Final Regulatory Impact Analysis and Summary and Analysis of Comments on the NPRM

Interim Control of Gasoline Volatility

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This Final Regulatory Impact Analysis (FRIA) comprises a significant portion of the supporting documentation for an interim national RVP control program, reducing gasoline volatility to 10.5, 9.5, and 9.0 psi, depending on the area of the country. Documentation not included in this Final RIA may be found in the Draft RIA associated with the August 19, 1987 volatility proposal or in the Preamble to the Final Rule for the interim RVP control program.

Included in the analyses found here are summaries of comments received on the issues pertaining to the choice of the period and location of RVP control, the cost, the environmental impact and the cost effectiveness of an interim control program and EPA's responses to them. Also included is a summary and analysis of comments received on how to treat alcohol blends under such a program. An appendix to this document contains the summary and analysis of comments on the enforcement aspects of this program. The Preamble addresses comments on the impact of gasoline volatility regulations on the natural gas liquids industry, the alcohol blend industry and small refiners.

Each chapter of this Final RIA begins with a brief synopsis of the methodology and significant input factors of the Draft RIA analysis. This is followed by a summary and analysis of the comments received. Completing each chapter is the final analysis of that aspect of the regulatory analysis.

Chapter 1

Volatility Control Period and Gasoline Distribution

I. Synopsis of NPRM Analysis

EPA's volatility proposal which would limit gasoline volatility during a determined regulatory control period was based on various analyses and assumptions. The length of the control period was decided upon after examining the seasonal pattern of ozone violations and the transition times necessary to blend down the high RVP gasoline to compliance RVP levels. Volatility control levels were based on the ASTM RVP class in each state. The relative RVP control levels for each ASTM RVP class were based on emission analyses showing roughly equal emissions when constant percentage reductions were applied to the ASTM limits. The following paragraphs summarize the analyses performed and the conclusions made.

A. Control Period

Ozone violations in non-attainment areas follow a seasonal trend, with the majority of violations occurring during the summer months. This is due to the higher temperatures and longer hours of daylight, both of which contribute to ozone formation. Because of this seasonal trend, hydrocarbon (HC) emission control measures which have the flexibility of being implemented for only a few months during the year are advantageous. Volatility control is one such HC emission control measure which can be implemented for only a few months during the year as needed. In order to determine the best period to implement this control, EPA in the DRIA examined both the trends of ozone violations in non-attainment areas and the time required by the gasoline distribution system to deliver RVP-controlled fuel to service stations.

1. Seasonal Pattern of Ozone Violations

The analysis which EPA used in the proposal to determine the period during which nationwide ozone violations occurred focused on the "design value day" of the non-attainment areas. This day is defined to be the day on which occurred the fourth highest daily maximum one-hour measured ozone concentration in the area over a three-year period (or, when less data is available, the third highest from a two-year period or the second highest from a single year's data). The analysis, therefore, focuses on a one-day period for each non-attainment area. EPA's analysis in the DRIA of seasonal ozone non-attainment examined the distribution of design value days over the twelve months in order to determine a period during which nearly all of these days would occur. The analysis used 1982-84 design value days for non-California urban non-attainment areas.

EPA also performed a second, broader analysis in the DRIA which examined all ozone exceedance days rather than just design value days. This analysis focused on 1981-83 exceedances rather than 1982-84. The total annual exceedances by month for the non-attainment areas were tabulated. Because exceedances were taken from each monitoring site and a non-attainment area may have more than one monitoring site, any specific non-attainment area could have more than 31 exceedances per month (one violation per day) depending on how many monitoring sites the area had.

Finally, EPA evaluated seasonal trends in peak ozone concentrations. The average of all areas' maximum ozone levels by month were used to determine over what period peak concentrations occurred.

Houston was singled out as a having a unique, year-round ozone problem and some of the analyses excluded Houston due to this fact. The ozone exceedance data for Houston showed a relatively large number of exceedances in 1980 and 1983. Also, Houston recorded exceedances in every month of both years; no other area recorded exceedances in more than eight months of either year.

Based on the results of the above evaluations, EPA found the two primary choices for seasonal ozone control to be May-September and June-September. Because of the greater potential to impact ozone exceedances, May-September was recommended as the period when ozone control should be regulated.

2. Transition Times for Compliance

The proposed volatility control program was aimed at the months during the year when the majority of ozone exceedances occur: May through September. EPA recognized the fact that in order to be in compliance at all points in the distribution system, fuel must be refined and shipped before the compliance date. Based on a contractor report ("Petroleum Storage and Transport Times," Jack Faucett Associates (hereafter Faucett Study)) and EPA evaluation, the Agency assumed that there would be an average shipping time of about four weeks prior to the beginning of the control period and four weeks at the end.

3. Starting and Ending Dates for the Regulatory Control Period

May 16 through September 15 was proposed as the regulatory control period and was intended to provide control during the entire May through September period. This took into account the calculated transition times at the beginning and end of the control period. It also assumed that for the estimated four week transitions at the beginning and end of the control

period, controlled fuel would increasingly enter the market, resulting in the equivalent of two weeks of complete control during each four week transition period.

B. State-by-State Volatility Classifications

In the Volatility DRIA, EPA proposed to adopt RVP control levels which represented a constant percent reduction from the current ASTM gasoline volatility classification system for each state or portion of a state during the May through September period. This was based on the observation that such a system yielded roughly consistent evaporative emissions in the 61 non-attainment areas. From the viewpoint of gasoline distribution, this was also the most straightforward system to use due to the fact that participants in the distribution system were already familiar with the classification system.

C. Relative RVP Standards in the ASTM Class A, B and C Areas

Proposed volatility standards in the NPRM were derived using Class C fuel as a base. Reductions in RVP levels proportional to the Class C reduction were then applied to Class A and B areas in order to obtain equivalent degrees of emission control in all areas of the country. Class C areas were used as the basis since the climate implicit in the Federal Test Procedure (FTP), used in developing our test data on the effect of RVP on emissions, most closely matches the climate in Class C areas.

II. Summary and Analysis of Comments

EPA received comments on each of the topics summarized above. The following sections will summarize the comments received in these areas and give EPA's response to these comments.

A. Control Period

Comments on the control period were divided into three main topics: 1) the seasonal pattern of ozone violations; 2) the length of time required to make the transition to the lower RVP fuel and problems that may occur during this transition; and 3) the starting and ending dates of the control period itself.

1. Seasonal Pattern of Ozone Violations

Although EPA proposed a four-month period for volatility controls (mid-May to mid-September) which when combined with the transition periods was intended to give sufficient control for the five month period of May through September, NRDC pointed out that ozone violations are not solely confined to

the summer months. They commented that EPA data show that nineteen cities experienced at least one ozone violation outside the May-September period in 1980. Because of this, there should also be concern about preventing ozone violations in early spring and "Indian summer."

SOHIO stated that if the necessary two-month transition periods were added to the proposed regulatory control period, the length of the control period would increase. This, however, would have a minimal impact on the ambient ozone levels since the emission reductions would occur before or after the "ozone season."

Whereas the DRIA analyses suggested that ozone control during May through September was most important, EPA has reanalyzed this issue using more recent ozone data. Ozone exceedance data from 1985-87 was examined to determine more precisely when ozone exceedances occurred. Analyses were performed to determine the percentage of exceedances that occurred during the proposed period of May through September, and then to look at the percentage and level of exceedances in April and October. The geographic locations of April and October exceedances were then examined to determine whether the pattern of exceedances was unduly influenced by any unusual local ozone problems.

Table 1-1 shows the results of an analysis which calculated the percentage of ozone exceedances which occurred during various monthly periods. Due to the fact that California and Houston both have serious ozone exceedance problems during many months of the year, the analysis was performed both with and without these areas. Their unique ozone problems influence the potential control period and will likely warrant extra local control strategies in both cases. EPA found that for the entire nation 88.5 percent of the exceedances fell in the May through September period. This increased to 95 percent when California and Houston were excluded.

EPA then looked at the months of April and October to determine how frequent were the exceedances in those months. For the entire nation, 4 percent of all exceedances fell in each of the months of April and October. When California and Houston were excluded, 3 percent of the exceedances occurred in April and only one percent in October. These results show that control during the period of May through September would affect approximately 95 percent of the nationwide exceedances.

In addition to looking at the frequency of the exceedances, the ozone levels associated with the 1985-87 exceedances in May and September as well as April and October were examined. At an ozone concentration greater than or equal

Table 1-1

1985-87 Ozone Exceedances by Month (Percent of Total)

	Entire Nation	Without CA and Houston
April	4	3
May-September	88.5	95
October	4	1
Percent of Exceedances Greater than or Equal to .14 ppm O_3		
April	45	36
May	38	32
September	44	22
October	69	67

to 0.14, additional control over the stationary and mobile source control which is currently being phased in may be necessary to bring an area into compliance. Table 1-1 shows the percentages of exceedances greater than or equal to 0.14 for each of the four months. In April, 45 percent of the exceedances for the entire nation were greater than or equal to 0.14. When California and Houston were excluded, this dropped to 36 percent. For comparison, in May 38 percent of exceedances nationwide were greater than or equal to 0.14. Excluding California and Houston, the percentage became 32 percent. In October for the entire nation, 69 percent were equal to or above 0.14. This only dropped to 67 percent when California and Houston were excluded. In September 44 percent of nationwide exceedances and 22 percent without California and Houston were greater than or equal to 0.14.

The uncontrolled diurnal index (UDI) is another measure of the desirability of applying RVP control to reduce the level of ozone exceedances, in this case evaluating the likely magnitude of evaporative emissions in an area. The indices are calculated using the actual temperature range of the city on the exceedance date, the atmospheric pressure of the area based on its elevation, the RVP level of the area based on its ASTM classification, and an assumed 61.5 percent full gas tank to account for fuel weathering and in-use tank level variability (see Chapter 2 of DRIA).

UDIs were calculated for the 1985-87 exceedances in April and October. A UDI equal to 2.0 represents the UDI level for 11.5 RVP fuel under FTP certification temperature and tank level conditions (representative of current ASTM Class C areas.) Areas with a UDI greater than 2.0, therefore, would likely be in need of control. UDIs were calculated for the April and October exceedances in order to determine the degree that evaporative emissions were contributing to these ozone exceedances. For the April exceedances, 58 percent were greater than 2.0, with an average UDI of 2.793. Similar results occurred in October, with 62% of UDIs being greater than 2.0, and with an average UDI of 3.311.

Both the UDI and ozone level analyses indicate that ozone control during April and October requires serious consideration. However, it must be remembered that only 3 and 1 percent of all ozone violations occur in April and October, respectively. Thus, while the violations are often severe and excess evaporative emissions are high, the violations are infrequent. Also, the dates on which these April and October exceedances occurred show that control during only a portion of each month may be sufficient. The majority of exceedances in April occurred during the last two weeks (79 percent), and in October 84 percent occurred during the first two weeks. Therefore, beginning the control period May 1 would likely

provide substantial control during the last two weeks of April. While ending control September 15 may only provide slight control in early October, the small fraction of ozone violations occurring during October made the extension of RVP control through September less efficient.

2. Transition Times for Compliance

Nearly all the comments received on this issue were from refiners who stated that two months are needed once refiners begin shipping low-RVP fuel to mix down the high RVP gasoline and be in compliance with the low RVP standard. API commented that although only four to five weeks are currently needed to make the transition, lowering the RVP even further would dramatically increase the transition time necessary for compliance. API estimated that 60-65 days will be needed for 95 percent of the low RVP gasoline to reach the consumer with the more stringent regulations. API stated that the Faucett study (which was used by EPA to determine the transportation times involved in the transition) did not accurately describe the transportation and storage times which would be experienced in a more stringent volatility controlled environment such as the one proposed by EPA.

After conducting their own survey of industry transportation and storage times, API commented that the estimated times of supplying gasoline presented by Faucett for the current regulations appeared somewhat low but were not unreasonable. However, the estimated transportation and storage times under the volatility proposal were underestimated by Faucett because a "plug flow" assumption was used to describe the movement of gasoline through the distribution system.

Amoco, in agreement with API, stated that the Faucett study did not recognize back-mixing effects in storage tanks. They asserted that Faucett's plug-flow assumption was overly optimistic and that the transition times were, therefore, underestimated. Amoco also stated that the transport times for marine movements used in the study were low. Valero Refining, in quantifying the effect of the proposed RVP regulations on their operations, modified the Bonner & Moore linear programming system to include a one month transition time as input unlike the two months that others were claiming. However, they also mentioned API's two month transition time as the amount of time that may actually be necessary.

In addition to increased costs, the problems brought up in the comments about the two month transition were problems of safety, driveability and increased HC emissions. According to comments, these problems would occur due to low RVP fuel reaching the consumer early in the transition period when there may still be cooler temperatures.

In response to these comments on EPA's transition assumptions, the transition times were reanalyzed in greater detail in order to take into account backmixing effects. This reanalysis used the transportation and storage times from the Faucett study as a basis in the analysis. Although some commenters felt these numbers weren't accurate, the Faucett estimates were in general agreement with API's values. In any event, the commenters did not provide sufficient justification for EPA to revise the Faucett values.

The goal of the reanalysis was to calculate the 70th percentile transition time for a terminal to mix down to compliance from an unregulated Class C RVP to a regulated Class B RVP. The 70th percentile time was chosen because refiners have some control over the distribution system, being able to send one RVP fuel to some regions while sending another elsewhere. However, this control is not absolute and some fuel must reach certain sites early for another to just be in compliance in time. The calculated transition time was an average of transition times for a one-terminal and a two-terminal line (in a two-terminal line the gasoline goes through two terminals before going to service stations). The analysis assumes 70/30 mixing (70 percent new fuel, 30 percent old fuel) for the one-terminal line, and 90/10 and 70/30 mixing for the two terminals in a two-terminal line, respectively. Terminals were assumed to receive new batches of fuel every five days for the first terminal, and every seven days for the second terminal in the line. (One-terminal lines are assumed to receive fuel every five days.)

The transition time includes the transportation time from the refinery to the first terminal by pipeline (9.4 days according to Faucett), the average amount of time necessary for the first terminal to mix down to compliance after the first batch of new fuel is received (15 days for a one-terminal line, 5 days for a two-terminal line); the average additional amount of time necessary for the second terminal to mix down to compliance after the first terminal is in compliance, if applicable (22 days); the extra amount of time needed for the 70th percentile terminal to come into compliance to account for the fact that all the base values from Faucett were for the 50th percentile terminal (5 days according to Faucett); and, finally, seven additional days to account for any delays. Thus, an average of about six weeks appears to be needed for terminal compliance at the beginning of an RVP control period.

For service stations, it was assumed that there was 80/20 mixing in the tanks and, based on the Faucett study, new fuel was received every three days. From this, an average of an extra five or six days will be needed, above the terminal compliance time, for service stations to come into compliance.

Transition times were also calculated for the situation of an additional mid-summer RVP change (i.e., from a Class C to a Class B or a Class B to a Class A requirement). The same assumptions as in the above calculations were used in this analysis. In this case since the RVP of the fuel has a shorter range by which to decrease, the transition time would be shorter than that for the first change of the control season and would take about 5 weeks for terminal compliance.

At the end of the control period, EPA determined in a similar analysis that the refineries can on average stop producing the controlled fuel 8 days before the end of the control period. This is the amount of time necessary, based on the Faucett study, for the 30th percentile terminal to receive its first batch of uncontrolled fuel from the refiner. This is not the same amount of time as at the start of the control period because, after this first batch has been mixed in at the terminal, the terminal is no longer in compliance with the lower RVP standard.

Therefore, when accounting for backmixing in the tanks, EPA concluded that under the proposed volatility regulations the required transition time at the beginning of the control period would be six weeks rather than the two months the comments suggested. In addition, refiners can stop production an average of one week early.

Finally, the potential problems raised by the commenters on safety, driveability, and increased HC emissions during the transition period only apply to the second proposed phase of RVP control and are not a factor for the first phase of control.

3. Starting and Ending Dates for the Regulatory Control Period

EPA proposed a control period of May 16 through September 15. In response to this, various other periods were suggested in the comments. Amoco suggested a two-month regulatory period of July 1-August 31. They reasoned that when adding the sixty day period needed to flush the distribution system, four months of control would result. NRDC and Chrysler both stated that the period of control may need to be extended to a five month period of May 1 - September 30. NRDC commented that because ozone violations also occur outside the summer months, year-round controls on volatility may be desirable to the extent that they are consistent with driveability considerations. NRDC suggested that at a minimum, the control period should be extended into the warmer periods of the spring and fall. Chrysler suggested that this longer control period is preferable because many southern areas have summer-like temperatures before May 16 and after September 15. They also commented that this period would be less disruptive to current

procedures of gasoline distribution. The New Jersey Department of Environmental Protection commented that the proposed season of May 16 through September 15 is too narrow to satisfy the needs of the Northeastern United States. They stated that the Northeast often experiences exceedances during April, early May, and late September. They suggested that an intermediate limit for volatility could be set for these time periods. Sun Oil Co. and NADA both stated that the control period had been appropriately limited. NADA commented that since very few ozone violations occur during the winter months, EPA is justified in focusing on the four month period of mid-May through mid-September. Volkswagen suggested that a longer control period (beyond May 16-September 15) should only be evaluated after this regulation has been implemented to see if an extension is warranted.

In order to respond to the comments received and to determine the appropriate regulatory control period, the amount of control obtained during the transition period and the RVP levels at terminals and service stations during the time period of March through mid-November were reanalyzed.

Using the calculated transition times, RVP levels at terminals and stations over the summertime period were determined for different regulatory control periods. Two cases were examined: one for a terminal compliance period of May 1 through September 30, and a second for a terminal compliance period of May 16 through September 15. In order to determine the RVP level obtained during the transition periods at the beginning and end of the control period, several assumptions were made. The partial control RVP levels were calculated assuming 70-30 mixing at the terminals with seven days between new batches of fuel and one-seventh of the total number of terminals receiving the new batch each day. For service stations, 80-20 mixing was assumed, with new batches coming every three days and one-third of the stations receiving the new fuel each day.

As shown in Tables 1-2 and 1-3, this analysis showed that a terminal compliance period of May 1 to September 30 gives, on average, full compliance at service stations from May 8 to September 30 and partial control beginning around April 1 and continuing as late as November 8. A terminal compliance period of May 16 to September 15 gives full station compliance from May 23 to September 15 and partial control beginning around April 15 and continuing as late as October 22. While the tables show the results of a reductions to 9.0 RVP, the times to blend down to 10.5 RVP are the same.

The results of this analysis show that when mixing down from an uncontrolled to a controlled RVP level, 85 percent of the RVP reduction at the service stations has been achieved two weeks prior to the start of the terminal control period. In mixing from a controlled to an uncontrolled level at the end of

Table 1-2

Transition RVP Levels
Terminal Compliance Period: May 1 - September 30*

Date		Refinery	Terminal	Service Station
March	1	13.50	13.50	13.50
	15	9.00	13.50	13.50
	30	9.00	13.50	13.50
April	1	9.00	12.86	13.33
	8	9.00	10.22	11.10
	15	9.00	9.36	9.65
	22	9.00	9.11	9.21
	30	9.00	9.03	9.05
May	1	9.00	9.00	9.04
	8	9.00	9.00	9.00
	15	9.00	9.00	9.00
	30	9.00	9.00	9.00
June		9.00	9.00	9.00
July		9.00	9.00	9.00
August		9.00	9.00	9.00
September	1	9.00	9.00	9.00
	15	13.50	9.00	9.00
	30	13.50	9.00	9.00
October	1	13.50	9.45	9.12
	8	13.50	12.28	11.38
	15	13.50	13.14	12.85
	22	13.50	13.39	13.29
	30	13.50	13.47	13.45
November	1	13.50	13.50	13.46
	8	13.50	13.50	13.50
	15	13.50	13.50	13.50

* Assumes transition from uncontrolled Class D fuel (13.5) to controlled Class C fuel (9.0).

Table 1-3

Transition RVP Levels
Terminal Compliance: May 16 - September 15*

Date		Refinery	Terminal	Service Station
March	1	13.50	13.50	13.50
	15	13.50	13.50	13.50
	30	13.50	13.50	13.50
April	1	9.00	13.50	13.50
	15	9.00	13.50	13.50
	16	9.00	12.86	13.33
	23	9.00	10.22	11.10
	30	9.00	9.36	9.65
May	7	9.00	9.11	9.21
	14	9.00	9.03	9.05
	15	9.00	9.00	9.04
	23	9.00	9.00	9.00
	30	9.00	9.00	9.00
June		9.00	9.00	9.00
July		9.00	9.00	9.00
August		9.00	9.00	9.00
September	1	13.50	9.00	9.00
	15	13.50	9.00	9.00
	16	13.50	9.45	9.12
	23	13.50	12.28	11.38
	30	13.50	13.14	12.85
October	6	13.50	13.39	13.29
	14	13.50	13.47	13.45
	15	13.50	13.50	13.46
	22	13.50	13.50	13.50
	30	13.50	13.50	13.50

* Assumes transition from uncontrolled Class D fuel (13.5) to controlled Class C fuel (9.0).

the control period, 85 percent of the control at the service stations is lost two weeks after the end of the control period. Therefore, a control period beginning May 1 at terminals would provide two weeks of additional, nearly complete control at service stations at the end of April and some control in early April. A control period ending on September 15 at the terminals, however, would provide little added control at service stations in October.

