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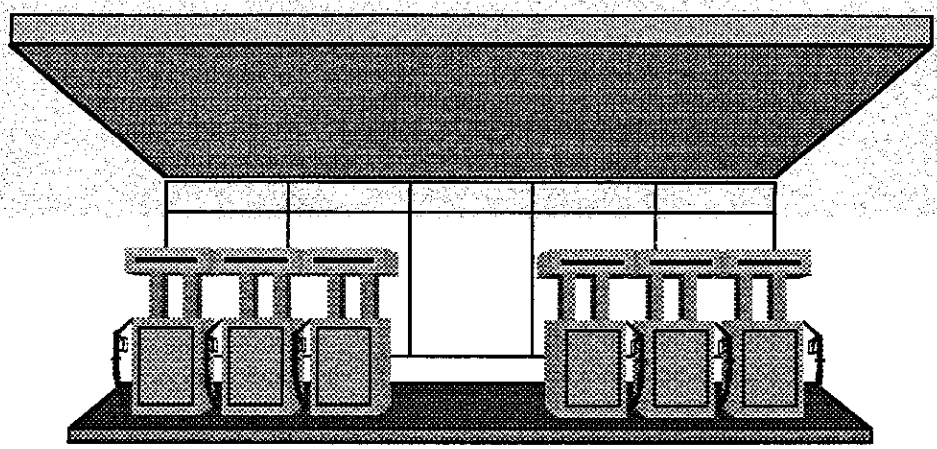
Air Resources Board

Staff Report



Proposed Amendments to the California Phase 2 Reformulated Gasoline Regulations, Including Amendments Providing for the Use of a Predictive Model

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REPORT SUMMARY AND RECOMMENDATIONS

A. INTRODUCTION

1. Why are we proposing amendments to the Phase 2 reformulated gasoline regulations?

We are proposing amendments to the California Phase 2 reformulated gasoline (Phase 2 RFG) regulations that would:

- o add an option to allow the use of a predictive model to evaluate and approve alternative Phase 2 RFG formulations, and
- o modify several sections of the Phase 2 RFG regulations to facilitate implementation.

The proposed amendments are designed to provide additional flexibility to gasoline producers[1] without sacrificing either the emission benefits or the enforceability of the Phase 2 RFG regulations. We expect this additional flexibility will allow producers to make more gasoline at a lower cost. This, in turn, will lower the expected cost to the consumers and minimize the potential for disruptions in the supply of gasoline.

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[1] The provisions in the Phase 2 RFG regulations applicable to producers and the gasoline they sell or supply from their production facilities also generally apply to persons who import California gasoline into the state ("importers") and the gasoline they sell or supply from their import facilities. To simplify the discussion of the regulations in this report, references to "producers" apply to both producers and importers unless otherwise indicated.

The term "producers" includes refiners and blenders -- entities that manufacture gasoline by combining blend stocks.

The proposed amendments are an important part of our ongoing comprehensive efforts to ensure that there is a smooth transition from the current conventional gasoline to Phase 2 RFG beginning in March 1996. These efforts include working with the producers to ensure that they are ready to produce the new fuel on time and in sufficient quantities. We will also continue to investigate ways to provide additional flexibility to gasoline producers and will return to the Air Resources Board (ARB or Board) if necessary to propose appropriate additional amendments.

2. How did the public participate in the development process?

We developed the proposed amendments with considerable public participation. Since the November 1991 public hearing, we have had four public workshops to discuss possible amendments to the Phase 2 RFG regulations. Three of these workshops specifically addressed the predictive model. In addition, we have worked closely with representatives of the Western States Petroleum Association (WSPA), particularly with two WSPA subcommittees addressing the predictive model and implementation issues. In addition, we have had numerous individual meetings and telephone conversations with industry representatives to discuss the proposed amendments.

We are also working closely with the United States Environmental Protection Agency (USEPA) on the phase-in of federal reformulated gasoline. The USEPA regulations are effective starting December 1, 1994 in Los Angeles, Orange, Ventura, and San Diego Counties, and in parts of Riverside and San Bernardino Counties.

3. What does this report include?

This report provides the basis for the proposed amendments. We will explain what a predictive model is, how the gasoline producers can use the predictive model, and why the particular model was selected over several alternative models. In addition, the report provides the basis for the modifications concerning the implementation of the Phase 2 RFG regulations and discusses potential environmental and economic impacts.

B. BACKGROUND

1. What do the Phase 2 RFG regulations require?

The Board adopted the Phase 2 RFG regulations in November 1991. The Phase 2 RFG regulations are an essential component of our overall strategy to reduce emissions from existing motor vehicles in California. In addition, the Phase 2 RFG regulations are expected to assist auto manufacturers in meeting the low-emission vehicle standards at a lower cost.

The Phase 2 RFG regulations define a comprehensive set of specifications for gasoline referred to as the Phase 2 RFG specifications. These specifications are designed to achieve the maximum reductions in emissions of criteria and toxic air contaminants from gasoline-

powered vehicles. All gasoline produced for sale in California will have to meet the specifications beginning March 1, 1996. The specifications address the following eight gasoline properties:

- o Reid vapor pressure (RVP)
- o Sulfur
- o Oxygen
- o Aromatic hydrocarbons
- o Benzene
- o Olefins
- o Temperature at which 90 percent of the fuel has evaporated (T90)
- o Temperature at which 50 percent of the fuel has evaporated (T50)

The Phase 2 RFG regulations include gasoline specifications that must be met at the time the gasoline is supplied from the production facility. Producers have the option of meeting either "flat" limits or, if available, "averaging" limits. The flat limits must not be exceeded in any gallon of gasoline leaving the production facility. For example, the sulfur content of gasoline, subject to the flat limit for sulfur content, could not exceed 40 parts per million by weight.

The averaging limits established in the regulations are numerically more stringent than the comparable flat limits. Under the averaging option, the producer may assign differing "designated alternative limits" (DALs) to different batches of gasoline being supplied from the production facility. Each batch of gasoline must meet the DAL for the batch. In addition, a producer supplying a batch of gasoline with a DAL less stringent than the averaging limit must, within 90 days before or after, supply from the same facility sufficient quantities of gasoline subject to more stringent DALs to fully offset the exceedances of the averaging limit.

The Phase 2 RFG regulations also contain "cap" limits. The cap limits are absolute limits that cannot be exceeded in any gallon of gasoline sold or supplied throughout the gasoline distribution system. Without the cap limits, there would be no practical way to enforce the Phase 2 RFG regulations at terminals, bulk plants, or service stations.

2. What are the benefits and costs of the Phase 2 RFG regulations?

The Phase 2 RFG regulations will achieve significant reductions in emissions of hydrocarbons, oxides of nitrogen, and carbon monoxide. These emission benefits are summarized in Table 1. In addition to these benefits, we also expect to reduce the emissions of toxic air contaminants by 30 percent. The emission reductions will be obtained primarily by reducing exhaust and evaporative emissions from motor vehicles. Some additional benefits will be obtained by reducing evaporative emission losses from the distribution and marketing of gasoline.

Table 1

Reductions in the Emissions from On-Road Gasoline-Powered Motor Vehicles Due to Phase 2 Reformulated Gasoline

Calendar Year	Percent Reduction in Emissions from On-Road Gasoline-Powered Motor Vehicles		
	Hydrocarbons	Oxides of Nitrogen	Carbon Monoxide
1996	17	11	11
2000	18	9	9
2005	17	5	7

Source: ARB Technical Support Division: EMFACE7F1.1/B7F1.1

At the time of adoption, we estimated the capital cost to produce Phase 2 RFG to be between three and six billion dollars. If all of the capital and operating costs are passed on to the consumer, the price of gasoline could increase by 12 to 17 cents per gallon. To the average consumer, this increased gasoline cost would result in a two percent increase in the annual cost of operating a motor vehicle. These cost estimates do not reflect the savings provided to production facilities by the additional flexibility afforded by the proposed amendments. We anticipate that substantial savings will occur, and will be passed on to the consumer. We are currently evaluating the cost estimates based on the producer's proposed facility modifications. As we obtain this information, we will update the cost estimates as appropriate.

C. SUMMARY OF THE PROPOSED AMENDMENTS RELATING TO THE CALIFORNIA PREDICTIVE MODEL

1. What is the California predictive model?

In general, a predictive model is a set of mathematical equations that allows one to estimate the change in exhaust emissions from motor vehicles that will occur when one or more selected fuel properties are changed. A predictive model is typically used to compare the emissions associated with the use of a gasoline with certain fuel properties versus another gasoline with a different set of properties.

Each mathematical equation applies to a different indicator of air pollution. For example, a mathematical equation could be developed for an air pollutant such as hydrocarbons; or, a mathematical equation could be developed for a calculated effect such as

the ozone-forming potential of the hydrocarbon emissions. The ozone-forming potential is a measure of the rate at which the emitted hydrocarbons form ozone under specified conditions.

A predictive model is typically characterized by:

- o the number of mathematical equations developed,
- o the number and type of motor vehicle emissions tests used in the development of the mathematical equations, and
- o the mathematical or statistical approach used to analyze the results of the emissions tests.

We developed three mathematical equations. Collectively, we refer to these three mathematical equations as the California predictive model. One equation will estimate the change in exhaust emissions of hydrocarbons, the second will estimate the change in exhaust emissions of oxides of nitrogen, and the third will estimate the change in the combined exhaust emissions of four toxic air contaminants. The four toxic air contaminants included in the equation are benzene, 1,3-butadiene, acetaldehyde, and formaldehyde. These toxic air contaminants are combined based on their relative potential to cause cancer, which we refer to as potency-weighting.

2. How did we develop the California predictive model?

We have compiled and analyzed the results of over 7,300 vehicle exhaust emissions tests. A summary of these tests is presented in Chapter III, and they are discussed further in Appendix C. For analysis, we divided the data into four different technology classes, represented by the model years of the vehicles. These classes are designed to approximate the different types of emissions controls present on vehicles. In developing the predictive model, we only used two technology classes, representing model years 1981 to 1985 and 1986 to 1995. Of the four technology classes, the data for these two technology classes were the most extensive. In addition, these two technology classes best represent the effects that the use of alternative gasoline formulations will have on the emissions from future gasoline-powered low-emission vehicles. We used a standard statistical approach to develop the mathematical equations to estimate changes in exhaust emissions. This approach is summarized in Chapter III and discussed in detail in Appendix D.

