0	
FCC Gaso (300-375)			0.6			
FCC Gaso (375-430)						
Total FCC Gasoline	36.1	38.2	33.6	34.8	28.6	27.4
Butenes						
Pentenenes			0.3	0.3	0.7	0.0
Poly Gasoline	0.6	0.6	0.5	0.6	0.6	0.4
Lt Coker Gasoline (C5-180)	1.3	0.5	0.5	0.8	1.1	0.7
Total Olefinic	1.9	1.1	1.3	1.7	2.4	1.1
Reformate (220-350 Feed)	13.6	14.5	20.4	20.7	16.2	21.5
Reformate (220-300 Feed)	5.4	5.3	1.7	1.1	3.3	0.7
BT Reformate (150-220 Feed)	3.5	3.0	0.1		0.6	3.0
HC Reformate (210-300)	2.6	2.5	4.3	3.8	3.2	0.1
Hvy Reformate (300+)	1.6	1.4	0.3	0.4	0.9	0.1
Toluene/Xylenes		0.1	0.1	0.1		0.2
Total Reformate[1]	26.7	26.8	26.8	26.0	24.3	25.5
Lt Reformate (C5-210)	1.4	1.3	0.9	0.6	0.9	
Lt Raffinate (C5-210)	2.5	2.8	4.4	4.6	3.5	1.0
Alkylate/Lt Alkylate (C3/C4)	10.6	13.1	11.3	9.3	7.7	10.1
Alkylate/Lt Alkylate (C5)			0.2	0.2		
Butanes	7.2	3.5	2.7	2.5	11.2	12.1
Natural/LSR Gasoline	0.1	1.0			1.2	0.5
BT Naphtha (150-220)			1.0		1.6	5.3
Pentanenes (I/N)			0.7	0.6	0.9	0.1
Isomerate (C5-C6)	6.0	6.0	5.2	6.7	4.3	7.1
Isomerate (C6)						
Lt Hydrocrackate (C5-180)	2.3	2.2	2.1	2.6	2.2	1.1
Medium Hydrocrackate (180-225)	2.7	2.7	2.4	2.9	2.6	1.2
MTBE	2.5	1.3	7.1	7.1	7.9	7.5
TAME			0.3	0.3	0.6	
Total Low Aromatics, Saturated	35.3	33.9	38.3	37.5	44.7	46.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE C1-9A
REFORMULATED GASOLINE POOL COMPOSITONS
1995/2000 FLEXIBILITY/2010 BASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
FCC Gasoline	19.6	20.5	22.9	22.3	17.1	19.7
Lt FCC 255-	2.7	10.1		0.7	1.2	
Hvy FCC 255+	4.7	7.7	3.0	7.7	7.2	5.5
Hvy FCC 255+ Desulf.						
FCC Gaso (100-180)			1.4	1.8	0.9	
FCC Gaso (180-225)			0.9	1.3	0.6	
FCC Gaso (225-300)			1.9	0.9	0.4	
FCC Gaso (300-375)						
FCC Gaso (375-430)						
Total FCC Gasoline	27.0	38.3	30.1	34.7	27.4	25.2
Butenes						
Pentenenes			0.5	0.1	0.6	
Poly Gasoline	4.9	1.8	0.8	1.0	0.7	0.8
Lt Coker Gasoline (C5-180)						
Total Olefinic	4.9	1.8	1.3	1.1	1.2	0.8
Reformate (220-350 Feed)	8.7	3.8	13.4	12.5	11.7	14.1
Reformate (220-300 Feed)	2.8		2.6	1.7		1.3
BT Reformate (150-220 Feed)						0.7
HC Reformate (210-300)	11.3	18.7	6.8	6.0	5.2	0.2
Hvy Reformate (300+)			0.5	0.6		
Toluene/Xylenes			0.1			
Total Reformate[1]	22.8	22.5	23.5	20.9	16.9	16.3
Lt Reformate (C5-210)						
Lt Raffinate (C5-210)	5.3	6.0	7.0	7.4	5.3	2.1
Alkylate/Lt Alkylate (C3/C4)	7.3	7.5	14.2	11.7	9.4	13.7
Alkylate/Lt Alkylate (C5)			0.3	0.2		
Butanes	6.0	3.0	2.0 *	2.0 *	11.3	11.9
Natural/LSR Gasoline		2.0				
BT Naphtha (150-220)			1.6		2.9	7.2
Pentanenes (I/N)			0.1	0.0		0.1
Isomerate (C5-C6)		3.6	4.9	6.1	6.3	10.7
Isomerate (C6)						
Lt Hydrocrackate (C5-180)	6.9		1.4	1.8	3.3	0.3
Medium Hydrocrackate (180-225)	8.1	3.6	1.7	2.3	4.1	
MTBE	11.7	11.7	11.2	11.2	10.5	11.7
TAME			0.5	0.5	1.3	
Total Low Aromatics, Saturated	45.3	37.4	45.1	43.3	54.4	57.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE C1-9B
CONVENTIONAL GASOLINE POOL COMPOSITONS
1995/2000 FLEXIBILITY/2010 BASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
FCC Gasoline	21.1	22.2	2.2	17.0	18.6	18.1
Lt FCC 255-	10.8	9.6	23.0	13.1	1.4	13.1
Hvy FCC 255+	7.1	6.6	10.8	4.2	4.3	
Hvy FCC 255+ Desulf.						
FCC Gaso (100-180)			0.8	0.6	5.3	
FCC Gaso (180-225)			0.4		2.9	
FCC Gaso (225-300)			0.6		2.1	
FCC Gaso (300-375)			1.8			
FCC Gaso (375-430)						
Total FCC Gasoline	39.0	38.4	39.6	34.9	34.7	31.3
Butenes						
Pentenes				0.6		0.1
Poly Gasoline		0.4				
Lt Coker Gasoline (C5-180)	0.9	0.5	1.3	2.1	2.9	1.7
Total Olefinic	0.9	0.9	1.3	2.7	2.9	1.8
Reformate (220-350 Feed)	13.6	15.9	32.3	34.5	18.6	33.6
Reformate (220-300 Feed)	5.5	6.0			8.8	
BT Reformate (150-220 Feed)	3.8	3.4	0.2		1.6	5.4
HC Reformate (210-300)	1.6	0.5			0.4	
Hvy Reformate (300+)	2.0	1.6			2.8	0.2
Toluene/Xylenes		0.1		0.2		0.5
Total Reformate[1]	26.5	27.5	32.5	34.7	32.3	39.8
Lt Reformate (C5-210)	1.7	1.4	2.5	1.6	2.8	
Lt Raffinate (C5-210)	2.2	2.4				
Alkylate/Lt Alkylate (C3/C4)	12.2	13.8	6.3	5.3	6.6	4.3
Alkylate/Lt Alkylate (C5)			0.1	0.1		
Butanes	6.8	3.6	3.8	3.4	11.1	11.9
Natural/LSR Gasoline		0.9				1.4
BT Naphtha (150-220)						1.2
Pentanes (I/N)			1.5	1.5	2.8	
Isomerate (C5-C6)	7.3	6.2	5.7	7.7	4.2	4.3
Isomerate (C6)						
Lt Hydrocrackate (C5-180)	1.6	2.5	3.1	3.9	1.2	1.8
Medium Hydrocrackate (180-225)	1.8	2.4	3.5	4.1	1.4	2.2
MTBE						
TAME						
Total Low Aromatics, Saturated	33.6	33.2	26.5	27.7	30.1	27.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE C1-9C
OXYGENATED GASOLINE POOL COMPOSITONS
1995/2000 FLEXIBILITY/2010 BASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
FCC Gasoline	6.7				17.9
Lt FCC 255-	7.6				
Hvy FCC 255+	5.7			1.6	9.5
Hvy FCC 255+ Desulf.					
FCC Gaso (100-180)				4.3	
FCC Gaso (180-225)				2.8	
FCC Gaso (225-300)				2.0	
FCC Gaso (300-375)					
FCC Gaso (375-430)					
Total FCC Gasoline	20.0			10.7	27.3
Butenes					
Pentenes					
Poly Gasoline					
Lt Coker Gasoline (C5-180)	6.2			5.3	
Total Olefinic	6.2			5.3	
Reformate (220-350 Feed)	23.9			31.5	11.0
Reformate (220-300 Feed)	5.5				
BT Reformate (150-220 Feed)	4.5			3.6	8.6
HC Reformate (210-300)	1.2			1.7	
Hvy Reformate (300+)					
Toluene/Xylenes					
Total Reformate[1]	35.1			36.7	19.6
Lt Reformate (C5-210)					
Lt Raffinate (C5-210)					
Alkylate/Lt Alkylate (C3/C4)				3.9	6.5
Alkylate/Lt Alkylate (C5)					
Butanes	11.7			12.4	13.3
Natural/LSR Gasoline					
BT Naphtha (150-220)					8.0
Pentanes (I/N)					
Isomerase (C5-C6)					0.8
Isomerase (C6)					
Lt Hydrocrackate (C5-180)	5.4			7.2	3.9
Medium Hydrocrackate (180-225)	6.6			8.7	5.8
MTBE	15.0			15.0	15.0
TAME					
Total Low Aromatics, Saturate	38.7			47.2	53.1
Total	100.0			100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE C1-9D
REFORMULATED – OXYGENATED GASOLINE POOL COMPOSITON
1995/2000 FLEXIBILITY/2010 BASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
FCC Gasoline	7.5			2.0	14.5
Lt FCC 255-	10.1			8.4	
Hvy FCC 255+	7.7			10.7	4.9
Hvy FCC 255+ Desulf.					
FCC Gaso (100-180)				0.7	
FCC Gaso (180-225)				0.5	
FCC Gaso (225-300)				0.5	
FCC Gaso (300-375)					
FCC Gaso (375-430)					
Total FCC Gasoline	25.3			22.9	19.3
Butenes					
Pentenes				2.7	
Poly Gasoline	5.8			1.5	
Lt Coker Gasoline (C5-180)					
Total Olefinic	5.8			4.1	
Reformate (220-350 Feed)				21.5	12.8
Reformate (220-300 Feed)	14.1			2.4	
BT Reformate (150-220 Feed)					0.5
HC Reformate (210-300)	6.8			3.1	
Hvy Reformate (300+)					
Toluene/Xylenes					
Total Reformate[1]	20.9			26.9	13.2
Lt Reformate (C5-210)	0.7				
Lt Raffinate (C5-210)	8.7			5.8	
Alkylate/Lt Alkylate (C3/C4)	4.2			5.6	22.8
Alkylate/Lt Alkylate (C5)					
Butanes	10.5			11.1	14.0
Natural/LSR Gasoline	5.8			6.8	
BT Naphtha (150-220)				1.6	14.6
Pentanes (I/N)				0.1	0.0
Isomerase (C5-C6)					
Isomerase (C6)					
Lt Hydrocrackate (C5-180)	1.4				0.4
Medium Hydrocrackate (180-225)	1.7				0.7
MTBE	15.0			15.0	15.0
TAME					
Total Low Aromatics, Saturated	48.0			46.0	67.5
Total	100.0			100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE C1-10
GASOLINE POOL PROPERTIES AND INCREMENTAL COSTS
1995/2000 FLEXIBILITY/2010 BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
Average Properties						
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.1
Aromatics, V%	28.7	30.5 *	27.2	27.6	24.5	23.5
Ethers, V%*	2.5	1.3	7.4	7.4	8.5	7.5
Oxygen, W%*	0.5	0.2	1.3	1.3	1.5	1.3
Olefins, V%	13.4	13.8	12.5	12.7	10.8	10.0
Benzene, V%*	1.6	1.6	1.1	1.0	1.1	1.3
Sulfur, WPPM	229	281	224 *	138	196	246
Reid Vapor Pressure, PSI*	9.8	7.8	7.1	7.3	11.9	12.5
Temperature at V/L = 20, °F	132	143	146	145	119	116
Distillation						
T10, °F	101	117	125	122	89	74
T50, °F	204	209	205	203	190	189
T90, °F	343	347	339	345	336	333
Specific Gravity	0.7396	0.7459	0.7450	0.7450	0.7312	0.7283
Heat Content, MBTU/G	113.0	114.0	112.8	112.7	110.8	110.8
V.O.C., gm/mile		1.03	0.87 *	0.90 *		
- % Reduction		20	32 *	30 *		
NOx, index		1.00	0.99	0.97 *	0.97 *	0.97 *
- % Reduction		0	1	3 *	3 *	3 *
T.A.P., mg/mile		49	41 *	41 *	36	37
- % Reduction		8	22 *	22 *	10	9
% Northern Grade, Fixed	40	40	40	40	40	80
Incremental Costs for Property						
Decrease, ¢/G Per Unit[1]						
(R+M)/2 Octane, Clear	(0.5)	(1.3)	(0.6)	(0.6)	(0.3)	(0.3)
Aromatics, V%		0.3				
Ethers, V%	(0.3)	(0.1)	(0.3)	(0.4)	(0.3)	(0.3)
Ethanol, %						
Olefins, V%						
Benzene, V%	0.2	0.6	1.4	1.5	0.2	0.2
Sulfur, 100 WPPM			0.0			
Reid Vapor Pressure, PSI	0.4	0.7	(1.5)	0.2 [2]	0.3	0.4
T90, 10 °F						
Butanes, V%				0.1		
V.O.C., 10%			1.2	0.4		
NOx, 10%				0.0	0.1	0.0
T.A.P., 10%			0.2	0.0		

* Input limit.

[1] Shadow costs for very small changes.

Not applicable for significant changes.

[2] Average of absolute values. RFG is at minimum RVP (negative cost), while CG is at maximum RVP (positive cost).

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TABLE C1-10A
REFORMULATED GASOLINE POOL PROPERTIES AND INCREMENTAL COST
1995/2000 FLEXIBILITY/2010 BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
<u>Average Properties</u>						
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.1
Aromatics, V%	23.4	27.2 *	23.5	24.1	20.3	18.2
Ethers, V%*	11.7	11.7	11.7	11.7	11.7	11.7
Oxygen, W%*	2.1	2.1	2.1	2.1	2.1	2.1
Olefins, V%	13.5	14.0	11.1	11.8	9.5	8.4
Benzene, V%*	0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM	305	305	233	122	153	239
Reid Vapor Pressure, PSI*	8.8	7.2	6.5	6.5	11.9	12.5
Temperature at V/L = 20, °F	137	145	149	149	119	115
<u>Distillation</u>						
T10, °F	123	129	135	134	92	74
T50, °F	201	207	202	203	186	182
T90, °F	325	326	333	345	334	336
Specific Gravity	0.7415	0.7490	0.7435	0.7452	0.7274	0.7226
Heat Content, MBTU/G	111.3	112.2	111.9	112.0	109.7	109.4
V.O.C., gm/mile		0.85	0.71 *	0.71 *		
– % Reduction		34	45 *	45 *		
NOx, index		1.04	1.00	0.97	0.96 *	0.97
– % Reduction		(4)	0	3	4 *	3
T.A.P., mg/mile		37	35	34	32	32
– % Reduction		29	34	35	20	19
% Northern Grade, Fixed	40	40	40	40	40	80

Incremental Costs for Property

Decrease, ¢/G Per Unit[1]

(R+M)/2 Octane, Clear	(0.4)	(1.2)	(0.5)	(0.5)	(0.3)	(0.3)
Aromatics, V%		0.3				
Ethers, V%	(0.4)	(0.1)	(0.3)	(0.4)	(0.5)	(0.3)
Ethanol, %						
Olefins, V%						
Benzene, V%	0.3	0.8	2.0	2.1	0.2	0.3
Sulfur, 100 WPPM						
Reid Vapor Pressure, PSI	0.4	0.7	(2.4)	(0.2)	0.3	0.4
T90, 10 °F						
Butanes, V%				0.2		
V.O.C., 10%			1.9	0.6		
NOx, 10%					0.1	
T.A.P., 10%						

* Input limit.

[1] Shadow costs for very small changes.

Not applicable for significant changes.

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TABLE C1-10B
CONVENTIONAL GASOLINE POOL PROPERTIES AND INCREMENTAL COST
1995/2000 FLEXIBILITY/2010 BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	1995 IIIC Q6 Summer	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
<u>Average Properties</u>						
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.1
Aromatics, V%	29.9	30.9 *	33.5	33.7	31.6	31.8
Ethers, V%						
Oxygen, W%						
Olefins, V%	13.8	13.8	14.8	14.3	13.0	13.2
Benzene, V%*	1.7	1.7	1.7	1.6	1.7	2.0
Sulfur, WPPM	211	278	210	165	282	255
Reid Vapor Pressure, PSI	9.7 *	7.9 *	8.3	8.6 *	11.9 *	12.5 *
Temperature at V/L = 20, °F	133	143	140	138	121	116
<u>Distillation</u>						
T10, °F	100	115	108	103	81	76
T50, °F	206	209	210	204	202	200
T90, °F	348	350	351	344	341	329
Specific Gravity	0.7402	0.7455	0.7475	0.7448	0.7366	0.7356
Heat Content, MBTU/G	113.6	114.2	114.4	114.0	113.2	113.0
V.O.C., gm/mile		1.06	1.15	1.23		
- % Reduction		17	11	4		
NOx, index		1.00	0.98	0.97 *	0.98	0.98
- % Reduction			2	3 *	2	2
T.A.P., mg/mile		50	52 *	52 *	44	43
- % Reduction		4	1 *	1 *	(10)	(6)
% Northern Grade, Fixed	40	40	40	40	40	80
<u>Incremental Costs for Property</u>						
<u>Decrease, ¢/G Per Unit[1]</u>						
(R+M)/2 Octane, Clear	(0.5)	(1.3)	(0.6)	(0.8)	(0.3)	(0.4)
Aromatics, V%		0.3				
Ethers, V%	(0.3)	(0.1)	(0.3)	(0.4)		(0.3)
Ethanol, %						
Olefins, V%						
Benzene, V%	0.2	0.6	0.3	0.6	0.2	0.2
Sulfur, 100 WPPM			0.1			
Reid Vapor Pressure, PSI	0.4	0.7		0.3	0.3	0.4
T90, 10 °F						
Butanes, V%						
V.O.C., 10%						
NOx, 10%				0.1		0.0
T.A.P., 10%			0.5	0.1		

* Input limit.

[1] Shadow costs for very small changes.

Not applicable for significant changes.

TABLE C1-10C
OXYGENATED GASOLINE POOL PROPERTIES AND INCREMENTAL COSTS
1995/2000 FLEXIBILITY/2010 BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
<u>Average Properties</u>					
(R+M)/2 Octane, Clear*	88.6			88.6	88.1
Aromatics, V%	25.4			22.9	21.3
Ethers, V%*	15.0			15.0	15.0
Oxygen, W%*	2.7			2.7	2.7
Olefins, V%	8.5			5.8	7.4
Benzene, V%*	1.7			1.7	1.7
Sulfur, WPPM	305			224	279
Reid Vapor Pressure, PSI*	11.9			11.9	12.5
Temperature at V/L = 20, °F	119			118	117
Distillation					
T10, °F	90			102	76
T50, °F	188			185	185
T90, °F	325			311	339
Specific Gravity	0.7353			0.7303	0.7333
Heat Content, MBTU/G	109.8			109.4	109.4
V.O.C., gm/mile					
– % Reduction					
NOx, index				0.97 *	0.98
– % Reduction				3 *	2
T.A.P., mg/mile				35	39
– % Reduction				13	3
% Northern Grade, Fixed	40			40	80
Incremental Costs for Property					
<u>Decrease, ¢/G Per Unit[1]</u>					
(R+M)/2 Octane, Clear	(0.4)			(0.3)	(0.3)
Aromatics, V%					
Ethers, V%	(0.4)			(0.5)	(0.3)
Ethanol, %					
Olefins, V%					
Benzene, V%	0.2			0.2	0.3
Sulfur, 100 WPPM					
Reid Vapor Pressure, PSI	0.4			0.3	0.4
T90, 10 °F					
Butanes, V%					
V.O.C., 10%					
NOx, 10%				0.1	
T.A.P., 10%					

* Input limit.

[1] Shadow costs for very small changes.

Not applicable for significant changes.

TABLE C1-10D
REFORMULATED – OXYGENATED GASOLINE POOL PROPERTIES AND INCREMENTAL COSTS
1995/2000 FLEXIBILITY/2010 BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 Annual	2010 IIIC F1 Summer	2010 IIIC F3 Summer	2000 IIIC Q6 Winter	2000 IIC Q6 Winter
<u>Average Properties</u>					
(R+M)/2 Octane, Clear*	88.6			88.6	88.1
Aromatics, V%	19.2			22.3	14.4
Ethers, V% *	15.0			15.0	15.0
Oxygen, W% *	2.7			2.7	2.7
Olefins, V%	13.6			10.6	5.7
Benzene, V% *	0.7			0.7	0.7
Sulfur, WPPM	305			142	208
Reid Vapor Pressure, PSI*	11.9			11.9	12.5
Temperature at V/L = 20, °F	119			119	117
<u>Distillation</u>					
T10, °F	99			97	42
T50, °F	180			180	188
T90, °F	303			336	329
Specific Gravity	0.7271			0.7314	0.7228
Heat Content, MBTU/G	109.1			109.6	108.9
V.O.C., gm/mile					
– % Reduction					
NOx, index				0.96 *	0.96
– % Reduction				4 *	4
T.A.P., mg/mile				33	30
– % Reduction				17	26
% Northern Grade, Fixed	40			40	80
<u>Incremental Costs for Property</u>					
<u>Decrease, ¢/G Per Unit[1]</u>					
(R+M)/2 Octane, Clear	(0.4)			(0.2)	(0.3)
Aromatics, V%					
Ethers, V%	(0.4)			(0.5)	(0.3)
Ethanol, %					
Olefins, V%					
Benzene, V%	0.3			0.2	0.3
Sulfur, 100 WPPM					
Reid Vapor Pressure, PSI	0.4			0.3	0.4
T90, 10 °F					
Butanes, V%					
V.O.C., 10%					
NOx, 10%				0.2	
T.A.P., 10%					

* Input limit.

[1] Shadow costs for very small changes.

Not applicable for significant changes.

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TABLE C1-11
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
1995/2000 FLEXIBILITY/2010 BASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	1995 IIIC F2 <u>Annual</u>	1995 IIIC Q6 <u>Summer</u>	2010 IIIC F1 <u>Summer</u>	2010 IIIC F3 <u>Summer</u>	2000 IIIC Q6 <u>Winter</u>	2000 IIC Q6 <u>Winter</u>
<u>No. 2 Diesel Compositions</u>						
Hvy Reformate (300+) 90 RON						
Hvy Reformate (300+) 100 RON						
FCC Heavy Gaso Tr(300-375)			0.7			
FCC Heavy Gaso Tr(375-430)						
Lt Cycle Oil - Treated	2.6	10.7	4.0	5.5	3.2	12.0
Coker Dist - Treated	<u>5.3</u>	<u>1.2</u>	<u>7.8</u>	<u>4.8</u>	<u>4.9</u>	<u>6.8</u>
Total High Aromatic	7.9	11.9	12.5	10.3	8.2	18.8
Heavy Alkylate (300+)			0.0		0.0	0.0
Lt Kero - Treated (300-375)	4.3	3.1	2.9	3.8	1.6	4.1
Kero - (375-500)	19.8	14.9	6.9	15.7	7.2	13.1
Kero - Treated (375-500)	19.0	28.7	23.0	23.7	25.1	22.7
Kero - Low Aromatics (375-500)						
Diesel Base	10.4	4.0	16.7	8.6	28.9	7.3
Diesel Base - Treated	<u>38.6</u>	<u>37.4</u>	<u>38.0</u>	<u>37.9</u>	<u>29.0</u>	<u>34.0</u>
Diesel Base - Low Aromatics						
Lt Cycle Oil - Low Aromatics						
Coker Dist - Low Aromatics						
Total Low Aromatic	<u>92.1</u>	<u>88.1</u>	<u>87.5</u>	<u>89.7</u>	<u>91.8</u>	<u>81.2</u>
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
<u>Properties</u>						
Diesel Ignition Improver						
Pour Point Depressant					Yes	Yes
Aromatics	24.6	27.4	27.2	25.5	26.9	28.7
<u>Jet A Compositions</u>						
Heavy Alkylate (300+)						
Lt Kero - Treated (300-375)	33.6	32.9	32.0	35.8	33.9	35.1
Kero - Treated (375-500)	36.4	34.8	45.9	40.7	38.4	39.3
Hydrocracked Jet (295-525)	<u>30.0</u>	<u>32.3</u>	<u>22.1</u>	<u>23.5</u>	<u>27.7</u>	<u>25.6</u>
Total	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE D-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 1995	Case S17 '95 Permit Delay	Case S5 '95 Full Opt In	Case S21 2000 All CARB 2
Reformulated Limits*					
Aromatics, Vol.%, Maximum Avg		27.9	27.9	27.9	22.0
Oxygen, Wt%, Minimum Avg		2.1	2.1	2.1	2.0
Olefins, Vol.%, Maximum Avg		14.1	14.1	14.1	4.0
Benzene, Vol%, Maximum Avg		0.7	0.7	0.7	0.8
Sulfur, WPPM, Maximum Avg		305	305	305	30
Reid Vapor Pressure, PSI, Min					
Reid Vapor Pressure, PSI, Max		7.2	7.2	7.2	6.6
Regulatory Cap		7.5	7.5	7.5	7.0
T50, °F, Maximum Avg					200
T90, °F, Maximum Avg		341	341	341	290
V.O.C., % Reduction					
T.A.P., % Reduction					
% Class C, Fixed	40	40	40	40	40
Ethers, V% Pool					
Purchased (Sold)	0.1	(1.0)	(0.8)	4.8	7.8
Manufactured	1.9	2.3	2.1	2.6	3.3
Gasoline Pool Properties					
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol. %	30.9	30.5 *	30.5 *	27.6	22.0 *
Ethers, Vol.% *	2.0	1.3	1.3	7.4	11.1
Oxygen, Wt.% *	0.4	0.2	0.2	1.3	2.0
Olefins, Vol. %	13.6	13.8	13.8	12.9	4.0 *
Benzene, Vol. %	1.8	1.6 *	1.6 *	1.1 *	0.8 *
Sulfur, WPPM	206	281	266	208	30 *
Reid Vapor Pressure, PSI*	7.9	7.8	7.8	7.5	6.6
Temperature at V/L = 20, °F	142	143	143	144	145
Distillation					
T10, °F	117	117	116	121	140
T50, °F	211	209	210	205	193
T90, °F	347	347	347	343	290 *
Specific Gravity	0.7469	0.7459	0.7463	0.7451	0.7347
Heat Content, MBTU/G	114.0	114.0	114.1	112.7	111.1
V.O.C., gm/mile	1.04	1.03	1.03	0.93	0.64
– % Reduction	19	20	20	28	50
NOx, index	0.98	1.00	1.00	0.99	0.92
– % Reduction	2	0	0	1	8
T.A.P., mg/mile	50	49	48	41	27
– % Reduction	6	8	8	22	49

* Input limit.

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9/17/92

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TABLE D-1A
REFORMULATED GASOLINE POOL PROPERTIES
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Reformulated Limits*</u>	Base Case Q6 1995	Case S17 '95 Permit Delay	Case S5 '95 Full Opt In	Case S21 2000 All CARB 2
Aromatics, Vol.%, Maximum Avg	27.9	27.9	27.9	22.0
Oxygen, Wt%, Minimum Avg	2.1	2.1	2.1	2.0
Olefins, Vol.%, Maximum Avg	14.1	14.1	14.1	4.0
Benzene, Vol%, Maximum Avg	0.7	0.7	0.7	0.8
Sulfur, WPPM, Maximum Avg	305	305	305	30
Reid Vapor Pressure, PSI, Min				
Reid Vapor Pressure, PSI, Max	7.2	7.2	7.2	6.6
Regulatory Cap	7.5	7.5	7.5	7.0
T50, °F, Maximum Avg				200
T90, °F, Maximum Avg	341	341	341	290
V.O.C., % Reduction				
T.A.P., % Reduction				
% Class C, Fixed	40	40	40	40

Ethers, V% Pool
Purchased (Sold)
Manufactured

Gasoline Pool Properties

(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6
Aromatics, Vol. %	27.2 *	27.2 *	25.6	22.0 *
Ethers, Vol. %*	11.7	11.7	11.7	11.1
Oxygen, Wt. %*	2.1	2.1	2.1	2.0
Olefins, Vol. %	14.0	14.0	12.2	4.0 *
Benzene, Vol. %*	0.7	0.7	0.7	0.8
Sulfur, WPPM	305	305	186	30 *
Reid Vapor Pressure, PSI*	7.2	7.2	7.2	6.6
Temperature at V/L = 20, °F	145	144	145	145
Distillation				
T10, °F	129	130	124	140
T50, °F	207	202	201	193
T90, °F	326	325	339	290 *
Specific Gravity	0.7490	0.7470	0.7450	0.7347
Heat Content, MBTU/G	112.2	112.1	111.9	111.1
V.O.C., gm/mile	0.85	0.84	0.84	0.64
– % Reduction	34	34	34	50
NOx, index	1.04	1.04	0.99	0.92
– % Reduction	(4)	(4)	1	8
T.A.P., mg/mile	37	37	37	27
– % Reduction	29	29	30	49

* Input limit.

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TABLE D-1B
CONVENTIONAL GASOLINE POOL PROPERTIES
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 <u>No FCAAA</u>	Base Case Q6 <u>1995</u>	Case S17 '95 Permit <u>Delay</u>	Case S5 '95 Full <u>Opt In</u>
<u>Conventional Limits*</u>				
Aromatics, Vol.%, Maximum Avg		30.9	30.9	30.9
Oxygen, Wt%, Minimum Avg				
Olefins, Vol.%, Maximum Avg		17.6	17.6	17.6
Benzene, Vol%, Maximum Avg		1.7	1.7	1.7
Sulfur, WPPM, Maximum Avg		381	381	381
Reid Vapor Pressure, PSI, Min				
Reid Vapor Pressure, PSI, Max	7.9	7.9	7.9	7.9
Regulatory Cap				
T50, °F, Maximum Avg				
T90, °F, Maximum Avg	356	356	356	356
V.O.C., % Reduction				
T.A.P., % Reduction				
% Class C, Fixed	40	40	40	40
<u>Ethers, V% Pool</u>				
Purchased (Sold)				
Manufactured				
<u>Gasoline Pool Properties</u>				
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6
Aromatics, Vol.%	30.9	30.9 *	30.9 *	30.9 *
Ethers, Vol.%*	2.0			
Oxygen, Wt.%*	0.4			
Olefins, Vol.%	13.6	13.8	13.8	14.2
Benzene, Vol.%	1.8	1.7	1.7 *	1.7
Sulfur, WPPM	206	278	261	245
Reid Vapor Pressure, PSI*	7.9	7.9	7.9	7.9
Temperature at V/L = 20, °F	142	143	143	143
Distillation				
T10, °F	117	115	115	116
T50, °F	211	209	211	211
T90, °F	347	350	350	351
Specific Gravity	0.7469	0.7455	0.7462	0.7452
Heat Content, MBTU/G	114.0	114.2	114.3	114.2
V.O.C., gm/mile	1.04	1.06	1.06	1.06
- % Reduction	19	17	17	18
NOx, index	0.98	1.00	0.99	0.99
- % Reduction	2	0	1	1
T.A.P., mg/mile	50	50	50	50
- % Reduction	6	4	5	5

* Input limit.

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TABLE D-2
SUMMARY OF COSTS – INCREASE OVER Q9 BASE CASE[1]
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Base Case Q6 1995[3]	Case S17 '95 Permit Delay	Case S5 '95 Full Opt In[3][4]	Case S21 2000 All CARB 2[3]
<u>Investment, MM\$</u>				
Refinery	825		2,352	10,194
MTBE[5]	9	(79)	3,779	5,720
Total	834	(79)	6,131	15,914
Range, MMM\$[6]	.7 – 1.1	(0.1) – (0.1)	5.2 – 8.3	13.5 – 21.5
<u>Daily Costs, M\$/D</u>				
Capital Charge[7]	454		1,587	7,814
Net Upgrading [8]	(438)	232	2,746	6,139
Variable Operating	234	184	(133)	1,885
Fixed Operating [9]	196		652	3,029
Total Refinery	446	416	4,852	18,867
<u>Annual Costs, MM\$/Yr.</u>				
Refinery	163	152	1,771	6,886
Other[10]	94 [11]	100 [11]	653	1,371
Total	257	252	2,424	8,257
<u>Total Unit Costs, ¢/G of Conventional Gasoline Upgraded</u>				
Average	4.8	4.6	8.0	17.1
Range[12]	3.9 – 6.1	4.3 – 4.9	6.4 – 10.7	14.7 – 21.5

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case. See C2 tables for Q6 case description.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.
- [3] Adjusted using individual unit capital charge/fixed operating costs multipliers to include the full cost of extra facilities for summer RFG as detailed on Table A3-19.
- [4] Adjusted CG RVP to 8.7 psi. For CG, refinery net upgrading costs were reduced 0.38¢/G and consumer (other) costs were increased 0.27¢/G resulting in a net cost reduction of 0.11¢/G. This equates to reducing the cost of RFG by 0.06¢/G.
- [5] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [6] For variations from investment curves of -15/+35%.
- [7] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- [8] Raw material upgrading costs.
- [9] For new refining facilities only.
- [10] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [11] Added consumer costs for RFG pool only in cases that allowed transferring oxygenates from the CG pool to the RFG pool.
- [12] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (± 0.2).

TABLE D-2A
SUMMARY OF COSTS – INCREASE OVER Q9 BASE CASE(1)
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS UNADJUSTED(2)
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	<u>Base Case Q6 1995</u>	<u>Case S17 '95 Permit Delay</u>	<u>Case S5 '95 Full Opt In</u>	<u>Case S21 2000 All CARB 2</u>
<u>Investment, MM\$</u>				
Refinery	825		2,352	10,194
MTBE(3)	<u>9</u>		<u>3,779</u>	<u>5,720</u>
Total	834		6,131	15,914
Range, MMM\$(4)	0.7 – 1.1		5.2 – 8.3	13.5 – 21.5
<u>Daily Costs, M\$/D</u>				
Capital Charge(5)	384		1,095	4,748
Net Upgrading (6)	(438)		2,936	6,139
Variable Operating	234		(133)	1,885
Fixed Operating(7)	<u>173</u>		<u>489</u>	<u>2,064</u>
Total Refinery	353		4,387	14,836
<u>Annual Costs, MM\$/Yr.</u>				
Refinery	129		1,601	5,415
Other(8)	<u>0</u>		<u>606</u>	<u>1,371</u>
Total	129		2,207	6,786
<u>Total Unit Costs, ¢/G of Conventional Gasoline Upgraded</u>				
Average	2.4		7.3	14.0
Range(9)	2.1 – 3.1		5.8 – 9.8	12.0 – 17.6

- (1) Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case. See C2 tables for Q6 case description.
- (2) For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average. Unadjusted LP case results shown before capital charge and CG RVP adjustments if these were required.
- (3) For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- (4) For variations from investment curves of -15/+35%.
- (5) Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- (6) Raw material upgrading costs.
- (7) For new refining facilities only.
- (8) Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- (9) For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (±0.2).

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TABLE D-3
REFINING RAW MATERIAL AND PRODUCT RATE – MBPCD
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 1995	Case S17 '95 Permit Delay	Case S5 '95 Full Opt In	Case S21 2000 All CARB 2
<u>Raw Materials</u>					
Domestic - S	1,985	1,984	1,985	1,985	1,985
HL	174	174	174	174	174
HH	692	669	669	669	692
Foreign - S	732	732	732	732	897
HL	669	698	698	698	669
HH	1,648	1,712	1,695	1,512	1,290
Subtotal Crudes	5,900	5,969	5,953	5,770	5,707
MTBE	3	(31)	(18)	152	254
Ethanol					
Normal Butane					
Isobutane	54	74	82	46	78
Natural Gas to H2 Plant Feed	20	20	20	24	40
Methanol	21	25	21	29	36
Other Raw Materials	447	447	447	447	447
Total Raw Materials	6,445	6,505	6,505	6,468	6,563
<u>Products</u>					
Motor Gasolines					
Conventional	3,151	2,793	2,796	1,176	
Oxygenated					
Reformulated/Oxygenated					
Reformulated		355	354	2,014	
CARB2					3,235
Kero Jet/Kerosene	686	686	686	686	686
Diesel/No. 2 Fuels					
Diesel - LA, ULS					
Diesel - 0.05%S	940	940	940	940	940
No. 2 Fuel	289	289	289	289	289
No. 6 Fuel (1% Sul)	57	57	57	57	57
No. 6 Bunker	57	57	57	57	58
Marketable Coke - 400 #	180	183	182	172	174
Catalytic Coke - 400 #	97	117	113	95	90
Vacuum Gas Oil					
Benzene	21	21	25	31	31
Toluene	25	25	21	12	12
Heavy Aromatic Gaso					
Pentanes to P/C					59
Natural Gasoline to P/C	134	134	134	134	33
Normal Butane	22	34	31	33	105
Isobutane	12	12	12	32	12
Propane	151	163	163	145	169
Process Gas/C2/C2=,FOE	365	388	388	339	353
Other Products	576	576	576	576	576
(Gain)/Loss	(318)	(325)	(320)	(320)	(316)
Total Products	6,445	6,505	6,505	6,468	6,563
<u>Crude Properties</u>					
Gravity, °API	32.8	32.8	32.8	32.9	33.1
Sulfur, Wt%	1.20	1.21	1.21	1.17	1.09
<u>Gasoline Demand Increase, %[1]</u>					
Results		(0.1)	0.0	1.2	2.7
Target		0.0	(0.1)	1.2	2.6

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

TABLE D-4
NEW PROCESS UNIT RATES – MBPSD
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6 1995	Case S5 '95 Full Opt In	Case S21 2000 All CARB 2
Crude – Atmospheric			
Heavy Naphtha Splitter			129
Catalytic Cracking			
FCC Gasoline Splitters			1,146
FCC Gasoline Fractionation			
Hydrocracking – 2 Stage			33
Hydrocracking – 2 Stage Distillate			
– Hvy Gasoline			196
Hydrocrackate Fractionation			388
Coker – Delayed			
Coker Lt Gasoline DS/Splitter			38
Hydrotreating – Naphtha			
– FCC/Coker C6s			207
– Distillate			146
– Heavy Gas Oil			
Reformer Feed Fractionation	608	1,476	1,612
Reformate Fractionation	237	267	507
Aromatics Extraction		66	105
Benzene Saturation	12	85	134
FCC Gasoline HDS			
Diesel Aromatics Saturation			
Alkylation			37
Alkylate Splitter			67
MTBE	19	34	31
TAME			
Isomerization – C5/C6			166
– C5/C6, Recycle			43
– C4			
Hydrogen – MMSCFPSD			789
Sulfur – LTPSD			
C4 Rerun – Saturates			203
– Unsaturation			501
Catalytic Reforming – 100 PSI			
Hydrotreating – Distillate Upgrade			
Dehydrogenation – IC4			
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TABLE D-5
NEW PROCESS UNIT INVESTMENTS
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(\$MM – in constant mid-1990 \$)

	Base Case Q6 1995	Case S5 '95 Full Opt In	Case S21 2000 All CARB 2
Crude Distillation			
Heavy Naphtha Splitter			108
Catalytic Cracking			
FCC Gasoline Splitters			1,222
FCC Gasoline Fractionation			
Hydrocracking – 2 Stage			222
Hydrocracking – 2 Stage Distillate – Heavy Gasoline			2,123
Hydrocrackate Fractionation			232
Coker – Delayed			
Coker Lt. Gasoline DS/Splitter			70
Hydrotreating – Naphtha			
– FCC Coker C6s			463
– Distillate			241
– Heavy Gas Oil			
Reformer Feed Fractionation	361	892	948
Reformate Fractionation	261	283	443
Aromatics Extraction		353	466
Benzene Saturation	44	289	399
FCC Gasoline HDS			
Diesel Aromatics Saturation			
Alkylation			193
Alkylate Splitter			114
MTBE	159	262	248
TAME			
Isomerization – C5/C6			330
– C5/C6, Recycle			143
– C4			
Hydrogen			1,209
Sulfur			
MTBE Storage & Blending		111	178
C4 Rerun – Saturates			236
– Unsaturation			444
C4 Fractionation Upgrade		162	162
Catalytic Reforming – 100 PSI			
Hydrotreating – Distillate Upgrade			
Dehydrogenation – IC4			
Total Refinery	825	2,352	10,194

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TABLE D-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 <u>NO FCAA</u>	Base Case Q6 <u>1995</u>	Case S17 '95 Permit <u>Delay</u>	Case S5 '95 Full <u>Opt In</u>	Case S21 2000 <u>All CARB 2</u>
Crude – Atmospheric	134.1	135.7	135.3	131.1	129.7
Heavy Naphtha Splitter					2.9
Catalytic Cracking[1]	50.2	54.1	53.5	48.1	46.7
Catalytic Cracking[2]	46.7	49.6	49.0	44.7	42.6
Conversion, %	77.5	77.6	77.9	77.6	79.0
Octane Catalyst, %	68.5	67.3	67.7	68.3	70.1
FCC Gasoline Splitters					24.5
FCC Gasoline Fractionation	11.7	11.7	11.7	11.7	
Hydrocracking – 2 Stage[1]	9.8	9.3	9.6	9.8	10.4
Jet Yield, % of Max	64.4	100.0	100.0	71.7	
300 – Gasoline Operation, %					18.6
Hydrocracking – 2 Stage Distillate					
Hydrocracking – Low Conversion	1.5	1.5	1.5	1.5	2.2
– Heavy Gasoline					3.9
– Combined[2]	11.3	10.8	11.1	11.3	16.2
Hydrocrackate Fractionation					7.7
Coking – Delayed	13.3	13.5	13.4	12.6	12.7
– Fluid	0.7	0.7	0.7	0.7	0.7
Coker Lt Gasoline DS/Splitter					0.8
Thermal Cracking, Visbreaking	1.5	0.6	0.6	1.5	1.5
Solvent Deasphalting	1.8	2.6	2.7	1.8	1.3
Catalytic Reforming – 100 PSI[1]	16.0	15.6	15.5	14.5	17.5
– 200 PSI[1]	11.1	11.1	11.1	10.3	10.3
– 450 PSI[1]	7.1	6.9	6.6	5.9	7.1
– Combined[2]	33.0	31.2	31.2	30.5	34.5
– RONC	96.9	98.3	98.8	95.1	94.6
Hydrotreating – Naphtha	31.5	32.6	32.5	30.9	33.7
– FCC/Coker C6s					4.3
– Distillate	33.3	33.1	32.9	32.9	36.4
– Heavy Gas Oil	16.3	16.3	16.3	16.3	17.3
– Residuum – Atm	6.9	6.9	6.9	6.9	6.9
Reformer Feed Fractionation		12.7		30.9	33.7
Reformate Fractionation	7.7	13.1	8.1	13.7	18.7
Aromatics Extraction	4.1	4.1	4.1	5.5	6.3
Benzene Saturation		0.2		1.8	2.8
FCC Gasoline HDS					
Diesel Aromatics Saturation					
Alkylation	8.4	9.5	9.7	7.3	11.5
Alkylate Splitter					1.3
Polymerization	0.4	0.4	0.4	0.4	
Dehydrogenation – IC4	0.7	0.7	0.7	0.7	0.7
MTBE	1.4	1.7	1.4	1.9	2.5
TAME					
Hydrodealkylation – Toluene				0.1	
Lubes	2.2	2.2	2.2	2.2	2.2
Isomerization – C5/C6	2.2	2.2	2.2	2.2	5.6
– C5/C6, Recycle	2.2	2.2	2.2	2.2	3.1
– C4	0.8	0.8	0.8	0.8	0.8
Hydrogen – MMSCFPCD	19.7	19.7	19.7	23.0	39.0
Sulfur, LTPCD	134	134	134	128	127
C4 Rerun – Saturates					4.2
– Unsaturates					10.5

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

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TABLE D-7
PROCESS UNIT UTILIZATIONS – %[1]
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 1995	Case S17 '95 Permit Delay	Case S5 '95 Full Opt In	Case S21 2000 All CARB 2
Crude Distillation – Atmospheric	85.7	86.7	86.5	83.9	82.9
Heavy Naphtha Splitter					97.0 *
Catalytic Cracking[2]	84.2	90.7	89.7	80.6	78.3
Catalytic Cracking[3]	78.3	83.1	82.2	75.0	71.4
FCC Gasoline Splitters					94.0 *
FCC Gasoline Fractionation	81.9	81.9	81.9	81.9	
Hydrocracking – 2 Stage[2]	87.0	83.3	85.3	87.0 *	87.0 *
Hydrocracking – 2 Stage Distillate					
– Low Conversion	58.5	58.5	58.5	58.5	87.0 *
– Heavy Gasoline					87.0 *
– Combined[3]	81.7	79.4	80.4	81.7	85.3
Hydrocrackate Fractionation					87.0 *
Coking – Delayed	86.1	87.7	87.1	81.9	82.1
– Fluid	85.9	85.9	85.9	85.9	85.9
Coker Lt Gasoline DS/Splitter					92.0 *
Thermal Cracking, Visbreaking	92.0 *	38.8	36.9	92.0 *	92.0 *
Solvent Deasphalting	40.3	60.4	61.6	40.9	30.2
Catalytic Reforming – 100 PSI[2]	84.4	82.2	81.3	76.3	92.0 *
– 200 PSI[2]	92.0 *	92.0 *	92.0 *	85.7	85.3
– 450 PSI[2]	69.3	67.3	64.4	57.6	69.3
– Combined[3]	79.8	75.5	75.5	74.0	83.6
Hydrotreating – Naphtha	73.5	76.0	75.8	72.0	78.5
– FCC/Coker C6s					92.0 *
– Distillate	92.0 *	91.4	91.0	90.8	92.0 *
– Heavy Gas Oil	86.6	86.6	86.6	86.6	92.0 *
– Residuum, Atm	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Reformer Feed Fractionation		92.0 *		92.0 *	92.0 *
Reformate Fractionation	85.0	92.0 *	92.0 *	92.0 *	92.0 *
Aromatics Extraction	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Benzene Saturation		92.0 *		92.0 *	92.0 *
FCC Gasoline HDS					
Diesel Aromatics Saturation					
Alkylation	69.5	78.1	79.7	60.1	89.0 *
Alkylate Splitter					89.0 *
Polymerization	45.0	45.0	45.0	45.0	
Dehydrogenation – IC4	86.4	89.0 *	89.0 *	89.0 *	89.0 *
MTBE	91.0 *	91.0 *	91.0 *	91.0 *	91.0 *
TAME	0.0	0.0	0.0	0.0	87.0 *
Hydrodealkylation – Toluene	0.0	0.0	0.0	15.2	0.0
Lubes	82.0	82.0	82.0	82.0	82.0
Isomerization – C5/C6	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
– C5/C6, Recycle	92.0 *	92.0 *	92.0 *	91.7	92.0 *
– C4	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *
Hydrogen	76.1	76.1	76.1	88.8	89.0 *
Sulfur	53.0	53.0	53.0	50.6	50.2
C4 Rerun – Saturates					92.0 *
– Unsaturation					92.0 *

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

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TABLE D-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 1995	Case S17 '95 Permit Delay	Case S5 '95 Full Opt In	Case S21 2000 All CARB 2
FCC Gasoline	20.8	21.9	21.7	18.9	
Lt. FCC 255-	9.5	9.7	9.6	9.5	
Hvy FCC 255+	6.8	6.6	6.8	6.6	
Hvy FCC 255+ Desulf.					
FCC Gaso (100-180)					1.5
FCC Gaso (180-225)					3.9
FCC Gaso (225-300)					6.2
FCC Gaso (300-375)					
FCC Gaso (375-430)					
Total FCC Gasoline	37.1	38.2	38.1	35.0	11.6
Butenes					
Pentenenes					
Poly Gasoline	0.6	0.6	0.6	0.6	
Lt. Coker Gasoline	1.3	0.5	0.7	1.2	
Total Olefinic	1.9	1.1	1.3	1.8	
Reformate	16.7	14.5	13.9	18.2	7.3
Reformate (220-300 Feed)	4.5	5.3	5.5	2.9	8.0
BT Reformate	5.0	3.0	3.1	0.8	
HC Reformate (210-300)	2.3	2.5	2.8	4.0	8.6
Heavy Reformate (300+)	1.5	1.4	1.7	1.0	3.0
Toluene/Xylenes	0.1	0.1	0.2	0.3	0.4
Total Reformates[1]	30.1	26.8	27.2	27.2	27.3
Lt. Reformate	1.3	1.3	1.2		
Lt. Raffinate B(C5-210)	2.4	2.8	2.2	4.5	7.4
Alkylate/Lt Alkylate (C3/C4)	11.7	13.1	13.4	9.9	10.7
Alkylate/Lt Alkylate (C5)					4.2
Butane	3.7	3.5	3.6	3.0	1.5 *
Natural/LSR Gaso	0.1	1.0	0.8		3.1
BT Naphtha (150-220)					
Pentanenes (I/N)					1.0
Isomate (C5-C6)	6.0	6.0	6.0	5.8	5.7
Isomate (C6)					5.9
Lt. Hydrocrackate (C5-180)	2.6	2.2	2.3	2.5	5.8
Medium Hydrocrackate (180-225)	1.1	2.7	2.6	2.9	4.6
MTBE	2.0	1.3	1.3	7.4	10.3
TAME					0.9
Alcohol					
Total Low Arom., Saturated	30.9	33.9	33.4	36.0	61.1
Total	100.0	100.0	100.0	100.0	100.0

* Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D-8A
REFORMULATED GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6 1995	Case S17 '95 Permit Delay	Case S5 '95 Full Opt In	Case S21 2000 All CARB 2
FCC Gasoline	20.5	22.2	30.1	
Lt. FCC 255-	10.1	9.7	1.1	
Hvy FCC 255+	7.7	7.0	3.9	
Hvy FCC 255+ Desulf.				
FCC Gaso (100–180)				1.5
FCC Gaso (180–225)				3.9
FCC Gaso (225–300)				6.2
FCC Gaso (300–375)				
FCC Gaso (375–430)				
Total FCC Gasoline	38.3	38.9	35.1	11.6
Butenes				
Pentenenes				
Poly Gasoline	1.8	1.4	0.9	
Lt. Coker Gasoline				
Total Olefinic	1.8	1.4	0.9	
Reformate	3.8	3.3	13.4	7.3
Reformate (220–300 Feed)			4.6	8.0
BT Reformate				
HC Reformate (210–300)	18.7	19.2	6.4	8.6
Heavy Reformate (300+)			0.3	3.0
Toluene/Xylenes			0.4	0.4
Total Reformates[1]	22.5	22.5	25.1	27.3
Lt. Reformate				
Lt. Raffinate B(C5–210)	6.0	8.9	7.0	7.4
Alkylate/Lt Alkylate (C3/C4)	7.5	7.5	7.2	10.6
Alkylate/Lt Alkylate (C5)				4.2
Butane	3.0	2.5	2.4	1.5 *
Natural/LSR Gaso	2.0	5.1		3.1
BT Naphtha (150–220)				
Pentanenes (I/N)				1.1
Isomerase (C5–C6)	3.6	1.5	8.0	5.7
Isomerase (C6)				5.9
Lt. Hydrocrackate (C5–180)			1.0	5.8
Medium Hydrocrackate (180–225)	3.6		1.6	4.6
MTBE	11.7	11.7	11.7	10.3
TAME				0.9
Alcohol				
Total Low Arom., Saturated	37.4	37.2	38.9	61.1
Total	100.0	100.0	100.0	100.0

* Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAA	Base Case Q6 1995	Case S17 '95 Permit Delay	Case S5 '95 Full Opt In
FCC Gasoline	20.8	22.2	21.6	
Lt. FCC 255–	9.5	9.6	9.6	23.9
Hvy FCC 255+	6.8	6.6	6.7	11.4
Hvy FCC 255+ Desulf.				
FCC Gaso (100–180)				
FCC Gaso (180–225)				
FCC Gaso (225–300)				
FCC Gaso (300–375)				
FCC Gaso (375–430)				
Total FCC Gasoline	37.1	38.4	37.9	35.3
Butenes				
Pentenes				
Poly Gasoline	0.6	0.4	0.5	
Lt. Coker Gasoline	1.3	0.5	0.7	3.1
Total Olefinic	1.9	0.9	1.2	3.1
Reformate	16.7	15.9	15.4	26.2
Reformate (220–300 Feed)	4.5	6.0	6.2	
BT Reformate	5.0	3.4	3.5	2.1
HC Reformate (210–300)	2.3	0.5	0.7	
Heavy Reformate (300+)	1.5	1.6	1.9	2.2
Toluene/Xylenes	0.1	0.1	0.3	
Total Reformates[1]	30.1	27.5	28.0	30.5
Lt. Reformate	1.3	1.4	1.3	
Lt. Raffinate B(C5–210)	2.4	2.4	1.4	0.1
Alkylate/Lt Alkylate (C3/C4)	11.7	13.8	14.2	14.6
Alkylate/Lt Alkylate (C5)				
Butane	3.7	3.6	3.8	3.9
Natural/LSR Gaso	0.1	0.9	0.2	
BT Naphtha (150–220)				
Pentanes (I/N)				
Isomerate (C5–C6)	6.0		6.5	2.3
Isomerate (C6)		6.2		
Lt. Hydrocrackate (C5–180)	2.6		2.5	5.1
Medium Hydrocrackate (180–225)	1.1	2.5	3.0	5.1
MTBE	2.0	2.4		
TAME				
Alcohol				
Total Low Arom., Saturated	30.9	33.2	32.9	31.1
Total	100.0	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D-9

GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]

IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(¢/G per unit in constant 1990 \$)

	<u>Base Case Q9 No FCAAA</u>	<u>Base Case Q6 1995</u>	<u>Case S17 '95 Permit Delay</u>	<u>Case S5 '95 Full Opt In</u>	<u>Case S21 2000 All CARB 2</u>
(R+M)/2 Octane, Clear	(0.5)	(1.3)	(1.2)	(0.4)	(1.0)
Aromatics, Vol. %		0.3	0.3		0.1
Ethers, Vol. %		(0.1)	(0.0)	(0.4)	(0.1)
Ethanol, %					
Olefins, Vol. %					0.3
Benzene, Vol. %		0.6	1.2	0.7	1.5
Sulfur, 100 Wt. PPM					2.8
Reid Vapor Pressure, PSI	0.4	0.7	0.7	0.4	2.5
T90, 10°F					2.5
Butane, Vol. %					0.8
V.O.C., 10%					
NOx, 10%					
T.A.P., 10%					

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D-9A**REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]****IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS****NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY**

(¢/G per unit in constant 1990 \$)

	<u>Base Case Q6 1995</u>	<u>Case S17 '95 Permit Delay</u>	<u>Case S5 '95 Full Opt In</u>	<u>Case S21 2000 All CARB 2</u>
(R+M)/2 Octane, Clear	(1.2)	(1.2)	(0.3)	(1.0)
Aromatics, Vol. %	0.3	0.3		0.1
Ethers, Vol. %	(0.1)		(0.4)	(0.1)
Ethanol, %				
Olefins, Vol. %				0.3
Benzene, Vol. %	0.8	1.3	1.0	1.5
Sulfur, 100 Wt. PPM				2.8
Reid Vapor Pressure, PSI	0.7	0.7	0.4	2.5
T90, 10°F				2.5
Butane, Vol. %				0.8
V.O.C., 10%				
NOx, 10%				
T.A.P., 10%				

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D-9B**CONVENTIONAL GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]****IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS****NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY****(¢/G per unit in constant 1990 \$)**

	<u>Base Case Q9 No FCAAA</u>	<u>Base Case Q6 1995</u>	<u>Case S17 '95 Permit Delay</u>	<u>Case S5 '95 Full Opt In</u>
(R+M)/2 Octane, Clear	(0.5)	(1.3)	(1.2)	(0.4)
Aromatics, Vol. %		0.3	0.3	
Ethers, Vol. %			(0.0)	(0.3)
Ethanol, %				
Olefins, Vol. %				
Benzene, Vol. %		0.6	1.1	0.1
Sulfur, 100 Wt. PPM				
Reid Vapor Pressure, PSI	0.4	0.7	0.7	0.4
T90, 10°F				
Butane, Vol. %				
V.O.C., 10%				
NOx, 10%				
T.A.P., 10%				

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IIIC – SUMMER 1995/2000 F2 – SF CASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 1995	Case S17 '95 Permit Delay	Case S5 '95 Full Opt In	Case S21 2000 All CARB 2
<u>No. 2 Diesel Compositions</u>					
Hvy Reformate (300+) 90 RON					2.4
Hvy Reformate (300+) 100 RON					
FCC Heavy Gaso Tr(300-375)					
FCC Heavy Gaso Tr(375-430)					7.0
Lt Cycle Oil - Treated	5.5	10.7	11.2	5.7	
Coker Dist - Treated	4.4	1.2		2.3	
Total High Aromatic	9.9	11.9	11.2	8.0	9.4
Heavy Alkylate (300+)					1.0
Lt Kero - Treated (300-375)	4.0	3.1	3.2	4.5	2.6
Kero (375-500)	15.6	14.9	14.9	15.6	6.1
Kero - Treated (375-500)	23.4	28.7	28.8	23.1	23.8
Kero - Low Aromatics (375-500)					
Diesel Base	8.3	4.0	4.1	8.5	14.3
Diesel Base - Treated	38.8	37.4	37.8	40.3	42.8
Diesel Base - Low Aromatics					
Lt Cycle Oil - Low Aromatics					
Coker Dist - Low Aromatics					
Total Low Aromatic	90.1	88.1	88.8	92.0	90.6
Total	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>					
Diesel Ignition Improver					
Pour Point Depressant					
Aromatics	25.4	27.4	27.3	25.4	27.4
<u>Jet A Compositions</u>					
Heavy Alkylate (300+)					
Lt Kero - Treated (300-375)	36.2	32.9	32.6	35.4	42.8
Kero - Treated (375-500)	41.7	34.8	34.3	40.0	55.2
Hydrocracked Jet (295-525)	22.1	32.3	33.1	24.6	2.0
Total	100.0	100.0	100.0	100.0	100.0

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TABLE D1-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case HQ40 High Δ V.O.C.	Case QN2 Q6N + 10.7% OL
<u>Reformulated Limits*</u>							
Aromatics, Vol.%, Maximum Avg							
Oxygen, Wt%, Minimum Avg		2.1	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg							10.7
Benzene, Vol%, Maximum Avg		0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg							
Reid Vapor Pressure, PSI, Min		6.5	6.5	6.5	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max							
Regulatory Cap							
T50, °F, Maximum Avg							
T90, °F, Maximum Avg							
V.O.C., % Reduction		45	45	35	40	48	45
T.A.P., % Reduction		30	30	30	30	30	30
% Class C, Fixed	40	40	40	40	40	40	40
<u>Ethers, V% Pool</u>							
Purchased (Sold)	0.1	4.1	4.4	4.7	4.8	8.8	4.5
Manufactured	1.9	3.3	3.0	2.7	2.6	2.9	2.9
<u>Gasoline Pool Properties</u>							
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	30.9	27.6	27.6	27.0	27.3	23.1	27.4
Ethers, Vol.%*	2.0	7.4	7.4	7.4	7.4	11.7	7.4
Oxygen, Wt.%*	0.4	1.3	1.3	1.3	1.3	2.1	1.3
Olefins, Vol.%	13.6	12.6	12.2	13.0	13.0	9.7	11.3 *
Benzene, Vol.%	1.8	1.0 *	1.1 *	1.1 *	1.0 *	0.7 *	1.1 *
Sulfur, WPPM	206	159	157	175	177	76	137
Reid Vapor Pressure, PSI*	7.9	7.3	7.0	7.7	7.5	6.5	7.3
Temperature at V/L = 20, °F	142	145	146	143	144	148	145
<u>Distillation</u>							
T10, °F	117	122	125	119	121	133	123
T50, °F	211	204	205	203	203	201	204
T90, °F	347	344	345	343 *	343	325	344
Specific Gravity	0.7469	0.7453	0.7461	0.7435	0.7443	0.7404	0.7451
Heat Content, MBTU/G	114.0	112.8	112.9	112.6	112.6	111.7	112.8
V.O.C., gm/mile	1.04	0.91 *	0.83 *	0.99 *	0.95 *	0.67 *	0.91 *
- % Reduction	19	29 *	35 *	23 *	26 *	48 *	30 *
NOx, index	0.98	0.97	0.97	0.98	0.98	0.95	0.96
- % Reduction	2	3	3	2	2	5	4
T.A.P., mg/mile	50	42 *	40	42 *	42 *	31	41 *
- % Reduction	6	21 *	24	20 *	20 *	41	21 *

* Input limit.

