FINAL REPORT

REFINING ECONOMICS OF DIESEL FUEL SULFUR STANDARDS

SUPPLEMENTAL ANALYSIS OF 15ppm SULFUR CAP

Prepared for

The Engine Manufacturers Association

By

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1. INTRODUCTION

This report assesses the refining economics of controlling the sulfur content of diesel fuel to meet EPA's proposed Tier 2 standard – a 15ppm cap on the sulfur content of *on-road* diesel fuel – along with two variants involving new sulfur standards on *off-road* diesel fuel as well.

This analysis is an extension of a previous study conducted by MathPro Inc. for the Engine Manufacturers Association (EMA) -- *Refining Economics of Diesel Fuel Sulfur Standards*, October 1999. In that study, we analyzed ten sets of sulfur standards for on-road and off-road diesel fuel, but none that matched EPA's proposed standard.

For this analysis, we used the same methodology, technical and economic data, and notional refinery model as before. And, we provide the analytical results in a set of exhibits that match those of our previous study.

2. SULFUR STANDARDS

We examined three Sulfur Control cases, each corresponding to a set of diesel fuel sulfur standards, as shown in the table below.

Sulfur Control Case	Sulfur Standards (ppm)	
	On-road	Off-road
11	15 cap	3500 average
12	15 cap	350 average
13	15 cap	15 cap

Case 11 corresponds to EPA's proposed Tier 2 standard.

We assumed that refiners would meet the 15ppm cap on the sulfur content of diesel fuel by producing diesel fuel with a pool-average sulfur content of 8ppm or less. In this report, we call this material "Tier 2 diesel fuel."

As in the previous study, we analyzed five variants for each Sulfur Control case.

1. No Retrofitting – Inflexible
2. No Retrofitting – Flexible
3. Retrofitting – De-rate/Parallel
4. Retrofitting – Series
5. Economies of Scale

(Table 3.2 in our October 1999 report lists the specific assumptions that each variant embodies.)

3. TECHNICAL APPROACH

We used the same methodology, technical and economic data, and notional refinery model for PADDs 1,2, and 3 in this analysis as in our previous study. We modified certain technical premises and procedures in order to analyze the 15ppm sulfur cap, as follows.

- Operating modes for Tier 2 desulfurization. In the previous study, we developed three operating modes for Tier 2 desulfurization processes – corresponding to average sulfur contents of 2, 10, and 100ppm. In this analysis, we configured Tier 2 distillate desulfurization to use a volume weighted average of the 2 and 10ppm modes (50% each) to produce Tier 2 diesel fuel (Ratio constraints in ARMS ensure that the operating modes for the two target sulfur levels handle the same mix of feed streams.)

- Blending restrictions. We allowed hydrocracked jet and distillate, but no undesulfurized or conventionally desulfurized blendsocks, to be blended in Tier 2 diesel fuel.

- De-rating factor. We used the same methodology as in the previous study to develop a de-rating factor for retrofitting the existing distillate desulfurization unit (producing EPA diesel) to produce Tier 2 diesel fuel. The calculated de-rating factor lies between the values estimated for the 2ppm and 20ppm cases in the previous study.

- Reprocessing rate. We used a reprocessing rate of 6% for Tier 2 diesel fuel (which is between the 4 and 8% rates used in the previous study for the 20 and 2ppm cases, respectively).

- Investment cost. We assumed that the unit investment cost (dollars per daily barrel) for distillate desulfurization units producing Tier 2 diesel was 10% higher than in the 20ppm cases in our previous study.

4. RESULTS

The results of this analysis are shown in attached **Exhibits 1 through 9**. The exhibits correspond to those in our previous study.

Exhibits 9a-c compare the estimated costs of the diesel fuel standards assessed in this analysis (identified by arrows) to those assessed in our previous study.

The reader may wonder why, in Exhibit 9a, the range of per gallon costs for Case 11 (15ppm cap/3500ppm average) is larger than for Case 12 (15ppm cap/350ppm average), whereas in Exhibits 9b & c, total costs and investment costs are lower. This seeming anomaly derives from the manner in which we calculate per gallon costs -- by dividing total refining costs for meeting the given standard by the volume of "affected" diesel fuel.

EPA's proposed Tier 2 standard sets a 15ppm cap on *on-road* diesel fuel, but does not tighten the standard for *off-road* diesel fuel. In Case 11, which represents the EPA proposal, *on-road* diesel fuel is the only "affected" diesel fuel. Hence, all costs are allocated only to on-road diesel fuel. In Cases 12 and 3, which represent a 15ppm cap on on-road diesel fuel with a 350ppm average sulfur level for off-road diesel and a 15ppm cap on both on-road and off-road diesel fuel, both the on- and off-road diesel pools are "affected." Hence, costs are allocated to the combined volume of on-road and off-road diesel. (In our previous study, except for Case 9a, the diesel fuel sulfur standards assessed affected both on-road and off-road diesel fuel, so costs were allocated to the combined volume of on-road and off-road diesel.)

Had we, instead, allocated costs over the entire diesel pool in Case 11, we would have obtained lower per gallon costs for EPA's proposed Tier 2 standard. But that result would have understated the unit cost of controlling the sulfur content of the target of the proposed standard -- on-road diesel fuel.

Exhibit 1: Process Unit Utilization, Additions, and Operations

Refining Processes	Diesel Fuel Cases									
	Case 11: 15cap/3500					Case 12: 15cap/350				
	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ
Distillate Desulf. (K Bbl/day)										
Conventional Desulfurization										
Existing Unit	8.2	8.2		31.1	31.1	16.5	19.4		35.0	38.0
Expansion									2.9	
Tier 2 Desulfurization										
De-rated Conventional Unit			17.8					17.8		
Series Processing Unit				29.4	29.4				34.1	34.0
Grassroots Unit	30.2	29.3	15.4			30.1	27.6	23.7		
Existing Capacity (K Bbl/day)										
Atmospheric Distillation	147.3	147.3	147.2	147.3	147.3	147.2	147.3	147.2	147.2	147.2
Fluid Cat Cracker	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0
Hydrocracker	9.5	10.3	10.3	10.3	10.3	9.5	10.3	10.3	10.3	10.3
Coking - Delayed	15.0	15.0	15.0	14.9	14.9	15.0	15.0	15.0	15.0	15.0
Alkylation	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
C5/C6 Isomerization	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Reforming (150-350 psi)	33.2	33.2	33.2	33.2	33.2	33.2	33.4	33.4	33.4	33.4
MTBE Plant	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
FCC Feed Desulfurization	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Naphtha & Isom Feed Desulf.	2.0	3.2	2.5	2.7	2.7	2.2	2.0	2.0	2.0	2.0
Reformer Feed Desulfurization	28.0	28.0	28.2	28.0	28.0	28.0	29.3	29.3	29.3	29.3
FCC Gasoline Desulfurization	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4
Light Naphtha Splitter	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Aromatics Plant	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Butane Isomerization	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Debutanization	10.6	10.7	10.7	10.7	10.7	10.6	10.7	10.7	10.7	10.7
Lubes & Waxes	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Sulfur Plant (tons/d)	137	137	137	137	137	141	141	141	141	141
Hydrogen Plant (MM scf/d)	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5
New Capacity (K Bbl/day)										
Merox Treatment of MTBE										
FCC Gasoline Desulfurization	0.1	0.0	0.0			0.1	0.0	0.0	0.0	0.0
Light Naphtha Splitter										
Debutanization		0.1	0.1	0.1	0.1					
FCC Gas Processing										
Hydrogen Plant (MM scf/d)	3.0	3.4	5.4	3.5	3.5	4.7	4.1	5.6	5.5	5.5
Operating Indices										
FCC Conversion (Vol %)	74.7	74.9	75.1	75.0	75.0	74.7	74.9	74.9	74.9	74.9
Reformer Severity (RON)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Charge Rates (K Bbl/day)										
Fluid Cat Cracker	54.5	54.3	54.2	54.2	54.2	54.5	54.3	54.3	54.3	54.3
Reformer (150-350 psi)	31.6	31.5	31.6	31.6	31.6	31.5	31.7	31.7	31.7	31.7
FCC Olefin Max Cat. (%)	2.2	2.3	2.5	2.3	2.3	2.2	2.3	2.3	2.3	2.3