3. How do we ensure that the use of the California predictive model will not have an adverse impact on air quality?

To ensure that the use of the predictive model will not have an adverse impact on air quality, we are proposing to require producers to demonstrate that the emissions from the use of their alternative Phase 2 RFG formulation will provide equivalent or lower emissions than those resulting from the use of fuel meeting the Phase 2 RFG specifications. As discussed previously, we are proposing to require the producers to make this demonstration for hydrocarbons, oxides of nitrogen, and toxic air contaminants.

We chose to develop mathematical equations for hydrocarbons and oxides of nitrogen to ensure that we would not approve an alternative Phase 2 RFG formulation that could result in an increase of ozone precursors. Similarly, we chose to develop a mathematical equation for the toxic air contaminants to ensure that we would not approve an alternative Phase 2 RFG formulation that could result in an increased potential cancer risk. The four identified toxic air contaminants represent over 95 percent of the potential risk from gasoline-powered motor vehicles.

In earlier versions of the predictive model, we considered including requirements that producers demonstrate that the use of an alternative Phase 2 RFG formulation would not increase emissions of carbon monoxide or increase the ozone-forming potential of gasoline. However, we are not now proposing such requirements.

We are not proposing to require the producers to make a demonstration for carbon monoxide because the Phase 2 RFG regulations require that all gasoline contain a minimum amount of oxygen in the wintertime, when the carbon monoxide concentrations are the highest. Oxygen is the fuel property that has the greatest effect on emissions of carbon monoxide. In addition, we expect all areas of California to attain the federal carbon monoxide standard by 1996, with the exception of the Los Angeles County, thus assuring that carbon monoxide reductions will not be as important to improving air quality as assuring equivalent reductions in hydrocarbons, oxides of nitrogen, and toxic air contaminants.

We are not proposing to require producers to make a demonstration for the ozone-forming potential for two reasons. First, alternative Phase 2 RFG specifications derived using the predictive model will likely have limits much closer to the Phase 2 RFG specifications than to conventional gasoline. In addition, use of an alternative Phase 2 RFG formulation must not result in an increase in the mass emissions of hydrocarbons. The potential variation in the ozone-forming potential is, therefore, likely to be small relative to the difference between Phase 2 RFG and conventional gasoline. Second, the database for the ozone-forming potential is not as robust as the other databases because of the relative lack of speciated hydrocarbon data. Thus, the results from a carbon monoxide equation would probably not be as reliable as the results from the equations for hydrocarbon and oxides of nitrogen.

4. How will the gasoline producers evaluate alternative Phase 2 RFG specifications using the California predictive model?

The producers will use the California predictive model to establish alternative Phase 2 RFG specifications that can be used in lieu of the Phase 2 RFG specifications. To receive approval for an alternative Phase 2 RFG formulation, a gasoline producer must demonstrate that the emissions from the use of gasoline meeting the alternative Phase 2 RFG specifications will provide equivalent or lower emissions than those resulting from the use of gasoline meeting the Phase 2 RFG specifications. As discussed previously, the producer must make this demonstration for emissions of hydrocarbons, oxides of nitrogen, and potency-weighted toxic air contaminants.

In proposing alternative Phase 2 RFG specifications, a producer may elect to change the value for any or all of the Phase 2 RFG properties with the exception of RVP. We are not proposing to allow the producers to vary RVP because the Phase 2 RFG regulations do not allow averaging for RVP. Thus, the flat limit of 7.00 pounds per square inch (psi) is equal to the cap limit. The flat limit was set equal to the cap limit to ensure that the evaporative emissions control systems on new vehicles would function properly. These emissions control systems are designed to meet the evaporative emissions standards using a certification fuel that has an RVP of 7.00 psi. A value less than 7.00 psi could adversely affect driveability and increase the explosivity potential of the fuel.

For each selected property, the producers may choose to specify either a flat limit or, for properties other than RVP and oxygen content, an averaging limit. The producer cannot use any value exceeding a cap limit. The chosen value of each alternative Phase 2 RFG property and the corresponding value for the Phase 2 RFG property are entered in the three mathematical equations (hydrocarbons, oxides of nitrogen, and toxic air contaminants). Each mathematical equation provides estimates of the emissions resulting from the alternative Phase 2 RFG specifications and from the gasoline meeting the Phase 2 RFG specifications. The producer then calculates the percent difference in emissions resulting from the use of the two gasolines. An acceptable alternative Phase 2 RFG formulation would have to provide equivalent or lower emissions for hydrocarbons, oxides of nitrogen, and potency-weighted toxic air contaminants.

5. How frequently can gasoline producers use the California predictive model?

We are proposing to allow gasoline producers to use the California predictive model for any batch of gasoline produced subject to the following conditions:

- a producer must notify the Executive Officer of the assigned value for each fuel property and the selected compliance option (flat limit or averaging limit) before the start of physical transfer of the gasoline from the production facility and in no case less than 12 hours before the producer either completes the physical transfer of gasoline or before the gasoline is mixed with other gasoline,

- a producer must offset all fuel property debits before switching from any averaging limit to any flat limit or from any averaging limit to any other averaging limit, and

- a producer must forego any accrued credits upon switching from an averaging limit to a flat limit or from any averaging limit to any other averaging limit.

We are proposing that the producers be permitted to use the predictive model throughout the year. However, alternative gasoline formulations must meet a minimum oxygen content of 1.8 percent by weight during specified winter months. These months vary

depending on the area of California. The oxygen content may not exceed 2.7 percent oxygen by weight at any time. Also, RVP would be allowed to vary during the winter months when RVP is currently not regulated.

6. Did we evaluate alternative predictive models?

Yes. In developing the proposed California predictive model, we evaluated three other modeling approaches. We evaluated the approach the USEPA used to develop a complex predictive model which applies in the federal reformulated gasoline regulations. At WSPA's request, we also evaluated a modified USEPA approach ("Hybrid" model). In addition, we also examined a version of the California predictive model that does not include the application of a simplification technique.

The USEPA used a different statistical approach to develop its complex model. The approach does not consider the interactions that result from the random errors occurring due to the individual effects of the vehicles used in the study. The USEPA approach also excludes certain terms prior to conducting the statistical analysis (pre-exclusion of terms), includes several techniques designed to eliminate outlier data, and uses a mathematical technique designed to simplify the model. This later technique is referred to as a "random balance." In addition, the USEPA complex model was designed to reflect the emissions impact associated with emission control technologies used for 1990 model-year vehicles only. Finally, it includes separate models for exhaust emissions from normal-emitting, and high-emitting vehicles, and for evaporative emissions.

The modified USEPA approach we evaluated differs from the USEPA approach in several respects. It generally does not include a consideration of the random errors occuring due to the individual vehicle effects. It also uses the California working database (which is somewhat larger than the USEPA database), applies to the same vehicle technology classes as the California predictive model, and uses slightly different initial assumptions relative to pre-excluding various statistical terms from the statistical analysis.

We also evaluated a version of the California predictive model that did not incorporate the random balance. After evaluating the random balance, we found that this is an appropriate and beneficial technique to simplify the model without sacrificing the explanatory power of the model. Therefore, our final proposed California predictive model incorporates the random balance.

We found that all of the models fit the data reasonable well. No procedure can guarantee that it will include the "best" choice of variables; thus, there is no "best" model. The California predictive model does not pre-exclude any terms, uses the most appropriate statistical approach, uses the most extensive database, and best represents the California motor vehicle fleet. Therefore, we believe that the California predictive model we are proposing is likely to yield relationships that are very close to the most satisfactory relationships that can be achieved.

7. Are we proposing to include any special provisions for small refiners when using the California predictive model?

No. We are not proposing any special provisions for small refiners. Small refiners must meet the Phase 2 RFG limits for RVP, oxygen, benzene, and aromatic hydrocarbons beginning March 1, 1996. If a small refiner meets specified conditions, it will not have to comply with the limits for sulfur, olefin, T50, and T90 until March 1, 1998. The small refiners have requested that Phase 2 RFG reference specifications be established for small refiners for the two year phase-in period. The small refiner reference specifications would have the same values as Phase 2 RFG for RVP, oxygen, benzene, and aromatic hydrocarbons but would have different values than Phase 2 RFG for the four fuel properties that are not regulated until 1998. Small refiners could then use the predictive model to certify an alternative Phase 2 RFG formulation where increases in benzene and aromatic hydrocarbons above the Phase 2 RFG limits could be offset by decreases in sulfur, olefin, T50, and T90 below the Phase 2 RFG reference specifications limit for small refiners.

We are not proposing an interim model for small refineries because we have not identified an acceptable approach that maintains the environmental benefits of the Phase 2 RFG regulations and is equitable among all refiners. The primary difficulty is establishing acceptable Phase 2 RFG reference specifications for the four properties that are not regulated until 1998.

8. What process would be used for making future revisions to the California predictive model based on new emissions test data?

Once adopted, the California predictive model could only be changed in a subsequent rulemaking with notice and public comment. We do not have any specific schedule for reviewing and updating the California predictive model. However, we expect to consider the implications that new emissions test data may have on the results of the predictive model. Any potential changes to the adopted predictive model would be presented to the public for review and discussions prior to any proposed formal regulatory action. This review would include our evaluation of the economic impacts any proposed change would have on a producer's ability to recover the substantial costs associated with producing Phase 2 RFG.

9. What regulatory amendments to implement the California predictive model are we proposing?

We are proposing the addition of section 2265 and conforming changes to several other sections. The "California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model" would be incorporated by reference into section 2265. This document contains the predictive model equations and the process that must be followed to determine if alternative Phase 2 RFG specifications can be used in lieu of meeting the Phase 2 RFG specification. In addition to the above, proposed section 2265 identifies prohibited activities, such as selling a gasoline that does not conform

with the alternative Phase 2 RFG specifications, and establishes requirements on how the ARB is to be notified when a producer changes gasoline specifications using the predictive model.