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TABLE D1-1A
RUN BASIS AND REFORMULATED GASOLINE POOL PROPERTIES
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Gasoline Specs*</u>	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case HQ40 High Δ V.O.C.	Case QN2 Q6N + 10.7% OL
Aromatics, Vol.%, Maximum Avg						
Oxygen, Wt%, Minimum Avg	2.1	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg						10.7
Benzene, Vol%, Maximum Avg	0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg						
Reid Vapor Pressure, PSI, Min	6.5	6.5	6.5	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max						
Regulatory Cap						
T50, °F, Maximum Avg						
T90, °F, Maximum Avg						
V.O.C., % Reduction	45	45	35	40	48	45
T.A.P., % Reduction	30	30	30	30	30	30
% Class C, Fixed	40	40	40	40	40	40
<u>Ethers, V% Pool</u>						
Purchased (Sold)						
Manufactured						
<u>Gasoline Pool Properties</u>						
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	24.7	23.7	24.1	23.8	23.1	24.0
Ethers, Vol.%*	11.7	11.7	11.7	11.7	11.7	11.7
Oxygen, Wt.%*	2.1	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%	11.6	10.7	13.0	12.3	9.7	10.7 *
Benzene, Vol.%*	0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM	144	141	171	173	76	137
Reid Vapor Pressure, PSI	6.5	6.5 *	7.2	6.8	6.5 *	6.5 *
Temperature at V/L = 20, °F	149	149	145	147	148	149
Distillation						
T10, °F	136	134	126	130	133	133
T50, °F	205	203	200	201	201	204
T90, °F	344	342	344 *	346	325	344
Specific Gravity	0.7463	0.7444	0.7433	0.7438	0.7404	0.7450
Heat Content, MBTU/G	112.1	112.0	111.7	111.8	111.7	112.0
V.O.C., gm/mile*	0.71	0.71	0.83	0.77	0.67	0.71
- % Reduction*	45	45	35	40	48	45
NOx, index	0.97	0.97	0.99	0.98	0.95	0.96
- % Reduction	3	3	2	2	5	4
T.A.P., mg/mile	35	34	37 *	36	31	35
- % Reduction	33	35	31 *	32	41	34

* Input limit.

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TABLE D1-1B
RUN BASIS AND CONVENTIONAL GASOLINE POOL PROPERTIES
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case QN2 Q6N + 10.7% OL
<u>Gasoline Specs*</u>						
Aromatics, Vol.%, Maximum Avg						
Oxygen, Wt%, Minimum Avg						
Olefins, Vol.%, Maximum Avg						12.2
Benzene, Vol%, Maximum Avg						
Sulfur, WPPM, Maximum Avg						
Reid Vapor Pressure, PSI, Min						
Reid Vapor Pressure, PSI, Max	7.9	8.7	7.9	8.7	8.7	8.7
Regulatory Cap	8.2	9.0	8.2	9.0	9.0	9.0
T50, °F, Maximum Avg						
T90, °F, Maximum Avg	356	356	356	356	356	356
V.O.C., % Reduction						
T.A.P., % Reduction						
% Class C, Fixed	40	40	40	40	40	40
<u>Ethers, V% Pool</u>						
Purchased (Sold)						
Manufactured						
<u>Gasoline Pool Properties</u>						
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	30.9	32.6	34.3	32.1	33.2	33.2
Ethers, Vol.% *	2.0					
Oxygen, Wt.% *	0.4					
Olefins, Vol.%	13.6	14.3	14.8	13.2	14.3	12.2 *
Benzene, Vol.%	1.8	1.6 *	1.7 *	1.7 *	1.6 *	1.7 *
Sulfur, WPPM	206	184	186	183	185	138
Reid Vapor Pressure, PSI	7.9 *	8.7 *	7.9 *	8.7 *	8.7 *	8.6 *
Temperature at V/L = 20, °F	142	138	143	138	138	138
<u>Distillation</u>						
T10, °F	117	99	109	107	105	106
T50, °F	211	203	208	207	207	206
T90, °F	347	343	351	342	341	344
Specific Gravity	0.7469	0.7438	0.7491	0.7440	0.7451	0.7454
Heat Content, MBTU/G	114.0	113.9	114.5	114.0	114.1	114.1
V.O.C., gm/mile	1.04	1.26	1.05	1.26	1.26	1.25
- % Reduction	19	2	18	2	2	3
NOx, index	0.98	0.97	0.97	0.97	0.97	0.95
- % Reduction	2	3	3	3	3	5
T.A.P., mg/mile	50	53 *	51	53 *	53 *	53 *
- % Reduction	6	0 *	4	0 *	0 *	(0) *

* Input limit.

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12/4/92

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TABLE D1-2
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS[2][3]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(in constant 1990 \$)

	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.[4]	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case HQ40 High Δ V.O.C.	Case QN2 Q6N + 10.7% OL
<u>Investment, MM\$</u>						
Refinery	2,954	2,719	1,962	2,362	4,508	3,179
MTBE[5]	3,415	3,572	3,768	3,767	7,008	3,619
Total	6,369	6,291	5,730	6,129	11,516	6,798
Range, MMM\$[6]	5.4 - 8.6	5.3 - 8.5	4.9 - 7.7	5.2 - 8.3	9.8 - 15.5	5.8 - 9.2
<u>Daily Costs, M\$/D</u>						
Capital Charge[7]	2,227	2,035	1,306	1,680	3,249	2,446
Net Upgrading[8]	2,725	2,901	2,924	3,032	6,686	3,070
Variable Operating	9	(24)	(207)	(175)	490	(158)
Fixed Operating[9]	931	857	538	698	1,299	1,005
Total Refinery	5,892	5,769	4,561	5,235	11,724	6,363
<u>Annual Costs, MM\$/Yr.</u>						
Refinery	2,151	2,106	1,665	1,911	4,280	2,322
Other[10]	563	563	667	634	1,081	559
Total	2,714	2,669	2,332	2,545	5,361	2,881
<u>Total Unit Costs, ¢/G of</u>						
<u>Conventional Gasoline Upgraded</u>						
Average	9.0	8.8	7.7	8.4	11.1	9.5
Range[11]	7.4 - 11.7	7.3 - 11.5	6.2 - 10.3	6.8 - 11.1	9.3 - 14.3	7.9 - 12.4

[1] Based on normal investment cost, capital charge, fixed costs, net upgrading and variable costs over base case Q9.

[2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.

[3] Adjusted using individual unit capital charge/fixed operating costs multipliers to include the full cost of extra facilities for summer RFG as detailed on Table A3-19.

[4] Adjusted CG RVP to 8.7 psi. For CG, refinery net upgrading costs were reduced 0.38¢/G and consumer (other) cost was increased 0.21¢/G resulting in a net cost reduction of 0.11¢/G. This equates to reducing the cost of RFG by 0.06¢/G.

[5] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).

[6] For variations from investment curves of -15/+35%.

[7] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.

[8] Raw material upgrading costs.

[9] For new refining facilities only.

[10] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.

[11] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (±0.2).

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3/16/93

TABLE D1-2A
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS UNADJUSTED[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Base Case Q6 45% Red. V.O.C.	Base Case Q6N 45% Red. V.O.C.	Case VLQ40 35% Red. V.O.C.	Case LQ40 40% Red. V.O.C.	Case HQ40 48% Red. V.O.C.
<u>Investment, MM\$</u>					
Refinery	2,954	2,719	1,962	2,362	4,508
MTBE[3]	<u>3,415</u>	<u>3,572</u>	<u>3,768</u>	<u>3,767</u>	<u>7,008</u>
Total	6,369	6,291	5,730	6,129	11,516
Range, MMM\$[4]	5.4 – 8.6	5.3 – 8.5	4.9 – 7.7	5.2 – 8.3	9.8 – 15.5
<u>Daily Costs, M\$/D</u>					
Capital Charge[5]	1,376	1,266	914	1,100	2,100
Net Upgrading[6]	2,725	3,090	2,924	3,032	6,686
Variable Operating	9	(24)	(207)	(175)	490
Fixed Operating[7]	<u>652</u>	<u>604</u>	<u>408</u>	<u>507</u>	<u>923</u>
Total Refinery	4,762	4,936	4,039	4,464	10,199
<u>Annual Costs, MM\$/Yr.</u>					
Refinery	1,738	1,802	1,474	1,629	3,723
Other[8]	<u>563</u>	<u>516</u>	<u>667</u>	<u>634</u>	<u>1,081</u>
Total	2,301	2,318	2,141	2,263	4,804
<u>Total Unit Costs, ¢/G of Conventional Gasoline Upgraded</u>					
Average	7.6	7.6	7.1	7.5	9.9
Range[9]	6.2 – 9.9	6.3 – 10.0	5.6 – 9.5	6.0 – 10.0	8.3 – 12.8

- [1] Based on normal investment cost, capital charge, fixed costs, net upgrading and variable costs over base case Q9.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average. Unadjusted LP case results shown before capital charge and CG RVP adjustments, if these were required.
- [3] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [4] For variations from investment curves of -15/+35%.
- [5] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- [6] Raw material upgrading costs.
- [7] For new refining facilities only.
- [8] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [9] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (± 0.2).
- [10] Adjusted to eliminate 10¢/gal Δ margin on incremental gasoline make of 570 MBPD or by \$873MM/yr.

TABLE D1-3
REFINING RAW MATERIAL AND PRODUCT RATES – MBPCD
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case HQ40 High Δ V.O.C.	Case QN2 Q6N + 10.7% OL
Raw Materials							
Domestic - S	1,985	1,985	1,985	1,985	1,985	1,985	1,985
HL	174	174	174	174	174	174	174
HH	692	692	692	692	692	692	692
Foreign - S	732	732	732	732	732	780	732
HL	669	669	669	669	669	669	669
HH	1,648	1,536	1,531	1,500	1,517	1,385	1,494
Subtotal Crudes	5,900	5,788	5,783	5,752	5,769	5,686	5,746
MTBE	3	132	141	152	152	282	143
Ethanol							
Normal Butane							
Isobutane	54	46	46	46	46	81	61
Natural Gas to H2 Plant Fee	20	24	24	24	24	27	24
Methanol	21	35	32	29	29	32	31
Other Raw Materials	447	447	447	447	447	447	447
Total Raw Materials	6,445	6,472	6,473	6,449	6,466	6,555	6,453
Products							
Motor Gasolines							
Conventional	3,151	1,177	1,173	1,177	1,176		1,176
Oxygenated							
Reformulated/Oxygenated							
Reformulated		2,008	2,009	2,015	2,014	3,221	2,009
CARB2							
Kero Jet/Kerosene	686	686	686	686	686	686	686
Diesel/No. 2 Fuels							
Diesel - LA, ULS							
Diesel - 0.05%S	940	940	940	940	940	940	940
No. 2 Fuel	289	289	289	289	289	289	289
No. 6 Fuel (1% Sul)	57	57	57	57	57	57	57
No. 6 Bunker	57	57	57	57	57	76	57
Marketable Coke - 400 #	180	174	174	172	173	168	172
Catalytic Coke - 400 #	97	95	94	94	94	89	90
Vacuum Gas Oil							
Benzene	21	21	21	21	21	21	21
Toluene	25	25	25	25	25	25	25
Heavy Aromatic Gaso							
Pentanes to P/C							
Natural Gasoline to P/C	134	134	134	134	134	135	134
Normal Butane	22	42	55	20	35	74	37
Isobutane	12	24	13	27	28	12	12
Propane	151	144	144	142	144	148	142
Process Gas/C2/C2=,FOE	365	338	337	334	337	323	332
Other Products	576	576	576	576	576	576	576
(Gain)/Loss	(318)	(317)	(311)	(316)	(320)	(284)	(302)
Total Products	6,445	6,472	6,473	6,449	6,466	6,555	6,453
Crude Properties							
Gravity, °API	32.8	32.9	32.9	32.9	32.9	33.0	32.9
Sulfur, Wt%	1.20	1.17	1.18	1.17	1.17	1.13	1.17
Gasoline Demand Increase, %[1]							
Results		1.1	1.0	1.2	1.2	2.2	1.1
Target		1.1	1.0	1.2	1.2	2.1	1.1

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

TABLE D1-4
NEW PROCESS UNIT RATES – MBPSD
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6 Target <u>Δ V.O.C.</u>	Base Case Q6N = Q6+ <u>Δ Cap. Chg.</u>	Case VLQ40 V. Low <u>Δ V.O.C.</u>	Case LQ40 Low <u>Δ V.O.C.</u>	Case HQ40 High <u>Δ V.O.C.</u>	Case QN2 Q6N + 10.7% OL
Crude – Atmospheric						
Heavy Naphtha Splitter					136	
Catalytic Cracking						
FCC Gasoline Splitters	726	135			763	122
FCC Gasoline Fractionation						
Hydrocracking – 2 Stage						
Hydrocracking – 2 Stage Distillate						
– Hvy Gasoline						
Hydrocrackate Fractionation						
Coker – Delayed						
Coker Lt Gasoline DS/Splitter	25	24			35	26
Hydrotreating – Naphtha						
– FCC/Coker C6s						
– Distillate					161	
– Heavy Gas Oil						
Reformer Feed Fractionation	1,497	1,463	1,488	1,468	1,420	1,448
Reformate Fractionation	258	255	251	251	534	247
Aromatics Extraction						
Benzene Saturation	64	62	58	60	195	56
FCC Gasoline HDS						
Diesel Aromatics Saturation						
Alkylation						91
Alkylate Splitter						
MTBE	27	26	35	35		23
TAME					20	
Isomerization – C5/C6						
– C5/C6, Recycle						
– C4						
Hydrogen – MMSCFPSD					171	
Sulfur – LTPSD						
C4 Rerun – Saturates	203	203		203	203	203
– Unsaturation	501	501		194	501	501
Catalytic Reforming – 100 PSI						
Hydrotreating – Distillate Upgrade						
Dehydrogenation – IC4						

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TABLE D1-5
NEW PROCESS UNIT INVESTMENTS
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(\$MM – in constant mid-1990 \$)

	Base Case Q6 Target <u>Δ V.O.C.</u>	Base Case Q6N = Q6+ <u>Δ Cap. Chg.</u>	Case VLQ40 V. Low <u>Δ V.O.C.</u>	Case LQ40 Low <u>Δ V.O.C.</u>	Case HQ40 High <u>Δ V.O.C.</u>	Case QN2 Q6N + 10.7% OL <u>Δ V.O.C.</u>
Crude Distillation						
Heavy Naphtha Splitter					112	
Catalytic Cracking						
FCC Gasoline Splitters	295	128			751	124
FCC Gasoline Fractionation						
Hydrocracking – 2 Stage						
Hydrocracking – 2 Stage Distillate – Heavy Gasoline						
Hydrocrackate Fractionation						
Coker – Delayed						
Coker Lt. Gasoline DS/Splitter	45	44			64	48
Hydrotreating – Naphtha – FCC Coker C6s – Distillate – Heavy Gas Oil					264	
Reformer Feed Fractionation	901	886	896	888	868	877
Reformate Fractionation	276	274	271	271	459	268
Aromatics Extraction						
Benzene Saturation	224	218	209	211	480	204
FCC Gasoline HDS						
Diesel Aromatics Saturation						
Alkylation						503
Alkylate Splitter						
MTBE	261	216	312	311		203
TAME					164	
Isomerization – C5/C6 – C5/C6, Recycle – C4						
Hydrogen					327	
Sulfur						
MTBE Storage & Blending	111	111	111	111	178	111
C4 Rerun – Saturates	236	236		236	236	236
– Unsaturation	444	444		172	444	444
C4 Fractionation Upgrade	162	162	162	162	162	162
Catalytic Reforming – 100 PSI						
Hydrotreating – Distillate Upgrade						
Dehydrogenation – IC4						
Total Refinery	2,954	2,719	1,962	2,362	4,508	3,179

TABLE D1-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case HQ40 High Δ V.O.C.	Case QN2 Q6N + 10.7% OL
Crude – Atmospheric	134.1	131.5	131.4	130.7	131.1	129.2	130.6
Heavy Naphtha Splitter						3.0	
Catalytic Cracking[1]	50.2	49.6	48.7	49.0	48.8	46.2	46.9
Catalytic Cracking[2]	46.7	46.2	45.3	45.6	45.4	42.0	43.5
Conversion, %	77.5	77.5	77.7	77.5	77.6	79.9	77.9
Octane Catalyst, %	68.5	68.4	68.9	68.3	68.7	71.7	69.1
FCC Gasoline Splitters		15.5	2.9			16.3	2.6
FCC Gasoline Fractionation	11.7	11.7	11.7	11.7	11.7		11.7
Hydrocracking – 2 Stage[1]	9.8	9.4	9.3	9.4	9.5	9.8	9.8
Jet Yield, % of Max	64.4	100.0	72.8	100.0	88.9	5.8	64.6
300 – Gasoline Operation, %						46.6	
Hydrocracking – 2 Stage Distillate							
Hydrocracking – Low Conversion	1.5	1.5	1.5	1.5	1.5	1.5	1.5
– Hvy Gasoline							
– Combined[2]	11.3	10.9	10.8	10.9	11.0	10.5	11.3
Hydrocrackate Fractionation							
Coking – Delayed	13.3	12.8	12.8	12.7	12.7	12.4	12.6
– Fluid	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Coker Lt Gasoline DS/Splitter		0.5	0.5			0.7	0.5
Thermal Cracking, Visbreaking	1.5	1.5	1.5	1.5	1.5		1.5
Solvent Deasphalting	1.8	1.7	1.7	1.7	1.7	3.2	1.8
Catalytic Reforming – 100 PSI[1]	16.0	14.0	14.0	14.0	14.0	13.1	14.1
– 200 PSI[1]	11.1	10.8	11.1	10.2	10.7	11.1	11.1
– 450 PSI[1]	7.1	5.7	5.7	5.7	5.7	5.6	5.7
– Combined[2]	33.0	29.7	30.0	29.6	29.5	30.7	30.1
– RONC	96.9	95.4	95.2	94.9	95.5	92.1	95.3
Hydrotreating – Naphtha	31.5	31.3	30.6	31.1	30.7	29.7	30.1
– FCC/Coker C6s							
– Distillate	33.3	31.7	33.3	31.7	32.2	36.7	33.3
– Heavy Gas Oil	16.3	16.3	16.3	16.3	16.3	17.3	16.3
– Residuum – Atm	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Reformer Feed Fractionation		31.3	30.6	31.1	30.7	29.7	30.1
Reformate Fractionation	7.7	13.5	13.5	13.4	13.4	19.3	13.3
Aromatics Extraction	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Benzene Saturation		1.3	1.3	1.2	1.2	4.1	1.2
FCC Gasoline HDS							
Diesel Aromatics Saturation							
Alkylation	8.4	7.6	8.0	7.4	7.4	9.5	8.3
Alkylate Splitter							
Polymerization	0.4	0.4	0.4	0.4	0.4	0.5	
Dehydrogenation – IC4	0.7	0.7	0.7	0.7	0.7	0.7	0.7
MTBE	1.4	1.9	1.9	1.9	1.9	1.4	1.8
TAME		0.5	0.3			0.9	0.2
Hydrodealkylation – Toluene							
Lubes	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Isomerization – C5/C6	2.2	2.2	2.2	2.2	2.2	2.2	2.2
– C5/C6, Recycle	2.2	2.2	2.2	2.2	2.2	1.9	2.2
– C4	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Hydrogen – MMSCFPCD	19.7	23.0	22.7	23.0	23.0	26.5	23.0
Sulfur, LTPCD	134	130	130	129	129	127	129
C4 Rerun – Saturates		4.2	4.2		4.2	4.2	4.2
– Unsaturation		10.2	10.5		4.0	10.5	10.5

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

TABLE D1-7
PROCESS UNIT UTILIZATIONS - %[1]
IIIC - SUMMER 2000 F2 - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case HQ40 High Δ V.O.C.	Case QN2 Q6N + 10.7% OL
Crude Distillation - Atmospheric	85.7	84.1	84.0	83.6	83.8	82.6	83.5
Heavy Naphtha Splitter						97.0 *	
Catalytic Cracking[2]	84.2	83.2	81.7	82.1	81.9	77.5	78.5
Catalytic Cracking[3]	78.3	77.4	75.9	76.3	76.1	70.4	72.9
FCC Gasoline Splitters		94.0 *	94.0 *			94.0 *	94.0 *
FCC Gasoline Fractionation	81.9	81.9	81.9	81.9	81.9		81.9
Hydrocracking - 2 Stage[2]	87.0	83.8	82.9	83.8	84.4	87.0 *	87.0 *
Hydrocracking - 2 Stage Distillate							
- Low Conversion	58.5	58.5	58.5	58.5	58.5	58.5	58.5
- Heavy Gasoline							
- Combined[3]	81.7	79.1	78.3	79.1	79.6	76.2	81.7
Hydrocrackate Fractionation							
Coking - Delayed	86.1	83.1	82.9	82.1	82.5	80.1	81.7
- Fluid	85.9	85.9	85.9	85.9	85.9	79.9	85.9
Coker Lt Gasoline DS/Splitter		92.0 *	92.0 *			92.0 *	92.0 *
Thermal Cracking, Visbreaking	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	0.0	92.0 *
Solvent Deasphalting	40.3	39.8	40.0	39.9	40.0	73.4	40.7
Catalytic Reforming - 100 PSI[2]	84.4	73.6	73.6	73.6	73.6	69.1	74.1
- 200 PSI[2]	92.0 *	89.6	92.0	85.1	88.8	92.0 *	92.0 *
- 450 PSI[2]	69.3	55.6	55.6	55.6	55.6	54.3	55.6
- Combined[3]	79.8	72.0	72.7	71.8	71.6	74.3	72.8
Hydrotreating - Naphtha	73.5	73.0	71.3	72.5	71.5	69.2	70.2
- FCC/Coker C6s							
- Distillate	92.0 *	87.6	92.0 *	87.5	88.9	92.0 *	92.0 *
- Heavy Gas Oil	86.6	86.6	86.6	86.6	86.0	92.0 *	86.6
- Residuum, Atm	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Reformer Feed Fractionation		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Reformate Fractionation	85.0	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Aromatics Extraction	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Benzene Saturation		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
FCC Gasoline HDS							
Diesel Aromatics Saturation							
Alkylation	69.5	62.5	65.9	61.1	61.1	78.1	58.4
Alkylate Splitter							
Polymerization	45.0	45.0	45.0	45.0	45.0	49.4	
Dehydrogenation - IC4	86.4	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *
MTBE	91.0 *	91.0 *	91.0 *	91.0 *	91.0 *	91.0 *	90.0 *
TAME	0.0	87.0 *	50.1	0.0	0.0	87.0 *	48.3
Hydrodealkylation - Toluene	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lubes	82.0	82.0	82.0	82.0	82.0	82.0	82.0
Isomerization - C5/C6	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
- C5/C6, Recycle	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	79.3	92.0 *
- C4	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *
Hydrogen	76.1	89.0 *	87.9	89.0 *	89.0 *	89.0 *	88.8
Sulfur	53.0	51.4	51.4	51.0	51.0	50.2	51.0
C4 Rerun - Saturates		92.0 *	92.0 *		92.0 *	92.0 *	92.0 *
- Unsaturates		92.0 *	92.0 *		92.0 *	92.0 *	92.0 *

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

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TABLE D1-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case HQ40 High Δ V.O.C.	Case QN2 Q6N + 10.7% OL
FCC Gasoline	20.8	20.3	19.7	19.8	19.8	11.1	18.4
Lt. FCC 255-	9.5	2.4	5.5	9.5	9.6		5.9
Hvy FCC 255+	6.8	6.6	6.6	6.7	6.6		6.6
Hvy FCC 255+ Desulf.							
FCC Gaso (100-180)		2.4	1.4			4.4	1.2
FCC Gaso (180-225)		1.4	0.8			2.7	0.8
FCC Gaso (225-300)		1.1	0.6			5.3	0.5
FCC Gaso (300-375)						2.5	
FCC Gaso (375-430)							
Total FCC Gasoline	37.1	34.2	34.6	36.0	36.0	26.0	33.5
Butenes		0.1					
Pentenes		0.7					
Poly Gasoline	0.6	0.6	0.6	0.6	0.6	0.6	
Lt. Coker Gasoline	1.3	0.5	0.5	0.8	0.8	0.7	0.5
Total Olefinic	1.9	1.9	1.1	1.4	1.4	1.3	0.5
Reformate	16.7	19.5	20.7	19.2	19.8	3.6	21.3
Reformate (220-300 Feed)	4.5	1.8	1.2	2.1	1.6	6.6	1.1
BT Reformate	5.0		0.1	0.2			
HC Reformate (210-300)	2.3	3.8	3.6	3.5	3.6	9.2	3.4
Heavy Reformate (300+)	1.5	0.3	0.3	0.3	0.3	4.6	0.3
Toluene / Xylenes	0.1		0.1	0.1	0.0		0.1
Total Reformates	30.1	25.4	26.0	25.4	25.3	24.0	26.2
Lt. Reformate	1.3	0.5	0.6	0.7	0.5		0.6
Lt. Raffinate B(C5-210)	2.4	4.6	4.5	4.3	4.4	8.7	4.2
Alkylate/Lt Alkylate (C3/C4)	11.7	10.5	10.1	10.0	10.1	10.3	10.7
Alkylate/Lt Alkylate (C5)			0.7			2.3	0.7
Butane	3.7	2.7	2.3	3.3	2.9	1.8	2.9
Natural/LSR Gaso	0.1	0.4	0.4	0.4	0.4	0.3	0.4
BT Naphtha (150-220)		0.6	0.5	0.5	0.8		0.9
Pentanes (I/N)		1.1	0.7			2.0	0.6
Isomerate (C5-C6)	6.0	5.9	5.9	5.9	5.8	5.4	5.9
Isomerate (C6)							
Lt. Hydrocrackate (C5-180)	2.6	2.2	2.4	2.2	2.3	3.1	2.6
Medium Hydrocrackate (180-225)	1.1	2.6	2.8	2.5	2.7	3.1	2.9
MTBE	2.0	6.8	7.0	7.4	7.4	10.6	7.1
TAME		0.6	0.4			1.2	0.3
Alcohol							
Total Low Arom., Saturated	30.9	38.5	38.3	37.2	37.3	48.8	39.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE D1-8A
REFORMULATED GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6 Target <u>Δ V.O.C.</u>	Base Case Q6N = Q6+ <u>Δ Cap. Chg.</u>	Case VLQ40 V. Low <u>Δ V.O.C.</u>	Case LQ40 Low <u>Δ V.O.C.</u>	Case HQ40 High <u>Δ V.O.C.</u>	Case QN2 Q6N + 10.7% OL
FCC Gasoline	20.5	22.4	29.4	27.1	11.1	26.7
Lt. FCC 255-			2.8	2.8		1.3
Hvy FCC 255+	8.3	6.1	5.3	6.4		4.9
Hvy FCC 255+ Desulf.						
FCC Gaso (100-180)	1.6	1.2			4.4	0.1
FCC Gaso (180-225)	1.0	0.8			2.7	0.0
FCC Gaso (225-300)	0.8	0.6			5.3	0.1
FCC Gaso (300-375)					2.5	
FCC Gaso (375-430)						
Total FCC Gasoline	<u>32.2</u>	<u>31.2</u>	<u>37.5</u>	<u>36.3</u>	<u>26.0</u>	<u>33.1</u>
Butenes	0.2					
Pentenenes	0.7					
Poly Gasoline	0.9	0.9	0.9	0.9	0.6	
Lt. Coker Gasoline	<u>0.7</u>	<u>0.7</u>	<u>—</u>	<u>—</u>	<u>0.7</u>	<u>0.7</u>
Total Olefinic	2.5	1.6	0.9	0.9	1.3	0.7
Reformate	13.2	14.3	14.4	13.1	3.6	15.7
Reformate (220-300 Feed)	2.7	1.9	0.8	0.6	6.6	0.6
BT Reformate						
HC Reformate (210-300)	6.0	5.8	5.6	5.8	9.2	5.5
Heavy Reformate (300+)		0.0			4.6	0.3
Toluene / Xylenes		0.1				
Total Reformates	<u>21.9</u>	<u>22.1</u>	<u>20.8</u>	<u>19.5</u>	<u>24.0</u>	<u>22.1</u>
Lt. Reformate						
Lt. Raffinate B(C5-210)	7.3	7.1	6.8	7.0	8.7	6.7
Alkylate/Lt Alkylate (C3/C4)	13.3	13.0	10.3	12.1	10.3	13.1
Alkylate/Lt Alkylate (C5)		1.2			2.3	1.1
Butane	2.0 *	2.0 *	2.5	2.0 *	1.8 *	2.0 *
Natural/LSR Gaso	0.7	0.6	0.6	0.6	0.3	0.6
BT Naphtha (150-220)	0.9	0.7	0.8	1.3		1.4
Pentanes (I/N)	0.2	0.0			2.0	0.0
Isomerase (C5-C6)	5.1	5.8	6.2	5.6	5.4	4.7
Isomerase (C6)						
Lt. Hydrocrackate (C5-180)	1.0	1.3	0.9	1.4	3.1	1.2
Medium Hydrocrackate (180-225)	1.1	1.6	1.0	1.6	3.1	1.5
MTBE	10.8	11.2	11.7	11.7	10.6	11.2
TAME	1.0	0.6			1.2	0.5
Alcohol						
Total Low Arom., Saturated	<u>43.4</u>	<u>45.0</u>	<u>40.8</u>	<u>43.3</u>	<u>48.8</u>	<u>44.1</u>
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

* Minimum.

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TABLE D1-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case QN2 Q6N + 10.7% OL
FCC Gasoline	20.8	20.0	15.0	3.2	7.1	4.3
Lt. FCC 255-	9.5	6.5	15.1	21.1	21.1	13.8
Hvy FCC 255+	6.8	3.6	7.4	8.9	6.8	9.6
Hvy FCC 255+ Desulf.						
FCC Gaso (100-180)		4.0	1.7			3.3
FCC Gaso (180-225)		2.1	0.8			2.0
FCC Gaso (225-300)		1.4	0.5			1.3
FCC Gaso (300-375)						
FCC Gaso (375-430)						
Total FCC Gasoline	37.1	37.6	40.5	33.2	35.0	34.2
Butenes						
Pentenenes		0.7				
Poly Gasoline	0.6					
Lt. Coker Gasoline	1.3		0.2	2.0	2.1	
Total Olefinic	1.9	0.7	0.2	2.0	2.1	
Reformate	16.7	30.5	31.6	27.5	31.2	30.8
Reformate (220-300 Feed)	4.5	0.3		4.5	3.4	1.9
BT Reformate	5.0		0.3	0.6		
HC Reformate (210-300)	2.3					
Heavy Reformate (300+)	1.5	0.9	0.8	0.9	0.9	0.3
Toluene / Xylenes	0.1	0.1		0.2	0.1	0.2
Total Reformates	30.1	31.8	32.7	33.7	35.6	33.3
Lt. Reformate	1.3	1.3	1.7	1.8	1.3	1.7
Lt. Raffinate B(C5-210)	2.4					
Alkylate/Lt Alkylate (C3/C4)	11.7	5.4	5.3	9.9	6.8	6.6
Alkylate/Lt Alkylate (C5)						
Butane	3.7	3.9	2.9	4.7	4.5	4.3
Natural/LSR Gaso	0.1					
BT Naphtha (150-220)						
Pentanenes (I/N)		2.6	1.8			1.7
Isomerate (C5-C6)	6.0	7.4	6.1	5.3	6.4	7.9
Isomerate (C6)						
Lt. Hydrocrackate (C5-180)	2.6	4.3	4.2	4.4	3.8	4.9
Medium Hydrocrackate (180-225)	1.1	5.0	4.8	5.0	4.5	5.4
MTBE	2.0					
TAME						
Alcohol						
Total Low Arom., Saturated	30.9	29.9	26.7	31.1	27.3	32.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE D1-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(¢/G per unit in constant 1990 \$)

	<u>Base Case Q9 No FCAAA</u>	<u>Base Case Q6 Target Δ V.O.C.</u>	<u>Base Case Q6N = Q6+ Δ Cap. Chg.</u>	<u>Case VLQ40 V. Low Δ V.O.C.</u>	<u>Case LQ40 Low Δ V.O.C.</u>	<u>Case HQ40 High Δ V.O.C.</u>	<u>Case QN2 Q6N + 10.7% OL</u>
(R+M)/2 Octane, Clear	(0.5)	(0.5)	(0.6)	(0.5)	(0.6)	(0.6)	(0.6)
Aromatics, Vol.%							
Ethers, Vol. %		(0.2)	(0.2)	(0.3)	(0.2)	(0.2)	(0.2)
Ethanol, %							
Olefins, Vol. %							0.1
Benzene, Vol. %		1.3	1.6	1.2	1.3	3.9	1.5
Sulfur, 100 Wt. PPM							
Reid Vapor Pressure, PSI	0.4	0.1	0.3 [2]	0.1	0.1	(8.0)	0.7 [2]
T90, 10°F				0.0			
Butane, Vol. %		(0.1)	(0.1)		0.1	(0.9)	(0.0)
V.O.C., 10%		2.1	0.4	1.1	1.9	6.6	0.7
NO _x , 10%							
T.A.P., 10%		0.1		0.2	0.1		0.1

[1] Shadow costs for very small changes.

Not applicable for significant changes.

[2] Average of absolute values. RFG is at minimum RVP (negative cost), while CG is at maximum RVP (positive cost).

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TABLE D1-9A
REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(¢/G per unit in constant 1990 \$)

	<u>Base Case Q6 Target Δ V.O.C.</u>	<u>Base Case Q6N = Q6+ Δ Cap. Chg.</u>	<u>Case VLQ40 V. Low Δ V.O.C.</u>	<u>Case LQ40 Low Δ V.O.C.</u>	<u>Case HQ40 High Δ V.O.C.</u>	<u>Case QN2 Q6N + 10.7% OL</u>
(R+M)/2 Octane, Clear	(0.5)	(0.5)	(0.4)	(0.5)	(0.6)	(0.5)
Aromatics, Vol. %						
Ethers, Vol. %	(0.4)	(0.4)	(0.4)	(0.4)	(0.2)	(0.3)
Ethanol, %						
Olefins, Vol. %						0.1
Benzene, Vol. %	1.7	2.1	1.5	1.7	3.9	2.0
Sulfur, 100 Wt. PPM						
Reid Vapor Pressure, PSI		(0.2)			(8.0)	(1.0)
T90, 10°F			0.1			
Butane, Vol. %	(0.1)	(0.2)		(0.1)	(0.9)	(0.1)
V.O.C., 10%	3.4	0.6	1.8	3.0	6.6	1.0
NOx, 10%						
T.A.P., 10%			0.1			

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D1-9B
CONVENTIONAL GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (\$/G per unit in constant 1990 \$)

	<u>Base Case Q9 No FCAAA</u>	<u>Base Case Q6 Target Δ V.O.C.</u>	<u>Base Case Q6N = Q6+ Δ Cap. Chg.</u>	<u>Case VLQ40 V. Low Δ V.O.C.</u>	<u>Case LQ40 Low Δ V.O.C.</u>	<u>Case QN2 Q6N + 10.7% OL</u>
(R+M)/2 Octane, Clear	(0.5)	(0.6)	(0.8)	(0.6)	(0.7)	(0.8)
Aromatics, Vol.%						
Ethers, Vol.%						(0.1)
Ethanol, %						
Olefins, Vol.%						0.1
Benzene, Vol.%		0.7	0.9	0.6	0.6	0.7
Sulfur, 100 Wt. PPM						
Reid Vapor Pressure, PSI	0.4	0.3	0.5	0.2	0.3	0.2
T90, 10°F						
Butane, Vol.%						
V.O.C., 10%						
NOx, 10%						
T.A.P., 10%		0.2		0.3	0.3	0.3

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE D1-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6 Target Δ V.O.C.	Base Case Q6N = Q6+ Δ Cap. Chg.	Case VLQ40 V. Low Δ V.O.C.	Case LQ40 Low Δ V.O.C.	Case HQ40 High Δ V.O.C.	Case QN2 Q6N + 10.7% OL
<u>No. 2 Diesel Compositions</u>							
Hvy Reformate (300+) 90 RON							
Hvy Reformate (300+) 100 RON							
FCC Heavy Gaso Tr(300-375)						2.8	
FCC Heavy Gaso Tr(375-430)						1.9	
Lt Cycle Oil - Treated	5.5	6.1	6.5	6.1	5.9		5.9
Coker Dist - Treated	4.4	4.4	3.3	3.9	3.5	8.5	3.2
Total High Aromatic	9.9	10.5	9.8	10.0	9.4	13.2	9.1
Heavy Alkylate (300+)						0.0	
Lt Kero - Treated (300-375)	4.0	3.2	4.3	3.4	3.8	2.8	3.9
Kero (375-500)	15.6	15.6	15.5	15.6	15.6	11.1	13.0
Kero - Treated (375-500)	23.4	26.3	23.0	25.9	24.8	18.8	24.5
Kero - Low Aromatics (375-500)							
Hydrocracked Jet (295-525)							
Diesel Base	8.3	8.2	7.6	8.3	8.3	11.3	11.0
Diesel Base - Treated	38.8	36.2	39.8	36.8	38.1	42.7	38.5
Diesel Base - Low Aromatics							
Lt Cycle Oil - Low Aromatics							
Coker Dist - Low Aromatics							
Total Low Aromatic	90.1	89.5	90.2	90.0	90.6	86.8	90.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>							
Diesel Ignition Improver						Yes	
Pour Point Depressant							
Aromatics	25.4	25.6	25.9	25.6	25.6	25.5	25.9
<u>Jet A Compositions</u>							
Heavy Alkylate (300+)							
Lt Kero - Treated (300-375)	36.2	32.8	35.7	32.8	33.9	42.4	36.3
Kero - Treated (375-500)	41.7	34.7	40.6	34.7	36.9	54.4	41.7
Hydrocracked Jet (295-525)	22.1	32.5	23.7	32.5	29.2	3.1	22.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE D2-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
<u>Reformulated Limits*</u>							
Aromatics, Vol.%, Maximum Avg							
Oxygen, Wt%, Minimum Avg		2.1	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg							
Benzene, Vol%, Maximum Avg		0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg							
Reid Vapor Pressure, PSI, Min		6.5	6.5	7.0	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max							
Regulatory Cap							
T50, °F, Maximum Avg							
T90, °F, Maximum Avg							
V.O.C., % Reduction		45	45	45	45	45	34
T.A.P., % Reduction		30	30	30	30	30	30
% Class C, Fixed	40	40	40	40	40	40	40
<u>Ethers, V% Pool</u>							
Purchased (Sold)	0.1	4.1	8.4	8.2	5.4	4.2	4.8
Manufactured	1.9	3.3	3.3	3.5	2.0	3.2	2.6
<u>Gasoline Pool Properties</u>							
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	30.9	27.6	24.7 *	20.5	27.2 *	27.3	27.9
Ethers, Vol.% *	2.0	7.4	11.7	11.7	7.4	7.4	7.4
Oxygen, Wt.% *	0.4	1.3	2.1	2.1	1.3	1.3	1.3
Olefins, Vol. %	13.6	12.6	10.7	8.9	11.3 *	10.1 *	12.9
Benzene, Vol. %	1.8	1.0 *	0.7 *	0.7 *	1.0 *	1.0 *	1.0 *
Sulfur, WPPM	206	159	125	58	194 *	82 *	184
Reid Vapor Pressure, PSI*	7.9	7.3	6.5	7.0	7.3	7.4	7.5
Temperature at V/L = 20, °F	142	145	148	143	145	144	144
<u>Distillation</u>							
T10, °F	117	122	132	130	124	123	123
T50, °F	211	204	204	192	205	207	203
T90, °F	347	344	341	295	343 *	339 *	343
Specific Gravity	0.7469	0.7453	0.7452	0.7324	0.7446	0.7447	0.7452
Heat Content, MBTU/G	114.0	112.8	112.0	110.8	112.8	112.8	112.7
V.O.C., gm/mile	1.04	0.91 *	0.71 *	0.71 *	0.92 *	0.91 *	0.92 *
- % Reduction	19	29 *	45 *	45 *	28 *	29 *	28 *
NOx, index	0.98	0.97	0.96	0.96	0.98	0.91	0.98
- % Reduction	2	3	4	4	2	9	2
T.A.P., mg/mile	50	42 *	35	26	41 *	40 *	41 *
- % Reduction	6	21 *	34	50	21 *	24 *	22 *

* Input limit.

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TABLE D2-1A
RUN BASIS AND REFORMULATED GASOLINE POOL PROPERTIES
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
Reformulated Limits*						
Aromatics, Vol.%, Maximum Avg						
Oxygen, Wt%, Minimum Avg	2.1	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg						
Benzene, Vol%, Maximum Avg	0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg						
Reid Vapor Pressure, PSI, Min	6.5	6.5	7.0	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max						
Regulatory Cap						
T50, °F, Maximum Avg						
T90, °F, Maximum Avg						
V.O.C., % Reduction	45	45	45	45	45	34
T.A.P., % Reduction	30	30	30	30	30	30
% Class C, Fixed	40	40	40	40	40	40
Ethers, V% Pool						
Purchased (Sold)						
Manufactured						
Gasoline Pool Properties						
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	24.7	24.7 *	20.5	24.2 *	24.5	24.7
Ethers, Vol.% *	11.7	11.7	11.7	11.7	11.7	11.7
Oxygen, Wt.% *	2.1	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%	11.6	10.7	8.9	11.1 *	5.2 *	13.1
Benzene, Vol.% *	0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM	144	125	58	174	30 *	151
Reid Vapor Pressure, PSI	6.5 *	6.5 *	7.0 *	6.5 *	6.6	7.2
Temperature at V/L = 20, °F	149	148	143	149	147	144
Distillation						
T10, °F	136	132	130	135	130	127
T50, °F	205	204	192	205	206	198
T90, °F	344	341	295	337	329	344
Specific Gravity	0.7463	0.7452	0.7324	0.7448	0.7432	0.7435
Heat Content, MBTU/G	112.1	112.0	110.8	112.0	112.0	111.7
V.O.C., gm/mile*	0.71	0.71	0.71	0.71	0.71	0.85
- % Reduction*	45	45	45	45	45	34
NOx, index	0.97	0.96	0.96	0.98	0.91	0.98
- % Reduction	3	4	4	2	9	2
T.A.P., mg/mile	35	35	26	35	33	36
- % Reduction	33	34	50	34	38	32

* Input limit.

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TABLE D2-1B
RUN BASIS AND CONVENTIONAL GASOLINE POOL PROPERTIES
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9	Base Case Q6 Target Δ V.O.C.	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
<u>Conventional Limits*</u>					
Aromatics, Vol.%, Maximum Avg					
Oxygen, Wt%, Minimum Avg					
Olefins, Vol.%, Maximum Avg					
Benzene, Vol%, Maximum Avg					
Sulfur, WPPM, Maximum Avg					
Reid Vapor Pressure, PSI, Min					
Reid Vapor Pressure, PSI, Max	7.9	8.7	8.7	8.7	7.9
Regulatory Cap	8.2	9.0	9.0	9.0	8.2
T50, °F, Maximum Avg					
T90, °F, Maximum Avg	356	349	356	356	356
V.O.C., % Reduction		0	0	0	18
T.A.P., % Reduction		0	0	0	6
% Class C, Fixed	40	40	40	40	40
<u>Ethers, V% Pool</u>					
Purchased (Sold)					
Manufactured					
<u>Gasoline Pool Properties</u>					
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	30.9	32.6	32.3	32.2	33.4
Ethers, Vol.%*	2.0				
Oxygen, Wt.%*	0.4				
Olefins, Vol.%	13.6	14.3	11.5 *	18.4 *	12.5
Benzene, Vol.%	1.8	1.6 *	1.4	1.6	1.6
Sulfur, WPPM	206	184 *	228 *	172 *	242
Reid Vapor Pressure, PSI	7.9 *	8.7 *	8.7	8.7 *	7.9 *
Temperature at V/L = 20, °F	142	138	138	140	143
Distillation					
T10, °F	117	99	105	111	115
T50, °F	211	203	206	210	210
T90, °F	347	343	352 *	356 *	341
Specific Gravity	0.7469	0.7438	0.7442	0.7472	0.7481
Heat Content, MBTU/G	114.0	113.9	114.0	114.3	114.5
V.O.C., gm/mile	1.04	1.26	1.28 *	1.27	1.05 *
- % Reduction	19	2	0 *	1	18 *
NOx, index	0.98	0.97	0.97	0.91	0.98
- % Reduction	2	3	3	9	2
T.A.P., mg/mile	50	53 *	53 *	53 *	50 *
- % Reduction	6	0 *	0 *	0 *	6 *

* Input limit.

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TABLE D2-2
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS[2][3]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(in constant 1990 \$)

	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
Investment, MM\$						
Refinery	2,954	3,219	6,400	3,107	3,582	1,960
MTBE[5]	3,415	6,776	6,759	5,191	3,444	3,784
Total	6,369	9,995	13,159	8,298	7,026	5,744
Range, MMM\$[6]	5.4 – 8.6	8.5 – 13.5	11.2 – 17.8	7.1 – 11.2	6.0 – 9.5	4.9 – 7.8
Daily Costs, M\$/D						
Capital Charge[7]	2,227	2,404	4,804	2,250	2,562	1,315
Net Upgrading[8]	2,725	6,150	6,951	1,494	3,010	2,781
Variable Operating	9	(82)	1,288	1,442	185	(179)
Fixed Operating[9]	931	982	1,913	926	1,068	531
Total Refinery	5,892	9,454	14,956	6,112	6,825	4,448
Annual Costs, MM\$/Yr.						
Refinery	2,151	3,450	5,459	2,231	2,491	1,624
Other[10]	563	938	1,517	559	559	653
Total	2,714	4,388	6,976	2,790	3,050	2,277
Total Unit Costs, ¢/G of Conventional Gasoline Upgraded						
Average	9.0	9.1	14.4	9.2 [12]	10.1	7.5
Range[11]	7.4 – 11.7	7.5 – 11.9	12.3 – 18.2	7.3 – 12.7	8.5 – 12.9	6.0 – 10.1

[1] Based on normal investment cost, capital charge, fixed costs, net upgrading and variable costs over base case Q9.

[2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.

[3] Adjusted using individual unit capital charge/fixed operating costs multipliers to include the full cost of extra facilities for RFG as detailed on Table A3-19.

[4] Adjusted CG RVP to 8.7 psi. For CG, refinery net upgrading costs were reduced 0.38¢/G and consumer (other) cost was increased 0.21¢/G resulting in a net cost reduction of 0.11¢/G. This equates to reducing the cost of RFG by 0.06¢/G.

[5] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).

[6] For variations from investment curves of -15/+35%.

[7] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.

[8] Raw material upgrading costs.

[9] For new refining facilities only.

[10] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.

[11] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (±0.2).

[12] Adjusted to eliminate 10¢/G Δ margin on incremental gasoline make of 740 MBPD or by \$1134MM/yr. At constant RFG cost of 7.5¢/G, incremental gasoline cost is 11.0¢/G below (10¢/G margin plus 1.0¢/G cost) input price.

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TABLE D2-2A
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS UNADJUSTED[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(in constant 1990 \$)

	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
<u>Investment, MM\$</u>						
Refinery	2,954	3,219	6,400	3,107	3,582	1,960
MTBE[3]	<u>3,415</u>	<u>6,776</u>	<u>6,759</u>	<u>5,191</u>	<u>3,444</u>	<u>3,784</u>
Total	6,369	9,995	13,159	8,298	7,026	5,744
Range, MMM\$[4]	5.4 – 8.6	8.5 – 13.5	11.2 – 17.8	7.1 – 11.2	6.0 – 9.5	4.9 – 7.8
<u>Daily Costs, M\$/D</u>						
Capital Charge[5]	1,376	1,499	2,981	1,447	1,668	913
Net Upgrading[6]	2,725	6,150	6,951	1,494	3,010	2,970
Variable Operating	9	(82)	1,288	1,442	185	(179)
Fixed Operating[7]	<u>652</u>	<u>685</u>	<u>1,318</u>	<u>663</u>	<u>775</u>	<u>398</u>
Total Refinery	4,762	8,252	12,538	5,046	5,638	4,102
<u>Annual Costs, MM\$/Yr.</u>						
Refinery	1,738	3,012	4,576	1,842	2,058	1,497
Other[8]	<u>563</u>	<u>938</u>	<u>1,517</u>	<u>559</u>	<u>559</u>	<u>606</u>
Total	2,301	3,950	6,093	2,401	2,617	2,103
<u>Total Unit Costs, ¢/G of</u>						
<u>Conventional Gasoline Upgraded</u>						
Average	7.6	8.2	12.6	7.9 [10]	8.6	6.9
Range[9]	6.2 – 9.9	6.7 – 10.7	10.7 – 15.9	6.1 – 11.1	7.2 – 11.1	5.5 – 9.3

- [1] Based on normal investment cost, capital charge, fixed costs, net upgrading and variable costs over base case Q9.
[2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average. Unadjusted LP case results shown before capital charge and CG RVP adjustments if these were required.
[3] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
[4] For variations from investment curves of -15/+35%.
[5] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
[6] Raw material upgrading costs.
[7] For new refining facilities only.
[8] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
[9] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (±0.2).
[10] Adjusted to eliminate 10¢/G Δ margin on incremental gasoline make of 740 MBPD or by \$1134MM/yr. At constant RFG cost of 6.8¢/G, incremental gasoline cost is 11.0¢/G below (10¢/G margin plus 1.0¢/G cost) input price.

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TABLE D2-3
REFINING RAW MATERIAL AND PRODUCT RATES – MBPCD
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
Raw Materials							
Domestic - S	1,985	1,985	1,985	1,985	1,985	1,985	1,984
HL	174	174	174	174	174	174	174
HH	692	692	692	692	692	692	669
Foreign - S	732	732	732	922	732	732	732
HL	669	669	669	669	669	669	698
HH	1,648	1,536	1,400	1,454	2,263	1,505	1,510
Subtotal Crudes	5,900	5,788	5,653	5,896	6,515	5,757	5,767
MTBE	3	132	270	267	212	133	153
Ethanol							
Normal Butane							
Isobutane	54	46	55	74	97	51	46
Natural Gas to H2 Plant Feed	20	24	24	32	24	24	24
Methanol	21	35	36	38	26	35	29
Other Raw Materials	447	447	447	447	447	447	447
Total Raw Materials	6,445	6,472	6,483	6,754	7,321	6,448	6,465
Products							
Motor Gasolines							
Conventional	3,151	1,177			1,451	1,171	1,172
Oxygenated							
Reformulated/Oxygenated							
Reformulated		2,008	3,207	3,244	2,474	2,013	2,015
CARB2							
Kero Jet/Kerosene	686	686	686	686	686	686	686
Diesel/No. 2 Fuels							
Diesel - LA, ULS							
Diesel - 0.05%S	940	940	940	940	940	940	940
No. 2 Fuel	289	289	289	289	289	289	289
No. 6 Fuel (1% Sul)	57	57	57	57	57	57	57
No. 6 Bunker	57	57	57	335	138	57	57
Marketable Coke - 400 #	180	174	167	123	192	172	172
Catalytic Coke - 400 #	97	95	88	91	114	88	93
Vacuum Gas Oil							
Benzene	21	21	21	21	21	21	31
Toluene	25	25	25	25	25	25	12
Heavy Aromatic Gaso							
Pentanes to P/C							
Natural Gasoline to P/C	134	134	135	69	98	134	134
Normal Butane	22	42	61	86	38	20	33
Isobutane	12	24	12	12	12	12	34
Propane	151	144	135	159	166	141	145
Process Gas/C2/C2=,FOE	365	338	313	324	389	333	339
Other Products	576	576	576	576	576	576	576
(Gain)/Loss	(318)	(317)	(285)	(283)	(345)	(287)	(318)
Total Products	6,445	6,472	6,483	6,754	7,321	6,448	6,465
Crude Properties							
Gravity, °API	32.8	32.9	32.9	33.0	32.5	32.9	32.9
Sulfur, Wt%	1.20	1.17	1.15	1.12	1.31	1.17	1.17
Gasoline Demand Increase, %[1]							
Results		1.1	1.8	3.0	N/A	1.0	1.1
Target		1.1	1.8	2.9	1.1	1.1	1.2

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

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TABLE D2-4
NEW PROCESS UNIT RATES – MBPSD
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6 Target <u>Δ V.O.C.</u>	Case S6 Q6 + <u>100% RFG</u>	Case SN1 S6 + <u>7 RVP</u>	Case QN1 Q6 + <u>Max. Gaso.</u>	Case S10 Q6 + <u>30 Sul.</u>	Case S19 1995 CF <u>Full Opt In</u>
Heavy Naphtha Splitter			111			
Catalytic Cracking						
FCC Gasoline Splitters	726	509	1,190	211	509	
FCC Gasoline Fractionation						
Hydrocracking – 2 Stage						
– Hvy Gasoline			89			
Hydrocrackate Fractionation						
Coker – Delayed						
Coker Lt Gasoline DS/Splitt	25	22	28	44	2	
Hydrotreating – Naphtha						
– FCC/Coker C6s			0			
– Distillate			114	152	40	
– Heavy Gas Oil						
Reformer Feed Fractionatio	1,497	1,490	1,519	1,664	1,519	1,425
Reformate Fractionation	258	403	778	325	303	257
Aromatics Extraction						
Benzene Saturation	64	145	249	125	68	89
Gasoline Selective Desulfurization					71	
Diesel Aromatics Saturation						
Alkylation						
Alkylate Splitter						
MTBE	27	23			22	25
TAME		7	43		5	
Isomerization – C5/C6				11	25	
– C5/C6, Recycle						
– C4						
Hydrogen – MMSCFPSD			392			
Sulfur – STPSD						
C4 Rerun – Saturates	203	203	203	203	203	
– Unsaturation	501	501		501	501	
Catalytic Reforming – 100 PSI						
Hydrotreating – Distillate Upgrade						
Dehydrogenation – IC4						

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TABLE D2-5
NEW PROCESS UNIT INVESTMENTS
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(\$MM – in constant mid-1990 \$)

	Base Case Q6 Target <u>Δ V.O.C.</u>	Case S6 Q6 + <u>100% RFG</u>	Case SN1 S6 + <u>7 RVP</u>	Case QN1 Q6 + <u>Max. Gaso.</u>	Case S10 Q6 + <u>30 Sul.</u>	Case S19 1995 CF <u>Full Opt In</u>
Heavy Naphtha Splitter			97			
Catalytic Cracking						
FCC Gasoline Splitters	295	230	1,026	112	570	
FCC Gasoline Fractionation						
Hydrocracking – 2 Stage						
– Heavy Gasoline			1,260			
Hydrocrackate Fractionation						
Coker – Delayed						
Coker Lt. Gasoline DS/Splitter	45	40	51	80	4	
Hydrotreating – Naphtha						
– FCC Coker C6s			1			
– Distillate			188	250	66	
– Heavy Gas Oil						
Reformer Feed Fractionation	901	897	910	970	910	870
Reformate Fractionation	276	377	614	324	308	276
Aromatics Extraction						
Benzene Saturation	224	392	569	357	232	281
Gasoline Selective Desulfurization					223	
Diesel Aromatics Saturation						
Alkylation						
Alkylate Splitter						
MTBE	261	202			197	260
TAME		61	360		39	
Isomerization – C5/C6				36	80	
– C5/C6, Recycle						
– C4						
Hydrogen			749			
Sulfur						
MTBE Storage & Blending	111	177	179	136	111	111
C4 Rerun – Saturates	236	236	236	236	236	
– Unsaturates	444	444		444	444	
C4 Fractionation Upgrades	162	162	162	162	162	162
Catalytic Reforming – 100 PSI						
Hydrotreating – Distillate Upgrade						
Dehydrogenation – IC4						
Total Refinery	2,954	3,219	6,400	3,107	3,582	1,960

TABLE D2-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
Crude – Atmospheric	134.1	131.5	128.5	134.0	148.1	130.8	131.1
Heavy Naphtha Splitter				2.4			
Catalytic Cracking[1]	50.2	49.6	46.7	48.6	56.1	45.4	48.1
Catalytic Cracking[2]	46.7	46.2	43.4	44.3	52.1	41.3	44.7
Conversion, %	77.5	77.5	77.8	79.0	77.7	80.0	77.5
Octane Catalyst, %	68.5	68.4	68.8	70.7	70.4	71.5	68.2
FCC Gasoline Splitters		15.5	6.9	25.4	4.5	10.9	
FCC Gasoline Fractionation	11.7	11.7	11.7		11.7	6.0	11.7
Hydrocracking – 2 Stage[1]	9.8	9.4	9.1	9.8	9.8	9.8	9.8
Jet Yield, % of Max	64.4	100.0	100.0			47.7	71.9
300 – Gasoline Operation, %				87.3			
Hydrocracking – 2 Stage Distillate							
Hydrocracking – Low Conversion	1.5	1.5	1.5	2.0	2.2	2.2	1.5
– Hvy Gasoline				1.8			
– Combined[2]	11.3	10.9	10.6	12.1	12.0	12.0	11.3
Hydrocrackate Fractionation							
Coking – Delayed	13.3	12.8	12.2	9.0	14.2	12.6	12.6
– Fluid	0.7	0.7	0.7	0.4	0.8	0.7	0.7
Coker Lt Gasoline DS/Splitter		0.5	0.5	0.6	0.9	0.0	
Thermal Cracking, Visbreaking	1.5	1.5	0.9	0.2	1.5	1.5	1.5
Solvent Deasphalting	1.8	1.7	2.4	4.0	3.4	1.8	1.8
Catalytic Reforming – 100 PSI[1]	16.0	14.0	13.1	14.5	17.5	17.3	14.5
– 200 PSI[1]	11.1	10.8	10.1	11.1	11.1	8.5	10.9
– 450 PSI[1]	7.1	5.7	5.2	5.2	8.4	5.7	5.9
– Combined[2]	33.0	29.7	29.4	31.0	37.1	31.7	30.3
– RONC	96.9	95.4	91.7	93.5	94.5	94.2	96.0
Hydrotreating – Naphtha	31.5	31.3	31.2	31.8	34.8	31.8	29.8
– FCC/Coker C6s				0.0			
– Distillate	33.3	31.7	33.3	35.7	36.5	34.1	32.9
– Heavy Gas Oil	16.3	16.3	16.3	17.3	16.6	16.7	16.3
– Residuum – Atm	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Reformer Feed Fractionation		31.3	31.2	31.8	34.8	31.8	29.8
Reformate Fractionation	7.7	13.5	16.6	24.4	14.9	14.5	13.5
Aromatics Extraction	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Benzene Saturation		1.3	3.0	5.2	2.6	1.4	1.9
FCC Gasoline HDS						1.5	
Diesel Aromatics Saturation							
Alkylation	8.4	7.6	8.1	10.2	10.8	8.1	7.2
Alkylate Splitter							
Polymerization	0.4	0.4	0.5		0.4	0.4	0.4
Dehydrogenation – IC4	0.7	0.7	0.7	0.7	0.7	0.7	0.7
MTBE	1.4	1.9	1.8	1.4	1.4	1.8	1.9
TAME		0.5	0.6	1.3	0.4	0.6	
Hydrodealkylation – Toluene							0.1
Lubes	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Isomerization – C5/C6	2.2	2.2	2.2	2.2	2.4	2.7	2.2
– C5/C6, Recycle	2.2	2.2	2.2	2.2	2.2	2.2	1.2
– C4	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Hydrogen – MMSCFPCD	19.7	23.0	23.0	30.9	23.0	23.0	23.0
Sulfur, LTPCD	134	130	126	115	153	130	129
C4 Rerun – Saturates		4.2	4.2	4.2	4.2	4.2	
– Unsaturation		10.5	10.5		10.5	10.5	