Exhibit 1: Process Unit Utilization, Additions, and Operations

Refining Processes	Diesel Fuel Cases Case 13: 15cap/15cap No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ
Distillate Desulf. (K Bbl/day)					
Conventional Desulfurization					
Existing Unit				35.0	38.0
Expansion				4.9	1.9
Tier 2 Desulfurization					
De-rated Conventional Unit			17.8		
Series Processing Unit				39.1	39.1
Grassroots Unit	50.4	49.3	26.5		
Existing Capacity (K Bbl/day)					
Atmospheric Distillation	147.1	147.2	147.2	147.2	147.2
Fluid Cat Cracker	55.0	55.0	55.0	55.0	55.0
Hydrocracker	9.5	10.3	10.3	10.3	10.3
Coking - Delayed	15.0	15.0	15.0	14.9	14.9
Alkylation	11.0	11.0	11.0	11.0	11.0
C5/C6 Isomerization	5.0	5.0	5.0	5.0	5.0
Reforming (150-350 psi)	33.2	33.4	33.4	33.4	33.4
MTBE Plant	1.2	1.2	1.2	1.2	1.2
FCC Feed Desulfurization	15.0	15.0	15.0	15.0	15.0
Naphtha & Isom Feed Desulf.	2.0	2.0	2.0	2.0	2.0
Reformer Feed Desulfurization	28.2	29.3	29.3	29.3	29.3
FCC Gasoline Desulfurization	31.4	31.4	31.4	31.4	31.4
Light Naphtha Splitter	8.5	8.5	8.5	8.5	8.5
Aromatics Plant	2.7	2.7	2.7	2.7	2.7
Butane Isomerization	1.1	1.1	1.1	1.1	1.1
Debutanization	10.7	10.7	10.7	10.7	10.7
Lubes & Waxes	2.0	2.0	2.0	2.0	2.0
Sulfur Plant (tons/d)	142	142	142	142	142
Hydrogen Plant (MM scf/d)	22.5	22.5	22.5	22.5	22.5
New Capacity (K Bbl/day)					
Merox Treatment of MTBE					
FCC Gasoline Desulfurization	0.1	0.0	0.0	0.0	0.0
Light Naphtha Splitter					
Debutanization					
FCC Gas Processing					
Hydrogen Plant (MM scf/d)	6.5	5.9	5.9	5.9	5.9
Operating Indices					
FCC Conversion (Vol %)	74.8	74.9	74.9	74.9	74.9
Reformer Severity (RON)	100.0	100.0	100.0	100.0	100.0
Charge Rates (K Bbl/day)					
Fluid Cat Cracker	54.4	54.3	54.3	54.3	54.3
Reformer (150-350 psi)	31.6	31.7	31.7	31.7	31.7
FCC Olefin Max Cat. (%)	2.2	2.3	2.3	2.3	2.3

Exhibit 2: Crude Oil, Other Inputs, and Refined Product Outputs

(K barrels/day)

Inputs & Products	Diesel Fuel Cases									
	Case 11: 15cap/3500					Case 12: 15cap/350				
	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ
Crude Oil										
Composite	147.3	147.3	147.2	147.3	147.3	147.2	147.3	147.2	147.2	147.2
Other Inputs										
Isobutane	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Butane	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Natural Gas Liquids	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Reformate	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Naphtha										
Distillate										
Heavy Gas Oil	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Residual Oil										
MTBE	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Methanol	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Energy Use										
Electricity (K Kwh)	773.7	780.7	784.2	780.7	780.7	789.4	788.6	789.0	789.7	789.8
Fuel (foeb)	12.7	12.7	12.8	12.7	12.7	12.8	12.8	12.8	12.8	12.8
Refined Products										
BTX	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Propane	5.5	5.6	5.6	5.6	5.6	5.5	5.6	5.6	5.6	5.6
Propylene	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Butane	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Naphtha	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Gasoline:										
Federal RFG	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Conventional	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Jet Fuel	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
On-Road Diesel	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Light Duty Diesel										
Off-Road Diesel	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Other Diesel*										
Carbon Black Feed	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Resid - High Sulfur	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Asphalt	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lubes & Waxes	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Coke										
Low Sulfur	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
High Sulfur	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Very High Sulfur	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Sulfur (tons/d)	137	137	137	137	137	141	141	141	141	141

Exhibit 2: Crude Oil, Other Inputs, and Refined Product Outputs

(K barrels/day)

Inputs & Products	Diesel Fuel Cases				
	Case 13: 15cap/15cap				
	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ
Crude Oil					
Composite	147.1	147.2	147.2	147.2	147.2
Other Inputs					
Isobutane	1.4	1.4	1.4	1.4	1.4
Butane	0.2	0.2	0.2	0.2	0.2
Natural Gas Liquids	2.0	2.0	2.0	2.0	2.0
Reformate	1.0	1.0	1.0	1.0	1.0
Naphtha					
Distillate					
Heavy Gas Oil	1.0	1.0	1.0	1.0	1.0
Residual Oil					
MTBE	1.5	1.5	1.5	1.5	1.5
Methanol	0.4	0.4	0.4	0.4	0.4
Energy Use					
Electricity (K Kwh)	793.1	791.8	791.8	792.8	792.8
Fuel (foeb)	12.8	12.8	12.8	12.8	12.8
Refined Products					
BTX	3.0	3.0	3.0	3.0	3.0
Propane	5.5	5.6	5.6	5.6	5.6
Propylene	2.0	2.0	2.0	2.0	2.0
Butane	1.0	1.0	1.0	1.0	1.0
Naphtha	3.0	3.0	3.0	3.0	3.0
Gasoline:					
Federal RFG	20.0	20.0	20.0	20.0	20.0
Conventional	60.0	60.0	60.0	60.0	60.0
Jet Fuel	13.0	13.0	13.0	13.0	13.0
On-Road Diesel	35.0	35.0	35.0	35.0	35.0
Light Duty Diesel					
Off-Road Diesel					
Other Diesel*					
Carbon Black Feed	0.5	0.5	0.5	0.5	0.5
Resid - High Sulfur	5.0	5.0	5.0	5.0	5.0
Asphalt	4.0	4.0	4.0	4.0	4.0
Lubes & Waxes	2.0	2.0	2.0	2.0	2.0
Coke					
Low Sulfur	0.8	0.8	0.8	0.8	0.8
High Sulfur	1.4	1.4	1.4	1.4	1.4
Very High Sulfur	1.4	1.4	1.4	1.4	1.4
Sulfur (tons/d)	142	142	142	142	142

Exhibit 3: Gasoline Properties, by Gasoline Type

	Case 11: 15cap/3500														
	No Retr. -- Inflex			No Retr. -- Flex			Retr. -- De-Rate			Retr. -- Series			Scale Economies		
Property	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool
RVP (psi)	6.8	8.3	7.9	6.8	8.3	7.9	6.8	8.3	7.9	6.8	8.3	7.9	6.8	8.3	7.9
Oxygen (wt%)	2.2	0.1	0.6	2.2	0.1	0.6	2.2	0.1	0.6	2.2	0.1	0.6	2.2	0.1	0.6
Aromatics (vol%)	21.7	32.7	30.0	22.9	32.3	29.9	22.9	32.3	30.0	22.6	32.4	30.0	22.6	32.4	30.0
Benzene (vol%)	0.70	1.10	1.00	0.70	1.10	1.00	0.70	1.10	1.00	0.70	1.10	1.00	0.70	1.10	1.00
Olefins (vol%)	9.5	11.0	10.6	9.7	10.9	10.6	9.3	11.0	10.6	6.6	11.9	10.6	7.5	11.6	10.6
Sulfur (ppm)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
E200 (vol% off)	50.2	44.6	46.0	52.0	43.9	45.9	51.7	44.1	46.0	54.4	43.2	46.0	54.4	43.2	46.0
E300 (vol% off)	83.3	79.7	80.6	82.3	80.2	80.7	82.5	80.1	80.7	83.7	79.7	80.7	83.7	79.7	80.7
T10	131	130	131	131	131	131	131	130	131	132	130	131	131	130	131
T50	201	214	211	196	215	210	196	215	210	186	217	209	186	217	209
T90	336	343	342	339	342	342	338	343	342	333	344	341	333	344	341
Estimated DI	1,136	1,181	1,170	1,123	1,183	1,168	1,124	1,183	1,168	1,088	1,191	1,165	1,090	1,191	1,166
En. Den. (MM Btu/bbl)	5.078	5.235	5.196	5.087	5.226	5.191	5.077	5.232	5.194	5.083	5.229	5.193	5.083	5.229	5.193