In the DRIA, April was shown to contain more design value days (4) than either May (0) or October (1). Also, April contained at least the same percentage of ozone violations (1 percent, excluding Houston and California) as October (0-1 percent); May contained more (1-3 percent). The more recent analysis shown in Table 1-1 here indicates the same: April contains a greater percentage of ozone violations (3 percent) than October (1 percent). Though a greater percentage of October's violations are over 0.14 ppm ozone, its total number of such violations is lower, due to its lower total number of violations. Therefore, it appears more important to obtain some control in late April than in early October and a regulatory control period of May 1 through September 15 for terminals is recommended.

2. State-by-State Volatility Classifications

As stated above, EPA proposed to enforce the current ASTM monthly volatility classifications and geographical boundaries, but with proportionally reduced RVPs during the control period. The one change to the ASTM system that EPA proposed was to eliminate the transition months, requiring compliance with the lower volatility class during months with two classifications. Marathon supported compliance in accordance with the ASTM schedule of seasonal and geographical volatility classes, stating that a different EPA-designated control period should not be required. Phillips supported this, as well, but stated that the current ASTM transition periods should be kept since eliminating them would significantly increase costs at the beginning and end of the ozone season.

CARB did not agree with enforcing the ASTM monthly classifications or geographical boundaries as they apply to California. They commented that, for California, the EPA system should match California's current requirements. California is currently divided into fourteen air basin areas, with five different ozone seasons. The seasons are all contained in the period of April-October. Volatility is limited to 9 RVP during the given ozone season. CARB commented that EPA's interim proposal for California is not as stringent as their current system and that any regulation should be at least as stringent as the current one.

Other commenters held various opinions as to where RVP-controlled fuel should be required. Sinclair commented that the control should only be required in areas where it is needed (i.e., ozone non-attainment areas), and, therefore, should not be imposed uniformly on all refiners. Sinclair suggested that either all gasoline refined in non-attainment areas be required to meet "ultra-low" RVP specifications or that RVP exemptions should be granted for gasoline shipped to attainment areas. Sinclair also suggested that since the Rockies and Plains were close to being in full compliance with the standard, they may not need the proposed regulation. Since only 40 percent of the fuel in the area is brought in from outside areas (namely, Texas and Louisiana), the regulated outside fuel would give enough of an RVP reduction to put the area in full compliance. SOHIO stated that RVP control must be enforced in all areas since refiners cannot segregate the gasoline between attainment and non-attainment areas. According to SOHIO, only segregation over broad regional areas is possible. (For this reason, SOHIO suggested that EPA should exercise all authority available to preempt and prevent state volatility regulations.)

API, in agreement with SOHIO's comment above, stated that the supply system is unable to differentiate between states, or parts of states, with different ASTM classes. As a consequence, they say, the lowest RVP gasoline for a given area must be supplied to the entire area. TOSCO also stated that the development of a patchwork of different volatility controls across the country would create uncertainty for refiners and marketers working to meet a variety of standards. This could result in gasoline supply problems in certain areas of the country. Wickland Oil raised a concern about the fungibility of gasoline. Since the gasoline distribution system is based on fungibility, they said, it cannot simultaneously handle large quantities of the same grade of gasoline with different RVPs. Wickland Oil currently sends 9.0 RVP gasoline to all areas which they supply, although California, Nevada, and Oregon have different requirements. Amoco commented that there may be driveability problems in those Class C areas adjacent to Class A areas (Denver, El Paso, Phoenix, Salt Lake City). According to Amoco, some exemptions may be necessary to amend this.

Volatility designations on a state-by-state basis were reevaluated to determine if any changes to the current ASTM class system should occur. (EPA does not refer here to a change of the ASTM RVP classification system, but to an EPA system whose RVP control levels are a function of the ASTM levels for each class.) Dual classification areas (i.e., states which according to the ASTM system are assigned either of two RVP classes in a particular month to allow for flexibility during transitions) were first examined to determine which single classification should be applied to the area. For states with non-attainment areas, the UDI on the

design value day was the determining factor in the choice of class. For those states without non-attainment areas, location with respect to surrounding class levels was the main factor. A UDI analysis was also performed for single-classification areas to determine whether any changes to the current ASTM class system might enhance the workability of the control program without the loss of non-attainment area emission benefits.

In the NPRM, EPA proposed that in dual classification areas the lower of the two RVP classes be the basis of the standard. This approach was reexamined on a state by state basis to determine how much control these areas need during the months of dual classification to achieve the same emission reduction as other areas. For non-attainment areas which had dual classifications in any of the months from May to September, UDIs were calculated for the temperature conditions on exceedance days in that month with gasoline at the current ASTM RVP levels. Where the UDIs in a particular state were above 2.0 (2.0 being the UDI level for 11.5 RVP at FTP certification temperatures and tank level conditions), the lower RVP class was generally chosen for that state in that month.

For those dual classification areas which had no non-attainment areas, geographic proximity to states with non-attainment areas was the main factor in the decision about the level of the RVP standard. The standard was chosen based on the RVP of surrounding states and on the ease with which the distribution system could get fuel to that state. Agreeing that the gasoline distribution system cannot easily distinguish ASTM boundaries, as many comments mentioned, EPA grouped the class areas in various regions of the country as much as possible for each month.

Another UDI analysis was performed to determine if any changes should occur in the relative RVP control levels of the three classes which were based on the current ASTM class system. As with the dual-classification analysis above, UDIs were calculated for 1985-87 exceedance days using the current ASTM RVP levels. By examining both the level of the UDIs and maps of the current ASTM system and pipeline networks, EPA constructed a revised system of RVP classes across the country which retains most emission benefits while improving the manageability of the program for the gasoline distribution system.

Table 1-4 shows a list of states (or parts thereof) whose control levels have been relaxed and the number of months it was relaxed. The majority of the revisions affect Northwest states which contain no non-attainment areas (ID, MN, ND, East OR, SD, East WA, and WY). These areas are now considered as being Class C areas even though ASTM classifies them as Class C/B or Class B. Relaxations from Class A to Class B of southern Nevada and southern California were performed for similar reasons, since they also contain no non-attainment

Table 1-4

States With Relaxed RVP Control Designations

Relaxation from Class B to Class C:

Montana (5)*	Nebraska (5)	N. Carolina (1)
Idaho (5)	Kansas (3)	S. Carolina (1)
Wyoming (5)	Oklahoma (1)	Georgia (1)
S. Dakota (5)	Arkansas (2)	Alabama (1)
E. Washington (4)	Missouri (2)	Mississippi (1)
E. Oregon (4)	Iowa (2)	Louisiana (1)
Colorado (1)	N. Dakota (4)	Tennessee (1)
N. Nevada (1)		
Utah (1)		

Relaxation from Class A to Class B:

S. Nevada (5)	Arizona (2)	W. Texas (2)
SE California (5)	N. New Mexico (1)	S. New Mexico (2)

* Number in () shows number of months relaxed

areas. Arizona was relaxed from Class A to Class B during September due to the fact that it would be the only Class A state in the nation during that month. The rest of the non-California relaxations were dual ASTM classifications which are now being treated as the higher of the two classes rather than the lower. These relaxations were based on an analysis of the UDIs for the exceedance days of that month using the two levels of RVP.[1]

After examining California's exceedances, EPA concluded that those California areas which are currently Class C or B/C are in need of a Class B level of control.[1] Also, the southeast area which is currently Class A during the period of May through September contains no non-attainment areas and was, therefore, relaxed to Class B. For these reasons, and also in response to CARB's comment that the RVP control boundaries in California should match their current boundaries, California was designated as Class B across the entire state for the May through September period. Table 1-5 shows all of the classifications which were reexamined and the final result, where revisions were made to the proposed control levels.

3. Relative RVP Standards in the ASTM Class A, B, and C Areas

In the NPRM, EPA proposed an RVP limit of 9.0 psi in Class C areas with proportional RVP reductions in Classes A and B in order to obtain equivalent emission reductions in all three classes. The majority of comments disagreed with this approach and stated that the RVP levels should be based on cost-effectiveness rather than proportional reductions. This will be considered in EPA's analysis of the final RVP level. Those opposed to proportional volatility reductions stated that reductions outside Class C areas are not cost-effective. This is considered in Chapter 5. Others stated that RVP levels below 9.0 psi in Class A and B areas will also cause driveability and safety problems, thus compromising the performance of the vehicle. This is an issue for the final analysis of the second level of RVP control.

SOHIO stated that there is insufficient data to indicate that emissions are reduced when volatility drops below 9.0 psi, citing some data which indicate that total exhaust emissions increase as the fuel volatility drops below 9.0 psi. Again, all this is not relevant in this analysis of the interim program.

NRDC questioned whether tying volatility levels to ASTM classes was appropriate since ASTM limits are keyed to motor vehicle performance, not air quality. They suggested that EPA examine whether lower RVP limits would be appropriate in some areas.

Phillips disagrees with basing standards on reductions from Class C RVP levels, stating that the test procedure most closely matches Class B areas or possibly a worst case Class C. Phillips suggested that test fuels be matched to ASTM Class

Table 1-5

Exceptions to the Proposed System Based Only on ASTM Class
(--- indicates no change from ASTM system)[1]

State	May ASTM	May Final EPA	June ASTM	June Final EPA	July ASTM	July Final EPA	August ASTM	August Final EPA	September ASTM	September Final EPA
Alabama	---	---	---	---	C/B	B	---	---	B/C	C
Arizona	B/A	B	---	---	---	---	---	---	A	B
Arkansas	---	---	C/B	C	---	---	---	---	B/C	C
California:										
North Coast	---	---	C/B	B	---	---	---	---	---	---
South Coast	C/B	B	---	---	---	---	---	---	---	---
Southeast	B/A	B	A	B	A	B	A	B	A	B
Interior	C/B	B	---	---	---	---	---	---	---	---
Colorado	C/B	C	---	---	B/A	A	A/B	A	---	---
Connecticut	D/C	C	---	---	---	---	---	---	C/D	C
Delaware	D/C	C	---	---	---	---	---	---	----	---
Georgia	---	---	---	---	C/B	B	---	---	B/C	C
Idaho	C/B	C	B	C	B	C	B	C	B	C
Illinois:										
North	D/C	C	---	---	----	---	---	---	---	---
South	---	---	---	---	C/B	B	B/C	B	---	---
Indiana	D/C	C	---	---	---	---	---	---	---	---
Iowa	---	---	C/B	C	B/C	C	---	---	---	---
Kansas	C/B	C	B	C	---	---	---	---	B	C
Louisiana	---	---	---	---	C/B	B	---	---	B/C	C
Maine	D/C	C	---	---	---	---	---	---	C/D	C
Maryland	D/C	C	---	---	---	---	---	---	---	---
Massachusetts	D/C	C	---	---	---	---	---	---	C/D	C
Michigan	D/C	C	---	---	---	---	---	---	C/D	C
Minnesota	D/C	C	---	---	---	---	---	---	---	---
Mississippi	---	---	---	---	C/B	B	---	---	B/C	C
Missouri	---	---	C/B	C	---	---	---	---	B/C	C
Montana	C/B	C	B	C	B	C	B	C	B/C	C
Nebraska	C/B	C	B	C	B	C	B	C	B	C
Nevada:										
North	C/B	C	---	---	---	---	---	---	---	---
South	B/A	B	A	B	A	B	A	B	A	B
New Hampshire	D/C	C	---	---	---	---	---	---	C/D	C
New Jersey	D/C	C	---	---	---	---	---	---	C/D	C
New Mexico:										
North	B/A	B	---	---	---	---	A/B	A	---	---
South	B/A	B	---	---	---	---	---	---	A/B	B
New York	D/C	C	---	---	---	---	---	---	C/D	C
North Carolina	---	---	---	---	C/B	B	---	---	B/C	C
North Dakota	D/C	C	C/B	C	B	C	B	C	B/C	C
Ohio	D/C	C	---	---	---	---	---	---	---	---
Oklahoma	C/B	C	---	---	---	---	---	---	---	---

Table 1-5 (cont'd)

Exceptions to the ASTM Class System
(--- indicates no change from ASTM system)

State	May ASTM	May Final EPA	June ASTM	June Final EPA	July ASTM	July Final EPA	August ASTM	August Final EPA	September ASTM	September Final EPA
Oregon:										
East	D/C	C	C/B	C	B	C	B	C	B/C	C
West	D/C	C	---	---	---	---	---	---	---	---
Pennsylvania	D/C	C	---	---	---	---	---	---	C/D	C
Rhode Island	D/C	C	---	---	---	---	---	---	C/D	C
South Carolina	---	---	---	---	C/B	B	---	---	B/C	C
South Dakota	C/B	C	B	C	B	C	B	C	B	C
Tennessee	---	---	---	---	C/B	B	---	---	B/C	C
Texas:										
East	---	---	C/B	B	---	---	---	---	---	---
West	B/A	B	---	---	---	---	---	---	A/B	B
Utah	C/B	C	---	---	B/A	A	A/B	A	---	---
Vermont	D/C	C	---	---	---	---	---	---	C/D	C
Washington:										
East	D/C	C	C/B	C	B	C	B	C	B/C	C
West	D/C	C	---	---	---	---	---	---	---	---
West Virginia	D/C	C	---	---	---	---	---	---	---	---
Wisconsin	D/C	C	---	---	---	---	---	---	---	---
Wyoming	C/B	C	B	C	B	C	B	C	B	C

---

1 When ASTM system indicated a transition month (e.g., A/B), EPA proposed that that area be considered in the lower class.

B volatility levels and that gasoline volatility be limited to ASTM's current levels.

In the NPRM, EPA demonstrated that adopting ASTM RVP class standards with proportional RVP reductions in each class would provide roughly equivalent emissions across the country. EPA has performed a new analysis of expected evaporative emissions to examine more specifically whether the proposed standards should be adjusted in order to achieve our goal.

Essentially, an analysis of emissions on ozone exceedance days was performed by comparing UDIs in Class A and B areas to those in Class C areas for both diurnals and running losses. This analysis examined the UDIs on a monthly as well as an overall basis. The proposed proportional-reduction RVPs were used in these calculations (9.0, 7.8, and 7.0). The temperatures used to calculate the UDI for the diurnal analysis were the actual daily high and low temperatures of the non-attainment area on the exceedance date during 1985-1987. To simulate running losses, a second UDI was calculated using the daily high as the initial temperature and a temperature 15°F above this as the ending temperature. The 15°F represents the tank temperature increase resulting from a single LA-4 trip. The mean UDIs for each class on a monthly basis were then calculated. For Class A, a single city, Phoenix, has a large effect on the mean UDI; calculations were made both including and excluding Phoenix. The results are shown in Table 1-6.

The UDI levels for both diurnals and running losses were as high or higher in Class A and B areas than the levels in Class C areas. Therefore, when comparing the UDI levels in A and B areas to the level in C areas, this analysis indicates that no increase in the relative RVP standard levels from the proposal for Class B and A areas can be made if the goal of equivalent emissions in all areas is desired. If any change were to be made, a decrease for Classes A and B would appear necessary. This is primarily an issue for the final level of RVP control. However, it does demonstrate that 9.5 RVP control in Class B areas should be quite beneficial.

Table 1-6

Non-Attainment Area UDIs on Exceedance Days

		Diurnals		Running Losses	
Class	Month	Mean UDI	w/o Phoenix	Mean UDI	w/o Phoenix
A	June	1.8137	1.6057	3.1366	2.4567
	July	1.2181	1.2181	1.8338	1.8338
	August	1.0631	1.0631	1.5920	1.5920
	Total	1.2990	1.2005	2.0497	1.8088
B	May	0.9269		1.1906	
	June	1.2383		1.7865	
	July	0.9954		1.5512	
	August	1.1548		1.7169	
	September	0.9405		1.3304	
	Total	1.0863		1.6112	
C	Total	0.9004		1.5352	

Chapter 2

Effect of RVP on Vehicle Emission Factors

I. Synopsis of NPRM Analysis

The estimation of the effect of fuel RVP on vehicle emissions is very complex, especially that for evaporative emissions. In the Draft RIA, EPA utilized two distinct types of models to estimate evaporative exhaust and refueling emissions.

The most complex model applied to the estimation of diurnal emissions. Here a chemical equilibrium model was developed to predict the relative effects of fuel RVP, temperature and vehicle fuel tank level on fuel tank emissions. The estimated fuel tank emissions were then correlated against the diurnal emission test results from EPA's in-use emission factor program to provide in-use emission estimates over a wide range of climatic conditions. The model was also used to generate suitable average in-use fuel tank levels to account for fuel weathering, RVP and temperature variability and the wide range of fuel tank levels occurring in-use. The assumptions behind this model were shown to hold when applied against the test results of a smaller number of vehicles which were tested over 27 different combinations of fuel RVP and temperature.

The models used to estimate hot-soak and exhaust emissions versus RVP were much simpler. They primarily involved correlating measured emission test results under FTP conditions versus fuel RVP. These correlations were used directly to represent emissions in Class C areas. For Class A and B areas, it was assumed that their emissions were the same as those of Class C areas when their respective fuel RVPs matched the ratio of ASTM RVP limits. For example, emissions in all areas were equal when Class A, B, and C fuel RVPs were 9, 10 and 11.5, respectively, or 7.0, 7.8 and 9.0 respectively.

The model used to estimate the effect of fuel RVP on refueling emissions was developed primarily for the Draft RIA in support of onboard refueling emission standards.[1] It had been published prior to its use in the Draft RIA for gasoline volatility control and received substantial comment and reanalysis.[2][3] No comments were received with sufficient technical support to warrant changing this model here. Thus, it will not be discussed any further.

II. Summary and Analysis of Comments

In general comments on the evaporative and exhaust emissions models contained in the DRIA fell into the following five categories: 1) accounting for weathering of in-use fuel, 2) the representativeness of temperature, RVP and tank fill level inputs used to calculate emission factors, 3) the validity of the UDI correlations developed for predicting controlled diurnal emissions, 4) the accuracy of EPA's emission factor testing and 5) the magnitude of the effect of ethanol blends on evaporative emissions. Comments in each of those areas are examined in more detail below.

A. Fuel Weathering

Comments submitted by Texaco, General Motors, and API maintained that the effects of weathering were not considered in the DRIA vehicle evaporative emission analysis. EPA stated in the DRIA that fuel weathering was an important factor in assessing vehicle evaporative emissions and, in fact, the decrease in vehicle fuel RVP as a result of the weathering phenomenon was taken into account in the vehicle evaporative emission analysis.

The DRIA considered two basic categories of evaporative emissions generation: 1) hot-soak losses and 2) diurnal losses. As explained on page 2-34 of the DRIA, fuel weathering was not included in the hot-soak emissions analysis because neither ambient temperature effects nor the effect of temperature and RVP variability have been included in the hot-soak model. It is also explained that including these effects would largely offset the predicted decrease in hot-soak emissions due to fuel weathering. No evidence was presented demonstrating that these effects did not or could not offset each other.

The effects of fuel weathering on vehicle duirnal evaporative emissions were described in the DRIA on pages 2-71 through 2-89. It is concluded in this section that the effect of weathering and the variability in in-use fuel tank levels can be incorporated into the average fleet evaporative in-use fuel tank fill level. The analysis presented in the DRIA calculates a design value day in-use fuel tank level of 61.5% which accounts for fuel weathering, RVP variability and average in-use fuel tank level. Similarly the value of 53.1% in-use fuel tank level was calculated for July average temperature emissions modeling which similarly incorporates the effects of fuel weathering, RVP variability, average in-use fuel tank level, as well as July temperature variability. These values were used, as stated in the DRIA, for the city-specific MOBILE3

environmental analysis runs. Without the consideration of weathering, these fuel tank levels would have been much lower and emissions much higher.

B. Emission Factor Modeling Inputs

In general comments related to the representativeness of the data used to calculate evaporative emission factors fell into three categories: 1) temperature data, 2) RVP values and 3) in-use fuel tank fill levels. Texaco objected to the use of a single design day temperature for estimating emissions. While EPA agrees that use of additional high-ozone day temperatures would improve the analysis, such information is difficult to gather for 61 cities each year as the design value day is changed. Also, EPA's analysis does not focus on any one city, but on all 61 cities, so the variation in the "average" of the 61 temperatures should be quite small regardless of whether 1, 2 or 3 days were used for each city. No commenter presented a suitable alternative to the inputs used in the DRIA analysis.

Commenters also stated that EPA should not have increased each area's RVP to the ASTM maximum limit if it was historically below that limit. They stated that the fuel distribution system was such that lower limits in adjacent states often kept fuel in a given state below its maximum level.

EPA's reasoning in raising the levels to the ASTM limits was that levels have been rising nationwide over time as newer vehicles were designed to handle higher and higher fuel RVP. In fact, since some areas are already above their ASTM limits, the use of these limits could be considered conservative. Also, the economic incentive to add butane to gasoline is the same at high or low RVP. Only vehicle performance, which is also a function of climate, vehicle model, and maintenance level, holds RVP in check. The role of high RVP in hindering vehicle performance is often masked by these other factors.

On the other hand, EPA now has two additional years' of MVMA summertime RVP surveys (1986 and 1987) and levels have not been rising. Thus, at least for this analysis of interim RVP control, 1987 RVP levels will be assumed to hold constant in the future absent RVP controls. These revised baseline RVPs are shown in Table 2-1.