Section 2265 also establishes limitations on switching between different gasoline formulations. A producer could not change alternative Phase 2 RFG specifications if there are outstanding requirements to provide offsets. Further, any previously accrued credits could not subsequently be used if a producer elects to switch from one set of alternative Phase 2 RFG specifications to another. We are proposing these provisions for two reasons. First, the value of a credit accrued under one set of alternative Phase 2 RFG specifications would not necessarily have the same value under a different set of alternative Phase 2 RFG specifications. Second, we believe that the provisions will significantly reduce the complexity of enforcing the regulations.

We are also proposing to add to section 2260 several definitions related to the predictive model. Changes are proposed to the existing section 2264 to address issues related to reporting designated alternative limits for alternative Phase 2 RFG specifications. Changes are also proposed to existing sections 2262 and 2270 to add references to the alternative Phase 2 RFG specifications.

D. SUMMARY OF THE PROPOSED AMENDMENTS RELATING TO THE IMPLEMENTATION OF THE PHASE 2 RFG REGULATIONS

1. What amendments to the Phase 2 RFG regulations are we proposing?

We are also proposing several amendments to the Phase 2 RFG regulations that are designed to provide additional flexibility to producers and to ease the transition to Phase 2 RFG. These are summarized in the following discussion.

Amendments to Modify the Allowable Frequency of Selecting Flat Limits or Averaging Limits for Fuels Meeting the Phase 2 RFG Specifications: We are proposing that gasoline producers be allowed to select flat limits or averaging limits more frequently than is permitted in the existing regulations.

Currently, the Phase 2 RFG regulations require producers to select between the flat limit or the averaging compliance option on an annual basis. The producers must make an initial selection by November 1, 1995 for the calendar year 1996. For each subsequent calendar year, the producer must identify any changes by October 1. We originally included these requirements to make enforcement of the regulations easier.

We are now proposing that the Board substantially revise these requirements to provide additional flexibility to the producers in selecting whether to use the flat or averaging limits. These revisions would apply when either the Phase 2 RFG specifications or alternative Phase 2 RFG specifications are applicable. We are

proposing that the Board delete the requirement that producers notify us of their initial selection by November 1, 1995. In addition, we are proposing that the Board delete the requirement that the elections be for a minimum of one calendar year. Under the proposal, producers would be allowed to switch essentially with each batch of gasoline produced.

The benefits provided to a producer in being better able to manage the routine operation of the production facility outweigh the added enforcement complexities. We are proposing the following amendments that will clearly specify the conditions and reporting requirements associated with the increased flexibility:

- a producer must notify the Executive Officer of the assigned fuel properties and the selected compliance option (flat limit or averaging limit) before the start of physical transfer of the gasoline from the production facility and in no case less than 12 hours before the producer either completes the physical transfer of gasoline or mixes the gasoline with other final blends,

- a producer must offset all fuel property debits before switching from any averaging limit to any flat limit or from any averaging limit to any other averaging limit, and

- a producer must forego any credits upon switching from an averaging limit to any flat limit, or from any averaging limit to any other averaging limit.

The fundamental rationale for the notification requirements is the need to know what specifications apply to the fuel at any time. The recordkeeping and reporting provisions in the Phase 2 RFG regulations provide the needed assurance that the regulations will be enforceable.

Amendments to Allow Additional Time for Compliance at Terminals, Bulk Plants and Service Stations: We are proposing that the Board modify the dates when various gasoline distribution facilities must comply with the cap limits in the Phase 2 RFG regulations. Currently, the Phase 2 RFG regulations require that all facilities comply by April 1, 1996. To provide for a smooth transition to Phase 2 RFG and to minimize potential disruptions in fuel supplies, we are proposing that facilities comply with the cap limits starting April 15, 1996 with two exceptions. The April 15 date would not apply to gasoline shipped from bulk plants (intermediate distribution facilities that receive gasoline solely by truck) or to gasoline dispensed into vehicles at service stations and end-user facilities. Starting June 1, 1996, all gasoline throughout the distribution system would have to meet the cap limits.

We are also proposing that a provision be added that will provide additional time for low-volume service stations. However, the operator must establish that any exceedance of the standards resulted from gasoline shipped before the compliance date for the cap limits.

Amendments to Allow Reporting of the Estimated Volume of Fuel MeetingAveraging Limits: For each final blend of fuel receiving a designated alternative limit, the Phase 2 RFG regulations require the producers to notify the Executive Officer of the volume, the designated alternative limit, the blend identity, and the location of each final blend. This notification must be received by the Executive Officer before the start of physical transfer of the gasoline from the production facility and in no case less than 12 hours before the producer either completes physical transfer or mixes the gasoline with other final blends.

We are proposing that the Board amend this requirement to allow producers to report the estimated volume of fuel shipped and then report the final volume shipped within 48 hours after completing the final transfer. As an option, a producer may enter into an enforcement protocol with the Executive Officer that would specify an alternative and equally enforceable requirement.

Amendments Concerning the Treatment of Imported Gasoline: We are proposing that the Board modify the Phase 2 RFG requirements on importers of gasoline originally refined in California. Currently, the Phase 2 RFG regulations require all importers to be subject to the requirements applicable to California refiners. This could be very burdensome for importers that transport gasoline in small batches by cargo tank truck.

To reduce this burden, we are proposing that California refiners be required to comply with the Phase 2 RFG producer limits when producing gasoline that will be offered for sale at an out-of-state terminal at where the fuel will be identified as gasoline suitable for sale in California. This would relieve the burden of compliance from the importer of gasoline originally refined in California and place the burden on the California refiners.

Amendments to Change the Number of Significant Digits for the Aromatic Hydrocarbon Limits: We are proposing that the Board change the flat, averaging, and cap limits for aromatic hydrocarbons from 25, 22, and 30 volume percent to 25.0, 22.0, and 30.0 volume percent, respectively. This proposed change would give the producers additional flexibility in meeting an averaging limit for aromatic hydrocarbons when using the California predictive model. By adding one significant digit, producers would be able to report batches to the tenth of a volume percent. Producers have indicated that having the ability to report batches to the tenth of a percent (i.e., 24.6 instead of 25), will significantly increase the usefulness of the alternative averaging limit option. Currently, there are test methods that can be used to verify aromatic hydrocarbon content to the tenth of a volume percent.

2. Are we evaluating other issues associated with the Phase 2 RFG regulations?

We are continuing to evaluate other implementation issues to ensure that there is a smooth transition from current gasoline to Phase 2 RFG. For example, we are evaluating the test methods identified in the regulations to determine how closely results can be reproduced in different laboratories. We are also evaluating the effect that test method reproducibility may have on complying with the designated alternative limits and the averaging limits. Some producers believe that our current enforcement practices, which are based on the reproducibility of the test methods, adversely affect their ability to use the averaging compliance option. We will continue to work with the producers to investigate these issues.

E. ENVIRONMENTAL AND ECONOMIC IMPACTS

1. Are there any environmental impacts associated with the proposed amendments?

We have not identified any significant adverse environmental impacts associated with this regulatory action. The California predictive model is designed to ensure that the emissions from a gasoline meeting alternative Phase 2 RFG specifications will provide the same benefits as a gasoline meeting Phase 2 RFG specifications. Similarly, we do not believe that any of the other proposed changes will result in any ongoing loss of effectiveness. A very small increase in emissions may occur during March 1 to June 1, 1996 due to the extension of the cap limit compliance date for terminals, bulk plants, and service stations. However, we believe that the emission increases due to these proposed changes will be insignificant since all gasoline leaving production facilities will have to meet the Phase 2 RFG limits beginning March 1, 1996.

We are not requiring that an alternative Phase 2 RFG formulation demonstrate that there is no increase in emissions of carbon monoxide. Therefore, there is a chance that emissions of carbon monoxide may increase in the summer when using the predictive model. However, all areas of the State are projected to be in attainment for the ambient air quality standard for carbon monoxide by 1996, except Los Angeles County. The federal reformulated gasoline regulations require that all gasoline sold in Los Angeles County and most of the rest of Southern California contain a minimum of 2.0 percent oxygen by weight throughout the year. This level of oxygen will help minimize the emissions of carbon monoxide. Furthermore, the Phase 2 RFG regulations require that all gasoline sold in the State contain a minimum of 1.8 percent oxygen by weight during the winter when carbon monoxide concentrations are highest.

2. Are there any adverse economic impacts associated with the proposed amendments?

The proposed amendments are designed to provide additional flexibility to producers. This should provide the opportunity to reduce the operating costs of complying with the Phase 2 RFG regulations for all parties that are affected directly or indirectly. The proposed amendments should also allow producers to maximize production capabilities and better address conditions that may affect the supply of fuel. Consequently, the proposed amendments add greater certainty that there will be no disruptions in the supply of gasoline. This should help avoid price increases due to any real or perceived fuel shortages. As such, the proposed amendments may have a small, but unquantifiable beneficial impact on California businesses.

F. RECOMMENDATIONS

We recommend that the Board take the following actions.

- Amend sections 2260, 2261, 2262.2, 2262.3, 2262.4, 2262.5, 2262.6, 2262.7, 2264, and 2270, and adopt sections 2264.2 and 2265, Title 13, California Code of Regulations, to:

  * allow an option to use a predictive model to evaluate alternative Phase 2 RFG specifications,

  * delete the requirement that producers notify us of their initial election of a flat limit or averaging compliance option by November 1, 1995,

  * eliminate the condition that a producer may only change between flat limits and averaging limits once per year, and substitute a requirement that to change between flat and averaging limits, a producer must notify the Executive Officer of the assigned fuel properties and the selected compliance option (flat limit or averaging limit) before the start of physical transfer of the gasoline from the production facility and in no case less than 12 hours before the producer either completes the physical transfer of gasoline or before the gasoline mixes with other fuel blends,

  * specify that a producer will be assigned a zero balance upon switching from any averaging limit to any flat limit or from any averaging limit to any other averaging limit,

  * specify that a producer must offset all fuel property debits before switching from any averaging limit to any flat limit or from any averaging limit to any other averaging limit,

* delete the requirement that all downstream distribution facilities must comply with the Phase 2 RFG regulations by April 1, 1996, and substitute a requirement that facilities must comply with the cap limits starting April 15, 1996 with two exceptions -- the April 15, 1996 date would not apply to gasoline shipped from bulk plants or to gasoline dispensed into vehicles at services stations and end-user facilities (Note that all gasoline throughout the distribution system would have to meet the cap limits staring June 1, 1996),

* add a provision that allows additional time for low-volume service stations provided the operator establishes any exceedance of the specifications resulted from gasoline shipped before the compliance dates for the cap limits,

* specify that a producer may report the estimated volume of gasoline for purposes of tracking compliance with the averaging limits, but must report the final volume within 48 hours after completing the transfer of the final blend of fuel,

* relieve importers of California-produced gasoline from the Phase 2 RFG importer requirements and place the responsibility for compliance on the California refiner, and

* modify the flat, averaging, and cap limits for aromatic hydrocarbons from 25, 22, and 30 volume percent to 25.0, 22.0, and 30.0 volume percent, respectively.

o Approve the proposed "California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model," incorporated by reference in section 2265, Title 13, California Code of Regulations.