Exhibit 3: Gasoline Properties, by Gasoline Type

	Case 12: 15cap/350														
	No Retr. -- Inflex			No Retr. -- Flex			Retr. -- De-Rate			Retr. -- Series			Scale Economies		
Property	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool
RVP (psi)	6.8	8.3	7.9	6.8	8.3	7.9	6.8	8.3	7.9	6.8	8.3	7.9	6.8	8.3	7.9
Oxygen (wt%)	2.2	0.1	0.6	2.2	0.1	0.6	2.2	0.1	0.6	2.2	0.1	0.6	2.2	0.1	0.6
Aromatics (vol%)	22.9	32.3	30.0	22.9	32.4	30.0	22.9	32.4	30.0	22.9	32.4	30.0	21.8	32.8	30.0
Benzene (vol%)	0.70	1.10	1.00	0.70	1.10	1.00	0.70	1.10	1.00	0.70	1.10	1.00	0.70	1.10	1.00
Olefins (vol%)	8.1	11.4	10.6	10.0	10.8	10.6	7.9	11.5	10.6	9.7	10.9	10.6	9.6	10.9	10.6
Sulfur (ppm)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
E200 (vol% off)	51.2	44.2	46.0	53.1	43.5	45.9	51.2	44.1	45.9	51.5	44.0	45.9	53.2	43.5	45.9
E300 (vol% off)	83.4	79.7	80.6	83.1	79.7	80.5	83.1	79.7	80.5	83.0	79.7	80.5	83.0	79.7	80.5
T10	131	130	131	131	130	131	131	130	131	132	130	131	131	131	131
T50	198	215	211	191	217	210	199	215	211	197	215	211	192	217	210
T90	335	344	341	337	343	342	336	344	342	337	343	342	337	343	342
Estimated DI	1,126	1,184	1,169	1,108	1,189	1,168	1,129	1,184	1,170	1,124	1,185	1,170	1,109	1,189	1,169
En. Den. (MM Btu/bbl)	5.077	5.234	5.195	5.079	5.236	5.197	5.079	5.236	5.197	5.076	5.237	5.197	5.082	5.235	5.197

Exhibit 3: Gasoline Properties, by Gasoline Type

	Case 13: 15cap/15cap														
	No Retr. -- Inflex			No Retr. -- Flex			Retr. -- De-Rate			Retr. -- Series			Scale Economies		
Property	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool
RVP (psi)	6.8	8.3	7.9	6.8	8.3	7.9	6.8	8.3	7.9	6.8	8.3	7.9	6.8	8.3	7.9
Oxygen (wt%)	2.2	0.1	0.6	2.2	0.1	0.6	2.2	0.1	0.6	2.2	0.1	0.6	2.2	0.1	0.6
Aromatics (vol%)	22.9	32.3	30.0	21.8	32.8	30.0	22.7	32.5	30.0	22.7	32.5	30.0	22.9	32.4	30.0
Benzene (vol%)	0.70	1.10	1.00	0.70	1.10	1.00	0.70	1.10	1.00	0.70	1.10	1.00	0.70	1.10	1.00
Olefins (vol%)	10.2	10.7	10.6	9.6	10.9	10.6	9.4	11.0	10.6	9.5	11.0	10.6	8.8	11.2	10.6
Sulfur (ppm)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
E200 (vol% off)	52.6	43.8	46.0	54.0	43.2	45.9	54.0	43.2	45.9	49.5	44.7	45.9	49.9	44.6	45.9
E300 (vol% off)	83.3	79.7	80.6	83.1	79.7	80.5	82.9	79.8	80.5	83.0	79.7	80.5	83.0	79.7	80.5
T10	131	130	131	131	131	131	131	131	131	131	130	131	132	130	131
T50	194	216	210	188	217	210	185	218	209	203	214	211	202	214	211
T90	336	343	342	337	343	342	337	343	342	337	343	342	336	344	342
Estimated DI	1,115	1,186	1,169	1,098	1,191	1,167	1,089	1,192	1,166	1,142	1,181	1,171	1,140	1,181	1,171
En. Den. (MM Btu/bbl)	5.076	5.236	5.196	5.084	5.234	5.197	5.090	5.232	5.197	5.086	5.233	5.197	5.084	5.234	5.197

Exhibit 4: Gasoline Composition and Volume, by Gasoline Type

Gasoline Composition & Volume	Case 11: 15cap/3500														
	No Retr. -- Inflex			No Retr. -- Flex			Retr. -- De-Rate			Retr. -- Series			Scale Economies		
	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool
Composition (vol%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C4s:	2.4	5.3	4.6	2.0	5.4	4.5	2.0	5.4	4.5	2.0	5.4	4.5	2.0	5.4	4.5
Butenes															
I-Butane	1.8	0.3	0.7		0.8	0.6	2.0	0.1	0.6	1.6	0.3	0.6		0.8	0.6
N-Butane	0.6	5.0	3.9	2.0	4.6	3.9		5.2	3.9	0.4	5.1	3.9	2.0	4.6	3.9
C5s & Isomerate	10.3	4.7	6.1	16.7	2.6	6.1	16.0	2.8	6.1	9.5	5.0	6.1	11.2	4.4	6.1
Raffinate	5.9		1.5	2.5	1.1	1.5	3.9	0.7	1.5	5.9		1.5	5.9		1.5
Natural Gas Liquids		0.1	0.0		1.6	1.2		0.7	0.5		1.1	0.8		1.1	0.8
Naphtha	0.4	5.0	3.8	0.1	3.5	2.7	0.7	4.2	3.3	4.7	2.5	3.1	3.9	2.8	3.1
C5-160	0.4	4.5	3.5		3.2	2.4	0.6	3.9	3.0	4.7	2.2	2.8	3.9	2.4	2.8
Coker Naphtha															
160-250		0.4	0.3	0.1	0.3	0.3	0.1	0.3	0.3		0.4	0.3		0.4	0.3
Alkylate	14.4	12.9	13.3	11.5	13.9	13.3	11.3	13.9	13.3	17.9	11.7	13.3	15.4	12.6	13.3
Hydrocrackate	2.4	3.1	2.9		4.1	3.0		4.0	3.0	1.0	3.8	3.1	1.1	3.7	3.1
FCC Gasoline:	34.7	38.3	37.4	35.8	37.9	37.3	34.3	38.4	37.3	24.3	41.6	37.3	27.4	40.6	37.3
Full Range															
Full Range - Desulf.	34.7	38.3	37.4	35.8	37.9	37.3	34.3	38.4	37.3	24.3	41.6	37.3	27.4	40.6	37.3
Light															
Light - Desullf.															
Medium															
Medum - Desulf.															
Heavy															
Heavy - Desulf.															
Reformate	17.4	30.1	27.0	19.3	29.4	26.9	19.7	29.3	26.9	22.5	28.4	27.0	21.0	28.9	27.0
Light		9.3	7.0		9.5	7.1		9.4	7.1		9.5	7.1		9.5	7.1
Heavy	17.4	20.8	20.0	19.3	20.0	19.8	19.7	19.9	19.8	22.5	18.9	19.8	21.0	19.4	19.8
Oxygenate	12.1	0.5	3.4	12.1	0.5	3.4	12.1	0.5	3.4	12.1	0.5	3.4	12.1	0.5	3.4
Gasoline Volume (K Bbl/day)	20.0	60.0	80.0	20.0	60.0	80.0	20.0	60.0	80.0	20.0	60.0	80.0	20.0	60.0	80.0

Exhibit 4: Gasoline Composition and Volume, by Gasoline Type

Gasoline Composition & Volume	Case 12: 15cap/350														
	No Retr. -- Inflex			No Retr. -- Flex			Retr. -- De-Rate			Retr. -- Series			Scale Economies		
	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool
Composition (vol%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C4s:	2.0	5.4	4.5	2.0	5.4	4.6	2.0	5.4	4.6	2.0	5.4	4.6	2.0	5.4	4.6
Butenes															
I-Butane		0.9	0.6	1.3	0.3	0.6	0.0	0.8	0.6		0.8	0.6		0.8	0.6
N-Butane	2.0	4.5	3.9	0.7	5.1	4.0	2.0	4.7	4.0	2.0	4.7	4.0	2.0	4.7	4.0
C5s & Isomerate	12.9	3.8	6.1	15.2	3.1	6.1	14.8	3.2	6.1	14.4	3.3	6.1	16.2	2.8	6.1
Raffinate	4.9	0.4	1.5	4.5	0.5	1.5	4.2	0.6	1.5	5.8	0.1	1.5	2.9	1.0	1.5
Natural Gas Liquids		0.3	0.2												
Naphtha	2.2	4.1	3.7	0.1	5.1	3.9	2.7	4.3	3.9	0.0	5.2	3.9	0.2	5.1	3.9
C5-160	2.2	3.7	3.3		4.6	3.5	2.5	3.8	3.5		4.6	3.5		4.6	3.5
Coker Naphtha															
160-250		0.4	0.3	0.1	0.5	0.4	0.1	0.5	0.4		0.5	0.4	0.2	0.5	0.4
Alkylate	13.2	13.3	13.3	12.7	13.5	13.3	13.8	13.1	13.3	11.1	14.0	13.3	13.1	13.3	13.3
Hydrocrackate	1.9	3.3	2.9		3.9	2.9	0.3	3.8	2.9		3.9	2.9		3.9	2.9
FCC Gasoline:	29.8	39.9	37.4	35.5	38.0	37.3	28.9	40.1	37.3	35.7	37.9	37.3	35.5	38.0	37.3
Full Range															
Full Range - Desulf.	29.8	39.9	37.4	35.5	38.0	37.3	28.9	40.1	37.3	35.7	37.9	37.3	35.5	38.0	37.3
Light															
Light - Desullf.															
Medium															
Medum - Desulf.															
Heavy															
Heavy - Desulf.															
Reformate	21.1	28.9	27.0	18.0	30.0	27.0	21.2	28.9	27.0	18.9	29.7	27.0	18.0	30.0	27.0
Light	1.1	9.0	7.0		9.2	6.9		9.1	6.9	1.0	8.8	6.8		9.1	6.8
Heavy	20.0	19.9	19.9	18.0	20.8	20.1	21.2	19.8	20.2	17.9	20.9	20.2	18.0	20.9	20.2
Oxygenate	12.1	0.5	3.4	12.1	0.5	3.4	12.1	0.5	3.4	12.1	0.5	3.4	12.1	0.5	3.4
Gasoline Volume (K Bbl/day)	20.0	60.0	80.0	20.0	60.0	80.0	20.0	60.0	80.0	20.0	60.0	80.0	20.0	60.0	80.0