C. UDI correlation

Texaco and API pointed out that the UDI equations for predicting duirnal emissions were derived from an EPA data base limited to three RVP test conditions. While this data base is limited with respect to the number of test conditions, the EPA

Table 2-1

In-Use Fuel Volatility (RVP) Data

MSA/CMSA Name	In-Use RVP* (psi) 1987
Boston MA	10.8
Greater Connecticut	10.8
New Bedford MA	10.8
Portland ME	10.8
Portsmouth-Dover-Rochester NH-ME	10.8
Providence RI	10.8
Springfield MA	12.8
Worcester MA	10.8
Atlantic City NJ	11.4
New York NY	11.2
Vineland-Millville-Bridgeton NJ	11.4
Allentown-Bethlehem PA-NJ	11.4
Baltimore MD	11.0
Erie PA	11.7
Harrisburg-Lebanon-Carlisle PA	11.4
Lancaster PA	11.4
Philadelphia PA-NJ	11.4
Pittsburgh PA	11.7
Reading PA	11.4
Richmond-Petersburg VA	11.0
Scranton-Wilkes Barre PA	12.2
Washington DC-MD-VA	11.0
York PA	11.4
Atlanta GA	10.7
Birmingham AL	11.5
Charlotte-Gastonia-Rockhill NC-SC	10.7
Chattanooga TN-GA	10.7
Huntington-Ashland WV-KY-OH	11.0
Louisville KY-IN	11.0
Memphis TN-AR-MS	10.7
Miami-Hialeah FL	10.3
Nashville TN	11.5
Tampa-St.Petersburg-Clearwater FL	10.3

* In-Use RVP associated with ozone design value day.

Table 2-1
(continued)

In-Use Fuel Volatility (RVP) Data

MSA/CMSA Name	In-Use RVP* (psi) 1987
Akron OH	11.7
Canton OH	11.7
Chicago IL	11.6
Cincinnati OH-KY-IN	11.7
Cleveland OH	11.7
Dayton-Springfield OH	11.7
Detroit MI	11.5
Grand Rapids MI	11.6
Indianapolis IN	11.6
Milwaukee WI	11.6
Muskegon MI	11.6
Baton Rouge LA	10.7
Beaumont-Port Arthur TX	9.9
Brazoria TX	9.9
Dallas-Ft.Worth TX	9.9
El Paso TX	9.0
Galveston-Texas City TX	10.7
Houston TX	10.7
Lake Charles LA	10.7
Long View-Marshall TX	9.9
New Orleans LA	11.4
San Antonio TX	10.3
Tulsa OK	9.8
Kansas City MO-KS	9.8
St. Louis MO-IL	10.1
Denver-Boulder CO**	9.7
Salt Lake City-Ogden UT**	9.7
Phoenix AZ	8.5

* In-Use RVP associated with ozone design value day.
** High-altitude area.

emission factor data base contains hundreds of vehicle tests, by far the largest of its kind, representing the broadest range of vehicle types, model years, etc. Also, it is important to note that additional data at 27 test conditions obtained in the ATL study described in the DRIA follows the same trends as the EPA date. This additional data is presented in Figure 2-10 of the DRIA and supports the best fit polynomial equations derived from the EPA data. In fact, use of the emission averages of the ATL data at the three EPA test conditions does a very good job of predicting all 27 data points. Thus, absent a better approach, EPA will continue to use the UDI model based on EPA test conditions.

As an alternative to EPA's model, a number of oil and auto companies submitted, and recommended that EPA use, a model recently developed by Radian, Inc. under the auspices of the the Coordinating Research Council. This model contains a number of features not able to be considered in the Draft RIA model, like the amount of each day's diurnal temperature rise idle vehicles tend to experience. However, the model at this point in its development contains a number of major disadvantages relative to EPA's which argue against its use at this time.

First, and foremost, the model is entirely statistical, consisting of correlations of data versus test parameters. This prevents its use outside of the test conditions, since no engineering model is used to demonstrate the validity of extrapolation. Unfortunately, the range of summer climates occurring in the U.S. is much wider than the range of test data and extrapolations must be performed.

Second, some of Radion's statistical techniques result in the consistent underestimation of measured emissions even at the test conditions. This arbitrarily leads to a reduction in the estimated effect of RVP on emissions, which is unacceptable.

Third, the most apparent advantage of the Radian model in estimating partial diurnal may not be as strong as it initially appears. Diurnal emissions are a function of available canister capacity, as well as fuel tank emissions to the canister. Recent modelling by EPA of the interaction of tank vapors, canister loadings, and purge rates to the engine indicates that canisters are likely full at the end of the day.[4] While more work needs to be done in this area, EPA's running loss testing confirms that many vehicles' canisters are fully loaded at today's RVPs on high temperature days typical of high ozone conditions.[5] Thus, at least at the initial conditions of this interim RVP control analysis, EPA's emission factor test conditions of a complete diurnal with a purged

canister is almost certainly more accurate than Radian's partial diurnals with a purged canister; reality being a combination of partial and full diurnals with a full canister.

D. Accuracy of EPA Emissions Modeling Testing

API and Sun Refining and Marketing Company expressed concern over the representativeness of the data base used for emissions modeling. Specifically fuel blending and the accuracy of measurement of tank fuel temperatures during test procedures were questioned.

With respect to fuel blending Sun Oil presented test data for a single vehicle showing that it was the difference in the high-end volatility (T_{90}) of EPA's 9 and 11.5 RVP test fuels, and not RVP, that caused the exhaust emission effect. In contrast, EPA's own comprehensive testing of a vehicle showed that it was not any difference in the liquid fuel, but tank vapors generated during the test, which caused the effect.[6]

Recent running loss test results indicate that exhaust emissions are strongly affected by tank vapors, much more than EPA's emissions factor testing would indicate.[7] Thus, even if part of the effect seen with the emission factor testing is due to differences in T_{90}, the whole effect estimated using EPA's emission factor testing likely underestimates the effect in-use. Thus, the DRIA analysis will continue to be used.

E. Ethanol Effects on Evaporative Emissions

The Ad Hoc Ethanol Committee submitted technical data describing the average volatility increase for ethanol blended fuels. Their data resulted in a 0.76 psi RVP increase for a 10% ethanol blend in gasoline rather than the 1 psi increase used by the EPA for its analysis. Further data submitted by API also supports this 0.76 psi RVP increase at 11.5 gasoline RVP.[8] However, API's model is more realistic in that it estimates an RVP increase which depends on the base fuel RVP. Thus, since the two models match at their commonality, but the API correlation is more flexible, the API correlation is preferable. However, since a temporary allowance of 1 psi is being granted to ethanol blend, until the final analysis of the second level of RVP control, this factor is not an issue here.

III. Final Analysis

The analysis of comments presented above indicates that EPA's DRIA emission factor models are still the most appropriate to use. EPA is continuing its development of these models and improvements will be forthcoming with the release of

MOBILE4 later in 1989. However, the modifications envisioned lead to an increase in the emissions effect of RVP. A preliminary analysis of these revisions shows this increase could be quite substantial.[9] Thus, continued use of the DRIA would be very conservative. As shown in Chapter 5, use of the DRIA estimates still results in a very cost effective interim program. Thus, for simplicity, the continued use of the DRIA estimates is sufficient. The preliminary inclusion of running losses, etc., referenced above, will only be used to indicate sensitivity and direction of effect. Use of revised emission factor models will be reserved for the final analysis of the second level of RVP control.

Reference - Chapter 2

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4. David B. Bartus, PT Evaporative Emissions Model, Description and Users Guide, U.S. EPA, OAR, OMS, ECTD, SDSB, September 1988.

5. Running Loss Test Program: Interim Results, U.S. EPA, OAR, OMS, ECTD, SDSB, September 16, 1988.

6. Alan E. Schuler, Effects of Gasoline Volatility on the Hydrocarbon Exhaust Emissions From a 1984 Oldsmobile Cutlass, U.S. EPA, OAR, OMS, ECTD, SDSB, August 1987.

7. Exhaust Emissions on Repeated LA-4s, Running Loss Test Program, Data Extracted from MICRO Data Base, January 18, 1989.

8. Letter from Dr. Terry F. Yosie, API, to Mr. Charles L. Gray, Jr., June 28, 1988.

9. Memorandum to The Administrator, The Effect of Vehicle Running Losses on Future Ozone Non-Attainment, from Don Clay, Acting Assistant Administrator, October 6, 1988.

Chapter 3

Environmental Impact

This chapter examines the environmental impact associated with the interim control of RVP. It discusses the control of VOC emissions in order to control tropospheric ozone levels; including discussions of the need for ozone control, the expected emission reduction effect of these controls, and the impact of the controls on ozone levels.

I. Need For Ozone Control

A. Synopsis of NPRM

Ozone is a powerful oxidant which is formed in the troposphere by photochemical reactions of volatile organic compounds (VOC) and oxides of nitrogen (NOx). Ozone affects humans by irritating the respiratory system and reducing lung function. Laboratory studies suggest that it also may actually damage lung and other tissues. This damage may impair breathing and reduce immunity to disease for people in good health, and may be even more severe for people with pre-existing respiratory diseases. In plants, oxidation by ozone can impair tissue function and reduce the yield of some crops. Oxidation by ozone may also damage materials such as rubber products.

Although various HC controls have already been implemented, many areas of the nation continue to violate the ozone NAAQS. Based on the three-year period of 1982-84, EPA determined that 73 urban areas were exceeding the ozone standard. (Twelve of these areas are located in California.)

In order to determine the need for future hydrocarbon control, EPA looked not only at the present state of ozone air quality, but also at projected future air quality trends. Estimates of future air quality were made for the 61 non-California urban non-attainment areas. (Since California has separate motor vehicle standards, California non-attainment areas were not modeled.) Current attainment areas were excluded from the future air quality projections even though some of the areas were close to the standard and may have been projected to become a non-attainment area in the future. The air quality modeling relied on certain assumptions regarding emission rates, growth rates, control technologies, emission standards, and control efficiencies that are described in more detail in the following sections. Based on these analyses of future air quality, EPA projected that there will likely be improvements in air quality from 1988 to 1995 due to the effect of current emission standards for mobile and stationary

sources, but that most of the large urban areas modeled remain in non-attainment throughout this period. However, without further controls, growth is projected to offset these improvements and to cause the problem to worsen after 1995. Based on estimates made by the EPA, VOC emission reductions of 50 to 80 percent appeared to be necessary to bring some urban areas into compliance.

Both the proposed volatility regulation and the proposed refueling regulation result in emission reductions in both non-attainment and attainment areas. The need for control in non-attainment areas is evident. It is also, however, beneficial to control volatility (and hence, VOC emissions) in attainment areas. Two key ozone benefits were noted in the NPRMs. Because VOC emissions from one area may be transported through the atmosphere to another area, emissions in attainment areas can add to the problems in non-attainment areas. Therefore, controlling emissions in attainment areas will also help non-attainment areas to reach compliance.

B. Summary and Analysis of Comments

The comments received concerning the need for ozone control addressed many different aspects of this issue. These many aspects, however, fall into three main areas: 1) the health effects of ozone exposures, 2) the extent of the ozone problem, and 3) the more general issue of the type of control needed.

1. Ozone Health Effects

Comments on health effects varied greatly. NRDC stated that at concentrations of 50 percent of the current ozone NAAQS, suppression of the immune system has been observed in laboratory animals. The American Lung Association (ALA) also agreed that the current ozone standard does not adequately protect public health. ALA commented that clinical studies have shown that adverse respiratory health effects result from experimental ozone exposure at the current standard level. NESCAUM stated that ozone pollution is one of the most serious and widespread public health problems in the Northeast U.S. It also stated that recent health data strongly suggests that the existing ozone NAAQS may not be strict enough to protect public health. It also claims that much terrestrial damage has occurred due to ozone exposure at ambient concentrations well below the current health standard.

Others commented, though, that any health effects are very short term in nature and that those showing health effects recover quickly. API commented that the line between attainment and non-attainment seems arbitrary and that it is

improbable that any real public health consequences are associated with the transition from non-attainment to attainment.

Commenting on the margin of safety required by the Clean Air Act, Chrysler felt that it is irrelevant whether or not an area is projected to be in borderline compliance, as long as they reach attainment. It felt that there already exists a significant safety margin built into the current standard to protect public health. Therefore, it argued, as long as compliance is met, no extra margin of safety is needed. NRDC, however, stated that recent scientific evidence shows that the ozone NAAQS will have to be tightened in order to protect the public health with an adequate margin of safety.

These comments demonstrate that additional information may be needed to resolve concerns about the appropriate level of the ozone standard. This rulemaking, however, is not the proper forum to attempt such a resolution. The Agency is already investigating this issue in its periodic (5-year cycle) review of each NAAQS. Should it be determined that modifications to the current ozone standard are necessary, they will be made in a separate rulemaking. At this time, control decisions have to be based on the current standard.

In response to Chrysler's comment, it is true that the Clean Air Act requires an adequate margin of safety to protect the public health. Thus, EPA does not base its regulatory decisions on areas that are in "borderline attainment". This does not, however, mean that the extent of an area's compliance is irrelevant. Concerns such as NRDC's on the margin of safety, as well as concerns about the accuracy of ozone projections, make the projection of an area to be in borderline attainment very significant.

2. Extent of Ozone Problem

Regardless of the level of ozone at which an unhealthy environment exists, the extent of the ozone problem which exists in the nation is also under debate. Phillips Petroleum commented that few urban areas frequently or significantly exceed the ozone standard. It also commented that, with the exception of Southern California, the ozone problem is largely unnoticed by the general public since exceedances of the ozone standard are so few. Other commenters also noted that on an hour-by-hour basis, most areas are in compliance with the ozone standard more than 99 percent of the time. API agreed with the EPA that there is an ozone problem, however, it felt this problem has been overstated by the EPA. Sun Oil also felt that EPA has overstated the problem. They believe that, except for the Los Angeles area, most non-attainment areas are in compliance with the ozone standard during most of the summer ozone season. MVMA commented that the EPA has already

determined through its NAAQS process that an ozone concentration of 0.12 ppm or less is by definition adequate to protect public health and welfare from any adverse effects.

Many comments stated that the EPA has over-estimated the current ozone problem because the method for determining whether or not an area was in attainment was erroneous. They feel that the method does not represent a quantitative view of ozone exposure and it overstates exposure duration and total population exposure. Sohio and API both commented that determining attainment or non-attainment with a single monitor is unrealistic and overstates the problem. Sohio feels that the average of all monitors in the area may be more representative of typical ozone season air quality. API and Sohio stated that overall ozone levels are well below the standard, but that the current method of reporting ozone non-attainment data does not show that. Sohio also feels that since the design value is based on a reading from a single monitor, it does not show the progress achieved in reducing ambient ozone levels, and, therefore, does not measure the extent of non-attainment. Sohio commented that monitors with exceedances may not be in highly populated areas. It said that in most non-attainment areas, the population living or working in the area is much lower than the total population. API and Sohio also stated that under the current method, one year's data, even if it is uncharacteristic, is enough to keep an area out of attainment for a three-year period. One last commenter questioned whether or not a one-hour standard for ozone was appropriate. They believe that a more practical long-term solution would be going to an eight or twenty-four hour average standard.

EPA does not deny that ozone levels in urban areas are generally below the level of the standard (0.125 ppm) the majority of the time, nor does it claim that its monitoring system reports an ozone level to which the entire area is exposed. Nevertheless, it does maintain that its current method of determining air quality, with respect to ozone levels, is reasonable. This is because the Agency considered these issues in setting the level of the standard. It was decided that one-hour ozone concentrations greater than 0.125 ppm, in any part of an area, more than once per year would be indicative of unacceptable air quality. EPA will consider comments on modifying the nature of the ozone standard at the appropriate time in its review of the ozone NAAQS. However, as noted before, such modifications are clearly beyond the scope of this rulemaking.

3. Necessary Control Programs

Many commenters stated that because many areas in the nation still have not reached attainment of the ozone standard, further control of HC emissions is necessary. Some commenters

argued for volatility controls, some argued for refueling controls, and some argued for both. The Texas Air Control Board felt that onboard controls would be a very cost effective strategy, as did API and many other commenters. API, however, does note that before forcing costly hydrocarbon controls, it would be useful to have a better understanding of the role of NOx, the role of transport, and the overall hydrocarbon inventory. It cited the "National Acid Precipitation Report", stating that two-thirds of VOC emissions east of the Mississippi and three-fourths of VOC emissions west of the Mississippi are from natural sources. The Conservation Law Foundation of New England (CLF) agreed with EPA's assumption behind the proposed volatility rule that vehicle-based controls alone are not enough to address the short-term ozone non-attainment problem. This is because emission reductions from such controls only occur after a long period of time needed for fleet turnover. It also felt that the EPA was correct in realizing that emission reductions beyond those available at zero cost are necessary to achieve short-term air quality improvement. It felt that the in-use fuel volatility restrictions are technically feasible and cost effective, and thus should be adopted. NRDC and the American Lung Association felt that HC reductions beyond those currently required in non-attainment areas are necessary to protect public health. They felt that volatility, onboard, and Stage II controls are all necessary to achieve attainment. NRDC stated that $2000 per ton should not be a cost-effectiveness ceiling for ozone or carcinogen controls. NESCAUM, in commenting on the ozone problem in the Northeast, stated that long-term attainment of the ozone standard can only be reached through a regionwide program based on all available control strategies. It also felt that a reason for the failure to attain the ozone standard in the Northeast has been an incomplete understanding of the complex process of ozone formation. This would lead some states to underestimate the required reductions to meet the ozone standard, and to overestimate the ozone reductions obtained from various control measures.

Some commenters, however, felt that there is not a problem of ever-worsening air quality. Therefore, they claim that no nationwide "crash" program is needed to reduce emissions. Toyota felt that the effectiveness of current control programs is being underestimated by EPA.

Clearly there is disagreement as to whether the proposed controls are necessary. However, none of these comments provided sufficient rationale to change EPA position on VOC control. The Agency remains convinced that cost effective VOC controls are the most appropriate ozone strategy at this time. (It should be noted that a $2000 per ton cost-effectiveness ceiling, as NRDC implied, does not exist in EPA's ozone policy.) Thus, the argument presented by the automotive industry that refueling emissions should not be controlled

since they only account for two percent of the VOC inventory is not valid; size of the reduction is not important, cost effectiveness is what matters, since many smaller benefits can account for large reductions when considered together. In regard to DOE's comment, it should be noted that EPA did consider both short-term and long-term costs and benefits before proposing these controls.

It is true that natural VOC emission can play an important role in ozone formation, and in fact, EPA is investigating this issue. The other issues such as the role of NOx and of transport are also important and should be investigated further. Nevertheless, this does not alter the fact that control of VOC emissions such as gasoline vapors is an effective means of reducing ozone levels.

II. Emission Inventories

A. Synopsis of NPRM Analysis

In order to estimate the environmental impacts of the control options, a computer model was first used to calculate VOC emission factors in grams per mile. The emission factors were calculated for exhaust, evaporative, and refueling, hydrocarbon (HC) emissions, and were multiplied by VMT estimates to obtain inventory projections of future VOC emissions. The inventory projections in turn were used to determine the emission reductions from the various control options.

The version of MOBILE3 used in the DRIA analysis was different than the released version. In order to incorporate RVP effects and refueling emissions, the analyses used an in-house version of MOBILE3 (hereafter refered to as MOBILE3.9). Since evaporative emissions are dependent on temperature, the in-house version also allowed for the use of climatic data reflecting actual temperatures in the areas modeled. This model was used for both the RVP and refueling analyses. The analyses differed, however, in that the RVP analyses incorporated city-specific temperatures and RVPs, while the refueling analyses did not.

In the RVP analyses, two different types of city-specific temperatures were used for the different analyses performed. Environmental impacts were modeled using temperatures from the design value day of the area. (The design value is defined to be the fourth highest one-hour ambient ozone concentration occuring in a three year period.) Inventory projections based on the design value day temperatures were used to compare and rank various control programs.

The economic impact of RVP control was determined using July average temperatures rather than design value day

nperatures. EPA used this average temperature approach cause the economic benefits of recovering evaporative issions occur throughout the summer, not just on high ozone ys. In particular, the average temperatures during the month July were used because they correspond to the in-use fuel latility survey data used in this study. As with the design lue day temperatures, July average temperatures were used to lculate emission inventories and emission reductions in ojection years under various control options. These ventories were then used to estimate economic credits (i.e., e evaporative recovery credit and the attainment area VOC ntrol credit).

City-specific alcohol-blend market shares were also used the modeling in order to obtain more accurate emission ctors by accounting for the fraction of alcohol blend fuel in e market. EPA estimated that alcohol blends have a 1.0 psi gher RVP than the base gasoline. The market share data was so used to evaluate the impact of various alternative eatments of alcohol blends. In the modeling, it was assumed at the RVP of gasohol was 1.2 psi greater than that of soline (i.e., 1.0 psi RVP effect with a 0.2 psi average mmingling effect). In those scenarios where alcohol blends re required to meet the same RVP restrictions as gasoline, e in-use RVP of alcohol blends was assumed to be 0.2 psi eater than gasoline, due solely to commingling.