Appendix A contains the proposed regulation order for the affected sections. Appendix B contains the proposed "California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model."

II.

BACKGROUND

A. THE CALIFORNIA PHASE 2 RFG REGULATIONS

1. What do the Phase 2 RFG regulations require?

On November 22, 1991, the Board approved the Phase 2 RFG regulations. These regulations define a comprehensive set of specifications for commercial gasoline (Phase 2 RFG specifications) designed to achieve the maximum reductions in emissions of criteria pollutants and toxic air contaminants from gasoline-powered vehicles. The regulations are an essential component of our overall strategy to reduce emissions from existing motor vehicles in California. In addition, the Phase 2 RFG regulations are expected to assist auto manufacturers in meeting the low-emission vehicle standards at a lower cost.

The Phase 2 RFG specifications address eight different gasoline properties. Table 2 lists these properties and specifications. Table 2 also lists values for typical California gasoline.

The Phase 2 RFG regulations allow the producers the option of meeting either "flat" limits or "averaging" limits. Each producer may choose either the flat limit or, if applicable, the averaging limit. The flat limits must not be exceeded in any gallon of gasoline leaving the production facility.

The averaging limits established in the regulations are numerically more stringent than the comparable flat limits. Under the averaging option, the producer may assign differing "designated alternative limits" (DALs) to different batches of gasoline being supplied from the production facility. Each batch of gasoline must meet the DAL for the batch. In addition, a producer supplying a batch of gasoline with a DAL less stringent than the averaging limit must, within 90 days before or after, supply from the same facility sufficient quantities of gasoline subject to more stringent DALs to fully offset the exceedances of the averaging limit.

As shown in Table 2, the Phase 2 RFG regulations also contain "cap" limits. The cap limits are absolute limits that cannot be exceeded in any gallon of gasoline sold or supplied throughout the gasoline distribution system. The cap limits are essential for the enforcement of the Phase 2 RFG regulations once the gasoline leaves the refinery.

Table 2

Properties and Specifications of Typical California Gasoline and Phase 2 Reformulated Gasoline

Gasoline Properties	Units	Typical California Average	Flat Limit	Averaging Limit	Cap Limit
Reid Vapor Pressure	psi	7.8	7.0 a/	--	7.0 a/
Sulfur	ppmw	150	40	30	80
Aromatic Hydrocarbons	vol. %	32	25	22	30
Benzene	vol. %	2.0	1.00	0.80	1.20
Olefins	vol. %	9.9	6.0	4.0	10.0
Oxygen	wt. %	0	1.8 - 2.2	--	2.7 (max) 1.8 (min)b/
T90 Distillation Temperature	deg. F	330	300	290 c/	330
T50 Distillation Temperature	deg. F	220	210	200	220

a/ Summertime Only
b/ Wintertime Only
c/ Refinery Cap = 310°F

2. What are the benefits and costs of the Phase 2 RFG regulations?

The Phase 2 RFG regulations will achieve significant reductions in emissions of hydrocarbons, oxides of nitrogen, and carbon monoxide. These emission benefits are summarized in Table 3. It should be noted that Table 3 does not include any reductions that result from the use of Phase 2 RFG in vehicles produced as low-emission vehicles. The emissions impact of Phase 2 RFG in these vehicles is reflected in their certification emissions. In addition to these benefits, we also expect a 30 percent reduction in the emissions of toxic air contaminants.

The emission reductions will be obtained primarily by reducing exhaust and evaporative emissions from motor vehicles. Some benefits will be obtained by reducing evaporative emission losses from the distribution and marketing of gasoline.

Table 3

Reductions in the Emissions from On-Road Gasoline-Powered Motor Vehicles Due to Phase 2 Reformulated Gasoline

Calendar Year	Percent Reduction in Emissions from On-Road Gasoline-Powered Motor Vehicles		
	Hydrocarbons	Oxides of Nitrogen	Carbon Monoxide
1996	17	11	11
2000	18	9	9
2005	17	5	7

Source: ARB Technical Support Division: EMFACE7F1.1/B7F1.1

At the time of adoption in November 1991, we estimated the capital cost to produce Phase 2 RFG to be between three to six billion dollars. If the entire capital and operating costs to produce Phase 2 RFG are passed on to the consumer, the price of gasoline could increase by 12 to 17 cents per gallon. To the average consumer, the increased gasoline cost would result in a two percent increase in the annual cost of operating a motor vehicle. These cost estimates do not reflect the savings provided to producers by the additional flexibility afforded by the proposed amendments. We anticipate that substantial savings will occur, and will be passed on to the consumer. We are currently evaluating the cost estimates based on the producer's proposed facility modifications. As we obtain this information, we will update the cost estimates as appropriate.

3. When must sources be in compliance with the Phase 2 RFG regulations?

The producers and importers of gasoline for sale in California must comply with the Phase 2 RFG regulations beginning March 1, 1996. All facilities must comply with the cap limits beginning April 1, 1996. These facilities include refineries, terminals, bulk plants, and service stations.

The Phase 2 RFG regulations require small refiners to comply with the limits for the RVP, oxygen, benzene, and aromatic hydrocarbon limits beginning March 1, 1996. However, the regulations allow small refiners to extend their schedule of compliance for sulfur content, olefin content, and the T50 and T90 distillation temperatures until March 1, 1998.

4. What other compliance options are included in the Phase 2 RFG regulations?

In meeting the requirements for gasoline when it is supplied from the production facility, the producers may choose to comply with either the flat limits or the averaging limits. The Phase 2 RFG regulations provide producers another compliance option involving the certification of an alternative Phase 2 RFG formulation based on comprehensive vehicle emissions tests.

The Phase 2 RFG regulations allow for an alternative Phase 2 RFG formulation if it can be shown through the vehicle testing option that emissions resulting from the use of the alternative Phase 2 RFG specifications are equal to or less than emissions resulting from the use of gasoline meeting the Phase 2 RFG specifications. The alternative Phase 2 RFG specifications would be defined by specific flat limits for each of the regulated fuel properties. A fuel property limit for an alternative Phase 2 RFG specifications cannot exceed the appropriate cap limit. The details of the testing option are contained in the "California Test Procedure for Alternative Specifications for Gasoline," incorporated by reference in section 2266, Title 13, California Code of Regulations.

B. THE USEPA REFORMULATED GASOLINE REGULATIONS

1. What do the federal reformulated gasoline regulations require?

The 1990 amendments to the Federal Clean Air Act (FCAA) require the USEPA to adopt regulations regarding reformulated gasoline (federal RFG). The FCAA provides that the federal regulations must require no increase in the emissions of oxides of nitrogen, a minimum 2.0 percent by weight oxygen content (with certain exceptions), a maximum 1.0 percent by volume benzene content, and limits on heavy metals. The federal regulations must also specify performance standards for hydrocarbons in the high ozone period and toxic compounds year-round.

The federal RFG program will be implemented in two phases. Phase I of the program begins on January 1, 1995 and Phase II begins on January 1, 2000. The regulations are to achieve reductions in emissions of hydrocarbons, oxides of nitrogen, and toxic air contaminants through the reformulation of conventional gasoline, considering cost, health and environmental impacts, and energy requirements. Section 211(k)(1) of the FCAA mandates that federal RFG be sold in the nation's metropolitan areas that have the most severe summertime ozone levels and other ozone nonattainment areas that opt into the program. In California, the regulations will apply in Los Angeles, Orange, Ventura, and San Diego Counties, and in parts of Riverside and San Bernardino Counties.

In December 1993, the USEPA promulgated standards for reformulated gasoline. Between December 1, 1994 and December 31, 1997 refiners may demonstrate compliance with emission reduction performance standards using either the "simple model" or the "Phase I complex model." The simple model has flat, averaging, and cap limits for RVP, oxygen and benzene; and a minimum percent reduction requirement for toxic compounds.

For RVP, the USEPA has identified two different control regions which they call "VOC Control Region 1" and "VOC Control Region 2." VOC Control Region 1 includes the southern states and California. The Phase I complex model has flat, averaging, and cap limits for oxygen and benzene; and flat and averaging minimum percent reduction requirements for hydrocarbon emissions, oxides of nitrogen emissions, and toxic compounds. Different hydrocarbon emission reductions are required depending on the control region. Between January 1, 1998 and December 31, 1999, refiners must demonstrate compliance using the Phase I complex model.

Beginning January 1, 2000, refiners must demonstrate compliance using the "Phase II complex model." The Phase II complex model has flat, average, and cap limits for oxygen and benzene; and a flat and average minimum percent reduction requirement for hydrocarbon emissions, oxides of nitrogen emissions, and toxic compounds. As with the Phase I model, different hydrocarbon reductions are required depending on the control region.

While the substantive federal standards will apply in most areas in southern California, the ARB has worked with the USEPA and producers to avoid unnecessary duplication of the enforcement requirements. The USEPA has exempted California producers from many of the federal enforcement requirements from March 1, 1996 to January 1, 2000, as long as certain criteria are met. In the case of two parts of the federal program, California producers are exempt before March 1996 as well. While in some instances the federal test methods differ from the ARB's, the federal regulations allow producers of California gasoline to use the California sampling and test methods in lieu of the applicable federal methods.