Exhibit 4: Gasoline Composition and Volume, by Gasoline Type

Gasoline Composition & Volume	Case 13: 15cap/15cap														
	No Retr. -- Inflex			No Retr. -- Flex			Retr. -- De-Rate			Retr. -- Series			Scale Economies		
	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool	RFG	Conv.	Pool
Composition (vol%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C4s:	2.0	5.4	4.6	2.0	5.4	4.6	2.9	5.1	4.6	2.7	5.2	4.6	2.5	5.3	4.6
Butenes															
I-Butane		0.8	0.6		0.8	0.6		0.8	0.6		0.8	0.6		0.8	0.6
N-Butane	2.0	4.6	3.9	2.0	4.7	4.0	2.9	4.4	4.0	2.7	4.4	4.0	2.5	4.5	4.0
C5s & Isomerate	16.3	2.7	6.1	16.3	2.7	6.1	9.8	4.9	6.1	9.9	4.9	6.1	12.0	4.2	6.1
Raffinate	4.6	0.5	1.5	1.6	1.4	1.5	5.9		1.5	5.9		1.5	5.9		1.5
Natural Gas Liquids															
Naphtha	0.1	5.1	3.9	0.2	5.1	3.9	0.1	5.1	3.9	0.0	5.2	3.9	1.4	4.7	3.9
C5-160		4.7	3.5		4.6	3.5		4.6	3.5		4.6	3.5	1.3	4.2	3.5
Coker Naphtha															
160-250	0.1	0.4	0.4	0.2	0.5	0.4	0.1	0.5	0.4		0.5	0.4	0.1	0.5	0.4
Alkylate	11.9	13.7	13.3	14.1	13.0	13.3	15.2	12.6	13.3	13.6	13.2	13.3	14.4	12.9	13.3
Hydrocrackate		3.9	2.9	0.3	3.8	2.9	0.3	3.8	2.9	2.0	3.2	2.9	0.3	3.8	2.9
FCC Gasoline:	35.7	37.9	37.4	35.3	38.0	37.3	34.6	38.2	37.3	34.7	38.2	37.3	31.6	39.2	37.3
Full Range															
Full Range - Desulf.	35.7	37.9	37.4	35.3	38.0	37.3	34.6	38.2	37.3	34.7	38.2	37.3	31.6	39.2	37.3
Light															
Light - Desullf.															
Medium															
Medum - Desulf.															
Heavy															
Heavy - Desulf.															
Reformate	17.3	30.2	27.0	18.1	30.0	27.0	19.2	29.6	27.0	19.1	29.7	27.0	19.8	29.4	27.0
Light		9.3	7.0		9.1	6.9		9.1	6.9	1.0	8.8	6.8		9.1	6.8
Heavy	17.3	20.9	20.0	18.1	20.8	20.2	19.2	20.5	20.2	18.1	20.9	20.2	19.8	20.3	20.2
Oxygenate	12.1	0.5	3.4	12.1	0.5	3.4	12.1	0.5	3.4	12.1	0.5	3.4	12.1	0.5	3.4
Gasoline Volume (K Bbl/day)	20.0	60.0	80.0	20.0	60.0	80.0	20.0	60.0	80.0	20.0	60.0	80.0	20.0	60.0	80.0

Exhibit 5: Kerosene and Diesel Properties

	Case 11: 15cap/3500																			
	No Retr. -- Inflex				No Retr. -- Flex				Retr. -- De-Rate				Retr. -- Series				Scale Economies			
	Kero-	Diesel			Kero-	Diesel			Kero-	Diesel			Kero-	Diesel			Kero-	Diesel		
Properties	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**
API Gravity	43.0	36.4	34.8	36.0	43.0	36.6	34.9	36.1	43.0	36.0	37.4	36.4	43.0	36.6	34.8	36.1	43.0	36.6	34.8	36.1
Sulfur (ppm)	666	7	3,526	912	666	7	3,527	912	666	8	3,581	927	666	7	3,527	912	666	7	3,527	912
Cetane Index		47.4	46.2	47.1		47.5	45.9	47.1		47.2	49.1	47.7		47.5	45.9	47.1		47.5	45.9	47.1
Aromatics (vol%	17.2	29.5	34.5	30.8	17.2	28.8	34.5	30.3	16.5	33.0	21.9	30.1	17.2	28.8	34.5	30.3	17.2	28.8	34.5	30.3
En. Den. (MM Btu/bbl)	5.615	5.779	5.804	5.785	5.615	5.775	5.801	5.781	5.614	5.783	5.756	5.776	5.615	5.775	5.801	5.782	5.615	5.775	5.801	5.782
Distillation (% off)																				
350°	4.6			0.0	4.6			0.0	6.0			0.0	4.6			0.0	4.6			0.0
375°	19.0	1.3		1.0	19.0	1.6		1.2	20.7	1.2		0.9	19.0	1.5		1.1	19.0	1.5		1.1
400°	40.4	3.2	0.4	2.5	40.4	3.5	0.4	2.7	41.6	3.1	0.5	2.4	40.4	3.5	0.4	2.7	40.4	3.5	0.4	2.7
425°	58.8	7.4	3.7	6.5	58.8	7.7	3.9	6.7	59.3	7.6	3.0	6.4	58.8	7.7	3.8	6.7	58.8	7.7	3.8	6.7
450°	75.2	16.3	14.1	15.7	75.2	16.5	14.8	16.1	75.2	17.0	13.3	16.0	75.2	16.5	14.7	16.0	75.2	16.5	14.7	16.0
475°	91.2	27.8	29.0	28.1	91.2	27.9	30.8	28.6	90.5	29.1	29.1	29.1	91.2	27.8	30.4	28.5	91.2	27.8	30.4	28.5
500°	98.4	40.5	44.4	41.5	98.4	40.5	46.9	42.1	97.9	42.1	45.2	42.9	98.4	40.5	46.4	42.0	98.4	40.5	46.4	42.0
525°		54.6	57.3	55.3		54.8	59.5	56.0		55.6	59.1	56.5		54.8	59.1	55.9		54.8	59.1	55.9
550°		67.7	68.8	68.0		68.1	70.4	68.7		68.2	71.1	68.9		68.1	70.1	68.6		68.1	70.1	68.6
575°		78.3	78.2	78.3		78.7	79.3	78.9		78.3	80.9	78.9		78.7	79.1	78.8		78.7	79.1	78.8
600°		87.4	86.7	87.2		87.7	87.3	87.6		87.0	89.5	87.6		87.7	87.2	87.6		87.7	87.2	87.6
625°		95.0	94.4	94.8		95.2	94.5	95.0		94.3	97.3	95.1		95.2	94.6	95.0		95.2	94.6	95.0
Volume (K bbl/d)	13.0	26.0	9.0	35.0	13.0	26.0	9.0	35.0	13.0	26.0	9.0	35.0	13.0	26.0	9.0	35.0	13.0	26.0	9.0	35.0