In addition to city-specific temperatures and alcohol end market shares, city-specific in-use fuel volatility rvey data were used in the RVP modeling. The 1983 RVP data presented average volatilities for non-alcohol-containing leaded gasolines in the summer months. These RVP levels were sed to develop the 1983 base year inventories. The 1985 rvey data were used in all the projection years. For these 85 values, if the area surveyed had an RVP less than the ASTM mit for that area, the ASTM limit was used in place of the rveyed RVP level. This was done based on the assumption that e RVP in the area would continue to rise until it reached the STM limit. If no RVP data was available for a given on-attainment area, the RVP of the nearest survey area was sed. Also, the most appropriate RVP value would be that for e month during which the design value day occurred. Since e surveys were performed only in July, if the design value ay was not in July, the RVP was adjusted to represent the orrect ASTM class for the month of the design value day.

The above city-specific input were incorporated into the OBILE3.9 model which then calculated HC emission factors for ach of the urban, non-California ozone non-attainment areas odeled. These non-attainment area emission factors were then onverted into nationwide emission factors based on a opulation-weighted average of the individual emission actors. Fleetwide exhaust, evaporative, and refueling

emission factors were calculated for each gasoline-fueled vehicle category (LDV, LDT, HDV). The HC emission factors for gasoline-fueled vehicles in the RVP analyses were calculated assuming both that onboard refueling emission controls would be in effect as of the 1990 model year and also assuming no onboard controls.

In estimating refueling emissions, because all the necessary city-specific inputs were not available, MOBILE3.9 was used to develop nationwide emission factors directly, using national average inputs such as fuel volatility and temperatures. The analysis also accounted for tampering with the evaporative emission control systems, which may occur in use. The types of tampering identified as those which could affect onboard refueling controls were disconnection and removal of the evaporative emissions storage canister. This was assumed to occur at rates equal to those of current control systems. As in the RVP analysis, fleetwide exhaust, evaporative, and refueling hydrocarbon emission factors were calculated for each gasoline-fueled vehicle category. It should be noted, however, that these were calculated assuming no RVP control.

Using the calculated nationwide emission factors, inventory projections of future VOC emissions were estimated. Non-California, urban, non-attainment area inventories were calculated for both mobile and stationary sources, both as a whole and subdivided into several individual source categories using assumptions concerning growth rates and future technological improvements.

These projections were used to generate projected emission reductions associated with each control strategy. The nationwide emission reductions were used in ranking control-effectiveness and cost-effectiveness of the RVP control programs. The non-attainment area inventories were used as input for the ozone air quality modeling and for estimating the cost effectiveness of RVP controls.

Nationwide inventory projections for the calculation of economic recovery credits for RVP control were made using emission factors based on July average temperatures for the non-attainment areas. For the ozone air quality modeling for RVP control, the analysis used emission factors based on the design value day conditions. The design value day was used as the basis for the emission projection since the ozone model focuses on that day. For all the RVP projections made, a base year of 1983 was used with projection years of 1988, 1990, 1992, 1995, 1997, 2000, 2010.

B. Summary and Analysis of Comments

Some comments were received on the type of temperature data used in the modeling. MVMA commented that there is no clear relationship between the design value level and the July average temperatures used. MVMA feels that better correlation with temperature could be obtained with an ozone statistic more robust than the design value. When MVMA repeated the analysis to calculate inventory projections, it used July minimum and maximum temperature data whereas EPA used the design value day minimum and maximum temperature data for each city. It noted that in some cities this resulted in higher temperatures, while in others it resulted in lower temperatures.

MVMA is correct in noting that there is no clear relationship between design value and July average temperatures. However, this is not surprising since there are many other city-specific factors that impact the magnitude of the design value, such as VOC emissions and VOC:NOx ratios. In regard to the minimum and maximum temperatures used in the modeling, MVMA presented no arguments that their approach was more appropriate, but did note that the difference was variable from city to city. Lacking other information, the design value day temperatures actually occured and produced high ozone levels. The July-average temperatures have a much weaker connection with ozone levels and the effect of emission controls on ozone levels. Thus, there is no reason for EPA to alter its use of temperatures in its air quality modeling.

MVMA commented that the growth rates used were not city-specific, yet should have been, since much of the other air quality projection data used was city-specific. It also suggested that growth rates should also be city-specific since they vary widely from city to city. J.G. Bathe stated that EPA's growth rates are too high, and lead to overestimated emissions.

EPA is, in fact, currently working to develop improved growth rate assumptions. This work includes consideration of city-specific aspects. Unfortunately though, this work is as yet incomplete, and thus not available for this rulemaking. Also, none of the commenters presented any information from which growth rates for each city could be developed, nor demonstrated that updated rates would be different. Even without any future growth, due to the magnitude of the current ozone problem, the conclusions drawn from the air quality analysis would not be substantively altered. Thus, for this analysis of near-term RVP control, EPA will use the same growth rates as were used in the NPRM analyses.

The choice of 1983 as the base year for the analysis was thought by some to introduce significant error in the results. Sun Oil stated that the summer of 1983 was unusually warm and

had an unusually large number of ozone exceedances. It felt the EPA must develop statistical attainment data using normal temperature information determined over an extended period of time (15-30 years). MVMA also commented that EPA selected an unrepresentative base year design level on which to base the air quality calculations.

While it is true that 1983 was among the warmest in recent years, this was not the reason EPA chose it. Actually, at the time the DRIA analysis was performed, the most recent three-year period of design values was 1982-1984, with 1983 being the middle, or base year. Also, it is not obvious that the high temperatures of 1983 would make it inappropriate for a base year. Furthermore, recent preliminary ozone data indicates that the summer of 1988 was even warmer and had an even more severe ozone problem.

MVMA objected to some of the adjustments made to the NEDS inventory for the base year 1983. It feels that the adjustments tended to decrease the contribution of all stationary sources to total NMHC emissions, and thus to increase the apparent importance of motor vehicles. It feels that this could not be validated with the current knowledge of emissions of stationary sources. MVMA also disagreed with the resulting trends in the inventory.

While it may be true that improvements could be made to the estimation of stationary source emissions, such improvements would not substantively change the conclusions of this analysis. The acceptability of these regulations will be judged based on the cost effectiveness of the reduction of mobile source emissions, and thus the estimation of stationary sources is not significant.

In the reanalysis which MVMA had done, they used more city-specific data than EPA, which they say is preferable. Whereas EPA used a 1983 implementation date for I/M programs for all cities, MVMA used city-specific implementation dates. MVMA also accounted for Stage II controls being implemented in New York, New Jersey and St. Louis, and used city-specific model year start dates and vehicle classes.

In past analyses, EPA has noted that its modeling was performed on a nationwide basis, and that as such, it was not appropriate to predict the exact impact of rules on each particular area. Nevertheless, this approach was sufficient given the nature of EPA's past mobile source controls. However, control of in-use RVP required a more city-specific approach than used previously. For this program, it was essential that EPA's model be able to account for city-specific RVPs and temperatures. Other inputs, such as for I/M programs, are not considered on a city-specific basis because the models are not capable of handling them at the present time. This

approach is expected to be sufficiently accurate given the nature of the Agency's modeling goal: to provide an estimate of the impact of control on a nationwide basis. In regard to MVMA's Stage II comment, it applies primarily to the onboard refueling analysis and not the RVP analysis.

Some commenters questioned the number of non-attainment areas that should be included in the analysis. MBS feels that only those areas expected to be in non-attainment in the future should be included. OMB went further to say that the effect of compliance due to volatility controls should also be considered.

It has been Agency policy to include all current non-attainment areas in air quality analyses. To ensure consistency it is necessary to continue this practice. Also, analyses based on future years would be very dependent upon the year selected, which could lead to significant policy problems. However, the number of non-attainment areas is expected to be very similar in either case without additional controls. Thus any change in this policy would not affect the conclusions drawn here.

MBS also noted that their analysis used a 30-year model of the fleet, instead of a 20-year model like EPA used. They feel that this is appropriate because vehicles more than 20 years old contribute significantly to total fuel consumption. Chrysler stated that MVMA statistics show that fleet turnover is slower than that used in the NPRM (e.g., it takes 15 years, not 13 years, for 90 percent of cars and trucks to be replaced).

While it is true that a 30-year model is likely to be more accurate than a 20-year model, the difference would not be expected to be substantial. EPA's model accounts for all model-years more than 19 years old on an aggregate basis. This is reasonable since such vehicles account for less than one percent of vehicle-miles travelled (VMT). Since Chrysler did not include information about the model years involved in the MVMA study showing 90 percent of vehicles being replaced after 15 years, it is not possible to resolve the difference from EPA's estimate. It is likely that MVMA estimate involved different model year than EPA's, which could explain the difference since vehicle sales vary from year to year due to economic influences.

C. Final Analysis

For the 1989 through 1991 timeframe, EPA will require gasoline sold during the summer months to have its volatility reduced below the maximum ASTM limits to 10.5 psi (primarily in Class C areas), 9.5 (primarily in Class B areas), and 9.0 (primarily in Class A areas, no reduction). (The specific standards for each area are outlined in Chapter 1.) The

analysis focuses on 1990 which is representative of the entire 1989-1991 control period.

The analysis of comments presented in Chapter 2 indicates that EPA's DRIA emission factor models are still the most appropriate to use. EPA is continuing its development of these models and improvements will be forthcoming with the release of MOBILE4 later in 1989. However, the modifications envisioned lead to an increase in the emissions effect of RVP. Thus, continued use of the DRIA would be very conservative. As shown in Chapter 5, use of the DRIA estimates still results in a very cost effective interim program. Thus, for simplicity, the emission inventories found in Chapter 3 of the DRIA for the case without prior onboard implementation will be used here to estimate the emission reductions resulting from volatility control. Unlike in the DRIA, however, estimates are being made on an ASTM class-specific basis. As a result, ASTM class specific emission reductions were derived by assuming that control to 9.5 in Class B was equivalent to 10.9 in Class C, and 9.0 in Class A equivalent to 11.5 in Class C. In addition, uncontrolled fuel is no longer considered to have an RVP of 11.7 psi, but rather to be 11.3 psi in Class C areas, 10.0 (11.5 equivalent) in Class B areas, and 8.6 (11.0 equivalent) in Class A areas (as determined in Chapter 4). This change caused emission reductions to decrease substantially below the DRIA estimates, and in fact caused emission reductions in Class A areas to disappear entirely.

One additional change from the methodology of the DRIA was the value used for 1990 nationwide VMT. Comments discussed in Chapter 4 stated that by using the MOBILE3 fuel consumption estimates EPA had significantly underestimated the refining costs. As a result, in Chapter 4, new refining cost estimates are based on DOE fuel consumption estimates.[1] In order to remain consistent with this change, 1990 nationwide VMT also had to be changed to reflect the DOE estimates. This was incorporated merely by multiplying the emission reduction estimates from the DRIA by the ratio of 1990 nationwide VMT as estimated by DOE (approximately 2068.57 billion miles), to that as used in the NPRM (1760.81 billion miles).

In order to determine the emission reductions in each ASTM class individually, the emission reductions were multiplied by the fraction of VMT (assumed to be the same as the fraction of fuel sales) which occurs in each ASTM region (4.02% in Class A, 34.19% in Class B, and 61.79% in Class C). The resulting VOC emission reductions are shown in Table 3-1.

As described in Chapter 2, these figures represent very conservative estimates given more recent knowledge concerning running losses and excess evaporative emissions. To show the potential for greater control, to these emission reductions were added a recent estimate of excess evaporative and running

Table 3-1

Nationwide Year Round Emission Reductions for the Interim RVP Control Program

Design Value Day (1000 ton/yr)

	DRIA Estimate	Preliminary Running Loss and Excess Evaporative Emissions	Preliminary Total (for Sensitivity Purposes)
Class A	0.0	0.0	0.0
Class B	208.46	413.18	621.64
Class C	465.30	887.62	1352.92
Nationwide	673.76	1300.80	1974.56

July Average (1000 ton/yr)

	DRIA Estimate	Preliminary Running Loss and Excess Evaporative Emissions	Preliminary Total (for Sensitivity Purposes)
Class A	0.0	0.0	0.0
Class B	158.25	313.67	471.92
Class C	360.05	686.83	1046.88
Nationwide	518.30	1000.50	1518.80

Note: Control period emission reduction estimates are estimated to be 42.56 percent of year-round reductions based on the fraction of fuel sold during that period.

loss emission reductions.[2] Running loss emission factors for the interim RVP control program were estimated by fitting a curve through the three data points of running loss emission factors as a function of fuel RVP, while excess evaporative emission factors were derived for the scenarios required by adjusting the estimates at 9 psi RVP by the ratio of the uncontrolled diurnal index (UDI) at the RVP required to that at 9 psi.[2] The difference between the base case and control case emission factors was then multiplied by the nationwide VMT estimate for the individual ASTM classes to determine the total excess evaporative and running loss emission reductions. (The nationwide VMT was estimated from the most recent DOE information, and then broken into ASTM classes by multiplying by the fraction of VMT occurring in each ASTM class area.[1]) July average excess evaporative and running loss emission reductions were then determined by using the ratio of July average to design value day emission reductions found in the DRIA. The resulting emission reductions are shown in Table 3-1.

III. Ozone Modelling

A. Butane and Oxygenate Reactivity

1. Synopsis of the NPRM Analysis

The photochemical reactivity of butane and some oxygenates (i.e., ethanol and methanol) was discussed in the NPRM. However, the previously established Agency policy was to treat all reactive compounds equally. While the rationale for this position was not discussed in detail in the NPRM, it would still be useful at this point to review some of the reasons why EPA has chosen in the past not to consider differential photochemical reactivity in its control programs. First, there is the issue of multi-day pollution episodes, of which there are two types: one where the pollution remains in one area for a prolonged period due to stagnation, and the other where the pollution is transported to another area without being substantially diluted. With both types of multi-day pollution, the rate at which a particular species reacts becomes less important since it has a longer time to react. For example, a slowly reacting compound may not react completely in a single city, but could be transported to another where it would continue to react. Consequently, rate data showing that attack by OH radical occurs slowly, or even single-day modeling studies showing a compound to be less reactive, are not sufficient to quantify the effect of a particular compound during a multiday episode.

Second, it has been shown that the absolute and relative reactivity of compounds can be affected by changes in HC to NOx ratios. Specifically, differences in reactivities are smaller at low HC to NOx ratios.[3] This is important because it is

expected that the current aggressive HC control strategy will result in lower HC to NOx ratios, and thus smaller differences in reactivity.

Third, in many respects the modeling capabilities and chemical data available are too limited to completely address this issue. The available models are only approximations of what happens in a real airshed, and thus the results cannot be considered to exactly describe the actual effect of any particular compound. Photochemical modeling requires a great deal of meteorolgical data to account for things such as transport and dispersion. Often these data are not completely available, and assumptions are necessary. Other modeling simplifications are generally included to reduce computational time (and thus costs). With respect to chemical data, it is noted that for complicated molecules there can be too many reaction pathways to model completely. Even for a relatively simple molecule like methanol, there has been some question about its reaction mechanisms.[4] This situation can result in the exclusion of several mechanisms that are deemed to be insignificant. Thus predicting the reactivity of a molecule requires simplifying assumptions, which all add some degree of uncertainty to any attempted analysis.

Finally, attempts to regulate while considering reactivity can easily result in unworkable regulations. As noted before, future changes in HC to NOx ratios could change the real-world reactivity of a compound, which combines with the potential for changes in modeling technology to make any analyses done at this point continually subject to change. Also, regulating on the basis of reactivity could require careful monitoring and controlling of the chemical composition of fuels. This would be much more difficult than controlling a fairly simple physical parameter such as RVP. Moreover, since fuels tend to contain a large number of components, the volume of data necessary to accurately predict the reactivity of some type of emission (e.g. evaporative emissions) could become overwhelming. While concerns about the ease of regulating are not adequate justification for not considering photochemical reactivities, they do need to be weighed against the potential for benefits from such consideration. A summary of the NPRM discussions of butane and alcohol are summarized separately below.

In the NPRM, the photochemical reactivity of butane was classified using a 1984 EPA report.[5] This report classifies compounds as "unreactive," "borderline," or "reactive;" reactive compounds being those which are significantly more reactive than ethane (based on smog chamber and/or rate data.) Using this system butane was classified as reactive. In support of this conclusion, it was noted that butane would also be classified as reactive using the GM scale that was developed in the mid-1960s.[6] The analysis went further to say:

> Modeling and smog chamber data also verify the contribution of butane to ozone formation in the troposphere. Based on available information, it is EPA's position that butane is a photochemically reactive compound which contributes to ground level ozone formation. Therefore, reductions in butane emissions through in-use fuel volatility control are expected to lead to subsequent reductions in ambient ozone levels.

Thus, no numerical consideration of the specific reactivity of butane relative to average VOC was attempted by EPA.

The photochemical reactivities of ethanol and methanol were discussed briefly in the NPRM; no other oxygenates, however, were discussed. The only oxygenate which EPA considered in its air quality analyses was ethanol. For calculational purposes, ethanol was assumed to be as reactive as average VOC on a per carbon atom basis, which meant that ethanol was assumed to be only 62 percent as reactive on a mass basis. This difference is because ethanol molecules contain oxygen atoms, and thus ethanol has a much higher mass to carbon atom ratio than most VOC. This approach was chosen since it is the oxidation of carbon that contributes to ozone formation in the troposphere. It was also noted that the rate at which ethanol reacts with OH radical in the atmosphere (the primary mechanism for oxidizing VOC) is on the same order as hydrocarbons such as butane or toluene.

The NPRM discussion also noted that studies had indicated that methanol is less reactive than typical hydrocarbon vapors. The studies showed the reactivity of methanol to be only 2-43 percent as reactive as average VOC on a carbon basis. These numbers were used to estimate the air quality impacts of methanol blends.

The increase in emissions of formaldehyde due to combustion of methanol blends was also discussed. Due to the very high reactivity of formaldehyde, which offsets the low reactivity of methanol, the reactivity of exhaust emissions from methanol blends was assumed to be the same as from gasoline.

2. <u>Summary and Analysis of Comments</u>

The Agency received many comments (from Sohio, the Ad Hoc Ethanol Committee, OFA, the Ohio Farm Bureau, NESCAUM, Sun Refining Co. and GM) which suggested that EPA ought to consider the photochemical reactivity of evaporative emissions in this rule. Most of the comments were with regard to butane (and other light paraffins) and/or oxygenated compounds. The commenters stated that these compounds are less reactive than

average VOC. This conclusion was based on rate constants for reaction with OH radical, the results of smog chamber studies, and the results of single-day computer modeling studies. Since light paraffins (and oxygenated compounds for oxygenate blends) make up a large part of evaporative emissions, the commenters felt that controlling such emissions will not be as effective in reducing ambient ozone as EPA has suggested.

Sohio stated that EPA should not rely on smog chamber studies to determine the reactivity of butane since smog chambers are not representative of real world conditions.

One of the modeling studies submitted, which was performed by Systems Applications Inc. (SAI), looked at various control strategies involving ethanol blends. The model predicted that even if ethanol blends had higher RVPs than straight gasoline, they would still result in less ozone production for many cities. The report explained that this was due to the combined effect of ethanol's reactivity and its effect on CO emissions (which contribute to ozone formation). The report went further to say that there are two key aspects of ethanol's chemistry that make it less reactive. First, it noted that the initial reaction of ethanol with hydroxyl radicals generates only half as much ozone as the initial reactions of typical hydrocarbons. Second, it stated that acetaldehyde, the principle intermediate product, is not highly reactive and can inhibit ozone formation by reacting with NOx to form peroxyacetylnitrate (PAN).

Similarly, the report stated reasons why the reactivity of butane is low. It noted the low rate constant for the reaction of OH radical with butane, which is much lower than the average value used for VOC in EKMA. It also stated that the main products of the reaction of OH with butane are acetaldehyde and methylethyl ketone, and that these products are "not much more important in further ozone formation than is butane itself."

Some of the comments did address the points noted above, regarding EPA's rationale for not considering reactivity. NESCAUM noted that there is generally an incomplete understanding of the photochemical formation of ozone. Sun noted that HC to NOx ratios can have a significant effect on reactivities, and thus that for some areas HC control without NOx control will not result in attainment. It added that the mechanisms of transport and dispersal are not well understood. It also noted that because there are processes which scavenge ozone in the atmosphere, compounds that produce ozone more slowly do not allow concentrations of ozone to reach levels as high as others might. They went further to say that this slow reaction rate would also allow the compound to be dispersed before it could produce large amounts of ozone in an urban area.

Much of the evidence presented to show that butane and many oxygenated compounds react slowly in the atmosphere was smog chamber data and rate constants for reaction with OH radical. This information, while valid, is insufficient to allow a quantified estimate of the reactivities of these compounds in real situations. The qualitative discussions in the SAI report are interesting; however, some of the points raised are misleading. First, the report claims that acetaldehyde is not highly reactive; however, at least one modeling study has shown acetaldehyde to be more reactive than formaldehyde, which is accepted as a highly reactive compound.[4] Moreover, the report notes that acetaldehyde scavenges NOx by reacting with it to form PAN. This would in fact be of some benefit with respect to ozone levels, but there are also negative aspects of PAN formation: PAN itself is an air pollutant which causes significant health effects, and it can be transported long distances before it decomposes and thus regenerates the NOX. EPA regulates ambient ozone levels as a surrogate for all oxidants, assuming that satisfactory levels of ozone will result in satisfactory levels of all oxidants. Substitution of PAN for ozone would clearly be unacceptable. Another misleading aspect is the comparison of rate constant of the reaction of OH with butane to the rate constants for reactions with the theoretical species of the Carbon Bond Mechanism (CBM) which is used in EKMA. This is not really appropriate since the butane rate constant represents only the initial reaction with OH, while the CBM rate constants represents an average of the reactions of all the carbon atoms initially present as paraffins. Thus the CBM rate constants also account for the products of the initial reaction, while the butane rate constant does not.