2. How do the federal RFG regulations compare to the California Phase 2 RFG regulations?

The USEPA's federal Phase I RFG regulations affect only four properties of gasoline and the benefits are significantly less than the benefits of the California Phase 2 RFG program. In addition, the federal program applies only in southern California where about one-half of the vehicular emissions occur. In southern California for the year 1996, the federal Phase I RFG program would achieve about 45 percent of the hydrocarbons benefits and about 40 percent of the oxides of nitrogen benefits achieved by the California Phase 2 RFG regulations.

The federal Phase II RFG requirements are implemented four years later than the California Phase 2 RFG regulations, thus foregoing significant benefits during these years. We are still evaluating fuels that will meet the requirements of the federal Phase II RFG program and the difference in the benefits between the two programs. Our preliminary analysis indicates that in southern California in the year 2000, the federal Phase II RFG

program would achieve most of the hydrocarbon benefits and about one-half of the oxides of nitrogen benefits achieved by the California Phase 2 RFG regulations. On a statewide basis, we expect the federal Phase II RFG program to achieve only about one-half of the hydrocarbon benefits and one-fourth of the oxides of nitrogen benefits achieved by the California Phase 2 RFG regulations. These comparisions may change as we develop more information about the differences between the two programs.

III.

DEVELOPMENT OF THE CALIFORNIA PREDICTIVE MODEL

This chapter discusses the development of the California predictive model. In the first section, we will identify what a predictive model is and the process we used to develop the model. Subsequent sections will discuss the emissions test data, the statistical approach we used, and how we evaluated the predictive model. Finally, we will discuss how we addressed several issues that arose during the development of the predictive model.

A. OVERVIEW

1. Why are we developing a predictive model?

We are developing the predictive model to provide additional flexibility to producers in meeting the requirements of the Phase 2 RFG regulations.

The producers can use the predictive model to establish specifications for an alternative gasoline formulation that can be used in lieu of meeting the Phase 2 RFG specifications. During the development of the Phase 2 RFG regulations, the producers requested that we consider this option. The producers believed that a predictive model would provide greater flexibility to the industry in the production of gasoline. This flexibility should translate to increased production capabilities and reduced production costs. Through the use of a predictive model, the producers would be able to show that an alternative Phase 2 RFG formulation would result in emission reductions equivalent or better than a gasoline meeting the Phase 2 RFG specifications. We recognized the merits of allowing industry to produce these alternative Phase 2 RFG formulations and committed to develop a predictive model subsequent to the November 1991 public hearing.

2. What is a predictive model?

In general, a predictive model is a set of mathematical equations that allows one to estimate the change in emissions from motor vehicles that will occur when one or more selected fuel properties are changed. A predictive model is typically used to compare the emissions associated with the use of one gasoline versus another gasoline.

Each mathematical equation applies to a different indicator of air pollution. For example, a mathematical equation could be developed for an air pollutant such as hydrocarbons; or, a mathematical equation could be developed for a calculated effect such as the ozone-forming potential of the hydrocarbon emissions. The ozone-forming potential is a measure of the rate at which the emitted hydrocarbons form ozone under specified conditions.

A predictive model is typically characterized by:

- the number of mathematical equations developed,
- the number and type of motor vehicle emissions tests used in the development of the mathematical equations, and
- the mathematical or statistical approach used to analyze the results of the emissions tests.

For our purposes, we developed three mathematical equations. Collectively, we refer to these three mathematical equations as the California predictive model. One equation will determine the change in exhaust emissions of hydrocarbons, the second will determine the change in exhaust emissions of oxides of nitrogen, and the third will determine the change in the combined exhaust emissions of four toxic air contaminants. The four toxic air contaminants included in the equation are benzene, 1,3-butadiene, acetaldehyde, and formaldehyde. They are combined based on their relative potential to cause cancer, which we refer to as potency-weighting.

3. How is the predictive model to be used?

The predictive model is used to determine if an alternative Phase 2 RFG formulation will provide the same emissions benefits as a fuel meeting the Phase 2 RFG specifications.

In specifying an alternative Phase 2 RFG formulation, a producer may elect to change the specifications of any or all of the Phase 2 RFG properties except for the RVP. We are proposing that the RVP be held constant at 7.00 psi. For each selected property, the producer may choose to use either the flat limit or the averaging limit. The producers cannot use any value exceeding a cap limit.

The value selected for each alternative Phase 2 RFG property is entered in each equation with the corresponding value of the Phase 2 RFG property. An acceptable alternative Phase 2 RFG formulation would have to provide equivalent or greater benefits in hydrocarbons, oxides of nitrogen, and potency-weighted toxic air contaminants.

4. How did we develop the California predictive model?

The concept of a predictive model arose during the development of the Phase 2 RFG regulations. The proposed gasoline properties and specifications were based on a number of studies conducted to evaluate the effects of fuel property changes on emissions. The comprehensive nature of these emission studies led to an evaluation of different compliance options that could be used to reduce the cost of complying with the Phase 2 RFG regulations and minimize the impact on production capabilities. A comprehensive model was not included in our original Phase 2 RFG proposal because a fully evaluated statistical approach was not available and several relevant studies that would be useful to supplement the existing data had not yet been completed.

After the public hearing, we began an extensive effort to consolidate all of the available data into a master database that could be used to develop a predictive model and began investigating various statistical approaches. The producers also began an independent effort at developing a predictive model.

In February 1992, we met with the producers to discuss issues related to the development of the predictive model. The issues discussed included the studies and available data, the appropriate statistical approach, and the variables to be included in the model. Also, we discussed the methodology for using the model. The Western States Petroleum Association (WSPA) formed a working group that met periodically with us to discuss the status and developments of the various modeling efforts. In March 1992, a public workshop was conducted to discuss the issues related to the development of the model.

The initial version of the model was developed under contract to the ARB by Dr. David Rocke of the University of California, Davis. From March 1992 to November 1992, we worked with Dr. Rocke on the further refinement of the ARB model and periodically met with the WSPA working group. We released the first version of the California predictive model in November 1992. This version of the ARB model was subsequently discussed with the public at a workshop in December 1992.

At the workshop, the producers expressed concerns about certain anomalies in the model predictions. Over the next several months, an in-depth analysis was made of the database. As a result of this analysis, we excluded some data for fuels with either a high oxygen content (greater than four percent by weight) or an RVP greater than ten pounds per square inch (psi). We generated a second set of models using the revised database.

The producers reviewed the results of the second set of models. We held meetings with the WSPA working group and with individual producers. The producers considered the second set of models as improvements over the previous models. However, they still had some concerns over the anomalies of some of these models. Therefore, we committed to continue working with the producers to arrive at a mutually acceptable model.

To address the anomalies, we agreed with the producers to include the results of several newly released Auto/Oil Air Quality Improvement Research Program studies on the

effects of sulfur and T90 distillation temperature on vehicle emissions. In January 1994, we completed the results of this modeling effort. The result of these models were then discussed at a public workshop held in February 1994. Since February, we have been analyzing the model responses and working to refine the model. The predictive model that we are proposing is the culmination of these efforts.

We have also examined several possible alternative approaches and models. We have examined the approach used by the USEPA in their development of a predictive model. At the producers' request, we have also evaluated an alternative model based on the USEPA's efforts to develop a complex model and examined the effects of using several model simplification techniques. These alternatives are discussed in more detail in Chapter V and Appendix E.

B. DEVELOPMENT OF THE VEHICLE EMISSIONS TESTS DATABASE

1. What is the source of the emissions testing data used to develop the California predictive model?

The data used to construct the California predictive model were obtained from studies conducted to investigate the effects of fuel property changes on emissions. All of the studies involved actual vehicle tests in which vehicles fueled with gasoline of known composition were driven at prescribed conditions over prescribed driving cycles. The vehicle tests were based on the Federal Test Procedure (FTP). The emissions from test vehicles were measured. The effects that varying fuel properties have on exhaust emissions were estimated using standard statistical techniques. The fuel properties varied in the test gasolines included RVP, sulfur, aromatic hydrocarbons, olefins, benzene, T50 and T90 distillation temperatures, and oxygen.

2. How was the master database constructed?

We established a master database by entering the data from the available studies into a Statistical Analysis System (SAS)-based spreadsheet. Depending on the individual study design, each study observation resulted in the measurement of up to 130 individual parameters.

3. What data are included in the working database?

The actual database used in the development of the California predictive model is a subset of the master database. This actual database is referred to as the working database. The working database includes information from 20 studies and represents over 7,700 individual vehicle tests. These 20 studies are summarized in Table 4. Appendix C briefly describes all of the studies that are included in the database. Specific information on the test fuels, the resulting gram per mile emissions, and the model year were extracted from the master database.

Table 4
Summary of Emission Test Studies Used in Developing the Working Database

Study Title	Fuel Properties Examined	Number of Tests
1. USEPA-Emission Factors	oxygenates	1512
2. Auto/Oil Program-AMOT	aromatic hydrocarbons, olefins, T90 distillation temperature, oxygenates	1660
3. Auto/Oil-Sulfur-Phase I	sulfur	300
4. Auto/Oil-Sulfur-Phase II	sulfur	224
5. Auto /Oil-Low Sulfur	sulfur	109
6. Auto/Oil RVP/Oxygenates	RVP, oxygenates (MTBE, ETBE, ethanol)	471
7. Auto/Oil-MTBE and TAME	MTBE, TAME	80
8. Auto/Oil T90-Heavy Hydrocarbons	Aromatics and T90 distillation temperatures	617
9. GM/WSPA/CARB-Driveability	RVP, T90 driveability index, oxygenates	234
10. API-RVP/Oxygenate Program	RVP, oxygenates	154
11. API/Aromatic Hydrocarbons	RVP, aromatic, sulfur, T50, T90	212
12. Chevron Distillation	T10, T50, T90 distillation temperatures, aromatic hydrocarbons, RVP	449
13. Unocal-RFG	T10, T50, T90 distillation temperatures, aromatic hydrocarbons, RVP, fuel octane, olefins, oxygenates, paraffins	744
14. NIPER-Benzene Precursor Study	benzene, aromatic hydrocarbons	90
15. CARB/ATL-Oxygenate	oxygen, oxygenates, RVP	257
16. ARCO EC-X	sulfur, T50 and T90 distillation temperatures, aromatic hydrocarbons, benzene, olefins, RVP, oxygenates	138
17. ARCO-T50/T90	T50 and T90 distillation temperatures	73
18. Auto/Oil-Methanol	Methanol	39
19. EPA/ATL-Phase I/II	RVP, oxygenates, T90 distillation temperatures, sulfur	278
20. ARB/GM-Confirmation	sulfur, T50 and T90 distillation temperatures, aromatic hydrocarbons, benzene, olefins, RVP, oxygenates	3
	Total	7724

Vehicles with different types of emissions control technologies will react differently to changes in fuel properties. For example, a vehicle with a catalytic converter will likely show an increase in emissions of hydrocarbons if the sulfur content of a fuel is increased. This occurs because sulfur has a detrimental effect on the catalyst metals. A vehicle without a catalyst should not show this effect. Therefore, we divided the working database into five technology classes that generally represent the type of vehicle emissions control technology in use. We refer to these technology classes as Tech classes. The five Tech classes were those as defined during the Phase 2 RFG rulemaking process. These Tech classes and the number of emissions tests in the database for each Tech class are shown in Table 5. Note that Tech 5 represents low-emission vehicles. There are no data in the working database for these vehicles.