Exhibit 5: Kerosene and Diesel Properties

	Case 12: 15cap/350																			
	No Retr. -- Inflex				No Retr. -- Flex				Retr. -- De-Rate				Retr. -- Series				Scale Economies			
	Kero-	Diesel			Kero-	Diesel			Kero-	Diesel			Kero-	Diesel			Kero-	Diesel		
Properties	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**	**sene**	**On-Rd.**	**Off-Rd.**	**Pool**
API Gravity	43.0	36.7	34.9	36.3	42.7	36.8	34.8	36.3	42.5	37.1	35.8	36.8	42.5	37.4	34.0	36.5	42.5	37.4	34.0	36.5
Sulfur (ppm)	666	7	353	96	665	8	353	97	664	8	355	97	664	7	351	96	664	7	351	96
Cetane Index		48.0	45.8	47.5		47.5	45.9	47.1		48.6	45.1	47.7		48.7	43.8	47.4		48.6	43.8	47.4
Aromatics (vol%	17.2	29.2	34.5	30.6	17.5	29.1	34.5	30.5	16.4	28.5	34.5	30.0	17.7	28.5	34.4	30.0	17.7	28.5	34.4	30.0
En. Den. (MM Btu/bbl)	5.615	5.773	5.801	5.780	5.624	5.771	5.805	5.780	5.627	5.765	5.786	5.770	5.627	5.760	5.819	5.775	5.627	5.760	5.818	5.775
Distillation (% off)																				
350°	4.6			0.0	2.3			0.0	1.8			0.0	1.9			0.0	1.9			0.0
375°	19.0	1.3		1.0	14.6	2.1		1.5	13.5	1.4	2.9	1.8	13.7	2.1	0.5	1.7	13.7	2.1	0.5	1.7
400°	40.4	3.3	0.4	2.5	34.3	4.2	0.3	3.2	32.7	3.2	5.0	3.7	33.0	4.2	1.4	3.5	33.0	4.2	1.4	3.5
425°	58.8	7.4	3.8	6.5	54.0	8.6	3.7	7.3	52.8	7.3	10.0	8.0	53.0	8.7	4.9	7.7	53.0	8.7	4.9	7.7
450°	75.2	16.3	14.3	15.8	72.2	17.2	13.7	16.3	71.6	16.1	20.1	17.1	71.5	17.3	15.2	16.7	71.5	17.3	15.2	16.7
475°	91.2	27.8	29.3	28.2	90.1	28.1	28.2	28.1	90.0	27.7	31.7	28.7	89.9	28.2	29.1	28.5	89.9	28.2	29.1	28.5
500°	98.4	40.5	44.7	41.6	98.2	40.5	43.2	41.2	98.2	40.5	44.3	41.5	98.2	40.5	43.9	41.4	98.2	40.5	43.9	41.4
525°		54.6	57.6	55.4		55.1	56.3	55.4		54.8	57.9	55.6		55.0	57.1	55.6		55.0	57.0	55.6
550°		67.8	69.2	68.1		68.8	68.2	68.6		68.1	70.6	68.7		68.6	68.8	68.7		68.6	68.8	68.7
575°		78.4	78.7	78.5		79.4	78.1	79.1		78.7	80.2	79.1		79.2	78.6	79.1		79.2	78.6	79.1
600°		87.5	87.3	87.4		88.1	87.0	87.8		87.7	87.9	87.8		87.9	87.5	87.8		87.9	87.5	87.8
625°		95.1	95.1	95.1		95.4	95.1	95.3		95.3	94.6	95.1		95.2	95.0	95.1		95.2	95.0	95.1
Volume (K bbl/d)	13.0	26.0	9.0	35.0	13.0	26.0	9.0	35.0	13.0	26.0	9.0	35.0	13.0	26.0	9.0	35.0	13.0	26.0	9.0	35.0

Exhibit 5: Kerosene and Diesel Properties

	Case 13: 15cap/15cap									
	No Retr. -- Inflex		No Retr. -- Flex		Retr. -- De-Rate		Retr. -- Series		Scale Economies	
Properties	Kero-sene	Diesel On&Off Rd.	Kero-sene	Diesel On&Off Rd.	Kero-sene	Diesel On&Off Rd.	Kero-sene	Diesel On&Off Rd.	Kero-sene	Diesel On&Off Rd.
API Gravity	43.0	36.8	42.5	36.9	42.5	36.9	42.6	36.6	42.6	36.6
Sulfur (ppm)	666	8	664	8	664	8	664	8	664	8
Cetane Index		48.2		48.0		48.0		47.6		47.6
Aromatics (vol%	16.8	29.8	15.7	30.2	15.7	30.2	17.6	30.0	17.6	30.0
En. Den. (MM Btu/bbl)	5.615	5.771	5.626	5.769	5.626	5.769	5.626	5.773	5.626	5.773
Distillation (% off)										
350°	4.6		2.5		2.5		2.2		2.2	
375°	18.8	1.0	14.9	1.5	14.9	1.5	14.3	1.5	14.3	1.5
400°	40.0	2.6	34.6	3.3	34.6	3.3	33.9	3.3	33.9	3.3
425°	58.5	6.7	54.3	7.5	54.3	7.5	53.7	7.5	53.7	7.5
450°	75.2	15.9	72.5	16.5	72.5	16.5	72.0	16.5	72.0	16.5
475°	91.2	28.3	90.3	28.3	90.3	28.3	90.0	28.3	90.0	28.3
500°	98.4	41.7	98.3	41.4	98.3	41.4	98.2	41.3	98.2	41.3
525°		55.5		55.6		55.6		55.5		55.5
550°		68.2		68.7		68.7		68.7		68.7
575°		78.5		79.1		79.1		79.0		79.0
600°		87.4		87.8		87.8		87.8		87.8
625°		95.0		95.1		95.1		95.1		95.1
Volume (K bbl/d)	13.0	35.0	13.0	35.0	13.0	35.0	13.0	35.0	13.0	35.0

Exhibit 6: Composition of Kerosene and Diesel

	Case 11: 15cap/3500																			
	No Retr. -- Inflex				No Retr. -- Flex				Retr. -- De-Rate				Retr. -- Series				Scale Economies			
Properties	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**
Composition (vol%)	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Naphtha	**20.0**			**5.4**	**20.0**			**5.4**	**18.3**			**5.0**	**20.0**			**5.4**	**20.0**			**5.4**
Straight Run	20.0			5.4	20.0			5.4	18.3			5.0	20.0			5.4	20.0			5.4
Desulf. -- Conv.																				
Desulf. -- Tier 2																				
Kerosene	**80.0**	**22.7**	**36.8**	**40.9**	**80.0**	**21.8**	**39.5**	**40.9**	**72.9**	**23.1**	**45.8**	**40.9**	**80.0**	**22.0**	**39.1**	**40.9**	**80.0**	**22.0**	**39.1**	**40.9**
Straight Run	17.1		36.8	11.5	17.1		39.5	12.0	26.8		45.8	15.8	17.1		39.1	12.0	17.1		39.1	12.0
Desulf. -- Conv.	62.9			17.0	62.9			17.0					62.9			17.0	62.9			17.0
Desulf. -- Tier 2		22.7		12.3		21.8		11.8	46.1	23.1		25.0		22.0		11.9		22.0		11.9
Hydrocracked		**9.2**	**7.9**	**6.5**		**11.9**	**8.6**	**8.1**	**8.8**	**8.4**	**8.6**	**8.5**		**11.7**	**8.6**	**7.9**		**11.7**	**8.6**	**7.9**
Jet		9.2		5.0		11.9		6.4	8.8	8.4		6.9		11.7		6.3		11.7		6.3
Distillate																				
Raw			7.9	1.5			8.6	1.6			8.6	1.6			8.6	1.6			8.6	1.6
Desulf. -- Tier 2		0.0		0.0		0.0		0.0						0.0		0.0		0.0		0.0
Distillate		**39.2**	**30.3**	**26.9**		**39.3**	**26.7**	**26.3**		**33.9**	**42.4**	**26.3**		**39.4**	**27.5**	**26.5**		**39.4**	**27.5**	**26.5**
Straight Run			30.3	5.7			26.7	5.0			42.4	7.9			27.5	5.2			27.5	5.2
Desulf. -- Conv.																				
Desulf. -- Tier 2		39.2		21.2		39.3		21.3		33.9		18.4		39.4		21.4		39.4		21.4
Light Cycle Oil		**18.0**	**25.1**	**14.4**		**16.5**	**25.2**	**13.7**		**24.1**	**3.2**	**13.7**		**16.6**	**24.9**	**13.7**		**16.6**	**24.9**	**13.7**
Raw			25.1	4.7			25.2	4.7			2.5	0.5			24.9	4.7			24.9	4.7
Desulf. -- Conv.																				
Desulf. -- Tier 2		18.0		9.7		16.5		9.0		24.1	0.8	13.2		16.6		9.0		16.6		9.0
Coker Distillate		**10.9**		**5.9**		**10.4**		**5.6**		**10.4**		**5.6**		**10.4**		**5.6**		**10.4**		**5.6**
Raw																				
Desulf. -- Conv.																				
Desulf. -- Tier 2		10.9		5.9		10.4		5.6		10.4		5.6		10.4		5.6		10.4		5.6
Volume (K bbl/d)	13.0	26.0	9.0	48.0	13.0	26.0	9.0	48.0	13.0	26.0	9.0	48.0	13.0	26.0	9.0	48.0	13.0	26.0	9.0	48.0