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

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TABLE D2-7
PROCESS UNIT UTILIZATIONS – %[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
Crude Distillation – Atmospheric	85.7	84.1	82.1	85.7	94.7	83.7	83.8
Heavy Naphtha Splitter				97.0 *			
Catalytic Cracking[2]	84.2	83.2	78.2	81.4	94.0 *	76.1	80.5
Catalytic Cracking[3]	78.3	77.4	72.7	74.2	87.4	69.2	74.9
FCC Gasoline Splitters		94.0 *	94.0 *	94.0 *	94.0 *	94.0 *	
FCC Gasoline Fractionation	81.9	81.9	81.9		81.9	84.1	81.9
Hydrocracking – 2 Stage[2]	87.0	83.8	81.5	87.0 *	87.0 *	87.0 *	87.0 *
– Low Conversion	58.5	58.5	58.5	79.7	87.0 *	87.0 *	58.5
– Heavy Gasoline				87.0 *			
– Combined[3]	81.7	79.1	77.2	76.8	87.0 *	87.0 *	81.7
Hydrocrackate Fractionation							
Coking – Delayed	86.1	83.1	79.4	58.2	92.0 *	81.8	81.8
– Fluid	85.9	85.9	79.9	46.0	92.0 *	85.9	85.9
Coker Lt Gasoline DS/Splitter		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	
Thermal Cracking, Visbreaking	92.0 *	92.0 *	54.2	13.6	92.0 *	92.0 *	92.0 *
Solvent Deasphalting	40.3	39.8	55.4	92.0 *	78.1	41.4	41.0
Catalytic Reforming – 100 PSI[2]	84.4	73.6	68.9	76.2	92.0 *	91.1	76.3
– 200 PSI[2]	92.0 *	89.6	84.4	92.0 *	92.0 *	70.6	90.4
– 450 PSI[2]	69.3	55.6	50.7	50.7	82.2	55.6	57.6
– Combined[3]	79.8	72.0	71.3	75.1	89.8	76.8	73.4
Hydrotreating – Naphtha	73.5	73.0	72.6	74.0	81.1	74.0	69.5
– FCC/Coker C6s				92.0 *			
– Distillate	92.0 *	87.6	92.0 *	92.0 *	92.0 *	92.0 *	90.9
– Heavy Gas Oil	86.6	86.6	86.6	92.0 *	88.3	89.0	86.6
– Residuum, Atm	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Reformer Feed Fractionation		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Reformate Fractionation	85.0	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Aromatics Extraction	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Benzene Saturation		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
FCC Gasoline HDS						92.0 *	
Diesel Aromatics Saturation							
Alkylation	69.5	62.5	66.8	83.7	89.0 *	67.1	59.5
Alkylate Splitter							
Polymerization	45.0	45.0	49.4	0.0	45.0	45.0	45.0
Dehydrogenation – IC4	86.4	89.0 *	89.0	89.0 *	89.0 *	89.0 *	89.0 *
MTBE	91.0 *	91.0 *	91.0 *	91.0 *	91.0 *	91.0 *	91.0 *
TAME	0.0	87.0 *	87.0 *	87.0 *	79.4	87.0 *	0.0
Hydrodealkylation – Toluene	0.0	0.0	0.0	0.0	0.0	0.0	19.5
Lubes	82.0	82.0	82.0	82.0	82.0	82.0	82.0
Isomerization – C5/C6	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
– C5/C6, Recycle	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	52.6
– C4	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *
Hydrogen	76.1	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *
Sulfur	53.0	51.4	49.8	45.5	60.5	51.4	51.0
C4 Rerun – Saturates		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	
– Unsaturates		92.0 *	92.0 *		92.0 *	92.0 *	

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

TABLE D2-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
FCC Gasoline	20.8	20.3	18.2		19.9	9.8	19.1
Lt. FCC 255-	9.5	2.4	0.0		2.7	4.9	9.6
Hvy FCC 255+	6.8	6.6	6.6		5.4	3.4	6.7
Hvy FCC 255+ Desulf.						2.0	
FCC Gaso (100-180)		2.4	3.2	6.9	1.8	3.0	
FCC Gaso (180-225)		1.4	1.9	4.1	1.1	1.8	
FCC Gaso (225-300)		1.1	1.4	8.2	0.8	3.3	
FCC Gaso (300-375)				3.1		1.8	
FCC Gaso (375-430)							
Total FCC Gasoline	37.1	34.2	31.4	22.3	31.6	30.1	35.2
Butenes		0.1					
Pentenes		0.7		1.1	0.2		
Poly Gasoline	0.6	0.6	0.6		0.5	0.6	0.6
Lt. Coker Gasoline	1.3	0.5	0.4	0.5	0.7		1.0
Total Olefinic	1.9	1.9	1.0	1.6	1.4	0.6	1.6
Reformate	16.7	19.5	14.6		19.6	17.8	20.7
Reformate (220-300 Feed)	4.5	1.8	0.3	1.9	2.3	4.5	0.9
BT Reformate	5.0						0.3
HC Reformate (210-300)	2.3	3.8	7.1	15.0	3.7	4.0	4.1
Heavy Reformate (300+)	1.5	0.3	2.0	3.4	1.2	1.6	0.4
Toluene / Xylenes	0.1					0.0	0.2
Total Reformates	30.1	25.4	24.0	20.3	26.8	27.8	26.6
Lt. Reformate	1.3	0.5				1.1	
Lt. Raffinate B(C5-210)	2.4	4.6	7.0	9.8	5.1	4.5	4.7
Alkylate/Lt Alkylate (C3/C4)	11.7	10.5	9.2	11.8	11.4	9.5	9.9
Alkylate/Lt Alkylate (C5)			1.7	1.8	0.6	1.5	
Butane	3.7	2.7	1.8	1.8	3.0	3.3	3.0
Natural/LSR Gaso	0.1	0.4	0.2	2.2	1.4	0.4	1.5
BT Naphtha (150-220)		0.6					0.2
Pentanes (I/N)		1.1	1.5	3.0	0.9	1.3	
Isomate (C5-C6)	6.0	5.9	5.8	5.8	5.0	6.6	4.6
Isomate (C6)				0.0			
Lt. Hydrocrackate (C5-180)	2.6	2.2	2.2	4.3	2.6	2.8	2.5
Medium Hydrocrackate (180-225)	1.1	2.6	2.5	3.5	2.8	3.1	2.9
MTBE	2.0	6.8	10.9	10.1	6.9	6.7	7.4
TAME		0.6	0.8	1.8	0.5	0.8	
Total Low Arom., Saturated	30.9	38.5	43.6	55.7	40.2	41.5	36.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*Minimum

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TABLE D2-8A
REFORMULATED GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
FCC Gasoline	20.5	18.2		26.8		29.7
Lt. FCC 255-		0.0		3.1	5.1	2.9
Hvy FCC 255+	8.3	6.6		0.3	1.0	5.4
Hvy FCC 255+ Desulf.					3.3	
FCC Gaso (100-180)	1.6	3.2	6.9			
FCC Gaso (180-225)	1.0	1.9	4.1	0.2	1.9	
FCC Gaso (225-300)	0.8	1.4	8.2	0.3	3.9	
FCC Gaso (300-375)			3.1			
FCC Gaso (375-430)						
Total FCC Gasoline	32.2	31.4	22.3	30.8	15.2	37.9
Butenes	0.2					
Pentenes	0.7		1.1	0.3		
Poly Gasoline	0.9	0.6		0.7	0.9	0.9
Lt. Coker Gasoline	0.7	0.4	0.5	0.4		
Total Olefinic	2.5	1.0	1.6	1.4	0.9	0.9
Reformate	13.2	14.6		15.0	25.1	13.5
Reformate (220-300 Feed)	2.7	0.3	1.9	3.7	0.9	0.3
BT Reformate						
HC Reformate (210-300)	6.0	7.1	15.0	5.9	6.4	6.0
Heavy Reformate (300+)		2.0	3.4	0.4	0.7	0.6
Toluene / Xylenes						0.4
Total Reformates	21.9	24.0	20.3	24.9	33.0	20.7
Lt. Reformate						
Lt. Raffinate B(C5-210)	7.3	7.0	9.8	8.0	7.1	7.4
Alkylate/Lt Alkylate (C3/C4)	13.3	9.2	11.8	12.8	11.6	9.2
Alkylate/Lt Alkylate (C5)		1.7	1.8	0.9	2.2	
Butane	2.0 *	1.8 *	1.8 *	2.0 *	2.0 *	2.6
Natural/LSR Gaso	0.7	0.2	2.2	2.2	0.6	2.3
BT Naphtha (150-220)	0.9					0.3
Pentanes (I/N)	0.2	1.5	3.0	0.2	0.0	
Isomerate (C5-C6)	5.1	5.8	5.8	2.6	9.9	5.1
Isomerate (C6)			0.0			
Lt. Hydrocrackate (C5-180)	1.0	2.2	4.3	1.1	2.6	0.8
Medium Hydrocrackate (180-225)	1.1	2.5	3.5	1.2	3.1	1.2
MTBE	10.8	10.9	10.1	11.0	10.6	11.7
TAME	1.0	0.8	1.8	0.7	1.2	
Total Low Arom., Saturated	43.4	43.6	55.7	42.9	50.9	40.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

*Minimum

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TURNER, MASON & COMPANY
Consulting Engineers

TABLE D2-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9	Base Case Q6 Target Δ V.O.C.	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
FCC Gasoline	20.8	20.0	8.4	26.6	0.9
Lt. FCC 255-	9.5	6.5	7.2	4.5	20.9
Hvy FCC 255+	6.8	3.6	9.2	7.5	8.8
Hvy FCC 255+ Desulf.					
FCC Gaso (100-180)		4.0	4.1	8.2	
FCC Gaso (180-225)		2.1	2.4	1.6	
FCC Gaso (225-300)		1.4	1.6	2.4	
FCC Gaso (300-375)				4.9	
FCC Gaso (375-430)					
Total FCC Gasoline	37.1	37.6	32.8	55.7	30.6
Butenes					
Pentenenes		0.7			
Poly Gasoline	0.6				
Lt. Coker Gasoline	1.3		1.2		2.7
Total Olefinic	1.9	0.7	1.2		2.7
Reformate	16.7	30.5	27.6	5.2	33.2
Reformate (220-300 Feed)	4.5	0.3		10.6	1.8
BT Reformate	5.0				0.8
HC Reformate (210-300)	2.3				0.9
Heavy Reformate (300+)	1.5	0.9	2.7	3.0	0.0
Toluene / Xylenes	0.1	0.1		0.1	
Total Reformates	30.1	31.8	30.3	18.9	36.7
Lt. Reformate	1.3	1.3		3.1	
Lt. Raffinate B(C5-210)	2.4				
Alkylate/Lt Alkylate (C3/C4)	11.7	5.4	9.0	5.8	11.1
Alkylate/Lt Alkylate (C5)			0.2	0.3	
Butane	3.7	3.9	4.6	5.7	3.7
Natural/LSR Gaso	0.1				
BT Naphtha (150-220)					
Pentanenes (I/N)		2.6	2.1	3.3	
Isomerate (C5-C6)	6.0	7.4	9.2	0.9	3.9
Isomerate (C6)					
Lt. Hydrocrackate (C5-180)	2.6	4.3	5.2	3.3	5.4
Medium Hydrocrackate (180-225)	1.1	5.0	5.4	3.0	5.8
MTBE	2.0				
TAME					
Total Low Arom., Saturated	30.9	29.9	35.7	25.4	30.0
Total	100.0	100.0	100.0	100.0	100.0

TABLE D2-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(¢/G per unit in constant 1990 \$)

	<u>Base Case Q9</u>	<u>Base Case Q6 Target Δ V.O.C.</u>	<u>Case S6 Q6 + 100% RFG</u>	<u>Case SN1 S6 + 7 RVP</u>	<u>Case QN1 Q6 + Max. Gaso.</u>	<u>Case S10 Q6 + 30 Sul.</u>	<u>Case S19 1995 CF Full Opt In</u>
(R+M)/2 Octane, Clear	(0.5)	(0.5)	(0.4)	(0.7)	(0.9)	(0.8)	(0.3)
Aromatics, Vol. %			0.0		0.0		
Ethers, Vol. %		(0.2)	(0.4)	(0.1)	(0.1)	(0.3)	(0.3)
Ethanol, %							
Olefins, Vol. %					0.0	0.0	
Benzene, Vol. %		1.3	3.2	4.1	1.3	1.5	0.4
Sulfur, 100 Wt. PPM					0.0	2.3	
Reid Vapor Pressure, PSI	0.4	0.1	(0.1)	(11.7)	(1.9)	0.0	0.1
T90, 10°F					0.0	0.0	
Butane, Vol. %		(0.1)	(0.3)	(0.4)	(0.1)	0.0	
V.O.C., 10%		2.1	0.7	7.3	1.6	0.3	0.1
NOx, 10%							
T.A.P., 10%		0.1			0.2	0.2	0.0

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D2-9A
REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(¢/G per unit in constant 1990 \$)

	Base Case Q6 Target <u>Δ V.O.C.</u>	Case S6 Q6 + <u>100% RFG</u>	Case SN1 S6 + <u>7 RVP</u>	Case QN1 Q6 + <u>Max. Gaso.</u>	Case S10 Q6 + <u>30 Sul.</u>	Case S19 1995 CF <u>Full Opt In</u>
(R+M)/2 Octane, Clear	(0.5)	(0.4)	(0.7)	(0.8)	(0.6)	(0.3)
Aromatics, Vol. %		0.0		0.0		
Ethers, Vol. %	(0.4)	(0.4)	(0.1)	(0.1)	(0.3)	(0.4)
Ethanol, %						
Olefins, Vol. %				0.0	0.0	
Benzene, Vol. %	1.7	3.2	4.1	2.0	2.4	0.5
Sulfur, 100 Wt. PPM					3.1	
Reid Vapor Pressure, PSI		(0.1)	(11.7)	(2.9)		
T90, 10°F						
Butane, Vol. %	(0.1)	(0.3)	(0.4)	(0.1)	(0.1)	
V.O.C., 10%	3.4	0.7	7.3	2.5	0.4	0.2
NOx, 10%						
T.A.P., 10%						

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D2-9B**CONVENTIONAL GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]****IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS****NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY**

(¢/G per unit in constant 1990 \$)

	<u>Base Case Q9</u>	<u>Base Case Q6 Target Δ V.O.C.</u>	<u>Case QN1 Q6 + Max. Gaso.</u>	<u>Case S10 Q6 + 30 Sul.</u>	<u>Case S19 1995 CF Full Opt In</u>
(R+M)/2 Octane, Clear	(0.5)	(0.6)	(0.9)	(1.1)	(0.4)
Aromatics, Vol. %					
Ethers, Vol. %					
Ethanol, %					
Olefins, Vol. %			0.0	0.1	
Benzene, Vol. %		0.7			
Sulfur, 100 Wt. PPM			0.0	0.8	
Reid Vapor Pressure, PSI	0.4	0.3		0.1	0.3
T90, 10°F			0.1	0.0	
Butane, Vol. %					
V.O.C., 10%			0.1		0.0
NOx, 10%					
T.A.P., 10%		0.2	0.5	0.4	0.1

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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10/16/92

TABLE D2-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case SN1 S6 + 7 RVP	Case QN1 Q6 + Max. Gaso.	Case S10 Q6 + 30 Sul.	Case S19 1995 CF Full Opt In
<u>No. 2 Diesel Compositions</u>							
Hvy Reformate (300+) 90 RON				3.6			
Hvy Reformate (300+) 100 RON							
FCC Heavy Gaso Tr(300-375)						0.1	
FCC Heavy Gaso Tr(375-430)							
Lt Cycle Oil – Treated	5.5	6.1	10.3	1.9	2.7	3.9	5.7
Coker Dist – Treated	4.4	4.4	8.4	2.4	8.5	8.2	2.3
Total High Aromatic	9.9	10.5	18.7	7.9	11.2	12.3	8.0
Heavy Alkylate (300+)				0.0			
Lt Kero – Treated (300-375)	4.0	3.2	2.3	3.0	5.2	3.8	4.5
Kero (375-500)	15.6	15.6	13.3	11.8	14.8	13.1	15.6
Kero – Treated (375-500)	23.4	26.3	26.7	19.9	17.0	21.7	23.1
Kero – Low Aromatics (375-500)							
Diesel Base	8.3	8.2	5.7	11.1	8.7	10.6	8.3
Diesel Base – Treated	38.8	36.2	33.2	46.2	43.0	38.6	40.4
Diesel Base – Low Aromatics							
Lt Cycle Oil – Low Aromatics							
Coker Dist – Low Aromatics							
Total Low Aromatic	90.1	89.5	81.3	92.1	88.8	87.7	92.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>							
Diesel Ignition Improver							
Pour Point Depressant							
Aromatics	25.4	25.6	27.4	25.5	25.5	25.5	25.4
<u>Jet A Compositions</u>							
Heavy Alkylate (300+)							
Lt Kero – Treated (300-375)	36.2	32.8	33.3	42.9	32.8	36.5	35.4
Kero – Treated (375-500)	41.7	34.7	35.7	55.3	65.2	46.9	40.0
Hydrocracked Jet (295-525)	22.1	32.5	31.0	1.9	2.0	16.6	24.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE D3-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 – Constant Demands					2010	
	Base Case Q9	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
<u>Reformulated Limits*</u>							
Aromatics, Vol.%, Maximum Avg							
Oxygen, Wt%, Minimum Avg		2.1	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg							
Benzene, Vol%, Maximum Avg		0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg							
Reid Vapor Pressure, PSI, Min		6.5	6.5	6.5	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max							
Regulatory Cap							
T50, °F, Maximum Avg							
T90, °F, Maximum Avg							
V.O.C., % Reduction		45	45	45	45	45	45
T.A.P., % Reduction		30	30	30	30	30	30
% Class C, Fixed	40	40	40	40	40	40	40
<u>Ethers, V% Pool</u>							
Purchased (Sold)	0.1	4.4	4.4	5.2	4.4	4.5	4.3
Manufactured	1.9	3.0	3.0	2.5	3.0	2.9	3.1
<u>Gasoline Pool Properties</u>							
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	30.9	27.6	26.9	27.3	27.2	27.2	27.6
Ethers, Vol.%	2.0 *	7.4 *	7.4 *	7.7	7.4 *	7.4 *	7.4 *
Oxygen, Wt. %	0.4 *	1.3 *	1.3 *	1.4	1.3 *	1.3	1.3
Olefins, Vol. %	13.6	12.2	12.4	11.9	12.6	12.5	12.7
Benzene, Vol. %	1.8	1.1 *	1.1 *	1.1 *	1.1 *	1.1 *	1.0
Sulfur, WPPM	206	157	188	185	186	224 *	138
Reid Vapor Pressure, PSI*	7.9	7.0	7.3	7.3	7.3	7.1	7.3
Temperature at V/L = 20, °F	142	146	145	145	145	146	145
Distillation							
T10, °F	117	125	123	125	123	125	122
T50, °F	211	205	204	206	204	205	203
T90, °F	347	345	344	344	344	339	345
Specific Gravity	0.7469	0.7461	0.7444	0.7455	0.7446	0.7450	0.7450
Heat Content, MBTU/G	114.0	112.9	112.7	112.8	112.7	112.8	112.7
V.O.C., gm/mile	1.04	0.83 *	0.91 *	0.90 *	0.91 *	0.87 *	0.90 *
- % Reduction	19	35 *	29 *	30 *	29 *	32 *	30 *
NOx, index	0.98	0.97	0.98	0.98	0.98	0.99	0.97 *
- % Reduction	2	3	2	2	2	1	3 *
T.A.P., mg/mile	50	40	41 *	41 *	41 *	41 *	41 *
- % Reduction	6	24	21 *	21 *	21 *	22 *	22 *

* Input limit.

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1/28/93

TABLE D3-1A
RUN BASIS AND REFORMULATED GASOLINE POOL PROPERTIES
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 – Constant Demands				2010	
	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
Reformulated Limits*						
Aromatics, Vol.%, Maximum Avg						
Oxygen, Wt%, Minimum Avg	2.1	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg						
Benzene, Vol%, Maximum Avg	0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg						
Reid Vapor Pressure, PSI, Min	6.5	6.5	6.5	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max						
Regulatory Cap						
T50, °F, Maximum Avg						
T90, °F, Maximum Avg						
V.O.C., % Reduction	45	45	45	45	45	45
T.A.P., % Reduction	30	30	30	30	30	30
% Class C, Fixed	40	40	40	40	40	40
Ethers, V% Pool						
Purchased (Sold)						
Manufactured						
Gasoline Pool Properties						
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	23.7	24.1	24.1	23.6	23.5	24.1
Ethers, Vol.% *	11.7	11.7	11.7	11.7	11.7	11.7
Oxygen, Wt.% *	2.1	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%	10.7	11.2	10.9	11.4	11.1	11.8
Benzene, Vol.% *	0.7	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM	141	198	183	187	233	122
Reid Vapor Pressure, PSI*	6.5	6.5	6.5	6.5	6.5	6.5
Temperature at V/L = 20, °F	149	149	149	149	149	149
Distillation						
T10, °F	134	134	134	135	135	134
T50, °F	203	205	205	204	202	203
T90, °F	342	342	343	344	333	345
Specific Gravity	0.7444	0.7449	0.7452	0.7444	0.7435	0.7452
Heat Content, MBTU/G	112.0	112.0	112.1	112.0	111.9	112.0
V.O.C., gm/mile*	0.71	0.71	0.71	0.71	0.71	0.71
- % Reduction*	45	45	45	45	45	45
NOx, index	0.97	0.99	0.98	0.98	1.00	0.97
- % Reduction	3	1	2	2	0	3
T.A.P., mg/mile	34	35	35	35	35	34
- % Reduction	35	34	34	34	34	35

* Input limit.

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1/28/93

TABLE D3-1B
RUN BASIS AND CONVENTIONAL GASOLINE POOL PROPERTIES
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 – Constant Demands					2010	
	Base Case Q9	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
<u>Conventional Limits*</u>							
Aromatics, Vol.%, Maximum Avg							
Oxygen, Wt%, Minimum Avg							
Olefins, Vol.%, Maximum Avg							
Benzene, Vol%, Maximum Avg		1.7	1.7	1.7	1.7	1.7	1.7
Sulfur, WPPM, Maximum Avg							
Reid Vapor Pressure, PSI, Min							
Reid Vapor Pressure, PSI, Max	7.9	7.9	8.7	8.7	8.7	8.7	8.7
Regulatory Cap	8.2	8.2	9.0	9.0	9.0		
T50, °F, Maximum Avg							
T90, °F, Maximum Avg	356	356	356	356	356	356	356
V.O.C., % Reduction							
T.A.P., % Reduction							
% Class C, Fixed	40	40	40	40	40	40	40
<u>Ethers, V% Pool</u>							
Purchased (Sold)							
Manufactured							
<u>Gasoline Pool Properties</u>							
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol. %	30.9	34.3	31.7	32.7	33.2	33.5	33.7
Ethers, Vol. %	2.0 *			0.9			
Oxygen, Wt. %	0.4 *			0.2			
Olefins, Vol. %	13.6	14.8	14.6	13.5	14.6	14.8	14.3
Benzene, Vol. %	1.8	1.7 *	1.7 *	1.7 *	1.7 *	1.7 *	1.6 *
Sulfur, WPPM	206	186	171	189	184	210 *	165
Reid Vapor Pressure, PSI	7.9 *	7.9 *	8.7 *	8.6 *	8.7 *	8.3	8.6 *
Temperature at V/L = 20, °F	142	143	138	139	138	140	138
<u>Distillation</u>							
T10, °F	117	109	105	109	102	108	103
T50, °F	211	208	204	206	204	210	204
T90, °F	347	351	347	346	343	351	344
Specific Gravity	0.7469	0.7491	0.7435	0.7459	0.7449	0.7475	0.7448
Heat Content, MBTU/G	114.0	114.5	113.9	114.0	114.0	114.4	114.0
V.O.C., gm/mile	1.04	1.05	1.26	1.23	1.26	1.15	1.23
- % Reduction	19	18	2	4	2	11	4
NOx, index	0.98	0.97	0.97	0.97	0.98	0.98	0.97 *
- % Reduction	2	3	3	3	2	2	3 *
T.A.P., mg/mile	50	51	53 *	53 *	53 *	52 *	52 *
- % Reduction	6	4	0 *	0 *	0 *	1 *	1 *

* Input limit.

CLM/GWM/REC
1/28/93

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TABLE D3-2
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(in constant 1990 \$)

	2000 F2 - Constant Demands				2010	
	Base Case[3][4] Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
Investment, MM\$						
Refinery	2,719	594			2,318	(392)
MTBE[5]	<u>3,572</u>	<u>(23)</u>	<u>1,262</u>	<u>(2)</u>	<u>586</u>	<u>(576)</u>
Total	6,291	571	1,262	(2)	2,904	(968)
Range, MMM\$[6]	5.3 - 8.5	0.5 - 0.8	1.1 - 1.7	(0.0) - (0.0)	2.5 - 3.9	(0.8) - (1.3)
Daily Costs, M\$/D						
Capital Charge[7]	2,035	284			1,201	(274)
Net Upgrading[8]	2,901	(1,214)	(1,060)	(337)	(6,048)	3,681
Variable Operating	(24)	217	1,052	123	1,854	(1,512)
Fixed Operating[9]	<u>857</u>	<u>115</u>	<u>—</u>	<u>—</u>	<u>502</u>	<u>(126)</u>
Total Refinery	5,769	(598)	(8)	(214)	(2,491)	1,769
Annual Costs, MM\$/Yr.						
Refinery	2,106	(218)	(3)	(78)	(909)	645
Other[10]	<u>563</u>	<u>47</u>	<u>5</u>	<u>94</u>	<u>53</u>	<u>82</u>
Total	2,669	(171)	2	16	(856)	727
Total Unit Costs, ¢/G of						
Upgraded Product or Crude						
Average	8.8	(1.9) [11]	0.0 [12]	1.2 [13]	(3.7) [14]	5.8 [15]
Range[16]	7.3 - 11.5	(2.2) - (1.4)	0.0 - 0.0	(0.5) - 2.9	(4.2) - (2.7)	6.1 - 5.2

[1] Based on normal investment costs, capital fixed costs, net upgrading and variable costs over case Q6N, which is over base case Q9.

[2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.

[3] Adjusted using individual unit capital charge/fixed operating costs multipliers to include the full cost of extra facilities for summer RFG as detailed on Table A3-19.

[4] Adjusted CG RVP to 8.7 psi. For CG, refinery net upgrading costs were reduced 0.38¢/G and consumer (other) costs were increased 0.21¢/G resulting in a net costs reduction of 0.11¢/G. This equates to reducing the costs of RFG by 0.06¢/G.

[5] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).

[6] For variations from investment curves of -15/+35%.

[7] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.

[8] Raw material upgrading costs.

[9] For new refining facilities only.

[10] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining included in refinery costs.

[11] Delivered crude costs Δ WTI/LHS - Arab Hvy = \$3.41/B input vs. calculated Δ RRV of \$2.60/B for a savings of \$0.81/B or 1.9¢/G switched (580 MBPD or 10% of run). LP took advantage of idle existing facilities to reduce Δ RRV.

[12] Adjusted to eliminate 10¢/G Δ margin on incremental gasoline make of 540 MBPD or by \$873MM/yr. Incremental costs for both CG and RFG is 10¢/G below CG base prices.

[13] Per gallon of additional Jet A produced. Refinery jet margin of 5.7¢/G (\$214M/D for 89MB/D (13%) additional Jet A) is offset by a reduction in the BTU content of the gasoline pool (\$94MM or 6.9¢/G Jet A) for a net cost of additional Jet A produced of 1.2¢/G.

[14] For incremental crude charge over base case Q6N = 3.7¢/G or \$1.55/B (increased earnings).

[15] For decremental crude charge over base case Q6N = 5.8¢/G or \$2.44/B cost (lost earnings).

[16] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G), and BTU mileage factor (±0.2).

REC/CLM

5/11/93

TURNER, MASON & COMPANY
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TABLE D3-2A
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IIIC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS UNADJUSTED[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Base Case Q6N = Q6 + Δ Cap. Chg.	Q3 Q6N Units Max. Gaso.
<u>Investment, MM\$</u>		
Refinery	2,719	
MTBE[3]	<u>3,572</u>	<u>1,262</u>
Total	6,291	1,262
Range, MMM\$[4]	5.3 – 8.5	1.1 – 1.7
<u>Daily Costs, M\$/D</u>		
Capital Charge[5]	1,266	
Net Upgrading[6]	3,090	(1,060)
Variable Operating	(24)	1,052
Fixed Operating[7]	<u>604</u>	<u> </u>
Total Refinery	4,936	(8)
<u>Annual Costs, MM\$/Yr.</u>		
Refinery	1,802	(3)
Other[8]	<u>516</u>	<u>5</u>
Total	2,318	2
<u>Total Unit Costs, ¢/G of</u>		
<u>Upgraded Conventional Gasoline</u>		
Average	7.6	0.0 [10]
Range[9]	6.3 – 10.0	0.0 – 0.0

[1] Based on normal investment costs, capital fixed costs, net upgrading and variable costs over base case.

[2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery will differ from average. Unadjusted LP case results shown before capital charge and GC RVP adjustments if these were required.

[3] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).

[4] For variations from investment curves of -15/+35%.

[5] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.

[6] Raw material upgrading costs.

[7] For new refining facilities only.

[8] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining included in refinery costs.

[9] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G), and BTU mileage factor (±0.2).

[10] Adjusted to eliminate 10¢/G Δ margin on incremental gasoline make of 570 MBPD or \$873MM/yr.

REC/CLM
10/16/92

TABLE D3-3
REFINING RAW MATERIAL AND PRODUCT RATES – MBPCD
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 – Constant Demands					2010	
	Base Case Q9	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
Raw Materials							
Domestic – S	1,985	1,985	1,405	1,985	1,985	1,965	1,999
HL	174	174	174	174	174	174	174
HH	692	692	692	692	692	252	1,077
Foreign – S	732	732	732	732	732	1,248	331
HL	669	669	669	669	669	1,111	4
HH	1,648	1,531	2,167	2,066	1,628	2,546	1,386
Subtotal Crudes	5,900	5,783	5,839	6,319	5,880	7,296	4,972
MTBE	3	141	139	193	141	163	119
Ethanol							
Normal Butane							
Isobutane	54	46	52	73	46	68	46
Natural Gas to H2 Plant Feed	20	24	24	24	24	48	21
Methanol	21	32	33	32	33	35	29
Other Raw Materials	447	447	447	447	447	455	455
Total Raw Materials	6,445	6,473	6,533	7,088	6,570	8,064	5,643
Products							
Motor Gasolines							
Conventional	3,151	1,173	1,177	1,370	1,177	1,321	1,030
Oxygenated							
Reformulated/Oxygenated							
Reformulated		2,009	2,010	2,350	2,010	2,265	1,754
CARB2							
Kero Jet/Kerosene	686	686	686	686	775	1,042	578
Diesel/No. 2 Fuels							
Diesel – LA, ULS							
Diesel – 0.05%S	940	940	940	940	940	1,192	799
No. 2 Fuel	289	289	289	289	289	366	246
No. 6 Fuel (1% Sul)	57	57	57	57	57	182	57
No. 6 Bunker	57	57	57	97	57	75	33
Marketable Coke – 400 #	180	174	222	192	180	192	170
Catalytic Coke – 400 #	97	94	100	108	98	119	79
Vacuum Gas Oil							
Benzene	21	21	21	21	21	24	21
Toluene	25	25	25	25	25	22	25
Heavy Aromatic Gaso							
Pentanes to P/C							
Natural Gasoline to P/C	134	134	134	134	134	116	86
Normal Butane	22	55	48	39	44	64	37
Isobutane	12	13	12	12	16	12	46
Propane	151	144	152	159	145	168	126
Process Gas/C2/C2=,FOE	365	337	353	374	342	421	301
Other Products	576	576	576	576	576	817	547
(Gain)/Loss	(318)	(311)	(326)	(342)	(317)	(334)	(293)
Total Products	6,445	6,473	6,533	7,088	6,570	8,064	5,643
Crude Properties							
Gravity, °API	32.8	32.9	32.0	32.6	32.8	33.2	32.0
Sulfur, Wt%	1.20	1.18	1.44	1.28	1.20	1.32	1.13
Gasoline Demand Increase, %[1]							
Results		1.0	1.1	1.1	1.1	1.0	1.1
Target		1.0	1.2	1.1	1.2	1.1	1.2

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

TABLE D3-4
NEW PROCESS UNIT RATES - MBPSD
IIIC - SUMMER - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 - Constant Demands				2010	
	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude[1][2]	Q3 Q6N Units Max. Gaso.[1]	Q5S Q6N Units Max K Jet[1]	F1 Hi Demand Base[1]	F3 Lo Demand Base[1]
Crude - Atmospheric					639	
Heavy Naphtha Splitter						
Catalytic Cracking						
FCC Gasoline Splitters	135	20			94	(18)
FCC Gasoline Fractionation						
Hydrocracking - 2 Stage						
Hydrocracking - 2 Stage Distillate						
- Hvy Gasoline						
Hydrocrackate Fractionation						
Coker - Delayed		69				
Coker Lt Gasoline DS/Splitter	24	25			6	(22)
Hydrotreating - Naphtha						
- FCC/Coker C6s						
- Distillate					582	
- Heavy Gas Oil						
Reformer Feed Fractionation	1,463				264	(150)
Reformat Fractionation	255				45	(18)
Aromatics Extraction						
Benzene Saturation	62				15	(14)
FCC Gasoline HDS						
Diesel Aromatics Saturation						
Alkylation						
Alkylate Splitter						
MTBE	26	0			8	(8)
TAME						
Isomerization - C5/C6						
- C5/C6, Recycle						
- C4						
Hydrogen - MMSCFPSD						
Sulfur - LTPSD						
C4 Rerun - Saturates	203				15	(39)
- Unsaturation	501				54	(74)
Catalytic Reforming - 100 PSI						
Hydrotreating - Distillate Upgrade						
Dehydrogenation - IC4						

[1] Additions to Q6N facilities.

[2] Required to run additional 10% of total crude runs as heavy high sulfur crude, reducing light low sulfur crude consumption.

TABLE D3-5
NEW PROCESS UNIT INVESTMENTS
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(\$MM – in constant mid-1990 \$)

	2000 F2 – Constant Demands				2010	
	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude[1]	Q3 Q6N Units Max. Gaso.[1]	Q5S Q6N Units Max K Jet[1]	F1 Hi Demand Base[1]	F3 Lo Demand Base[1]
Crude Distillation					695	
Heavy Naphtha Splitter						
Catalytic Cracking						
FCC Gasoline Splitters	128	15			133	(15)
FCC Gasoline Fractionation						
Hydrocracking – 2 Stage						
Hydrocracking – 2 Stage Distillate – Heavy Gasoline						
Hydrocrackate Fractionation						
Coker – Delayed		532				
Coker Lt. Gasoline DS/Splitter	44	45			12	(41)
Hydrotreating – Naphtha						
– FCC Coker C6s						
– Distillate					1,068	
– Heavy Gas Oil						
Reformer Feed Fractionation	886				158	(97)
Reformate Fractionation	274				46	(18)
Aromatics Extraction						
Benzene Saturation	218				53	(29)
FCC Gasoline HDS						
Diesel Aromatics Saturation						
Alkylation						
Alkylate Splitter						
MTBE	216	2			71	(66)
TAME						
Isomerization – C5/C6						
– C5/C6, Recycle						
– C4						
Hydrogen						
Sulfur						
MTBE Storage & Blending	111				16	(12)
C4 Rerun – Saturates	236				18	(49)
– Unsaturation	444				48	(65)
C4 Fractionation Upgrades	162					
Catalytic Reforming – 100 PSI						
Hydrotreating – Distillate Upgrade						
Dehydrogenation – IC4						
Total Refinery	2,719	594			2,318	(392)

[1] Above Q6N facilities investment.

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TABLE D3-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 – Constant Demands					2010	
	Base Case Q9	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
Crude – Atmospheric	134.1	131.4	132.7	143.6	133.6	165.8	113.0
Heavy Naphtha Splitter							
Catalytic Cracking[1]	50.2	48.7	49.0	56.1	49.4	54.9	42.5
Catalytic Cracking[2]	46.7	45.3	45.4	51.5	45.9	50.8	39.4
Conversion, %	77.5	77.7	77.9	77.8	77.5	79.0	77.8
Octane Catalyst, %	68.5	68.9	68.8	68.7	69.5	74.1	67.7
FCC Gasoline Splitters		2.9	3.3	2.9	2.9	4.9	2.5
FCC Gasoline Fractionation	11.7	11.7	11.7	11.7	11.7	11.7	9.9
Hydrocracking – 2 Stage[1]	9.8	9.3	8.9	9.8	9.8	9.8	8.6
Jet Yield, % of Max	64.4	72.8	78.2	63.7	100.0	100.0	66.1
300 – Gasoline Operation, %							
Hydrocracking – 2 Stage Distillate							
Hydrocracking – Low Conversion	1.5	1.5	1.5	2.2	2.2	1.5	1.3
– Hvy Gasoline							
– Combined[2]	11.3	10.8	10.4	12.0	12.0	11.3	9.9
Hydrocrackate Fractionation							
Coking – Delayed	13.3	12.8	15.6	14.2	13.2	14.2	12.6
– Fluid	0.7	0.7	0.8	0.8	0.7	0.8	0.6
Coker Lt Gasoline DS/Splitter		0.5	1.0	0.5	0.5	0.6	0.0
Thermal Cracking, Visbreaking	1.5	1.5	1.5	1.5	1.2	1.5	1.5
Solvent Deasphalting	1.8	1.7	1.8	2.6	2.0	4.0	1.2
Catalytic Reforming – 100 PSI[1]	16.0	14.0	14.9	17.5	14.3	17.4	12.0
– 200 PSI[1]	11.1	11.1	9.2	11.1	10.1	11.0	10.6
– 450 PSI[1]	7.1	5.7	5.7	5.7	5.7	6.6	4.7
– Combined[2]	33.0	30.0	29.7	34.2	29.7	34.6	26.8
– RONC	96.9	95.2	94.6	94.9	94.9	94.7	95.2
Hydrotreating – Naphtha	31.5	30.6	30.5	34.2	31.1	36.1	27.4
– FCC/Coker C6s							
– Distillate	33.3	33.3	33.3	33.3	33.3	45.5	28.0
– Heavy Gas Oil	16.3	16.3	17.2	17.3	16.3	16.3	16.3
– Residuum – Atm	6.9	6.9	6.9	6.9	6.9	6.9	6.9
Reformer Feed Fractionation		30.6	30.5	31.3	30.6	36.1	27.4
Reformate Fractionation	7.7	13.5	8.7	13.5	13.5	14.4	13.1
Aromatics Extraction	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Benzene Saturation		1.3	1.3	1.3	1.3	1.6	1.0
FCC Gasoline HDS							
Diesel Aromatics Saturation							
Alkylation	8.4	8.0	8.2	9.9	7.9	9.6	6.0
Alkylate Splitter							
Polymerization	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Dehydrogenation – IC4	0.7	0.7	0.7	0.7	0.7	0.7	0.7
MTBE	1.4	1.9	1.9	1.9	1.9	2.1	0.7
TAME		0.3	0.3	0.3	0.3	0.3	0.2
Hydrodealkylation – Toluene							
Lubes	2.2	2.2	2.2	2.2	2.2	2.2	1.5
Isomerization – C5/C6	2.2	2.2	2.2	2.2	2.2	2.2	2.2
– C5/C6, Recycle	2.2	2.2	2.2	2.2	2.2	2.2	2.2
– C4	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Hydrogen – MMSCFPCD	19.7	22.7	23.0	22.8	23.0	23.0	20.7
Sulfur, STPCD	134	130	149	149	134	166	112
C4 Rerun – Saturates		4.2	4.2	4.2	4.2	4.6	3.4
– Unsaturation		10.5	10.5	10.5	10.5	11.6	8.9

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

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TABLE D3-7
PROCESS UNIT UTILIZATIONS - %[1]
IIIC - SUMMER - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 - Constant Demands					2010	
	Base Case Q9	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
Crude Distillation - Atmospheric	85.7	84.0	84.8	91.8	85.5	97.0 *	72.2
Heavy Naphtha Splitter							
Catalytic Cracking[2]	84.2	81.7	82.1	94.0 *	82.8	92.0	71.2
Catalytic Cracking[3]	78.3	75.9	76.0	86.4	77.0	85.2	66.1
FCC Gasoline Splitters		94.0 *	94.0 *	94.0 *	94.0 *	94.0 *	94.0 *
FCC Gasoline Fractionation	81.9	81.9	81.9	81.9	81.9	81.9	69.3
Hydrocracking - 2 Stage[2]	87.0	82.9	79.1	87.0 *	87.0 *	87.0 *	76.7
Hydrocracking - 2 Stage Distillate							
- Low Conversion	58.5	58.5	58.5	87.0 *	87.0 *	58.5	50.7
- Heavy Gasoline							
- Combined[3]	81.7	78.3	75.3	87.0 *	87.0 *	81.7	71.8
Hydrocrackate Fractionation							
Coking - Delayed	86.1	82.9	92.0 *	92.0 *	85.8	92.0 *	81.6
- Fluid	85.9	85.9	92.0 *	92.0 *	85.9	92.0 *	72.6
Coker Lt Gasoline DS/Splitter		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Thermal Cracking, Visbreaking	92.0 *	92.0 *	92.0 *	92.0 *	74.4	92.0 *	88.1
Solvent Deasphalting	40.3	40.0	41.5	58.9	45.8	92.0 *	28.3
Catalytic Reforming - 100 PSI[2]	84.4	73.6	78.4	92.0 *	75.4	91.3	63.1
- 200 PSI[2]	92.0 *	92.0	76.8	92.0 *	84.0	91.6	88.6
- 450 PSI[2]	69.3	55.6	55.6	55.6	55.6	64.4	45.9
- Combined[3]	79.8	72.7	72.0	82.9	72.0	83.7	65.0
Hydrotreating - Naphtha	73.5	71.3	71.2	79.7	72.4	84.2	64.0
- FCC/Coker C6s							
- Distillate	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	77.2
- Heavy Gas Oil	86.6	86.6	91.4	92.0 *	86.6	86.6	86.6
- Residuum, Atm	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Reformer Feed Fractionation		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Reformate Fractionation	85.0	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Aromatics Extraction	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Benzene Saturation		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
FCC Gasoline HDS							
Diesel Aromatics Saturation							
Alkylation	69.5	65.9	67.7	81.2	64.9	78.8	49.8
Alkylate Splitter							
Polymerization	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Dehydrogenation - IC4	86.4	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *
MTBE	91.0 *	91.0 *	91.0 *	91.0 *	91.0 *	90.0 *	90.0 *
TAME	0.0	50.1	55.0	49.6	49.9	51.4	40.3
Hydrodealkylation - Toluene	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lubes	82.0	82.0	82.0	82.0	82.0	82.0	56.0
Isomerization - C5/C6	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
- C5/C6, Recycle	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
- C4	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *	89.0 *
Hydrogen	76.1	87.9	89.0 *	88.3	89.0 *	89.0 *	80.3
Sulfur	53.0	51.4	58.9	58.9	53.0	65.6	44.3
C4 Rerun - Saturates		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
- Unsaturates		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

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TABLE D3-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 - Constant Demands					2010	
	Base Case	Base Case	S3HH	Q3	Q5S	F1 Hi	F3 Lo
	Q9	Q6N = Q6+ Δ Cap. Chg.	Q6N Units + HH Crude	Q6N Units Max. Gaso.	Q6N Units Max K Jet	Demand Base	Demand Base
FCC Gasoline	20.8	19.7	19.4	20.8	19.9	15.3	20.3
Lt. FCC 255-	9.5	5.5	5.6	4.8	5.6	8.4	5.2
Hvy FCC 255+	6.8	6.6	6.1	5.7	6.7	5.9	6.4
Hvy FCC 255+ Desulf.							
FCC Gaso (100-180)		1.4	1.4	1.1	1.3	1.2	1.4
FCC Gaso (180-225)		0.8	0.8	0.7	0.8	0.8	0.8
FCC Gaso (225-300)		0.6	0.8	0.6	0.6	1.4	0.6
FCC Gaso (300-375)			0.2			0.6	
FCC Gaso (375-430)							
Total FCC Gasoline	37.1	34.6	34.2	33.6	34.9	33.6	34.8
Butenes							
Pentenes			0.2		0.3	0.3	0.3
Poly Gasoline	0.6	0.6	0.6	0.5	0.6	0.5	0.6
Lt. Coker Gasoline	1.3	0.5	0.9	0.6	0.5	0.5	0.8
Total Olefinic	1.9	1.1	1.7	1.0	1.4	1.3	1.7
Reformate	16.7	20.7	18.7	21.8	18.7	20.4	20.7
Reformate (220-300 Feed)	4.5	1.2	2.8	1.4	2.7	1.7	1.1
BT Reformate	5.0	0.1	0.2		0.1	0.1	
HC Reformate (210-300)	2.3	3.6	3.2	2.9	3.4	4.3	3.8
Heavy Reformate (300+)	1.5	0.3	0.7	0.3	0.3	0.3	0.4
Toluene / Xylenes	0.1	0.1	0.1	0.2	0.2	0.1	0.1
Total Reformates[1]	30.1	26.0	25.8	26.5	25.4	26.8	26.0
Lt. Reformate	1.3	0.6	0.7	0.7	0.9	0.9	0.6
Lt. Raffinate B(C5-210)	2.4	4.5	4.2	3.6	4.2	4.4	4.6
Alkylate/Lt Alkylate (C3/C4)	11.7	10.1	10.6	10.9	10.4	11.3	9.3
Alkylate/Lt Alkylate (C5)		0.7	0.5	0.6	0.3	0.2	0.2
Butane	3.7	2.3	2.8	2.9	2.7	2.7	2.5
Natural/LSR Gaso	0.1	0.4	0.3	0.9	0.5		
BT Naphtha (150-220)		0.5	0.3	0.9	0.3	1.0	
Pentanes (I/N)		0.7	0.9	0.6	0.6	0.7	0.6
Isomerate (C5-C6)	6.0	5.9	5.9	5.0	5.9	5.2	6.7
Isomerate (C6)							
Lt. Hydrocrackate (C5-180)	2.6	2.4	2.2	2.3	2.4	2.1	2.6
Medium Hydrocrackate (180-225)	1.1	2.8	2.6	2.6	2.7	2.4	2.9
MTBE	2.0	7.0	7.0	7.4	7.0	7.1	7.1
TAME		0.4	0.4	0.3	0.4	0.3	0.3
Alcohol							
Total Low Arom., Saturated	30.9	38.3	38.4	38.8	38.3	38.3	37.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.
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TABLE D3-8A
REFORMULATED GASOLINE POOL COMPOSITIONS - %
IIIC - SUMMER - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 - Constant Demands				2010	
	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
FCC Gasoline	22.4	24.4	26.8	21.6	22.9	22.3
Lt. FCC 255-		0.4				0.7
Hvy FCC 255+	6.1	4.0	4.3	6.9	3.0	7.7
Hvy FCC 255+ Desulf.						
FCC Gaso (100-180)	1.2	0.0	0.2	1.7	1.4	1.8
FCC Gaso (180-225)	0.8	0.0	0.1	1.1	0.9	1.3
FCC Gaso (225-300)	0.6	1.3	0.2	0.8	1.9	0.9
FCC Gaso (300-375)		0.3				
FCC Gaso (375-430)						
Total FCC Gasoline	31.2	30.4	31.7	32.1	30.1	34.7
Butenes						
Pentenes		0.3		0.4	0.5	0.1
Poly Gasoline	0.9	0.9	0.8	0.9	0.8	1.0
Lt. Coker Gasoline	0.7	1.4	0.4	0.7		
Total Olefinic	1.6	2.6	1.2	2.0	1.3	1.1
Reformate	14.3	17.2	15.8	15.5	13.4	12.5
Reformate (220-300 Feed)	1.9	0.8	2.3	0.7	2.6	1.7
BT Reformate						
HC Reformate (210-300)	5.8	5.1	4.6	5.3	6.8	6.0
Heavy Reformate (300+)	0.0	0.5	0.4	0.1	0.5	0.6
Toluene/Xylenes	0.1		0.3		0.1	
Total Reformates[1]	22.1	23.6	23.3	21.6	23.5	20.9
Lt. Reformate						
Lt. Raffinate B(C5-210)	7.1	6.7	5.8	6.7	7.0	7.4
Alkylate/Lt Alkylate (C3/C4)	13.0	12.6	13.5	13.6	14.2	11.7
Alkylate/Lt Alkylate (C5)	1.2	0.8	0.9	0.5	0.3	0.2
Butane*	2.0	1.9	1.9	2.0	2.0	2.0
Natural/LSR Gaso	0.6	0.4	1.5	0.5		
BT Naphtha (150-220)	0.7	0.5	1.4	0.5	1.6	
Pentanes (I/N)	0.0	0.0	0.0	0.0	0.1	0.0
Isomate (C5-C6)	5.8	5.2	5.0	5.2	4.9	6.1
Isomate (C6)						
Lt. Hydrocrackate (C5-180)	1.3	1.5	0.9	1.6	1.4	1.8
Medium Hydrocrackate (180-225)	1.6	1.8	1.1	1.9	1.7	2.3
MTBE	11.2	11.1	11.2	11.2	11.2	11.2
TAME	0.6	0.6	0.5	0.6	0.5	0.5
Alcohol						
Total Low Arom., Saturated	45.0	43.3	43.8	44.3	45.1	43.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

* Minimum.

[1] Excluding Lt. Reformate and Lt. Raffinate.

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TABLE D3-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS – %
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 - Constant Demands					2010	
	Base Case Q9	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
FCC Gasoline	20.8	15.0	10.8	10.5	16.9	2.2	17.0
Lt. FCC 255-	9.5	15.1	14.3	12.8	15.0	23.0	13.1
Hvy FCC 255+	6.8	7.4	9.6	8.0	6.2	10.8	4.2
Hvy FCC 255+ Desulf.							
FCC Gaso (100-180)		1.7	3.7	2.7	0.9	0.8	0.6
FCC Gaso (180-225)		0.8	2.2	1.6	0.3	0.4	
FCC Gaso (225-300)		0.5		1.0	0.2	0.6	
FCC Gaso (300-375)						1.8	
FCC Gaso (375-430)							
Total FCC Gasoline	37.1	40.5	40.5	36.8	39.5	39.6	34.9
Butenes							
Pentenes			0.0				0.6
Poly Gasoline	0.6						
Lt. Coker Gasoline	1.3	0.2		0.8	0.2	1.3	2.1
Total Olefinic	1.9	0.2	0.0	0.8	0.2	1.3	2.7
Reformate	16.7	31.6	21.3	32.1	24.4	32.3	34.5
Reformate (220-300 Feed)	4.5		6.2		6.0		
BT Reformate	5.0	0.3	0.6		0.2	0.2	
HC Reformate (210-300)	2.3						
Heavy Reformate (300+)	1.5	0.8	1.0		0.7		
Toluene / Xylenes	0.1		0.4		0.5		0.2
Total Reformates[1]	30.1	32.7	29.5	32.1	31.8	32.5	34.7
Lt. Reformate	1.3	1.7	1.9	2.0	2.4	2.5	1.6
Lt. Raffinate B(C5-210)	2.4						
Alkylate/Lt Alkylate (C3/C4)	11.7	5.3	7.3	6.4	4.8	6.3	5.3
Alkylate/Lt Alkylate (C5)			0.1	0.2	0.1	0.1	0.1
Butane	3.7	2.9	4.2	4.6	3.8	3.8	3.4
Natural/LSR Gaso	0.1				0.6		
BT Naphtha (150-220)							
Pentanes (I/N)		1.8	2.3	1.5	1.8	1.5	1.5
Isomerate (C5-C6)	6.0	6.1	7.0	5.1	7.0	5.7	7.7
Isomerate (C6)							
Lt. Hydrocrackate (C5-180)	2.6	4.2	3.4	4.5	3.8	3.1	3.9
Medium Hydrocrackate (180-225)	1.1	4.8	4.0	5.1	4.2	3.5	4.1
MTBE	2.0			0.9			
TAME							
Alcohol							
Total Low Arom., Saturated	30.9	26.7	30.0	30.3	28.5	26.5	27.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D3-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(¢/G per unit in constant 1990 \$)

	2000 F2 - Constant Demands					2010	
	Base Case Q9	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F 1 Hi Demand Base	F3 Lo Demand Base
(R+M)/2 Octane, Clear	(0.5)	(0.6)	(0.5)	(1.0)	(0.6)	(0.6)	(0.6)
Aromatics, Vol. %							
Ethers, Vol. %		(0.2)	(0.2)	(0.0)	(0.4)	(0.3)	(0.4)
Ethanol, %							
Olefins, Vol. %							
Benzene, Vol. %		1.6	0.6	2.0	1.3	1.4	1.5
Sulfur, 100 Wt. PPM						0.0	
Reid Vapor Pressure, PSI	0.4	0.3 [2]	0.3 [2]	(2.4)	0.3 [2]	(1.5)	0.2 [2]
T90, 10°F							
Butane, Vol. %		(0.1)	(0.1)	0.0	(0.1)	(0.0)	0.1
V.O.C., 10%		0.4	0.4	2.0	0.4	1.2	0.4
NOx, 10%							0.0
T.A.P., 10%			0.1	0.3	0.1	0.2	0.0

[1] Shadow costs for very small changes.

Not applicable for significant changes.

[2] Average of absolute values. RFG is at minimum RVP (negative cost), while CG is at maximum (positive cost).

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TABLE D3-9A
REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – SUMMER – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(\$/G per unit in constant 1990 \$)

	2000 F2 – Constant Demands				2010	
	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
(R+M)/2 Octane, Clear	(0.5)	(0.4)	(1.0)	(0.5)	(0.5)	(0.5)
Aromatics, Vol. %						
Ethers, Vol. %	(0.4)	(0.3)	(0.0)	(0.4)	(0.3)	(0.4)
Ethanol, %						
Olefins, Vol. %						
Benzene, Vol. %	2.1	0.9	2.9	1.9	2.0	2.1
Sulfur, 100 Wt. PPM						
Reid Vapor Pressure, PSI	(0.2)	(0.3)	(3.8)	(0.3)	(2.4)	(0.2)
T90, 10°F						
Butane, Vol. %	(0.2)	(0.1)	(0.1)	(0.2)	(0.0)	0.2
V.O.C., 10%	0.6	0.6	3.1	0.7	1.9	0.6
NOx, 10%						
T.A.P., 10%						

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D3-9B
CONVENTIONAL GASOLINE PROPERTY DECREASE - INCREMENTAL COSTS[1]
IIIC - SUMMER - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(¢/G per unit in constant 1990 \$)

	2000 F2 - Constant Demands					2010	
	Base Case Q9	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
(R+M)/2 Octane, Clear	(0.5)	(0.8)	(0.5)	(1.1)	(0.7)	(0.6)	(0.8)
Aromatics, Vol. %							
Ethers, Vol. %			(0.1)		(0.4)	(0.3)	(0.4)
Ethanol, %							
Olefins, Vol. %							
Benzene, Vol. %		0.9	0.0	0.3	0.4	0.3	0.6
Sulfur, 100 Wt. PPM						0.1	
Reid Vapor Pressure, PSI	0.4	0.5	0.3		0.3		0.3
T90, 10°F							
Butane, Vol. %							
V.O.C., 10%							
NOx, 10%							0.1
T.A.P., 10%			0.2	0.8	0.2	0.5	0.1

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D3-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IIIC - SUMMER - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	2000 F2 - Constant Demands					2010	
	Base Case Q9	Base Case Q6N = Q6+ Δ Cap. Chg.	S3HH Q6N Units + HH Crude	Q3 Q6N Units Max. Gaso.	Q5S Q6N Units Max K Jet	F1 Hi Demand Base	F3 Lo Demand Base
No. 2 Diesel Compositions							
Hvy Reformate (300+) 90 RON					0.1		
Hvy Reformate (300+) 100 RON							
FCC Heavy Gaso Tr(300-375)						0.7	
FCC Heavy Gaso Tr(375-430)							
Lt Cycle Oil - Treated	5.5	6.5	4.8	2.9	7.8	4.0	5.5
Coker Dist - Treated	4.4	3.3	8.0	9.1	3.3	7.8	4.8
Total High Aromatic	9.9	9.8	12.7	11.9	11.2	12.5	10.3
Heavy Alkylate (300+)					0.0	0.0	
Lt Kero - Treated (300-375)	4.0	4.3	3.7	3.3	3.4	2.9	3.8
Kero (375-500)	15.6	15.5	15.5	15.6	13.8	6.9	15.7
Kero - Treated (375-500)	23.4	23.0	22.5	23.3	25.5	23.0	23.7
Kero - Low Aromatics (375-500)							
Hydrocracked Jet (295-525)							
Diesel Base	8.3	7.6	7.3	7.9	10.3	16.7	8.6
Diesel Base - Treated	38.8	39.8	38.3	37.9	35.8	38.0	37.9
Diesel Base - Low Aromatics							
Lt Cycle Oil - Low Aromatics							
Coker Dist - Low Aromatics							
Total Low Aromatic	90.1	90.2	87.3	88.1	88.8	87.5	89.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Properties							
Diesel Ignition Improver							
Pour Point Depressant					Yes		
Aromatics	25.4	25.9	25.7	25.4	25.3	27.2	25.5
Jet A Compositions							
Heavy Alkylate (300+)							
Lt Kero - Treated (300-375)	36.2	35.7	35.5	28.4	33.6	32.0	35.8
Kero - Treated (375-500)	41.7	40.6	40.2	49.2	36.3	45.9	40.7
Hydrocracked Jet (295-525)	22.1	23.7	24.2	22.4	30.1	22.1	23.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE D4-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9Y 2000	Base Case F2 1995	Case S7 1990 Prod Regs	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
<u>Reformulated Limits*</u>					
Aromatics, Vol.%, Maximum Avg		27.9		27.9	27.9
Oxygen, Wt%, Minimum Avg		2.1		2.1	2.1
Olefins, Vol.%, Maximum Avg		14.1		14.1	14.1
Benzene, Vol%, Maximum Avg		0.7		0.7	0.7
Sulfur, WPPM, Maximum Avg		305		305	305
Reid Vapor Pressure, PSI, Min					
Reid Vapor Pressure, PSI, Max		8.8		8.8	8.8
Regulatory Cap		9.1		9.1	9.1
T50, °F, Maximum Avg					
T90, °F, Maximum Avg		341		341	341
V.O.C., % Reduction					
T.A.P., % Reduction					
% Class C, Fixed	40	40	40	40	40
<u>Ethers, V% Pool</u>					
Purchased (Sold)	0.1	(0.1)		(0.1)	(0.1)
Manufactured	1.9	2.6	1.3	2.6	2.6
<u>Gasoline Pool Properties</u>					
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol. %	29.2	28.7	29.8	28.8	29.5
Ethers, Vol. % *	2.0	2.5	1.3	2.5	2.5
Oxygen, Wt. % *	0.4	0.5	0.2	0.5	0.5
Olefins, Vol. %	13.0	13.4	12.6	13.3	13.3
Benzene, Vol. %	1.7	1.6 *	1.8 *	1.6 *	1.6 *
Sulfur, WPPM	199	229	209	229	305
Reid Vapor Pressure, PSI *	9.9	9.8	10.6	9.8	9.8
Temperature at V/L = 20, °F	131	132	126	132	132
<u>Distillation</u>					
T10, °F	102	101	101	101	103
T50, °F	206	204	197	204	205
T90, °F	343	343	342	343	345
Specific Gravity	0.7401	0.7396	0.7366	0.7398	0.7407
Heat Content, MBTU/G	113.2	113.0	112.9	113.0	113.2
V.O.C., gm/mile					
– % Reduction					
NOx, index					
– % Reduction					
T.A.P., mg/mile					
– % Reduction					

* Input limit.

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TABLE D4-1A
REFORMULATED GASOLINE POOL PROPERTIES
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Reformulated Limits*</u>	Base Case F2 1995	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
Aromatics, Vol.%, Maximum Avg	27.9	27.9	27.9
Oxygen, Wt%, Minimum Avg	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg	14.1	14.1	14.1
Benzene, Vol%, Maximum Avg	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg	305	305	305
Reid Vapor Pressure, PSI, Min			
Reid Vapor Pressure, PSI, Max	8.8	8.8	8.8
Regulatory Cap	9.1	9.1	9.1
T50, °F, Maximum Avg			
T90, °F, Maximum Avg	341	341	341
V.O.C., % Reduction			
T.A.P., % Reduction			
% Class C, Fixed	40	40	40

Ethers, V% Pool

Purchased (Sold)

Manufactured

Reformulated Pool Properties

(R+M)/2 Octane, Clear*	88.6	88.6	88.6
Aromatics, Vol. %	23.4	23.3	27.2
Ethers, Vol. % *	11.7	11.7	11.7
Oxygen, Wt. % *	2.1	2.1	2.1
Olefins, Vol. %	13.5	13.6	13.6
Benzene, Vol. % *	0.7	0.7	0.7
Sulfur, WPPM	305	162	305
Reid Vapor Pressure, PSI*	8.8	8.8	8.8
Temperature at V/L = 20, °F	137	137	135
Distillation			
T10, °F	123	124	120
T50, °F	201	199	197
T90, °F	325	317	323
Specific Gravity	0.7415	0.7410	0.7428
Heat Content, MBTU/G	111.3	111.2	111.6
V.O.C., gm/mile			
- % Reduction			
NOx, index			
- % Reduction			
T.A.P., mg/mile			
- % Reduction			

* Input limit.