The corresponding photochemical modeling study is more useful, yet it still does not resolve the concerns noted above, especially the concern regarding multi-day pollution. Thus none of the comments are sufficient to justify reversing established Agency policy. Also, it should be noted that Sohio was incorrect in stating that EPA relies solely on smog chamber studies when considering reactivity.

EPA does not deny that butane and many oxygenated additives react more slowly than average VOC, or that such slowly reacting compounds can result in somewhat less ozone than other compounds. Rather it holds that at this time, it is not possible to accurately address reactivity issues such that consideration would be workable and appropriate.

This precedent was reaffirmed just recently in the rulemaking that established standards for methanol-fueled vehicles. That rule regulated organic emissions on a carbon basis, and did not give any allowance for lower reactivity, even though there is some evidence that methanol has a very low photochemical reactivity.

The SAI report submitted by the Ad Hoc Ethanol Committee, le it does not resolve the concerns noted above, does gest that the potential reduction of CO from vehicles fueled ı ethanol blends could also impact ozone levels. Since the nistry of CO is fairly simple and well understood, ıtifying the impact of CO reduction does not involve the e degree of uncertainty as when dealing with reactivity efits of other compounds. For this reason, the Agency is ı to considering the effect of CO on ozone levels, when ling with alcohol blends. Unfortunately though, the ormation currently available is not sufficient to quantify effect, especially considering the fact that the effect can y greatly.

B. Air Quality Projections

1. Synopsis of the NPRMs

The ozone air quality analysis, which predicted future ne concentrations, was done using the EKMA computer models. NMOC emission inventories were used as input to predict the ure concentrations for the non-California urban ozone -attainment areas. The model is primarily a nationwide el. City-specific information was only used as input for base year ozone concentration and for the ratios of NMOC to . Meteorological conditions for the EKMA model are based on a from one of three cities: a) Los Angeles - for modeling ifornia coastal cities (therefore, not used in this lysis), b) Denver - for modeling cities in Arizona, orado, Nevada, New Mexico, and Utah, and c) St. Louis - for eling all other areas.

2. Summary and Analysis of Comments

Both MVMA and GM commented on what they believe is an erly simplistic methodology used in EKMA. MVMA stated that eir analysis showed that even if the ozone design level for areas varied little, the per capita data, as well as the al NMHC inventory emissions, could be very different. It so stated that EPA's EKMA calculations may show too large of change in ozone design levels even for relatively small luctions in NMHC emissions (as with the proposed volatility ıtrol program). Since EKMA is actually a nationwide model, feels that the air quality projections for individual cities e oversimplified. It did, however, request that EPA present e results of each city separately. It commented that by ing such a simplistic modeling approach, EPA has necessarily introduced considerable uncertainty into the air ality predictions. MVMA felt that by using nationwide erages in the model, EKMA projections should only be used in relative, not an absolute sense. It stated that the EKMA del was developed in order to quantify the current derstanding of ozone chemistry. No model on ozone formation

has yet been universally accepted. Therefore, it argued, the EKMA model should only be used as guide to the development of control strategies in a relative and not an absolute way.

The fact that the design values for two areas could be similar while NMHC emissions are very different is not surprising. Ozone is a complex pollutant, and is dependent on many other variables such as NOx emissions. In regard to the comments challenging the accuracy of EKMA, it is noted that this approach has been defended at length elsewhere and these arguments will not be repeated here. Concerning the appropriate role of the model, it is agreed that because of the simplified nature of this approach, it should not be used in an absolute, or city-specific, sense. Rather, its role is to translate VOC reductions into ozone impacts using the limited available data. As was noted, no model has been universally accepted yet. However, it has been recognized that EKMA is a reasonably accurate method of relating VOC emissions to ozone impacts. Thus both the use of EKMA and the role it plays in EPA analyses are appropriate at this time.

3. Final Analysis

Like the final emission estimates of Section II.C, the final future ozone projections here will be those of the DRIA. The DRIA analysis projected that 40 non-California areas would be in non-attainment in 1990 without RVP control, dropping to 36 with RVP control to 10.5 RVP. This somewhat overstates the benefits of this interim RVP control program since the DRIA assumed Class A and B fuel would 8.2 and 9.1 RVP, respectively, where now they will be 9.0 and 9.5 RVP.

A more recent set of ozone projections was performed based on the same DRIA analysis which included preliminary estimates of running losses and excess evaporative emissions, utilizes 1982-84 ozone design values, and uses 1988 as the base year (based on the fact that 1988 ozone levels were very near those of 1983).[7] This rough analysis projects all 61 areas will remain in non-attainment in 1990. Only RVP control down to 9 psi was evaluated. Under this more stringent scenario, 42-44 non-attainment areas remained in 1990. Thus, the inclusion of running losses has the potential to worsen the future ozone picture, even after interim RVP control.

References (Chapter 3)

1. "The Motor Fuel Consumption Model Thirteenth Periodical Report," Prepared for U.S. DOE by Energy and Environmental Analysis, Inc., DOE/OR/21400-H5, January, 1988

2. "Effect of Running Losses and Excess Evaporative Emissions on Future VOC Emission Inventories," Memorandum from Richard A. Rykowski, Senior Project Manager, EPA/OAR/OMS/MVEL/ECTD/SDSB, to The Record, December 22, 1988.

3. Dodge, M.C., "Combined Effects of Organic Reactivity and NMHC/NOx Ratio on Photochemical Oxidant Formation - A Modeling Study," Atmospheric Environment, August 1984.

4. Ito, K., et. al., "Photochemical Reaction of Alcohol-Fueled Engine Exhaust Gases," 7th International Symposium on Alcohol Fuels, 1986, 433-438.

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6. Caplan, J.D., "Smog Chemistry Points the Way to Rational Vehicle Emission Control," SAE Transactions, Vol. 74, 1966.

7. "The Effect of Vehicle Running Losses on Future Ozone Non-Attainment," EPA Memorandum from Don Clay, Acting Assistant Administrator for the Office of Air and Radiation, to the Administrator, EPA, October 6, 1988.

Chapter 4

Economic Impact

The societal cost of RVP control is composed of several elements, all of which will be presented in this chapter. First, refineries incur a cost when reducing the RVP of the fuel. Second, increases in fuel energy density and reductions in fuel evaporative emissions result in savings to the consumer. Changes in drivability and safety also have an economic impact on society. Finally, enforcement of RVP regulations also results in a minor cost to society. These economic considerations are the subject of this section. Finally, the effect of RVP controls on crude oil imports will also be evaluated.

I. Refining Costs

A. Synopsis of NPRM

Chapter 5 of the Draft RIA accompanying the NPRM evaluated the economic costs and credits associated with the proposed RVP regulations. Modeling work performed by Bonner and Moore which evaluated the cost of RVP controls at 1 and 2 psi increments was used in determine refining cost. Fuel survey data was used to determine a national average baseline RVP. By applying Bonner and Moore's modeling results, average nationwide costs of control were determined for a number of RVP control scenarios.

B. Summary and Analysis of Comments

The majority of comments which were recieved on the economic impact analysis presented in the Draft RIA pertained to the proposed 1992 regulations of 7.0, 7.8, and 9.0 psi RVP fuel in Class A, B, and C areas, respectively; particularly the cost and feasibility of RVP control below 9 psi. However, a significant portion of the comments received dealt with issues applicable to both the interim and 1992 regulations, and some with the interim regulations specifically. Those comments will be dealt with here.

1. Feasibility of and Leadtime for Interim Control Program

There was widespread agreement among commenters, including all refiners, that the proposed interim control program would not present difficult technological problems for the production of Class C fuel. Although some concern was expressed about reductions below 9 RVP in Class A areas, no commenter expressed concern about specific technological barriers to the proposed

program. In evaluating an interim program based on Class A, B, and C RVP standards of 9.0, 9.5, and 10.5, respectively, API raised no concerns relating to feasibility or leadtime and stated that this level of control would require little or no capital investment. Most refiners either agreed with API or were silent on the issue of an interim program. Chevron specifically projected that the required RVP reduction would be made primarily by reducing the amount of butane in the blends, and that no capital investment would be necessary.

Conversely, Texaco commented that certain refiners would be required to spend capital investment funds for distillation and butane disposal to comply with an interim 10.5 psi standard in Class C, but provided no supporting evidence, and did not identify which refiners the comment applied to. Given the current degree of discretionary butane blending by the refinery industry it is unlikely that this would be the case. Another commenter, Sinclair Oil Corporation, stated that EPA's proposed Phase I regulations would require investments of $200,000 at two Wyoming refineries. However, as described in Chapter 2, many of the Rocky Mountain and Central Plains states which the Sinclair refineries service have been reclassified to less stringent levels (the most stringent standard has been relaxed from 8.2 to 9.5 RVP). Thus, for many of these states, meeting control levels will actually require no reduction in RVP from baseline levels.

EPA continues to believe that reductions in RVP to 9, 9.5 and 10.5 psi in Class A, B, and C areas, respectively, are achievable for all refiners without capital investment and with very little leadtime. Such interim standards would achieve some RVP reduction in Class B and C areas and would cap RVP in Class A areas at current levels. A recent letter to EPA from API stated that 45 days would be required to begin production of controlled fuel, allowing time for changes in refining processes and changes in arrangements regarding crude oil and butane. The letter lacked specifics as to why these tasks should generally take six weeks, and what refiners might do to hasten these events. While six weeks may allow all refiners to proceed in a business-as-usual fashion, EPA expects that some refiners may have to modify their standard practices relating to purchasing and distribution.

EPA believes that providing 70 days after promulgation of the standards will allow all refiners to provide terminals with complying fuel. Some refiners may elect to use flexibilities available to them to minimize the time they require to make purchasing changes and to get production going, and others may take advantage of options in the distribution system to reduce the refinery-to-terminal transportation time. Most refiners, we believe, will not require unusual efforts or expense in either production or distribution. Finally, as discussed in Chapter 1, an additional 30 days after compliance should allow all end users to come into compliance as well.

2. Volume of Fuel Controlled

Comments were recieved on EPA's draft analysis stating that the gasoline demand projected using the MOBILE3 fuel consumption model for future years was too low. EPA agrees and has based this analysis of refining costs on DOE fuel consumption projections.[1]

3. Cost of Interim RVP Control

Several commenters provided refining cost estimates for interim volatility controls which differed with the analyses performed by Bonner and Moore and EPA in several areas. One such commenter, API, included in their comments an estimate of compliance costs for the same interim controls evaluated in this RIA. API estimated the cost of controlling fuel RVP to 9, 9.5, and 10.5 in Class A, B, and C areas to be $540 million annually, significantly higher than the costs presented in section III of this chapter. Since the API analysis included all of the major comments received on interim RVP control, rather than deal with each commenter individually, the major areas of difference between API's and EPA's analysis will be presented here.

One of the major areas of difference between API's costs and those of EPA lies in assumptions regarding the length of the transition period neccessary for compliance with summer RVP regulations. In their comments, API stated that low-RVP fuel would have to be produced as early as mid-March, and further, that fuel produced in early spring would require a substantially greater RVP reduction, since March, April, and May ASTM limits are significantly higher than summer levels. API increased their refining costs by approximately $150 million to reflect this. As discussed in Chapter 2, EPA believes that API has overestimated the length of the required transition period, and further that the current lag between sales and production already neccessitates that volatility specifications for a fuel sold in one month be met by fuel produced during the preceding month. Consequently, this increase in refining costs is unwarranted. By eliminating this adjustment, API's cost estimate would be reduced to $407 million.

API also increased their estimated costs by $109 million to correct for improper amortization of capital equipment by Bonner and Moore, and to reflect increased operating costs due to the need for an additional month for transition in the spring. EPA believes that Bonner and Moore has properly amortized capital equipment costs (which apply to long-term control costs and not to short-term costs) and that an additional month of transition time is unwarranted. When this cost adjustment is excluded, API's estimated costs total $298 million per year.

API also commented that an R-value of 0.6 should be used in assessing fuel economy improvements. Correspondingly, API increased their refining cost estimates by $43 million per

year. As will be discussed in section III below, EPA's reanalysis of this issue concludes that an R-value of 0.85 should be used and that API has overestimated refining costs in this respect as well.

A further reason why the refining costs presented later in this chapter are lower than those of API relates to the baseline RVPs assumed in the analyses. In the NPRM, an average baseline RVP level of 11.7 psi (Class C equivalent) was used in determining costs as well as emission reductions. More recent analysis of survey data indicate that baseline RVP levels are somewhat lower and should remain so in the near future. (These are shown in Table 2-1.) As shown in Table 3-1, average baseline RVP levels in Class C areas are roughly 11.3 psi. Baseline levels in Class B areas are approximately 10 psi (11.5 psi Class C equivalent), while baseline levels in Class A areas are approximately 8.6 psi (11.0 psi Class C equivalent). This change in baseline RVP levels decreases calculated RVP control costs by roughly $60 million per year. Adjusting for the difference in R-value and for lower baseline RVP levels would reduce API's costs to $195 million, which is very close to EPA's estimate of $196 million for refining costs less fuel economy savings (presented later in this chapter).

API also included approximately $100 million in their cost estimates for compliance verification, the estimated cost of testing every shipment of gasoline. API did not present data in support of this estimate, however, and EPA believes it to be rather excessive. Thus, by subracting compliance verification costs, one sees that API's refining cost estimates are actually lower than EPA's. This is due to the fact that API underestimated control costs by using Bonner and Moore's long term control costs as a basis for their analysis. EPA beleives that the short-term, "no-investment" costs presented by Bonner and Moore are more representative for interim RVP controls, and has used these costs preferentially in the analysis presented below.

C. Refinery Cost of RVP Control

The interim control of summer gasoline volatility currently under consideration (volatility limits of 9.0, 9.5, and 10.5 psi in Class A, B, and C areas, respectively) will increase the cost of gasoline production, but should not require any short term capital investment (as discussed further below). The cost to refiners will merely be that of replacing butane, (a relatively cheap, high-octane, and high RVP blending component) with other gasoline components and with additional processing, to meet sales volume and pool octane requirements. The cost of compliance presented in this chapter should decrease in future years as refiners install and

employ facilities to convert butane into a low RVP, high octane blending component (e.g. MTBE, ETBE, etc.), unless the second level of RVP control takes place first.

The refinery cost modeling work performed for EPA by Bonner and Moore Management Science for this final analysis is improved in several ways over the modeling done for the NPRM. (The latest modeling results were placed in the docket shortly after the NPRM was published.) First, it was possible to incorporate directly into the model the estimated effect on refineries of reducing the demand for gasoline under a range of volatility-control scenarios. (RVP control reduces the amount of purchased gasoline which is lost to evaporation, thus reducing the volume of gasoline sold.) Second, the latest modeling was able to estimate the impact of a drop in the price of butane on refiners' raw material purchases and on the demand for the natural gas liquids (NGL) industry's products. A final improvement was to extend the range of the original modeling (which evaluated RVP reductions of only one and two psi) to evaluate reductions of one, two, and three psi. (This latter change has improved the accuracy of EPA's estimates of refinery costs at lower levels of RVP control.)

In addition to having Bonner and Moore improve the modeling itself, EPA modified the modeling results in three important ways to better reflect reality. First, we excluded the results for Bonner and Moore's Region 4 (California) because the model's predicted base case fuel contained unrealistically high levels of butane and low levels of pentane. Second, the estimate of the reduction in gasoline volume due to recovered evaporative emissions was revised to reflect the new higher evaporative emission factors. Third, case results were adjusted to reflect the $20 per barrel crude cost used in the NPRM.

EPA also applied the results of the modeling in a more sophisticated manner. Using the revised state-by-state RVP baseline levels and standards discussed above, EPA determined the current and final RVP level of each state's fuel by month for each control scenario and applied a refinery cost to each case. This allowed the determination of a separate cost for each of the three control levels (9.0., 9.5, and 10.5 RVP). As described in Section II, initial RVP levels thus calculated were somewhat lower than those in the NPRM.

Table 4-1 shows results of the Bonner and Moore modeling for Regions 1, 2, and 3 as described in their study. The cost estimates shown represent the additional cost incurred by the refinery in producing low RVP fuel (the cost to the refinery of producing the control case volume of reduced-RVP gasoline less the cost of producing the base case volume of base-RVP gasoline). This cost can theoretically be separated into three

Table 4-1

Bonner and Moore RVP Control Costs
(W/ Investment, $22/bbl crude, excluding California)

	RVP Reduction Level			
Region 1	Base	1st	2nd	3rd
Pool Avg RVP (psi)	11.75	10.73	9.71	8.69
Gasoline Volume (MBPD)	648.94	645.52	642.91	640.38
Direct Refining Cost (M$/D)	--	11.0	94.6	259.1
Direct Refining Cost ($/bbl*)	--	0.017	0.146	0.399
Region 2				
Pool Avg RVP (psi)	11.01	10.05	9.09	8.14
Gasoline Volume (MBPD)	2075.17	2064.17	2055.87	2047.78
Direct Refining Cost (M$/D)	--	173.4	664.7	1339.6
Direct Refining Cost ($/bbl)	--	0.084	0.320	0.646
Region 3				
Pool Avg RVP (psi)	10.92	9.97	9.02	8.07
Gasoline Volume (MBPD)	3132.91	3116.30	3103.77	3091.55
Direct Refining Cost(M$/D)	--	370.8	926.4	1554.0
Direct Refining Cost ($/bbl)	--	0.118	0.296	0.496
National				
Pool Avg RVP (psi)	11.04	10.08	9.12	8.16
Gasoline Volume (MBPD)	5857.02	5825.99	5802.55	5779.71
Direct Refining Cost (M$/D)	--	555.2	1685.7	3152.7
Direct Refining Cost ($/bbl)	--	0.095	0.288	0.538

* Denominator is barrels of gasoline produced in base case

individual components: 1) the cost to the refiner of reducing the RVP of the entire base volume of gasoline to the control level, 2) the savings to the refiner in production costs resulting from a slight fuel economy increase and corresponding volume reduction, and 3) the savings to the refiner resulting from evaporative emission reductions and the corresponding decrease in gasoline volume requirements.

For the purpose of estimating RVP control costs for different ASTM classifications, it is advantageous to determine the first component of the cost separately, and to subsequently take credits for fuel economy improvements and emission reductions. To do this, the cost savings to the refinery resulting from the reduced gasoline volume requirements was determined by multiplying the gasoline volume reduction in each control case by the pool-average incremental gasoline cost. By adding this value to the costs shown in Table 4-1, the cost of controlling RVP (excluding volume reduction savings) as a function of RVP levels was determined.

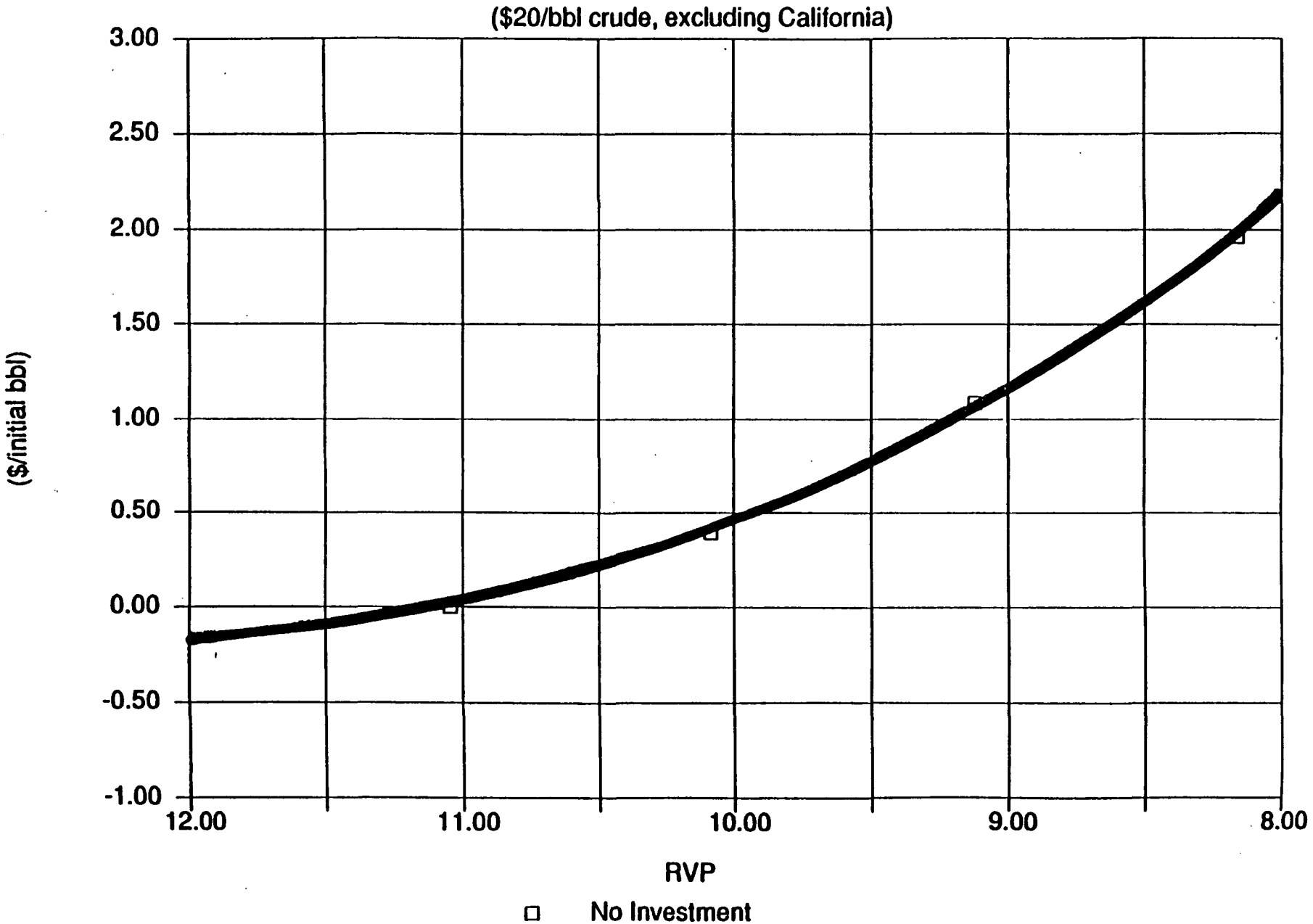
Several adjustments were subsequently made to these values. First, costs were adjusted to a crude oil price of $20 per barrel. Bonner and Moore had evaluated the sensitivity of RVP control costs to crude oil price with modeling runs in Region 3. Cases were run under $22, $17, and $27 per barrel crude scenarios. By interpolation, the cost of RVP control at $20 per barrel was determined for Region 3, and costs for Regions 1 and 2 were adjusted proportionally.