Table 5

Vehicle Technology Classes Used in the ARB Database

Technology Class	Model Years	Dominant Emissions Control Technology	Number of Tests in the Database
Tech 1	Pre 1975	Non-catalysts vehicles	159
Tech 2	1975 - 1980	Open-loop oxidizing catalysts	238
Tech 3	1981 - 1985	Early closed-loop three-way catalysts	1,487
Tech 4	1986 - 1995	Closed-loop three-way catalysts	5,840
Tech 5	Post 1995	Low-emission vehicles	0

4. What data were excluded from the database?

In evaluating the database, we concluded that certain fuels should not be included because they would tend to inappropriately influence the statistical analysis. We excluded fuels with an RVP greater than 10 pounds per square inch because these fuels would clearly not be produced in the summertime in California. For similar reasons, we excluded fuels with a sulfur content greater than 1000 parts per million by weight, oxygen content greater than four percent by weight, the 50 percent distillation temperature greater than 250 degrees Fahrenheit, and the 90 percent distillation temperature greater than 374 degrees Fahrenheit. We also excluded Fuel "Y" from the ARB/ATL Oxygenate Study because an engineering analysis indicates that there were problems in blending the fuel that resulted in inaccurately reporting the values. Table 6 presents a summary of the excluded data and the number of data points affected. In total, approximately 1100 tests out 8800 tests or 12 percent were excluded.

Table 6

Summary of Data Excluded from the ARB Working Database

Excluded Data	Number of Emission Tests Excluded by Technology Class			
	Tech 1	Tech 2	Tech 3	Tech 4
Reid vapor pressure > 10 psi	2	5	343	595
Sulfur > 1000 ppmw	0	0	0	1
Oxygen > 4 % by weight	0	0	0	110
T50 > 250 degrees Fahrenheit	0	0	8	16
T90 > 374 degrees Fahrenheit	0	0	6	15
Fuel "Y" from ARB/ATL Oxygenate Study	1	2	4	7

C. STATISTICAL APPROACH USED TO DEVELOP THE CALIFORNIA PREDICTIVE MODEL

This section presents a general overview of the statistical approach used to develop the California predictive model. A detailed discussion of the statistical approach used to develop the California predictive model is presented in Appendix D.

The California predictive model is based on statistical analysis of the ARB working database. A set of equations was developed using standard statistical techniques to relate specific properties of the gasoline used in vehicle tests to emissions of hydrocarbons, oxides of nitrogen, and the potency-weighted toxic air contaminants (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde weighted relative to their estimated cancer-causing potential). Each equation represents a "best-fit" line or curve explaining the relationship between fuel properties and exhaust emissions.

The statistical approach involves the following: (1) defining which Tech classes to address, (2) defining the mathematical form of the model, and (3) simplifying the model.

1. What technology classes are included in the California predictive model?

As discussed previously, the effect of fuel properties on emissions varies as a function of the type of vehicle emissions control technology generally in use. Therefore, it is appropriate to develop separate equations for vehicles with common emissions control technologies. In the earlier versions of the predictive model, we developed equations for

each of the four Tech classes. We are proposing that the final California predictive model include equations for the Tech class 3 and Tech class 4 only. Our rationale for this decision follows.

First, the mathematical equations developed for Tech class 1 and Tech class 2 are based on a database that is much smaller than the database used to develop the Tech class 3 and Tech class 4 equations. Tech class 1 and Tech class 2 have a total of 160 and 240 emissions tests, respectively; the Tech class 3 and Tech class 4 have a total of 1,491 and 5,847 emissions tests, respectively. Thus, there is much less confidence in the ability of models to estimate the true effects that a change in fuel properties may have on emissions in these Tech classes.

In addition, Tech class 3 and Tech class 4 are likely to best represent the technology used to comply with the low-emission vehicle program. In the year 2005, low-emission vehicles produce about 40 percent of the hydrocarbon exhaust emissions and 60 percent of the oxides of nitrogen emissions. In 1994, new vehicles will begin to be certified on Phase 2 RFG. In estimating the benefits of Phase 2 RFG, we did not include any benefits for the use of Phase 2 RFG in low-emission vehicles because those benefits had been included in the low-emission vehicle program. However, we believe it is necessary to consider the effects that alternative Phase 2 RFG specifications that would be allowed by using the predictive model will have on the emissions from future vehicles. We expect that Tech class 3 and Tech class 4 will best represent the effects of changes in fuel properties on low-emission vehicles compared to including all four Tech classes.

2. What statistical approach did we use in developing the California predictive model?

We used the SAS Institute's Mixed Model Procedure to develop the California predictive model. The term "mixed" means we are including both fixed effects and random effects. A fixed effect is the change in emissions that result from a change in a particular value of a fuel property. Random effects are the changes in emissions that result from the vehicle and vehicle by fuel parameter interactions.

We ran SAS Mixed Model Procedure for each pollutant and for each Tech class to develop an equation relating fuel properties and emissions. Table 7 identifies the individual equations developed.

Table 7

Summary of Individual Equations Developed

Pollutant	Individual Equations Developed	
	Tech Class 3	Tech Class 4
Hydrocarbons	X	X
Oxides of Nitrogen	X	X
Benzene	X	X
1,3-Butadiene	X	X
Formaldehyde	X	X
Acetaldehyde	X	X

Each equation consists of an intercept, a series of seven potential first order terms, and 28 potential second order terms. A first order term represents the relationship that a change in an individual fuel property has on vehicle emissions. A second order term represents the interactive effects of fuel properties on vehicle emissions.

Each equation has several terms that relate the concentration of a fuel property to the emissions of a specific pollutant. For the hydrocarbon and oxides of nitrogen equations, we have included all seven potential linear terms on the premise that the influence of these controlled parameters on emissions should be accounted for. The SAS Mixed Model Procedure identifies those second-order terms that are significant. In general, most of the second-order terms are eliminated. Table D-3 of Appendix D identifies the significant terms included in the Tech class 3 and Tech class 4 equations for both hydrocarbons and oxides of nitrogen.

For the toxic air contaminant equations, we have included the same seven linear terms as in the hydrocarbons and oxides of nitrogen equations. We also evaluated the significance of adding a linear benzene term to the toxic air contaminant equations. We did not include the benzene term in those equations where it was shown to have an insignificant effect. Significance was determined through a standard t-statistic evaluation where a significant term was one whose probability of random occurrence was less than 0.05. The benzene term was eliminated from the 1,3-butadiene equations for Tech class 3 and Tech class 4, from the formaldehyde equations for Tech class 3 and Tech class 4, and from the acetaldehyde equation for Tech class 3. We did include the benzene term in the benzene equations for Tech class 3 and Tech class 4, and the acetaldehyde equation for Tech class 4. We did not identify any significant second-order terms for any of the toxic air contaminants.

3. How did we simplify the equations?

The random balance is a statistical technique used to reduce the number of terms in the equations without adversely affecting the explanatory power of the equations. The theory is that over a narrow interval, a curved surface can be adequately approximated by a straight line. The narrower the interval, the better the approximation. In terms of the equations, a curved surface is the result of the inclusion of second-order terms. If the curved surface can be replaced with a straight line, second-order terms would be eliminated, and the equation would be simplified.

The random balance approach uses numerical techniques to identify the terms that are contributing most to the explanatory power of the equations. This is done by generating thousands of random fuels balanced through the space defined by the random balance box. The set of random fuels and estimated emissions then can be assembled so that a numerical analysis can estimate the contribution of each term to the overall fit of the surface in the defined region. Any term that contributes less than one percent to the predictive power of the equation can be eliminated.

The random balance approach was applied to the hydrocarbons and oxides of nitrogen equations for both Tech class 3 and Tech class 4. Table D-5 of Appendix D lists the terms of the final equation after the random balance was applied. The random balance was not applied to the equations for the toxic air contaminants because there were no second-order terms included in these equations.

4. How are the final equations used?

The equations are used to calculate the percent difference in predicted emissions of a candidate fuel to those from the reference fuel. The reference fuel specifications are equal to Phase 2 RFG at the flat or averaging limits. If the candidate fuel has an averaging limit for a fuel property, then the appropriate averaging limit is used for the reference fuel specification. If the candidate fuel has a flat limit for a fuel property, then the appropriate flat limit is used for the reference fuel specification.

As mentioned earlier, a separate equation has been developed for Tech class 3 and Tech class 4 and for each emissions criterion. To develop a single predictive model for each of the three emissions criteria, Tech class 3 and Tech class 4 results must be combined. The method used to combine the results is referred to as the technology class weighing. The detailed methodology for combining the individual equations is presented in Appendix D.

For the hydrocarbons and oxides of nitrogen emissions criteria, the technology class weightings were based on the average contribution from each technology class to the total emissions from the two technology classes.

Once the composite values are determined, the percent difference between the predicted values for the alternative Phase 2 specifications and the Phase 2 RFG reference specifications is calculated.