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TABLE D4-1B
CONVENTIONAL GASOLINE POOL PROPERTIES
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Conventional Limits*</u>	Base Case Q9Y 2000	Base Case F2 1995	Case S7 1990 Prod Regs	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
Aromatics, Vol.%, Maximum Avg		30.9		30.9	30.9
Oxygen, Wt%, Minimum Avg					
Olefins, Vol.%, Maximum Avg		17.6		17.6	17.6
Benzene, Vol%, Maximum Avg		1.7		1.7	1.7
Sulfur, WPPM, Maximum Avg		381		381	381
Reid Vapor Pressure, PSI, Min					
Reid Vapor Pressure, PSI, Max	9.9	9.7	10.6	9.7	9.7
Regulatory Cap					
T50, °F, Maximum Avg					
T90, °F, Maximum Avg	356	356	356	356	356
V.O.C., % Reduction					
T.A.P., % Reduction					
% Class C, Fixed	40	40	40	40	40
<u>Ethers, V% Pool</u>					
Purchased (Sold)					
Manufactured					
<u>Conventional Pool Properties</u>					
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	29.2	29.9	29.8	29.9	29.9
Ethers, Vol.% *	2.0		1.3		
Oxygen, Wt.% *	0.4		0.2		
Olefins, Vol.%	13.0	13.8	12.6	13.8	13.8
Benzene, Vol.%	1.7	1.7 *	1.8 *	1.7 *	1.7 *
Sulfur, WPPM	199	211	209	227	305
Reid Vapor Pressure, PSI*	9.9	9.7	10.6	9.7	9.7
Temperature at V/L = 20, °F	131	133	126	133	133
Distillation					
T10, °F	102	100	101	100	102
T50, °F	206	206	197	206	207
T90, °F	343	348	342	349	350
Specific Gravity	0.7401	0.7402	0.7366	0.7403	0.7405
Heat Content, MBTU/G	113.2	113.6	112.9	113.6	113.6
V.O.C., gm/mile					
- % Reduction					
NOx, index					
- % Reduction					
T.A.P., mg/mile					
- % Reduction					

* Input limit.

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TABLE D4-1C
OXYGENATED GASOLINE POOL PROPERTIES
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Oxygenated Limits*</u>	Base Case F2 1995	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
Aromatics, Vol.%, Maximum Avg	30.9	30.9	30.9
Oxygen, Wt%, Minimum Avg	2.7	2.7	2.7
Olefins, Vol.%, Maximum Avg	17.6	17.6	17.6
Benzene, Vol%, Maximum Avg	1.7	1.7	1.7
Sulfur, WPPM, Maximum Avg	381	381	381
Reid Vapor Pressure, PSI, Min			
Reid Vapor Pressure, PSI, Max	11.9	11.9	11.9
Regulatory Cap			
T50, °F, Maximum Avg			
T90, °F, Maximum Avg	356	356	356
V.O.C., % Reduction			
T.A.P., % Reduction			
% Class C, Fixed	40	40	40

Ethers, V% Pool

Purchased (Sold)

Manufactured

Oxygenated Pool Properties

(R+M)/2 Octane, Clear*	88.6	88.6	88.6
Aromatics, Vol.%	25.4	26.4	29.4
Ethers, Vol.%*	15.0	15.0	15.0
Oxygen, Wt.%*	2.7	2.7	2.7
Olefins, Vol.%	8.5	7.5	6.5
Benzene, Vol.%*	1.7	1.7	1.7
Sulfur, WPPM	305	305	305
Reid Vapor Pressure, PSI*	11.9	11.9	11.9
Temperature at V/L = 20, °F	119	120	120
Distillation			
T10, °F	90	88	89
T50, °F	188	191	194
T90, °F	325	326	332
Specific Gravity	0.7353	0.7370	0.7411
Heat Content, MBTU/G	109.8	110.0	110.7
V.O.C., gm/mile			
- % Reduction			
NOx, index			
- % Reduction			
T.A.P., mg/mile			
- % Reduction			

* Input limit.

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TABLE D4-1D
REFORMULATED-OXYGENATED GASOLINE POOL PROPERTIES
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Reformulated-Oxygenated Limits*</u>	<u>Base Case F2 1995</u>	<u>Case S12 1995 All ULS Diesel</u>	<u>Case S8 S12 + All LA Diesel</u>
Aromatics, Vol.%, Maximum Avg	27.9	27.9	27.9
Oxygen, Wt%, Minimum Avg	2.7	2.7	2.7
Olefins, Vol.%, Maximum Avg	14.1	14.1	14.1
Benzene, Vol%, Maximum Avg	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg	305	305	305
Reid Vapor Pressure, PSI, Min			
Reid Vapor Pressure, PSI, Max	11.9	11.9	11.9
Regulatory Cap			
T50, °F, Maximum Avg			
T90, °F, Maximum Avg	341	341	341
V.O.C., % Reduction			
T.A.P., % Reduction			
% Class C, Fixed	40	40	40
<u>Ethers, V% Pool</u>			
Purchased (Sold)			
Manufactured			
<u>Reformulated-Oxygenated Pool Properties</u>			
(R+M)/2 Octane, Clear*	88.6	88.6	88.6
Aromatics, Vol.%	19.2	19.1	23.5
Ethers, Vol.% *	15.0	15.0	15.0
Oxygen, Wt.% *	2.7	2.7	2.7
Olefins, Vol. %	13.6	13.6	13.6
Benzene, Vol.% *	0.7	0.7	0.7
Sulfur, WPPM*	305	305	305
Reid Vapor Pressure, PSI*	11.9	11.9	11.9
Temperature at V/L = 20, °F	119	117	120
Distillation			
T10, °F	99	98	96
T50, °F	180	180	193
T90, °F	303	314	311
Specific Gravity	0.7271	0.7263	0.7356
Heat Content, MBTU/G	109.1	109.1	110.2
V.O.C., gm/mile			
- % Reduction			
NOx, index			
- % Reduction			
T.A.P., mg/mile			
- % Reduction			

* Input limit.

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TABLE D4-2
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(in constant 1990 \$)

	Base Case F2 1995[3]	Case S7 1990 Prod Regs	Case S12[4] 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
<u>Investment, MM\$</u>				
Refinery	628	(3,243)	756	4,542
MTBE[5]	70	(212)		
Total	698	(3,455)	756	4,542
Range, MMM\$[6]	0.6 – 0.9	(4.7) – (2.9)	0.6 – 1.0	
<u>Daily Costs, M\$/D</u>				
Capital Charge[7]	293	(1,510)	353	2,114
Net Upgrading[8]	(456)	847	1	1,161
Variable Operating	75	(460)	154	572
Fixed Operating[9]	125	(563)	169	781
Total Refinery	37	(1,686)	677	4,628
<u>Annual Costs, MM\$/Yr</u>				
Refinery	13	(615)	247	1,689
Other[10]	245 [11]	137		
Total	258	(478)	247	1,689
<u>Total Unit Costs, ¢/G of Upgraded Product</u>				
Average	2.9 [13]	(2.1) [14]	4.3 [15]	8.3 [15]
Range[12]	2.1 – 3.9	(3.0) – (1.8)	4.0 – 5.1	7.8 – 9.6

- [1] S7 and F2 are based on Q9Y while S12 is based on F2 and S8 is based on S12. Based on normal investment costs, capital fixed costs, net upgrading and variable costs over base case.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.
- [3] Adjusted using individual unit capital charge/fixed operating costs multipliers to include the full cost of extra facilities for summer RFG as detailed on Table A3-19.
- [4] Increase over PADD III C Annual Case F2 to upgrade 374 MBPD diesel.
- [5] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [6] For variations from investment curves of -15/+35%.
- [7] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- [8] Raw material upgrading costs.
- [9] For new refining facilities only.
- [10] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining included in refinery costs.
- [11] Added consumer costs for RFG pool only in cases that allowed transferring oxygenates from the CG to the RFG pool.
- [12] For variations in capital charge (-15/+35%).
- [13] Conventional gasoline upgraded.
- [14] Upgraded diesel cost of about \$286MM/Yr based on estimated savings from downgrading conventional gasoline (by +0.7 RVP, -0.7% MTBE) of about 0.6¢/G or \$304MM/Yr, including \$25MM/Yr Δ BTU cost (LP Δ BTU cost off by \$112MM/Yr.).
- [15] Upgraded diesel.

TABLE D4-2A
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS UNADJUSTED[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Base Case F2 1995	Case S7 1990 Prod Regs	Case S12[3] 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
<u>Investment, MM\$</u>				
Refinery	1,180			
MTBE[4]	70			
Total	1,250			
Range, MMM\$[5]	1.1 – 1.7			
<u>Daily Costs, M\$/D</u>				
Capital Charge[6]	550			
Net Upgrading [7]	(456)			
Variable Operating	75			
Fixed Operating [8]	226			
Total Refinery	395			
<u>Annual Costs, MM\$/Yr.</u>				
Refinery	144			
Other[9]	91			
Total	235			
<u>Total Unit Costs, ¢/G of Upgraded Product</u>				
Average	2.6 [11]			
Range[10]	2.1 – 3.6			

- [1] Based on normal investment costs, capital fixed costs, net upgrading and variable costs over base case.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average. Unadjusted LP case results shown before capital charge and GC RVP adjustments if these were required.
- [3] Increase over PADD III C Annual Case F2 to upgrade 374 MBPD diesel.
- [4] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [5] For variations from investment curves of -15/+35%.
- [6] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- [7] Raw material upgrading costs.
- [8] For new refining facilities only.
- [9] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining included in refinery costs.
- [10] For variations in capital charge (-15/+35%).
- [11] Conventional gasoline upgraded.

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TABLE D4-3
REFINING RAW MATERIAL AND PRODUCT RATES – MBPCD
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9Y 2000	Base Case F2 1995	Case S7 1990 Prod Regs	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
Raw Materials					
Domestic – S	1,985	1,984	1,984	1,984	1,984
HL	174	174	174	174	174
HH	692	669	692	669	669
Foreign – S	732	732	732	732	732
HL	669	698	669	698	698
HH	1,496	1,518	1,431	1,519	1,626
Subtotal Crudes	5,748	5,775	5,682	5,776	5,883
MTBE	4	(4)		(4)	
Ethanol					
Normal Butane	109	102	124	102	116
Isobutane	46	46	46	46	46
Natural Gas to H2 Plant Feed	20	21	20	22	26
Methanol	20	28	14	28	28
Other Raw Materials	447	447	447	447	447
Total Raw Materials	6,394	6,415	6,333	6,417	6,546
Products					
Motor Gasolines					
Conventional	3,086	2,509	3,091	2,509	2,508
Oxygenated		236		236	236
Reformulated/Oxygenated		74		74	74
Reformulated		271		271	271
CARB2					
Kero Jet/Kerosene	727	727	727	727	727
Diesel/No. 2 Fuels					
Diesel – LA, ULS					1,255
Diesel – 0.05%S	881	881	440 [2]	1,255	
No. 2 Fuel	374	374	815		
No. 6 Fuel (1% Sul)	56	56	56	56	56
No. 6 Bunker	60	60	60	60	157
Marketable Coke – 400 #	177	178	173	178	190
Catalytic Coke – 400 #	92	98	92	97	93
Vacuum Gas Oil					
Benzene	21	21	21	21	21
Toluene	25	25	25	25	25
Heavy Aromatic Gaso					
Pentanes to P/C					
Natural Gasoline to P/C	134	134	2	134	134
Normal Butane	12	12	12	12	12
Isobutane	12	22	59	22	7
Propane	143	147	144	146	149
Process Gas/C2/C2=,FOE	344	349	362	351	362
Other Products	555	555	555	555	555
(Gain)/Loss	(305)	(314)	(301)	(312)	(286)
Total Products	6,394	6,415	6,333	6,417	6,546
Crude Properties					
Gravity, °API	32.8	32.9	32.9	32.9	32.9
Sulfur, Wt%	1.20	1.18	1.15	1.18	1.20
Gasoline Demand Increase, %[1]					
Results		0.1	0.2	0.1	0.1
Target		0.2	0.2	0.2	0.0

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

[2] 0.25% sulfur premium diesel.

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TABLE D4-4
NEW PROCESS UNIT RATES – MBPSD
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Base Case F2 1995</u>	<u>Case S7 1990 Prod Regs[1]</u>	<u>Case S12 1995 All ULS Diesel</u>	<u>Case S8 S12 + All LA Diesel</u>
Crude – Atmospheric				
Heavy Naphtha Splitter				
Catalytic Cracking				
FCC Gasoline Splitters				
FCC Gasoline Fractionation				
Hydrocracking – 2 Stage		(69)		
Hydrocracking – 2 Stage Distillate – Hvy Gasoline				
Hydrocrackate Fractionation				
Coker – Delayed				
Coker Lt Gasoline DS/Splitter				
Hydrotreating – Naphtha		(105)		
– FCC/Coker C6s				
– Distillate		(134)	343	508
– Heavy Gas Oil		(21)		
Reformer Feed Fractionation	589		594	594
Reformate Fractionation				
Aromatics Extraction				
Benzene Saturation				
FCC Gasoline HDS				
Diesel Aromatics Saturation				1,259
Alkylation		(6)		
Alkylate Splitter				
MTBE	37	(54)	36	34
TAME				
Isomerization – C5/C6		(42)		
– C5/C6, Recycle				
– C4		(11)		
Hydrogen – MMSCFPSD		(230)		278
Sulfur – LTPSD		(528)		
C4 Rerun – Saturates				
– Unsaturation				
Catalytic Reforming – 100 PSI		(76)		
Hydrotreating – Distillate Upgrade		(894)		
Dehydrogenation – IC4		(34)		

[1] Added capacity removed for investment purposes. Capacity removed from Hydrocracking, MTBE, C5/C6 Isomerization, C4 Isomerization and Hydrogen exceeded excess capacity available in the LP case results.

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TABLE D4-5
NEW PROCESS UNIT INVESTMENTS
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY
(\$MM – in constant mid-1990 \$)

	<u>Base Case F2 1995</u>	<u>Case S7 1990 Prod Regs</u>	<u>Case S12 1995 All ULS Diesel</u>	<u>Case S8 S12 + All LA Diesel</u>
Crude Distillation				
Heavy Naphtha Splitter				
Catalytic Cracking				
FCC Gasoline Splitters				
FCC Gasoline Fractionation				
Hydrocracking – 2 Stage		(414)		
Hydrocracking – 2 Stage Distillate – Heavy Gasoline				
Hydrocrackate Fractionation				
Coker – Delayed				
Coker Lt. Gasoline DS/Splitter				
Hydrotreating – Naphtha		(129)		
– FCC Coker C6s				
– Distillate		(226)	756	978
– Heavy Gas Oil		(44)		
Reformer Feed Fractionation	353		355	355
Reformate Fractionation				
Aromatics Extraction				
Benzene Saturation				
FCC Gasoline HDS				
Diesel Aromatics Saturation				3,862
Alkylation		(39)		
Alkylate Splitter				
MTBE	275	(352)	273	278
TAME				
Isomerization – C5/C6		(71)		
– C5/C6, Recycle				
– C4		(39)		
Hydrogen		(275)		453
Sulfur		(132)		
MTBE Storage & Blending				
C4 Rerun – Saturates				
– Unsaturation				
C4 Fractionation Upgrade		(59)		
Catalytic Reforming – 100 PSI		(227)		
Hydrotreating – Distillate Upgrade		(837)		
Dehydrogenation – IC4		(399)		
Total Refinery	<u>628</u>	<u>(3,243)</u>	<u>1,384</u>	<u>5,926</u>

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TABLE D4-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9% 2000	Base Case F2 1995	Case S7 1990 Prod Regs	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
Crude – Atmospheric	130.6	131.3	129.2	131.3	133.7
Heavy Naphtha Splitter					
Catalytic Cracking[1]	46.5	48.0	44.8	47.8	47.5
Catalytic Cracking[2]	43.1	44.5	41.1	44.3	43.2
Conversion, %	78.1	78.3	79.5	78.4	80.0
Octane Catalyst, %	69.8	70.6	71.7	70.8	81.2
FCC Gasoline Splitters					
FCC Gasoline Fractionation	11.7	11.7	11.7	11.7	11.7
Hydrocracking – 2 Stage[1]	9.4	9.4	8.9	9.4	5.0
Jet Yield, % of Max	81.9	97.4	78.8	100.0	43.7
300 – Gasoline Operation, %					
Hydrocracking – 2 Stage Distillate					
Hydrocracking – Low Conversion	1.5	1.5	2.0	1.5	1.5
– Hvy Gasoline					
– Combined[2]	10.9	10.9	10.9	10.9	6.5
Hydrocrackate Fractionation					
Coking – Delayed	13.0	13.1	12.7	13.1	14.0
– Fluid	0.7	0.7	0.7	0.7	0.8
Coker Lt Gasoline DS/Splitter					
Thermal Cracking, Visbreaking	1.5	1.5	1.1	1.5	0.5
Solvent Deasphalting	1.8	1.8	2.3	1.8	3.9
Catalytic Reforming – 100 PSI[1]	15.5	13.9	15.6	14.0	17.1
– 200 PSI[1]	10.8	10.8	10.8	10.8	8.7
– 450 PSI[1]	5.5	6.0	7.1	6.0	6.0
– Combined[2]	31.3	29.6	31.4	29.8	31.0
– RONC	96.0	96.8	98.5	96.8	96.3
Hydrotreating – Naphtha	30.8	30.9	30.5	31.1	31.2
– FCC/Coker C6s					
– Distillate	32.1	31.4	20.3	39.6	43.0
– Heavy Gas Oil	15.9	15.9	13.9	15.9	15.9
– Residuum – Atm	6.7	6.7	6.7	6.7	1.3
Reformer Feed Fractionation		12.0		12.1	12.1
Reformate Fractionation	8.0	8.0	7.5	8.0	8.0
Aromatics Extraction	4.0	4.0	4.0	4.0	4.0
Benzene Saturation					
FCC Gasoline HDS					
Diesel Aromatics Saturation					25.7
Alkylation	7.7	7.6	7.1	7.5	7.8
Alkylate Splitter					
Polymerization	0.4	0.4	0.4	0.4	0.4
Dehydrogenation – IC4	0.7	0.7		0.7	0.7
MTBE	1.3	1.9	0.9	1.9	1.8
TAME					
Hydrodealkylation – Toluene					
Lubes	2.2	2.2	2.2	2.2	2.2
Isomerization – C5/C6	2.1	2.1	2.1	2.1	2.1
– C5/C6, Recycle	2.1	2.1	2.1	2.1	1.1
– C4	0.7	0.7	0.7	0.7	0.7
Hydrogen – MMSCFPCD	19.7	20.1	19.7	21.0	25.2
Sulfur, LTPCD	128	128	117	132	122
C4 Rerun – Saturates					
– Unsaturates					

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

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TABLE D4-7
PROCESS UNIT UTILIZATIONS - %[1]
IIIC - ANNUAL 1995/2000 F2 - SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9Y 2000	Base Case F2 1995	Case S7 1990 Prod Regs	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
Crude Distillation - Atmospheric	83.5	83.9	82.6	83.9	85.5
Heavy Naphtha Splitter					
Catalytic Cracking[2]	77.9	80.5	75.0	80.2	79.6
Catalytic Cracking[3]	72.3	74.6	68.9	74.3	72.4
FCC Gasoline Splitters					
FCC Gasoline Fractionation	81.9	81.9	81.9	81.9	81.9
Hydrocracking - 2 Stage[2]	84.0 *	84.0 *	84.0 *	84.0 *	44.6
Hydrocracking - 2 Stage Distillate					
- Low Conversion	62.7	62.7	84.0 *	62.7	62.7
- Heavy Gasoline					
- Combined[3]	80.2	80.2	80.2	80.2	47.7
Hydrocrackate Fractionation					
Coking - Delayed	84.5	85.2	82.5	85.1	91.0 *
- Fluid	86.1	86.1	86.1	86.1	91.0 *
Coker Lt Gasoline DS/Splitter					
Thermal Cracking, Visbreaking	90.0 *	90.0 *	66.2	90.0 *	31.4
Solvent Deasphalting	42.3	41.3	52.3	41.6	90.0 *
Catalytic Reforming - 100 PSI[2]	81.3	73.0	90.0 *	73.8	90.0 *
- 200 PSI[2]	90.0 *	90.0 *	90.0 *	90.0 *	72.5
- 450 PSI[2]	53.6	58.5	68.8	58.5	58.5
- Combined[3]	75.9	71.7	76.0	72.1	75.0
Hydrotreating - Naphtha	71.7	72.0	75.2	72.6	72.6
- FCC/Coker C6s					
- Distillate	88.7	86.6	61.3	90.0 *	90.0 *
- Heavy Gas Oil	84.5	84.5	75.8	84.5	84.5
- Residuum, Atm	90.0 *	90.0 *	90.0 *	90.0 *	17.2
Reformer Feed Fractionation		90.0 *		90.0 *	90.0 *
Reformate Fractionation	69.3	90.0 *	84.9	90.0 *	90.0 *
Aromatics Extraction	60.0	90.0 *	90.0 *	90.0 *	90.0 *
Benzene Saturation					
FCC Gasoline HDS					
Diesel Aromatics Saturation					90.0 *
Alkylation	63.4	62.3	58.9	62.1	64.1
Alkylate Splitter					
Polymerization	44.1	44.1	44.1	44.1	44.1
Dehydrogenation - IC4	84.4	87.0 *		87.0 *	87.0 *
MTBE	88.0 *	88.0 *	88.0 *	88.0 *	88.0 *
TAME	0.0	0.0	0.0	0.0	0.0
Hydrodealkylation - Toluene	0.0	0.0	0.0	0.0	0.0
Lubes	82.0	82.0	82.0	82.0	82.0
Isomerization - C5/C6	90.0 *	90.0 *	90.0 *	90.0 *	90.0 *
- C5/C6, Recycle	90.0 *	90.0 *	90.0 *	90.0 *	45.1
- C4	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
Hydrogen	76.3	78.1	87.0 *	81.4	87.0 *
Sulfur	50.6	50.6	48.5	52.2	48.2
C4 Rerun - Saturates					
- Unsaturates					

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

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TABLE D4-8
COMBINED GASOLINE POOL COMPOSITIONS - %
IIIC - ANNUAL 1995/2000 F2 - SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9% 2000	Base Case F2 1995	Case S7 1990 Prod Regs	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
FCC Gasoline	18.6	19.4	17.2	19.3	18.8
Lt. FCC 255-	9.8	9.8	9.8	9.8	9.8
Hvy FCC 255+	6.8	6.9	6.8	6.7	6.8
Hvy FCC 255+ Desulf.					
FCC Gaso (100-180)					
FCC Gaso (180-225)					
FCC Gaso (225-300)					
FCC Gaso (300-375)					
FCC Gaso (375-430)					
Total FCC Gasoline	35.2	36.1	33.8	35.8	35.4
Butenes					
Pentenes					
Poly Gasoline	0.6	0.6	0.6	0.6	0.6
Lt. Coker Gasoline	1.3	1.3	1.2	1.3	1.2
Total Olefinic	1.9	1.9	1.8	1.9	1.8
Reformate	15.2	13.6	14.4	13.8	17.3
Reformate (220-300 Feed)	5.1	5.4	5.1	5.5	3.4
BT Reformate	4.7	3.5	5.0	3.5	3.8
HC Reformate (210-300)	2.6	2.6	2.2	2.6	2.6
Heavy Reformate (300+)	1.6	1.6	1.5	1.6	1.6
Toluene / Xylenes			0.1		
Total Reformates[1]	29.2	26.7	28.3	27.0	28.7
Lt. Reformate	1.4	1.4	1.3	1.4	1.4
Lt. Raffinate B(C5-210)	2.5	2.5	2.3	2.5	2.5
Alkylate/Lt Alkylate (C3/C4)	10.9	10.6	9.9	10.6	10.9
Alkylate/Lt Alkylate (C5)					
Butane	7.3	7.2	7.8	7.2	7.5
Natural/LSR Gaso	0.1	0.1	4.3	0.1	1.7
BT Naphtha (150-220)					
Pentanes (I/N)					
Isomate (C5-C6)	6.0	6.0	5.9	6.0	4.5
Isomate (C6)					
Lt. Hydrocrackate (C5-180)	2.4	2.3	2.4	2.3	1.5
Medium Hydrocrackate (180-225)	1.1	2.7	0.9	2.7	1.6
MTBE	2.0	2.5	1.3	2.5	2.5
TAME					
Alcohol					
Total Low Arom., Saturated	33.7	35.3	36.1	35.3	34.1
Total	100.0	100.0	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D4-8A
REFORMULATED GASOLINE POOL COMPOSITIONS - %
IIIC - ANNUAL 1995/2000 F2 - SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case F2 1995	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
FCC Gasoline	19.6	19.2	23.6
Lt. FCC 255-	2.7	3.5	4.0
Hvy FCC 255+	4.7	5.6	4.7
Hvy FCC 255+ Desulf.			
FCC Gaso (100-180)			
FCC Gaso (180-225)			
FCC Gaso (225-300)			
FCC Gaso (300-375)			
FCC Gaso (375-430)			
Total FCC Gasoline	27.0	28.3	32.3
Butenes			
Pentenes			
Poly Gasoline	4.9	4.8	3.2
Lt. Coker Gasoline			
Total Olefinic	4.9	4.8	3.2
Reformate	8.7	0.5	5.9
Reformate (220-300 Feed)	2.8	9.5	
BT Reformate			
HC Reformate (210-300)	11.3	11.8	18.6
Heavy Reformate (300+)			
Toluene/Xylenes			
Total Reformates[1]	22.8	21.8	24.5
Lt. Reformate			
Lt. Raffinate B(C5-210)	5.3	6.6	4.8
Alkylate/Lt Alkylate (C3/C4)	7.3	7.3	7.1
Alkylate/Lt Alkylate (C5)			
Butane	6.0	5.9	5.2
Natural/LSR Gaso			11.2
BT Naphtha (150-220)			
Pentanes (I/N)			
Isomate (C5-C6)			
Isomate (C6)			
Lt. Hydrocrackate (C5-180)	6.9	6.4	
Medium Hydrocrackate (180-225)	8.1	7.2	
MTBE	11.7	11.7	11.7
TAME			
Alcohol			
Total Low Arom., Saturated	45.3	45.1	40.0
Total	100.0	100.0	100.0

[1] Excluding Lt. Reformate and Lt. Raffinate.

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TABLE D4-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS – %
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9% 2000	Base Case F2 1995	Case S7 1990 Prod Regs	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
FCC Gasoline	18.6	21.1	17.2	21.2	19.6
Lt. FCC 255-	9.8	10.8	9.8	10.8	11.6
Hvy FCC 255+	6.8	7.1	6.8	7.3	7.3
Hvy FCC 255+ Desulf.					
FCC Gaso (100–180)					
FCC Gaso (180–225)					
FCC Gaso (225–300)					
FCC Gaso (300–375)					
FCC Gaso (375–430)					
Total FCC Gasoline	35.2	39.0	33.8	39.3	38.5
Butenes					
Pentenes					
Poly Gasoline	0.6		0.6		
Lt. Coker Gasoline	1.3	0.9	1.2	0.9	0.9
Total Olefinic	1.9	0.9	1.8	0.9	0.9
Reformate	15.2	13.6	14.4	13.8	17.5
Reformate (220–300 Feed)	5.1	5.5	5.1	5.3	3.2
BT Reformate	4.7	3.8	5.0	3.8	4.1
HC Reformate (210–300)	2.6	1.6	2.2	1.6	0.7
Heavy Reformate (300+)	1.6	2.0	1.5	2.0	2.0
Toluene / Xylenes			0.1		
Total Reformates[1]	29.2	26.5	28.3	26.5	27.5
Lt. Reformate	1.4	1.7	1.3	1.7	1.7
Lt. Raffinate B(C5–210)	2.5	2.2	2.3	2.1	2.5
Alkylate/Lt Alkylate (C3/C4)	10.9	12.2	9.9	12.1	12.5
Alkylate/Lt Alkylate (C5)					
Butane	7.3	6.8	7.8	6.7	7.2
Natural/LSR Gaso	0.1		4.3		
BT Naphtha (150–220)					
Pentanes (I/N)					
Isomate (C5–C6)	6.0	7.3	5.9	7.3	5.5
Isomate (C6)					
Lt. Hydrocrackate (C5–180)	2.4	1.6	2.4	1.6	1.8
Medium Hydrocrackate (180–225)	1.1	1.8	0.9	1.8	1.9
MTBE	2.0		1.3		
TAME					
Alcohol					
Total Low Arom., Saturated	33.7	33.6	36.1	33.3	33.1
Total	100.0	100.0	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D4-8C
OXYGENATED GASOLINE POOL COMPOSITIONS – %
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Base Case F2 1995	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
FCC Gasoline	6.7	6.7	6.6
Lt. FCC 255–	7.6	5.3	0.6
Hvy FCC 255+	5.7	4.8	3.9
Hvy FCC 255+ Desulf.			
FCC Gaso (100–180)			
FCC Gaso (180–225)			
FCC Gaso (225–300)			
FCC Gaso (300–375)			
FCC Gaso (375–430)			
Total FCC Gasoline	20.0	16.8	11.1
Butenes			
Pentenes			
Poly Gasoline			1.0
Lt. Coker Gasoline	6.2	6.5	6.7
Total Olefinic	6.2	6.5	7.7
Reformate	23.9	27.1	34.6
Reformate (220–300 Feed)	5.5	5.5	4.6
BT Reformate	4.5	4.5	6.4
HC Reformate (210–300)	1.2	1.2	1.8
Heavy Reformate (300+)			
Toluene/Xylenes			
Total Reformates[1]	35.1	38.3	47.4
Lt. Reformate			
Lt. Raffinate B(C5–210)			
Alkylate/Lt Alkylate (C3/C4)			
Alkylate/Lt Alkylate (C5)			
Butane	11.7	12.1	12.3
Natural/LSR Gaso			5.8
BT Naphtha (150–220)			
Pentanes (I/N)			
Isomerate (C5–C6)			
Isomerate (C6)			
Lt. Hydrocrackate (C5–180)	5.4	4.5	
Medium Hydrocrackate (180–225)	6.6	6.8	0.7
MTBE	15.0	15.0	15.0
TAME			
Alcohol			
Total Low Arom., Saturated	38.7	38.4	33.8
Total	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D4-8D
REFORMULATED-OXYGENATED GASOLINE POOL COMPOSITIONS – %
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case F2 1995	Case S12 1995 All ULS Diesel	Case S8 S12 + All LA Diesel
FCC Gasoline	7.5		10.0
Lt. FCC 255-	10.1	15.3	1.4
Hvy FCC 255+	7.7	6.3	7.1
Hvy FCC 255+ Desulf.			
FCC Gaso (100-180)			
FCC Gaso (180-225)			
FCC Gaso (225-300)			
FCC Gaso (300-375)			
FCC Gaso (375-430)			
Total FCC Gasoline	25.3	21.6	18.5
Butenes			
Pentenes			
Poly Gasoline	5.8	6.1	8.9
Lt. Coker Gasoline			
Total Olefinic	5.8	6.1	8.9
Reformate			
Reformate (220-300 Feed)	14.1	16.9	18.5
BT Reformate			0.4
HC Reformate (210-300)	6.8	8.1	10.1
Heavy Reformate (300+)			
Toluene/Xylenes			
Total Reformates[1]	20.9	25.0	29.0
Lt. Reformate	0.7	0.2	
Lt. Raffinate B(C5-210)	8.7	8.0	
Alkylate/Lt Alkylate (C3/C4)	4.2	4.0	4.4
Alkylate/Lt Alkylate (C5)			
Butane	10.5	10.5	10.6
Natural/LSR Gaso	5.8	5.9	13.2
BT Naphtha (150-220)			
Pentanes (I/N)			
Isomerase (C5-C6)			
Isomerase (C6)			
Lt. Hydrocrackate (C5-180)	1.4	1.7	0.2
Medium Hydrocrackate (180-225)	1.7	2.0	0.2
MTBE	15.0	15.0	15.0
TAME			
Alcohol			
Total Low Arom., Saturated	48.0	47.3	43.6
Total	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D4-9
GASOLINE PROPERTY DECREASE - INCREMENTAL COSTS[1]
IIIC - ANNUAL 1995/2000 F2 - SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (\$/G per unit in constant 1990 \$)

	<u>Base Case Q97 2000</u>	<u>Base Case F2 1995</u>	<u>Case S7 1990 Prod Regs</u>	<u>Case S12 1995 All ULS Diesel</u>	<u>Case S8 S12 + All LA Diesel</u>
(R+M)/2 Octane, Clear	(0.4)	(0.5)	(1.0)	(0.5)	(0.5)
Aromatics, Vol. %					
Ethers, Vol. %		(0.3)		(0.4)	(0.4)
Ethanol, %					
Olefins, Vol. %					
Benzene, Vol. %		0.2	0.8	0.2	0.1
Sulfur, 100 Wt. PPM					
Reid Vapor Pressure, PSI	0.4	0.4	0.5	0.4	0.4
T90, 10°F					
Butane, Vol. %					
V.O.C., 10%					
NOx, 10%					
T.A.P., 10%					

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE D4-9A
REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (\$/G per unit in constant 1990 \$)

	<u>Base Case F2 1995</u>	<u>Case S12 1995 All ULS Diesel</u>	<u>Case S8 S12 + All LA Diesel</u>
(R+M)/2 Octane, Clear	(0.4)	(0.4)	(0.3)
Aromatics, Vol. %			
Ethers, Vol. %	(0.4)	(0.4)	(0.4)
Ethanol, %			
Olefins, Vol. %			
Benzene, Vol. %	0.3	0.3	0.2
Sulfur, 100 Wt. PPM			
Reid Vapor Pressure, PSI	0.4	0.4	0.4
T90, 10°F			
Butane, Vol. %			
V.O.C., 10%			
NOx, 10%			
T.A.P., 10%			

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE D4-9B
CONVENTIONAL GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (\$/G per unit in constant 1990 \$)

	<u>Base Case Q95 2000</u>	<u>Base Case F2 1995</u>	<u>Case S7 1990 Prod Regs</u>	<u>Case S12 1995 All ULS Diesel</u>	<u>Case S8 S12 + All LA Diesel</u>
(R+M)/2 Octane, Clear	(0.4)	(0.5)	(1.0)	(0.5)	(0.5)
Aromatics, Vol. %					
Ethers, Vol. %		(0.3)		(0.4)	(0.4)
Ethanol, %					
Olefins, Vol. %					
Benzene, Vol. %		0.2	0.8	0.2	0.1
Sulfur, 100 Wt. PPM					
Reid Vapor Pressure, PSI	0.4	0.4	0.5	0.4	0.4
T90, 10°F					
Butane, Vol. %					
V.O.C., 10%					
NOx, 10%					
T.A.P., 10%					

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE D4-9C
OXYGENATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (\$/G per unit in constant 1990 \$)

	<u>Base Case F2 1995</u>	<u>Case S12 1995 All ULS Diesel</u>	<u>Case S8 S12 + All LA Diesel</u>
(R+M)/2 Octane, Clear	(0.4)	(0.4)	(0.3)
Aromatics, Vol. %			
Ethers, Vol. %	(0.4)	(0.4)	(0.4)
Ethanol, %			
Olefins, Vol. %			
Benzene, Vol. %	0.2	0.2	0.1
Sulfur, 100 Wt. PPM			
Reid Vapor Pressure, PSI	0.4	0.4	0.4
T90, 10°F			
Butane, Vol. %			
V.O.C., 10%			
NOx, 10%			
T.A.P., 10%			

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE D4-9D**REFORMULATED – OXYGENATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]****IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY****(¢/G per unit in constant 1990 \$)**

	<u>Base Case F2 1995</u>	<u>Case S12 1995 All ULS Diesel</u>	<u>Case S8 S12 + All LA Diesel</u>
(R+M)/2 Octane, Clear	(0.4)	(0.4)	(0.3)
Aromatics, Vol. %			
Ethers, Vol. %	(0.4)	(0.4)	(0.4)
Ethanol, %			
Olefins, Vol. %			
Benzene, Vol. %	0.3	0.3	0.2
Sulfur, 100 Wt. PPM			
Reid Vapor Pressure, PSI	0.4	0.4	0.4
T90, 10°F			
Butane, Vol. %			
V.O.C., 10%			
NOx, 10%			
T.A.P., 10%			

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D4-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IIIC – ANNUAL 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Base Case Q9Y 2000</u>	<u>Base Case F2 1995</u>	<u>Case S7 1990 Prod Regs</u>	<u>Case S12 1995 All ULS Diesel</u>	<u>Case S8 S12 + All LA Diesel</u>
<u>No. 2 Diesel Compositions</u>					
Hvy Reformate (300+) 90 RON					
Hvy Reformate (300+) 100 RON					
FCC Heavy Gaso Tr(300-375)					
FCC Heavy Gaso Tr(375-430)					
Lt Cycle Oil - Treated	3.8	2.6	1.4	5.8	
Coker Dist - Treated	<u>3.3</u>	<u>5.3</u>	<u>1.9</u>	<u>1.8</u>	
Total High Aromatic	7.1	7.9	3.3	7.6	
Heavy Alkylate (300+)					
Lt Kero - Treated (300-375)	3.3	4.3	3.0	3.5	7.2
Kero (375-500)	13.2	19.8	35.8		
Kero - Treated (375-500)	23.5	19.0		39.2	
Kero - Low Aromatics (375-500)					21.6
Hydrocracked Jet (295-525)					
Diesel Base	17.0	10.4	36.2	0.9	0.4
Diesel Base - Treated	35.9	38.6	21.7	48.8	
Diesel Base - Low Aromatics					59.3
Lt Cycle Oil - Low Aromatics					1.5
Coker Dist - Low Aromatics					10.0
Total Low Aromatic	<u>92.9</u>	<u>92.1</u>	<u>96.7</u>	<u>92.4</u>	<u>100.0</u>
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
<u>Properties</u>					
Diesel Ignition Improver					
Pour Point Depressant					
Aromatics	25.1	24.6	24.9	25.0	7.3
<u>Jet A Compositions</u>					
Heavy Alkylate (300+)					
Lt Kero - Treated (300-375)	35.1	33.6	35.3	33.4	23.6
Kero - Treated (375-500)	39.4	36.4	40.1	35.9	68.5
Hydrocracked Jet (295-525)	25.5	30.0	24.6	30.7	7.9
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

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TABLE D5-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
<u>Reformulated Limits*</u>						
Aromatics, Vol.%, Maximum Avg						
Oxygen, Wt%, Minimum Avg		2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg						
Benzene, Vol%, Maximum Avg		0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg						
Reid Vapor Pressure, PSI, Min				6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max		11.9	11.9			
Regulatory Cap						
T50, °F, Maximum Avg						
T90, °F, Maximum Avg						
V.O.C., % Reduction				45	45	45
T.A.P., % Reduction		30	30	30	30	30
% Class C, Fixed		40	40	40	40	40
<u>Ethers, V% Pool</u>						
Purchased (Sold)	0.1	5.6	5.7	4.5	4.4	4.4
Manufactured	1.9	2.9	2.8	2.9	3.0	3.0
<u>Gasoline Pool Properties</u>						
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	27.6	24.5	24.2	27.2	28.6	28.3
Ethers, Vol.% *	2.0	8.5	8.5	7.4	7.4	7.4
Oxygen, Wt.% *	0.4	1.5	1.5	1.3	1.3	1.3
Olefins, Vol.%	12.4	10.8	12.4	12.5	11.7	11.9
Benzene, Vol.%	1.6	1.1 *	1.1 *	1.1 *	1.1 *	1.1 *
Sulfur, WPPM	186	196	220	224 *	178	182
Reid Vapor Pressure, PSI*	11.9	11.9	11.9	7.1	7.3	7.3
Temperature at V/L = 20, °F	120	119	119	146	145	145
<u>Distillation</u>						
T10, °F	80	89	85	125	124	123
T50, °F	200	190	188	205	204	204
T90, °F	339	336	332	339	341	330
Specific Gravity	0.7333	0.7312	0.7311	0.7450	0.7469	0.7457
Heat Content, MBTU/G	112.4	110.8	110.8	112.8	112.9	112.7
V.O.C., gm/mile				0.87 *	0.91 *	0.90 *
- % Reduction				32 *	29 *	30 *
NOx, index	0.96	0.97 *	0.98	0.99	0.98	0.98 *
- % Reduction	4	3 *	2	1	2	2 *
T.A.P., mg/mile	39	36	36	41 *	42 *	41 *
- % Reduction	2	10	10	22 *	20 *	23 *

* Input limit.

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TABLE D5-1A
RUN BASIS AND REFORMULATED GASOLINE POOL PROPERTIES
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
<u>Reformulated Limits*</u>					
Aromatics, Vol.%, Maximum Avg					
Oxygen, Wt%, Minimum Avg	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg					
Benzene, Vol%, Maximum Avg	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg					
Reid Vapor Pressure, PSI, Min			6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max	11.9	11.9			
Regulatory Cap					
T50, °F, Maximum Avg					
T90, °F, Maximum Avg					
V.O.C., % Reduction			45	45	45
T.A.P., % Reduction	30	30	30	30	30
% Class C, Fixed	40	40	40	40	40
<u>Ethers, V% Pool</u>					
Purchased (Sold)					
Manufactured					
<u>Gasoline Pool Properties</u>					
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	20.3	19.6	23.5	25.2	24.9
Ethers, Vol.%*	11.7	11.7	11.7	11.7	11.7
Oxygen, Wt.%*	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%	9.5	11.5	11.1	12.3	10.9
Benzene, Vol.%*	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM	153	174	233	201	174
Reid Vapor Pressure, PSI	11.9 *	11.9 *	6.5 *	6.5 *	6.6
Temperature at V/L = 20, °F	119	118	149	149	149
<u>Distillation</u>					
T10, °F	92	86	135	135	134
T50, °F	186	181	202	204	205
T90, °F	334	334	333	342	325
Specific Gravity	0.7274	0.7251	0.7435	0.7477	0.7458
Heat Content, MBTU/G	109.7	109.5	111.9	112.2	112.0
V.O.C., gm/mile			0.71 *	0.71 *	0.71 *
- % Reduction			45 *	45 *	45 *
NOx, index	0.96 *	0.97	1.00	0.99	0.98
- % Reduction	4 *	3	0	1	2
T.A.P., mg/mile	32	32	35	36	34
- % Reduction	20	21	34	33	36

* Input limit.

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TABLE D5-1B
RUN BASIS AND CONVENTIONAL GASOLINE POOL PROPERTIES
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
<u>Conventional Limits*</u>						
Aromatics, Vol.%, Maximum Avg						
Oxygen, Wt%, Minimum Avg						
Olefins, Vol.%, Maximum Avg						
Benzene, Vol%, Maximum Avg		1.7	1.7	1.7	1.7	1.7
Sulfur, WPPM, Maximum Avg						
Reid Vapor Pressure, PSI, Min						
Reid Vapor Pressure, PSI, Max	11.9	11.9	11.9	8.7	8.7	8.7
Regulatory Cap						
T50, °F, Maximum Avg						
T90, °F, Maximum Avg	356	356	356	356	356	356
V.O.C., % Reduction						
T.A.P., % Reduction						
% Class C, Fixed	40	40	40	40	40	40
<u>Ethers, V% Pool</u>						
Purchased (Sold)						
Manufactured						
<u>Gasoline Pool Properties</u>						
(R+M)/2 Octane, Clear*	88.6	88.6	88.6	88.6	88.6	88.6
Aromatics, Vol.%	27.6	31.6	31.6	33.5	34.3	34.0
Ethers, Vol.% *	2.0					
Oxygen, Wt.% *	0.4					
Olefins, Vol.%	12.4	13.0	12.7	14.8	10.7	13.7
Benzene, Vol.%	1.6	1.7 *	1.7 *	1.7 *	1.7 *	1.7 *
Sulfur, WPPM	186	282	307	210 *	138	196
Reid Vapor Pressure, PSI	11.9 *	11.9 *	11.9 *	8.3	8.7 *	8.6 *
Temperature at V/L = 20, °F	120	121	122	140	137	139
<u>Distillation</u>						
T10, °F	80	81	91	108	106	105
T50, °F	200	202	203	210	204	202
T90, °F	339	341	337	351	339	336
Specific Gravity	0.7333	0.7366	0.7389	0.7475	0.7455	0.7455
Heat Content, MBTU/G	112.4	113.2	113.3	114.4	114.2	114.0
V.O.C., gm/mile				1.15	1.26	1.23
– % Reduction				11	2	4
NOx, index	0.96	0.98	0.98	0.98	0.94	0.97 *
– % Reduction	4	2	2	2	6	3 *
T.A.P., mg/mile	39	44	44	52 *	53 *	53 *
– % Reduction	2	(10)	(10)	1 *	*	*

* Input limit.

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TABLE D5-1C
RUN BASIS AND OXYGENATED GASOLINE POOL PROPERTIES
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6W	Q5W Q6 Units Max K Jet
<u>Oxygenated Limits*</u>		
Aromatics, Vol.%, Maximum Avg		
Oxygen, Wt%, Minimum Avg	2.7	2.7
Olefins, Vol.%, Maximum Avg		
Benzene, Vol%, Maximum Avg	1.7	1.7
Sulfur, WPPM, Maximum Avg		
Reid Vapor Pressure, PSI, Min		
Reid Vapor Pressure, PSI, Max	11.9	11.9
Regulatory Cap		
T50, °F, Maximum Avg		
T90, °F, Maximum Avg	356	356
V.O.C., % Reduction		
T.A.P., % Reduction		
% Class C, Fixed	40	40
<u>Ethers, V% Pool</u>		
Purchased (Sold)		
Manufactured		
<u>Gasoline Pool Properties</u>		
(R+M)/2 Octane, Clear*	88.6	88.6
Aromatics, Vol. %	22.9	25.6
Ethers, Vol. % *	15.0	15.0
Oxygen, Wt. % *	2.7	2.7
Olefins, Vol. %	5.8	13.7
Benzene, Vol. % *	1.7	1.7
Sulfur, WPPM	224	234
Reid Vapor Pressure, PSI*	11.9	11.9
Temperature at V/L = 20, °F	118	120
Distillation		
T10, °F	102	91
T50, °F	185	184
T90, °F	311	332
Specific Gravity	0.7303	0.7391
Heat Content, MBTU/G	109.4	110.1
V.O.C., gm/mile		
– % Reduction		
NOx, index	0.97 *	1.00
– % Reduction	3 *	0
T.A.P., mg/mile	35	39
– % Reduction	13	3

* Input limit.

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TABLE D5-1D
RUN BASIS AND REFORMULATED-OXYGENATED GASOLINE POOL PROPERTIES
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6W	Q5W Q6 Units Max K Jet
<u>Reformulated-Oxygenated Limits*</u>		
Aromatics, Vol.%, Maximum Avg		
Oxygen, Wt%, Minimum Avg	2.7	2.7
Olefins, Vol.%, Maximum Avg		
Benzene, Vol%, Maximum Avg	0.7	0.7
Sulfur, WPPM, Maximum Avg		
Reid Vapor Pressure, PSI, Min		
Reid Vapor Pressure, PSI, Max	11.9	11.9
Regulatory Cap		
T50, °F, Maximum Avg		
T90, °F, Maximum Avg		
V.O.C., % Reduction		
T.A.P., % Reduction	30	30
% Class C, Fixed	40	40
<u>Ethers, V% Pool</u>		
Purchased (Sold)		
Manufactured		
<u>Gasoline Pool Properties</u>		
(R+M)/2 Octane, Clear*	88.6	88.6
Aromatics, Vol.%	22.3	22.4
Ethers, Vol.% *	15.0	15.0
Oxygen, Wt.% *	2.7	2.7
Olefins, Vol. %	10.6	13.7
Benzene, Vol.% *	0.7	0.7
Sulfur, WPPM	142	174
Reid Vapor Pressure, PSI*	11.9	11.9
Temperature at V/L = 20, °F	119	117
Distillation		
T10, °F	97	73
T50, °F	180	176
T90, °F	336	316
Specific Gravity	0.7314	0.7307
Heat Content, MBTU/G	109.6	109.4
V.O.C., gm/mile		
– % Reduction		
NOx, index	0.96 *	0.99
– % Reduction	4 *	1
T.A.P., mg/mile	33	31
– % Reduction	17	23

* Input limit.

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TABLE D5-2
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
<u>Investment, MM\$</u>					
Refinery	1,709	0		(875)	(1,245)
MTBE[3]	4,275	83		(603)	(1,102)
Total	5,984	83		(1,478)	(2,347)
Range, MMM\$[4]	5.0 – 7.9	0.1 – 0.1		(2.0) – (1.3)	(3.2) – (2.0)
<u>Daily Costs, M\$/D</u>					
Capital Charge[5]	796	0		(474)	(737)
Net Upgrading[6]	3,434	(423)		3,764	7,541
Variable Operating	(270)	186		(966)	(1,838)
Fixed Operating [7]	376	0		(183)	(317)
Total Refinery	4,336	(237)		2,141	4,649
<u>Annual Costs, MM\$/Yr.</u>					
Refinery	1,582	(86)		782	1,697
Other[8]	672	(9)		(47)	47
Total	2,254	(95)		735	1,744
<u>Total Unit Costs, ¢/G of Product Upgraded</u>					
Average	7.4 [9]	(7.2) [10]		11.9 [11]	14.2 [11]
Range[12]	5.8 – 9.9	(7.7) – (6.0)		9.6 – 13.1	12.5 – 14.9

[1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case: Q6W over Q9W; Q5W over Q6W; S20M and S20H over F1.

[2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.

[3] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).

[4] For variations from investment curves of -15/+35%.

[5] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.

[6] Raw material upgrading costs.

[7] For new refining facilities only.

[8] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.

[9] Per gallon of Conventional Gasoline Upgraded.

[10] Per gallon of additional Jet A produced.

[11] Per gallon of decreased gasoline production (based on 403 MBPD for S20M and 802 MBPD for S20H). Equals 1.5¢/G for S20M and 4.1¢/G for S20H higher cost for remaining gasoline production.

[12] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (±0.2).

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TABLE D5-3
REFINING RAW MATERIAL AND PRODUCT RATE – MBPCD
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
Raw Materials						
Domestic – S	1,985	1,985	1,985	1,965	1,985	1,985
HL	174	174	174	174	174	174
HH	692	692	692	252	692	692
Foreign – S	732	678	678	1,248	1,081	992
HL	669	528	528	1,111	963	930
HH	1,357	1,372	1,545	2,546	1,926	1,613
Subtotal Crudes	5,609	5,429	5,602	7,296	6,821	6,386
MTBE	4	171	176	163	140	123
Ethanol						
Normal Butane	210	234	182			
Isobutane	46	46	46	68	46	46
Natural Gas to H2 Plant Feed	21	23	23	48	48	48
Methanol	19	30	29	35	33	28
Other Raw Materials	447	447	447	455	455	455
Total Raw Materials	6,356	6,379	6,504	8,064	7,542	7,086
Products						
Motor Gasolines						
Conventional	3,020	1,017	1,019	1,321	1,176	1,029
Oxygenated		84	83			
Reformulated/Oxygenated		536	538			
Reformulated		1,426	1,424	2,265	2,007	1,755
CARB2						
Kero Jet/Kerosene	768	768	847	1,042	1,042	1,042
Diesel/No. 2 Fuels						
Diesel – LA, ULS						
Diesel – 0.05%S	821	821	821	1,192	1,192	1,192
No. 2 Fuel	460	460	460	366	366	366
No. 6 Fuel (1% Sul)	55	55	55	182	57	57
No. 6 Bunker	63	63	63	75	138	102
Marketable Coke – 400 #	174	167	181	192	192	191
Catalytic Coke – 400 #	86	82	87	119	95	78
Vacuum Gas Oil						
Benzene	21	21	21	24	26	30
Toluene	25	25	25	22	18	14
Heavy Aromatic Gaso						
Pentanes to P/C						
Natural Gasoline to P/C	134	134	134	116	91	73
Normal Butane				64	49	54
Isobutane	23	52	76	12	35	60
Propane	137	127	137	168	151	141
Process Gas/C2/C2=,FOE	325	294	314	421	392	365
Other Products	536	534	534	817	817	817
(Gain)/Loss	(292)	(286)	(315)	(334)	(303)	(280)
Total Products	6,356	6,379	6,504	8,064	7,542	7,086
Crude Properties						
Gravity, °API	33.0	32.9	32.8	33.2	33.0	33.1
Sulfur, Wt%	1.14	1.13	1.17	1.32	1.23	1.18
Gasoline Demand Increase, %[1]						
Results		1.4	1.4			
Target		1.4	1.4			

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

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TABLE D5-4
NEW PROCESS UNIT RATES – MBPSD
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Base Case Q6W</u>	<u>Q5W Q6 Units Max K Jet[1]</u>	<u>2010 F1 Base</u>	<u>S20M Medium Alt Fuels[2]</u>	<u>S20H High Alt Fuels[2]</u>
Crude – Atmospheric			639	(488)	(639)
Heavy Naphtha Splitter				53	514
Catalytic Cracking					
FCC Gasoline Splitters	248		229	(33)	(112)
FCC Gasoline Fractionation					
Hydrocracking – 2 Stage					
Hydrocracking – 2 Stage Distillate – Hvy Gasoline					14
Hydrocrackate Fractionation					
Coker – Delayed					
Coker Lt Gasoline DS/Splitter			30		
Hydrotreating – Naphtha					
– FCC/Coker C6s					
– Distillate			582	4	17
– Heavy Gas Oil					
Reformer Feed Fractionation	1,359		1,727	(120)	(263)
Reformate Fractionation	247		300	(28)	(23)
Aromatics Extraction					
Benzene Saturation	33		77	(19)	(27)
FCC Gasoline HDS					
Diesel Aromatics Saturation					
Alkylation					
Alkylate Splitter					1
MTBE	18		34	(12)	(20)
TAME					
Isomerization – C5/C6					
– C5/C6, Recycle					
– C4					
Hydrogen – MMSCFPSD					
Sulfur – LTPSD					
C4 Rerun – Saturates			218	(9)	(27)
– Unsaturates			555	(55)	(233)
Catalytic Reforming – 100 PSI					
Hydrotreating – Distillate Upgrade					
Dehydrogenation – IC4					

[1] Additions to Q6 facilities.

[2] Changes to 2010 F1 facilities.

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TABLE D5-5
NEW PROCESS UNIT INVESTMENTS
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(\$MM – in constant mid-1990 \$)

	Base Case Q6W Target <u>Δ V.O.C.</u>	Q5W Q6 Units <u>Max K Jet[1]</u>	2010 F1 <u>Base</u>	S20M Medium <u>Alt Fuels[2]</u>	S20H High <u>Alt Fuels[2]</u>
Crude Distillation			695	(531)	(695)
Heavy Naphtha Splitter				49	283
Catalytic Cracking					
FCC Gasoline Splitters	186		322	(48)	(192)
FCC Gasoline Fractionation					
Hydrocracking – 2 Stage					
Hydrocracking – 2 Stage Distillate – Heavy Gasoline					101
Hydrocrackate Fractionation					
Coker – Delayed					
Coker Lt. Gasoline DS/Splitter			55		
Hydrotreating – Naphtha					
– FCC Coker C6s					
– Distillate			1,068	7	31
– Heavy Gas Oil					
Reformer Feed Fractionation	873		1,033	(73)	(166)
Reformate Fractionation	268		306	(30)	(24)
Aromatics Extraction					
Benzene Saturation	118		268	(68)	(99)
FCC Gasoline HDS					
Diesel Aromatics Saturation					
Alkylation					
Alkylate Splitter					1
MTBE	153		287	(106)	(215)
TAME					
Isomerization – C5/C6					
– C5/C6, Recycle					
– C4					
Hydrogen					
Sulfur					
MTBE Storage & Blending	111		127	(17)	(28)
C4 Rerun – Saturates			254	(11)	(32)
– Unsaturation			493	(48)	(210)
C4 Fractionation Upgrade			162		
Catalytic Reforming – 100 PSI					
Hydrotreating – Distillate Upgrade					
Dehydrogenation – IC4					
Total Refinery	1,709		5,072	(875)	(1,245)

[1] Additions to Q6 facilities investment.

[2] Changes to 2010 F1 facilities investment.

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TABLE D5-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
Crude – Atmospheric	127.5	123.4	127.3	165.8	155.0	145.1
Heavy Naphtha Splitter					1.2	11.3
Catalytic Cracking[1]	42.8	38.6	40.7	54.9	45.3	39.1
Catalytic Cracking[2]	39.7	37.5	38.8	50.8	42.2	36.4
Conversion, %	79.0	76.4	77.5	79.0	78.7	78.6
Octane Catalyst, %	71.5	70.8	73.9	74.1	71.8	75.0
FCC Gasoline Splitters		5.0	2.8	4.9	4.2	2.5
FCC Gasoline Fractionation	11.3	11.3	11.3	11.7	11.7	9.4
Hydrocracking – 2 Stage[1]	9.1	8.9	9.1	9.8	9.8	9.8
Jet Yield, % of Max	100.0	100.0	100.0	100.0	100.0	100.0
300 – Gasoline Operation, %						
Hydrocracking – 2 Stage Distillate						0.3
Hydrocracking – Low Conversion	1.5	1.5	1.9	1.5	2.2	2.2
– Heavy Gasoline						
– Combined[2]	10.5	10.3	11.0	11.3	12.0	12.3
Hydrocrackate Fractionation						
Coking – Delayed	12.8	12.2	13.4	14.2	14.2	14.2
– Fluid	0.7	0.7	0.7	0.8	0.8	0.7
Coker Lt Gasoline DS/Splitter			0.5 [3]	0.6	0.6	0.6
Thermal Cracking, Visbreaking	1.5	1.5	1.5	1.5	1.5	1.5
Solvent Deasphalting	2.0	1.9	1.9	4.0	3.8	2.5
Catalytic Reforming – 100 PSI[1]	13.7	11.9	11.9	17.4	16.3	13.7
– 200 PSI[1]	10.6	10.6	10.6	11.0	10.4	11.1
– 450 PSI[1]	5.5	4.5	4.5	6.6	6.1	4.7
– Combined[2]	29.3	26.8	26.3	34.6	32.2	29.2
– RONC	95.6	94.6	96.3	94.7	96.4	95.8
Hydrotreating – Naphtha	30.2	27.2	27.5	36.1	33.6	30.6
– FCC/Coker C6s						
– Distillate	31.0	31.1	31.9	45.5	45.6	45.8
– Heavy Gas Oil	15.6	15.6	15.6	16.3	16.3	15.0
– Residuurn – Atm	6.6	6.6	5.1	6.9	6.9	4.1
Reformer Feed Fractionation		27.2	27.2	36.1	33.6	30.6
Reformate Fractionation	8.0	12.7	12.7	14.4	13.8	13.9
Aromatics Extraction	4.0	3.9	3.9	4.1	4.1	4.1
Benzene Saturation		0.7	1.0	1.6	1.2	1.1
FCC Gasoline HDS						
Diesel Aromatics Saturation						
Alkylation	6.9	5.4	5.2	9.6	7.1	5.6
Alkylate Splitter						0.0
Polymerization	0.4	0.4	0.4	0.4	0.4	0.4
Dehydrogenation – IC4	0.6	0.7	0.7	0.7	0.7	0.7
MTBE	1.3	1.6	1.7	2.1	1.8	1.7
TAME		0.4	0.3	0.3	0.4	0.2
Hydrodealkylation – Toluene						
Lubes	2.2	2.2	2.2	2.2	2.2	2.2
Isomerization – C5/C6	2.1	2.1	2.1	2.2	2.2	2.2
– C5/C6, Recycle	2.1	1.0	2.0	2.2	2.2	2.2
– C4	0.7	0.7	0.7	0.8	0.8	0.8
Hydrogen – MMSCFPCD	20.3	22.0	22.0	23.0	23.0	23.0
Sulfur, LTPCD	123	119	122	166	148	131
C4 Rerun – Saturates				4.6	4.2	4.0
– Unsaturates				11.6	10.5	6.7

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

[3] Capacity added in Q6 Summer base case and, therefore, available in cases based on the Q6 base cases.