Second, Bonner and Moore also ran cases for Region 3 which determined the cost of RVP control assuming no investments were made by refineries. Since interim RVP regulations will require compliance before significant investments can be made, these no-investment case results are more representative of the short term situation. Thus, the relative cost of fuel control in Region 3 under the "no-investment" and "investment" scenarios was evaluated. Next, a proportional adjustment was made to "investment" control costs in Regions 1 and 2. The end result of these adjustments were "no-investment, $20 per barrel crude" RVP control costs defined for three different levels of RVP control. The national average costs of RVP control are shown in Figure 4-1.

Costs taken from this curve were applied on a state by state basis to estimate the national cost of the interim regulations. EPA estimated the current RVP of each states fuel by month from MVMA fuel survey data.[2] As described in Section B.3. above, these values were lower than those used in the NPRM. The control RVP level was then determined for each state according to state-by-state RVP standards, as revised from the NPRM (see Chapter 1). An RVP control cost was then applied to the volume

Figure 4-1

RVP Control Costs



of fuel sold in each state over the entire compliance period of roughly five months, using EIA estimates of monthly sales of petroleum products.[3] Costs were aggregated according to volatility control classification for use in determining class specific cost-effectiveness.

Results of the analysis showed that in those areas which would be required to meet the 9.0 psi Class A standard, no control costs would be incurred. This is because fuel currently sold in Class A areas in slightly less than 9.0 psi already, and because all Class A/B areas have been reclassified as Class B. For fuel sold in areas required to meet the 9.5 psi Class B standard, an average compliance cost of 0.57 cents per gallon was calculated. Compliance costs vary in Class B areas, however. In those areas formerly defined as Class A which have been relaxed to Class B, no cost will be incurred. At the other extreme, in B/C areas, fuel required to comply with Class B regulations will cost an additional 1.63 cents per gallon. Average compliance costs for those areas required to meet the 10.5 psi Class C standard will be 0.56 cents per gallon, with variations similar to those in Class B. The total refinery cost of the interim standard will be 0.54 cents per gallon, or $247 million per year.

II. Fuel Economy and Evaporative Emission Recovery Credits

A. Synopsis of the Draft Regulatory Impact Analysis

The DRIA examined the fuel economy impact associated with volatility control. Specifically, since the heat of combustion of gasoline is projected to increase with volatility control, the fuel economy of the gasoline-fueled fleet is expected to have a proportional increase. Increasing fleet fuel economy has a cost savings associated with it, and as a result, this was evaluated in the DRIA.

1. Relationship of Fuel Volatility to Heat of Combustion

The relationship between fuel RVP and the fuel heat of combustion involves complex refinery modeling, since octane and other performance requirements must be maintained as the butane and other light hydrocarbons are removed from the fuel, as well as due to the wide range of commercial fuel heats of combustion for any given fuel RVP. The results of a linear programming model developed by Bonner and Moore were verified using MVMA fuel survey data and used to estimate a 0.25 percent increase in fuel heat of combustion with a 1 psi reduction in fuel RVP, and a 0.56 percent increase with a 2 psi reduction.

2. Relationship of Heat of Combustion to Fuel Economy

If a vehicle were 100 percent effective in utilizing the additional energy available in the fuel due to volatility control (no change in vehicle energy efficiency), the fuel economy would be expected to increase 0.25 percent for the 1 psi reduction in RVP and 0.56 percent for the 2 psi reduction. Due to heat losses in the engine and certain vehicle operational characteristics, a vehicle typically is less than 100 percent effective in utilizing additional energy in the fuel. The result is that the percent change in fuel economy is less than the percent change in fuel heat of combustion associated with fuel volatility control. This ratio is defined to be "R".

In an attempt to evaluate R, a review of available data showing both fuel economy and fuel heat of combustion from testing with different fuels was performed. However, for a variety of reasons, this test data could not be used to define a representative value for R. Among these reasons were:

1) The large error in fuel economy and fuel heat of combustion measurements (at best 1.0 percent and 0.9 percent respectively) compared to the maximum expected change in fuel economy of 1.6 percent, and the resulting wide scatter in the R values calculated;

2) The age of much of the data and the corresponding ability of newer closed-loop fuel-injected vehicles to better take advantage of differences in the fuel;

3) The fact that typically the data was collected for a purpose other than to determine R, resulting in variables atypical of just volatility control changing during testing;

4) Test fuel differences inconsistent with those expected to result from volatility control of commercial fuel (e.g., Large differences in fuel sulfur levels, aromatic levels, distillation curves, etc.) causing fuel economy changes independent of the fuel heat of combustion differences;

5) Testing of vehicles on different fuels without first modifying the vehicle to react properly to those fuels (i.e., testing with very high volatility fuels at high temperatures resulting in overwhelming of the evaporative control system, or testing with very low volatility fuels under very low temperatures resulting in poor drivability).

Because of the difficulties in using available test data to determine the appropriate value for R, a theoretical analysis of the combustion of fuel in the engine was performed. The model selected analyzed heat losses in the engine as a function of not only changes in the fuel heat of combustion, but also the mean effective temperature of the cylinder charge, the fuel-air ratio, the fuel specific gravity, the change in air volume required, and the specific heat of the cylinder charge. The model was then developed further to take into account the average efficiency of a gasoline vehicle, the effects of coast and idle operation, the effects of changes in engine friction, and the effects of changes in fuel pump losses. Other things such as cold starting on a lower RVP fuel, test cycle transients, open loop warm-up operation, and possible changes in fuel/air mixture homogeneity and distribution were found to either have no affect on the value of R, or to affect it in a small but unquantifiable way.

The result of this analysis was an R value calculated to be approximately 0.82 using the fuel changes expected with volatility control. This is well within the range of the available test data mentioned above. In addition, the theoretical R value using the model and the average value from test data on propane matched extremely well. Information on methanol vehicle efficiencies was then used to determine a value for R of 0.95. Due to the large differences in fuel economy and heat of combustion between methanol and gasoline, the errors in measurement become less significant, and the result more reliable. As a result, this value was selected as an upper bound for R, while 0.82 was kept as a lower bound.

3. Relationship of Gasoline Volatility to Fuel Economy

When the relationship between the fuel volatility and energy density of the fuel was combined with our best estimate for the relationship between the energy density and fuel economy, the relationship of gasoline volatility to fuel economy was determined. The result was that the 0.25 percent increase in fuel energy density for a 1 psi reduction in RVP was estimated to result in a 0.205 to 0.238 percent increase in fuel economy, while the 0.56 percent increase in energy density for a 2 psi reduction in RVP was estimated to result in a 0.459 to 0.532 percent increase. When these fuel economy increases were applied nationwide, the fuel saved was credited at a retail price (minus taxes) of $0.82 per gallon of gasoline.

4. Relationship of Evaporative Purge to Fuel Economy

In addition to the changes in the fuel causing a small change in the fuel economy of the vehicle, the efficiency of the vehicle at burning the vapors (assumed to be butane) purged from the evaporative control system was also determined. Assuming that the vehicle can compensate for the purge to maintain stoichiometry, and applying the range in the R value discussed above, the vehicle was found to be anywhere from 0.976 to 3.492 percent more efficient at burning the butane from the purge, than from burning the gasoline directly from the tank. These percentages were then applied to estimates of the reductions in evaporative HC emissions with RVP control as described in Chapter 5 of the DRIA.

B. Summary and Analysis of Comments

1. Relationship of Fuel Volatility to Heat of Combustion

No comments were received on this aspect of the analysis. However, based on more recent work with the Bonner and Moore model, new estimates for nationwide increases in heat of combustion with volatility control have been made. Following the refinery modeling described in Section 4-I, volatility control across the country to 10.5 psi in Class C areas (9.5 in Class B areas, and 9.0 in Class A areas) results in a 0.160 percent increase in the heat of combustion of gasoline (0.0, 0.108, and 0.199 for Class A, B, and C areas respectively).

2. Relationship of Heat of Combustion to Fuel Economy

There were a number of comments on the proper use of the available test data to determine the appropriate R value for volatility control. In the DRIA the available test data were determined to be unacceptable for defining an appropriate value for R, and instead were used merely to show that the value derived through theoretical modeling was in the range of possible values. Certain comments from MVMA, GM, and API tend to support our reasons for this decision, although none of them agree with eliminating the use of the test data entirely in favor of theoretical modeling.

GM stated that combining the data from the different sources ignores the effects on fuel economy of changes in fuel properties other than the heat of combustion. They conclude that each data set (since it is real world) should be analyzed individually to determine if there were too many variables changing, not enough data available, or if the technology represented was too old to accurately define the current value of R.

We agree with GM that real world data is always preferable to theoretical modeling when reliable data exists. Unfortunately, in this situation reliable data did not exist. All of the available data, aside from being severely inaccurate due to the error associated with fuel economy and fuel heat of combustion measurement, also tends to be unrepresentative of the situation we are trying to model - fuel economy improvement associated with a reduction in fuel RVP. The majority of available data was collected using fuels drastically different in fuel sulfur level, specific gravity, aromatics content, stoichiometric fuel/air ratio, or boiling range, compared to that which would be expected with volatility control. In addition, testing was often done under conditions atypical of average in-use vehicle operation, such as using low RVP fuels at low temperatures and high RVP fuels at high temperatures, causing drivability problems which could lower any measured value of R, or using vehicles which are unrepresentative of today's electronically controlled fuel-injected vehicles. The result is that for the available data sets, there are typically too many variables changing, not enough data collected, and/or obsolescent technology represented to accurately define a value for R representative of volatility control.

MVMA pointed out a number of problems with a number of the available data sets, showing that these studies included far more variables than just the heating value of the fuel. As a result, they concluded that aggregating the data from all sources by model year was devoid of any statistical or technical rationale, and went on to say that none of the data would support a change from the R value of 0.6.

EPA agrees with this comment by MVMA in general, however, the value of 0.6 suffers from the same limitations they mention. The test data which determined this value was from 1970 and 1972 vehicles which could not be maintained at stoichiometry (i.e., frequently ran rich which tends to decrease R). The fuels used in the testing were not production gasolines, and as a result had significant differences in percent aromatics, specific gravity, and distillation curves in addition to the heat of combustion differences. In addition, the heat of combustion was not measured, but estimated based on other fuel properties, and the fuel economy was measured by weighing the fuel and measuring the distance traveled. As a result there was a significant degree of error associated with this testing as well even though replicate testing was performed. The report itself states that "[B]ecause of the limited number of cars involved, these tests can only give an indication of 1970 and 1972 car performance in general." Calculation of R from the small changes in fuel economy and heat of combustion is hardly a "general" observation. The bottom line is that MVMA is correct in stating that the available data cannot support a change from the R value of 0.6

which they support. However, neither can the available data be used to support the R value of 0.6 (or any other value). As a result, EPA did not use the data either individually or aggregated to determine R, but instead selected theoretical modeling to determine the R value associated with volatility control.

In their effort to support the use of test data as opposed to theoretical modeling, API stated that experimental data properly interpreted and sufficiently representative of actual conditions provides the best estimate of R, since theoretical mechanisms are not well understood. They went on to say that reliable experimental results can be generated when test variability exceeds the measured effect by multiple testing of certain combinations of parameters, and that it is possible to determine cause and effect relationships from limited data sets. They then stated that although the data on recent model vehicles suggests that the R value may be higher for newer vehicles than that measured on older vehicles, the data is too limited to place any confidence in this assertion. Instead, they emphasize that Chevron data on 1973-6 model year vehicles is the most acceptable since it was done using commercial fuels, and that a value of 0.6 for R based on this data is the most appropriate estimate.

We also agree with API that test data is generally the most reliable source of information. However, we do not believe, nor did they establish, that any of the available data met the stated conditions of being sufficiently representative and of having included multiple testing of certain combinations of parameters. As stated above, none of the data sets meet these requirements. This includes the Chevron data, which suffers from unrepresentative levels of aromatics and sulfur in the fuels, differences in distillation curves and API gravity, vehicles unrepresentative of today's vehicles, and vehicle testing aimed at poor drivability which may affect R. Theoretical analysis even with all of its uncertainties appears to be the best available option.

In addition to comments on the use of test data, a number of comments were also received concerning the accuracy of the theoretical model developed to evaluate R. Although there were a few comments concerning possible errors in the modeling, the majority of these comments focused on parameters the commenters believed would affect the value of R which were not taken into account in the model.

API reiterated comments on the volatility study which questioned the effects of cold starting, idling and braking, and transient operation on the value of R. All of these have already been discussed at length in the DRIA. Cold start was determined to cause a likely decrease in the value of R, but

was not found to be quantifiable. The effects of idling and braking have a similar directive effect, and were, if anything, overcompensated for in the model, and transients were determined to have little or no effect on the value of R. Thus, there appears to be a good balance in the unquantified nature of these parameters.

In addition, API made the comment that the poorer driveability associated with lower volatility fuels will result in lower fuel economy and therefore, lower R values. For this statement to be true, not only must the level of volatility control being proposed result in overall poorer vehicle drivability, but the resulting difference in driveability must also significantly affect the value of R. In answer to the first part, it is not necessarily true that a fuel volatility reduction of the magnitude proposed will result in overall poorer driveability. Few vehicles (mainly older, carbureted, and improperly maintained vehicles) are expected to experience noticably poorer cold-temperature driveability on fuels controlled to the levels proposed by EPA. In addition, any possible detriment at cold temperatures will likely be negated by improved driveability on vehicles (mainly older, carbureted vehicles) at high temperatures. The result is that even if driveability affects the value of R, the direction of the effect is uncertain, and is likely negligible. This especially true for the level of volatility control proposed in this interim rulemaking. As discussed in Section 4-III, no detriment in vehicle cold-temperature driveability is expected with this level of volatility control, only an unquantified hot-temperature driveability improvement.

In answer to the second part of the comment, although poor driveability probably tends to decrease the value of R, for driveability to affect it significantly the reduction in driveability will have to be much more pronounced than that expected to result from volatility control. Data provided by API in their comments on the DRIA tends to support this statement. Testing on 6 recent model vehicles at 3 temperatures ranging from 42°F to 80°F, and on 4 fuels ranging in RVP from 6.5 to 10.5 resulted in no correlation between the level of drivability demerits and the R value due to volatility control (there was a more pronounced effect of temperature). As a result, it is doubtful that driveability effects resulting from the range of volatility control in question will have any substantial impact on the value of R.

API also discovered a small error in the model. For the calculation of the gas flow per unit time which was an input into the model, the thermal efficiency of the vehicle was assumed to remain constant for all cases at 38 percent. However, in order for R to be anything other than one, the thermal efficiency must change. Fortunately, the effect of

assuming thermal efficiency constant for this purpose over the range of change in the actual thermal efficiency expected is negligible, and the model's outputs remain the same. Since there is no significant effect, and since changing the model to correct this error would make it even more complicated, no change will be made.

GM made the comment that the hydrogen to carbon (H/C) ratio and heat of combustion of the fuel (in BTU/lb) should also be taken into account in the modeling, since the H/C ratio affects the heat losses from the engine. Both of these points are true to some extent, and that is why the heat of combustion per pound of fuel has already been taken into account in the model. The H/C ratio, on the other hand, is only a secondary measure of other primary changes which take place with the fuel. As a result, the influence of H/C on the heat of combustion of the fuel has already been taken into account directly by dealing with the heat of combustion itself. As stated by GM the H/C ratio also affects the stoichiometry of the fuel. The H/C ratio, however, proves to be a rather poor measure for moles of products per mole of reactants (which is how GM tried to use it in their comment). Although the H/C ratio decreases with volatility control, stoichiometric analysis using the fuel properties shown in Table 4-2 reveals that the ratio of moles of products to moles of reactants actually increases slightly with volatility control. As a result, any additional changes to the modeling based on GM's comment and the above discussion would if anything increase the value of R. The magnitude of the difference is not significant enough, however, to warrant a change to the model.

API raised a related issue which they felt should also be taken into account in the calculation of R. The maximum pressure rise and resulting work output from the engine is a direct function of the number of moles of working fluid (in addition to temperature). However, for equivalent speed and power, a higher energy density fuel requires less fuel which in turn results in fewer moles of working fluid. Therefore, this will tend to decrease the value of R. In addition, the reduction in fuel required results in a lower demand for air. This in turn results in higher throttling losses which also will decrease the value of R.

Stoichiometric evaluation of both 11.5 and 9 RVP fuels using the calculated fuel properties shown in Table 4-2, reveals API's comment to be true, at least in part. If we assume constant energy input into the cylinder, the 9 RVP fuel requires approximately 2.94 percent fewer moles (0.73 percent fewer gallons) of fuel resulting in a slight (0.05 percent) decrease in the number of moles of combustion reactants and products. However, there is actually a very slight increase in the amount of air required for stoichiometric combustion.

Table 4-2

Fuel Properties

Fuel Parameter	Butane	9 RVP	11.5 RVP*
Heat of Combustion:			
BTU/lb	19643	18500	18540.9
BTU/Gallon	95661.4	114330	113489.9
BTU/mole	1141729.7	2053618.4	1993233.3
Avg Molecular Weight	58.124	111.006	107.505
Avg Chemical Formula	C_4H_{10}	$C_8H_{14.8}$	$C_{7.735}H_{14.482}$
H/C Ratio	2.25	1.85	1.87
Molar A°/F° Ratio (Stoic)	30.94	55.692	54.053
Mass base F/A (Stoic)	0.065115	0.069087	0.068937
Specific Gravity	0.5836	0.7405	0.7335
Density (lb/Gallon)	4.87	6.18	6.121
Charge Specific Heat (BTU//lbm °R)	0.2847	0.2826	0.28267

* Values calculated based on the replacement of 1.8 volume percent of liquid gasoline with butane per 1 psi increase in fuel RVP.

Note: Some values may vary slightly from those in the DRIA. Those shown here are thought to be more internally consistent since they are calculated based onstoichiometry.

This effect can be analyzed by using a simplified model. If we assume that miles driven are proportional to the moles of products of combustion, then the fuel economy increases by appoximately 0.685 percent (over an assumed baseline of 28.35 mpg with the 11.5 RVP fuel) for a 0.74 percent increase in the heat of combustion of the fuel per gallon. This yields an R value of 0.93. Therefore, API was correct in their comment that the R value should decrease due to a decreasing number of moles of working fluid (assuming constant energy input). However, since this is a different modeling technique than that done by EPA in the DRIA, it is a decrease below 1.0, not a decrease below the EPA values. (EPA's model looked at a change in the energy required to go one mile. This model looks at a change in distance traveled assuming a constant energy input.) This value is then reduced by other effects such as idle operation just as the initial R value of 0.931 from EPA's model in the RIA was reduced. The result that the R value from this new model is very similar to that calculated in EPA's earlier modeling. As a result, no change will be made to EPA's existing model due to this comment.

Contrary to API's comment, the effect of throttling losses does not decrease the value of R. As stated above, although less fuel is required at lower RVP, slightly more air is required, tending to decrease throttling losses and increase the value of R. However, the small change in air required, and the small percentage of throttling losses to the total energy consumption of the vehicle (only a portion of the 6 percent allocated for pumping losses in the DRIA) results in no significant changes to the value of R.

In another comment, API questioned the appropriateness of using experimental values from methanol and propane to verify the model. The intent in using these fuels was to provide significant differences in the measured heat of combustion and the measured fuel economy. As a result, the errors in fuel economy and heat of combustion measurement were small in comparison to the differences in those properties between the fuels. Thus greater confidence could be placed in the R values calculated using these fuels than when two gasolines were used which only had slight differences in properties. Unfortunately, while a greater level of confidence can be placed in the accuracy of the R values calculated if fuels as widely different from gasoline as propane and methanol are used, the R values calculated are no longer representative of those expected from volatility control. Many parameters other than the fuel heat of combustion affect fuel economy, and many of these are taken into account in the model used to determine R. However, the differences in these parameters resulting from volatility control are very different from those which exist between gasoline and propane or gasoline and methanol. Therefore the only accurate means of determining an R value

associated with volatility control is to use only those changes in fuel properties and vehicle operating parameters expected to result from volatility control. As a result, EPA will not use the results from comparing propane or methanol to gasoline as a means to determine a representative value for R for the case of gasoline volatility control.