Exhibit 6: Composition of Kerosene and Diesel

	Case 12: 15cap/350																			
	No Retr. -- Inflex				No Retr. -- Flex				Retr. -- De-Rate				Retr. -- Series				Scale Economies			
Properties	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**	**Kero**	**On-Rd.**	**Off-Rd.**	**Pool**
Composition (vol%)	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Naphtha	**20.0**			**5.4**	**10.2**			**2.8**	**6.7**		**4.5**	**2.7**	**8.1**		**2.3**	**2.6**	**8.1**		**2.3**	**2.6**
Straight Run	20.0			5.4	10.2			2.8	6.7		4.5	2.7	8.1		2.3	2.6	8.1		2.3	2.6
Desulf. -- Conv.																				
Desulf. -- Tier 2																				
Kerosene	**80.0**	**23.0**	**35.9**	**40.9**	**89.8**	**18.8**	**34.0**	**40.9**	**93.3**	**23.7**	**14.8**	**40.9**	**91.9**	**18.2**	**32.6**	**40.9**	**91.9**	**18.2**	**32.6**	**40.9**
Straight Run	17.1			4.6	3.7			1.0	29.6		14.8	10.8	18.3		12.4	7.3	18.3		11.4	7.1
Desulf. -- Conv.	62.9		35.9	23.8	86.1		34.0	29.7					73.5		20.2	23.7	73.5		21.1	23.9
Desulf. -- Tier 2		23.0		12.5		18.8		10.2	63.8	23.7		30.1		18.2		9.9		18.2		9.9
Hydrocracked		**9.5**	**7.9**	**6.6**		**16.9**	**8.6**	**10.8**		**10.4**	**27.9**	**10.8**		**17.1**	**8.6**	**10.8**		**17.1**	**8.6**	**10.8**
Jet		9.5		5.1		16.9		9.2		10.4	19.3	9.2		17.1		9.2		17.1		9.2
Distillate																				
Raw			7.9	1.5			8.6	1.6			8.6	1.6			8.6	1.6			8.6	1.6
Desulf. -- Tier 2																				
Distillate		**39.7**	**28.7**	**26.9**		**38.2**	**30.1**	**26.3**		**40.7**	**22.6**	**26.3**		**37.0**	**33.3**	**26.3**		**37.0**	**33.3**	**26.3**
Straight Run			0.1	0.0			0.1	0.0											0.3	0.1
Desulf. -- Conv.			28.6	5.4			30.0	5.6												
Desulf. -- Tier 2		39.7		21.5		38.2		20.7		40.7	22.6	26.3		37.0	33.3	26.3		37.0	33.0	26.2
Light Cycle Oil		**17.0**	**27.5**	**14.3**		**15.7**	**27.3**	**13.6**		**15.6**	**27.9**	**13.7**		**17.2**	**23.3**	**13.7**		**17.2**	**23.3**	**13.7**
Raw																				
Desulf. -- Conv.			27.5	5.2			27.3	5.1												
Desulf. -- Tier 2		17.0		9.2		15.7		8.5		15.6	27.9	13.7		17.2	23.3	13.7		17.2	23.3	13.7
Coker Distillate		**10.9**		**5.9**		**10.4**		**5.6**		**9.6**	**2.3**	**5.6**		**10.4**		**5.6**		**10.4**		**5.6**
Raw																				
Desulf. -- Conv.																				
Desulf. -- Tier 2		10.9		5.9		10.4		5.6		9.6	2.3	5.6		10.4		5.6		10.4		5.6
Volume (K bbl/d)	13.0	26.0	9.0	48.0	13.0	26.0	9.0	48.0	13.0	26.0	9.0	48.0	13.0	26.0	9.0	48.0	13.0	26.0	9.0	48.0

Exhibit 6: Composition of Kerosene and Diesel

	Case 13: 15cap/15cap														
	No Retr. -- Inflex			No Retr. -- Flex			Retr. -- De-Rate			Retr. -- Series			Scale Economies		
Properties	**Kero**	**On&Off Rd.**	**Pool**	**Kero**	**On&Off Rd.**	**Pool**	**Kero**	**On&Off Rd.**	**Pool**	**Kero**	**On&Off Rd.**	**Pool**	**Kero**	**On&Off Rd.**	**Pool**
Composition (vol%)	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Naphtha	**18.3**		**5.0**	**9.9**		**2.7**	**9.9**		**2.7**	**9.5**		**2.6**	**9.5**		**2.6**
Straight Run	18.3		5.0	9.9		2.7	9.9		2.7	9.5		2.6	9.5		2.6
Desulf. -- Conv.															
Desulf. -- Tier 2															
Kerosene	**81.1**	**25.9**	**40.8**	**90.1**	**22.6**	**40.9**	**90.1**	**22.6**	**40.9**	**90.5**	**22.4**	**40.9**	**90.5**	**22.4**	**40.9**
Straight Run	26.8		7.3	28.8		7.8	28.8		7.8	18.2		4.9	18.2		4.9
Desulf. -- Conv.										72.2		19.6	72.2		19.6
Desulf. -- Tier 2	54.3	25.9	33.6	61.3	22.6	33.1	61.3	22.6	33.1		22.4	16.4		22.4	16.4
Hydrocracked	**0.6**	**9.5**	**7.1**		**14.9**	**10.9**		**14.9**	**10.9**		**14.9**	**10.9**		**14.9**	**10.9**
Jet	0.6	7.5	5.6		12.7	9.2		12.7	9.2		12.7	9.2		12.7	9.2
Distillate															
Raw															
Desulf. -- Tier 2		2.0	1.5		2.2	1.6		2.2	1.6		2.2	1.6		2.2	1.6
Distillate		**36.8**	**26.8**		**36.1**	**26.3**		**36.1**	**26.3**		**36.1**	**26.3**		**36.1**	**26.3**
Straight Run															
Desulf. -- Conv.															
Desulf. -- Tier 2		36.8	26.8		36.1	26.3		36.1	26.3		36.1	26.3		36.1	26.3
Light Cycle Oil		**19.7**	**14.4**		**18.7**	**13.7**		**18.7**	**13.7**		**18.9**	**13.8**		**18.9**	**13.8**
Raw															
Desulf. -- Conv.															
Desulf. -- Tier 2		19.7	14.4		18.7	13.7		18.7	13.7		18.9	13.8		18.9	13.8
Coker Distillate		**8.1**	**5.9**		**7.7**	**5.6**		**7.7**	**5.6**		**7.7**	**5.6**		**7.7**	**5.6**
Raw															
Desulf. -- Conv.															
Desulf. -- Tier 2		8.1	5.9		7.7	5.6		7.7	5.6		7.7	5.6		7.7	5.6
Volume (K bbl/d)	13.0	35.0	48.0	13.0	35.0	48.0	13.0	35.0	48.0	13.0	35.0	48.0	13.0	35.0	48.0