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TABLE D5-7
PROCESS UNIT UTILIZATIONS – %[1]
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
Crude Distillation – Atmospheric	81.5	78.9	81.4	97.0 *	97.0 *	92.8
Heavy Naphtha Splitter					97.0 *	97.0 *
Catalytic Cracking[2]	71.7	64.7	68.3	92.0	76.0	65.5
Catalytic Cracking[3]	66.5	62.9	65.0	85.2	70.7	61.1
FCC Gasoline Splitters		88.0 *	88.0 *	94.0 *	94.0 *	94.0 *
FCC Gasoline Fractionation	79.2	79.2	79.2	81.9	81.9	65.8
Hydrocracking – 2 Stage[2]	81.0 *	79.0	81.0 *	87.0 *	87.0 *	87.0 *
Hydrocracking – 2 Stage Distillate						87.0 *
– Low Conversion	60.5	60.5	81.0 *	58.5	87.0 *	87.0 *
– Heavy Gasoline						
– Combined[3]	77.4	75.8	81.0 *	81.7	87.0 *	87.0 *
Hydrocrackate Fractionation						
Coking – Delayed	83.1	79.3	86.8	92.0 *	92.0 *	92.0 *
– Fluid	85.2	85.2	85.2	92.0 *	92.0 *	85.9
Coker Lt Gasoline DS/Splitter			90.0 *	92.0 *	92.0 *	92.0 *
Thermal Cracking, Visbreaking	88.0 *	88.0 *	88.0 *	92.0 *	92.0 *	92.0 *
Solvent Deasphalting	44.9	44.2	44.4	92.0 *	86.6	57.0
Catalytic Reforming – 100 PSI[2]	72.1	62.7	62.7	91.3	85.9	72.2
– 200 PSI[2]	88.0 *	88.0 *	88.0 *	91.6	86.7	92.0 *
– 450 PSI[2]	53.7	43.9	43.9	64.4	59.5	45.9
– Combined[3]	71.0	65.0	63.8	83.7	77.9	70.7
Hydrotreating – Naphtha	70.3	63.4	64.0	84.2	78.3	71.3
– FCC/Coker C6s						
– Distillate	85.5	85.9	88.0 *	92.0 *	92.0 *	92.0 *
– Heavy Gas Oil	82.7	82.7	82.7	86.6	86.6	79.7
– Residuum, Atm	88.0 *	88.0 *	68.2	92.0 *	92.0 *	55.1
Reformer Feed Fractionation		88.0 *	88.0 *	92.0 *	92.0 *	92.0 *
Reformate Fractionation	69.3	88.0 *	88.0 *	92.0 *	92.0 *	92.0 *
Aromatics Extraction	59.9	88.0 *	88.0 *	92.0 *	92.0 *	92.0 *
Benzene Saturation		88.0 *	68.8	92.0 *	92.0 *	92.0 *
FCC Gasoline HDS						
Diesel Aromatics Saturation						
Alkylation	56.9	44.8	42.5	78.8	58.5	46.3
Alkylate Splitter						89.0 *
Polymerization	43.1	43.1	43.1	45.0	45.0	45.0
Dehydrogenation – IC4	82.4	85.0 *	85.0 *	89.0 *	89.0 *	89.0 *
MTBE	84.0 *	84.0 *	78.5	90.0 *	90.0 *	90.0 *
TAME	0.0	81.0 *	49.2	51.4	70.6	46.8
Hydrodealkylation – Toluene	0.0	0.0	0.0	0.0	0.0	0.0
Lubes	82.0	82.0	82.0	82.0	82.0	82.0
Isomerization – C5/C6	88.0 *	88.0 *	88.0 *	92.0 *	92.0 *	92.0 *
– C5/C6, Recycle	88.0 *	41.9	82.6	92.0 *	92.0 *	92.0 *
– C4	85.0 *	85.0 *	85.0 *	89.0 *	89.0 *	89.0 *
Hydrogen	78.2	85.0 *	85.0 *	89.0 *	89.0 *	89.0 *
Sulfur	48.9	47.3	48.5	65.6	58.5	51.8
C4 Rerun – Saturates				92.0 *	92.0 *	92.0 *
– Unsaturates				92.0 *	92.0 *	92.0 *

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

[4] Capacity added in the Q6 Summer base case and, therefore, available in cases based on the Q6 base cases.

TABLE D5-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
FCC Gasoline	17.0	14.5	15.5	15.3	17.5	18.5
Lt. FCC 255-	9.7	2.5	5.7	8.4	4.1	4.8
Hvy FCC 255+	6.7	6.6	6.7	5.9	6.3	6.1
Hvy FCC 255+ Desulf.						
FCC Gaso (100-180)		2.4	1.4	1.2	1.9	1.4
FCC Gaso (180-225)		1.5	0.7	0.8	1.1	0.8
FCC Gaso (225-300)		1.0	0.6	1.4	1.0	0.6
FCC Gaso (300-375)				0.6		
FCC Gaso (375-430)						
Total FCC Gasoline	33.4	28.6	30.5	33.6	31.9	32.2
Butenes			0.9			
Pentenenes		0.7	0.5	0.3	0.5	0.4
Poly Gasoline	0.6	0.6	0.6	0.5	0.6	0.6
Lt. Coker Gasoline	1.3	1.1	1.0	0.5	0.6	0.6
Total Olefinic	1.9	2.4	2.9	1.3	1.6	1.7
Reformate	13.7	16.2	15.6	20.4	20.1	8.3
Reformate (220-300 Feed)	5.6	3.3	2.5	1.7	3.0	13.7
BT Reformate	3.8	0.6	0.7	0.1		
HC Reformate (210-300)	2.6	3.2	3.5	4.3	4.5	5.4
Heavy Reformate (300+)	1.7	0.9	0.1	0.3	0.4	0.4
Toluene/Xylenes			0.2	0.1	0.2	0.4
Total Reformates[1]	27.4	24.3	22.7	26.8	28.1	28.1
Lt. Reformate	1.4	0.9		0.9	0.7	1.0
Lt. Raffinate B(C5-210)	2.5	3.5	3.6	4.4	4.4	4.6
Alkylate/Lt Alkylate (C3/C4)	10.0	7.7	7.1	11.3	9.5	8.5
Alkylate/Lt Alkylate (C5)				0.2	0.2	0.2
Butane	11.0	11.2	9.8	2.7	2.9	2.6
Natural/LSR Gaso		1.2	0.0			
BT Naphtha (150-220)		1.6	3.7	1.0	1.6	0.3
Pentanenes (I/N)		0.9	0.7	0.7	0.9	0.8
Isomerase (C5-C6)	6.0	4.3	5.7	5.2	5.9	6.7
Isomerase (C6)						
Lt. Hydrocrackate (C5-180)	2.2	2.2	2.3	2.1	2.4	2.8
Medium Hydrocrackate (180-225)	2.0	2.6	2.7	2.4	2.8	3.2
MTBE	2.0	7.9	8.1	7.1	6.9	7.0
TAME		0.6	0.4	0.3	0.5	0.4
Alcohol						
Total Low Arom., Saturated	37.1	44.7	43.9	38.3	38.5	38.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

* Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D5-8A
REFORMULATED GASOLINE POOL COMPOSITIONS – %
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
FCC Gasoline	17.1	10.5	22.9	27.7	24.7
Lt. FCC 255-	1.2	10.9			
Hvy FCC 255+	7.2	9.4	3.0	5.1	3.8
Hvy FCC 255+ Desulf.					
FCC Gaso (100-180)	0.9		1.4		
FCC Gaso (180-225)	0.6		0.9		
FCC Gaso (225-300)	0.4		1.9	1.5	0.9
FCC Gaso (300-375)					
FCC Gaso (375-430)					
Total FCC Gasoline	27.4	30.8	30.1	34.3	29.4
Butenes					
Pentenes	0.6	0.4	0.5	0.8	0.6
Poly Gasoline	0.7	1.1	0.8	0.9	1.0
Lt. Coker Gasoline					
Total Olefinic	1.2	1.4	1.3	1.7	1.6
Reformate	11.7	12.8	13.4	10.8	5.4
Reformate (220-300 Feed)			2.6	2.2	11.0
BT Reformate					
HC Reformate (210-300)	5.2	3.5	6.8	7.1	8.6
Heavy Reformate (300+)			0.5	0.6	
Toluene/Xylenes			0.1		
Total Reformates[1]	16.9	16.3	23.5	20.7	24.9
Lt. Reformate					
Lt. Raffinate B(C5-210)	5.3	7.7	7.0	6.9	7.3
Alkylate/Lt Alkylate (C3/C4)	9.4	8.7	14.2	11.2	11.0
Alkylate/Lt Alkylate (C5)			0.3	0.2	0.2
Butane	11.3	10.4	2.0 *	2.0 *	2.0 *
Natural/LSR Gaso					
BT Naphtha (150-220)	2.9	4.6	1.6	2.3	0.4
Pentanes (I/N)		1.2	0.1		
Isomerase (C5-C6)	6.3	5.5	4.9	3.4	4.1
Isomerase (C6)					
Lt. Hydrocrackate (C5-180)	3.3	0.8	1.4	2.5	3.3
Medium Hydrocrackate (180-225)	4.1	1.0	1.7	3.0	3.9
MTBE	10.5	11.3	11.2	11.0	11.1
TAME	1.3	0.4	0.5	0.8	0.6
Alcohol					
Total Low Arom., Saturated	54.4	51.4	45.1	43.3	44.0
Total	100.0	100.0	100.0	100.0	100.0

* Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D5-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS – %
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
FCC Gasoline	17.0	18.6	18.1	2.2		7.9
Lt. FCC 255-	9.7	1.4	1.5	23.0	11.1	13.0
Hvy FCC 255+	6.7	4.3	4.0	10.8	8.2	10.0
Hvy FCC 255+ Desulf.						
FCC Gaso (100-180)		5.3	3.5	0.8	5.1	3.7
FCC Gaso (180-225)		2.9	2.1	0.4	3.0	2.2
FCC Gaso (225-300)		2.1	1.5	0.6		
FCC Gaso (300-375)				1.8		
FCC Gaso (375-430)						
Total FCC Gasoline	33.4	34.7	30.7	39.6	27.3	36.9
Butenes			1.3			
Pentenenes						
Poly Gasoline	0.6					
Lt. Coker Gasoline	1.3	2.9	2.9	1.3	1.5	1.7
Total Olefinic	1.9	2.9	4.2	1.3	1.5	1.7
Reformate	13.7	18.6	23.2	32.3	36.0	13.2
Reformate (220-300 Feed)	5.6	8.8	5.6		4.3	18.2
BT Reformate	3.8	1.6	1.7	0.2		
HC Reformate (210-300)	2.6	0.4				
Heavy Reformate (300+)	1.7	2.8	0.4			1.1
Toluene/Xylenes			0.7		0.5	1.0
Total Reformates[1]	27.4	32.3	31.6	32.5	40.8	33.5
Lt. Reformate	1.4	2.8		2.5	1.8	2.7
Lt. Raffinate B(C5-210)	2.5					
Alkylate/Lt Alkylate (C3/C4)	10.0	6.6	8.9	6.3	6.5	4.3
Alkylate/Lt Alkylate (C5)				0.1	0.1	0.1
Butane	11.0	11.1	10.8	3.8	4.4	3.6
Natural/LSR Gaso						
BT Naphtha (150-220)					0.2	
Pentanenes (I/N)		2.8	0.2	1.5	2.4	2.0
Isomerate (C5-C6)	6.0	4.2	1.0	5.7	10.1	11.2
Isomerate (C6)						
Lt. Hydrocrackate (C5-180)	2.2	1.2	5.7	3.1	2.3	1.9
Medium Hydrocrackate (180-225)	2.0	1.4	6.8	3.5	2.4	2.0
MTBE	2.0					
TAME						
Alcohol						
Total Low Arom., Saturated	37.1	30.1	33.5	26.5	30.4	27.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

* Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D5-8C
OXYGENATED GASOLINE POOL COMPOSITIONS – %
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6W	Q5W Q6 Units Max K Jet
FCC Gasoline	17.1	10.3
Lt. FCC 255-	1.2	4.3
Hvy FCC 255+	7.2	10.5
Hvy FCC 255+ Desulf.		
FCC Gaso (100-180)	0.9	7.0
FCC Gaso (180-225)	0.6	3.7
FCC Gaso (225-300)	0.4	2.5
FCC Gaso (300-375)		
FCC Gaso (375-430)		
Total FCC Gasoline	<u>27.4</u>	<u>38.2</u>
Butenes	0.6	1.0
Pentenes	0.7	
Poly Gasoline		
Lt. Coker Gasoline	<u> </u>	<u>0.6</u>
Total Olefinic	1.2	1.6
Reformate	11.7	11.6
Reformate (220-300 Feed)		7.4
BT Reformate		3.7
HC Reformate (210-300)	5.2	
Heavy Reformate (300+)		
Toluene/Xylenes		
Total Reformates[1]	<u>16.9</u>	<u>22.7</u>
Lt. Reformate		
Lt. Raffinate B(C5-210)	5.3	
Alkylate/Lt Alkylate (C3/C4)	9.4	
Alkylate/Lt Alkylate (C5)		
Butane	11.3	11.2
Natural/LSR Gaso		0.7
BT Naphtha (150-220)	2.9	10.0
Pentanes (I/N)		0.7
Isomerase (C5-C6)	6.3	
Isomerase (C6)		
Lt. Hydrocrackate (C5-180)	3.3	
Medium Hydrocrackate (180-225)	4.1	
MTBE	10.5	15.0
TAME	1.3	
Alcohol		
Total Low Arom., Saturated	<u>54.4</u>	<u>37.6</u>
Total	<u>100.0</u>	<u>100.0</u>

* Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE D5-8D
REFORMULATED-OXYGENATED GASOLINE POOL COMPOSITIONS – %
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6W	Q5W Q6 Units Max K Jet
FCC Gasoline	2.0	24.2
Lt. FCC 255-	8.4	
Hvy FCC 255+	10.7	3.7
Hvy FCC 255+ Desulf.		
FCC Gaso (100-180)	0.7	
FCC Gaso (180-225)	0.5	
FCC Gaso (225-300)	0.5	0.1
FCC Gaso (300-375)		
FCC Gaso (375-430)		
Total FCC Gasoline	<u>22.9</u>	<u>28.1</u>
Butenes		2.8
Pentenes	2.7	1.7
Poly Gasoline	1.5	0.3
Lt. Coker Gasoline		
Total Olefinic	<u>4.1</u>	<u>4.8</u>
Reformat	21.5	9.4
Reformat (220-300 Feed)	2.4	2.5
BT Reformat		
HC Reformat (210-300)	3.1	10.6
Heavy Reformat (300+)		
Toluene/Xylenes		
Total Reformates[1]	<u>26.9</u>	<u>22.4</u>
Lt. Reformat		
Lt. Raffinate B(C5-210)	5.8	
Alkylate/Lt Alkylate (C3/C4)	5.6	0.4
Alkylate/Lt Alkylate (C5)		
Butane	11.1	6.0
Natural/LSR Gaso	6.8	
BT Naphtha (150-220)	1.6	7.3
Pentanes (I/N)	0.1	0.1
Isomate (C5-C6)		15.7
Isomate (C6)		
Lt. Hydrocrackate (C5-180)		
Medium Hydrocrackate (180-225)		
MTBE	15.0	14.1
TAME		1.0
Alcohol		
Total Low Arom., Saturated	<u>46.0</u>	<u>44.7</u>
Total	<u>99.9</u>	<u>100.0</u>

* Minimum.

[1] Excluding Lt Reformat and Lt Raffinate.

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TABLE D5-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(¢/G per unit in constant 1990 \$)

	Base Case Q9W	Base Case Q6W	Q5W Q6 Units Max K Jet	2010 F1 Base	S20M Medium Alt Fuels	S20H High Alt Fuels
(R+M)/2 Octane, Clear	(0.3)	(0.3)	(0.3)	(0.6)	(0.5)	(0.6)
Aromatics, Vol. %						
Ethers, Vol. %		(0.3)	(0.5)	(0.3)	(0.4)	(0.4)
Ethanol, %						
Olefins, Vol. %						
Benzene, Vol. %		0.2	0.3	1.4	1.6	2.1
Sulfur, 100 Wt. PPM				0.0		
Reid Vapor Pressure, P	0.3	0.3	0.2	(1.5)	0.4 [2]	0.1
T90, 10°F						
Butane, Vol. %				(0.0)	(0.0)	(0.1)
V.O.C., 10%				1.2	0.4	0.3
NOx, 10%		0.1				0.0
T.A.P., 10%				0.2	0.1	0.0

[1] Shadow costs for very small changes. Not applicable for significant changes.

[2] Average of absolute values. RFG is at minimum RVP (negative cost), while CG is at maximum RVP (positive cost).

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TABLE D5-9A
REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(¢/G per unit in constant 1990 \$)

	<u>Base Case Q6W</u>	<u>Q5W Q6 Units Max K Jet</u>	<u>2010 F1 Base</u>	<u>S20M Medium Alt Fuels</u>	<u>S20H High Alt Fuels</u>
(R+M)/2 Octane, Clear	(0.3)	(0.3)	(0.5)	(0.5)	(0.5)
Aromatics, Vol. %					
Ethers, Vol. %	(0.5)	(0.5)	(0.3)	(0.4)	(0.4)
Ethanol, %					
Olefins, Vol. %					
Benzene, Vol. %	0.2	0.4	2.0	1.8	2.7
Sulfur, 100 Wt. PPM					
Reid Vapor Pressure, PSI	0.3	0.2	(2.4)	(0.6)	
T90, 10°F					
Butane, Vol. %			(0.0)	(0.0)	(0.2)
V.O.C., 10%			1.9	0.7	0.5
NOx, 10%	0.1				
T.A.P., 10%					

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D5-9B
CONVENTIONAL GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(¢/G per unit in constant 1990 \$)

	<u>Base Case Q9W</u>	<u>Base Case Q6W</u>	<u>Q5W Q6 Units Max K Jet</u>	<u>2010 F1 Base</u>	<u>S20M Medium Alt Fuels</u>	<u>S20H High Alt Fuels</u>
(R+M)/2 Octane, Clear	(0.3)	(0.3)	(0.3)	(0.6)	(0.5)	(0.6)
Aromatics, Vol. %						
Ethers, Vol. %			(0.5)	(0.3)	(0.4)	(0.4)
Ethanol, %						
Olefins, Vol. %						
Benzene, Vol. %		0.2	0.3	0.3	1.2	1.1
Sulfur, 100 Wt. PPM				0.1		
Reid Vapor Pressure, PSI	0.3	0.3	0.2		0.1	0.2
T90, 10°F						
Butane, Vol. %						
V.O.C., 10%						
NOx, 10%						0.1
T.A.P., 10%				0.5	0.2	0.1

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D5-9C
OXYGENATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (¢/G per unit in constant 1990 \$)

	Base Case Q6W	Q5W Q6 Units Max K Jet
(R+M)/2 Octane, Clear	(0.3)	(0.3)
Aromatics, Vol. %		
Ethers, Vol. %	(0.5)	(0.5)
Ethanol, %		
Olefins, Vol. %		
Benzene, Vol. %	0.2	0.4
Sulfur, 100 Wt. PPM		
Reid Vapor Pressure, PSI	0.3	0.2
T90, 10°F		
Butane, Vol. %		
V.O.C., 10%		
NOx, 10%	0.1	
T.A.P., 10%		

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE D5-9D
REFORMULATED-OXYGENATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(¢/G per unit in constant 1990 \$)

	Base Case Q6W	Q5W Q6 Units Max K Jet
(R+M)/2 Octane, Clear	(0.2)	(0.3)
Aromatics, Vol. %		
Ethers, Vol. %	(0.5)	(0.5)
Ethanol, %		
Olefins, Vol. %		
Benzene, Vol. %	0.2	0.4
Sulfur, 100 Wt. PPM		
Reid Vapor Pressure, PSI	0.3	0.2
T90, 10°F		
Butane, Vol. %		
V.O.C., 10%		
NOx, 10%	0.2	
T.A.P., 10%		

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE D5-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IIIC – WINTER 2000 F2/SUMMER 2010 F1 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Base Case Q9W</u>	<u>Base Case Q6W</u>	<u>Q5W Q6 Units Max K Jet</u>	<u>2010 F1 Base</u>	<u>S20M Medium Alt Fuels</u>	<u>S20H High Alt Fuels</u>
<u>No. 2 Diesel Compositions</u>						
Hvy Reformate (300+) 90 RON			2.7			
Hvy Reformate (300+) 100 RON			0.4			
FCC Heavy Gaso Tr(300-375)				0.7	0.3	
FCC Heavy Gaso Tr(375-430)					0.1	
Lt Cycle Oil - Treated	2.6	3.2		4.0	5.3	6.2
Coker Dist - Treated	1.9	4.9	6.6	7.8	7.8	7.8
Total High Aromatic	4.5	8.2	9.7	12.5	13.5	14.0
Heavy Alkylate (300+)		0.0	0.0	0.0	0.0	0.1
Lt Kero - Treated (300-375)	2.2	1.6	0.7	2.9	4.5	4.7
Kero (375-500)	9.6	7.2	11.9	6.9	4.0	6.6
Kero - Treated (375-500)	25.0	25.1	18.0	23.0	19.4	19.1
Kero - Low Aromatics (375-500)						
Hydrocracked Jet (295-525)						
Diesel Base	26.7	28.9	23.9	16.7	18.7	14.7
Diesel Base - Treated	32.1	29.0	35.8	38.0	39.9	40.9
Diesel Base - Low Aromatics						
Lt Cycle Oil - Low Aromatics						
Coker Dist - Low Aromatics						
Total Low Aromatic	95.5	91.8	90.3	87.5	86.5	86.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>						
Diesel Ignition Improver						
Pour Point Depressant			Yes		Yes	Yes
Aromatics	26.6	26.9	26.9	27.2	27.3	27.3
<u>Jet A Compositions</u>						
Heavy Alkylate (300+)						
Lt Kero - Treated (300-375)	34.0	33.9	33.0	32.0	27.9	35.9
Kero - Treated (375-500)	37.6	38.4	40.8	45.9	49.5	41.0
Hydrocracked Jet (295-525)	28.4	27.7	26.1	22.1	22.6	23.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE E-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer			Annual	
	Base Case Q9 No FCAAA	S17 '95 Permit Delay	S21 2000 All CARB 2	Base Case Q9Y No FCAAA	S7 1990 Prod Regs
<u>Reformulated Limits*</u>					
Aromatics, Vol.%, Maximum Avg		27.9	22.0		
Oxygen, Wt%, Minimum Avg		2.1	2.0		
Olefins, Vol.%, Maximum Avg		15.6	4.0		
Benzene, Vol%, Maximum Avg		0.7	0.8		
Sulfur, WPPM, Maximum Avg		356	30		
Reid Vapor Pressure, PSI, Min					
Reid Vapor Pressure, PSI, Max		7.3	6.6		
Regulatory Cap			7.0		
T50, °F, Maximum Avg					
T90, °F, Maximum Avg		341	290		
V.O.C., % Reduction					
T.A.P., % Reduction					
% Class C, Fixed	80	80	80	80	80
<u>Ethers, V% Pool</u>					
Purchased (Sold)	1.2	4.3	8.6	1.2	1.0
Manufactured	0.8	0.8	2.5	0.8	0.7
<u>Gasoline Pool Properties</u>					
(R+M)/2 Octane, Clear*	88.9	88.9	88.9	88.9	88.9
Aromatics, Vol.%	31.2	28.8 *	22.0 *	29.6	29.2
Ethers, Vol.% *	2.0	5.1	11.1	2.0	1.7
Oxygen, Wt.% *	0.4	0.9	2.0	0.4	0.3
Olefins, Vol.%	15.9	15.0 *	4.0 *	16.1	15.8
Benzene, Vol.%	1.8 *	1.5 *	0.8 *	1.8	1.8
Sulfur, WPPM	341	333	29 *	341	336
Reid Vapor Pressure, PSI*	8.2	8.0	6.6	10.2	11.0
Temperature at V/L = 20, °F	141	142	145	130	125
<u>Distillation</u>					
T10, °F	116	119	137	101	94
T50, °F	212	208	193	208	206
T90, °F	354	351	290 *	352	351
Specific Gravity	0.7479	0.7462	0.7355	0.7413	0.7387
Heat Content, MBTU/G	114.1	113.3	111.2	113.3	113.1
V.O.C., gm/mile	1.13	1.06	0.65		
– % Reduction	10	15	48		
NOx, index	1.03	1.03	0.92		
– % Reduction	(3)	(3)	8		
T.A.P., mg/mile	54	49	27		
– % Reduction	(4)	6	49		

* Input limit.

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TABLE E-1A
REFORMULATED GASOLINE POOL PROPERTIES
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer	
	S17 '95 Permit Delay	S21 2000 All CARB 2
<u>Reformulated Limits*</u>		
Aromatics, Vol.%, Maximum Avg	27.9	22.0
Oxygen, Wt%, Minimum Avg	2.1	2.0
Olefins, Vol.%, Maximum Avg	15.6	4.0
Benzene, Vol%, Maximum Avg	0.7	0.8
Sulfur, WPPM, Maximum Avg	356	30
Reid Vapor Pressure, PSI, Min		
Reid Vapor Pressure, PSI, Max	7.3	6.6
Regulatory Cap	7.6	7.0
T50, °F, Maximum Avg		
T90, °F, Maximum Avg	341	290
V.O.C., % Reduction		
T.A.P., % Reduction		
% Class C, Fixed	80	80
<u>Ethers, V% Pool</u>		
Purchased (Sold)		
Manufactured		
<u>Reformulated Pool Properties</u>		
(R+M)/2 Octane, Clear*	88.9	88.9
Aromatics, Vol.%	20.8	22.0 *
Ethers, Vol.%*	11.7	11.1
Oxygen, Wt.%*	2.1	2.0
Olefins, Vol.%*	15.6	4.0
Benzene, Vol.%*	0.7	0.8
Sulfur, WPPM	305	29 *
Reid Vapor Pressure, PSI*	7.3	6.6
Temperature at V/L = 20, °F	145	145
Distillation		
T10, °F	127	137
T50, °F	199	193
T90, °F	337	290 *
Specific Gravity	0.7392	0.7355
Heat Content, MBTU/G	111.4	111.2
V.O.C., gm/mile	0.85	0.65
– % Reduction	32	48
NOx, index	1.04	0.92
– % Reduction	(4)	8
T.A.P., mg/mile	35	27
– % Reduction	33	49

* Input limit.

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TABLE E-1B
CONVENTIONAL GASOLINE POOL PROPERTIES
IC - 1995/2000 F2 - SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer		Annual	
	Base Case Q9 No FCAAA	S17 '95 Permit Delay	Base Case Q9Y No FCAAA	S7 1990 Prod Regs
<u>Conventional Limits*</u>				
Aromatics, Vol.%, Maximum Avg		31.7		
Oxygen, Wt%, Minimum Avg				
Olefins, Vol.%, Maximum Avg		19.5		
Benzene, Vol%, Maximum Avg		1.8		
Sulfur, WPPM, Maximum Avg		445		
Reid Vapor Pressure, PSI, Min				
Reid Vapor Pressure, PSI, Max	8.2	8.2	10.2	11.0
Regulatory Cap				
T50, °F, Maximum Avg				
T90, °F, Maximum Avg	356	356	356	356
V.O.C., % Reduction				
T.A.P., % Reduction				
% Class C, Fixed	80	80	80	80
<u>Ethers, V% Pool</u>				
Purchased (Sold)			1.2	1.0
Manufactured			0.8	0.7
<u>Conventional Pool Properties</u>				
(R+M)/2 Octane, Clear*	88.9	88.9	88.9	88.9
Aromatics, Vol.%	31.2	31.7 *	29.6	29.2
Ethers, Vol.%*	2.0	2.7	2.0	1.7
Oxygen, Wt.%*	0.4	0.5	0.4	0.3
Olefins, Vol.%	15.9	14.8	16.1	15.8
Benzene, Vol.%*	1.8 *	1.8 *	1.8	1.8
Sulfur, WPPM	341	344	341	336
Reid Vapor Pressure, PSI*	8.2	8.2	10.2	11.0
Temperature at V/L = 20, °F	141	141	130	125
Distillation				
T10, °F	116	116	101	94
T50, °F	212	212	208	206
T90, °F	354	356 *	352	351
Specific Gravity	0.7479	0.7487	0.7413	0.7387
Heat Content, MBTU/G	114.1	113.9	113.3	113.1
V.O.C., gm/mile	1.13	1.14		
- % Reduction	10	9		
NOx, index	1.03	1.02		
- % Reduction	(3)	(2)		
T.A.P., mg/mile	54	55		
- % Reduction	(4)	(6)		

* Input limit.

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TABLE E-2
SUMMARY OF COSTS – INCREASE OVER Q9 BASE CASE[1]
IC – 1995/2000 F2 – SF CASE RESULTS[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Summer		Annual
	S17	S21	S7
	'95 Permit	2000 All	1990 Prod
	Delay	CARB 2[3]	Regs[3]
<u>Investment, MM\$</u>			
Refinery		3,727	(643)
MTBE[4]	513	1,314	(46)
Total	513	5,041	(689)
Range, MMM\$[5]	0.4 – 0.7	4.3 – 6.8	(0.9) – (0.6)
<u>Daily Costs, M\$/D</u>			
Capital Charge[6]		2,700	(332)
Net Upgrading[7]	417	1,406	(108)
Variable Operating	(76)	857	(85)
Fixed Operating[8]		1,053	(131)
Total Refinery	341	6,016	(656)
<u>Annual Costs, MM\$/Yr</u>			
Refinery	124	2,196	(240)
Other[9]	77	295	20
Total	201	2,491	(220)
<u>Total Unit Costs, ¢/G of Gasoline/Diesel Upgraded</u>			
Average	7.2	24.2	(4.3) [10]
Range[11]	5.4 – 10.2	21.3 – 29.8	(4.6) – (4.2)

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.
- [3] Adjusted using individual unit capital charge/fixed operating costs multipliers to include the full cost of extra facilities for summer RFG as detailed on Table A3-19.
- [4] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [5] For variations from investment curves of -15/+35%.
- [6] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- [7] Raw material upgrading costs.
- [8] For new refining facilities only.
- [9] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [10] Save 4.3¢/G in costs on 263 MPD of 0.05%S diesel downgraded to 0.25%S diesel and No. 2 fuel based on estimated savings from downgrading conventional gasoline (by +0.8 RVP, -0.3% MTBE) of about 0.4¢/G or \$46MM/Yr, including about \$20MM/Yr Δ BTU cost.
- [11] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (± 0.2).

TABLE E-2A
SUMMARY OF COSTS – INCREASE OVER Q9 BASE CASE[1]
IC – 1995/2000 F2 – SF CASE RESULTS UNADJUSTED[2]
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Summer		Annual
	S17	S21	S7
	'95 Permit	2000 All	1990 Prod
	Delay	CARB 2	Regs
<u>Investment, MM\$</u>			
Refinery		3,727	(643)
MTBE[3]		<u>1,314</u>	<u>(46)</u>
Total		5,041	(689)
Range, MMM\$[4]		4.3 – 6.8	(0.9) – (0.6)
<u>Daily Costs, M\$/D</u>			
Capital Charge[5]		1,736	(300)
Net Upgrading[6]		1,406	(108)
Variable Operating		857	(85)
Fixed Operating[7]		<u>730</u>	<u>(121)</u>
Total Refinery		4,729	(614)
<u>Annual Costs, MM\$/Yr</u>			
Refinery		1,726	(224)
Other[8]		<u>295</u>	<u>20</u>
Total		2,021	(204)
<u>Total Unit Costs, ¢/G of Gasoline/Diesel Upgraded</u>			
Average		19.7	(3.9) [9]
Range[10]		17.3 – 24.1	(4.1) – (3.8)

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable cost over base case.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average. Unadjusted LP case results shown before capital charge and CG RVP adjustments if these were required.
- [3] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [4] For variations from investment curves of -15/+35%.
- [5] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- [6] Raw material upgrading costs.
- [7] For new refining facilities only.
- [8] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [9] Save 3.9¢/G in costs on 263 MPD of 0.05%S diesel downgraded to 0.25%S diesel and No. 2 fuel based on estimated savings from downgrading conventional gasoline (by +0.8 RVP, -0.3% MTBE) of about 0.4¢/G or \$46MM/Yr.
- [10] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (± 0.2).

TABLE E-3
REFINING RAW MATERIAL AND PRODUCT RATES – MBPCD
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer			Annual	
	Base Case Q9	S17 '95 Permit Delay	S21 2000 All CARB 2	Base Case Q9Y	S7 1990 Prod Regs
Raw Materials					
Domestic - S	14	14	14	14	14
HL					
HH	29	29	29	29	29
Foreign - S	515	515	590	515	515
HL	171	171	171	171	171
HH	410	387	314	356	345
Subtotal Crudes	1,139	1,116	1,118	1,085	1,074
MTBE	8	29	59	8	7
Ethanol					
Normal Butane	4	2		25	37
Isobutane	1	3	1	1	1
Natural Gas to H2 Plant Feed	2	2	7	2	2
Methanol	2	2	6	2	2
Other Raw Materials	204	204	204	204	204
Total Raw Materials	1,360	1,359	1,395	1,327	1,326
Products					
Motor Gasolines					
Conventional	670	492		673	675
Oxygenated					
Reformulated/Oxygenated					
Reformulated		182			
CARB2			688		
Kero Jet/Kerosene	86	86	86	88	88
Diesel/No. 2 Fuels					
Diesel - LA ULS					
Diesel - 0.05%S	281	281	281	263	132 [2]
No. 2 Fuel	35	35	35	61	192
No. 6 Fuel (1% Sul)	62	62	62	49	48
No. 6 Bunker	6	6	14	7	7
Marketable Coke - 400 #	18	16	17	24	24
Catalytic Coke - 400 #	26	26	21	26	26
Vacuum Gas Oil					
Benzene	2	2	5	2	2
Toluene	6	6	3	6	6
Heavy Aromatic Gaso					
Pentanes to P/C			8		
Natural Gasoline to P/C					
Normal Butane			4		
Isobutane	1	1	1	1	1
Propane	28	30	33	27	26
Process Gas/C2/C2=,FOE	70	66	69	67	65
Other Products	125	125	125	94	94
(Gain)/Loss	(56)	(58)	(59)	(61)	(60)
Total Products	1,360	1,359	1,395	1,327	1,326
Crude Properties					
Gravity, °API	31.8	31.9	32.4	32.2	32.2
Sulfur, Wt%	1.31	1.28	1.09	1.18	1.17
Gasoline Demand Increase, %[1]					
Results		0.7	2.6		0.3
Target		0.7	2.6		0.2

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

[2] Premium diesel with 0.25 wt % sulfur.

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TABLE E-4
NEW PROCESS UNIT RATES – MBPSD
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Summer</u>	<u>Annual</u>
	S21	S7[1]
	2000 All	1990 Prod
	<u>CARB 2</u>	<u>Regs</u>
Crude – Atmospheric		
Heavy Naphtha Splitter		
Catalytic Cracking		
FCC Gasoline Splitters	289	
FCC Gasoline Fractionation		
Hydrocracking – 2 Stage	8	
Hydrocracking – 2 Stage Distillate		
– Hvy Gasoline	59	
Hydrocrackate Fractionation	70	
Coker – Delayed		
Coker Lt Gasoline DS/Splitter	3	
Hydrotreating – Naphtha		
– FCC/Coker C6s	73	
– Distillate		(40)
– Heavy Gas Oil	119	
Reformer Feed Fractionation	272	
Reformate Fractionation	61	
Aromatics Extraction		
Benzene Saturation	22	
FCC Gasoline HDS		
Diesel Aromatics Saturation	2	
Alkylation	54	(15)
Alkylate Splitter	63	
MTBE	10	(6)
TAME		
Isomerization – C5/C6	52	
– C5/C6, Recycle	17	
– C4	17	(8)
Hydrogen – MMSCFPSD	248	(8)
Sulfur – LTPSD		(69)
C4 Rerun – Saturates	39	
– Unsaturation	106	
Catalytic Reforming – 100 PSI		
Hydrotreating – Distillate Upgrade		(199)
Dehydrogenation – IC4		

[1] Added capacity removed for investment purposes. Capacity removed from Alkylation, MTBE and C4 Isomerization exceeded excess capacity available in the LP case results.

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TABLE E-5
NEW PROCESS UNIT INVESTMENTS
IC - 1995/2000 F2 - SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(\$MM - in constant mid 1990-\$)

	Summer		Annual
	S17[1]	S21	S7
	'95 Permit	2000 All	1990 Prod
	Delay	CARB 2	Regs
Crude Distillation			
Heavy Naphtha Splitter			
Catalytic Cracking			
FCC Gasoline Splitters		346	
FCC Gasoline Fractionation			
Hydrocracking - 2 Stage		71	
Hydrocracking - 2 Stage Distillate			
- Heavy Gasoline		712	
Hydrocrackate Fractionation		55	
Coker - Delayed			
Coker Lt. Gasoline DS/Splitter		7	
Hydrotreating - Naphtha			
- FCC Coker C6s		169	
- Distillate			(88)
- Heavy Gas Oil		242	
Reformer Feed Fractionation		224	
Reformate Fractionation		73	
Aromatics Extraction			
Benzene Saturation		82	
FCC Gasoline HDS			
Diesel Aromatics Saturation		22	
Alkylation		467	(111)
Alkylate Splitter		52	
MTBE		92	(67)
TAME			
Isomerization - C5/C6		120	
- C5/C6, Recycle		67	
- C4		100	(28)
Hydrogen		542	(67)
Sulfur			(29)
MTBE Storage & Blending		45	
C4 Rerun - Saturates		56	
- Unsaturation		126	
C4 Fractionation Upgrades		57	(2)
Catalytic Reforming - 100 PSI			
Hydrotreating - Distillate Upgrade			(251)
Dehydrogenation - IC4			
Total Refinery		3,727	(643)

[1] Although no investment is shown for MTBE Storage & Blending, refiners may have a difficult time handling purchased MTBE inventory requirements without additional tankage.

TABLE E-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Summer			Annual	
	Base Case Q9	S17 '95 Permit Delay	S21 2000 All CARB 2	Base Case Q9%	S7 1990 Prod Regs
Crude – Atmospheric	103.5	101.5	101.6	98.6	97.7
Heavy Naphtha Splitter					
Catalytic Cracking [1]	47.9	47.3	46.0	47.2	46.5
Catalytic Cracking [2]	44.7	43.0	41.8	44.1	43.8
Conversion, %	78.6	80.0	80.0	78.6	78.1
Octane Catalyst, %	79.8	79.3	78.9	79.7	79.7
FCC Gasoline Splitters			24.7		
FCC Gasoline Fractionation	17.5	17.5		16.9	16.9
Hydrocracking – 2 Stage[1]	4.4	4.4	5.0	4.2	4.2
Jet Yield, % of Max	94.4	100.0	0.0	100.0	100.0
300 – Gasoline Operation, %			0.1		
Hydrocracking – 2 Stage Distillate					
Hydrocracking – Low Conversion	1.0	1.0	1.1	1.0	1.0
– Heavy Gasoline			4.6		
– Combined[2]	5.4	5.4	10.7	5.2	5.2
Hydrocrackate Fractionation			5.5		
Coking – Delayed	2.7	2.7	2.9	2.9	2.9
– Fluid	3.5	3.5	3.5	3.7	3.5
Coker Lt Gasoline DS/Splitter			0.3		
Thermal Cracking, Visbreaking	0.8	0.8	0.8	0.8	0.8
Solvent Deasphalting					
Catalytic Reforming – 100 PSI [1]	8.6	8.0	9.9	7.8	7.5
– 200 PSI[1]	7.6	6.4	7.6	6.9	7.5
– 450 PSI[1]	6.5	5.5	7.0	6.4	5.4
– Combined[2]	20.6	18.5	22.9	19.4	19.1
– RONC	99.3	98.4	97.2	98.4	98.3
Hydrotreating – Naphtha	21.2	19.5	22.8	19.9	19.6
– FCC/Coker C6s			6.1		
– Distillate	31.2	31.5	33.0	31.4	21.2
– Heavy Gas Oil	8.8	8.8	19.6	8.5	8.5
– Residuum – Atm					
Reformer Feed Fractionation			22.8		
Reformate Fractionation	2.7	2.7	11.4	2.6	2.6
Aromatics Extraction	2.1	2.1	2.2	2.1	2.1
Benzene Saturation			1.8		
FCC Gasoline HDS					
Diesel Aromatics Saturation			0.2		
Alkylation	7.3	7.5	12.1	7.3	7.2
Alkylate Splitter			5.1		
Polymerization	0.8	0.6		0.6	0.6
Dehydrogenation – IC4					
MTBE	0.5	0.5	1.7	0.5	0.5
TAME					
Hydrodealkylation – Toluene					
Lubes	1.0	1.0	1.0	1.0	1.0
Isomerization – C5/C6	2.6	2.6	6.9	2.5	2.5
– C5/C6, Recycle			1.4		
– C4	0.9	0.9	2.3	0.9	0.9
Hydrogen – MMSCFPCD	7.9	7.9	28.8	7.9	7.9
Sulfur, LTPCD	91	87	87	89	80
C4 Rerun – Saturates			3.0		
– Unsaturates			9.6		

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

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TABLE E-7
PROCESS UNIT UTILIZATIONS – %[1]
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Summer			Annual	
	Base Case Q9 No FCAAA	S17 '95 Permit Delay	S21 2000 All CARB 2	Base Case Q9Y No FCAAA	S7 1990 Prod Regs
Crude Distillation – Atmospheric	87.7	85.9	86.1	83.5	82.7
Heavy Naphtha Splitter					
Catalytic Cracking[2]	85.9	84.9	82.4	84.7	83.4
Catalytic Cracking[3]	80.1	77.2	74.9	79.0	78.5
FCC Gasoline Splitters			94.0 *		
FCC Gasoline Fractionation	84.6	84.6		81.9	81.9
Hydrocracking – 2 Stage[2]	87.0 *	87.0 *	87.0 *	84.0 *	84.0 *
– Low Conversion	78.4	78.4	87.0 *	75.4	75.4
– Heavy Gasoline			87.0 *		
– Combined[3]		85.2	87.0 *	82.2	82.2
Hydrocrackate Fractionation			87.0 *		
Coking – Delayed	84.8	84.8	92.0 *	91.0 *	91.0 *
– Fluid	84.7	84.7	84.7	89.6	85.4
Coker Lt Gasoline DS/Splitter			92.0 *		
Thermal Cracking, Visbreaking	92.0 *	92.0 *	92.0 *	90.0 *	90.0 *
Solvent Deasphalting					
Catalytic Reforming – 100 PSI[2]	80.3	74.6	92.0 *	72.7	70.0
– 200 PSI[2]	92.0 *	77.2	92.0 *	82.5	90.0 *
– 450 PSI[2]	60.0	50.8	64.6	59.1	49.8
– Combined[3]	69.0	61.9	76.8	65.0	63.9
Hydrotreating – Naphtha	59.2	54.6	63.7	55.7	54.8
– FCC/Coker C6s			92.0 *		
– Distillate	83.6	84.4	88.4	84.1	63.1
– Heavy Gas Oil	83.5	83.5	92.0 *	80.8	80.8
– Residuum, Atm					
Reformer Feed Fractionation			92.0 *		
Reformate Fractionation	92.0 *	92.0 *	92.0 *	87.9	87.9
Aromatics Extraction	87.3	87.3	92.0 *	88.1	88.1
Benzene Saturation			92.0 *		
FCC Gasoline HDS					
Diesel Aromatics Saturation			92.0 *		
Alkylation	84.3	86.4	89.0 *	84.6	87.0 *
Alkylate Splitter			89.0 *		
Polymerization	58.5	44.9	0.0	43.9	43.9
Dehydrogenation – IC4					
MTBE	87.0 *	87.0 *	87.0 *	84.0 *	84.0 *
TAME	0.0	0.0	87.0 *	0.0	0.0
Hydrodealkylation – Toluene	0.0	0.0	0.0	0.0	0.0
Lubes	82.0	82.0	82.0	82.0	82.0
Isomerization – C5/C6	92.0 *	92.0 *	92.0 *	90.0 *	90.0 *
– C5/C6, Recycle			92.0 *		
– C4	89.0 *	89.0 *	89.0 *	87.0 *	87.0 *
Hydrogen	80.0	80.0	89.0 *	79.5	85.9
Sulfur	55.5	53.1	53.1	54.1	50.6
C4 Rerun – Saturates			92.0 *		
– Unsaturates			92.0 *		

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

TABLE E-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Summer			Annual	
	Base Case Q9 No FCAAA	S17 '95 Permit Delay	S21 2000 All CARB 2	Base Case Q9Y No FCAAA	S7 1990 Prod Regs
FCC Gasoline	13.3	11.9		13.5	13.1
Lt. FCC 255–	16.9	16.8		16.3	16.3
Hvy FCC 255+	11.8	11.7		11.4	11.3
Hvy FCC 255+ Desulf.					
FCC Gaso (100–180)			1.3		
FCC Gaso (180–225)			4.7		
FCC Gaso (225–300)			5.3		
FCC Gaso (300–375)					
Total FCC Gasoline	42.0	40.4	11.3	41.2	40.7
Butenes				0.7	0.6
Pentenenes					
Poly Gasoline	1.3	1.0		1.0	1.0
Lt. Coker Gasoline	0.6	0.3		0.6	0.6
Total Olefinic	1.9	1.3		2.3	2.2
Reformate	18.2	17.3	9.9	18.6	18.2
Reformate (220–300 Feed)	2.8	2.9	5.8	0.9	1.0
BT Reformate	4.9	3.0		5.3	5.2
HC Reformate (210–300)			7.8		
Heavy Reformate (300+)	0.5	0.5	2.7	0.2	0.2
Toluene/Xylenes	0.8	0.8	0.2	1.0	1.0
Total Reformates(1)	27.2	24.5	26.4	26.0	25.6
Lt. Reformate	0.5	0.5		0.6	0.6
Lt. Raffinate B(C5–210)	0.9	0.9	5.0	0.8	0.8
Alkylate/Lt Alkylate (C3/C4)	12.4	12.7	13.0	12.1	11.8
Alkylate/Lt Alkylate (C5)			4.8		
Butane	4.4	4.0	1.5	7.2	8.8
Natural/LSR Gaso	2.2	2.3		1.9	1.9
BT Naphtha (150–220)		1.4	2.7		
Pentanenes (I/N)			2.2		
Isomerate (C5–C6)	4.2	4.2	6.1	4.1	4.1
Isomerate (C6)			7.0		
Lt. Hydrocrackate (C5–180)	1.4	1.3	5.3	1.3	1.3
Medium Hydrocrackate (180–225)	0.9	1.4	3.5	0.5	0.5
MTBE	2.0	5.1	10.2	2.0	1.7
TAME			1.0		
Total Low Arom., Saturated	28.9	33.8	62.3	30.5	31.5
Total	100.0	100.0	100.0	100.0	100.0

(1) Excluding Lt Reformate and Lt Raffinate.

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TABLE E-8A
REFORMULATED GASOLINE POOL COMPOSITIONS - %
IC - 1995/2000 F2 - SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer	
	S17 '95 Permit Delay	S21 2000 All CARB 2
FCC Gasoline	34.0	
Lt. FCC 255-		
Hvy FCC 255+	1.6	
Hvy FCC 255+ Desulf.		
FCC Gaso (100-180)		1.3
FCC Gaso (180-225)		4.7
FCC Gaso (225-300)		5.3
FCC Gaso (300-375)		
Total FCC Gasoline	35.6	11.3
Butenes		
Pentenenes		
Poly Gasoline	3.7	
Lt. Coker Gasoline		
Total Olefinic	3.7	
Reformate	8.5	9.9
Reformate (220-300 Feed)	3.6	5.8
BT Reformate		
HC Reformate (210-300)		7.8
Heavy Reformate (300+)		2.7
Toluene/Xylenes	2.9	0.2
Total Reformates(1)	15.0	26.4
Lt. Reformate		
Lt. Raffinate B(C5-210)	3.2	5.0
Alkylate/Lt Alkylate (C3/C4)	16.6	13.0
Alkylate/Lt Alkylate (C5)		4.8
Butane	2.6	1.5
Natural/LSR Gaso		
BT Naphtha (150-220)	4.6	2.7
Pentanenes (I/N)		2.2
Isomerase (C5-C6)	7.0	6.1
Isomerase (C6)		7.0
Lt. Hydrocrackate (C5-175)		5.3
Medium Hydrocrackate (180-225)		3.5
MTBE	11.7	10.2
TAME		1.0
Total Low Arom., Saturated	45.7	62.3
Total	100.0	100.0

(1) Excluding Lt Reformate and Lt Raffinate.

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TABLE E-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS - %
IC - 1995/2000 F2 - SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer		Annual	
	Base Case Q9 No FCAAA	S17 '95 Permit Delay	Base Case Q9Y No FCAAA	S7 1990 Prod Regs
FCC Gasoline	13.3	3.7	13.5	13.1
Lt. FCC 255-	16.9	23.1	16.3	16.3
Hvy FCC 255+	11.8	15.4	11.4	11.3
Hvy FCC 255+				
FCC Gaso (100-180)				
FCC Gaso (180-225)				
FCC Gaso (225-300)				
FCC Gaso (300-375)				
Total FCC Gasoline	42.0	42.2	41.2	40.7
Butenes			0.7	0.6
Pentenenes				
Poly Gasoline	1.3		1.0	1.0
Lt. Coker Gasoline	0.6	0.5	0.6	0.6
Total Olefinic	1.9	0.5	2.3	2.2
Reformate	18.2	20.6	18.6	18.2
Reformate (220-300 Feed)	2.8	2.7	0.9	1.0
BT Reformate	4.9	4.2	5.3	5.2
HC Reformate (210-300)				
Heavy Reformate (300+)	0.5	0.7	0.2	0.2
Toluene/Xylenes	0.8		1.0	1.0
Total Reformates(1)	27.2	28.2	26.0	25.6
Lt. Reformate	0.5	0.6	0.6	0.6
Lt. Raffinate B(C5-210)	0.9		0.8	0.8
Alkylate/Lt Alkylate (C3/C4)	12.4	11.2	12.1	11.8
Alkylate/Lt Alkylate (C5)				
Butane	4.4	4.5	7.2	8.8
Natural/LSR Gaso	2.2	3.1	1.9	1.9
BT Naphtha (150-220)		0.1		
Pentanenes (I/N)				
Isomerate (C5-C6)	4.2	3.1	4.1	4.1
Isomerate (C6)				
Lt. Hydrocrackate	1.4	1.8	1.3	1.3
Hydrocrackate (175-225)	0.9	2.0	0.5	0.5
MTBE	2.0	2.7	2.0	1.7
TAME				
Total Low Arom., Saturated	28.9	29.1	30.5	31.5
Total	100.0	100.0	100.0	100.0

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TABLE E-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (¢/G per unit in constant 1990 \$)

	Summer			Annual	
	Base Case Q9	S17 '95 Permit Delay	S21 2000 All CARB 2	Base Case Q9Y	S7 1990 Prod Regs
(R+M)/2 Octane, Clear	(0.8)	(1.1)	(1.1)	(0.3)	(0.4)
Aromatics, Vol. %		0.1	0.2		
Ethers, Vol. %		(0.1)	0.1		
Ethanol, %					
Olefins, Vol. %		0.1	0.3		
Benzene, Vol. %	0.2	2.3	2.6		
Sulfur, 100 Wt. PPM			2.7		
Reid Vapor Pressure, PSI	0.5	0.7	3.5	0.4	0.4
T90, 10°F			3.1		
Butane, Vol. %			1.2		
V.O.C., 10%					
NOx, 10%					
T.A.P., 10%					

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE E-9A
REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (¢/G per unit in constant 1990 \$)

	Summer	
	S17 '95 Permit Delay	S21 2000 All CARB 2
(R+M)/2 Octane, Clear	(0.8)	(1.1)
Aromatics, Vol. %		0.2
Ethers, Vol. %	(0.1)	0.1
Ethanol, %		
Olefins, Vol. %	0.1	0.3
Benzene, Vol. %	4.0	2.6
Sulfur, 100 Wt. PPM		2.7
Reid Vapor Pressure, PSI	0.8	3.5
T90, 10°F		3.1
Butane, Vol. %		1.2
V.O.C., 10%		
NOx, 10%		
T.A.P., 10%		

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE E-9B
CONVENTIONAL GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IC – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (¢/G per unit in constant 1990 \$)

	Summer		Annual	
	Base Case Q9	S17 '95 Permit Delay	Base Case Q9¥	S7 1990 Prod Regs
(R+M)/2 Octane, Clear	(0.8)	(1.2)	(0.3)	(0.4)
Aromatics, Vol. %		0.1		
Ethers, Vol. %		(0.1)		
Ethanol, %				
Olefins, Vol. %				
Benzene, Vol. %	0.2	1.7		
Sulfur, 100 Wt. PPM				
Reid Vapor Pressure, PSI	0.5	0.7	0.4	0.4
T90, 10°F				
Butane, Vol. %				
V.O.C., 10%				
NOx, 10%				
T.A.P., 10%				

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE E-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IC - 1995/2000 F2 - SF CASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer			Annual	
	Base Case Q9 No FCAAA	S17 '95 Permit Delay	S21 2000 All CARB 2	Base Case Q9% No FCAAA	S7 1990 Prod Regs
No. 2 Diesel Compositions					
Hvy Reformate (300+) 90 RON					
Hvy Reformate (300+) 100 RON					
FCC Heavy Gaso Tr (300-375)					
FCC Heavy Gaso Tr (375-430)			2.9		
Lt Cycle Oil - Treated	12.9	12.8	10.8	15.0	17.9
Coker Dist - Treated	3.1	2.8	3.1	3.4	0.8
Total High Aromatic	16.0	15.6	16.8	18.4	18.7
Heavy Alkylate (300+)			2.9		
Lt Kero - Treated (300-375)	4.0	5.6	3.4	6.3	8.9
Kero (375-500)	2.1		5.0	9.3	14.5
Kero - Treated (375-500)	30.0	26.0	22.3	20.6	12.7
Kero - Low Aromatics (375-500)		5.6			
Diesel Base	8.6	3.6	3.9	3.4	32.5
Diesel Base - Treated	39.3	43.6	45.0	42.0	12.7
Diesel Base - Low Aromatics					
Lt Cycle Oil - Low Aromatics			0.7		
Coker Dist - Low Aromatics					
Total Low Aromatic	84.0	84.4	83.2	81.6	81.3
Total	100.0	100.0	100.0	100.0	100.0
Properties					
Diesel Ignition Improver					
Pour Point Depressant				Yes	
Aromatics	30.0	29.7	30.1	30.7	31.8
Jet A Compositions					
Heavy Alkylate (300+)					
Lt Kero - Treated (300-375)	34.0	33.5	42.8	34.0	25.7
Kero - Treated (375-500)	37.0	36.0	55.2	37.1	45.4
Hydrocracked Jet (295-525)	29.0	30.5	2.0	28.9	28.9
Total	100.0	100.0	100.0	100.0	100.0

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TABLE E1-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9S	Base Case Q6 Target Δ V.O.C.	Case Q3 Q6 Units Max. Gaso.	Case S10 Q6 + 30 Sul	Case QN2M Q6 + 11.1% OL	Case QN2H Q6 + 8.6% OL
<u>Reformulated Limits*</u>						
Aromatics, Vol.%, Maximum Avg						
Oxygen, Wt%, Minimum Avg		2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg					11.1	8.6
Benzene, Vol%, Maximum Avg		0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg				30		
Reid Vapor Pressure, PSI, Min		6.5	6.5	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max						
Regulatory Cap						
T50, °F, Maximum Avg						
T90, °F, Maximum Avg						
V.O.C., % Reduction		40	40	40	40	40
T.A.P., % Reduction		30	30	30	30	30
% Class C, Fixed	80	90	90	90	90	90
<u>Ethers, V% Pool</u>						
Purchased (Sold)	1.2	9.2	9.7	10.0	9.3	9.3
Manufactured	0.8	2.5	2.0	1.7	2.4	2.4
<u>Gasoline Pool Properties</u>						
(R+M)/2 Octane, Clear*	88.9	88.9	88.9	88.9	88.9	88.9
Aromatics, Vol.%	31.2	24.4	25.4	27.0	24.3	24.3
Ethers, Vol.% *	2.0	11.7	11.7	11.7	11.7	11.7
Oxygen, Wt.% *	0.4	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%	15.9	13.1	14.2	10.2	11.1 *	8.6 *
Benzene, Vol.% *	1.8	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM	341	233 *	247 *	30 *	239	214 *
Reid Vapor Pressure, PSI	8.2 *	6.5 *	6.5 *	6.7	6.5 *	6.5 *
Temperature at V/L = 20, °F	141	148	149	147	148	148
<u>Distillation</u>						
T10, °F	116	132	132	130	133	133
T50, °F	212	206	209	205	205	205
T90, °F	354	340	346	346	339	337
Specific Gravity	0.7479	0.7443	0.7467	0.7461	0.7440	0.7436
Heat Content, MBTU/G	114.1	112.1	112.3	112.3	112.1	112.0
V.O.C., gm/mile	1.13	0.73 *	0.73 *	0.73 *	0.73 *	0.73 *
– % Reduction	9	41 *	41 *	41 *	41 *	41 *
NOx, index	1.03	1.01	1.02	0.93	1.00	0.98
– % Reduction	(3)	(1)	(2)	7	0	2
T.A.P., mg/mile	54	35	36	34	36	35
– % Reduction	(4)	32	31	35	32	32

* Input limit.

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TABLE E1-2
SUMMARY OF COSTS – INCREASE OVER Q9 BASE CASE[1]
IC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Base Case Q6 Target <u>Δ V.O.C.</u>	Case Q3 Q6 Units <u>Max. Gaso.</u>	Case S10 Q6 + <u>30 Sul</u>	Case QN2M Q6 + <u>11.1% OL</u>	Case QN2H Q6 + <u>8.6% OL</u>
<u>Investment, MM\$</u>					
Refinery	914	0	1,098	1,178	1,398
MTBE[3]	1,407	305	1,499	1,415	1,419
Total	2,321	305	2,597	2,593	2,817
Range, MMM\$[4]	2.0 – 3.1	0.3 – 0.4	2.2 – 3.5	2.2 – 3.5	2.4 – 3.8
<u>Daily Costs, M\$/D</u>					
Capital Charge[5]	658	0	684	918	1,058
Net Upgrading Costs[6]	1,413	(121)	2,199	1,399	1,423
Variable Operating Costs	(46)	203	19	(77)	(16)
Fixed Operating Costs[7]	270	0	289	373	432
Total Refinery	2,295	82	3,191	2,613	2,897
<u>Annual Cost, MM\$/Yr.</u>					
Refinery	838	30	1,165	953	1,057
Other[8]	208	(21)	182	208	219
Total	1,046	9	1,347	1,161	1,276
<u>Total Unit Cost, ¢/G of Conventional Gasoline Upgraded</u>					
Average	10.2	0.6 [9]	13.1	11.3	12.4
Range[10]	8.5 – 13.1	(0.4) – 2.8	11.4 – 16.2	9.5 – 14.6	10.5 – 15.9

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case Q9. Case Q3 costs are over base case Q6. Cost multipliers to include the full cost of extra facilities for summer RFG are detailed on Table A3-19.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.
- [3] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [4] For variations from investment curves of -15/+35%.
- [5] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- [6] Raw material upgrading costs.
- [7] For new refining facilities only.
- [8] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [9] Adjusted to eliminate 10¢/gal Δ margin on incremental gasoline make of 99 MBPD (14.5%) or by \$152MM/yr.
- [10] For variations in capital charge (-15/+35%), MTBE cost (-10/+20¢/G), and BTU mileage factor (±0.2).

TABLE E1-3
REFINING RAW MATERIAL AND PRODUCT RATES – MBPCD
IC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9S	Base Case Q6 Target Δ V.O.C.	Case Q3 Q6 Units Max. Gaso.	Case S10 Q6 + 30 Sul	Case QN2M Q6 + 11.1% OL	Case QN2H Q6 + 8.6% OL
Raw Materials						
Domestic – S	14	14	14	14	14	14
HL						
HH	29	29	29	29	29	29
Foreign – S	515	519	614	690	515	515
HL	171	171	171	171	171	171
HH	410	348	360	245	355	356
Subtotal Crudes	1,139	1,081	1,188	1,149	1,084	1,085
MTBE	8	63	76	68	63	64
Ethanol						
Normal Butane	4				6	11
Isobutane	1	1	1	1	1	1
Natural Gas to H2 Plant Feed	2	2	2	2	2	3
Methanol	2	6	5	4	6	6
Other Raw Materials	204	204	204	204	204	204
Total Raw Materials	1,360	1,357	1,476	1,429	1,366	1,373
Products						
Motor Gasolines						
Conventional	670					
Oxygenated						
Reformulated/Oxygenated						
Reformulated		682	781	680	682	682
CARB2						
Kero Jet/Kerosene	86	86	86	86	86	86
Diesel/No. 2 Fuels						
Diesel – LA ULS						
Diesel – 0.05%S	281	281	281	281	281	281
No. 2 Fuel	35	35	35	35	35	35
No. 6 Fuel (1% Sul)	62	62	62	47	62	62
No. 6 Bunker	6	6	6	6	6	15
Marketable Coke – 400 #	18	14	16	15	13	12
Catalytic Coke – 400 #	26	24	26	16	25	25
Vacuum Gas Oil				81	10	7
Benzene	2	4	3	4	4	4
Toluene	6	4	3	4	4	4
Heavy Aromatic Gaso						
Pentanes to P/C						
Natural Gasoline to P/C		1	16	1		
Normal Butane		3	8	7		
Isobutane	1	1	1	1	1	1
Propane	28	24	23	21	25	22
Process Gas/C2/C2=,FOE	70	57	62	59	57	58
Other Products	125	125	125	125	125	125
(Gain)/Loss	(57)	(52)	(58)	(40)	(50)	(47)
Total Products	1,360	1,357	1,476	1,429	1,366	1,373
Crude Properties						
Gravity, °API	31.8	32.2	32.4	33.0	32.2	32.2
Sulfur, Wt%	1.31	1.17	1.12	0.90	1.18	1.18
Gasoline Demand Increase, %[1]						
Results		1.8		1.5	1.8	1.8
Target		1.8	1.6	1.6	1.8	1.8

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

[2] Premium diesel with 0.25 wt. % sulfur.