In the process of evaluating these comments, it was discovered that the portion of the model dealing with engine friction was in error. Since engine friction is expected to decrease due to an increase in the power output per stroke, an increase in the energy density of the fuel should increase the value of R. The effect of the previous modeling was just the opposite. Upon reanalysis, it appears that the power output per stroke is proportional to the heat energy per mole of reactants in the cylinder, as well as to the heat losses from the cylinder walls, and not proportional to the heat energy per pound of air in the cylinder. The effect of this change will be shown in the conclusion of this section.

3. Relationship of Gasoline Volatility to Fuel Economy

There were no comments on this portion of the analysis, and as a result, the only changes made are those which result from the changes in the previous sections.

4. Relationship of Evaporative Purge to Fuel Economy

In the DRIA EPA took a credit for the energy value of evaporative emission reductions which resulted from its volatility control program. To do this EPA multiplied the emission reductions by a recovery factor or combustion efficiency of the vapor in the engine. Ford raised the comment that the manner in which this evaporative recovery factor was applied was in error. They stated that the evaporative recovery factor as determined is only applicable to the evaporative emission reductions which result from vehicle control (i.e., are captured by the canister and burned in the engine). The evaporative emission reductions which result from fuel control (i.e., uncontrolled vehicle evaporative emissions, running losses, evaporation from storage and handling, etc.) directly replace fuel going into the vehicle, and as a result should be credited on a one for one basis with liquid gasoline.

Ford is correct; the manner in which the evaporative recovery factor was applied in the DRIA was in error. Only those emission reductions which result from vehicle control should be multiplied by the evaporative recovery factor since they are the only emissions which are burned in the engine as purged vapor. Emission reductions which result from fuel control should not be multiplied by this factor, since they are not burned in the engine as purged vapor. As stated by Ford,

the appropriate "factor" to be applied to the emission reductions resulting from fuel control is 1.0, since they are converted to liquid fuel. The appropriate factor to be applied to the emission reductions resulting from vehicle control, however, received a number of comments.

MVMA stated in their comments that instantaneous control of the air to fuel ratio is not possible due to the broad range of control needed for the range of vehicle operation. As a result, the ratio of the combustion efficiency of the purged vapor compared to fuel from the tank should be less than 100 percent. Ford echoed this statement, but gave different justification. According to Ford, vehicles often purge the canisters during periods when the vehicle is not doing useful work (i.e., idling). As a result, they estimate the combustion efficiency of the purged vapor to be only 50 to 60 percent of that for whole gasoline.

EPA staff do not believe Ford's comment to be relevant, since very few vehicles purge during idle, and even for the small fraction that do, the fuel consumed during idle is only a small fraction of the total fuel consumption of the vehicle.

The concern expressed by MVMA has some validity. Today's vehicles typically use exhaust oxygen sensors to maintain engine operation at stoichiometry. When a slug of hydrocarbon from a canister enters the engine, there is a time lag between when the engine burns the hydrocarbon, and when the oxygen sensor reads a low oxygen level. As a result, until the vehicle can correct back to stoichiometry the vehicle will operate rich, and not achieve optimum use of the vapors from the canister. Improved purge solenoids which slowly increase the purge rate to the engine instead of allowing a "slug" of hydrocarbon to enter the engine are expected to go a long way in improving the engine's effectiveness at burning the purged vapors, but nevertheless the vehicle will still operate slightly rich during the time lags associated with the number of small increases in purge. (For this rulemaking, EPA has assumed that these more sophisticated and slightly more costly purge solenoids will be used on future vehicles to meet the exhaust emission standards.) Although this can be used to explain why the actual combustion efficiency of purged vapor compared to liquid fuel may be less than that which is theoretically possible (determined to be 1.00976 to 1.03492 by EPA in the DRIA), it does not help quantify the effect.

GM also supported a reduction in the assumed combustion efficiency of purged vapor. They performed 22 repetitive tests on a prototype vehicle equipped with an onboard refueling canister in which they measured simultaneously over the 1972 FTP the fuel economy and the mass of hydrocarbon purged to the engine. On the basis of this testing they estimated the

combustion efficiency of the purged vapor including any improvement due to R to be 90 percent, and suggested 80 percent as a value practical for real world application.

Unfortunately, GM provided little supportive information describing how the testing was performed, and no supportive information for why the real world value should be so much lower. Nothing was said as to the vehicle tested, the type of purge control system, the method used to measure the mass of the purge, as well as many other important criteria for evaluating the data. It is assumed that GM performed the testing on a vehicle equipped with a current evaporative control system, and a saturated onboard canister. The onboard canister GM used was likely larger than that required by EPA for the evaporative controls proposed in August of 1987. Purging this saturated canister would result in a worst case flow of hydrocarbon vapor to the engine. Since it is likely that the combustion efficiency of this purged vapor decreases once the amount and concentration of HC purged to the engine exceeds the capability of the engine to fully adjust, the low combustion efficiency determined by GM using a vehicle with a "stock" purge control system and an oversize canister appears reasonable. However, EPA expects manufacturers to introduce improved purge control hardware and software on their new vehicles to eliminate the majority of operation outside of the vehicle's ability to properly adjust for the purge. EPA expects this to be true even under the current proposals which will likely require larger canisters to control running losses and other currently uncontrolled evaporative emissions.

The hardware and software necessary to accomplish this task appears to already exist as is evidenced by the performance of vehicles in EPA's running loss test program. Some of the vehicles, as shown in Table 4-3, appeared able to effectively handle the amount of vapor being purged even with the use of current high RVP fuels at high temperatures (well above the 95°F starting temperature). The vehicles maintained low emission rates without experiencing elevated exhaust HC and CO emissions (indicative of stoichiometric operation). As a result, it can be said that vehicles exist today that appear able to handle large quantities of vapor without deviating from stoichiometry and most likely without encountering fuel economy detriments. Thus, it appears that the ratio of the combustion efficiency of purged vapor to liquid fuel is likely to be close to the theoretical maximum for new vehicles designed for such conditions. In addition, these vehicles were tested under conditions of elevated temperature which are much more severe than the July-average temperatures used by EPA to determine the evaporative recovery credits. Using July-average temperatures, the evaporative control systems on the vehicles would have been less severely stressed, and as a result, would likely have maintained stoichiometry even better.

Table 4-3

Running Loss Test Program Results

			1st LA4			2nd LA4		
Veh No	Temp °F	Fuel RVP	Exh HC (g/mi)	CO (g/mi)	Running Losses	Exh HC	CO	RL
255	95	11.7	0.521	5.415	0.36	0.377	3.988	2.59
256	95	11.7	0.285	5.152	0.00	0.179	3.781	0.00
259	95	11.7	0.292	3.307	0.06	0.216	2.962	0.01
260	95	11.7	0.365	4.617	0.04	0.260	5.377	0.02
261	95	11.7	0.534	6.872	0.04	0.384	6.547	0.61

In the DRIA, EPA assumed, based on R value calculations, that the combustion efficiency of the purged vapor was slightly greater than 1.0. The theory of purge control, and the subsequent combustion in the engine, suggests that this is a maximum, and that the real world value is probably something less. GM's data probably represents an overly pessimistic conditions; thus, the evaporative recovery factor is probably greater than 0.90. As a result, a realistic option may be to assume the combustion efficiency of the purged vapor compared to liquid gasoline (the evaporative recovery factor) to be 1.0. Therefore, whether the emission reductions are expected to result from fuel control or vehicle control, they will be credited at 100 percent of the value of the liquid fuel which they displace.

C. Conclusions

1. Relationship of Fuel Volatility to Heat of Combustion

The comments provided by the manufacturers resulted in few significant changes to the R value analysis. EPA still believes that theoretical modeling is the best available option for estimating R due to the severe limitations on the test data. The only change to the DRIA's theoretical modeling resulted from a discovery of an error in the previous model. The corrected model is now:

$$Q_2 = (0.62)Q_2\frac{(Q_{cyl2})}{Q_{cyl1}} + Q_1(0.04)\frac{(Q_{c2})}{Q_{c1}} + 0.21Q_1 +$$

$$(0.13)Q_1 * \frac{Q_{f1} * (A°/F°_2 + 1) * Q_{cyl2}}{Q_{f2} * (A°/F°_1 + 1) * Q_{cyl1}}$$

Where:

Q	=the energy required to travel one mile
Q_{cyl}	=the ratio of heat lost to the cylinder walls to the heat of combustion of the fuel
Q_c	=the heat of combustion of the fuel per gallon
Q_f	=the heat of combustion of the fuel per mole
$A°/F°$	=the molar stoichiometric air to fuel ratio of the fuel
1	=the baseline fuel
2	=the new fuel

Solving this equation for Q_2/Q_1 using the fuel property data in Table 4-2 yields a value of 1.00107 which when substituted into equations 2 and 3 from Chapter 5, Section V of the DRIA yields an R value of 0.85, just slightly greater than the value of 0.82 in the DRIA.

Due to the unrepresentativeness of other fuels of the fuel changes expected with RVP control, the R value of 0.95 in the DRIA based on methanol is probably not appropriate, and as a result, the value of 0.85 based on the theoretical model stands alone as the best estimate for R.

2. Evaporative Recovery Factor

The comments provided by the manufacturers resulted in only a minor change to the evaporative recovery factor. Comments by Ford indicated that while EPA had assumed there to be only one evaporative recovery factor, there were actually two: one for use with evaporative emission reductions resulting from fuel control, defined to be 1.0; and one for use with evaporative emission reductions resulting from vehicle control. Following analysis of the comments, this latter factor was reduced from a value slightly greater than 1.0 as used in the DRIA, to a value of 1.0. Since the evaporative recovery factors were approximated to be 1.0 regardless of the source of the evaporative emission reduction, the treatment of the fuel related and vehicle related emission reductions in the cost effectiveness section of this document will be identical (consistent with the DRIA).

3. Summary of Credits

The refinery costs presented in Section 4-I do not include a credit for increased fuel economy or decreased evaporative emissions, however. Based on the R factor analysis above, and the Bonner and Moore estimates of the fuel energy density increases and corresponding gasoline volume demand decreases expected with RVP control, the total reduction in gasoline volume demand was calculated. The societal cost savings associated with this reduction in gasoline volume will be approximately $51 million per year. The interim regulations will also result in evaporative emission reduction of 190,000 tons per year, derived as in the Draft RIA (616,000 tons per year including running loss estimates, See Table 3-2). The economic credit associated with recovery of these evaporative emissions is a approximately $54 million ($174 million) annually (See Table 5-1).

III. Drivability and Safety Impacts

A. Synopsis of Draft Regulatory Impact Analysis

1. Volatility Increases and Driveability Problems

In the period from 1974 to 1985 the volatility of unleaded regular gasoline increased by 10 to 20 percent depending on the area of the country. In 1985 for the first time the average nationwide summer volatility surpassed the average ASTM

recommended limits. The result has been that even though vehicles during the same period have been designed to operate better on higher volatility fuels, some vehicles have begun to experience varying levels of vapor lock and fuel foaming causing unacceptable driveability. This statement was supported by comments on the 1985 Volatility Study, information provided by automobile manufacturers, and also by a number of studies in the literature which had looked into the problems of hot temperature driveability. These studies showed that volatility levels were indeed to a point where driveability problems could be expected on some vehicles. At the same time, other studies demonstrated that for the period of control and the level of control proposed, cold temperature driveability should not be a significant concern. This last statement was supported by in-use information from California where volatility has already been controlled for some time.

2. Driveability Cost Estimation

The cost associated with current driveability problems (or the cost savings resulting from improved driveability with volatility control) was estimated by assuming that people whose vehicles are experiencing driveability problems were willing to pay an extra 1¢ to 3¢ per gallon for fuel which would avoid those problems. Temperature and population data for the 10 largest ozone non-attainment cities were used to approximate the nation as a whole. This information was then used along with vehicle age distributions, usage patterns and information on the fraction of vehicles with unacceptable driveability from Coordinated Research Council (CRC) testing to determine the fraction of fuel sold nationwide which is burned under conditions of unacceptable driveability. Multiplying this amount of fuel by the 1¢ to 3¢ per gallon yielded estimates of up to $78 million per year for the nationwide cost of poor hot-temperature driveability.

Although EPA did not rely on it for the final cost estimation, GM and Chrysler provided information on in-use vehicles which also demonstrated that the costs associated with hot temperature driveability problems were real. On the basis of the information they provided, annual warranty costs due to hot temperature driveability problems amount to roughly $8.1 million annually, and costs associated with vehicle design modifications to avoid hot temperature driveability problems have amounted to roughly $124.1 million annually. EPA decided that not all of these design costs could be recovered if fuel volatility were reduced, however, since they are costs that have already been incurred to fix the problems. Still, the estimated cost savings if volatility were reduced due to removal of certain corrective parts from the vehicle was estimated to be $44 million annually. Since the accuracy of the methods used to extrapolate the information provided by

Chrysler and GM into nationwide costs was unknown, these costs were not relied on. However, they did serve to support the costs calculated above.

B. Summary and Analysis of Comments

1. Hot Temperature Driveability

In general, the comments on the hot temperature driveability analysis were somewhat limited. The oil companies who commented on the topic of driveability were generally in favor of EPA setting volatility standards, but the level of control recommended was typically that of the current ASTM levels or slightly lower. They cited reasons such as poor cold temperature driveability, the lack of a clear benefit for further reductions, and fuel explosivity at low temperatures as reasons why reductions much below ASTM were not justified. The motor vehicle manufacturers, consumer groups, and environmental groups who commented, however, cited hot temperature driveability problems and hot temperature/high volatility safety problems as justification for supporting EPA's proposed level of control, with some recommending levels even lower.

API, Texaco, and Sunoco provided the only substantive comments on the topic of hot temperature driveability with their criticism of EPA's use of CRC driveability studies. They stated that the CRC hot temperature driveability test, due to (among other things) its extremely severe nature, is not representative of in-use operation. As a result, they stated that comparisons of the results from this testing are not directly applicable to consumer acceptability of a given fuel. They also stated that some of the testing had confounding results, and that typically it was necessary to exceed the recommended ASTM ratings to obtain markedly poorer driveability. They also pointed out that Figure 5-13 of the DRIA (from which the cost estimates of poor hot temperature driveability were derived) was used incorrectly. They stated that the figure, taken from a CRC report, was used as a measure of consumer satisfaction for a given fuel RVP, while in fact the figure was derived from CRC trained rater data.

Based on information contained in the DRIA, the comments discussed above, and comments by other vehicle and consumer groups, it is still apparent that hot temperature driveability problems exist, and represent a significant cost to society. However, EPA's earlier attempt to quantify that cost appears to have been flawed. The vehicle manufacturer information used to support the cost credits, however, remains as a justification for hot temperature driveability credits with volatility control. However, since the accuracy of these estimates on a nationwide basis are unknown, it does not appear appropriate to take a cost credit for improved hot temperature driveability. Also, since the driveability cost benefit proved to have such a small effect on the cost effectiveness of volatility control in the DRIA, this change should have little overall effect on the regulation.

2. Cold Temperature Driveability and Safety

In comparison to hot temperature driveability, a great deal of comments were received on the topic of potential cold temperature driveability problems if fuel volatility is reduced significantly below the ASTM ratings. However, since no comments were recieved suggesting that the gasoline volatility control proposed in this regulation will have any detrimental effect on cold temperature driveability and safety, the comments on this topic will not be discussed in this rulemaking.

3. Hot Temperature Fuel Safety

In addition to comments on cold temperature, low fuel volatility safety, comments were also received on hot temperature, high fuel volatility safety. IIHS, CAS, and NADA all provided comments describing the current safety hazard of high volatility fuels during high temperature operation, and stated that EPA's proposed volatility control will go a long way toward eliminating this problem. CAS stated that since 1979, 71 fires, 25 injuries, and 2 deaths have been linked to 12 vehicle recalls linked to fuel system overpressurization and fuel volatility. While they acknowledge that vehicle design also plays a significant role in fuel system overpressurization and fuel spurting issues, they also maintain that control of in-use fuel volatility will reduce the problem.

The issue of hot-temperature safety is also an issue of merit. Reducing the volatility of in-use gasoline should serve to reduce the problems of fuel spurting and fuel system overpressurization. However, it is not possible on the basis of existing data to determine to what extent historical hot-temperature safety problems would have been avoided or substantially reduced in severity if fuel volatility had been lower, much less to project this into the future. As a result, no evaluation of possible benefits due to RVP control is attempted here.

C. Driveability and Safety Economic Impacts

Although economic impacts of hot temperature driveability and safety were discovered, no good method of quantifying their effect could be found. As a result, no credit is taken for driveability or safety impacts in this rulemaking. In addition, since the level of volatility control in this rulemaking is low, no cold temperature impacts are expected.

IV. Enforcement Costs

The costs of several different enforcement options were presented in the Draft RIA. Costs for the enforcement options evaluated were estimated to range from $0.3 to 2.3 million per year. EPA does not expect that actual enforcement costs will

differ significantly from these levels. Since these enforcement costs are small relative to the other elements of the RVP control (such as refinery costs, etc.), the cost of enforcement was not included in the cost effectiveness calculations of Chapter 5.

V. Effect of Volatility Regulations on Imports

One issue which has received extensive comments is the effect volatility controls will have on imports of crude oil. Since RVP regulations will result in the displacement of domestically produced discretionary butane from the gasoline pool, purchases of crude oil will necessarily increase in order to meet a fixed gasoline energy demand. This is especially true in the short term, before investments can be made to install equipment neccessary to convert butane to MTBE, ETBE, alkylate, etc. As additional processing equipment is installed, and as a price decrease establishes butane as a competitive petrochemical feedstock, purchases of additional crude will decrease, by approximately 50 percent as indicated by Bonner and Moore modeling in Region 3.

In order to assess this issue, the maximum quantity of n-butane rejected from the gasoline pool in order to achieve the given RVP reduction was estimated for each of Bonner and Moore's control scenarios, using a blending value of 65 psi for n-butane. The energy content of this rejected butane, less the energy content of recovered evaporative emissions, was then compared against incremental crude purchases made in each control scenario. Results of this analysis showed that, on average, the energy of the incremental crude purchased exceeded that lost by the displacement of butane by a factor of approximately 1.8.

Given this information, an analysis of the effect of the interim volatility standards on imports was made. For all fuel undergoing a volatility reduction, an estimate of the maximum quantity of discretionary n-butane which would have to be rejected was made. A total of 12.4 million barrels of butane per year was calculated (assuming a 5 month refining period). However, under the interim standards, 190,000 tons per year of evaporative emissions will be recovered, the energy equivalent of 1.9 million barrels of butane. Thus, the energy equivalent of 10.5 million barrels of butane, (increased by a factor of 1.8), will be required in incremental crude oil. This totals approximately 12.3 million barrels per year (81,000 barrels per day) or $246 million per year at a $20 per barrel crude price.

It should be noted that this represents a short-term estimate of incremental crude purchases. Bonner and Moore's modeling showed that, in the long term, as butane price falls and refiners are able (by modifying processing) to use more butane (in applications such as petrochemical feed, alkylation, and isomerization) the import effect may be halved. With increased purchase of MTBE and ETBE facilities, imports would be reduced further still. Of course, inclusion of running losses in the estimate of evaporative emissions recovered would have a large effect on the amount of crude oil purchased, reducing it to as low as 48,000 barrels per day in the short term, and less than half that in the long term.

References (Chapter 4)

1. "The Motor Fuel Consumption Model Thirteenth Periodical Report," Prepared for U.S. DOE by Energy and Environmental Analysis, Inc., DOE/OR/21400-H5, January, 1988.

2. "MVMA National Gasoline Survey--Summer Season", Sampling Date - July 15,1987.

3. "Petroleum Marketing Annual, 1985, Volume 2," Energy Information Administration, Office of Oil and Gas, U.S. DOE, DOE/EIA-0487(85)/2, December, 1986.

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Chapter 5

Cost Effectiveness

EPA's methodology for determining the cost effectiveness of various alternative combinations of vehicle-based and fuel-based excess evaporative emissions control programs has evolved over a number of years. The November 1985 study of these issues published an earlier methodology, which after public comment and internal EPA development was revised and used in the proposal.[1,2]

Sections I.A and I.B below describe the methodology found in the volatility NPRM, Section II contains the summary and analysis of the comments on that methodology, and finally, Section III presents the cost-effectiveness of the interim proposal of volatility control to 10.5 in ASTM Class C areas, 9.5 in B areas, and 9.0 in A areas.

I. Synopsis of NPRM Methodology

A. Basic Model

The cost-effectiveness (C/E) model developed relationships between the costs of various alternatives and the VOC emission reductions projected to result from those alternatives. These C/E results were used in two ways -- both to compare RVP control with other VOC programs and to compare the various RVP control alternatives with one another. In the NPRM the model was used to calculate C/E for eight control cases ranging from 11.5 RVP to 8.0 RVP in half-psi increments (i.e., summertime control to the specified RVP in Class C areas with proportional reductions in other areas coupled with certification fuel RVP matched to the Class C RVP).