Exhibit 7: Distillate Desulfurization --
Feed and Output Volumes and Properties

	Diesel Fuel Cases									
	Case 11: 15cap/3500					Case 12: 15cap/350				
	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ
CONVENTIONAL										
Feed (K bbl/d)	**8.2**	**8.2**	**0.0**	**8.2**	**8.2**	**16.5**	**19.4**	**0.0**	**11.4**	**11.5**
Heavy Naphtha	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
Kerosene	8.2	8.2		8.2	8.2	11.4	14.3		11.4	11.5
Virgin Distillate	0.0	0.0		0.0	0.0	2.6	2.7		0.0	0.0
Light Cycle Oil	0.0	0.0		0.0	0.0	2.5	2.5		0.0	0.0
Coker Distillate	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
Other	0.0	0.0		0.0	0.0	0.0	0.0		0.0	0.0
Output (K bbl/d)	**8.2**	**8.2**	**0.0**	**8.2**	**8.2**	**16.5**	**19.4**	**0.0**	**11.4**	**11.5**
Feed Properties										
API Gravity	41.8	41.9		41.9	41.9	37.7	38.3		41.9	41.8
Sulfur (ppm)	2,180	2,180		2,180	2,180	3,470	3,090		2,200	2,200
Cetane Index	48.0	48.0		48.0	48.0	45.8	46.2		48.0	48.0
Aromatics (vol%)	18.4	18.4		18.4	18.4	27.6	26.1		18.4	18.4
Output Properties										
API Gravity	42.4	42.4		42.4	42.4	38.7	39.2		42.4	42.4
Sulfur (ppm)	330	330		330	330	350	310		330	330
Cetane Index	49.0	49.0		49.0	49.0	47.2	47.5		49.0	49.0
Aromatics (vol%)	17.4	17.4		17.4	17.4	26.7	25.1		17.4	17.4
H2 Use: MM scf/d	**0.5**	**0.5**	**0.0**	**0.5**	**0.5**	**2.2**	**2.3**	**0.0**	**0.7**	**0.7**
Scf/bbl	**63**	**63**		**63**	**63**	**133**	**120**		**63**	**63**
TIER 2										
Feed (K bbl/d)	**23.5**	**22.9**	**29.8**	**22.9**	**22.9**	**23.5**	**21.6**	**36.2**	**26.6**	**26.5**
Heavy Naphtha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kerosene	5.9	5.7	12.0	5.7	5.7	6.0	4.9	14.4	4.7	4.7
Virgin Distillate	10.2	10.2	8.8	10.2	10.2	10.3	9.9	12.6	12.6	12.6
Light Cycle Oil	4.6	4.2	6.3	4.3	4.3	4.3	4.0	6.5	6.5	6.5
Coker Distillate	2.9	2.7	2.7	2.7	2.7	2.9	2.7	2.7	2.7	2.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Output (K bbl/d)	**23.8**	**23.1**	**30.1**	**23.2**	**23.2**	**23.7**	**21.8**	**36.6**	**26.9**	**26.9**
Feed Properties										
API Gravity	32.3	32.5	33.9	32.5	32.5	32.8	32.5	34.4	31.7	31.7
Sulfur (ppm)	9,030	8,890	7,410	8,950	8,950	8,740	8,960	6,820	8,410	8,410
Cetane Index	43.4	43.7	43.7	43.7	43.7	44.1	44.1	44.8	43.6	43.5
Aromatics (vol%)	34.5	33.8	34.1	33.9	33.9	34.1	34.4	32.0	37.0	37.1
Output Properties										
API Gravity	35.8	35.9	37.0	35.9	35.9	36.1	35.9	37.4	35.2	35.2
Sulfur (ppm)	6	6	6	6	6	6	6	6	6	6
Cetane Index	47.5	47.8	47.6	47.8	47.8	48.3	48.3	48.4	47.9	47.9
Aromatics (vol%)	30.7	30.1	30.6	30.2	30.2	30.4	30.7	28.6	33.2	33.2
H2 Use: MM scf/d	**9.9**	**9.4**	**11.8**	**9.4**	**9.4**	**9.7**	**9.1**	**12.8**	**12.0**	**11.9**
Scf/bbl	**422**	**411**	**395**	**412**	**412**	**413**	**421**	**353**	**450**	**450**
COMBINED										
Feed (K bbl/d)	**31.7**	**31.0**	**29.8**	**31.1**	**31.1**	**40.0**	**41.0**	**36.2**	**37.9**	**38.0**
Heavy Naphtha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kerosene	14.1	13.8	12.0	13.9	13.9	17.4	19.1	14.4	16.1	16.2
Virgin Distillate	10.2	10.2	8.8	10.2	10.2	12.9	12.6	12.6	12.6	12.6
Light Cycle Oil	4.6	4.2	6.3	4.3	4.3	6.8	6.5	6.5	6.5	6.5
Coker Distillate	2.9	2.7	2.7	2.7	2.7	2.9	2.7	2.7	2.7	2.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Output (K bbl/d)	**32.0**	**31.3**	**30.1**	**31.3**	**31.3**	**40.2**	**41.2**	**36.6**	**38.3**	**38.3**
Feed Properties										
API Gravity	34.8	34.9	33.9	34.9	34.9	34.8	35.2	34.4	34.7	34.7
Sulfur (ppm)	7,343	7,198	7,410	7,247	7,247	6,605	6,229	6,820	6,632	6,621
Cetane Index	44.6	44.8	43.7	44.8	44.8	44.8	45.1	44.8	44.9	44.9
Aromatics (vol%)	30.3	29.8	34.1	29.8	29.8	31.4	30.4	32.0	31.4	31.4
Output Properties										
API Gravity	37.5	37.6	37.0	37.6	37.6	37.2	37.5	37.4	37.3	37.4
Sulfur (ppm)	87	88	6	88	88	146	148	6	100	100
Cetane Index	47.9	48.1	47.6	48.1	48.1	47.8	47.9	48.4	48.2	48.2
Aromatics (vol%)	27.3	26.8	30.6	26.8	26.8	28.9	28.1	28.6	28.5	28.5
H2 Use: MM scf/d	**10.5**	**9.9**	**11.8**	**10.0**	**10.0**	**11.9**	**11.4**	**12.8**	**12.7**	**12.7**
Scf/bbl	**330**	**319**	**395**	**320**	**320**	**298**	**278**	**353**	**334**	**333**

Exhibit 7: Distillate Desulfurization -- Feed and Output Volumes and Properties

	Diesel Fuel Cases				
	Case 13: 15cap/15cap				
	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ
CONVENTIONAL					
Feed (K bbl/d)	**0.0**	**0.0**	**0.0**	**9.4**	**9.4**
Heavy Naphtha				0.0	0.0
Kerosene				9.4	9.4
Virgin Distillate				0.0	0.0
Light Cycle Oil				0.0	0.0
Coker Distillate				0.0	0.0
Other				0.0	0.0
Output (K bbl/d)	**0.0**	**0.0**	**0.0**	**9.4**	**9.4**
Feed Properties					
API Gravity				41.9	41.9
Sulfur (ppm)				2,180	2,180
Cetane Index				48.0	48.0
Aromatics (vol%)				18.4	18.4
Output Properties					
API Gravity				42.4	42.4
Sulfur (ppm)				330	330
Cetane Index				49.0	49.0
Aromatics (vol%)				17.4	17.4
H2 Use: MM scf/d	**0.0**	**0.0**	**0.0**	**0.6**	**0.6**
Scf/bbl				**63**	**63**
TIER 2					
Feed (K bbl/d)	**39.3**	**38.4**	**38.4**	**30.5**	**30.5**
Heavy Naphtha	0.0	0.0	0.0	0.0	0.0
Kerosene	16.1	15.8	15.8	7.8	7.8
Virgin Distillate	12.9	12.6	12.6	12.6	12.6
Light Cycle Oil	6.8	6.5	6.5	6.5	6.5
Coker Distillate	2.9	2.7	2.7	2.7	2.7
Other	0.7	0.8	0.8	0.8	0.8
Output (K bbl/d)	**39.7**	**38.8**	**38.8**	**30.8**	**30.8**
Feed Properties					
API Gravity	34.6	34.7	34.7	32.8	32.8
Sulfur (ppm)	6,610	6,520	6,520	7,660	7,660
Cetane Index	44.8	45.0	45.0	44.1	44.1
Aromatics (vol%)	31.6	31.3	31.3	34.8	34.8
Output Properties					
API Gravity	37.5	37.6	37.6	36.0	36.0
Sulfur (ppm)	6	6	6	6	6
Cetane Index	48.4	48.5	48.5	48.1	48.1
Aromatics (vol%)	28.2	27.9	27.9	31.1	31.1
H2 Use: MM scf/d	**13.6**	**13.0**	**13.0**	**12.4**	**12.4**
Scf/bbl	**345**	**338**	**338**	**408**	**408**
COMBINED					
Feed (K bbl/d)	**39.3**	**38.4**	**38.4**	**39.9**	**39.9**
Heavy Naphtha	0.0	0.0	0.0	0.0	0.0
Kerosene	16.1	15.8	15.8	17.2	17.2
Virgin Distillate	12.9	12.6	12.6	12.6	12.6
Light Cycle Oil	6.8	6.5	6.5	6.5	6.5
Coker Distillate	2.9	2.7	2.7	2.7	2.7
Other	0.7	0.8	0.8	0.8	0.8
Output (K bbl/d)	**39.7**	**38.8**	**38.8**	**40.2**	**40.2**
Feed Properties					
API Gravity	34.6	34.7	34.7	34.9	34.9
Sulfur (ppm)	6,610	6,520	6,520	6,425	6,425
Cetane Index	44.8	45.0	45.0	45.0	45.0
Aromatics (vol%)	31.6	31.3	31.3	30.9	30.9
Output Properties					
API Gravity	37.5	37.6	37.6	37.5	37.5
Sulfur (ppm)	6	6	6	80	80
Cetane Index	48.4	48.5	48.5	48.3	48.3
Aromatics (vol%)	28.2	27.9	27.9	27.9	27.9
H2 Use: MM scf/d	**13.6**	**13.0**	**13.0**	**13.0**	**13.0**
Scf/bbl	**345**	**338**	**338**	**327**	**327**

Exhibit 8: Estimated Cost of Diesel Fuel Standards

	Diesel Fuel Cases														
	Case 11: 15cap/3500					Case 12: 15cap/350					Case 13: 15cap/15cap				
Measure	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ	No Retr. Inflex	No Retr. Flex	Retr. De-Rate	Retr. Series	Scale Econ
Total Average Cost (¢/gal.)	**7.0**	**7.3**	**6.8**	**4.7**	**4.6**	**5.8**	**5.5**	**6.1**	**4.5**	**4.1**	**7.8**	**7.6**	**6.5**	**5.1**	**4.7**
Variable Refining Cost	0.3	0.3	0.5	0.2	0.4	0.4	0.5	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.8
Capital Charge	5.6	5.6	5.0	3.2	2.9	4.3	4.1	4.5	3.0	2.5	5.9	5.8	4.8	3.4	2.9
Ancillary Refining Cost	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Delta Additives Cost	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3
Mileage Loss	0.4	0.7	0.7	0.6	0.6	0.4	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4
Total Annual Cost ($ million)*	**2,290**	**2,390**	**2,230**	**1,540**	**1,500**	**2,550**	**2,400**	**2,680**	**2,000**	**1,820**	**3,410**	**3,360**	**2,880**	**2,250**	**2,080**
Variable Refining Cost	90	90	160	80	130	200	230	250	260	310	260	280	280	280	340
Capital Charge	1,850	1,830	1,620	1,050	960	1,910	1,790	1,980	1,330	1,110	2,620	2,570	2,100	1,520	1,290
Ancillary Refining Cost	140	140	140	120	120	180	170	180	170	160	190	190	180	170	170
Delta Additives Cost	80	80	80	80	80	80	80	80	80	80	110	110	110	110	110
Mileage Loss	130	250	230	210	210	180	130	190	160	160	230	210	210	170	170
Investment ($ million)*	**6,080**	**6,030**	**5,490**	**3,400**	**3,110**	**6,280**	**5,890**	**6,670**	**4,320**	**3,600**	**8,640**	**8,450**	**7,050**	**4,920**	**4,170**
Diesel Volume Affected															
Notional Refinery (K bbl/d)	26	26	26	26	26	35	35	35	35	35	35	35	35	35	35
U.S. (ex Calif.) (MM bbl/d)**	2.1	2.1	2.1	2.1	2.1	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9

* In $2000; excludes California.