TABLE E1-4
NEW PROCESS UNIT RATES – MBPSD
IC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6 Target <u>Δ V.O.C.</u>	Case Q3[1] Q6 Units Max. Gaso. <u>Max. Gaso.</u>	Case S10 Q6 + 30 Sul <u>30 Sul</u>	Case QN2M Q6 + 11.1% OL <u>11.1% OL</u>	Case QN2H Q6 + 8.6% OL <u>8.6% OL</u>
Crude – Atmospheric					
Heavy Naphtha Splitter					
Catalytic Cracking					
FCC Gasoline Splitters	96		143	100	148
FCC Gasoline Fractionation			91		
Hydrocracking – 2 Stage					
Hydrocracking – 2 Stage Distillate					
– Hvy Gasoline					
Hydrocrackate Fractionation					
Coker – Delayed					
Coker Lt Gasoline DS/Splitter	2		2		
Hydrotreating – Naphtha					
– FCC/Coker C6s			0	3	30
– Distillate					
– Heavy Gas Oil					
Reformer Feed Fractionation	250		289	240	240
Reformat Fractionation	50		67	44	27
Aromatics Extraction					
Benzene Saturation	27		38	23	13
FCC Gasoline HDS			88	0	
Diesel Aromatics Saturation	4				
Alkylation				34	34
Alkylate Splitter					
MTBE	8		4	8	8
TAME					
Isomerization – C5/C6			4	6	34
– C5/C6, Recycle					
– C4	5			14	20
Hydrogen – MMSCFPSD			4	5	14
Sulfur – LTPSD					
C4 Rerun – Saturates	36		36	36	36
– Unsaturation	115		63	115	115
Catalytic Reforming – 100 PSI					
Hydrotreating – Distillate Upgrade					
Dehydrogenation – IC4					

[1] Additions to Q6 Case.

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TABLE E1-5
NEW PROCESS UNIT INVESTMENTS
IC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(\$MM – in constant mid-1990 \$)

	Base Case Q6 Target <u>Δ V.O.C.</u>	Case Q3[1] Q6 Units <u>Max. Gaso.</u>	Case S10 Q6 + <u>30 Sul</u>	Case QN2M Q6 + <u>11.1% OL</u>	Case QN2H Q6 + <u>8.6% OL</u>
Crude Distillation					
Heavy Naphtha Splitter					
Catalytic Cracking					
FCC Gasoline Splitters	104		101	89	142
FCC Gasoline Fractionation			49		
Hydrocracking – 2 Stage					
Hydrocracking – 2 Stage Distillate – Heavy Gasoline					
Hydrocrackate Fractionation					
Coker – Delayed					
Coker Lt. Gasoline DS/Splitter	5		3		
Hydrotreating – Naphtha					
– FCC Coker C6s			1	10	100
– Distillate					
– Heavy Gas Oil					
Reformer Feed Fractionation	212		234	206	205
Reformate Fractionation	64		78	58	41
Aromatics Extraction					
Benzene Saturation	95		139	86	59
FCC Gasoline HDS			192	0	
Diesel Aromatics Saturation	37				
Alkylation				238	238
Alkylate Splitter					
MTBE	85		51	89	84
TAME					
Isomerization – C5/C6			14	22	101
– C5/C6, Recycle					
– C4	29			84	112
Hydrogen			11	11	32
Sulfur – MSTPSD					
MTBE Storage & Blending	45		45	45	45
C4 Rerun – Saturates	56		56	56	56
– Unsaturation	126		69	126	126
C4 Fractionation Upgrades	57		57	57	57
Catalytic Reforming – 100 PSI					
Hydrotreating – Distillate Upgrade					
Dehydrogenation – IC4					
Total Refinery	914		1,098	1,178	1,398

[1] Additions to Q6 Case.

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TABLE E1-6
PROCESS UNIT RATES PER REFINERY - MBPCD
IC - SUMMER 2000 F2 - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9S	Base Case Q6 Target Δ V.O.C.	Case Q3 Q6 Units Max. Gaso.	Case S10 Q6 + 30 Sul	Case QN2M Q6 + 11.1% OL	Case QN2H Q6 + 8.6% OL
Crude - Atmospheric	103.5	98.2	108.0	104.5	98.5	98.6
Heavy Naphtha Splitter						
Catalytic Cracking[1]	47.9	47.3	52.2	40.1	45.2	45.3
Catalytic Cracking[2]	44.7	43.0	47.5	36.5	41.1	41.1
Conversion, %	78.6	80.0	80.0	80.0	80.0	80.0
Octane Catalyst, %	79.8	79.0	79.6	85.0	78.8	64.9
FCC Gasoline Splitters		8.2	5.7	12.2	8.5	12.6
FCC Gasoline Fractionation	17.5	7.8	7.8	27.1		
Hydrocracking - 2 Stage[1]	4.4	3.0	4.4	2.9	4.4	4.4
Jet Yield, % of Max	94.4	93.5	100.0		100.0	100.0
300 - Gasoline Operation, %						
Hydrocracking - 2 Stage Distillate						
Hydrocracking - Low Conversion	1.0	1.1	1.0	1.0	1.0	1.0
- Heavy Gasoline						
- Combined[2]	5.4	4.1	5.4	3.9	5.4	5.4
Hydrocrackate Fractionation						
Coking - Delayed	2.7	2.9	2.5	2.9	1.8	1.8
- Fluid	3.5	2.3	2.3	2.3	2.3	2.3
Coker Lt Gasoline DS/Splitter		0.2	0.2	0.1		
Thermal Cracking, Visbreaking	0.8	0.8	0.8	0.8	0.8	0.8
Solvent Deasphalting						
Catalytic Reforming - 100 PSI[1]	8.6	6.0	7.0	8.9	6.9	6.9
- 200 PSI[1]	7.6	6.7	7.6	7.2	6.4	6.7
- 450 PSI[1]	6.5	5.0	5.6	6.0	5.0	5.0
- Combined[2]	20.6	18.4	21.3	22.0	18.7	18.7
- RONC	99.3	91.0	90.5	94.1	91.8	92.8
Hydrotreating - Naphtha	21.2	20.9	23.3	24.2	20.1	20.1
- FCC/Coker C6s				0.0	0.2	2.5
- Distillate	31.2	32.6	31.9	34.1	31.9	31.9
- Heavy Gas Oil	8.8	9.7	9.7	9.7	8.8	8.8
- Residuum - Atm						
Reformer Feed Fractionation		20.9	20.9	24.2	20.1	20.1
Reformate Fractionation	2.7	9.4	9.4	12.5	8.3	5.0
Aromatics Extraction	2.1	2.2	2.2	2.0	2.0	2.2
Benzene Saturation		2.2	2.2	3.2	1.9	1.1
FCC Gasoline HDS				7.4	0.0	
Diesel Aromatics Saturation		0.3	0.3			
Alkylation	7.3	7.7	7.7	6.6	8.8	9.6
Alkylate Splitter						
Polymerization	0.8	0.3	0.7	0.3		
Dehydrogenation - IC4						
MTBE	0.5	1.1	1.1	0.8	1.1	1.1
TAME		0.4	0.3	0.3	0.4	0.4
Hydrodealkylation - Toluene						
Lubes	1.0	1.0	1.0	1.0	1.0	1.0
Isomerization - C5/C6	2.6	2.6	2.6	2.9	3.1	5.4
- C5/C6, Recycle						
- C4	0.9	1.3	1.0	0.9	2.1	2.6
Hydrogen - MMSCFPCD	7.9	8.8	7.9	9.0	9.1	9.9
Sulfur, LTPCD	91	81	87	64	80	78
C4 Rerun - Saturates		3.0	3.0	3.0	3.0	3.0
- Unsaturation		9.6	9.6	5.3	9.6	9.6

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

TABLE E1-7
PROCESS UNIT UTILIZATIONS – %[1]
IC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9S	Base Case Q6 Target Δ V.O.C.	Case Q3 Q6 Units Max. Gaso.	Case S10 Q6 + 30 Sul	Case QN2M Q6 + 11.1% OL	Case QN2H Q6 + 8.6% OL
Crude Distillation – Atmospheric	87.7	83.2	91.5	88.5	83.5	83.6
Heavy Naphtha Splitter						
Catalytic Cracking[2]	85.9	84.7	93.7	71.9	81.0	81.1
Catalytic Cracking[3]	80.1	77.0	85.2	65.4	73.7	73.8
FCC Gasoline Splitters		94.0 *	64.9	94.0 *	94.0 *	94.0 *
FCC Gasoline Fractionation	84.6	37.8	37.8	94.0 *		
Hydrocracking – 2 Stage[2]	87.0 *	59.7	87.0 *	57.5	87.0 *	87.0 *
Hydrocracking – 2 Stage Distillate						
– Low Conversion	78.4	87.0 *	78.4	78.4	78.4	78.4
– Heavy Gasoline						
– Combined[3]	85.2	65.3	85.2	61.7	85.2	85.2
Hydrocrackate Fractionation						
Coking – Delayed	84.8	92.0 *	79.1	92.0 *	56.5	56.5
– Fluid	84.7	56.3	56.3	56.3	56.3	56.3
Coker Lt Gasoline DS/Splitter		92.0 *	92.0 *	92.0 *		
Thermal Cracking, Visbreaking	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Solvent Deasphalting						
Catalytic Reforming – 100 PSI[2]	80.3	55.9	65.5	82.7	64.3	64.3
– 200 PSI[2]	92.0 *	80.2	92.0 *	86.1	77.5	80.2
– 450 PSI[2]	60.0	46.1	52.1	55.4	46.1	46.1
– Combined[3]	69.0	61.5	71.4	73.8	62.6	62.7
Hydrotreating – Naphtha	59.2	58.6	65.1	67.5	56.2	56.1
– FCC/Coker C6s				92.0 *	92.0 *	92.0 *
– Distillate	83.6	87.5	85.4	91.4	85.5	85.5
– Heavy Gas Oil	83.5	92.0 *	92.0 *	92.0 *	83.5	83.5
– Residuum, Atm						
Reformer Feed Fractionation		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Reformate Fractionation	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
Aromatics Extraction	87.3	92.0 *	92.0 *	82.8	82.8	92.0 *
Benzene Saturation		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
FCC Gasoline HDS				92.0 *	92.0 *	
Diesel Aromatics Saturation		92.0 *	92.0 *			
Alkylation	84.3	89.0 *	89.0 *	75.9	74.6	82.0
Alkylate Splitter						
Polymerization	58.5	22.1	49.9	22.1	0.0 *	0.0 *
Dehydrogenation – IC4						
MTBE	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
TAME	0.0	87.0 *	60.7	60.7	87.0 *	87.0 *
Hydrodealkylation – Toluene	0.0	0.0	0.0	0.0	0.0	0.0
Lubes	82.0	82.0	82.0	82.0	82.0	82.0
Isomerization – C5/C6	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
– C5/C6, Recycle						
– C4	89.0 *	89.0 *	65.0	89.0 *	89.0 *	89.0 *
Hydrogen	80.0	89.0 *	80.0	89.0 *	89.0 *	89.0 *
Sulfur	55.5	49.4	53.1	39.0	48.8	47.6
C4 Rerun – Saturates		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *
– Unsaturates		92.0 *	92.0 *	92.0 *	92.0 *	92.0 *

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

TABLE E1-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9S	Base Case Q6 Target Δ V.O.C.	Case Q3 Q6 Units Max. Gaso.	Case S10 Q6 + 30 Sul	Case QN2M Q6 + 11.1% OL	Case QN2H Q6 + 8.6% OL
FCC Gasoline	13.3	14.6	20.2		23.9	17.6
Lt. FCC 255-	16.9	7.4	6.5	15.1		
Hvy FCC 255+	11.8	5.1	4.5			
Hvy FCC 255+ Desulf.				12.1	0.0	
FCC Gaso (100-180)		2.7	1.7	2.0	2.5	
FCC Gaso (180-225)		1.4	0.9	1.0	1.6	2.5
FCC Gaso (225-300)		2.9	1.8	1.6	3.3	4.8
FCC Gaso (300-375)		1.9	1.3		2.1	3.3
FCC Gaso (375-430)		0.0	0.7		0.0	0.1
Total FCC Gasoline	42.0	36.2	37.6	31.8	33.5	28.3
Butenes						
Pentenenes		0.3	0.5	0.6		
Poly Gasoline	1.3	0.5	1.0	0.5		
Lt. Coker Gasoline	0.6	0.2	0.2			
Total Olefinic	1.9	1.0	1.6	1.1		
Reformate	18.3	13.3	15.7	13.3	15.6	19.4
Reformate (220-300 Feed)	2.8	0.5	0.2	0.4	0.4	1.6
BT Reformate	4.9					
HC Reformate (210-300)		5.9	5.3	8.7	5.6	2.7
Heavy Reformate (300+)	0.5	2.0	1.7	3.3	1.5	0.1
Toluene/Xylenes	0.8	0.6	0.6	0.3	0.3	0.6
Total Reformates[1]	27.3	22.4	23.5	25.9	23.4	24.4
Lt. Reformate	0.5					
Lt. Raffinate B(C5-210)	0.9	5.1	4.5	6.6	4.6	3.2
Alkylate/Lt Alkylate (C3/C4)	12.4	11.8	11.3	10.8	12.9	13.1
Alkylate/Lt Alkylate (C5)		0.9			1.3	2.4
Butane	4.4	1.9 *	2.0 *	2.1	2.0	1.9 *
Natural/LSR Gaso	2.2	1.7	1.0	2.2	1.9	1.9
BT Naphtha (150-220)						
Pentanenes (I/N)		1.1	0.8	0.8	1.1	1.7
Isomerate (C5-C6)	4.2	4.1	3.6	4.6	4.5	4.5
Isomerate (C6)				0.0	0.3	4.1
Lt. Hydrocrackate (C5-180)	1.4	1.0	1.2	1.2	1.3	1.3
Medium Hydrocrackate (180-22	0.9	1.1	1.2	1.2	1.4	1.4
MTBE	2.0	11.1	11.3	11.2	11.1	11.1
TAME		0.7	0.4	0.5	0.7	0.7
Alcohol						
Total Low Arom., Saturated	28.9	40.5	37.2	41.2	43.2	47.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

* Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE E1-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(¢/G per unit in constant 1990 \$)

	Base Case Q9S	Base Case Q6 Target Δ V.O.C.	Case Q3 Q6 Units Max. Gaso.	Case S10 Q6 + 30 Sul	Case QN2M Q6 + 11.1% OL	Case QN2H Q6 + 8.6% OL
(R+M)/2 Octane, Clear	(0.8)	(0.6)	(1.6)	(0.5)	(0.5)	(0.6)
Aromatics, Vol. %						
Ethers, Vol. %	(0.1)	(0.3)	0.1	(0.3)	(0.3)	(0.3)
Ethanol, %						
Olefins, Vol. %					0.4	0.4
Benzene, Vol. %	0.2	3.5	13.6	4.6	4.8	5.2
Sulfur, 100 Wt. PPM		0.8	1.0	6.5		0.1
Reid Vapor Pressure, PSI	0.5	(0.1)	(0.1)		(2.0)	(2.0)
T90, 10°F						
Butane, Vol. %		0.5	0.1			(0.0)
V.O.C., 10%		1.2	0.9	0.4	1.9	2.0
NOx, 10%						
T.A.P., 10%						

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE E1-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IC – SUMMER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9S	Base Case Q6 Target Δ V.O.C.	Case Q3 Q6 Units Max. Gaso.	Case S10 Q6 + 30 Sul	Case QN2M Q6 + 11.1% OL	Case QN2H Q6 + 8.6% OL
<u>No. 2 Diesel Compositions</u>						
Hvy Reformate (300+) 90 RON						
Hvy Reformate (300+) 100 RON						
FCC Heavy Gaso Tr(300-375)						
FCC Heavy Gaso Tr(375-430)			0.2			
Lt Cycle Oil - Treated	12.9	14.2	15.7	14.6	14.3	14.4
Coker Dist - Treated	3.1	2.5	2.6	3.2	2.2	2.0
Total High Aromatic	15.9	16.8	18.5	17.8	16.5	16.4
Heavy Alkylate (300+)						
Lt Kero - Treated (300-375)	4.0	6.3	5.1	6.2	5.9	5.9
Kero (375-500)	2.1	5.6	6.1	5.5	5.6	5.6
Kero - Treated (375-500)	30.0	23.5	26.2	23.9	25.5	25.6
Kero - Low Aromatics (375-500)						
Hydrocracked Jet (295-525)						
Diesel Base	8.6	2.3	2.1	2.4	2.2	2.3
Diesel Base - Treated	39.3	44.2	40.7	44.2	44.3	44.3
Diesel Base - Low Aromatics						
Lt Cycle Oil - Low Aromatics		1.2	1.2			
Coker Dist - Low Aromatics						
Total Low Aromatic	84.1	83.2	81.5	82.2	83.5	83.6
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>						
Diesel Ignition Improver						
Pour Point Depressant						
Aromatics	30.0	30.1	30.1	30.1	30.1	30.1
<u>Jet A Compositions</u>						
Heavy Alkylate (300+)						
Lt Kero - Treated (300-375)	34.0	36.8	23.4	42.9	33.6	33.6
Kero - Treated (375-500)	37.0	42.9	47.2	55.3	36.2	36.2
Hydrocracked Jet (295-525)	29.0	20.3	29.4	1.8	30.2	30.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

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TABLE F-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Reformulated Limits*</u>	Base Case Q9 No FCAAA	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
Aromatics, Vol.%, Maximum Avg		27.9				
Oxygen, Wt%, Minimum Avg		2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg		13.6				
Benzene, Vol%, Maximum Avg		0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg		308				
Reid Vapor Pressure, PSI, Min			6.5	6.5	6.8	6.8
Reid Vapor Pressure, PSI, Max		7.6				
Regulatory Cap		7.9				
T50, °F, Maximum Avg						
T90, °F, Maximum Avg		340				
V.O.C., % Reduction			41	41	38	41
T.A.P., % Reduction			30	30	30	30
% Class C, Fixed	80	80	80	80	80	80
<u>Ethers, V% Pool</u>						
Purchased (Sold)	0.6	5.1	5.9	10.8	9.1 [1]	9.8 [1]
Manufactured	1.4	1.4	0.6	0.9	0.8	0.1
<u>Gasoline Pool Properties</u>						
(R+M)/2 Octane, Clear*	88.1	88.1	88.1	88.1	88.1	88.1
Aromatics, Vol.%	31.8	27.6 *	28.1	23.9	24.3	23.6
Ethers, Vol.% *	2.0	6.5	6.5	11.7	9.9 [1]	9.9 [1]
Oxygen, Wt.% *	0.4	1.2	1.2	2.1	2.1	2.1
Olefins, Vol.%	12.3	11.5	12.0	10.3	10.3	10.0
Benzene, Vol.%	2.1	1.3 *	1.3 *	0.7 *	0.7 *	0.7 *
Sulfur, WPPM	312	288	262	236	193 *	86
Reid Vapor Pressure, PSI	8.4 *	8.0 *	7.1 *	6.6	6.8 *	6.8 *
Temperature at V/L = 20, °F	140	141	146	148	147	146
<u>Distillation</u>						
T10, °F	113	118	125	131	130	130
T50, °F	210	204	205	208	209	209
T90, °F	345	340 *	344	342	334	327
Specific Gravity	0.7479	0.7440	0.7472	0.7439	0.7438	0.7408
Heat Content, MBTU/G	114.1	112.9	113.2	112.0	112.0	111.8
V.O.C., gm/mile	1.17	1.04	0.85 *	0.74 *	0.77 *	0.74 *
– % Reduction	6	16	32 *	41 *	38 *	41 *
NOx, index	1.00	1.00	1.00	1.00	0.98	0.95
– % Reduction	(0)	(0)	(0)	0	2	5
T.A.P., mg/mile	57	45	43 *	35	35	32
– % Reduction	(9)	14	18 *	33	32	39

* Input limit.

[1] Total Ether plus ethanol, including 1.7% Ethanol.

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TABLE F-1A
RUN BASIS AND REFORMULATED GASOLINE POOL PROPERTIES
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
<u>Reformulated Limits*</u>					
Aromatics, Vol.%, Maximum Avg	27.9				
Oxygen, Wt%, Minimum Avg	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg	13.6				
Benzene, Vol%, Maximum Avg	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg	308				
Reid Vapor Pressure, PSI, Min		6.5	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max	7.6				
Regulatory Cap	7.9				
T50, °F, Maximum Avg					
T90, °F, Maximum Avg	340				
V.O.C., % Reduction		41	41	42	45
T.A.P., % Reduction		30	30	30	30
% Class C, Fixed	80	80	80	80	80
<u>Ethers, V% Pool</u>					
Purchased (Sold)					
Manufactured					
<u>Reformulated Pool Properties</u>					
(R+M)/2 Octane, Clear*	88.1	88.1	88.1	88.1	88.1
Aromatics, Vol.%	24.3	22.2	23.9	26.0	21.8
Ethers, Vol.%*	11.7	11.7	11.7	11.7	11.7
Oxygen, Wt.%*	2.1	2.1	2.1	2.1	2.1
Olefins, Vol.%	11.4	10.7	10.3	9.3	10.4
Benzene, Vol.%*	0.7	0.7	0.7	0.7	0.7
Sulfur, WPPM	281	273	236	200 *	86
Reid Vapor Pressure, PSI	7.6 *	6.5 *	6.6	6.5 *	6.5 *
Temperature at V/L = 20, °F	142	149	148	148	147
<u>Distillation</u>					
T10, °F	120	134	131	133	129
T50, °F	197	203	208	205	211
T90, °F	340 *	348	342	331	330
Specific Gravity	0.7406	0.7439	0.7439	0.7457	0.7385
Heat Content, MBTU/G	111.5	112.0	112.0	112.1	111.8
V.O.C., gm/mile	0.94	0.74 *	0.74 *	0.73 *	0.68 *
– % Reduction	25	41 *	41 *	42 *	45 *
NOx, index	1.01	1.00	1.00	0.98	0.96
– % Reduction	(1)		0	2	4
T.A.P., mg/mile	38	36 *	35	36	31
– % Reduction	27	32 *	33	31	41

* Input limit.

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TABLE F-1B
RUN BASIS AND CONVENTIONAL GASOLINE POOL PROPERTIES
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Conventional Limits*</u>	<u>Base Case Q9 No FCAAA</u>	<u>Case S5 '95 Full Opt in</u>	<u>Base Case Q6 Target Δ V.O.C.</u>
Aromatics, Vol.%, Maximum Avg		31.8	
Oxygen, Wt%, Minimum Avg			
Olefins, Vol.%, Maximum Avg		17.0	
Benzene, Vol%, Maximum Avg		2.1	2.1
Sulfur, WPPM, Maximum Avg		385	
Reid Vapor Pressure, PSI, Min			
Reid Vapor Pressure, PSI, Max	8.4	8.4	8.7
Regulatory Cap	8.7	8.7	9.0
T50, °F, Maximum Avg			
T90, °F, Maximum Avg	356	356	356
V.O.C., % Reduction			
T.A.P., % Reduction			
% Class C, Fixed	80	80	80
<u>Ethers, V% Pool</u>			
Purchased (Sold)			
Manufactured			
<u>Conventional Pool Properties</u>			
(R+M)/2 Octane, Clear*	88.1	88.1	88.1
Aromatics, Vol. %	31.8	31.8 *	35.6
Ethers, Vol. % *	2.0		
Oxygen, Wt. % *	0.4		
Olefins, Vol. %	12.3	11.7	13.6
Benzene, Vol. %	2.1	2.1 *	2.1 *
Sulfur, WPPM	312	298	248
Reid Vapor Pressure, PSI	8.4 *	8.4 *	7.8
Temperature at V/L = 20, °F	140	141	142
Distillation			
T10, °F	113	116	113
T50, °F	210	213	208
T90, °F	345	345	338
Specific Gravity	0.7479	0.7483	0.7512
Heat Content, MBTU/G	114.1	114.6	114.8
V.O.C., gm/mile	1.17	1.17	0.99
- % Reduction	6	6	21
NOx, index	1.00	0.99	0.99
- % Reduction	(0)	1	1
T.A.P., mg/mile	57	57	52 *
- % Reduction	(9)	(9)	0 *

* Input limit.

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TABLE F-1E
RUN BASIS AND REFORMULATED-E GASOLINE POOL PROPERTIES[1]
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Case S13 S6 + <u>Hi EtOH</u>	Case S13H S13 + <u>S6 Δ V.O.C.</u>
<u>Reformulated-E Limits*</u>		
Aromatics, Vol.%, Maximum Avg		
Oxygen, Wt%, Minimum Avg	2.1	2.1
Olefins, Vol.%, Maximum Avg		
Benzene, Vol%, Maximum Avg	0.7	0.7
Sulfur, WPPM, Maximum Avg		
Reid Vapor Pressure, PSI, Min	7.5	7.5
Reid Vapor Pressure, PSI, Max		
Regulatory Cap		
T50, °F, Maximum Avg		
T90, °F, Maximum Avg		
V.O.C., % Reduction	29	31
T.A.P., % Reduction	30	30
% Class C, Fixed	80	80
<u>Ethers, V% Pool</u>		
Purchased (Sold)		
Manufactured		
<u>Reformulated/EtOH Pool Properties</u>		
(R+M)/2 Octane, Clear*	88.1	88.1
Aromatics, Vol. %	20.3	28.0
EtOH, Vol. % *	5.7	5.7
Oxygen, Wt. % *	2.1	2.1
Olefins, Vol. %	12.4	9.0
Benzene, Vol. % *	0.7	0.7
Sulfur, WPPM	178	85
Reid Vapor Pressure, PSI*	7.5	7.5
Temperature at V/L = 20, °F	145	143
Distillation		
T10, °F	124	133
T50, °F	217	204
T90, °F	341	320
Specific Gravity	0.7394	0.7464
Heat Content, MBTU/G	111.8	111.9
V.O.C., gm/mile*	0.89	0.86
– % Reduction*	29	31
NOx, index	0.99	0.95
– % Reduction	1	5
T.A.P., mg/mile	35	35
– % Reduction	34	34

* Input limit.

[1] Reformulated gasoline with ethanol as the oxygen source.

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TABLE F-2
SUMMARY OF COSTS – INCREASE OVER Q9 BASE CASE[1]
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS[2][3]
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Case S5 '95 Full Opt in[4]	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
<u>Investment, MM\$</u>					
Refinery	1,124	1,605	2,166	2,356	2,997
MTBE[5]	1,878	2,091	4,178	3,714	3,698
Total	3,002	3,696	6,344	6,070	6,695
Range, MMM\$[6]	2.6 – 4.1	3.1 – 5.0	5.4 – 8.6	5.2 – 8.2	5.7 – 9.0
<u>Daily Costs, M\$/D</u>					
Capital Charge[7]	767	1,233	1,600	1,567	2,122
Net Upgrading[8]	1,190	1,808	3,249	2,441	3,015
Variable Operating	(186)	(114)	(240)	(85)	85
Fixed Operating[9]	320	514	678	673	882
Total Refinery	2,091	3,441	5,287	4,596	6,104
<u>Annual Costs, MM\$/Yr.</u>					
Refinery	763	1,256	1,930	1,677	2,228
Other[10]	313	234	552	552	606
Total	1,076	1,490	2,482	2,229	2,834
<u>Total Unit Costs, ¢/G of Conventional Gasoline Upgraded</u>					
Average	7.5	10.5	9.6	8.6 [11]	11.0 [11]
Range[12]	5.9 – 10.4	8.6 – 13.9	7.7 – 13.0	6.9 – 11.8	9.0 – 14.5

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.
- [3] Adjusted using individual unit capital charge/fixed operating costs multipliers to include the full cost of extra facilities for summer RFG as detailed on Table A3–19.
- [4] Adjusted CG RVP to 8.7 psi. For CG, refinery net upgrading costs were reduced 0.19¢/G and consumer (other) costs were increased 0.12¢/G resulting in a net costs reduction of 0.07¢/G. This equates to reducing the costs of RFG by 0.06¢/G.
- [5] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs). S13 and S13H include ethanol investments of \$950MM outside of refineries.
- [6] For variations from investment curves of –15/+35%.
- [7] Based on expected 10% DCF rate of return on new refining facilities investment with mid–1990 \$.
- [8] Raw material upgrading costs.
- [9] For new refining facilities only.
- [10] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [11] Includes federal subsidy on ethanol of 54¢/G on 30 MBPD or 0.9¢/G of RFG. Ignored comingling impact for Cases S13 and S13H saved an added 1.6¢/G of RFG cost.
- [12] For variations in capital charge (–15/+35%), MTBE costs (–10/+20¢/G) and BTU mileage factor (±0.2).

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TABLE F-2A
SUMMARY OF COSTS – INCREASE OVER Q9 BASE CASE[1]
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS UNADJUSTED[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	<u>Case S5</u> <u>'95 Full</u> <u>Opt in</u>
<u>Investment, MM\$</u>	
Refinery	1,007
MTBE[3]	<u>1,878</u>
Total	2,885
Range, MMM\$[4]	2.5 – 3.9
<u>Daily Costs, M\$/D</u>	
Capital Charge[5]	469
Net Upgrading[6]	1,249
Variable Operating	(186)
Fixed Operating[7]	<u>221</u>
Total Refinery	1,753
<u>Annual Costs, MM\$/Yr.</u>	
Refinery	640
Other[8]	<u>313</u>
Total	953
<u>Total Unit Costs, ¢/G of</u> <u>Conventional Gasoline Upgraded</u>	
Average	6.7
Range[9]	5.1 – 9.3

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average. Unadjusted LP case results shown before capital charge and CG RVP adjustments if these were required.
- [3] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [4] For variations from investment curves of -15/+35%.
- [5] Based on expected 10% DCF rate of return on new refining facilities investment with mid-1990 \$.
- [6] Raw material upgrading costs.
- [7] For new refining facilities only.
- [8] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [9] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (± 0.2).

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TABLE F-3
REFINING RAW MATERIAL AND PRODUCT RATE - MBPCD
IIC - SUMMER 1995/2000 F2 - SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
Raw Materials						
Domestic - S	1,223	1,223	1,223	1,223	1,223	1,223
HL	371	371	371	371	371	371
HH	226	226	226	226	226	226
Foreign - S	259	278	259	259	259	259
HL	166	172	166	166	166	166
HH	752	632	687	581	618	659
Subtotal Crudes	2,997	2,902	2,932	2,826	2,863	2,904
MTBE	10	88	100	184	127	139
Ethanol					30	30
Normal Butane	17	10				
Isobutane	22	33	36	40	49	53
Natural Gas to H2 Plant Feed	5	5	5	5	11	5
Methanol	8	8	4	5	5	1
Other Raw Materials	102	102	102	102	102	102
Total Raw Materials	3,162	3,148	3,178	3,163	3,187	3,234
Products						
Motor Gasolines						
Conventional	1,682	750	752			
Oxygenated						
Reformulated/Oxygenated						
Reformulated		950	945	1,713	1,198	1,205
Reformulated-E					514	512
Kero Jet/Kerosene	205	205	205	205	205	205
Diesel/No. 2 Fuels						
Diesel - LA ULS						
Diesel - 0.05%S	580	580	580	580	580	580
No. 2 Fuel	102	102	102	102	102	102
No. 6 Fuel (1% Sul)	14	14	14	14	14	14
No. 6 Bunker	11	11	11	11	11	38
Marketable Coke - 400 #	60	54	59	52	55	61
Catalytic Coke - 400 #	52	50	50	49	50	50
Vacuum Gas Oil						
Benzene	2	2	2	2	2	2
Toluene	5	5	5	5	5	3
Heavy Aromatic Gaso						
Pentanes to P/C						
Natural Gasoline to P/C	38	38	38	36	37	39
Normal Butane			24	25	30	34
Isobutane						
Propane	98	92	94	86	90	92
Process Gas/C2/C2=,FOE	162	138	144	120	132	135
Other Products	271	271	271	271	271	271
(Gain)/Loss	(120)	(114)	(118)	(107)	(109)	(108)
Total Products	3,162	3,148	3,178	3,163	3,187	3,234
Crude Properties						
Gravity, °API	33.9	34.2	34.1	34.3	34.2	34.2
Sulfur, Wt%	1.18	1.11	1.14	1.09	1.11	1.13
Gasoline Demand Increase, %[1]						
Results		1.1	0.9	1.8	1.8	2.1
Target		1.1	0.8	1.9	1.9	2.1

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

TABLE F-4
NEW PROCESS UNIT RATES – MBPSD
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 <u>No FCAAA</u>	Case S5 '95 Full <u>Opt in[1]</u>	Base Case Q6 Target <u>Δ V.O.C.[1]</u>	Case S6 Q6 + <u>100% RFG[1]</u>	Case S13 S6 + <u>Hi EtOH[1]</u>	Case S13H S13 + <u>S6 Δ V.O.C.[1]</u>
Crude – Atmospheric						
Heavy Naphtha Splitter						
Catalytic Cracking						
FCC Gasoline Splitters				117	117	269
FCC Gasoline Fractionation				7		412
Hydrocracking – 2 Stage						
Hydrocracking – 2 Stage Distillate – Hvy Gasoline						
Hydrocrackate Fractionation						
Coker – Delayed	11					
Coker Lt Gasoline DS/Splitter			15	13	13	13
Hydrotreating – Naphtha						
– FCC/Coker C6s				13	18	9
– Distillate	59				51	29
– Heavy Gas Oil						
Reformer Feed Fractionation		822	756	813	827	889
Reformat Fractionation		97	71	163	194	264
Aromatics Extraction						
Benzene Saturation		48	34	93	105	130
FCC Gasoline HDS					1	52
Diesel Aromatics Saturation						
Alkylation						
Alkylate Splitter						
MTBE	18					
TAME						
Isomerization – C5/C6						
– C5/C6, Recycle						
– C4						
Hydrogen – MMSCFPSD						
Sulfur – LTPSD						
C4 Rerun – Saturates			101	101	101	101
– Unsaturation			260	260	260	260
Catalytic Reforming – 100 PSI						
Hydrotreating – Distillate Upgrade						
Dehydrogenation – IC4						

[1] Additions to Q9 base case.

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TABLE F-5
NEW PROCESS UNIT INVESTMENTS
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(\$MM – in constant mid-1990 \$)

	Base[1] Case Q9 <u>No FCAAA</u>	Case S5 '95 Full <u>Opt in[2]</u>	Base Case Q6 Target <u>Δ V.O.C.[2]</u>	Case S6 Q6 + <u>100% RFG[2]</u>	Case S13 S6 + <u>Hi EtOH[2]</u>	Case S13H S13 + <u>S6 Δ V.O.C.[2]</u>
Crude Distillation						
Heavy Naphtha Splitter						
Catalytic Cracking						
FCC Gasoline Splitters				106	111	233
FCC Gasoline Fractionation				7		240
Hydrocracking – 2 Stage						
Hydrocracking – 2 Stage Distillate						
– Heavy Gasoline						
Hydrocrackate Fractionation						
Coker – Delayed	112					
Coker Lt. Gasoline DS/Splitter			33	28	28	29
Hydrotreating – Naphtha						
– FCC Coker C6s				47	66	33
– Distillate	106				101	57
– Heavy Gas Oil						
Reformer Feed Fractionation		682	643	677	685	720
Reformate Fractionation		164	131	235	266	330
Aromatics Extraction						
Benzene Saturation		214	148	370	400	461
FCC Gasoline HDS					3	197
Diesel Aromatics Saturation						
Alkylation						
Alkylate Splitter						
MTBE	216					
TAME						
Isomerization – C5/C6						
– C5/C6, Recycle						
– C4						
Hydrogen						
Sulfur						
MTBE/EtOH Storage & Blending		64	64	110	110	110
C4 Rerun – Saturates			162	162	162	162
– Unsaturation			312	312	312	312
C4 Fractionation Upgrade			113	113	113	113
Catalytic Reforming – 100 PSI						
Hydrotreating – Distillate Upgrade						
Dehydrogenation – IC4						
Total Refinery	434	1,124	1,605	2,166	2,356	2,997

[1] Base case investment reflects anticipated 1996 capacity from survey that was utilized by LP case and subsequently dropped because it was speculative.

[2] Additional investment over Q9 base case.

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TABLE F-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
Crude – Atmospheric	88.1	85.4	86.2	83.1	84.2	85.4
Heavy Naphtha Splitter						
Catalytic Cracking[1]	32.4	32.0	32.7	31.1	31.5	30.2
Catalytic Cracking[2]	29.7	29.3	29.9	28.5	28.8	27.5
Conversion, %	78.1	77.9	77.0	77.4	77.8	79.4
Octane Catalyst, %	72.3	71.0	70.6	71.2	71.6	75.2
FCC Gasoline Splitters				3.0	3.0	6.9
FCC Gasoline Fractionation	4.3	4.3	4.5	5.1	4.5	15.5
Hydrocracking – 2 Stage[1]	3.2	3.2	3.2	2.9	3.2	3.2
Jet Yield, % of Max	62.4	82.7	40.5	79.6	45.2	
300 – Gasoline Operation, %						
Hydrocracking – 2 Stage Distillate						
Hydrocracking – Low Conversion	0.6	0.6	0.8	0.6	0.8	0.8
– Heavy Gasoline						
– Combined[2]	3.7	3.7	4.0	3.4	3.9	4.0
Hydrocrackate Fractionation						
Coking – Delayed	8.0	6.5	6.9	5.4	5.3	5.8
– Fluid						
Coker Lt Gasoline DS/Splitter			0.4	0.3	0.3	0.3
Thermal Cracking, Visbreaking	0.7	0.7	0.7	0.7	0.6	0.7
Solvent Deasphalting	0.6	0.6	0.7	0.6	1.0	1.0
Catalytic Reforming – 100 PSI[1]	8.2	6.9	6.5	6.1	6.5	7.3
– 200 PSI[1]	7.2	6.3	6.8	6.7	7.2	7.2
– 450 PSI[1]	6.7	6.2	5.7	5.2	5.2	6.2
– Combined[2]	20.8	19.2	18.0	18.8	19.7	21.8
– RONC	97.5	93.7	96.5	88.2	89.4	90.0
Hydrotreating – Naphtha	22.5	21.0	19.3	20.8	21.2	22.7
– FCC/Coker C6s				0.3	0.4	0.2
– Distillate	22.6	22.6	22.2	21.7	22.4	23.4
– Heavy Gas Oil	8.7	8.7	9.3	8.4	9.3	9.3
– Residuum – Atm	0.3	0.3	0.3	0.3	0.3	0.3
Reformer Feed Fractionation		21.0	19.3	20.8	21.2	22.7
Reformate Fractionation	1.4	3.9	3.2	5.6	6.7	9.1
Aromatics Extraction	0.9	0.9	0.9	0.9	0.9	0.9
Benzene Saturation		1.2	0.9	2.4	2.7	3.3
FCC Gasoline HDS					0.0	1.3
Diesel Aromatics Saturation						
Alkylation	5.9	6.1	6.3	6.2	6.7	6.8
Alkylate Splitter						
Polymerization	0.2		0.2	0.2	0.1	0.1
Dehydrogenation – IC4						
MTBE	0.7	0.7	0.3	0.3	0.3	
TAME			0.0	0.2	0.1	0.1
Hydrodealkylation – Toluene						
Lubes	0.7	0.7	0.7	0.7	0.7	0.7
Isomerization – C5/C6	3.1	3.1	1.5	2.0	2.7	2.7
– C5/C6, Recycle	0.1		1.6	1.3	0.8	0.5
– C4	0.4	0.4	0.4	0.4	0.4	0.4
Hydrogen – MMSCFPCD	6.1	6.1	6.1	6.4	7.1	6.5
Sulfur, LTPCD	66	61	64	58	60	60
C4 Rerun – Saturates			2.6	2.6	2.6	2.6
– Unsaturates			6.6	6.6	6.6	6.6

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

TABLE F-7
PROCESS UNIT UTILIZATIONS - %[1]
IIC - SUMMER 1995/2000 F2 - SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
Crude Distillation - Atmospheric	85.3	84.0	84.8	81.8	82.9	84.1
Heavy Naphtha Splitter						
Catalytic Cracking[2]	82.3	83.2	85.0	80.8	81.9	78.6
Catalytic Cracking[3]	75.6	76.2	77.9	74.0	74.9	71.5
FCC Gasoline Splitters				87.0 *	87.0 *	87.0 *
FCC Gasoline Fractionation	75.7	75.7	79.7	87.0 *	79.7	87.0 *
Hydrocracking - 2 Stage[2]	83.0 *	83.0 *	83.0 *	74.6	83.0 *	83.0 *
Hydrocracking - 2 Stage Distillate						
- Low Conversion	58.5	58.5	83.0 *	58.5	80.7	83.0 *
- Heavy Gasoline						
- Combined[3]	78.2	78.2	83.0 *	71.5	82.5	83.0 *
Hydrocrackate Fractionation						
Coking - Delayed	86.0 *	72.6	76.9	60.1	59.3	63.9
- Fluid						
Coker Lt Gasoline DS/Splitter			86.0 *	86.0 *	86.0 *	86.0 *
Thermal Cracking, Visbreaking	87.0 *	87.0 *	87.0 *	87.0 *	74.7	87.0 *
Solvent Deasphalting	51.0	48.0	60.4	49.7	87.0 *	87.0 *
Catalytic Reforming - 100 PSI[2]	82.8	69.3	65.3	61.3	65.5	73.7
- 200 PSI[2]	87.0 *	75.7	81.3	80.1	87.0 *	87.0 *
- 450 PSI[2]	56.3	52.1	47.9	43.7	43.7	52.1
- Combined[3]	69.0	63.6	59.6	62.4	65.2	72.3
Hydrotreating - Naphtha	72.1	68.4	62.8	67.6	68.8	73.9
- FCC/Coker C6s				87.0 *	87.0 *	87.0 *
- Distillate	87.0	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
- Heavy Gas Oil	76.3	81.1	87.0 *	78.4	87.0 *	87.0 *
- Residuum, Atm	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
Reformer Feed Fractionation		87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
Reformate Fractionation	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
Aromatics Extraction	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
Benzene Saturation		87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
FCC Gasoline HDS					87.0 *	87.0 *
Diesel Aromatics Saturation						
Alkylation	72.1	75.2	77.4	76.8	82.4	84.0 *
Alkylate Splitter						
Polymerization	42.0	0.0	42.0	42.0	13.7	13.7
Dehydrogenation - IC4						
MTBE	83.0 *	83.0 *	84.0 *	84.0 *	84.0 *	0.0
TAME	0.0	0.0	7.8	84.0 *	47.7	27.0
Hydrodealkylation - Toluene	0.0	0.0	0.0	0.0	0.0	0.0
Lubes	82.0	82.0	82.0	82.0	82.0	82.0
Isomerization - C5/C6	87.0 *	87.0 *	47.5	64.9	84.7	87.0 *
- C5/C6, Recycle	4.6	0.0	87.0 *	71.9	45.3	29.2
- C4	84.0 *	84.0 *	84.0 *	84.0 *	84.0 *	84.0 *
Hydrogen	70.4	70.4	70.4	74.0	82.0	74.7
Sulfur	50.4	53.0	55.8	50.6	52.3	52.3
C4 Rerun - Saturates			87.0 *	87.0 *	87.0 *	87.0 *
- Unsaturates			87.0 *	87.0 *	87.0 *	87.0 *

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

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TABLE F-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
FCC Gasoline	25.1	24.3	24.3	21.4	22.8	
Lt. FCC 255–	5.1	5.1	5.4		3.0	17.0
Hvy FCC 255+	3.5	3.5	3.7	4.1		
Hvy FCC 255+ Desulf.						2.7
FCC Gaso (100–180)				1.9	0.4	0.3
FCC Gaso (180–225)				1.2	0.2	0.2
FCC Gaso (225–300)				0.9	1.7	4.8
FCC Gaso (300–375)					1.4	1.0
FCC Gaso (375–430)						
Total FCC Gasoline	33.7	32.9	33.3	29.4	29.4	26.0
Butenes						
Pentenenes				0.4		
Poly Gasoline	0.5		0.4	0.4	0.1	0.1
Lt. Coker Gasoline	0.8	0.7	0.5			
Total Olefinic	1.3	0.7	0.9	0.8	0.1	0.1
Reformate	25.5	24.0	24.6	23.3	22.4	20.9
Reformate (220–300 Feed)	1.1	0.6	0.1	0.2	0.2	0.4
BT Reformate	7.0	2.9	2.1			
HC Reformate (210–300)		1.9	1.0	4.3	5.2	7.2
Heavy Reformate (300+)	0.5	0.2	0.1	0.3	1.0	2.5
Toluene/Xylenes	0.1	0.2	0.2	0.0	0.0	0.1
Total Reformates[1]	34.2	29.8	28.2	28.1	28.8	31.1
Lt. Reformate	0.5	0.3	0.2			
Lt. Raffinate B(C5–210)	0.4	3.0	2.1	5.7	6.3	7.5
Alkylate/Lt Alkylate (C3/C4)	11.8	12.3	12.6	11.7	13.0	13.4
Alkylate/Lt Alkylate (C5)			0.1	0.7	0.4	0.3
Butane	5.2	4.5	2.5	2.1	2.0 *	1.9 *
Natural/LSR Gaso						
BT Naphtha (150–220)	1.9	1.5	4.3			
Pentanenes (I/N)			0.1	0.9	0.4	0.3
Isomerate (C5–C6)	6.3	6.0	6.1	5.9	5.9	5.9
Isomerate (C6)				0.6	0.9	0.4
Lt. Hydrocrackate (C5–180)	1.3	1.2	1.4	1.1	1.4	1.6
Medium Hydrocrackate (180–225)	1.4	1.3	1.5	1.2	1.4	1.6
MTBE	2.0	6.5	6.5	11.3	8.0	8.1
TAME			0.0	0.4	0.2	0.1
Alcohol					1.7	1.7
Total Low Arom., Saturated	30.8	36.6	37.6	41.7	41.7	42.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

* Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE F-8A
REFORMULATED GASOLINE POOL COMPOSITIONS – %
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
FCC Gasoline	32.2	26.3	21.4	23.0	
Lt. FCC 255-				0.7	17.6
Hvy FCC 255+	2.1	6.3	4.1		
Hvy FCC 255+ Desulf.					1.4
FCC Gaso (100-180)			1.9	0.4	0.0
FCC Gaso (180-225)			1.2	0.2	0.0
FCC Gaso (225-300)			0.9	2.5	6.3
FCC Gaso (300-375)				1.6	
FCC Gaso (375-430)					
Total FCC Gasoline	34.3	32.5	29.4	28.4	25.4
Butenes					
Pentenenes			0.4		
Poly Gasoline		0.8	0.4		0.2
Lt. Coker Gasoline					
Total Olefinic		0.8	0.8		0.2
Reformate	20.6	15.2	23.3	22.2	29.5
Reformate (220-300 Feed)	1.1	0.2	0.2	0.3	0.6
BT Reformate					
HC Reformate (210-300)	3.5	1.9	4.3	7.4	
Heavy Reformate (300+)		0.1	0.3	0.3	3.2
Toluene/Xylenes	0.3	0.4	0.0	0.0	
Total Reformates[1]	25.5	17.8	28.1	30.1	33.3
Lt. Reformate					
Lt. Raffinate B(C5-210)	5.3	3.8	5.7	9.0	4.3
Alkylate/Lt Alkylate (C3/C4)	8.0	18.5	11.7	8.0	15.0
Alkylate/Lt Alkylate (C5)		0.2	0.7	0.2	0.3
Butane	3.0	2.0 *	2.1	2.0 *	1.9 *
Natural/LSR Gaso					
BT Naphtha (150-220)		6.3			
Pentanes (I/N)			0.9	0.0	0.1
Isomerate (C5-C6)	10.8	6.1	5.9	6.1	7.6
Isomerate (C6)			0.6	1.3	
Lt. Hydrocrackate (C5-180)	0.7	0.2	1.1	1.5	0.1
Medium Hydrocrackate (180-225)	0.7	0.2	1.2	1.7	0.1
MTBE	11.7	11.6	11.3	11.4	11.5
TAME		0.1	0.4	0.3	0.2
Alcohol					
Total Low Arom., Saturated	40.2	48.9	41.7	41.5	41.1
Total	100.0	100.0	100.0	100.0	100.0

*Minimum

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE F-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS – %
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Case S5 '95 Full Opt in	Base Case Q6 Target <u>Δ V.O.C.</u>
FCC Gasoline	25.1	14.2	21.8
Lt. FCC 255–	5.1	11.4	12.1
Hvy FCC 255+	3.5	5.5	0.5
Hvy FCC 255+ Desulf.			
FCC Gaso (100–180)			
FCC Gaso (180–225)			
FCC Gaso (225–300)			
FCC Gaso (300–375)			
FCC Gaso (375–430)			
Total FCC Gasoline	<u>33.7</u>	<u>31.1</u>	<u>34.3</u>
Butenes			
Pentenes			
Poly Gasoline	0.5		
Lt. Coker Gasoline	<u>0.8</u>	<u>1.6</u>	<u>1.2</u>
Total Olefinic	1.3	1.6	1.2
Reformate	25.5	28.2	36.4
Reformate (220–300 Feed)	1.1		
BT Reformate	7.0	6.6	4.7
HC Reformate (210–300)			
Heavy Reformate (300+)	0.5	0.5	0.1
Toluene/Xylenes	<u>0.1</u>		
Total Reformates[1]	<u>34.2</u>	<u>35.3</u>	<u>41.2</u>
Lt. Reformate	0.5	0.7	0.5
Lt. Raffinate B(C5–210)	0.4		
Alkylate/Lt Alkylate (C3/C4)	11.8	17.8	5.2
Alkylate/Lt Alkylate (C5)			
Butane	5.2	6.3	3.2
Natural/LSR Gaso			
BT Naphtha (150–220)	1.9	3.5	1.9
Pentanes (I/N)			0.3
Isomerate (C5–C6)	6.3		6.0
Isomerate (C6)			
Lt. Hydrocrackate (C5–180)	1.3	1.8	3.0
Medium Hydrocrackate (180–225)	1.4	1.9	3.1
MTBE	2.0		
TAME			
Alcohol			
Total Low Arom., Saturated	<u>30.8</u>	<u>32.0</u>	<u>23.3</u>
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE F-8E
REFORMULATED-E GASOLINE POOL COMPOSITIONS – %
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
FCC Gasoline	22.3	
Lt. FCC 255-	8.3	15.4
Hvy FCC 255+		
Hvy FCC 255+ Desulf.	0.1	5.6
FCC Gaso (100-180)	0.1	1.2
FCC Gaso (180-225)	0.1	0.7
FCC Gaso (225-300)	0.1	1.2
FCC Gaso (300-375)	0.7	3.3
FCC Gaso (375-430)		
Total FCC Gasoline	31.9	27.4
Butenes		
Pentenenes		
Poly Gasoline	0.5	
Lt. Coker Gasoline		
Total Olefinic	0.5	
Reformate	22.7	0.5
Reformate (220-300 Feed)		
BT Reformate		
HC Reformate (210-300)	0.2	24.0
Heavy Reformate (300+)	2.6	1.1
Toluene/Xylenes		0.4
Total Reformates[1]	25.5	26.0
Lt. Reformate		
Lt. Raffinate B(C5-210)		15.0
Alkylate/Lt Alkylate (C3/C4)	24.6	9.7
Alkylate/Lt Alkylate (C5)	1.0	0.2
Butane	2.0 *	1.9 *
Natural/LSR Gaso		
BT Naphtha (150-220)		
Pentanenes (I/N)	1.4	0.5
Isomerase (C5-C6)	5.5	2.0
Isomerase (C6)		1.5
Lt. Hydrocrackate (C5-180)	1.0	5.0
Medium Hydrocrackate (180-225)	0.8	5.1
MTBE		
TAME		
Alcohol	5.7	5.7
Total Low Arom., Saturated	42.1	46.7
Total	100.0	100.0

* Minimum

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE F-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (\$/G per unit in constant 1990 \$)

	Base Case Q9 No FCAAA	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
(R+M)/2 Octane, Clear	(0.5)	(0.6)	(0.8)	(0.6)	(0.9)	(1.4)
Aromatics, Vol. %		0.0				
Ethers, Vol. %		(0.2)	(0.1)	(0.2)	(0.0)	0.1
Ethanol, %					0.0	0.0
Olefins, Vol. %						
Benzene, Vol. %		1.8	1.4	4.1	4.6	4.6
Sulfur, 100 Wt. PPM					0.1	
Reid Vapor Pressure, PSI	0.5	0.6	(1.0)		(4.1)	(14.0)
T90, 10°F		0.1				
Butane, Vol. %			(0.0)		(0.2)	(1.3)
V.O.C., 10%			1.0	0.4	3.3	11.2
NOx, 10%						
T.A.P., 10%			0.2			

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE F-9A
REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(\$/G per unit in constant 1990 \$)

	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
(R+M)/2 Octane, Clear	(0.5)	(0.7)	(0.6)	(0.9)	(1.4)
Aromatics, Vol.%					
Ethers, Vol.%	(0.2)	(0.1)	(0.2)	(0.1)	0.2
Olefins, Vol.%					
Benzene, Vol.%	2.7	2.1	4.1	4.6	4.7
Sulfur, 100 Wt. PPM				0.1	
Reid Vapor Pressure, PSI	0.6	(1.7)		(2.9)	(12.5)
T90, 10°F	0.1				
Butane, Vol.%		(0.0)		(0.2)	(1.3)
V.O.C., 10%		1.7	0.4	2.9	11.4
NOx, 10%					
T.A.P., 10%		0.0			

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE F-9B
CONVENTIONAL GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (\$/G per unit in constant 1990 \$)

	<u>Base Case Q9 No FCAAA</u>	<u>Case S5 '95 Full Opt in</u>	<u>Base Case Q6 Target Δ V.O.C.</u>
(R+M)/2 Octane, Clear	(0.5)	(0.7)	(0.8)
Aromatics, Vol. %		0.1	
Ethers, Vol. %		(0.2)	
Ethanol, %			
Olefins, Vol. %			
Benzene, Vol. %		0.6	0.4
Sulfur, 100 Wt. PPM			
Reid Vapor Pressure, PSI	0.5	0.6	
T90, 10° F			
Butane, Vol. %			
V.O.C., 10%			
NOx, 10%			
T.A.P., 10%			0.5

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE F-9E
REFORMULATED-E GASOLINE PROPERTY DECREASE - INCREMENTAL COSTS[1]
IIC - SUMMER 1995/2000 F2 - SF AND 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (¢/G per unit in constant 1990 \$)

	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
(R+M)/2 Octane, Clear	(0.9)	(1.5)
Aromatics, Vol. %		
Ethanol, Vol. %	0.0	0.0
Olefins, Vol. %		
Benzene, Vol. %	4.6	4.5
Sulfur, 100 Wt. PPM		
Reid Vapor Pressure, PSI	(6.9)	(17.6)
T90, 10°F		
Butane, Vol. %	(0.2)	(1.3)
V.O.C., 10%	4.1	10.8
NOx, 10%		
T.A.P., 10%		

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE F-10

NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IIC – SUMMER 1995/2000 F2 – SF AND 4/92 CF CASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Case S5 '95 Full Opt in	Base Case Q6 Target Δ V.O.C.	Case S6 Q6 + 100% RFG	Case S13 S6 + Hi EtOH	Case S13H S13 + S6 Δ V.O.C.
<u>No. 2 Diesel Compositions</u>						
Hvy Reformate (300+) 90 RON						
Hvy Reformate (300+) 100 RON						
FCC Heavy Gaso Tr(300-375)						3.1
FCC Heavy Gaso Tr(375-430)					0.8	7.8
Lt Cycle Oil – Treated	17.1	17.3	17.5	16.5	16.7	6.6
Coker Dist – Treated	7.3	6.3			2.6	5.0
Total High Aromatic	24.4	23.6	17.5	16.5	20.1	22.6
Heavy Alkylate (300+)						0.0
Lt Kero – Treated (300-375)	2.0	2.4	4.0	4.1	3.6	0.9
Kero (375-500)	4.6	7.7	9.9	9.9	9.2	0.2
Kero – Treated (375-500)	32.0	33.1	29.3	29.1	29.0	30.8
Kero – Low Aromatics (375-500)						
Hydrocracked Jet (295-525)						
Diesel Base	7.4	2.6	5.5	5.5	4.9	12.5
Diesel Base – Treated	29.6	30.6	33.8	34.9	33.1	33.0
Diesel Base – Low Aromatics						
Lt Cycle Oil – Low Aromatics						
Coker Dist – Low Aromatics						
Total Low Aromatic	75.6	76.4	82.5	83.5	79.9	77.4
Total	100.0	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>						
Diesel Ignition Improver						
Pour Point Depressant			Yes		Yes	Yes
Aromatics	30.5	30.5	28.8	28.8	29.4	30.5
<u>Jet A Compositions</u>						
Heavy Alkylate (300+)						
Lt Kero – Treated (300-375)	22.0	35.9	39.5	36.8	39.1	24.2
Kero – Treated (375-500)	60.7	41.1	48.3	42.7	47.5	73.9
Hydrocracked Jet (295-525)	17.3	23.0	12.3	20.6	13.4	1.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

TABLE F1-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Reformulated Limits*</u>	<u>Base Case Q9W</u>	<u>Base Case Q6W</u>
Aromatics, Vol.%, Maximum Avg		
Oxygen, Wt%, Minimum Avg		2.1
Olefins, Vol.%, Maximum Avg		
Benzene, Vol%, Maximum Avg		0.7
Sulfur, WPPM, Maximum Avg		
Reid Vapor Pressure, PSI, Min		
Reid Vapor Pressure, PSI, Max		12.5
Regulatory Cap		
T50, °F, Maximum Avg		
T90, °F, Maximum Avg		
V.O.C., % Reduction		
T.A.P., % Reduction		30
% Class C, Fixed	80	80
<u>Ethers, V% Pool</u>		
Purchased (Sold)	1.4	6.9
Manufactured	0.6	0.6
<u>Gasoline Pool Properties</u>		
(R+M)/2 Octane, Clear*	88.1	88.1
Aromatics, Vol. %	27.3	23.5
Ethers, Vol. % *	2.0	7.5
Oxygen, Wt. % *	0.4	1.3
Olefins, Vol. %	11.0	10.0
Benzene, Vol. %	1.9	1.3 *
Sulfur, WPPM	256	246
Reid Vapor Pressure, PSI*	12.5	12.5
Temperature at V/L = 20, °F	116	116
<u>Distillation</u>		
T10, °F	80	74
T50, °F	199	189
T90, °F	339	333
Specific Gravity	0.7317	0.7283
Heat Content, MBTU/G	112.2	110.8
V.O.C., gm/mile		
– % Reduction		
NOx, index	0.97	0.97 *
– % Reduction	3	3 *
T.A.P., mg/mile	42	37
– % Reduction	(4)	9

* Input limit.

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TABLE F1-1A
RUN BASIS AND REFORMULATED GASOLINE POOL PROPERTIES
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Reformulated Limits*</u>	<u>Base Case Q6W</u>
Aromatics, Vol.%, Maximum Avg	
Oxygen, Wt%, Minimum Avg	2.1
Olefins, Vol.%, Maximum Avg	
Benzene, Vol%, Maximum Avg	0.7
Sulfur, WPPM, Maximum Avg	
Reid Vapor Pressure, PSI, Min	
Reid Vapor Pressure, PSI, Max	12.5
Regulatory Cap	
T50, °F, Maximum Avg	
T90, °F, Maximum Avg	
V.O.C., % Reduction	
T.A.P., % Reduction	30
% Class C, Fixed	80
<u>Ethers, V% Pool</u>	
Purchased (Sold)	
Manufactured	
<u>Gasoline Pool Properties</u>	
(R+M)/2 Octane, Clear*	88.1
Aromatics, Vol.%	18.2
Ethers, Vol.% *	11.7
Oxygen, Wt.% *	2.1
Olefins, Vol.%	8.4
Benzene, Vol.% *	0.7
Sulfur, WPPM	239
Reid Vapor Pressure, PSI*	12.5
Temperature at V/L = 20, °F	115
Distillation	
T10, °F	74
T50, °F	182
T90, °F	336
Specific Gravity	0.7226
Heat Content, MBTU/G	109.4
V.O.C., gm/mile	
– % Reduction	
NOx, index	0.97
– % Reduction	3
T.A.P., mg/mile	32
– % Reduction	19

* Input limit.