A key concept utilized by EPA in the volatility NPRM was that of "incremental" C/E analysis. Because a wide range of alternatives are available which all address excess evaporative emissions to some degree (i.e., various levels of combined fuel-based and vehicle-based control), it is most useful to compare the C/E of each level of control incremental to the immediately preceding level of control and to other control programs. Thus the model results in a range of incremental C/E values which show the effect of each degree of control.

For each level of control analyzed, the model calculated a cost and an emission reduction for that increment and presented their ratio in terms of dollars per ton of VOC reduced. The following paragraphs discuss these emission reduction and cost calculations.

Most VOC control programs reduce emissions and incur costs throughout the year. This is not true for the proposed gasoline volatility control. The NPRM assumed that VOC reductions in the summertime are most effective at reducing ozone levels, and are hence the most valuable reductions to achieve. In comparing various 5-month volatility control programs to such year-round programs, it is necessary to make an adjustment for when emission reductions occur. One way of doing this would be to modify the cost effectiveness calculation of other year-round programs such that only emission reductions which occur during the ozone season are fully credited. However, the simpler and more practical method chosen by EPA was to modify the cost effectiveness of volatility control to make it look like a year-round control option. To do this, EPA used the nationwide emission inventories presented in Chapter 3 of the DRIA which were projections of summertime emissions over the period of a whole year (i.e., the same as multiplying the actual 5-month summer emissions reductions by 12/5).

EPA then made a second adjustment in accounting for emission reductions. Because the primary purpose of VOC control programs is to achieve reductions in ozone non-attainment areas, EPA focused the analysis of volatility control on reductions to be achieved in these areas. To do this, the nationwide inventory reduction value at each control level (from Chapter 3 of the DRIA) was multiplied by the estimated fraction of national VMT occurring in ozone non-attainment areas (0.395). A credit was applied for attainment areas emission reductions, which is discussed later.

The methodology which EPA used for computing cost values involved a summation of several terms representing various costs and savings. The factors the model incorporated at each level of control were the following: 1) total national refinery costs, 2) an economic credit for control in attainment areas, 3) a credit for improved driveability, 4) a credit for improved fuel economy, 5) a credit for utilizing captured evaporative emissions, 6) an economic penalty for increased vehicle weight, plus 7) the change in vehicle cost. The following paragraphs summarize how these factors were determined.

The refinery-level cost came from multiplying the per-gallon refinery cost figures from the Bonner and Moore modeling (Chapter 5 of the DRIA) by projected nationwide fuel consumption. Four economic credits were then calculated and applied against this refinery cost. An assessment in Chapter 5 of the value of improved driveability as fuel volatility is reduced led to a projected economic benefit at each level of control which was then built into the C/E model. Next, improved fuel economy at each control level due to fuel of greater energy density (Chapter 5) was multiplied by national fuel consumption and the

pre-tax price of gasoline. Since the improved fuel economy values from Table 5-19 in Chapter 5 were presented for R-values of both 0.82 and 0.95, both sets of values were incorporated into the C/E model to delineate the likely range for this economic credit.

Another aspect of EPA's evaluation which led to a credit was the recovery and combustion of vapors currently lost to the atmosphere. The methodology, as detailed in Chapter 5, was to convert prevented (or recovered) VOC emissions (assumed for simplicity to be all butane) to an equivalent amount of gasoline on an energy basis and then multiply by two factors: 1) the pre-tax retail price of gasoline and 2) combustion efficiency factors (Chapter 5, Section V.B.4).

The final credit was a response to the focus of the model on non-attainment area emission reductions, as described above. While health-related emission reductions occur where the ozone standard is being violated, EPA assumed that there would be some value to a program such as RVP control that could by its nature also reduce ozone in areas currently in attainment (e.g., by preventing crop damage, etc.). Thus, as a way of making the C/E results more comparable to the many VOC control programs which clearly provide little benefit outside non-attainment areas, EPA attributed a credit to RVP control for attainment area emission reductions. The value of attainment-area VOC reductions had not been rigorously evaluated by EPA, but a previously used estimate of $250 per ton was applied to the 60.5 percent of nationwide emission reductions assumed to occur in attainment areas.

In addition to these credits, EPA calculated and added a small fuel economy penalty which would result from increased vehicle weight under vehicle-based control scenarios (Chapter 4). Finally, the cost of vehicle improvements under the various scenarios, as calculated in Chapter 4, were added to the other costs and credits. The sum of all these factors at each level of control resulted in C/E values comparable to other VOC control programs.

B. Types of C/E Analyses

EPA used the basic C/E model to calculate a full set of cost-effectiveness values for two distinct analyses, a series of single-year analyses and a 33-year average analysis.

1. Single-Year Analyses

The single-year analyses had two purposes. The first was to evaluate steady-state C/E as represented by the C/E in the year 2010. By that time, turnover of the vehicle fleet will be essentially complete; nearly all vehicles can be assumed to be equipped with improved evaporative systems. This

"steady-state" type of analysis thus allowed a "snapshot" of the programs C/E once it has been fully implemented.

The second purpose of the single-year analyses was to examine short-term RVP control options. Short-term analysis showed for a given long-term RVP level whether temporary deeper RVP reductions (without matching certification fuel volatility reductions) prior to 2010 would also be cost effective.

2. 33-Year Average Analysis

The other type of cost effectiveness analysis is analogous in most ways to the single-year analysis. The only difference is that here C/E was evaluated for each of 33 years, including the earlier years of the program when start-up costs would be incurred. Costs and emission reductions were calculated for each year to reflect, for example, the gradual turnover of the vehicle fleet. The present value of both costs and emission reductions was then calculated using a discount rate of ten percent.

C. Comparative C/E Value

The NPRM used a C/E of $2000 per ton as a guideline for comparing RVP control programs to other VOC programs. The $2000/ton benchmark was based on a judgement of how cost effective remaining programs likely to be required to reduce ozone will be. EPA noted that a number of programs being considered will have significantly higher C/E values (52 FR 31286).

D. Sensitivity of C/E Analyses to Various Factors

EPA performed several separate steady-state and 33-year average analyses to test the sensitivity of the cost effectiveness results to certain key assumptions. The assumptions tested were the following: 1) The presence or absence of onboard refueling control requirements; 2) the future cost of crude oil; 3) the use of nationwide costs and emission reductions versus separate costs and emission reductions for the individual ASTM class areas; and 4) the influence of the number of non-attainment areas in which emission reductions are projected to occur. In addition EPA also performed the latter two analyses for the case of $33/barrel crude oil with federal income taxes excluded.

E. Cost Effectiveness of Mid-Range Volatility

Finally, using a separate methodology, EPA analyzed the cost effectiveness of controlling the mid-range volatility of fuel, as measured by the percent of fuel evaporated at 160°F ($\%_{160}$). Because EPA received no specific comments about the methodology used for determining the C/E of $\%_{160}$ control, the

description of that methodology found in Chapter 6, Section II of the Draft RIA is not repeated here.

II. Summary and Analysis of Comments

This section will focus on comments directed at the volatility NPRM's cost effectiveness methodology. A number of issues raised by commenters affect C/E but are actually directed at the inputs which form the foundation of the C/E methodology. These comments are summarized and addressed in the appropriate section elsewhere in this document (i.e., refinery costs in Chapter 4, emission reductions in Chapter 3, etc.).

Similarly, several commenters re-calculated C/E results using different input values. The results themselves are not appropriately considered comments on C/E since they depend entirely on the input values, which are addressed elsewhere in this document.

A. Basic Model

While no commenters took issue with the incremental nature of EPA's cost effectiveness analysis, there were a number of comments on the basic model EPA used to compare the cost effectiveness of volatility control to other control options.

1. Method of Adjusting for Full Year Comparison

One of the more significant comments involved objections to the method EPA used to adjust the cost effectiveness values of the 5-month volatility program to emulate those of other VOC control programs which are year-round. Texaco, API, and others commented that adjusting the emission reductions to reflect year-round emission reductions without adjusting the costs, distorts the C/E analysis and places a high value on nonexistent emission reductions.

While EPA agrees that this adjustment distorts the actual emission reductions available with RVP control, the C/E analysis was performed to compare volatility control to various other year-round control options from which the $2000/ton guideline was derived, and for this purpose the adjustment actually corrects a distortion. Basically what was done in adjusting the C/E results of this proposed rulemaking was to multiply the actual 5-month control period emission reductions by 12/5 in order to extrapolate the C/E of volatility control to that of a year-long program instead of multiplying the emission reductions of the alternative year-round VOC control programs by 5/12 to adjust their C/E to reflect the fact that emissions in non-summer months have a much smaller benefit. Both adjustments have the same affect when comparing control options, and the former was much simpler to perform.

Therefore, modifying this aspect of EPA's C/E methodology would itself result in a distortion of comparisons with other control options, and no change will be made.

2. Attainment Area Credits

A topic receiving a great number of comments involved the benefit of $250 per ton which EPA placed on emission reductions in attainment areas. The Conservation Law Foundation and the National Resources Defence Council supported EPA taking a credit for emission reductions in attainment areas. Reasons cited include: 1) benefits associated with reducing the problems of ozone and VOC transport to and from non-attainment areas; 2) reducing the possibility of future non-attainment of current attainment areas due to growth in emissions; 3) the possibility of a future lower ozone standard bringing many current attainment areas into non-attainment; 4) possible health benefits in attainment areas due to little or no margin of safety associated with the current ozone standard; 5) welfare effects such as materials, crop, and forest damage at concentrations below the current ozone standard; 6) reduction in the contribution of ground-level ozone to the greenhouse effect; 7) reduction in air toxics emissions resulting from the reduction in gasoline related VOC emissions. On the basis of these attainment area benefits of VOC control, NRDC supported an attainment area benefit much greater than the assumed value of $250 per ton.

Contrary to these comments, Phillips, MVMA, API, GM, and Chrysler all provided comments stating that the $250 per ton credit taken by EPA was completely unjustified. The comments, GM's in particular, focused around the lack of scientific support for the credit, and also around EPA's lack of legal authority to claim benefits in attainment areas.

Concerning EPA's legal authority to take a credit for emission reductions in attainment areas, GM, MVMA, and Chrysler appear to misunderstand either the Clean Air Act, or what we proposed. In the NPRM, EPA clearly stated that the primary purpose of the volatility control program was to improve compliance with the ambient ozone standard. That is why only non-attainment area emissions appear in the denominator of the C/E equation. However, when EPA implements a nationwide emission control program such as volatility control, EPA is required to consider the costs and benefits of the program in non-attainment areas and attainment areas alike. Therefore it is also most appropriate for EPA to take credit for any benefits which occur in attainment areas, as well as non-attainment areas. This is unrelated to EPA's legal mandate to protect human health.

Aside from the legal authority, the question still remains as to what value should be placed on the benefits in attainment

areas. The value of $250 per ton was taken from a sensitivity analysis performed by GM, and was not based on any scientific data. Few if any of the commenters stated that they believed the value to be zero, yet they presented no information to show that it was anything other than zero. GM belittled the value of VOC emission reductions in attainment areas, citing reasons such as high VOC/NOx ratios, high naturally occurring VOC emissions, non-zero background ozone levels, as well as transport of stratospheric ozone in attainment areas. While most of GM's arguements are valid to one degree or another, they do not result in a conclusion that VOC reductions in attainment areas as a whole have no value, rather that the value is smaller than in NA areas as is assumed by EPA. EPA has been working on placing a value on reductions of VOCs in attainment areas as well as non-attainment areas. While the work is not yet complete, the preliminary results are significantly higher than the $250 per ton used in the proposal for this regulation. Benefits of control which EPA is considering include:

1) Reduced ozone and ozone precursor transport to non-attainment areas;
2) Health benefits at ozone concentrations below the standard;
3) Welfare benefits at ozone concentrations below the standard (materials, crop, forest damage);
4) Reduced air toxics emissions (e.g., benzene);
5) Reduced contribution to ambient particulate matter and the problems associated with particulate (Through condensation and formation of secondary aerosols, VOCs can form particulate matter);
6) Odors, soiling, and morbidity associated directly with volatilization of organic compounds emitted to the atmosphere.

Based on these benefits a non-zero value seems appropriate, and for purposes of this rulemaking the value of $250 will be retained.

Also on the topic of attainment area credits, API questioned the manner in which EPA applied the value of $250/ton. API stated that it should be multiplied by 5/12 since the emission reductions will only occur in the summertime. Actually, the $250/ton figure is $250 per year-round ton of VOC reduction, or on the same basis as the $2000/ton guideline used for NA areas. As a result, the actual summertime attainment area emission reductions need to be adjusted by 12/5 in order to put them on a year-round basis; just like the non-attainment area reductions.

3. General Methodology

Texaco stated that due to fuel weathering, the cost effectiveness must be shifted to allow for a 1.5 psi margin between marketed fuel and the fuel actually used by the engine. The effects of weathering, however, were taken into account when the evaporative emission factors were calculated in the DRIA and again in Chapter 2 of this Final RIA, and need not be corrected for again as Texaco suggests.

4. Transport Regions

NRDC stated that an alternative means of taking a credit for some of the benefits which acrue in attainment areas might be simply to include the transport regions and borderline non-attainment areas into the fraction of the country currently in non-attainment, and credit emission reductions in those areas as in non-attainment areas. EPA recognizes the rationale behind such a strategy, and as stated in Chapter 3, EPA is studying the transport phenomenon. By examining the ratio of $2000 to $250 per ton, it is clear that this approach would only require one eighth of the tonnage to be equivalent to the $250/ton credit. This would only be 7.5 percent of nationwide VMT, or less than 20 percent of non-attainment area VMT. However, until the transport work is completed we believe that the method chosen by EPA is the more justified of the two alternatives, and will not change approaches for this rulemaking.

B. Types of C/E Analyses

All comments provided apply more specifically to the basic model or to one of the other areas, and as a result will not be repeated here.

C. Comparative C/E value

A number of comments were recieved not only on the value to be placed on emission reductions in attainment areas, but also on the $2000 per ton used as a guideline for acceptable cost effectiveness of VOC control. NRDC stated that there is no legal or scientific support for setting a maximum cost per ton of control at $2000. Chrysler stated that EPA had not shown that a cost of $2000 per ton was cost effective. Sohio supported Chrysler's statement, and went on to state that the $1100 per ton used by EPA in the lead phasedown regulation should be selected as an upper bound. NESCAUM on the other hand pointed out that many other control measures implemented and being considered in the Northeast have costs much higher than $2000/ton associated with them.

In so far as EPA has not performed a cost benefit analysis which attempts to place a cost savings to society for all of

the benefits which result from VOC control and ozone level reductions, Chrysler and Sohio are correct. EPA is developing such an analysis, but it will not be completed for some time. Instead, EPA (as NESCAUM suggested) focused on the cost effectiveness of other control options which might be implemented to reduce VOC to bring non-attainment areas into compliance.

EPA's Office of Policy Planning and Evaluation commissioned a study which estimated the cost of current and potential VOC control options.[3] The cost effectiveness of these options ranged from -$3260 to $80853 per ton. If all currently available control options were applied, many areas of the country were found to still require additional VOC reductions. The average cost of emission control programs to achieve addition emission reductions was then estimated to be within the $2000 to $10000 per ton range. The value assumed by EPA in the NPRM of $2000/ton represents the low end of this range, and as a result appears reasonable for use as a guideline to demonstrate the cost effectiveness of volatility control. However, as NRDC stated, this level is not to be considered as an absolute ceiling for the C/E of a VOC control program.

D. Sensitivity of C/E to Various Factors

A few of the commenters estimated the C/E of volatility control on their own using different values for many of the input variables, adding to the sensitivity runs already performed by EPA. Selection of the appropriate input variable, however, is typically not part of the cost effectiveness model itself, but is addressed elsewhere in the RIA. As a result these comments will be addressed in those places. In addition to these comments, NRDC commented that due to the uncertainties surrounding the adequacy of the current ozone standard, EPA should perform sensitivity runs assuming ozone standards of 0.08 and 0.10 ppm. Such sensitivity runs, although useful for observing the effects of reductions in the ozone standard, would not add significantly to this rulemaking since we conclude that the program is cost effective even at the current ozone standard.

OMB provided comments suggesting that the cost effectiveness of volatility control in Class A and B areas should be examined independently of Class C areas, since the C/E of volatility control for Class A and B fuels is greater than Class C fuels. In Section C below, the class-specific cost effectiveness runs are performed in addition to the nationwide cost effectiveness.

E. Alternative Programs

Comments were provided by GM and a number of other organizations supporting various modifications or substitutions for the regulations proposed by EPA. All of these comments lacked sufficient analysis to justify any deviation by EPA from its proposals. In some cases partial analyses or results of analyses were presented. However, even with this information there was no reason to believe that the alternatives proposed by the commenters would result in an equal or greater level of VOC control at an equal or lower cost.

III. Final Analysis

For the 1989 through 1991 timeframe, EPA will require gasoline sold during the summer months to have its volatility reduced below the maximum ASTM limits to 10.5 psi (primarily in Class C areas), 9.5 (primarily in Class B areas), and 9.0 (primarily in Class A areas, no reduction). (The specific standards for each area are outlined in Chapter 1.) The cost effectiveness analysis for this level of control is very similar to that performed in the proposal. However, since this is only a short term control program, a 33-year cost effectiveness analysis is not applicable, and no vehicle costs are involved. The cost effectiveness analysis is performed for 1990 and assumed to be representative of the entire 1989-1991 control period.

A. Class-Specific Emission Reduction Estimates

Class-specific emission reduction estimates were derived in Chapter 3 and presented in Table 3-2, and will not be shown again here. Running loss and excess evaporative emission reduction estimates were also derived, and are included here as a sensitivity analysis.

B. Class-Specific Control Cost Estimates

The refining cost per barrel of gasoline of controlling the volatility of the fuel for the control case described above was taken from Chapter 4. The refining cost for each ASTM class area was then determined by multiplying these per barrel costs by the total nationwide gasoline consumption as estimated by DOE for 1990, and the fraction of gasoline sold in each area.[4] From these costs were then subtracted credits for: increased fuel economy using the same methodology as in the DRIA but with an R factor of 0.85, fuel energy density estimates from Chapter 4, and fuel consumption estimates from DOE; fuel recovery through a reduction in evaporative emissions, also following the methodology in the DRIA, but now using a fuel recovery factor of 1.0, and new summertime July average emission reduction estimates (less exhaust emission reductions); and an attainment area credit of $250 per ton of

emission reductions occuring in attainment areas (44.6% in Class C areas, 75% in Class B areas, and 76% in Class A areas) using the year-round July average emission reductions found in Table 3-2. Unlike the NPRM, no credit was taken for vehicle driveability improvement with lower volatility fuels. In addition, since no vehicle control will be required, there are no vehicle costs or weight penalty costs which must be added into the analysis. The resulting net costs of this gasoline volatility control scenario (adjusted for summertime and nationwide control) are shown in Table 5-1. As can be seen, if running loss and excess evaporative emission reductions are included, the credits are larger than the refining costs, and the adjusted costs become negative. Since the average gasoline currently in-use in Class A areas is less than the level of control currently being promulgated, there are no control costs in Class A areas.

3. Cost Effectiveness

The cost effectiveness of the control program was then determined by dividing the net adjusted costs from Table 5-1 by the year round design value day emission reductions occurring in NA areas as shown in Table 3-2. The resulting cost effectiveness of this volatility control program are well with the $2000/ton guideline ($236/ton nationwide, $165/ton in Class C areas, $576/ton in Class B areas, and $0/ton in Class A areas). If the running loss and excess evaporative emission reductions are included, then the resulting C/E are all less than zero (-$201/ton nationwide, -$155/ton in Class C areas, -$425/ton in Class B areas, and $0/ton in Class A areas. Thus, this volatility control option can be considered to be very cost effective.

Table 5-1

Cost Estimates for the Interim RVP Program ($million/yr)

	Summer Refining Cost	Fuel Economy Credit	Fuel Recovery Credit	Net Cost	Attainment Area Credit	Adjusted Net Cost
DRIA Emission Reductions Only						
Class A	0.0	0.0	0.0	0.0	0.0	0.0
Class B	88.56	11.70	17.11	59.75	29.64	30.11
Class C	158.03	38.95	36.42	82.67	40.17	42.49
Nationwide	247.09	50.69	53.53	142.88	69.81	73.06
Including Running Loss and Excess Evaporative Emission (for Sensitivity)						
Class A	0.0	0.0	0.0	0.0	0.0	0.0
Class B	88.56	11.66	54.72	22.17	88.39	-66.22
Class C	158.03	38.81	118.78	0.44	116.81	-116.37
Nationwide	247.09	50.52	173.51	23.06	205.20	-182.14

References (Chapter 5)

1. "Study of Gasoline Volatility and Hydrocarbon Emissions from Motor Vehicles," U.S. EPA, OAR/OMS/ECTD, EPA-AA-SDSB-85-05, November 1985.

2. "Draft Regulatory Impact Analysis, Contol of Gasoline Volatility and Evaporative Hydrocarbon Emissions from New Motor Vehicles," U.S. EPA, OAR/OMS/ECTD, July 1987.

3. "National Assessment of VOC, CO, and NOx Controls, Emissions, and Costs," Prepared for Office of Policy Planning and Evaluation, U.S. EPA, by E.H. Pechan and Associates, Inc., September 1988.

4. "The Motor Fuel Consumption Model Thirteenth Periodical Report," Prepared for U.S. DOE by Energy and Environmental Analysis, Inc., DOE/OR/21400-H5, January, 1988.