We are proposing that potency-weighted mass of toxics be used to evaluate equivalency of toxic emissions among fuels. The proposed California predictive model evaluates the percent difference between the potency-weighted emissions of the alternative Phase 2 RFG specifications and the Phase 2 RFG reference specifications. In developing regulations to control emissions of toxic air contaminants, the ARB's practice is to consider the potency-weighted emissions of the particular toxic air contaminant. The ARB has identified benzene, 1,3-butadiene, formaldehyde, and acetaldehyde as toxic air contaminants.

Table 8 lists the relative potencies of 1,3-butadiene, benzene, formaldehyde, and acetaldehyde. The relative potencies of these toxic compounds are based on cancer potency values provided by the Office of Environmental Health Hazard Assessment (OEHHA). The cancer potency value for each pollutant has been divided by the cancer potency value for 1,3-butadiene. If the model evaluated toxics on a mass basis, the relative impact of a gram/mile reduction of formaldehyde would be equal to a gram/mile reduction of 1,3-butadiene. This approach does not consider the potential cancer risk associated with each pollutant. As shown in Table 8, the potential cancer risk associated with 1,3-butadiene is 62.5 times that of acetaldehyde. We believe the model should take this into account when evaluating the equivalency of two fuels.

Table 8

Potency Weighting Factors
(relative to 1,3-Butadiene)

	Unit Risk $(\mu g/m^3)^{-1}$	Relative Potency
1,3-Butadiene	1.7E-4	1.0
Benzene	2.9E-5	0.17
Formaldehyde	6.0E-6	0.035
Acetaldehyde	2.7E-6	0.016

Reference: California Air Pollution Control Officers Association, Air Toxics Hot Spots Program, Revised 1992 Risk Assessment Guidelines, October 1993

For the potency-weighted toxic air contaminants, there are eight different equations that must be combined (four toxic air contaminants and two Tech classes). There is also not an emissions inventory for the toxic air contaminants from mobile sources. Therefore, the comparison between two fuels is based on ensuring that there is no increase in the relative potential number of cancer cases. The detailed methodology for combining the individual equations for the toxic air contaminants is presented in Appendix D.

For an alternative gasoline formulation to be acceptable, the percent difference in emissions of hydrocarbons, oxides of nitrogen, and potency-weighted toxic air contaminants for the alternative gasoline formulation compared to the Phase 2 RFG reference fuel must be less than or equal to 0.04 percent for all pollutants.

5. How well do the California predictive model predictions compare with observation?

The best approach for determining how well the California predictive model performs is to compare the model's predictions to the results of a study that is not part of the database. Unfortunately, there is no such study available at this time. As an alternative, we selected certain studies that are part of the ARB working database to compare predictions versus observations. Two groups of studies were selected. The first group represented well-designed studies on fuels outside the Phase 2 region (most fuel property values are well above Phase 2 limits). For this group, the Auto/Oil AMOT (study 2 in Table 4) and the Auto/Oil T90 (study 8 in Table 4) studies were selected. The second group represented well-designed studies on fuels within the Phase 2 region (most fuel property values meet the Phase 2 limits). For this group, we selected the ARCO-EC-X (study 16 in Table 4), ARB/GM-Confirmation (study 20 in Table 4) and the GM/WSPA/CARB (study 9 in Table 4) studies.

Comparing the observed percent change to the predicted percent change for each set of fuels, we found that the predicted percent change in emissions was generally within 10 percent of the observed values. The California predictive model appears to predict better for fuels in the Phase 2 region and does better in predicting the percent change in hydrocarbons than oxides of nitrogen. These two points support the use of the California predictive model. Alternative Phase 2 RFG specifications should be close to Phase 2 values where the model predicts better. Variability in emissions measurement tends to be greater with hydrocarbons than oxides of nitrogen. This favors the selection of a model that predicts better for hydrocarbons than for oxides of nitrogen. Additional details concerning this analysis are presented in Appendix D.

D. ISSUES RELATED TO THE DEVELOPMENT OF THE PROPOSED CALIFORNIA PREDICTIVE MODEL

The following section identifies and discusses the major issues associated with developing the California predictive model.

1. Should we retain the carbon monoxide test requirement in the California predictive model?

No. The proposed California predictive model does not include a carbon monoxide equation. In earlier versions of the California predictive model, separate equations were developed to estimate the emissions of carbon monoxide. As with hydrocarbons and oxides of nitrogen, estimated carbon monoxide emissions were to be used as one criteria for evaluating a candidate fuel. We propose not to include a carbon monoxide equation in the California predictive model because the carbon monoxide exceedances are mainly a wintertime phenomenon.

In 1991, there were eight areas in California designated as nonattainment for the federal ambient air quality standard for carbon monoxide. In the fall of 1991, the ARB adopted the California Wintertime Oxygenate Program. This program requires gasoline sold in California to have a minimum oxygen content of 1.8 percent by weight and a wintertime maximum oxygen content of 2.2 percent by weight.

The Wintertime Oxygenates Program has a sunset clause that ends the program on February 29, 1996. However, the oxygen content requirements of the Wintertime Oxygenates Program have been incorporated into the Phase 2 RFG regulations. By 1996, the ARB projects that all of California, except Los Angeles County, will be in attainment for both the federal and state ambient air quality standards for carbon monoxide.

As a result, inclusion of a carbon monoxide criterion in the California predictive model is not necessary.

2. Should we retain the "Ozone-Forming Potential" test requirement in the California predictive model?

No. The proposed California predictive model does not include an ozone-forming potential equation. Earlier versions of the California predictive model included ozone-forming potential, or reactivity, as a criterion for evaluating a candidate fuel. The ozone-forming potential of the rate at which the emitted hydrocarbon ozone under specified conditions is a measure of how effective emissions of organic gases are in producing ozone. Motor vehicle hydrocarbon emissions consist of scores of individual species that vary significantly in ozone-forming potential. Changing the composition of fuels alters the composition of exhaust emissions. We are not proposing to include an ozone-forming potential equation in the proposed California predictive model for the following reasons.

The Low-Emission Vehicles and Clean Fuels regulations use reactivity adjustment factors (RAFs) to correct the exhaust emission standards for differences between the ozone-forming potential of Phase 1 gasoline and other fuels. The RAF is the ratio between the ozone-forming potential (on a mass basis) of a candidate fuel's exhaust from a certain vehicle type to the reactivity of Phase 1 gasoline exhaust from that same vehicle type. The RAFs for Phase 2 gasoline are 0.98 and 0.94 for Transitional Low-Emission Vehicles (TLEVs) and Low-Emission Vehicles (LEVs), respectively. In other words, the ozone-forming potential of exhaust emissions from a TLEV fueled with Phase 2 gasoline is about 2 percent less than an equal weight of TLEV exhaust emissions with Phase 1 gasoline. Since any candidate fuel evaluated with the predictive model would have specifications similar to Phase 2 gasoline, and since the potential variation in ozone-forming potential between the two fuels is small, [and since the predictive model is not as statistically robust for ozone-forming potential compared to other exhaust parameters because of the relative lack of organic gas exhaust profiles,] we do not believe inclusion of an ozone-forming potential criterion in the model is necessary.

3. Should we develop a California predictive model for wintertime application?

No, not at this time. As discussed in Chapter I, we are proposing to allow the proposed California predictive model to be used during the wintertime oxygenate season. However, we do plan to evaluate the need for, and the feasibility of, developing a separate predictive model for the wintertime oxygenate season. If we developed a wintertime model, our intention at this time would be to allow producers the option of using this model.

In developing a wintertime oxygenate model, we would more closely evaluate the impact that different RVP fuels may have on the model. We would reevaluate the current database and determine if additional RVP data should be used to develop predictive model equations. The current version of the California predictive model excludes RVP data greater than 10 psi. We would evaluate if sufficient emissions data exists at wintertime temperatures. Because changing the RVP also affects exhaust emissions of carbon monoxide, we would evaluate the need for including a carbon monoxide model component in a wintertime model.

4. Are we providing small refiners any special provisions when using the California predictive model to qualify alternative fuels in the 1996 - 1998 time frame?

No, not at this time. As discussed in Chapter I, section B, we are not proposing any special provisions for small refiners to use the proposed California predictive model during the 1996 - 1998 time frame. Small refiners have a two-year extension for meeting the Phase 2 RFG requirements for sulfur, olefins, T50, and T90. The small refiners have requested that a small-refiner Phase 2 RFG reference specification be established that would have the same values as Phase 2 RFG for RVP, oxygen, benzene, and aromatic hydrocarbons but would have a different value for sulfur, olefins, T50, and T90. Some suggested we allow small refiners to certify fuels against a reference fuel with ASTM values for sulfur, olefins, T50, and T90. We did not agree with this approach since it would result in a loss of most of

the emission benefits from regulating the other four fuel properties. We have examined several alternatives but are not in a position to recommend an approach that we believe would maintain the environmental benefits of the Phase 2 RFG regulations and be equitable among all small refiners. As a result, we are not proposing any special provisions for small refiners when using the California predictive model.

IV.

SUMMARY OF THE PROPOSED AMENDMENTS TO THE PHASE 2 RFG REGULATIONS

In this regulatory action, we are proposing amendments to the Phase 2 RFG regulations. These amendments affect sections 2260-2265 and section 2270, Title 13, California Code of Regulations (CCR). In particular, we are proposing amendments that would:

- o add an option to allow the use of a predictive model to evaluate and approve alternative Phase 2 RFG formulations, and
- o modify several sections of the Phase 2 RFG regulations to facilitate implementation.

The following discussion presents the proposed amendments. The first section discusses the predictive model procedures. The second section discusses proposed amendments to the regulations to authorize the use of the predictive model procedures. The third section discusses issues associated with the implementation of the Phase 2 RFG regulations.

A. PREDICTIVE MODEL PROCEDURES

The California predictive model will allow producers to establish specifications for alternative Phase 2 RFG formulations that can be used in lieu of meeting the Phase 2 RFG specifications. Through the use of a predictive model, the producers will be able to evaluate whether the emissions from the use of alternative Phase 2 RFG specifications will result in emission reductions equivalent or better than using a gasoline meeting the Phase 2 RFG specifications.