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TABLE F1-1B
RUN BASIS AND CONVENTIONAL GASOLINE POOL PROPERTIES
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Conventional Limits*</u>	<u>Base Case Q9W</u>	<u>Base Case Q6W</u>
Aromatics, Vol.%, Maximum Avg		
Oxygen, Wt%, Minimum Avg		
Olefins, Vol.%, Maximum Avg		
Benzene, Vol%, Maximum Avg		2.0
Sulfur, WPPM, Maximum Avg		
Reid Vapor Pressure, PSI, Min		
Reid Vapor Pressure, PSI, Max	12.5	12.5
Regulatory Cap		
T50, °F, Maximum Avg		
T90, °F, Maximum Avg	356	356
V.O.C., % Reduction		
T.A.P., % Reduction		
% Class C, Fixed	80	80
<u>Ethers, V% Pool</u>		
Purchased (Sold)		
Manufactured		
<u>Gasoline Pool Properties</u>		
(R+M)/2 Octane, Clear*	88.1	88.1
Aromatics, Vol. %	27.3	31.8
Ethers, Vol. % *	2.0	
Oxygen, Wt. % *	0.4	
Olefins, Vol. %	11.0	13.2
Benzene, Vol. %	1.9	2.0 *
Sulfur, WPPM	256	255
Reid Vapor Pressure, PSI*	12.5	12.5
Temperature at V/L = 20, °F	116	116
Distillation		
T10, °F	80	76
T50, °F	199	200
T90, °F	339	329
Specific Gravity	0.7317	0.7356
Heat Content, MBTU/G	112.2	113.0
V.O.C., gm/mile		
– % Reduction		
NOx, index	0.97	0.98 *
– % Reduction	3	2 *
T.A.P., mg/mile	42	43
– % Reduction	(4)	(6)

* Input limit.

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TABLE F1-1C
RUN BASIS AND OXYGENATED GASOLINE POOL PROPERTIES
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Oxygenated Limits*</u>	<u>Base Case Q6W</u>
Aromatics, Vol.%, Maximum Avg	
Oxygen, Wt%, Minimum Avg	2.7
Olefins, Vol.%, Maximum Avg	
Benzene, Vol%, Maximum Avg	1.7
Sulfur, WPPM, Maximum Avg	
Reid Vapor Pressure, PSI, Min	
Reid Vapor Pressure, PSI, Max	12.5
Regulatory Cap	
T50, °F, Maximum Avg	
T90, °F, Maximum Avg	356
V.O.C., % Reduction	
T.A.P., % Reduction	
% Class C, Fixed	80
<u>Ethers, V% Pool</u>	
Purchased (Sold)	
Manufactured	
<u>Gasoline Pool Properties</u>	
(R+M)/2 Octane, Clear*	88.1
Aromatics, Vol.%	21.3
Ethers, Vol.% *	15.0
Oxygen, Wt.% *	2.7
Olefins, Vol. %	7.4
Benzene, Vol.% *	1.7
Sulfur, WPPM	279
Reid Vapor Pressure, PSI*	12.5
Temperature at V/L = 20, °F	117
Distillation	
T10, °F	76
T50, °F	185
T90, °F	339
Specific Gravity	0.7333
Heat Content, MBTU/G	109.4
V.O.C., gm/mile	
– % Reduction	
NOx, index	0.98
– % Reduction	2
T.A.P., mg/mile	39
– % Reduction	3

* Input limit.

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TABLE F1-1D
RUN BASIS AND REFORMULATED-OXYGENATED GASOLINE POOL PROPERTIES
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Reformulated/Oxygenated Limits*</u>	<u>Base Case Q6W</u>
Aromatics, Vol.%, Maximum Avg	
Oxygen, Wt%, Minimum Avg	2.7
Olefins, Vol.%, Maximum Avg	
Benzene, Vol%, Maximum Avg	0.7
Sulfur, WPPM, Maximum Avg	
Reid Vapor Pressure, PSI, Min	
Reid Vapor Pressure, PSI, Max	12.5
Regulatory Cap	
T50, °F, Maximum Avg	
T90, °F, Maximum Avg	
V.O.C., % Reduction	
T.A.P., % Reduction	30
% Class C, Fixed	80
<u>Ethers, V% Pool</u>	
Purchased (Sold)	
Manufactured	
<u>Gasoline Pool Properties</u>	
(R+M)/2 Octane, Clear*	88.1
Aromatics, Vol.%	14.4
Ethers, Vol.% *	15.0
Oxygen, Wt.% *	2.7
Olefins, Vol.%	5.7
Benzene, Vol.% *	0.7
Sulfur, WPPM	208
Reid Vapor Pressure, PSI*	12.5
Temperature at V/L = 20, °F	117
Distillation	
T10, °F	50
T50, °F	188
T90, °F	329
Specific Gravity	0.7228
Heat Content, MBTU/G	108.9
V.O.C., gm/mile	
– % Reduction	
NOx, index	0.96
– % Reduction	4
T.A.P., mg/mile	30
– % Reduction	26

* Input limit.

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TABLE F1-2
SUMMARY OF COSTS - INCREASE OVER Q9W BASE CASE[1]
IIC - WINTER 2000 F2 - 4/92 CF CASE RESULTS[2]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Base Case Q6W
<u>Investment, MM\$</u>	
Refinery	867
MTBE[3]	2,253
Total	3,120
Range, MMM\$[4]	2.7 - 4.2
<u>Daily Costs, M\$/D</u>	
Capital Charge[5]	404
Net Upgrading[6]	1,540
Variable Operating	(237)
Fixed Operating[7]	184
Total Refinery	1,891
<u>Annual Costs, MM\$/Yr.</u>	
Refinery	690
Other[8]	377
Total	1,067
<u>Total Unit Costs, ¢/G of</u>	
<u>Conventional Gasoline Upgraded</u>	
Average	6.8
Range[9]	5.2 - 9.5

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.
- [3] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [4] For variations from investment curves of -15/+35%.
- [5] Based on expected 10% DCF rate of return on new refining facilities investment with mid-1990 \$.
- [6] Raw material upgrading costs.
- [7] For new refining facilities only.
- [8] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [9] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (± 0.2).

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TABLE F1-3
REFINING RAW MATERIAL AND PRODUCT RATE – MBPCD
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W
<u>Raw Materials</u>		
Domestic - S	1,223	1,223
HL	371	371
HH	226	226
Foreign - S	298	259
HL	166	121
HH	423	409
Subtotal Crudes	2,707	2,609
MTBE	24	117
Ethanol		
Normal Butane	143	148
Isobutane	29	23
Natural Gas to H2 Plant Feed	5	5
Methanol	3	3
Other Raw Materials	102	102
Total Raw Materials	3,013	3,006
<u>Products</u>		
Motor Gasolines		
Conventional	1,658	657
Oxygenated		99
Reformulated/Oxygenated		88
Reformulated		836
Reformulated-E		
Kero Jet/Kerosene	213	213
Diesel/No. 2 Fuels		
Diesel - LA ULS		
Diesel - 0.05%S	548	548
No. 2 Fuel	134	134
No. 6 Fuel (1% Sul)	14	14
No. 6 Bunker	13	13
Marketable Coke - 400 #	65	57
Catalytic Coke - 400 #	45	43
Vacuum Gas Oil		
Benzene	2	2
Toluene	5	5
Heavy Aromatic Gaso		
Pentanes to P/C		
Natural Gasoline to P/C		
Normal Butane		
Isobutane		
Propane	86	81
Process Gas/C2/C2=,FOE	136	118
Other Products	202	202
(Gain)/Loss	(109)	(105)
Total Products	3,013	3,006
<u>Crude Properties</u>		
Gravity, °API	34.6	34.6
Sulfur, Wt%	1.00	0.99
<u>Gasoline Demand Increase, %[1]</u>		
Results		1.3
Target		1.3

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

TABLE F1-4
NEW PROCESS UNIT RATES – MBPSD
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case <u>Q9W</u>	Base Case <u>Q6W</u>
Crude – Atmospheric		
Heavy Naphtha Splitter		
Catalytic Cracking		
FCC Gasoline Splitters		
FCC Gasoline Fractionation		
Hydrocracking – 2 Stage		
Hydrocracking – 2 Stage Distillate		
– Hvy Gasoline		
Hydrocrackate Fractionation		
Coker – Delayed		
Coker Lt Gasoline DS/Splitter		8
Hydrotreating – Naphtha		
– FCC/Coker C6s		
– Distillate	20	18
– Heavy Gas Oil		
Reformer Feed Fractionation		726
Reformate Fractionation		39
Aromatics Extraction		
Benzene Saturation		18
FCC Gasoline HDS		
Diesel Aromatics Saturation		
Alkylation		
Alkylate Splitter		
MTBE		
TAME		
Isomerization – C5/C6		
– C5/C6, Recycle		
– C4		
Hydrogen – MMSCFPSD		
Sulfur – LTPSD		
C4 Rerun – Saturates		
– Unsaturates		
Catalytic Reforming – 100 PSI		
Hydrotreating – Distillate Upgrade		
Dehydrogenation – IC4		
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TABLE F1-5
NEW PROCESS UNIT INVESTMENTS
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(\$MM – in constant mid-1990 \$)

	<u>Base Case Q9W</u>	<u>Base Case Q6W</u>
Crude Distillation		
Heavy Naphtha Splitter		
Catalytic Cracking		
FCC Gasoline Splitters		
FCC Gasoline Fractionation		
Hydrocracking – 2 Stage		
Hydrocracking – 2 Stage Distillate – Heavy Gasoline		
Hydrocrackate Fractionation		
Coker – Delayed		
Coker Lt. Gasoline DS/Splitter		17
Hydrotreating – Naphtha		
– FCC Coker C6s		
– Distillate	39	36
– Heavy Gas Oil		
Reformer Feed Fractionation		625
Reformate Fractionation		87
Aromatics Extraction		
Benzene Saturation		77
FCC Gasoline HDS		
Diesel Aromatics Saturation		
Alkylation		
Alkylate Splitter		
MTBE		
TAME		
Isomerization – C5/C6		
– C5/C6, Recycle		
– C4		
Hydrogen		
Sulfur		
MTBE Storage & Blending		64
C4 Rerun – Saturates		
– Unsaturation		
C4 Fractionation Upgrade		
Catalytic Reforming – 100 PSI		
Hydrotreating – Distillate Upgrade		
Dehydrogenation – IC4		
Total Refinery	<u>39</u>	<u>906</u>

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TABLE F1-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W
Crude – Atmospheric	79.6	76.7
Heavy Naphtha Splitter		
Catalytic Cracking[1]	28.0	25.7
Catalytic Cracking[2]	26.1	24.0
Conversion, %	77.8	78.1
Octane Catalyst, %	73.0	73.4
FCC Gasoline Splitters		
FCC Gasoline Fractionation	4.3	4.3
Hydrocracking – 2 Stage[1]	3.0	3.0
Jet Yield, % of Max	100.0	100.0
300 – Gasoline Operation, %		
Hydrocracking – 2 Stage Distillate		
Hydrocracking – Low Conversion	0.7	0.7
– Heavy Gasoline		
– Combined[2]	3.7	3.7
Hydrocrackate Fractionation		
Coking – Delayed	7.6	7.6
– Fluid		
Coker Lt Gasoline DS/Splitter		0.2
Thermal Cracking, Visbreaking	0.6	0.6
Solvent Deasphalting	1.0	0.6
Catalytic Reforming – 100 PSI[1]	6.6	5.0
– 200 PSI[1]	6.9	5.5
– 450 PSI[1]	5.4	4.9
– Combined[2]	18.4	15.1
– RONC	94.7	94.9
Hydrotreating – Naphtha	20.6	17.7
– FCC/Coker C6s		
– Distillate	20.6	20.6
– Heavy Gas Oil	8.0	8.0
– Residuum – Atm	0.3	0.3
Reformer Feed Fractionation		17.7
Reformate Fractionation	1.3	2.2
Aromatics Extraction	0.8	0.9
Benzene Saturation		0.4
FCC Gasoline HDS		
Diesel Aromatics Saturation		
Alkylation	5.5	4.9
Alkylate Splitter		
Polymerization	0.2	0.2
Dehydrogenation – IC4		
MTBE	0.3	0.3
TAME		
Hydrodealkylation – Toluene		
Lubes	0.7	0.7
Isomerization – C5/C6	2.6	2.6
– C5/C6, Recycle	0.4	1.0
– C4	0.4	0.4
Hydrogen – MMSCFPCD	5.7	5.7
Sulfur, LTPCD	56	52
C4 Rerun – Saturates		
– Unsaturates		

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

TABLE F1-7
PROCESS UNIT UTILIZATIONS – %[1]
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W
Crude Distillation – Atmospheric	78.3	75.5
Heavy Naphtha Splitter		
Catalytic Cracking[2]	72.8	66.9
Catalytic Cracking[3]	67.9	62.3
FCC Gasoline Splitters		
FCC Gasoline Fractionation	76.3	76.3
Hydrocracking – 2 Stage[2]	77.0 *	77.0 *
Hydrocracking – 2 Stage Distillate		
– Low Conversion	77.0 *	77.0 *
– Heavy Gasoline		
– Combined[3]	77.0 *	77.0 *
Hydrocrackate Fractionation		
Coking – Delayed	84.0 *	84.0 *
– Fluid		
Coker Lt Gasoline DS/Splitter		84.0 *
Thermal Cracking, Visbreaking	83.0 *	83.0 *
Solvent Deasphalting	82.3	54.2
Catalytic Reforming – 100 PSI[2]	66.4	49.8
– 200 PSI[2]	83.0 *	66.5
– 450 PSI[2]	45.4	41.5
– Combined[3]	61.1	50.1
Hydrotreating – Naphtha	66.9	57.6
– FCC/Coker C6s		
– Distillate	83.0 *	83.0 *
– Heavy Gas Oil	74.8	74.8
– Residuum, Atm	83.0 *	83.0 *
Reformer Feed Fractionation		83.0 *
Reformate Fractionation	83.0 *	83.0 *
Aromatics Extraction	73.7	83.0 *
Benzene Saturation		83.0 *
FCC Gasoline HDS		
Diesel Aromatics Saturation		
Alkylation	67.6	60.9
Alkylate Splitter		
Polymerization	40.0	40.0
Dehydrogenation – IC4		
MTBE	80.0 *	80.0 *
TAME	0.0	0.0
Hydrodealkylation – Toluene	0.0	0.0
Lubes	82.0	82.0
Isomerization – C5/C6	83.0 *	83.0 *
– C5/C6, Recycle	23.7	51.6
– C4	80.0 *	80.0 *
Hydrogen	66.3	66.3
Sulfur	49.1	45.6
C4 Rerun – Saturates		
– Unsaturation		

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

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TABLE F1-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W
FCC Gasoline	21.5	18.7
Lt. FCC 255-	5.2	5.1
Hvy FCC 255+	3.6	3.6
Hvy FCC 255+ Desulf.		
FCC Gaso (100-180)		
FCC Gaso (180-225)		
FCC Gaso (225-300)		
FCC Gaso (300-375)		
FCC Gaso (375-430)		
Total FCC Gasoline	<u>30.3</u>	<u>27.4</u>
Butenes		
Pentenes		0.0
Poly Gasoline	0.4	0.4
Lt. Coker Gasoline	<u>0.8</u>	<u>0.7</u>
Total Olefinic	1.2	1.1
Reformate	22.4	21.5
Reformate (220-300 Feed)	0.2	0.7
BT Reformate	8.4	3.0
HC Reformate (210-300)	0.4	0.1
Heavy Reformate (300+)	0.2	0.1
Toluene/Xylenes	<u>0.0</u>	<u>0.2</u>
Total Reformates[1]	31.6	25.5
Lt. Reformate	0.5	
Lt. Raffinate B(C5-210)	0.4	1.0
Alkylate/Lt Alkylate (C3/C4)	11.4	10.1
Alkylate/Lt Alkylate (C5)		
Butane	12.3	12.1
Natural/LSR Gaso	1.9	0.5
BT Naphtha (150-220)		5.3
Pentanes (I/N)		0.1
Isomerase (C5-C6)	6.1	7.1
Isomerase (C6)		
Lt. Hydrocrackate (C5-180)	1.1	1.1
Medium Hydrocrackate (180-225)	1.2	1.2
MTBE	2.0	7.5
TAME		
Alcohol		
Total Low Arom., Saturated	<u>36.9</u>	<u>46.0</u>
Total	<u>100.0</u>	<u>100.0</u>

*Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE F1-8A
REFORMULATED GASOLINE POOL COMPOSITIONS – %
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case <u>Q6W</u>
FCC Gasoline	19.7
Lt. FCC 255-	
Hvy FCC 255+	5.5
Hvy FCC 255+ Desulf.	
FCC Gaso (100-180)	
FCC Gaso (180-225)	
FCC Gaso (225-300)	
FCC Gaso (300-375)	
FCC Gaso (375-430)	
Total FCC Gasoline	<u>25.2</u>
Butenes	
Pentenenes	
Poly Gasoline	0.8
Lt. Coker Gasoline	
Total Olefinic	<u>0.8</u>
Reformate	14.1
Reformate (220-300 Feed)	1.3
BT Reformate	0.7
HC Reformate (210-300)	0.2
Heavy Reformate (300+)	
Toluene/Xylenes	
Total Reformates[1]	<u>16.3</u>
Lt. Reformate	
Lt. Raffinate B(C5-210)	2.1
Alkylate/Lt Alkylate (C3/C4)	13.7
Alkylate/Lt Alkylate (C5)	
Butane	11.9
Natural/LSR Gaso	
BT Naphtha (150-220)	7.2
Pentanenes (I/N)	0.1
Isomerase (C5-C6)	10.7
Isomerase (C6)	
Lt. Hydrocrackate (C5-180)	0.3
Medium Hydrocrackate (180-225)	
MTBE	11.7
TAME	
Alcohol	
Total Low Arom., Saturated	<u>57.7</u>
Total	<u>100.0</u>

*Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE F1-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS – %
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9W	Base Case Q6W
FCC Gasoline	21.5	18.1
Lt. FCC 255-	5.2	13.1
Hvy FCC 255+	3.6	
Hvy FCC 255+ Desulf.		
FCC Gaso (100-180)		
FCC Gaso (180-225)		
FCC Gaso (225-300)		
FCC Gaso (300-375)		
FCC Gaso (375-430)		
Total FCC Gasoline	<u>30.3</u>	<u>31.3</u>
Butenes		
Pentenes		0.1
Poly Gasoline	0.4	
Lt. Coker Gasoline	<u>0.8</u>	<u>1.7</u>
Total Olefinic	1.2	1.8
Reformate	22.4	33.6
Reformate (220-300 Feed)	0.2	
BT Reformate	8.4	5.4
HC Reformate (210-300)	0.4	
Heavy Reformate (300+)	0.2	0.2
Toluene/Xylenes	<u>0.0</u>	<u>0.5</u>
Total Reformates[1]	31.6	39.8
Lt. Reformate	0.5	
Lt. Raffinate B(C5-210)	0.4	
Alkylate/Lt Alkylate (C3/C4)	11.4	4.3
Alkylate/Lt Alkylate (C5)		
Butane	12.3	11.9
Natural/LSR Gaso	1.9	1.4
BT Naphtha (150-220)		1.2
Pentanes (I/N)		
Isomerate (C5-C6)	6.1	4.3
Isomerate (C6)		
Lt. Hydrocrackate (C5-180)	1.1	1.8
Medium Hydrocrackate (180-225)	1.2	2.2
MTBE	2.0	
TAME		
Alcohol		
Total Low Arom., Saturated	<u>36.9</u>	<u>27.1</u>
Total	100.0	100.0

* Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE F1-8C
OXYGENATED GASOLINE POOL COMPOSITIONS – %
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6W
FCC Gasoline	17.9
Lt. FCC 255-	
Hvy FCC 255+	9.5
Hvy FCC 255+ Desulf.	
FCC Gaso (100-180)	
FCC Gaso (180-225)	
FCC Gaso (225-300)	
FCC Gaso (300-375)	
FCC Gaso (375-430)	
Total FCC Gasoline	27.3
Butenes	
Pentenenes	
Poly Gasoline	
Lt. Coker Gasoline	
Total Olefinic	
Reformate	11.0
Reformate (220-300 Feed)	
BT Reformate	8.6
HC Reformate (210-300)	
Heavy Reformate (300+)	
Toluene/Xylenes	
Total Reformates[1]	19.6
Lt. Reformate	
Lt. Raffinate B(C5-210)	
Alkylate/Lt Alkylate (C3/C4)	6.5
Alkylate/Lt Alkylate (C5)	
Butane	13.3
Natural/LSR Gaso	
BT Naphtha (150-220)	8.0
Pentanenes (I/N)	
Isomerase (C5-C6)	0.8
Isomerase (C6)	
Lt. Hydrocrackate (C5-180)	3.9
Medium Hydrocrackate (180-225)	5.8
MTBE	15.0
TAME	
Alcohol	
Total Low Arom., Saturated	53.1
Total	100.0

*Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE F1-8D
REFORMULATED-OXYGENATED GASOLINE POOL COMPOSITIONS - %
IIC - WINTER 2000 F2 - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6W
FCC Gasoline	14.5
Lt. FCC 255-	
Hvy FCC 255+	4.9
Hvy FCC 255+ Desulf.	
FCC Gaso (100-180)	
FCC Gaso (180-225)	
FCC Gaso (225-300)	
FCC Gaso (300-375)	
FCC Gaso (375-430)	
Total FCC Gasoline	19.3
Butenes	
Pentenes	
Poly Gasoline	
Lt. Coker Gasoline	
Total Olefinic	
Reformate	12.8
Reformate (220-300 Feed)	
BT Reformate	0.5
HC Reformate (210-300)	
Heavy Reformate (300+)	
Toluene/Xylenes	
Total Reformates[1]	13.2
Lt. Reformate	
Lt. Raffinate B(C5-210)	
Alkylate/Lt Alkylate (C3/C4)	22.8
Alkylate/Lt Alkylate (C5)	
Butane	14.0
Natural/LSR Gaso	
BT Naphtha (150-220)	14.6
Pentanes (I/N)	0.0
Isomerase (C5-C6)	
Isomerase (C6)	
Lt. Hydrocrackate (C5-180)	0.4
Medium Hydrocrackate (180-225)	0.7
MTBE	15.0
TAME	
Alcohol	
Total Low Arom., Saturated	67.5
Total	100.0

*Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE F1-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (¢/G per unit in constant 1990 \$)

	Base Case Q9W	Base Case Q6W
(R+M)/2 Octane, Clear	(0.4)	(0.3)
Aromatics, Vol.%		
Ethers, Vol.%		(0.3)
Ethanol, %		
Olefins, Vol.%		
Benzene, Vol.%		0.2
Sulfur, 100 Wt. PPM		
Reid Vapor Pressure, PSI	0.4	0.4
T90, 10°F		
Butane, Vol.%		
V.O.C., 10%		
NOx, 10%		0.0
T.A.P., 10%		

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE F1-9A
REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (¢/G per unit in constant 1990 \$)

	Base Case Q6W
(R+M)/2 Octane, Clear	(0.3)
Aromatics, Vol. %	
Ethers, Vol. %	(0.3)
Ethanol, %	
Olefins, Vol. %	
Benzene, Vol. %	0.3
Sulfur, 100 Wt. PPM	
Reid Vapor Pressure, PSI	0.4
T90, 10°F	
Butane, Vol. %	
V.O.C., 10%	
NOx, 10%	
T.A.P., 10%	

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE F1-9B
CONVENTIONAL GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (\$/G per unit in constant 1990 \$)

	Base Case Q9W	Base Case Q6W
(R+M)/2 Octane, Clear	(0.4)	(0.4)
Aromatics, Vol. %		
Ethers, Vol. %		(0.3)
Ethanol, %		
Olefins, Vol. %		
Benzene, Vol. %		0.2
Sulfur, 100 Wt. PPM		
Reid Vapor Pressure, PSI	0.4	0.4
T90, 10°F		
Butane, Vol. %		
V.O.C., 10%		
NOx, 10%		0.0
T.A.P., 10%		

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE F1-9C
OXYGENATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (\$/G per unit in constant 1990 \$)

	<u>Base Case Q6W</u>
(R+M)/2 Octane, Clear	(0.3)
Aromatics, Vol. %	
Ethers, Vol. %	(0.3)
Ethanol, %	
Olefins, Vol. %	
Benzene, Vol. %	0.3
Sulfur, 100 Wt. PPM	
Reid Vapor Pressure, PSI	0.4
T90, 10°F	
Butane, Vol. %	
V.O.C., 10%	
NOx, 10%	
T.A.P., 10%	

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE F1-9D

REFORMULATED-OXYGENATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]

IIC – WINTER 2000 F2 – 4/92 CF CASE RESULTS

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(¢/G per unit in constant 1990 \$)

	Base Case Q6W
(R+M)/2 Octane, Clear	(0.3)
Aromatics, Vol. %	
Ethers, Vol. %	(0.3)
Ethanol, %	
Olefins, Vol. %	
Benzene, Vol. %	0.3
Sulfur, 100 Wt. PPM	
Reid Vapor Pressure, PSI	0.4
T90, 10°F	
Butane, Vol. %	
V.O.C., 10%	
NOx, 10%	
T.A.P., 10%	

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE F1-10

NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES

IIC - WINTER 2000 F2 - 4/92 CF CASE RESULTS - %

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case <u>Q9W</u>	Base Case <u>Q6W</u>
<u>No. 2 Diesel Compositions</u>		
Hvy Reformate (300+) 90 RON		
Hvy Reformate (300+) 100 RON		
FCC Heavy Gaso Tr(300-375)		
FCC Heavy Gaso Tr(375-430)		
Lt Cycle Oil - Treated	13.7	12.0
Coker Dist - Treated	6.8	6.8
Total High Aromatic	20.5	18.8
Heavy Alkylate (300+)	0.0	0.0
Lt Kero - Treated (300-375)	3.5	4.1
Kero (375-500)	13.1	13.1
Kero - Treated (375-500)	24.6	22.7
Kero - Low Aromatics (375-500)		
Hydrocracked Jet (295-525)		
Diesel Base	7.2	7.3
Diesel Base - Treated	31.1	34.0
Diesel Base - Low Aromatics		
Lt Cycle Oil - Low Aromatics		
Coker Dist - Low Aromatics		
Total Low Aromatic	79.5	81.2
Total	100.0	100.0
<u>Properties</u>		
Diesel Ignition Improver		
Pour Point Depressant	Yes	Yes
Aromatics	28.7	28.7
<u>Jet A Compositions</u>		
Heavy Alkylate (300+)		
Lt Kero - Treated (300-375)	35.2	35.1
Kero - Treated (375-500)	39.4	39.3
Hydrocracked Jet (295-525)	25.4	25.6
Total	100.0	100.0

TABLE G-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IV – 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Summer		Annual		
	Base	S21	Base	S7	S12
	Case Q9	2000 All	Case Q9Y	1990 Prod.	1995 All
	No FCAAA	CARB 2	No FCAAA	Regs.	LS Diesel
<u>Reformulated Limits*</u>					
Aromatics, Vol.%, Maximum Avg		22.0			
Oxygen, Wt%, Minimum Avg		2.0			
Olefins, Vol.%, Maximum Avg		4.0			
Benzene, Vol%, Maximum Avg		0.8			
Sulfur, WPPM, Maximum Avg		30			
Reid Vapor Pressure, PSI, Min					
Reid Vapor Pressure, PSI, Max		6.6			
Regulatory Cap		7.0			
T50, °F, Maximum Avg		200			
T90, °F, Maximum Avg		290			
V.O.C., % Reduction					
T.A.P., % Reduction					
% Class C, Fixed	40	40	40	40	40
<u>Ethers, V% Pool</u>					
Purchased (Sold)	1.4	10.4	2.0	0.9	2.0
Manufactured	0.6	0.7			
<u>Gasoline Pool Properties</u>					
(R+M)/2 Octane, Clear*	86.6	86.6	86.6	86.6	86.6
Aromatics, Vol. %	28.0	18.0	26.9	26.5	27.5
Ethers, Vol. % *	2.0	11.1	2.0	0.9	2.0
Oxygen, Wt. % *	0.4	2.0	0.4	0.2	0.4
Olefins, Vol. %	14.6	4.0 *	14.1	13.3	14.9
Benzene, Vol. %	1.9 *	0.8 *	1.9	1.9	1.9
Sulfur, WPPM	287	30 *	248	234	314
Reid Vapor Pressure, PSI*	7.9	6.6	9.9	10.7	9.9
Temperature at V/L = 20, °F	142	145	131	127	131
Distillation					
T10, °F	122	135	107	100	107
T50, °F	206	193	203	202	202
T90, °F	344	290 *	342	341	342
Specific Gravity	0.7431	0.7292	0.7371	0.7342	0.7382
Heat Content, MBTU/G	113.7	110.7	112.9	112.8	113.0
V.O.C., gm/mile	1.04	0.63			
– % Reduction	19	51			
NOx, index	1.01	0.93			
– % Reduction	(1)	7			
T.A.P., mg/mile	49	25			
– % Reduction	7	52			

* Input limit.

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TABLE G-2
SUMMARY OF COSTS – INCREASE OVER Q9 BASE CASE[1]
IV – 1995/2000 F2 – SF CASE RESULTS[2]
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Summer	Annual	
	S21	S7[4]	S12[4]
	2000 All	1990 Prod.	1995 All
	CARB 2[3]	Regs.	LS Diesel
<u>Investment, MM\$</u>			
Refinery	1,183	(617)	106
MTBE[5]	555	(39)	—
Total	1,738	(656)	106
Range, MMM\$[6]	1.5 – 2.3	(0.9) – (0.6)	0.1 – 0.1
<u>Daily Costs, M\$/D</u>			
Capital Charge[7]	961	(288)	49
Net Upgrading[8]	1,098	62	73
Variable Operating	120	(53)	(10)
Fixed Operating[9]	442	(130)	19
Total Refinery	2,621	(409)	131
<u>Annual Costs, MM\$/Yr</u>			
Refinery	957	(149)	48
Other[10]	119	4	4
Total	1,076	(145)	52
<u>Total Unit Costs, ¢/G of Gasoline/Diesel Upgraded</u>			
Average[12]	28.5	(9.3) [13]	8.4
Range[11]	25.4 – 34.4	(12.1) – (8.1)	7.9 – 9.4

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.
- [3] Adjusted using individual unit capital charge/fixed operating costs multipliers to include the full cost of extra facilities for summer RFG as detailed on Table A3–19.
- [4] Increase over PADD IV Annual Case Q9¥ to upgrade (82) and 40 MBPD diesel in cases S7 and S12 respectively.
- [5] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [6] For variations from investment curves of –15/+35%.
- [7] Based on expected 10% DCF rate of return on new refining facilities investment in mid–1990 \$.
- [8] Raw material upgrading costs.
- [9] For new refining facilities only.
- [10] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [11] For variations in capital charge (–15/+35%), MTBE costs (–10/+20¢/G) and BTU mileage factor (±0.2).
- [12] Costs reduced by including part of extra survey capacities for 1995 in Q9 base case and by allowing heavy aromatic gasoline component sales.
- [13] Downgraded diesel cost savings based on estimated savings from downgrading conventional gasoline (by +0.8 RVP, –1.2% MTBE) of about 0.8¢/G or \$28MM/Yr.

TABLE G-2A
SUMMARY OF COSTS – INCREASE OVER Q9 BASE CASE[1]
IV – 1995/2000 F2 – SF CASE RESULTS UNADJUSTED[2]
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY
(in constant 1990 \$)

	Summer		Annual		
	Base Case Q9 No FCAAA	S21 2000 All CARB 2	Base Case Q9Y No FCAAA	S7 1990 Prod. Regs.	S12 1995 All LS Diesel
<u>Investment, MM\$</u>					
Refinery		1,183			
MTBE[3]		555			
Total		1,738			
Range, MMM\$[4]		1.5 – 2.3			
<u>Daily Costs, M\$/D</u>					
Capital Charge[5]		551			
Net Upgrading[6]		1,098			
Variable Operating		120			
Fixed Operating[7]		288			
Total Refinery		2,057			
<u>Annual Costs, MM\$/Yr.</u>					
Refinery		751			
Other[8]		119			
Total		870			
<u>Total Unit Costs, ¢/G of Conventional Gasoline Upgraded</u>					
Average[10]		23.1			
Range[9]		20.6 – 27.6			

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average. Unadjusted LP case results shown before capital charge and CG RVP adjustments if these were required.
- [3] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [4] For variations from investment curves of -15/+35%.
- [5] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- [6] Raw material upgrading costs.
- [7] For new refining facilities only.
- [8] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [9] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (±0.2).
- [10] Costs reduced by including part of extra survey capacities for 1995 in Q9 base case and by allowing heavy aromatic gasoline component sales.

TABLE G-3
REFINING RAW MATERIAL AND PRODUCT RATES – MBPCD
IV – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer		Annual		
	Base Case Q9	S21 2000 All CARB 2	Base Case Q9%	S7 1990 Prod. Regs.	S12 1995 All LS Diesel
Raw Materials					
Domestic – S	230	255	230	230	230
HL	69	69	69	69	69
HH	131	98	102	98	107
Foreign – S	5	5	5	5	5
HL	33	33	33	33	33
HH	19	19	19	19	19
Subtotal Crudes	487	479	458	454	463
MTBE	4	26	3	2	5
Ethanol					
Normal Butane	7	4	16	20	14
Isobutane	1	5	1	1	1
Natural Gas to H2 Plant Feed	1	1	0	0	0
Methanol	0	1	0		
Other Raw Materials	1	1	1	1	1
Total Raw Materials	501	517	480	478	484
Products					
Motor Gasolines					
Conventional	246		238	239	238 [1]
Oxygenated					
Reformulated/Oxygenated					
Reformulated					
CARB2		252			
Kero Jet/Kerosene	34	34	35	35	35
Diesel/No. 2 Fuels					
Diesel – LA ULS					
Diesel – 0.05%S	86	86	82		122
No. 2 Fuel	42	42	40	122	
No. 6 Fuel (1% Sul)	2	2	2	2	2
No. 6 Bunker	1	1	1	1	1
Marketable Coke – 400 #	9	10	8	8	8
Catalytic Coke – 400 #	8	6	7	7	8
Vacuum Gas Oil					
Benzene					
Toluene					
Heavy Aromatic Gaso		17			
Pentanes to P/C					
Natural Gasoline to P/C	5		5	5	5
Normal Butane					
Isobutane	6		8	5	10
Propane	9	9	8	8	9
Process Gas/C2/C2=,FOE	26	24	23	23	24
Other Products	40	40	34	34	34
(Gain)/Loss	(13)	(6)	(11)	(11)	(12)
Total Products	501	517	480	478	484
Crude Properties					
Gravity, °API	33.6	34.7	34.4	34.5	34.3
Sulfur, Wt%	1.15	1.00	1.05	1.03	1.07
Gasoline Demand Increase, % [2]					
Results		2.7		0.2	(0.2)
Target		2.7		0.1	(0.1)

[1] Case run without oxygenated gasoline to calculate all LS diesel economics.

[2] To maintain constant miles traveled with lower BTU content reformulated gasoline.

TABLE G-4
NEW PROCESS UNIT RATES – MBPSD
IV – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer		Annual		
	Base Case Q9	S21 2000 All CARB 2	Base Case Q9¥	S7 1990 Prod. Regs.[1]	S12 1995 All LS Diesel
Crude – Atmospheric					
Heavy Naphtha Splitter		27			
Catalytic Cracking	2 [2]				
FCC Gasoline Splitters		91			
FCC Gasoline Fractionation					
Hydrocracking – 2 Stage					
Hydrocracking – 2 Stage Distillate					
– Hvy Gasoline		2			
Hydrocrackate Fractionation		6			
Coker – Delayed				(13)	
Coker Lt Gasoline DS/Splitter		2			
Hydrotreating – Naphtha					
– FCC/Coker C6s		33			
– Distillate	55	61	56		90
– Heavy Gas Oil				(37)	
Reformer Feed Fractionation		114			
Reformat Fractionation		29			
Aromatics Extraction					
Benzene Saturation		13			
FCC Gasoline HDS					
Diesel Aromatics Saturation					6
Alkylation	1 [2]	26			
Alkylate Splitter					
MTBE					
TAME		2 [3]			
Isomerization – C5/C6		14			
– C5/C6, Recycle					
– C4		4		(5)	
Hydrogen – MMSCFPSD	17 [2]	36			
Sulfur – LTPSD	228 [2]	207	216	151	218
C4 Rerun – Saturates		16			
– Unsaturates		39			
Catalytic Reforming – 100 PSI					
Hydrotreating – Distillate Upgrade				(68)	
Dehydrogenation – IC4					

[1] Added capacity removed for investment purposes. Capacity removed from Heavy Gas Oil Hydrotreating and C4 Isomerization exceeded surplus capacity available in the LP results.

[2] Based on including part of NPC survey estimated process unit capacity additions for 1995 that are not under construction.

[3] MTBE capacity used for TAME.

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TABLE G-5
NEW PROCESS UNIT INVESTMENTS
IV – 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY
(\$MM – in constant mid-1990 \$)

	Summer		Annual		
	Base Case Q9	S21 2000 All CARB 2	Base Case Q9Y	S7 1990 Prod. Regs.	S12 1995 All LS Diesel
Crude Distillation					
Heavy Naphtha Splitter		32			
Catalytic Cracking	16				
FCC Gasoline Splitters		200			
FCC Gasoline Fractionation					
Hydrocracking – 2 Stage					
Hydrocracking – 2 Stage Distillate – Heavy Gasoline		39			
Hydrocrackate Fractionation		11			
Coker – Delayed				(157)	
Coker Lt. Gasoline DS/Splitter		6			
Hydrotreating – Naphtha					
– FCC Coker C6s		124			
– Distillate	148	173	159		211
– Heavy Gas Oil				(98)	
Reformer Feed Fractionation		139			
Reformate Fractionation		52			
Aromatics Extraction					
Benzene Saturation		61			
FCC Gasoline HDS					
Diesel Aromatics Saturation					54
Alkylation	17	253			
Alkylate Splitter					
MTBE					
TAME		11 [1]			
Isomerization – C5/C6		55			
– C5/C6, Recycle					
– C4		34		(21)	
Hydrogen	62	93			
Sulfur	110	100	104	73	105
MTBE Storage & Blending		16			
C4 Rerun – Saturates		36			
– Unsatulates		67			
C4 Fractionation Upgrade		34		(22)	
Catalytic Reforming – 100 PSI					
Hydrotreating – Distillate Upgrade				(129)	
Dehydrogenation – IC4					
Total Refinery	353	1,536	263	(354)	370

[1] MTBE capacity used for TAME.

TABLE G-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IV – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer		Annual		
	Base Case Q9 No FCAAA	S21 2000 All CARB 2	Base Case Q9¥ No FCAAA	S7 1990 Prod. Regs.	S12 1995 All LS Diesel
Crude – Atmospheric	28.6	28.2	27.0	26.7	27.2
Heavy Naphtha Splitter		1.5			
Catalytic Cracking[1]	9.7	8.7	8.8	8.5	9.0
Catalytic Cracking[2]	8.9	7.9	8.2	8.1	8.2
Conversion, %	79.4	78.9	78.3	77.9	79.7
Octane Catalyst, %	76.9	68.0	76.2	76.0	57.5
FCC Gasoline Splitters		4.6			
FCC Gasoline Fractionation	1.8		1.7	1.7	1.7
Hydrocracking – 2 Stage[1]	0.4	0.4	0.4	0.4	0.4
Jet Yield, % of Max	100.0	0.0	100.0	100.0	100.0
300 – Gasoline Operation, %		40.0			
Hydrocracking – Low Conversion	0.1	0.1	0.1	0.1	0.1
– Heavy Gasoline		0.1			
– Combined[2]	0.5	0.6	0.4	0.4	0.5
Hydrocrackate Fractionation		0.3			
Coking – Delayed	1.3	1.8	1.2	1.1	1.3
– Fluid	0.4	0.4	0.3	0.3	0.3
Coker Lt Gasoline DS/Splitter		0.1			
Thermal Cracking, Visbreaking					
Solvent Deasphalting	0.3	0.5	0.2	0.2	0.2
Catalytic Reforming – 100 PSI[1]					
– 200 PSI[1]	3.2	3.2	3.2	3.0	3.2
– 450 PSI[1]	1.9	1.7	1.6	1.7	1.8
– Combined[2]	4.9	5.1	4.6	4.6	4.8
– RONC	96.6	91.6	96.0	96.1	96.7
Hydrotreating – Naphtha	5.0	6.4	4.8	4.8	4.9
– FCC/Coker C6s		1.7			
– Distillate	7.4	7.7	7.3	3.7	8.9
– Heavy Gas Oil	2.8	3.1	2.7	2.7	2.7
– Residuum – Atm					
Reformer Feed Fractionation		6.4			
Reformate Fractionation		1.5			
Aromatics Extraction					
Benzene Saturation		0.6			
FCC Gasoline HDS					
Diesel Aromatics Saturation					0.3
Alkylation	1.7	3.0	1.4	1.6	1.3
Alkylate Splitter					
Polymerization	0.3		0.3	0.3	0.4
Dehydrogenation – IC4					
MTBE	0.1				
TAME		0.1 [3]			
Hydrodealkylation – Toluene					
Lubes	0.1	0.1	0.1	0.1	0.1
Isomerization – C5/C6	0.3	1.0	0.3	0.3	0.3
– C5/C6, Recycle					
– C4	0.6	0.9	0.6	0.6	0.6
Hydrogen – MMSCFPCD	2.2	3.1	1.2	1.2	1.2
Sulfur, STPCD	16	15	15	12	16
C4 Rerun – Saturates		0.8			
– Unsaturates		2.0			

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

[3] MTBE capacity used for TAME.

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TABLE G-7
PROCESS UNIT UTILIZATIONS – %[1]
IV – 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Summer		Annual		
	Base Case Q9 No FCAAA	S21 2000 All CARB 2	Base Case Q9Y No FCAAA	S7 1990 Prod. Regs.	S12 1995 All LS Diesel
Crude Distillation – Atmospheric	90.0	88.5	84.7	83.8	85.5
Heavy Naphtha Splitter		96.0 *			
Catalytic Cracking[2]	87.0 *	79.1	79.9	77.6	81.8
Catalytic Cracking[3]	80.0	72.1	75.0	73.4	74.8
FCC Gasoline Splitters		87.0 *			
FCC Gasoline Fractionation	77.8		75.8	75.8	75.8
Hydrocracking – 2 Stage[2]	83.0 *	83.0 *	80.0 *	80.0 *	80.0 *
– Low Conversion	66.4	83.0 *	62.2	62.2	80.0 *
– Heavy Gasoline		83.0 *			
– Combined[3]		79.5	76.5	76.5	80.0 *
Hydrocrackate Fractionation		83.0 *			
Coking – Delayed	65.2	86.0 *	56.3	85.0 *	63.3
– Fluid	77.2	86.0 *	76.1	71.4	60.4
Coker Lt Gasoline DS/Splitter		86.0 *			
Thermal Cracking, Visbreaking					
Solvent Deasphalting	27.8	51.6	23.9	16.1	21.8
Catalytic Reforming – 100 PSI[2]					
– 200 PSI[2]	87.0 *	87.0 *	85.0 *	81.4	85.0 *
– 450 PSI[2]	60.2	51.1	51.1	57.9	61.5
– Combined[3]	71.6	71.2	67.8	68.7	70.9
Hydrotreating – Naphtha	68.3	87.0 *	64.8	64.4	66.5
– FCC/Coker C6s		87.0 *			
– Distillate	87.0 *	87.0 *	85.0 *	70.3	85.0 *
– Heavy Gas Oil	79.1	87.0 *	76.2	85.0 *	76.2
– Residuum, Atm					
Reformer Feed Fractionation		87.0 *			
Reformate Fractionation		87.0 *			
Aromatics Extraction					
Benzene Saturation		87.0 *			
FCC Gasoline HDS					
Diesel Aromatics Saturation					85.0 *
Alkylation	84.0 *	84.0 *	72.9	82.0 *	67.5
Alkylate Splitter					
Polymerization	77.2	0.0	77.1	62.0	82.0 *
Dehydrogenation – IC4					
MTBE	83.0				
TAME		84.0 *[4]			
Hydrodealkylation – Toluene					
Lubes	82.0	82.0	82.0	82.0	82.0
Isomerization – C5/C6	87.0 *	87.0 *	85.0 *	85.0 *	85.0 *
– C5/C6, Recycle					
– C4	84.0 *	84.0 *	82.0 *	82.0 *	82.0 *
Hydrogen	84.0 *	84.0 *	75.7	75.7	75.7
Sulfur	82.0 *	82.0 *	80.0 *	80.0 *	80.0 *
C4 Rerun – Saturates		87.0 *			
– Unsaturates		87.0 *			

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

[4] MTBE capacity used for TAME.

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TABLE G-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IV – 1995/2000 F2 – SF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY

	Summer		Annual		
	Base Case Q9[1]	S21 2000 All CARB 2[2]	Base Case Q9Y[1]	S7 1990 Prod. Regs.[1]	S12 1995 All LS Diesel[1]
FCC Gasoline	22.9		21.3	20.4	21.3
Lt. FCC 255-	7.2		7.2	7.3	7.3
Hvy FCC 255+	5.0		4.9	5.0	5.0
Hvy FCC 255+ Desulf.					
FCC Gaso (100–180)		1.8			
FCC Gaso (180–225)		3.8			
FCC Gaso (225–300)		6.2			
FCC Gaso (300–375)					
FCC Gaso (375–430)					
Total FCC Gasoline	35.1	11.8	33.4	32.7	33.6
Butenes					0.8
Pentenes					
Poly Gasoline	2.3		2.5	1.9	2.6
Lt. Coker Gasoline	0.7		0.7	0.6	0.6
Total Olefinic	3.0		3.2	2.5	4.0
Reformate	21.8	11.1	21.4	21.1	21.9
Reformate (220–300 Feed)	0.6	8.5	0.6	0.6	0.6
BT Reformate	6.0		6.0	6.0	6.0
HC Reformate (210–300)		4.5			
Heavy Reformate (300+)		0.8			
Toluene/Xylenes					
Total Reformates[3]	28.4	24.9	28.0	27.7	28.5
Lt. Reformate					
Lt. Raffinate B(C5–210)		4.5			
Alkylate/Lt Alkylate (C3/C4)	11.7	15.2	9.9	11.4	9.2
Alkylate/Lt Alkylate (C5)		4.2			
Butane	4.0	1.5	7.5	9.1	6.6
Natural/LSR Gaso	6.7	9.2	6.9	6.7	6.9
BT Naphtha (150–220)	6.3	6.6	6.4	6.4	6.5
Pentanes (I/N)		2.6			
Isomerate (C5–C6)	1.8	1.6	1.8	1.7	1.8
Isomerate (C6)		5.0			
Lt. Hydrocrackate (C5–180)	0.4	0.9	0.4	0.4	0.4
Medium Hydrocrackate (180–225)	0.6	0.8	0.5	0.5	0.5
MTBE	2.0	10.4	2.0	0.9	2.0
TAME		0.8			
Alcohol					
Total Low Arom., Saturated	33.5	63.3	35.4	37.1	33.9
Total	100.0	100.0	100.0	100.0	100.0

[1] All Conventional Gasoline.

[2] All Reformulated Gasoline.

[3] Excluding Lt Reformate and Lt Raffinate.

TABLE G-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IV – 1995/2000 F2 – SF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(¢/G per unit in constant 1990 \$)

	Summer		Annual		
	Base Case Q9	S21 2000 All CARB 2	Base Case Q9¥	S7 1990 Prod. Regs.	S12 1995 All LS Diesel
(R+M)/2 Octane, Clear	(0.4)	(1.1)	(0.3)	(0.4)	(0.3)
Aromatics, Vol. %					
Ethers, Vol. %		0.2			
Ethanol, %					
Olefins, Vol. %		0.4			
Benzene, Vol. %	0.1	3.7			
Sulfur, 100 Wt. PPM		7.2			
Reid Vapor Pressure, PSI	0.4	4.9	0.4	0.4	0.3
T90, 10°F		4.5			
Butane, Vol. %		1.7			
V.O.C., 10%					
NOx, 10%					
T.A.P., 10%					

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE G-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IV - 1995/2000 F2 - SF CASE RESULTS - %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Summer		Annual		
	Base Case Q9 No FCAAA	S21 2000 All CARB 2	Base Case Q9% No FCAAA	S7 1990 Prod. Regs.	S12 1995 All LS Diesel
<u>No. 2 Diesel Compositions</u>					
Hvy Reformate (300+) 90 RON					
Hvy Reformate (300+) 100 RON					
FCC Heavy Gaso Tr(300-375)					
FCC Heavy Gaso Tr(375-430)		4.4			
Lt Cycle Oil - Treated	14.5	13.5	15.0	15.6	10.4
Coker Dist - Treated	3.3	2.1	3.1	3.3	3.9
Total High Aromatic	17.8	20.0	18.1	18.9	14.3
Heavy Alkylate (300+)					
Lt Kero - Treated (300-375)	6.1	6.1	6.6	6.5	5.3
Kero (375-500)	19.7	11.9	15.6	29.7	
Kero - Treated (375-500)	11.6	17.7	14.4		30.4
Kero - Low Aromatics (375-500)					
Diesel Base	6.4	12.6	9.2	44.8	1.2
Diesel Base - Treated	38.4	31.7	36.1	0.1	44.6
Diesel Base - Low Aromatics					
Lt Cycle Oil - Low Aromatics					4.2
Coker Dist - Low Aromatics					
Total Low Aromatic	82.2	80.0	81.9	81.1	85.7
Total	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>					
Diesel Ignition Improver					
Pour Point Depressant		Yes	Yes		Yes
Aromatics	30.1	31.3	30.3	31.1	28.0
<u>Jet A Compositions</u>					
Heavy Alkylate (300+)					
Lt Kero - Treated (300-375)	40.0	43.3	40.3	40.3	40.2
Kero - Treated (375-500)	49.4	56.0	49.9	49.9	49.9
Hydrocracked Jet (295-525)	10.6	0.7	9.8	9.8	9.9
Total	100.0	100.0	100.0	100.0	100.0

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TABLE G1-1
RUN BASIS AND COMBINED GASOLINE POOL PROPERTIES
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6	Case S3 Q6 Units + HH Crude	Case S6 Q6 + 100% RFG	Case S10 S6 + 30 Sul
<u>Reformulated Limits*</u>					
Aromatics, Vol.%, Maximum Avg					
Oxygen, Wt%, Minimum Avg		2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg					
Benzene, Vol%, Maximum Avg		0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg					30
Reid Vapor Pressure, PSI, Min Avg		6.5	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max					
Regulatory Cap					
T50, °F, Maximum Avg					
T90, °F, Maximum Avg					
V.O.C., % Reduction		45	45	45	45
T.A.P., % Reduction		30	30	30	30
% Class C, Fixed	40	40	40	40	40
<u>Ethers, V% Pool</u>					
Purchased (Sold)	1.4	0.9	0.9	11.7	11.7
Manufactured	0.6	0.6	0.6	0.0	0.0
<u>Gasoline Pool Properties</u>					
(R+M)/2 Octane, Clear*	86.6	86.6	86.6	86.6	86.6
Aromatics, Vol. %	28.0	28.1	27.9	21.9	20.8
Ethers, Vol.%*	2.0	1.5	1.5	11.7	11.7
Oxygen, Wt.%*	0.4	0.3	0.3	2.1	2.1
Olefins, Vol.%	14.6	14.3	14.7	11.3	10.4
Benzene, Vol.%*	1.9	1.6	1.6	0.7	0.7
Sulfur, WPPM	287	260 *	295	196	30 *
Reid Vapor Pressure, PSI	7.9 *	8.4 *	8.4 *	6.6	6.8
Temperature at V/L = 20, °F	142	139	139	148	145
Distillation					
T10, °F	122	118	117	135	133
T50, °F	206	205	207	205	206
T90, °F	344	345	344	340	328
Specific Gravity	0.7431	0.7415	0.7411	0.7399	0.7352
Heat Content, MBTU/G	113.7	113.6	113.6	111.6	111.4
V.O.C., gm/mile	1.04	1.20 *	1.20 *	0.71 *	0.71 *
– % Reduction	19	7 *	7 *	45 *	45 *
NOx, index	1.01	1.00	1.01 *	0.99	0.94
– % Reduction	(1)	0	(1) *	1	6
T.A.P., mg/mile	49	51 *	50 *	34	30
– % Reduction	7	4 *	4 *	35	43

* Input limit.

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TABLE G1-1A
RUN BASIS AND REFORMULATED GASOLINE POOL PROPERTIES
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6	Case S3 Q6 Units + HH Crude	Case S6 Q6 + 100% RFG	Case S10 S6 + 30 Sul
<u>Reformulated Limits*</u>				
Aromatics, Vol.%, Maximum Avg				
Oxygen, Wt%, Minimum Avg	2.1	2.1	2.1	2.1
Olefins, Vol.%, Maximum Avg				
Benzene, Vol%, Maximum Avg	0.7	0.7	0.7	0.7
Sulfur, WPPM, Maximum Avg				30
Reid Vapor Pressure, PSI, Min Avg	6.5	6.5	6.5	6.5
Reid Vapor Pressure, PSI, Max Regulatory Cap				
T50, °F, Maximum Avg				
T90, °F, Maximum Avg				
V.O.C., % Reduction	45	45	45	45
T.A.P., % Reduction	30	30	30	30
% Class C, Fixed	40	40	40	40
<u>Ethers, V% Pool</u>				
Purchased (Sold)				
Manufactured				
<u>Gasoline Pool Properties</u>				
(R+M)/2 Octane, Clear*	86.6	86.6	86.6	86.6
Aromatics, Vol.%	28.9	27.8	21.9	20.8
Ethers, Vol.%*	11.7	11.7	11.7	11.7
Oxygen, Wt.%*	2.1	2.1	2.1	2.1
Olefins, Vol.%	7.1	8.2	11.3	10.4
Benzene, Vol.%*	0.7	0.7	0.7	0.7
Sulfur, WPPM	100 *	199	196	30 *
Reid Vapor Pressure, PSI	6.5 *	6.5 *	6.6	6.8
Temperature at V/L = 20, °F	147	148	148	145
Distillation				
T10, °F	131	133	135	133
T50, °F	205	214	205	206
T90, °F	337	325	340	328
Specific Gravity	0.7502	0.7482	0.7399	0.7352
Heat Content, MBTU/G	112.4	112.4	111.6	111.4
V.O.C., gm/mile*	0.71	0.71	0.71	0.71
– % Reduction*	45	45	45	45
NOx, index	0.94	0.98	0.99	0.94
– % Reduction	6	2	1	6
T.A.P., mg/mile	37 *	36 *	34	30
– % Reduction	30 *	31 *	35	43

* Input limit.

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TABLE G1-1B
RUN BASIS AND CONVENTIONAL GASOLINE POOL PROPERTIES
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6	Case S3 Q6 Units + HH Crude
<u>Conventional Limits*</u>			
Aromatics, Vol.%, Maximum Avg			
Oxygen, Wt%, Minimum Avg			
Olefins, Vol.%, Maximum Avg			
Benzene, Vol%, Maximum Avg	1.9	1.9	1.9
Sulfur, WPPM, Maximum Avg			
Reid Vapor Pressure, PSI, Min			
Reid Vapor Pressure, PSI, Max	7.9	8.7	8.7
Regulatory Cap	8.2	9.0	9.0
T50, °F, Maximum Avg			
T90, °F, Maximum Avg	356	356	356
V.O.C., % Reduction			
T.A.P., % Reduction			
% Class C, Fixed	40	40	40
<u>Ethers, V% Pool</u>			
Purchased (Sold)			
Manufactured			
<u>Gasoline Pool Properties</u>			
(R+M)/2 Octane, Clear*	86.6	86.6	86.6
Aromatics, Vol. %	28.0	28.0	27.9
Ethers, Vol. % *	2.0		0.0
Oxygen, Wt. % *	0.4		0.0
Olefins, Vol. %	14.6	15.4	15.6
Benzene, Vol. %	1.9 *	1.7	1.7
Sulfur, WPPM	287	284	310
Reid Vapor Pressure, PSI*	7.9	8.7	8.7
Temperature at V/L = 20, °F	142	138	138
Distillation			
T10, °F	122	116	115
T50, °F	206	205	207
T90, °F	344	346	346
Specific Gravity	0.7431	0.7402	0.7401
Heat Content, MBTU/G	113.7	113.7	113.8
V.O.C., gm/mile	1.04	1.27	1.27
– % Reduction	19	1	1
NOx, index	1.01	1.01	1.02 *
– % Reduction	(1)	(1)	(2) *
T.A.P., mg/mile	49	52 *	52 *
– % Reduction	7	0 *	0 *

* Input limit.

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TABLE G1-2
SUMMARY OF COSTS – INCREASE OVER BASE CASE[1]
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS[2][3]
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	(in constant 1990 \$)			
	Base Case Q6	Case S3 Q6 Units + HH Crude	Case S6 Q6 + 100% RFG	Case S10 S6 + 30 Sul
<u>Investment, MM\$</u>				
Refinery	146	69	470	749
MTBE[4]	(30)	(1)	616	617
Total	116	68	1,086	1,366
Range, MMM\$[5]	0.1 – 0.2	0.1 – 0.1	0.9 – 1.5	1.2 – 1.8
<u>Daily Costs, M\$/D</u>				
Capital Charge[6]	104	32	342	496
Net Upgrading[7]	(39)	(148)	634	738
Variable Operating	(9)	30	(49)	22
Fixed Operating[8]	57	25	171	249
Total Refinery	113	(61)	1,098	1,505
<u>Annual Costs, MM\$/Yr.</u>				
Refinery	41	(22)	401	549
Other[9]	4	0	83	91
Total	45	(22)	484	640
<u>Total Unit Costs, ¢/G of Upgraded Gasoline or Crude</u>				
Average[10]	9.3	(3.0) [12]	12.8	17.0
Range[11]	8.3 – 11.4	(3.2) – (2.5)	10.7 – 16.6	14.6 – 21.4

- [1] Based on normal investment costs, capital charge, fixed costs, net upgrading and variable costs over base case: Q6, S6 and S10R over Q9 Base; S3 over Q6 Base.
- [2] For reformulation runs, based on a composite model of conversion refineries. Individual refinery cost will differ from average.
- [3] Adjusted using individual unit capital charge/fixed operating costs multipliers to include the full cost of extra facilities for summer RFG as detailed on Table A3-19.
- [4] For MTBE, methanol and butane isom plus dehydro plants outside of refineries, their capital and fixed costs are included in refinery raw material costs (net upgrading and variable costs).
- [5] For variations from investment curves of -15/+35%.
- [6] Based on expected 10% DCF rate of return on new refining facilities investment in mid-1990 \$.
- [7] Raw material upgrading costs.
- [8] For new refining facilities only.
- [9] Added consumer costs for extra gasoline used due to lower BTU content: retail price less 10¢/G refining margin included in refinery costs.
- [10] Costs reduced by including part of extra survey capacities for 1995 in Q9 base case.
- [11] For variations in capital charge (-15/+35%), MTBE costs (-10/+20¢/G) and BTU mileage factor (± 0.2).
- [12] Delivered crude costs Δ MT Rebeki/Wy Swt – Wy Platte/Sour = \$4.80/B input vs. calculated Δ RRV of \$3.54B for a savings of \$1.26/B or 3.0¢/G switched (49MBPD or 10% of run). LP took advantage of idle existing facilities to reduce Δ RRV.

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TABLE G1-3
REFINING RAW MATERIAL AND PRODUCT RATES - MBPCD
IV - SUMMER 1995/2000 F2 - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6	Case S3 Q6 Units + HH Crude	Case S6 Q6 + 100% RFG	Case S10 S6 + 30 Sul
<u>Raw Materials</u>					
Domestic - S	230	230	180	230	241
HL	69	69	69	69	69
HH	131	131	179	104	101
Foreign - S	5	5	5	5	5
HL	33	33	33	33	33
HH	19	19	19	19	19
Subtotal Crudes	487	487	485	460	468
MTBE	4	2	2	29	29
Ethanol					
Normal Butane	7	10	11	4	3
Isobutane	1	1	1	1	1
Natural Gas to H2 Plant Feed	1	0	1	1	1
Methanol	0	1	1		
Other Raw Materials	1	1	1	1	1
Total Raw Materials	501	502	500	496	503
<u>Products</u>					
Motor Gasolines					
Conventional	246	214	214		
Oxygenated					
Reformulated/Oxygenated					
Reformulated		32	32	250	251
CARB2					
Kero Jet/Kerosene	34	34	29	34	34
Diesel/No. 2 Fuels					
Diesel - LA ULS					
Diesel - 0.05%S	86	86	86	85	86
No. 2 Fuel	42	42	42	42	42
No. 6 Fuel (1% Sul)	2	2	2	2	2
No. 6 Bunker	1	1	4	1	1
Marketable Coke - 400 #	9	9	11	6	9
Catalytic Coke - 400 #	8	8	8	7	6
Vacuum Gas Oil					
Benzene					
Toluene					
Heavy Aromatic Gaso					
Pentanes to P/C					
Natural Gasoline to P/C	5	5	4	5	5
Normal Butane					
Isobutane	6	7	7	5	5
Propane	9	9	9	7	8
Process Gas/C2/C2=,FOE	26	26	26	20	23
Other Products	40	40	40	40	40
(Gain)/Loss	(13)	(13)	(15)	(10)	(10)
Total Products	501	502	500	496	503
<u>Crude Properties</u>					
Gravity, °API	33.6	33.6	32.0	34.4	34.5
Sulfur, Wt%	1.15	1.15	1.40	1.06	1.03
<u>Gasoline Demand Increase, %[1]</u>					
Results		0.0	0.0	1.8	2.0
Target		0.1	0.1	1.8	2.1

[1] To maintain constant miles traveled with lower BTU content reformulated gasoline.