** Based on projected daily U.S. volume of 3.79 MM bbl/d for 2005 (Table A11, *1999 Annual Energy Outlook* , EIA), less 15% heating oil share, minus 344 K bbl/d of California production (CEC projections for 2005).

Exhibit 9a: Per Gallon Cost of Desulfurization Standards

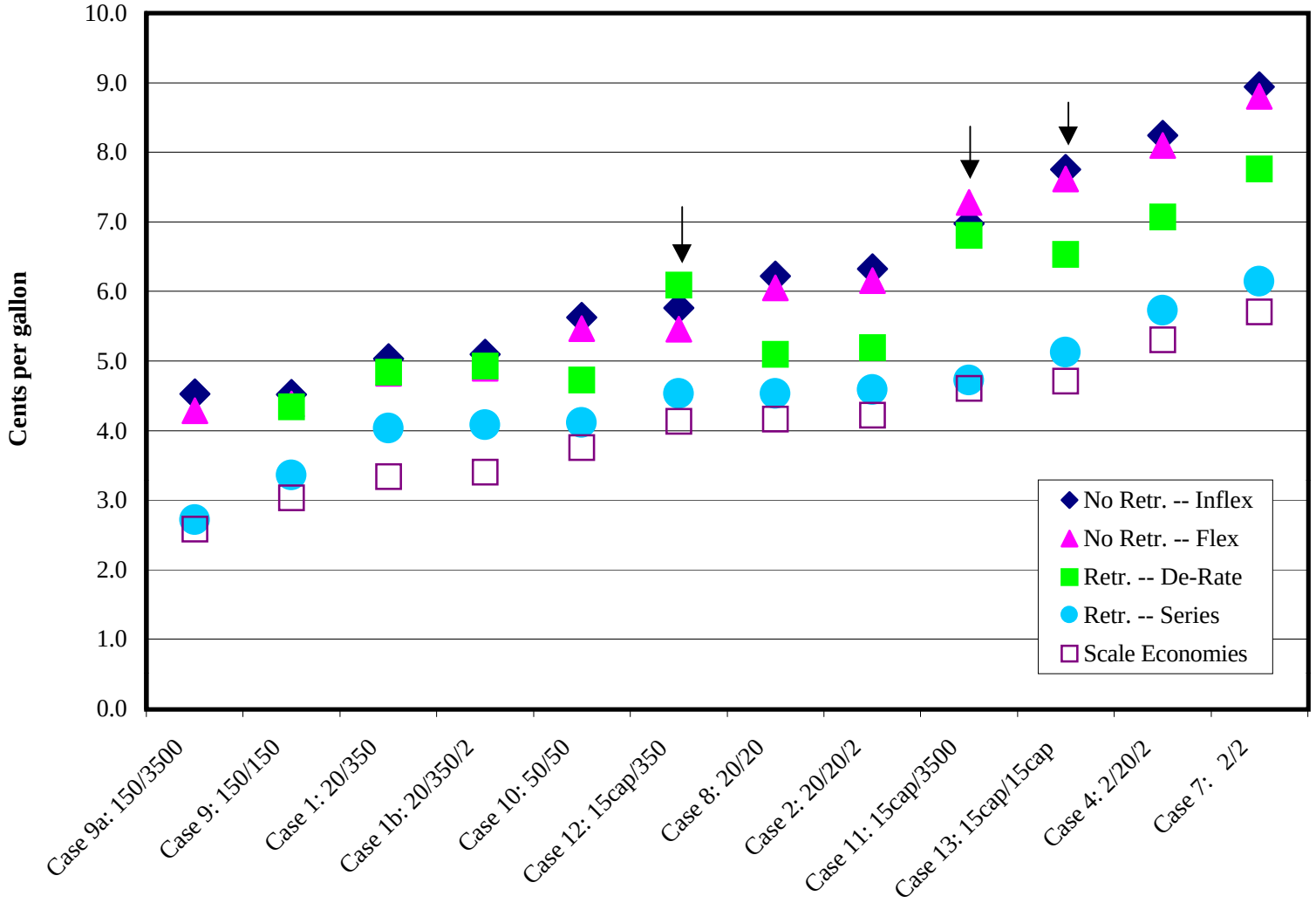

Exhibit 9b: Annual Cost of Desulfurization Standards

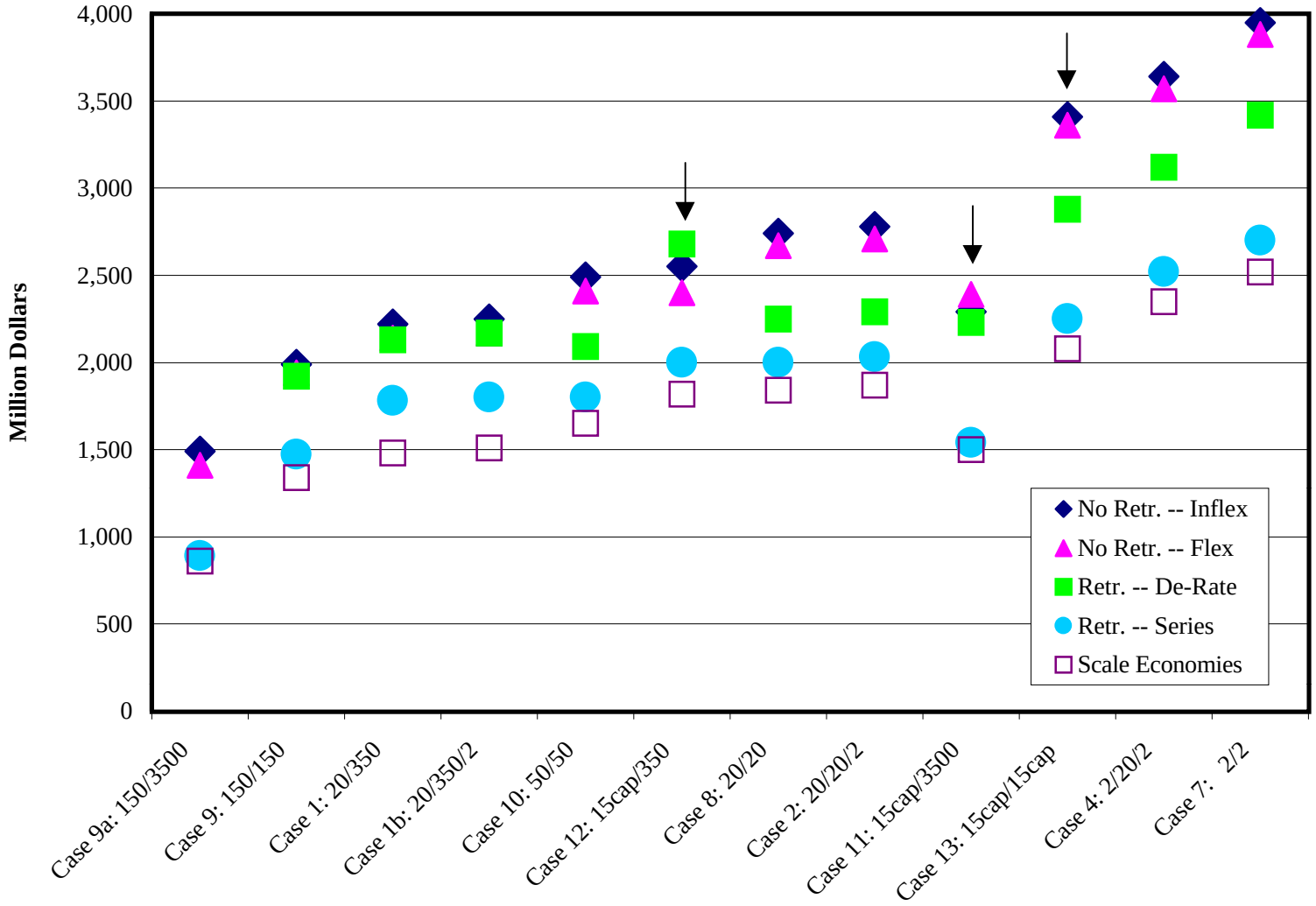

Exhibit 9c: Investment Cost of Desulfurization Standards