TABLE G1-4
NEW PROCESS UNIT RATES – MBPSD
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Base Case Q9 No FCAAA</u>	<u>Base Case Q6[1]</u>	<u>Case S3 Q6 Units + HH Crude[2]</u>	<u>Case S6 Q6 + 100% RFG[1]</u>	<u>Case S10 S6 + 30-Sul[1]</u>
Crude – Atmospheric					
Heavy Naphtha Splitter					
Catalytic Cracking	2 [3]				
FCC Gasoline Splitters		10		20	34
FCC Gasoline Fractionation					44
Hydrocracking – 2 Stage					
Hydrocracking – 2 Stage Distillate – Hvy Gasoline					
Hydrocrackate Fractionation					
Coker – Delayed					
Coker Lt Gasoline DS/Splitter			2	0	3
Hydrotreating – Naphtha					16
– FCC/Coker C6s					2
– Distillate	55			3	
– Heavy Gas Oil					
Reformer Feed Fractionation		23		102	142
Reformate Fractionation		7		30	33
Aromatics Extraction					
Benzene Saturation		4	0	16	18
FCC Gasoline HDS					19
Diesel Aromatics Saturation			1		
Alkylation	1 [3]				
Alkylate Splitter					
MTBE		2			
TAME					
Isomerization – C5/C6					1
– C5/C6, Recycle					
– C4					
Hydrogen – MMSCFPSD	17 [3]				10
Sulfur – LTPSD	228 [3]		104		
C4 Rerun – Saturates		4		16	16
– Unsaturation		10		32	16
Catalytic Reforming – 100 PSI					
Hydrotreating – Distillate Upgrade					
Dehydrogenation – IC4					

[1] Additions to Q9 facilities.

[2] Additions to Q6 facilities.

[3] Based on including part of NPC survey estimated process unit capacity additions for 1995 that are not under construction.

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TABLE G1-5
NEW PROCESS UNIT INVESTMENTS
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

(\$MM – in constant mid-1990 \$)

	Base Case Q9 <u>No FCAAA</u>	Base Case <u>Q6[1]</u>	Case S3 Q6 Units + <u>HH Crude[2]</u>	Case S6 Q6 + <u>100% RFG[1]</u>	Case S10 S6 + <u>30 Sul[1]</u>
Crude Distillation					
Heavy Naphtha Splitter					
Catalytic Cracking	16				
FCC Gasoline Splitters		11		22	58
FCC Gasoline Fractionation					38
Hydrocracking – 2 Stage					
Hydrocracking – 2 Stage Distillate – Heavy Gasoline					
Hydrocrackate Fractionation					
Coker – Delayed					
Coker Lt. Gasoline DS/Splitter			7	0	9
Hydrotreating – Naphtha					35
– FCC Coker C6s					10
– Distillate	148			8	
– Heavy Gas Oil					
Reformer Feed Fractionation		29		129	162
Reformate Fractionation		15		61	69
Aromatics Extraction					
Benzene Saturation		21	0	70	78
FCC Gasoline HDS					93
Diesel Aromatics Saturation			16		
Alkylation	17				
Alkylate Splitter					
MTBE		30			
TAME					
Isomerization – C5/C6					4
– C5/C6, Recycle					
– C4					
Hydrogen	62				39
Sulfur	110		46		
MTBE Storage & Blending		7		56	57
C4 Rerun – Saturates		8		35	35
– Unsaturation		17		55	28
C4 Fractionation Upgrade		8		34	34
Catalytic Reforming – 100 PSI					
Hydrotreating – Distillate Upgrade					
Dehydrogenation – IC4					
Total Refinery	353	146	69	470	749

[1] Above Q9 facilities investments.

[2] Above Q6 facilities investments.

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TABLE G1-6
PROCESS UNIT RATES PER REFINERY – MBPCD
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6	Case S3 Q6 Units + HH Crude	Case S6 Q6 + 100% RFG	Case S10 S6 + 30 Sul
Crude – Atmospheric	28.6	28.7	28.5	27.1	27.5
Heavy Naphtha Splitter					
Catalytic Cracking[1]	9.7	9.6	9.6	8.3	7.9
Catalytic Cracking[2]	8.9	8.8	9.0	8.0	7.2
Conversion, %	79.4	79.5	78.0	77.0	80.0
Octane Catalyst, %	76.9	76.7	77.0	39.2	75.0
FCC Gasoline Splitters		0.5	0.5	1.0	1.8
FCC Gasoline Fractionation	1.8	1.8	1.8	1.8	4.3
Hydrocracking – 2 Stage[1]	0.4	0.4	0.4	0.4	0.4
Jet Yield, % of Max	100.0	100.0	9.4	100.0	100.0
300 – Gasoline Operation, %					
Hydrocracking – 2 Stage Distillate					
Hydrocracking – Low Conversion	0.1	0.1	0.1	0.1	0.1
– Heavy Gasoline					
– Combined[2]	0.5	0.5	0.5	0.4	0.5
Hydrocrackate Fractionation					
Coking – Delayed	1.3	1.3	1.8	0.8	1.8
– Fluid	0.4	0.4	0.4	0.4	0.4
Coker Lt Gasoline DS/Splitter			0.1	0.0	0.2
Thermal Cracking, Visbreaking					
Solvent Deasphalting	0.3	0.2	0.6	0.4	0.3
Catalytic Reforming – 100 PSI[1]					
– 200 PSI[1]	3.2	3.2	3.2	3.1	3.2
– 450 PSI[1]	1.9	2.2	2.2	1.8	2.5
– Combined[2]	4.9	5.1	5.2	5.2	6.1
– RONC	96.6	96.2	95.4	86.2	85.8
Hydrotreating – Naphtha	5.0	5.2	5.2	5.4	7.2
– FCC/Coker C6s					0.1
– Distillate	7.4	7.2	7.2	7.5	7.3
– Heavy Gas Oil	2.8	2.8	3.1	2.8	2.8
– Residuum – Atm					
Reformer Feed Fractionation		1.2	1.2	5.2	7.2
Reformate Fractionation		0.4	0.4	1.5	1.7
Aromatics Extraction					
Benzene Saturation		0.2	0.2	0.8	0.9
FCC Gasoline HDS					1.0
Diesel Aromatics Saturation			0.1		
Alkylation	1.7	1.7	1.7	1.6	1.7
Alkylate Splitter					
Polymerization	0.3	0.4	0.4	0.3	0.2
Dehydrogenation – IC4					
MTBE	0.1	0.1	0.1		
TAME					
Hydrodealkylation – Toluene					
Lubes	0.1	0.1	0.1	0.1	0.1
Isomerization – C5/C6	0.3	0.3	0.3	0.3	0.3
– C5/C6, Recycle					
– C4	0.6	0.6	0.6	0.6	0.6
Hydrogen – MMSCFPCD	2.2	1.2	1.3	2.1	3.0
Sulfur, LTPCD	16	16	21	14	14
C4 Rerun – Saturates		0.2	0.2	0.8	0.8
– Unsaturation		0.5	0.5	1.6	0.8

[1] Include effects of nonunitary capacity for some feedstocks and severities.

[2] Based on actual feed rates, ignoring severity effects.

[3] MTBE capacity used for TAME.

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TABLE G1-7
PROCESS UNIT UTILIZATIONS - %[1]
IV - SUMMER 1995/2000 F2 - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6	Case S3 Q6 Units + HH Crude	Case S6 Q6 + 100% RFG	Case S10 S6 + 30 Sul
Crude Distillation - Atmospheric	90.0	90.0	89.5	85.0	86.4
Heavy Naphtha Splitter					
Catalytic Cracking[2]	87.0 *	87.0 *	87.0 *	75.8	72.3
Catalytic Cracking[3]	80.0	79.8	82.1	72.9	65.8
FCC Gasoline Splitters		87.0 *	87.0 *	87.0 *	87.0 *
FCC Gasoline Fractionation	77.8	77.8	77.8	77.8	87.0 *
Hydrocracking - 2 Stage[2]	83.0 *	83.0 *	83.0 *	83.0 *	83.0 *
Hydrocracking - 2 Stage Distillate					
- Low Conversion	66.4	83.0 *	83.0 *	41.5	83.0 *
- Heavy Gasoline					
- Combined[3]		83.0 *	83.0 *	74.5	83.0 *
Hydrocrackate Fractionation					
Coking - Delayed	65.2	65.9	86.0 *	37.1	86.0 *
- Fluid	77.2	77.2	86.0 *	77.2	86.0 *
Coker Lt Gasoline DS/Splitter			86.0 *	86.0 *	86.0 *
Thermal Cracking, Visbreaking					
Solvent Deasphalting	27.8	18.4	66.8	40.5	33.7
Catalytic Reforming - 100 PSI[2]					
- 200 PSI[2]	87.0 *	87.0 *	87.0 *	83.9	87.0 *
- 450 PSI[2]	60.2	75.3	72.5	60.3	85.2
- Combined[3]	71.6	76.1	77.2	78.2	91.4
Hydrotreating - Naphtha	68.3	71.0	70.1	72.9	87.0 *
- FCC/Coker C6s					87.0 *
- Distillate	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
- Heavy Gas Oil	79.1	79.1	87.0 *	79.1	79.1
- Residuum, Atm					
Reformer Feed Fractionation		87.0 *	87.0 *	87.0 *	87.0 *
Reformate Fractionation		87.0 *	87.0 *	87.0 *	87.0 *
Aromatics Extraction					
Benzene Saturation		87.0 *	87.0 *	87.0 *	87.0 *
FCC Gasoline HDS					87.0 *
Diesel Aromatics Saturation			87.0 *		
Alkylation	84.0 *	84.0 *	84.0 *	82.6	84.0 *
Alkylate Splitter					
Polymerization	77.2	84.0 *	84.0 *	56.8	53.4
Dehydrogenation - IC4					
MTBE	83.0	84.0 *	84.0 *		
TAME					
Hydrodealkylation - Toluene					
Lubes	82.0	82.0	82.0	82.0	82.0
Isomerization - C5/C6	87.0 *	87.0 *	87.0 *	87.0 *	87.0 *
- C5/C6, Recycle					
- C4	84.0 *	84.0 *	84.0 *	84.0 *	84.0 *
Hydrogen	84.0 *	72.0	80.4	84.0 *	84.0 *
Sulfur	82.0 *	82.0 *	82.0 *	82.0 *	82.0 *
C4 Rerun - Saturates		87.0 *	87.0 *	87.0 *	87.0 *
- Unsaturation		87.0 *	87.0 *	87.0 *	87.0 *

* Unit Maximum.

[1] Calendar day rates divided by stream day capacity.

[2] Include effects of nonunitary capacity factors for some feedstocks and severities.

[3] Based on actual feed rates, ignoring severity effects.

[4] MTBE capacity used for TAME.

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TABLE G1-8
COMBINED GASOLINE POOL COMPOSITIONS – %
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6	Case S3 Q6 Units + HH Crude	Case S6 Q6 + 100% RFG	Case S10 S6 + 30 Sul
FCC Gasoline	22.9	22.4	22.8	19.2	
Lt. FCC 255-	7.2	3.7	6.8	0.6	16.9
Hvy FCC 255+	5.0	5.0	1.9	4.6	
Hvy FCC 255+ Desulf.					6.8
FCC Gaso (100-180)		1.2	0.2	2.2	0.1
FCC Gaso (180-225)		0.8	0.1	1.3	0.0
FCC Gaso (225-300)		0.5	1.2	1.1	2.3
FCC Gaso (300-375)			1.2	0.1	
FCC Gaso (375-430)			0.7		
Total FCC Gasoline	35.1	33.6	35.0	29.2	26.1
Butenes					
Pentenenes		0.4			
Poly Gasoline	2.3	2.6	2.6	0.4	1.6
Lt. Coker Gasoline	0.7	0.3	0.5	1.7	
Total Olefinic	3.0	3.2	3.0	2.1	1.6
Reformate	21.8	22.1	23.2	20.8	25.0
Reformate (220-300 Feed)	0.6	0.6	0.1	0.6	0.6
BT Reformate	6.0	4.3	4.3		
HC Reformate (210-300)		1.2	1.2	4.8	5.3
Heavy Reformate (300+)				0.2	0.1
Toluene/Xylenes					
Total Reformates[1]	28.4	28.2	28.8	26.5	30.9
Lt. Reformate					
Lt. Raffinate B(C5-210)		1.4	1.4	5.7	6.5
Alkylate/Lt Alkylate (C3/C4)	11.7	10.9	11.0	9.8	10.8
Alkylate/Lt Alkylate (C5)		0.3	0.3	1.0	0.3
Butane	4.0	4.9	5.0	1.9	2.0
Natural/LSR Gaso	6.7	7.1	6.5	6.8	7.0
BT Naphtha (150-220)	6.3	5.6	4.2	1.6	
Pentanenes (I/N)		0.5	0.2	0.9	0.2
Isomerate (C5-C6)	1.8	1.8	1.8	1.7	1.3
Isomerate (C6)					0.7
Lt. Hydrocrackate (C5-180)	0.4	0.4	0.6	0.4	0.4
Medium Hydrocrackate (180-225)	0.6	0.6	0.7	0.5	0.5
MTBE	2.0	1.5	1.5	11.7	11.7
TAME					
Alcohol					
Total Low Arom., Saturated	33.5	35.0	33.2	42.2	41.4
Total	100.0	100.0	100.0	100.0	100.0

*Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE G1-8A
REFORMULATED GASOLINE POOL COMPOSITIONS – %
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q6	Case S3 Q6 Units + HH Crude	Case S6 Q6 + 100% RFG	Case S10 S6 + 30 Sul
FCC Gasoline	8.3	12.3	19.2	
Lt. FCC 255-			0.6	16.9
Hvy FCC 255+	6.5	4.2	4.6	
Hvy FCC 255+ Desulf.				6.8
FCC Gaso (100-180)		1.7	2.2	0.1
FCC Gaso (180-225)		0.6	1.3	0.0
FCC Gaso (225-300)	0.6	9.3	1.1	2.3
FCC Gaso (300-375)			0.1	
FCC Gaso (375-430)				
Total FCC Gasoline	15.4	28.0	29.2	26.1
Butenes				
Pentenes	3.2			
Poly Gasoline			0.4	1.6
Lt. Coker Gasoline			1.7	
Total Olefinic	3.2		2.1	1.6
Reformate	30.5	22.4	20.8	25.0
Reformate (220-300 Feed)			0.6	0.6
BT Reformate				
HC Reformate (210-300)	9.0	9.0	4.8	5.3
Heavy Reformate (300+)			0.2	0.1
Toluene/Xylenes				
Total Reformates[1]	39.5	31.4	26.5	30.9
Lt. Reformate				
Lt. Raffinate B(C5-210)	11.1	6.9	5.7	6.5
Alkylate/Lt Alkylate (C3/C4)	0.6	2.3	9.8	10.8
Alkylate/Lt Alkylate (C5)	2.1	2.1	1.0	0.3
Butane	1.9	2.0	1.9	2.0
Natural/LSR Gaso	1.9	6.9	6.8	7.0
BT Naphtha (150-220)	4.8	2.7	1.6	
Pentanes (I/N)	0.1	1.6	0.9	0.2
Isomate (C5-C6)	7.8	4.2	1.7	1.3
Isomate (C6)				0.7
Lt. Hydrocrackate (C5-180)			0.4	0.4
Medium Hydrocrackate (180-225)			0.5	0.5
MTBE	11.6	11.7	11.7	11.7
TAME				
Alcohol				
Total Low Arom., Saturated	42.0	40.5	42.2	41.4
Total	100.0	100.0	100.0	100.0

*Minimum.

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE G1-8B
CONVENTIONAL GASOLINE POOL COMPOSITIONS – %
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	Base Case Q9 No FCAAA	Base Case Q6	Case S3 Q6 Units + HH Crude
FCC Gasoline	22.9	24.6	24.4
Lt. FCC 255-	7.2	4.3	7.9
Hvy FCC 255+	5.0	4.8	1.5
Hvy FCC 255+ Desulf.			
FCC Gaso (100-180)		1.3	
FCC Gaso (180-225)		0.8	
FCC Gaso (225-300)		0.5	
FCC Gaso (300-375)			1.4
FCC Gaso (375-430)			0.8
Total FCC Gasoline	35.1	36.4	36.0
Butenes			
Pentenenes			
Poly Gasoline	2.3	2.9	2.9
Lt. Coker Gasoline	0.7	0.3	0.5
Total Olefinic	3.0	3.2	3.5
Reformate	21.8	20.8	23.3
Reformate (220-300 Feed)	0.6	0.7	0.1
BT Reformate	6.0	4.9	5.0
HC Reformate (210-300)			
Heavy Reformate (300+)			
Toluene/Xylenes			
Total Reformates[1]	28.4	26.4	28.4
Lt. Reformate			
Lt. Raffinate B(C5-210)			0.6
Alkylate/Lt Alkylate (C3/C4)	11.7	12.5	12.2
Alkylate/Lt Alkylate (C5)			
Butane	4.0	5.4	5.5
Natural/LSR Gaso	6.7	7.9	6.4
BT Naphtha (150-220)	6.3	5.8	4.5
Pentanenes (I/N)		0.6	
Isomerate (C5-C6)	1.8	0.9	1.4
Isomerate (C6)			
Lt. Hydrocrackate (C5-180)	0.4	0.5	0.7
Medium Hydrocrackate (180-225)	0.6	0.7	0.8
MTBE	2.0		0.0
TAME			
Alcohol			
Total Low Arom., Saturated	33.5	34.0	32.1
Total	100.0	100.0	100.0

[1] Excluding Lt Reformate and Lt Raffinate.

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TABLE G1-9
GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991–92 STUDY OF U.S. REFINING INDUSTRY
(¢/G per unit in constant 1990 \$)

	<u>Base Case Q9 No FCAAA</u>	<u>Base Case Q6</u>	<u>Case S3 Q6 Units + HH Crude</u>	<u>Case S6 Q6 + 100% RFG</u>	<u>Case S10 S6 + 30 Sul</u>
(R+M)/2 Octane, Clear	(0.4)	(0.5)	(1.3)	(0.4)	(0.8)
Aromatics, Vol.%					
Ethers, Vol.%		(0.4)	0.1	(0.5)	(0.1)
Ethanol, %					
Olefins, Vol.%					
Benzene, Vol.%	0.1	0.1	0.3	6.6	6.0
Sulfur, 100 Wt. PPM		(0.0)			11.0
Reid Vapor Pressure, PSI	0.4	0.2 [2]	0.5 [2]		
T90, 10°F					
Butane, Vol.%		(0.0)		(0.6)	
V.O.C., 10%		0.1	0.3	1.0	0.6
NOx, 10%			0.1		
T.A.P., 10%		0.2	0.6		

[1] Shadow costs for very small changes. Not applicable for significant changes.

[2] Average of absolute values. RFG is at minimum (negative cost) while CG is at maximum (positive cost).

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12/3/92

TABLE G1-9A
REFORMULATED GASOLINE PROPERTY DECREASE – INCREMENTAL COSTS[1]
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
(¢/G per unit in constant 1990 \$)

	Base Case Q6	Case S3 Q6 Units + HH Crude	Case S6 Q6 + 100% RFG	Case S10 S6 + 30 Sul
(R+M)/2 Octane, Clear	(0.5)	(1.3)	(0.4)	(0.8)
Aromatics, Vol. %				
Ethers, Vol. %	(0.4)	0.1	(0.5)	(0.1)
Ethanol, %				
Olefins, Vol. %				
Benzene, Vol. %	0.5	2.0	6.6	6.0
Sulfur, 100 Wt. PPM	(0.0)			11.0
Reid Vapor Pressure, PSI	(0.3)	(1.7)		
T90, 10°F				
Butane, Vol. %	(0.0)		(0.6)	
V.O.C., 10%	0.6	1.9	1.0	0.6
NOx, 10%				
T.A.P., 10%	0.0	0.0		

[1] Shadow costs for very small changes.
Not applicable for significant changes.

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TABLE G1-9B
CONVENTIONAL GASOLINE PROPERTY DECREASE - INCREMENTAL COSTS[1]
IV - SUMMER 1995/2000 F2 - 4/92 CF CASE RESULTS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY
 (¢/G per unit in constant 1990 \$)

	Base Case Q9 <u>No FCAAA</u>	Base Case Q6	Case S3 Q6 Units + <u>HH Crude</u>
(R+M)/2 Octane, Clear	(0.4)	(0.5)	(1.3)
Aromatics, Vol. %			
Ethers, Vol. %		(0.4)	0.1
Ethanol, %			
Olefins, Vol. %			
Benzene, Vol. %	0.1		
Sulfur, 100 Wt. PPM			
Reid Vapor Pressure, PSI	0.4	0.2	0.4
T90, 10°F			
Butane, Vol. %			
V.O.C., 10%			
NOx, 10%			0.2
T.A.P., 10%		0.2	0.7

[1] Shadow costs for very small changes.
 Not applicable for significant changes.

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TABLE G1-10
NO. 2 DIESEL AND JET A COMPOSITIONS & PROPERTIES
IV – SUMMER 1995/2000 F2 – 4/92 CF CASE RESULTS – %
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Base Case Q9 No FCAAA</u>	<u>Base Case Q6</u>	<u>Case S3 Q6 Units + HH Crude</u>	<u>Case S6 Q6 + 100% RFG</u>	<u>Case S10 S6 + 30 Sul</u>
<u>No. 2 Diesel Compositions</u>					
Hvy Reformate (300+) 90 RON					
Hvy Reformate (300+) 100 RON					
FCC Heavy Gaso Tr(300-375)					
FCC Heavy Gaso Tr(375-430)					5.7
Lt Cycle Oil - Treated	14.5	13.9	14.6	17.6	10.7
Coker Dist - Treated	3.3	4.0	4.8	2.7	4.7
Total High Aromatic	17.8	17.9	19.5	20.3	21.1
Heavy Alkylate (300+)		0.0		0.0	
Lt Kero - Treated (300-375)	6.1	4.8	4.0	5.8	3.9
Kero (375-500)	19.7	13.9	12.9	10.5	11.3
Kero - Treated (375-500)	11.6	17.5	17.5	17.0	17.2
Kero - Low Aromatics (375-500)					
Hydrocracked Jet (295-525)				2.8	2.4
Diesel Base	6.4	14.7	14.2	13.1	14.9
Diesel Base - Treated	38.4	31.1	30.9	30.5	29.2
Diesel Base - Low Aromatics					
Lt Cycle Oil - Low Aromatics			1.0		
Coker Dist - Low Aromatics					
Total Low Aromatic	82.2	82.1	80.5	79.7	78.9
Total	100.0	100.0	100.0	100.0	100.0
<u>Properties</u>					
Diesel Ignition Improver					
Pour Point Depressant		Yes	Yes	Yes	Yes
Aromatics	30.1	30.3	31.3	31.3	31.3
<u>Jet A Compositions</u>					
Heavy Alkylate (300+)					
Lt Kero - Treated (300-375)	40.0	40.0	41.5	43.5	42.9
Kero - Treated (375-500)	49.4	49.2	56.5	56.6	55.3
Hydrocracked Jet (295-525)	10.6	10.9	1.9		1.9
Total	100.0	100.0	100.0	100.0	100.0

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12/3/92

TURNER, MASON & COMPANY
Consulting Engineers

July 31, 1992

Mr. T. Stan McGowin
Manager – Products
Texaco Refining & Marketing, Inc.
P.O. Box 1404
Houston, Texas 77251

Re: U.S. Refinery Ether
Supply and Demand

Dear Stan:

As requested by the NPC Supply, Demand and Logistics Task Group (SDLTG), we have calculated the U.S. refining ether demand and refining production, as well as outside purchases. We computed this ether balance for a representative group of base and issue scenarios. These were picked to cover the spectrum of probable ether demands.

Our results are summarized on Table X-1 for the entire U.S. The more detailed PADD balances are shown on Table X-2. Table X-2 presents the PADD case results, as well as calculated results for the PADDs which were not run in our refinery LP, to provide ether balances for the entire U.S. Alternative ether purchase and production rates are also shown for each scenario, if our premises were revised to fully utilize available TAME capacity. In most of our cases, TAME capacity was not used because it was not economic under our premise of no existing FCC gasoline C₅ fractionation capacity. In our LP model, it was economic to build FCC gasoline C₅ fractionation to make TAME only when C₅ reduction for RVP/V.O.C. control (or olefin reduction) was required.

Total U.S. refining ether demand ranged from about 80 to 140 MBPD for the base scenarios, assuming no FCAAA. With the FCAAA in 1995, ether demand increased to about 220 MBPD for summer and about 340 MBPD for annual. With full opt-in in 2000, summer ether demand increased to about 500 to 540 MBPD. Summer ether demand grew further to about 800 MBPD for 100% CARB 2 RFG. The incremental annual over summer oxygenate requirement in 2000 would decrease from about 120 MBPD in 1995 to less than 50 MBPD. (We have not run any annual or winter cases for 2000 yet.)

Refinery ether production ranged from about 60 to 100 MBPD in base and 1995 summer scenarios. It increased to about 140 MBPD for our scenarios without C₅ reduction. It grew to about 200 MBPD when C₅ reduction was required (and TAME was economic).

Mr. T. Stan McGowin
July 31, 1992
Page 2

Most of the refinery ether production was made from FCC and coker isobutene and isopentene. In refineries, we premised only the three C₄ dehydro-based ether units that are under construction with 34 MBPSD ether capacity.

By copy of this letter, I am asking Andy Oliver to fax it (with enclosures) to the NPC SDLTG members who need it and to the NPC PQTG members not listed below. Please call Charlie Miller or me if you have questions concerning these ether balances.

Sincerely,

A handwritten signature in cursive script, appearing to read "Bob Cunningham".

Robert E. Cunningham

/ew

Enclosures

c: Keith Zarker
Phil Hodges
Andy Oliver

TABLE W-1
SUMMARY ETHER BALANCE FOR U.S. REFINING INDUSTRY - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Case</u>	<u>Base Results</u>				<u>Full TAME Utilization (1)</u>	
	<u>MTBE Purchased</u>	<u>MTBE Produced</u>	<u>TAME Produced</u>	<u>Total Ether</u>	<u>Adj. TAME Produced</u>	<u>Adj. MTBE Purchased</u>
<u>No FCAAA - 2000 - All CG</u>						
Q9 - Summer Base(2)	35	103	0	138	18	19
Q9Y - Annual Base(2)	35	100	0	135	18	19
S7 - Annual - 1990 Product Regs	23	58	0	81	14	10
<u>FCAAA - 1995 - SF(3)</u>						
Q6 - Summer Base	121	100	0	221	13	109
F2 - Annual Base	200	139	0	339	14	187
S5 - Summer Full Opt-in	363	140	0	503	34	333
<u>FCAAA - 2000 Summer</u>						
Q6 - 45% Delta V.O.C. - CF(4)	354	146	40	540	40	354
Q40L - 40% Delta V.O.C. - CF(4)	394	143	0	537	34	364
S21 - All CARB 2	598	141	63	802	63	598

(1) U.S. total base TAME capacity is 39.7 MBPSD. Oxygen content of TAME is equivalent to 89% of MTBE oxygen content.

(2) Q9 cases premise no FCAAA and 100% conventional gasoline (CG) containing 2% MTBE.

(3) SF = simple formula.

(4) CF = complex formula.

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7/31/92

TABLE W-2
ETHER BALANCE FOR U.S. REFINING INDUSTRY - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Case	Base Results				Full TAME Utilization (1)	
	MTBE Purchased	MTBE Produced	TAME Produced	Total Ether	Adj. TAME Produced	Adj. MTBE Purchased
<u>Q9 Cases - 2000 Summer Base, No FCAAA, All CG(2)</u>						
PADD I Conversion	8	5	0	13	5	4
PADD II Conversion	10	24	0	34	6	4
PADD III Conversion	3	60	0	63	3	0
PADD IV	4	1	0	5	0	4
PADD VC Conversion	6	13	0	19	3	3
PADD VOC Conversion	4	0	0	4	0	4
Total U.S.	35	103	0	138	18	19
<u>Q9Y Cases - 2000 Annual Base, No FCAAA, All CG(2)</u>						
PADD I Conversion	8	5	0	13	5	4
PADD II Conversion	10	23	0	33	6	4
PADD III Conversion	4	58	0	62	4	0
PADD IV	3	1	0	4	0	3
PADD VC Conversion	6	13	0	19	3	3
PADD VOC Conversion	4	0	0	4	0	4
Total U.S.	35	100	0	135	18	19
<u>S7 Cases - 2000 Annual, No FCAAA, 1990 Prod. Regs., All CG</u>						
PADD I Conversion	7	5	0	12	5	3
PADD II Conversion	7	9	0	16	6	1
PADD III Conversion	0	39	0	39	0	0
PADD IV	2	0	0	2	0	2
PADD VC Conversion	7	5	0	12	3	4
PADD VOC Conversion	0	0	0	0	0	0
Total U.S.	23	58	0	81	14	10
<u>Q6 Cases - 1995 Summer Base</u>						
PADD I Conversion	65	16	0	81	5	61
PADD II Conversion	5	27	0	32	6	0
PADD III Conversion	0	41	0	41	0	0
PADD IV	0	0	0	0	0	0
PADD VC Conversion	51	16	0	67	3	48
PADD VOC Conversion	0	0	0	0	0	0
Total U.S.	121	100	0	221	13	109

TABLE W-2
ETHER BALANCE FOR U.S. REFINING INDUSTRY - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

Case	Base Results			Full TAME Utilization (1)		
	MTBE Purchased	MTBE Produced	TAME Produced	Total Ether	Adj. TAME Produced	Adj. MTBE Purchased
F2 Cases - 1995 Annual Base						
PADD I Conversion	78	15	0	93	5	74
PADD II Conversion	20	26	0	46	6	14
PADD III Conversion	0	78	0	78	0	0
PADD IV	5	1	0	6	0	5
PADD VC Conversion	88	16	0	104	3	85
PADD VOC Conversion	9	3	0	12	0	9
Total U.S.	200	139	0	339	14	187
S5 Cases - 1995 Summer Full RFG Opt-In						
PADD I Conversion	65	16	0	81	5	61
PADD II Conversion	87	24	0	111	6	81
PADD III Conversion	153	83	0	236	20	135
PADD IV	3	1	0	4	0	3
PADD VC Conversion	51	16	0	67	3	48
PADD VOC Conversion	4	0	0	4	0	4
Total U.S.	363	140	0	503	34	333
Q6 Cases - 2000 Summer CF Base With 45% VOC Reduction						
PADD I Conversion	60	16	5	81	5	60
PADD II Conversion	77	29	6	112	6	77
PADD III Conversion	132	84	20	236	20	132
PADD IV	3	1	0	4	0	3
PADD VC Conversion (3)	78	16	9	103	9	78
PADD VOC Conversion	4	0	0	4	0	4
Total U.S.	354	146	40	540	40	354
Q4OL Cases - 2000 Summer CF With 40% VOC Reduction						
PADD I Conversion	65	16	0	81	5	61
PADD II Conversion	84	27	0	111	6	78
PADD III Conversion	152	83	0	235	20	134
PADD IV	3	1	0	4	0	3
PADD VC Conversion(3)	86	16	0	102	3	83
PADD VOC Conversion	4	0	0	4	0	4
Total U.S.	394	143	0	537	34	364

TABLE W-2
ETHER BALANCE FOR U.S. REFINING INDUSTRY - MBPCD
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

<u>Case</u>	<u>Base Results</u>				<u>Full TAME Utilization (1)</u>	
	<u>MTBE Purchased</u>	<u>MTBE Produced</u>	<u>TAME Produced</u>	<u>Total Ether</u>	<u>Adj. TAME Produced</u>	<u>Adj. MTBE Purchased</u>
<u>S21 Cases - 2000 Summer All CARB 2(3)</u>						
PADD I Conversion	59	11	7	77	7	59
PADD II Conversion	160	29	15	204	15	160
PADD III Conversion	254	81	28	363	28	254
PADD IV	26	0	2	28	2	26
PADD VC Conversion	78	16	9	103	9	78
PADD VOC Conversion	21	4	2	27	2	21
Total U.S.	598	141	63	802	63	598
<u>S17 Cases - 1995 Summer With Permit Delays</u>						
PADD I Conversion	29	5	0	34	5	25
PADD III Conversion	0	41	0	41	0	0
<u>Other Cases for PADD III Only</u>						
S8 1995 Annual, All LS/LA Dsl	0	78	0	78	0	0
S12 1995 Annual, All LS Dsl	0	78	0	78	0	0
Q9 2000 Winter	4	60	0	64	4	0

(1) Base TAME capacity, MBPSD: PADD I - 5.5; PADD II - 7.7; PADD III - 23.1; PADD VCC - 3.4; U.S. total - 39.7. Oxygen content of TAME equivalent to 89% of MTBE oxygen content.

(2) 2% MTBE premixed - 100% conventional gasoline.

(3) CARB 2 requirements.

Estimated or from other LP runs.

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7/31/92

TABLE X-1

**Δ V.O.C. AND Δ NO_x IMPACTS OF GASOLINE PROPERTIES CHANGES FROM NPC PADD III CASE Q6
1/93 API FIRST ORDER EXHAUST AND EPA NON-EXHAUST – PHASE II COMPLEX FORMULAS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY**

	<u>Statutory Base</u>	<u>Q6</u>	<u>Change</u>							
<u>Gasoline Properties</u>										
Oxygen, Wt. %	0	2.1	+0.4							
Sulfur, ppm	339	144	-80							
RVP , psi	8.7	6.5	-0.5							
E200, Vol. %	41.9	49.0	+2.5							
E300, Vol. %	82.1	82.2	+3.3							
Aromatics, Vol. %	32.0	24.7	-2.5							
Olefins, Vol. %	9.2	11.6	-2.0							
Benzene, Vol. %	1.5	0.7	-							
				<u>V.O.C.</u>			<u>NOx</u>			
				<u>Grams/Mile</u>			<u>Grams/Mile</u>		<u>Percent</u>	
				<u>Exhaust</u>	<u>Non-exhaust</u>	<u>Total</u>	<u>Exhaust</u>	<u>Δ From SB</u>	<u>Δ From SB</u>	<u>Δ From Q6</u>
Statutory Base (SB)	0.907	0.540	1.447	0.000	0.00	31.51	1.340	0.000	0.00	7.84
Case Q6	0.736	0.255	0.991	(0.456)	(31.51)	0.00	1.235	(0.105)	(7.84)	0.00
<u>Changed from Case Q6</u>										
Oxygen	0.726	0.255	0.981	(0.466)	(32.20)	(0.69)	1.240	(0.100)	(7.46)	0.37
Sulfur	0.724	0.255	0.979	(0.468)	(32.34)	(0.83)	1.192	(0.148)	(11.04)	(3.21)
RVP	0.727	0.220	0.947	(0.500)	(34.55)	(3.04)	1.229	(0.111)	(8.28)	(0.45)
E200	0.738	0.255	0.993	(0.454)	(31.38)	0.14	1.237	(0.103)	(7.69)	0.15
E300	0.717	0.255	0.972	(0.475)	(32.83)	(1.31)	1.236	(0.104)	(7.76)	0.07
Aromatics	0.728	0.255	0.983	(0.464)	(32.07)	(0.55)	1.231	(0.109)	(8.13)	(0.30)
Olefins	0.743	0.255	0.998	(0.449)	(31.03)	0.48	1.226	(0.114)	(8.51)	(0.67)

TRH – 4/16/93

NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

TABLE X-3

**Δ V.O.C. AND Δ NO_x IMPACTS OF GASOLINE PROPERTIES CHANGES FROM NPC PADD III CASE Q6
4/92 EPA EXHAUST AND NON-EXHAUST COMPLEX FORMULAS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY**

	<u>Statutory Base</u>	<u>Q6</u>	<u>Change</u>							
<u>Gasoline Properties</u>										
Oxygen, Wt. %	0	2.1	+0.4							
Sulfur, ppm	339	144	-80							
RVP , psi	8.7	6.5	-0.5							
T50, °F	218	205	-8							
T90, °F	330	344	-15							
Aromatics, Vol. %	32.0	24.7	-2.5							
Olefins, Vol. %	9.2	11.6	-2.0							
Benzene, Vol. %	1.5	0.7	-							
	<u>V.O.C.</u>						<u>NOx</u>			
	<u>Grams/Mile</u>			<u>Percent</u>			<u>Grams/Mile</u>		<u>Percent</u>	
	<u>Exhaust</u>	<u>Non-exhaust</u>	<u>Total</u>	<u>Δ From SB</u>	<u>Δ From SB</u>	<u>Δ From Q6</u>	<u>Exhaust</u>	<u>Δ From SB</u>	<u>Δ From SB</u>	<u>Δ From Q6</u>
Statutory Base (SB)	0.460	0.824	1.284	0.000	0.00	44.86	1.00	0.000	0.00	2.99
Case Q6	0.411	0.297	0.708	(0.576)	(44.86)	0.00	0.97	0.030	(2.99)	0.00
<u>Changed from Case Q6</u>										
Oxygen	0.409	0.297	0.706	(0.578)	(44.99)	(0.13)	0.974	(0.026)	(2.62)	1.37
Sulfur	0.396	0.297	0.693	(0.591)	(46.03)	(1.17)	0.947	(0.053)	(5.33)	(2.33)
RVP	0.411	0.219	0.629	(0.655)	(50.98)	(6.12)	0.970	(0.030)	(2.99)	0.00
T90	0.388	0.297	0.686	(0.598)	(46.59)	(1.73)	0.977	(0.023)	(2.27)	0.72
Aromatics	0.404	0.297	0.702	(0.582)	(45.36)	(0.50)	0.971	(0.029)	(2.87)	0.12
Olefins	0.415	0.297	0.713	(0.571)	(44.48)	(0.38)	0.960	(0.040)	(4.01)	(1.02)

TRH - 4/16/93

TABLE X-4

**Δ T.A.P. IMPACTS OF GASOLINE PROPERTIES CHANGES FROM NPC PADD III CASE Q6
1/93 API FIRST ORDER EXHAUST AND EPA NON-EXHAUST – PHASE II COMPLEX FORMULAS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY**

	<u>Statutory Base</u>	<u>Q6</u>	<u>Change</u>
<u>Gasoline Properties</u>			
Oxygen, Wt. %	0	2.1	+0.4
Sulfur, ppm	339	144	-80
RVP, psi	8.7	6.5	-0.5
E200, Vol. %	41.9	49.0	+2.5
E300, Vol. %	82.1	82.2	+3.3
Aromatics, Vol. %	32.0	24.7	-2.5
Olefins, Vol. %	9.2	11.6	-2.0
Benzene, Vol. %	1.5	0.7	-0.25

	<u>T.A.P.</u>					
	<u>Milligrams/Mile</u>			<u>Percent</u>		
	<u>Exhaust</u>	<u>Non-exhaust</u>	<u>Total</u>	<u>Δ From SB</u>	<u>Δ From SB</u>	<u>Δ From Q6</u>
Statutory Base (SB)	73.22	6.06	79.28	0.00	0.00	31.72
Case Q6	52.64	1.49	54.13	(25.15)	(31.72)	0.00
<u>Changed from Case Q6</u>						
Oxygen	52.73	1.47	54.20	(25.08)	(31.63)	0.09
Sulfur	51.34	1.49	52.83	(26.45)	(33.36)	(1.64)
RVP	52.44	1.34	53.78	(25.50)	(32.16)	(0.44)
E200	52.20	1.49	53.69	(25.59)	(32.28)	(0.55)
E300	51.41	1.49	52.90	(26.38)	(33.27)	(1.55)
Aromatics	51.02	1.49	52.51	(26.77)	(33.77)	(2.04)
Olefins	51.95	1.49	53.44	(25.84)	(32.59)	(0.87)
Benzene	50.85	0.96	51.81	(27.47)	(34.65)	(2.93)

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TABLE X-5

Δ T.A.P. IMPACTS OF GASOLINE PROPERTIES CHANGES FROM NPC PADD III CASE Q6**1/93 EPA PHASE II COMPLEX FORMULAS****NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY**

	<u>Statutory Base</u>	<u>Q6</u>	<u>Change</u>
<u>Gasoline Properties</u>			
Oxygen, Wt. %	0	2.1	+0.4
Sulfur, ppm	339	144	-80
RVP, psi	8.7	6.5	+0.5
T50, °F	218	205	-8
T90, °F	330	344	-15
Aromatics, Vol. %	32.0	24.7	-2.5
Olefins, Vol. %	9.2	11.6	-2.0
Benzene, Vol. %	1.5	0.7	-0.25

	<u>T.A.P.</u>					
	<u>Milligrams/Mile</u>			<u>Percent</u>		
	<u>Exhaust</u>	<u>Non-exhaust</u>	<u>Total</u>	<u>Δ From SB</u>	<u>Δ From SB</u>	<u>Δ From Q6</u>
Statutory Base (SB)	73.20	6.06	79.26	0.00	0.00	22.02
Case Q6	60.32	1.49	61.81	(17.45)	(22.02)	0.00
<u>Changed from Case Q6</u>						
Oxygen	61.33	1.47	62.80	(16.46)	(20.77)	1.25
Sulfur	59.16	1.49	60.65	(18.62)	(23.49)	(1.46)
RVP (+0.5)	56.62	1.68	58.30	(20.96)	(26.44)	(4.42)
RVP (-0.5)	78.49	1.34	79.84	0.58	0.73	22.75
T50	58.18	1.49	59.67	(19.59)	(24.72)	(2.70)
T90	59.22	1.49	60.71	(18.55)	(23.40)	(1.38)
Aromatics	58.05	1.49	59.54	(19.72)	(24.88)	(2.86)
Olefins	54.44	1.49	58.93	(20.33)	(25.65)	(3.63)
Benzene	59.08	0.96	60.03	(19.23)	(24.26)	(2.24)

TABLE X-6

Δ T.A.P. IMPACTS OF GASOLINE PROPERTIES CHANGES FROM NPC PADD III CASE Q6
4/92 EPA EXHAUST AND NON-EXHAUST COMPLEX FORMULAS
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Statutory Base</u>	<u>Q6</u>	<u>Change</u>			
<u>Gasoline Properties</u>						
Oxygen, Wt. %	0	2.1	+0.4			
Sulfur, ppm	339	144	−80			
RVP, psi	8.7	6.5	−0.5			
T50, °F	218	205	−8			
T90, °F	330	344	−15			
Aromatics, Vol. %	32.0	24.7	−2.5			
Olefins, Vol. %	9.2	11.6	−2.0			
Benzene, Vol. %	1.5	0.7	−0.25			
T.A.P.						
Milligrams/Mile				Percent		
	<u>Exhaust</u>	<u>Non-exhaust</u>	<u>Total</u>	<u>Δ From SB</u>	<u>Δ From SB</u>	<u>Δ From Q6</u>
Statutory Base (SB)	43.42	9.24	52.65	0.00	0.00	33.07
Case Q6	35.19	0.06	35.24	(17.41)	(33.07)	0.00
<u>Changed from Case Q6</u>						
Oxygen	35.31	0.06	35.37	(17.29)	(32.83)	0.24
Sulfur	33.95	0.06	34.00	(18.65)	(35.42)	(2.35)
RVP	35.19	(0.44)	34.74	(17.91)	(34.02)	(0.95)
T90	33.25	0.06	33.31	(19.35)	(36.74)	(3.67)
Aromatics	33.80	0.06	33.85	(18.80)	(35.71)	(2.64)
Olefins	35.44	0.06	35.49	(17.16)	(32.59)	0.48
Benzene	34.33	0.04	34.37	(18.28)	(34.73)	(1.66)

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TABLE Y-1

ENERGY BALANCE IMPACTS OF ETHANOL

AT CONSTANT Δ VOC – PADD II SUMMER 2000 CASES S13H vs S6[1]

NPC 1991-93 STUDY OF U. S. REFINING INDUSTRY

Products	S6	MBPCD S13H	Δ	BFOE/ Liq B	MBPCD FOE
Gasolines					
RFG-E		512.0	512.0	0.746	382.0
RFG-M	1,712.7	1,204.7	(508.0)	0.752	(382.0)
Sub-total	1,712.7	1,716.7	4.0		0.0
Bunker	11.0	37.8	26.8	1.00	26.8
Marketable Coke, FOE	51.8	61.1	9.3	1.00	9.3
Petrochem Gaso	32.1	35.2	3.1	0.69	2.1
Toluene	5.0	3.0	(2.0)	0.84	(1.7)
NC4	24.9	33.7	8.8	0.68	6.0
Propane	80.0	86.0	6.0	0.60	3.6
Plant Fuel Burned, FOE	185.5	200.7	15.2	1.00	15.2
Loss (Gain)	(104.4)	(105.2)	(0.8)		0.0
Other	1,164.6	1,164.6	0.0		0.0
Total	3,163.2	3,233.6	70.4		61.3
<u>Raw Materials</u>					
Crude	2,826.4	2,904.4	78.0	0.92	71.8
IC4	40.0	53.2	13.2	0.65	8.6
MTBE	184.3	138.8	(45.5)	0.62	(28.2)
Methonal	5.4	0.6	(4.8)	0.38	(1.8)
Ethanol		29.4	29.4	0.51	15.0
Nat Gas to H2 Plant	5.1	5.2	0.1	1.00	0.1
Other	102.0	102.0	0.0		0.0
Total	3,163.2	3,233.6	70.4		65.5
<u>Net Inputs (Raw Mat less Prod)</u>					4.2
<u>Utilities</u>					
Nat Gas Purch, FOE	68.2	70.9	2.7	1.00	2.7
Elec, MMKWH/D	23.3	25.9	2.6	1.60	4.2
Plant Fuel Burned, FOE					15.2
Total Utilities Used					22.1
<u>Lost Energy</u>					
Total Net Inputs plus Utilities, FOE					26.3
Percent of Energy in Gasoline[2]					6.9%
Percent of Energy in Ethanol[3]					175%

[1] S13H VOC Reduction = 41% based on 4/92 EPA CF. Gasoline pool = 30% RFG-E + 70% RFG-M

S6 VOC Reduction = 41% based on 4/92 EPA CF. Gasoline pool = 100% RFG-M.

[2] 26.3 MBPCD FOE lost/382 MBPCD FOE in gasoline switched from RFG-M to RFG-E.

[3] 26.3 MBPCD FOE lost/15 MBPCD FOE in Ethanol used.

TABLE Y-2

ENERGY BALANCE IMPACTS OF ETHANOL

AT LOWER Δ VOC – PADD II SUMMER 2000 CASES S13L vs S6[1]

NPC 1991-93 STUDY OF U. S. REFINING INDUSTRY

<u>Products</u>	<u>MBPCD</u>			<u>BFOE/ Liq B</u>	<u>MBPCD FOE</u>
	<u>S6</u>	<u>S13L</u>	<u>Δ</u>		
<u>Gasolines</u>					
RFG-E		514.0	514.0	0.743	382.0
RFG-M	1,712.7	1,198.2	(514.5)	0.743	(382.0)
Sub-total	1,712.7	1,712.2	(0.5)		0.0
Marketable Coke, FOE	51.8	54.8	3.0	1.00	3.0
Petrochem Gaso	32.1	33.6	1.5	0.70	1.1
NC4	24.9	30.2	5.3	0.68	3.6
Propane	80.0	83.8	3.8	0.60	2.3
Plant Fuel Burned, FOE	185.5	198.4	12.9	1.00	12.9
Loss (Gain)	(104.4)	(107.2)	(2.8)		0.0
Other	1,180.6	1,180.6	0.0		0.0
Total	3,163.2	3,186.4	23.2		22.9
<u>Raw Materials</u>					
Crude	2,826.4	2,863.4	37.0	0.92	34.0
IC4	40.0	48.8	8.8	0.65	5.7
MTBE	184.3	126.7	(57.6)	0.62	(35.7)
Methanol	5.4	4.6	(0.8)	0.38	(0.3)
Ethanol		29.5	29.5	0.51	15.0
Nat Gas to H2 Plant	5.1	11.4	6.3	1.00	6.3
Other	102.0	102.0	0.0		0.0
Total	3,163.2	3,186.4	23.2		25.0
<u>Net Inputs (Raw Mat less Prod)</u>					2.1
<u>Utilities</u>					
Nat Gas Fuel, FOE	68.2	61.3	(6.9)	1.00	(6.9)
Elec, MMKWH/D	23.3	24.6	1.3	1.60	2.1
Plant Fuel Burned, FOE					12.9
Total Utilities Used					8.1
<u>Lost Energy</u>					
Total Net Inputs plus Utilities, FOE					10.2
Percent of Energy in Gasoline[2]					2.7%
Percent of Energy in Ethanol[3]					68%

[1] S13L VOC Reduction = 38% based on 4/92 EPA CF. Gasoline pool = 30% RFG-E + 70% RFG-M

S6 VOC Reduction = 41% based on 4/92 EPA CF. Gasoline pool = 100% RFG-M.

[2] 10.2 MBPCD FOE lost/382 MBPCD FOE in gasoline switched from RFG-M to RFG-E.

[3] 10.2 MBPCD FOE lost/15 MBPCD FOE in Ethanol used.

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TURNER, MASON & COMPANY
Consulting Engineers

TABLE Y-3

ETBE VERSUS MTBE ECONOMICS ESTIMATE SUMMARY

FOR PROPOSED RFG REGS AT CONSTANT RVP – 2000 PADD II SUMMER

NPC 1991-93 STUDY OF U.S. REFINING INDUSTRY

- Based on PADD II 100% RFG-M (with MTBE) LP Case S6 gasoline pool.
- Proposed identical RVP and Δ VOC average standard for RFG-M and RFG-EE (with ETBE) would make them fully fungible.
- For simplicity, we backed out all MTBE and added ETBE and butane to maintain RVP constant and make 100% RFG-EE. Calculated pool properties are shown on Table Y-4.
- Assume MTBE plants outside of refineries are converted to ETBE operation. Isomerization and dehydrogenation facilities remain full to provide a fixed amount of isobutylene to etherification plant as shown on Table Y-5.
- Several MTBE plants with assumed average 12.5 MB/SD capacity are expanded to make 14.3 MBPSD of ETBE with added facilities for ethanol recovery. Estimated investment costs for modifications are about \$9 million/average plant, including \$5 million for larger ether plant and \$4 million for an additional fractionation tower. At 15% ROI, the incremental daily capital charge is about \$6,000/average plant, or 1¢/gallon ETBE.
- Etherification plant yields and economics are shown on Table Y-5. If there were no ethanol subsidy, ETBE price would have to be \$9.66/barrel (23¢/gallon) higher than MTBE price in order to break even. With the existing subsidy of 54¢/gallon of ethanol, ETBE breakeven price is \$0.21/barrel (0.5¢/gallon) higher than MTBE.
- The refinery RFG blending economics differences between the two ethers are shown on Table Y-6. Cost of RFG-EE is calculated from the cost of RFG-M with credit for MTBE and added cost for ETBE and butane with a further debit for heating value loss. Then there are credits for higher octane and lower benzene due to the ETBE content being higher than the MTBE content at a constant oxygen level.
- Without the ethanol subsidy, RFG-EE would cost 3.2¢/gallon more than RFG-M. With the existing 54¢/gallon ethanol subsidy, the costs of the two types of RFG are much closer to equal (0.2¢/gallon higher cost for RFG-EE), as shown in Table Y-6. This

TABLE Y-4A
ESTIMATED GASOLINE EMISSIONS REDUCTION WITH ETBE VS. MTBE
IIC SUMMER 2000 F2 – ALTERNATE COMPLEX FORMULAS
NPC 1991-93 STUDY OF U.S. REFINING INDUSTRY

	<u>Case S6 RFG-M</u>	<u>Estimated Case QN3</u>
<u>Emissions Reduction From Statutory Base</u>		
<u>API 6/92 1st Order CF</u>		
VOC, %	38.8	39.2
NOx, %	6.8	8.4
TAP, %	24.7	26.4
<u>API 1/93 Non 1st Order CF</u>		
VOC, %	29.8	30.7
NOx, %	1.9	2.2
TAP, %	22.5	21.1
<u>API 1/93 1st Order CF</u>		
VOC, %	29.0	29.4
NOx, %	4.6	4.9
TAP, %	30.1	28.5
<u>EPA 1/93 CF</u>		
VOC, %	27.3	28.6
NOx, %	(3.1)	(0.5)
TAP, %	22.2	25.6
<u>Emissions</u>		
<u>API 6/92 1st Order CF</u>		
VOC, gm/mile	0.763	0.759
NOx, gm/mile	1.247	1.226
TAP, mg/mile	35.39	34.59
<u>API 1/93 Non 1st Order CF</u>		
VOC, gm/mile	0.999	0.986
NOx, gm/mile	1.314	1.310
TAP, mg/mile	61.25	62.31
<u>API 1/93 1st Order CF</u>		
VOC, gm/mile	1.011	1.005
NOx, gm/mile	1.279	1.274
TAP, mg/mile	55.22	56.50
<u>EPA 1/93 CF</u>		
VOC, gm/mile	1.011	0.993
NOx, gm/mile	1.381	1.346
TAP, mg/mile	60.32	57.74

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TABLE Y-5
ETHER COMPLEX YIELDS AND ECONOMICS
PROCESS CONVERSION FROM MTBE TO ETBE
NPC 1991-93 STUDY OF U.S. REFINING INDUSTRY

	Ether Unit Yields, Utilities		Average Rates, MBPCD			No Subsidy		With Subsidy	
	MTBE	ETBE	MTBE	ETBE	Δ MB/D	\$/Bbl.	M\$/D	\$/Bbl.	M\$/D
Isobutylene	(0.800)	(0.715)	(10.000)	(10.000)	0		0		0
MeOH	(0.350)		(4.375)		4.375	23.18	101.41	23.18	101.41
EtOH		(0.425)		(5.944)	(5.944)	49.87	(296.43)	27.19	(161.62)
MTBE	1.000		12.500		(12.500)	38.06	(475.75)	38.06	(475.75)
ETBE/TBA[1]		1.020		14.266	14.266	47.72	680.73	38.27	545.92
Loss	<u>0.150</u>	<u>0.120</u>	<u>1.875</u>	<u>1.678</u>	<u>(0.197)</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
Total	(0)	0	0	0	0	158.83	9.96	126.70	9.96
					<u>Δ Units</u>	<u>\$/Unit</u>			
Steam M#/Bbl. Ether	(130)	(130)	(1.625)	(1.818)	(0.193)	0.45	(0.09)		(0.09)
Power MKWH/B Ether	(2.5)	(2.5)	(31.25)	(34.97)	(3.72)	0.04	(0.15)		(0.15)
OVC \$M/Bbl. Ether	(2.5)	(2.5)	(31.25)	(34.97)	(3.72)	1	(3.72)		(3.72)
Invest. Chg. \$M/Bbl. Ether					(6.0)	1	<u>(6.00)</u>		<u>(6.00)</u>
Total							(9.96)		(9.96)
Grand Total[1]							0		0

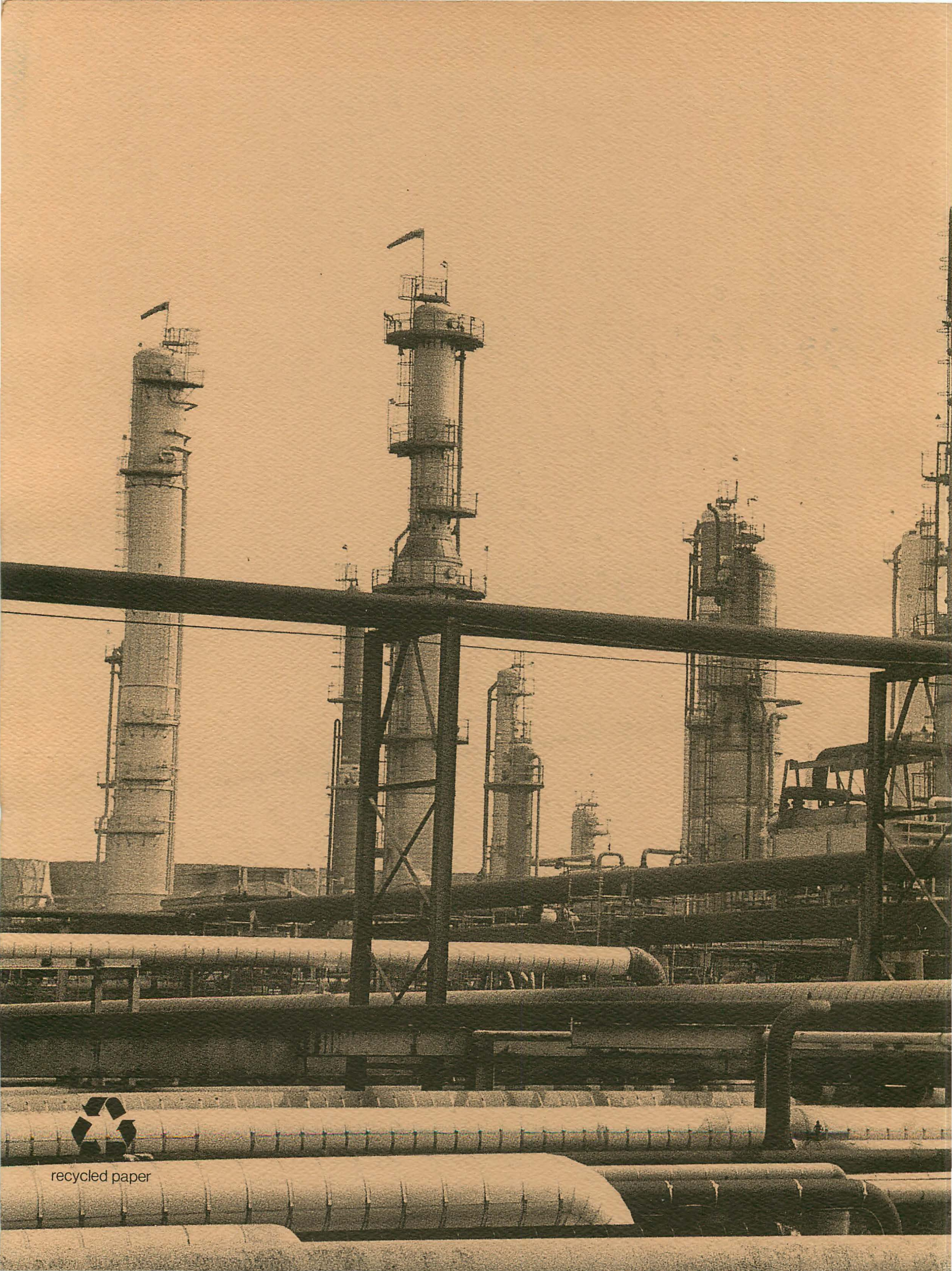
[1] ETBE unit prices calculated to break even with MTBE price.

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TABLE Y-6
ETBE VS. MTBE ECONOMICS ESTIMATE
GASOLINE BLENDING OF EXTERNAL ETBE VS. EXTERNAL MTBE
NPC 1991-92 STUDY OF U.S. REFINING INDUSTRY

	<u>Yields Material Balance</u>	<u>Without Subsidy ¢/Gal.</u>	<u>With Subsidy ¢/Gal.</u>
<u>RFG-EE COST</u>			
<u>Material Balance</u>			
RFG-M From Case S6	1.0000	59.4	59.4
MTBE	(0.1167)	90.6	90.6
ETBE	0.1395	113.6	91.1
NC4	0.0088	27.9	27.9
RFG-EE From Case QN3	1.0316	62.9	59.9
 <u>Other Adjustments</u>			
Higher Octane: 0.5 @ .6¢/Gal.		(0.3)	(0.3)
Lower Benzene: 0.02 @ 4.1¢/Gal.		(0.1)	(0.1)
Additional Value Heating Loss		0.1	0.1
Net Cost of RFG-EE		62.6	59.6
 RFG-EE Cost Above RFG-M		3.2	0.2
 <u>ETBE COSTS ABOVE MTBE</u>			
Lower ETBE Valve		23.7	1.5
Added ETBE Storage & Handling Costs		1.0	1.0
Total ETBE Added Costs		24.7	2.5
 <u>REQUIRED ETHANOL SUBSIDY</u>			
added to breakeven		60	6

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