In this regulatory action, we are proposing that the Board adopt new procedures entitled "California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model" (predictive model procedures or procedures). The proposed procedures would be incorporated by reference in section 2265, Title 13, CCR. The complete text of the proposed section 2265 is included in Appendix A. The complete text of the proposed procedures is included in Appendix B.

A producer will have to evaluate the candidate alternative Phase 2 RFG specifications in accordance with the proposed procedures before electing to have the alternative Phase 2 RFG specifications apply to the producer's gasoline. The proposed procedures set forth a set of equations that are used to:

- predict the mass exhaust emissions for hydrocarbons, oxides of nitrogen, and toxic air contaminants (calculated individually for benzene, 1,3-butadiene, formaldehyde and acetaldehyde) by vehicle technology class,

- combine the predicted mass emissions for hydrocarbons and oxides of nitrogen for each vehicle technology class into a single total mass emissions value for hydrocarbons and oxides of nitrogen using technology class emissions weighting factors,

- weight the predicted mass emissions of each toxic air contaminant by the weighting factor for vehicle miles traveled (VMT) and the potency weighting factor,

- combine the potency and VMT weighted emissions for each toxic compound into a single total potency/VMT weighted value,

- calculate the percent difference in the combined mass emission values of hydrocarbons and oxides of nitrogen for the candidate fuel (the alternative Phase 2 RFG specifications being evaluated) with respect to the combined mass emission values of hydrocarbons and oxides of nitrogen for the reference fuel (Phase 2 RFG specifications),

- calculate the percent difference in the potency/VMT weighted emissions value for the candidate fuel with respect to the potency-weighted emissions value for the reference fuel, and

- compare the percent difference in emissions for the candidate fuel with respect to the reference fuel for hydrocarbons, oxides of nitrogen, and potency-weighted toxic air contaminants using the criterion that the difference must be 0.04 percent or less for each pollutant for the alternative Phase 2 RFG specifications to be deemed acceptable.

The proposed procedures define terms used in the procedures, provide reference fuel specifications, establish vehicle technology classes and technology class emissions and VMT weightings, establish potency-weighting factors, provide the general mathematical form of all the equations, provide the specific predictive equations with coefficients and standardization factors, provide the pass/fail criterion, and establish reporting notification requirements. Below is a summary of the information and requirements contained in the procedures.

Definitions: The procedures define terms that are used throughout the document. Standard definitions are used to define terms such as candidate fuel, reference fuel, and executive officer. Definitions are provided for all the regulated fuel properties. These definitions include the units of measurement for the property and the number of significant figures to be used, and are necessary to ensure that the procedures are clear and free from ambiguity. When a fuel property can be subject to either a flat or an averaging limit, the producer will determine whether the candidate alternative Phase 2 RFG specifications will apply as a flat or an averaging limit. The producer would then identify the reference fuel specification for that property, based on the standard in the regulations under that compliance option.

Reference fuel specifications: For each of the eight fuel properties regulated by the Phase 2 RFG regulations, the procedures identify the specifications to assigned to the reference fuel. These specifications are based on the various limits in the regulations. The procedures contain an optional worksheet to help an applicant determine each reference fuel property value. Table 6, in the proposal procedures, identifies the reference and candidate fuel property values for oxygen content when the candidate property value is outside the 1.8 to 2.2 volume percent range.

Vehicle Technology Classes and Technology Class emissions weightings: The procedures define two technology classes -- Tech class 3 (model years 1981-1985) and Tech class 4 (model years 1986-1995). The emissions weighting factors correspond to the average contribution of Tech class 3 and Tech class 4 to the on-road motor vehicle emissions for the years 1996, 2000, and 2005.

VMT weightings: The procedures establish VMT weighting factors for the four toxic air contaminants. These factors were calculated by taking the average of the VMT fractions for Tech classes 3 and 4 for the years 1996, 2000, and 2005.

Potency weighting factors: The procedures establish potency weighting factors for benzene, 1,3-butadiene, formaldehyde, and acetaldehyde. The weighting factors represent the cancer potency value for each toxic pollutant relative to the cancer potency value for 1,3-butadiene.

General form of the predictive equations: The procedures contain a general description, in the form of mathematical equations, of how mass emissions are predicted, how the combined emissions are determined using Technology class weighting factors and potency weighting factors, and how the final comparison of the candidate to reference fuel is made.

Predictive equations: The bulk of the procedures contain detailed mathematical equations used to predict the mass emissions for hydrocarbons, oxides of nitrogen, and toxic air contaminants. The fuel property values for the candidate fuel and then the reference fuel are substituted into the equations to calculate the mass emissions for each pollutant by technology class. The mass emissions by technology class are combined for each pollutant in a second series of equations. The combined emissions for the candidate fuel and the reference fuel are then compared in a third equation. Separate equations are provided for each of the six pollutants and for the two technology classes. Thus, a total of 12 equations are used. Each equation has a unique intercept and a unique coefficient for each linear term (all the regulated pollutants) and any significant second order terms. Each equation contains a unique set of constants to standardize the fuel property value for each term.

Pass/Fail criterion: The procedures require that the percent increase in emissions for the candidate fuel with respect to the reference fuels for hydrocarbons, oxides of nitrogen, and potency-weighted toxic air contaminants be 0.04 percent or less. A candidate fuel must pass on each pollutant individually to be deemed an acceptable alternative gasoline formulation.

Reporting requirements: The procedures require that the applicant notify the Executive Officer of the ARB for each set of alternative Phase 2 RFG specifications that the producer intends to assign to gasoline supplied from its production facility. This information will be in a format agreed upon by the Executive Officer. At a minimum, the information must identify the fuel or the period of time for which the alternative Phase 2 RFG formulation is applicable, the value of and the selected compliance option for each Phase 2 RFG specification, the reference fuel specifications, and the percent difference in emissions between the candidate fuel and the reference fuel.

B. REQUIREMENTS FOR USE OF THE PREDICTIVE MODEL

Proposed new section 2265 contains the requirements for selling gasoline subject to alternative specifications identified through application of an predictive model. Amendments are proposed for section 2260 (Definitions), section 2264 (Designated Alternative Limits), and section 2270 (Testing and Recordkeeping). Below is a summary of the provisions contained in section 2265.

Section 2265(a) establishes the procedures for evaluating alternative specifications using the California predictive model. It also establishes the requirements for notifying the ARB regarding alternative Phase 2 RFG specifications evaluated in accordance with the predictive model. The subsection:

- Incorporates by reference the "California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model."

- Provides that a producer electing to supply a batch of gasoline from its production facility subject to alternative Phase 2 RFG specifications evaluated under the procedures must notify the Executive Officer of the following information: the identity, location, and estimated volume of the batch of gasoline, the predictive model alternative specifications that apply, the compliance option for each fuel property, and the numerical values for the percent change in emissions for hydrocarbons, oxides of nitrogen, and potency weighted toxic air contaminants. This information is necessary for ARB personnel to confirm that the alternative specifications meet the criteria in the procedures and to verify that the gasoline being supplied conforms with applicable requirements.

- Requires notification of a predictive model alternative Phase 2 RFG formulation at least 12 hours before the start of physical transfer and in no case less than 12 hours before physical transfer is completed or the final blend is commingled with other fuel. This notification time frame is identical to the applicable time frame for reporting designated alternative limits.

- Provides that once a batch of gasoline is supplied from a production facility subject to alternative specifications, all batches subsequently shipped from the facility will be subject to the alternative specifications until the ARB is advised otherwise.

Section 2265(b) identifies prohibited activities for producers supplying gasoline subject to predictive model alternative specifications. These prohibitions include:

- Supplying gasoline that is identified as meeting a predictive model alternative specification, but does not meet the criteria for approval under the predictive model procedures.

- Supplying a gasoline that does not meet a flat limit identified in the predictive model alternative specifications.

- Supplying gasoline that is subject to an alternative specification averaging limit and no designated alternative limit when the producer fails the requirements applicable to averaging limits.

- Supplying gasoline subject to predictive model alternative specifications where the producer was prohibited from electing such specifications by the restrictions discussed immediately below.

Section 2265(c) identifies several restrictions regarding the election of predictive model alternative specifications. These restrictions include:

- prohibitions against switching to a predictive model alternative specifications or to a different predictive model alternative specifications if there is any outstanding requirement to provide offsets, and

- o prohibitions against using any previously generated designated alternative limit credits when switching to or between predictive model alternative specifications.

In addition to the above, conforming changes are needed to sections 2260, 2262.2, 2262.3, 2262.4, 2262.5, 2262.6, 2262.7, 2264, and 2270. The changes to section 2260 involve adding definitions related to use of the predictive model. The changes to section 2262.2 through 2262.7 reference the option of using the predictive model procedures. The changes to section 2264 clarify that the election of the compliance option for predictive model alternative specifications shall be made under section 2265 rather than section 2264. The changes to section 2270 add references to the applicability of the testing and recordkeeping provisions to predictive model alternative specifications.

C. OTHER PROPOSED AMENDMENTS

1. Compliance Dates for the Cap Limits

As adopted, the Phase 2 RFG regulations require producers and importers to comply with the flat or averaging limits at their production and import facilities starting March 1, 1996. Compliance with the cap limits is required throughout the distribution system starting April 1, 1996. The March 1 and April 1 dates coincide with the annual compliance dates for the RVP standards in southern California. We are proposing that the Board extend the dates for complying with the cap limits, so that they apply starting April 15, 1996 to sales or supplies of gasoline from all facilities other than bulk plants, retail outlets, or bulk purchaser-consumer facilities, and apply throughout the distribution system starting June 1, 1996. The proposed amendments are contained in section 2261(a).

The annual one-month transition period for the RVP regulations was intended to approximate the time needed to "turn" the gasoline distribution system from wintertime gasoline to summertime gasoline. At the same time, selection of a one-month period reflected a need to avoid a lengthy annual transition where either the full benefits of low-RVP gasoline could be delayed in potentially high-ozone periods, or driveability problems could result from the use of low-RVP gasoline during colder wintertime conditions.

In the case of the one-time transition to Phase 2 RFG, we believe a longer transition period is appropriate. We expect that in the normal course, not all tanks would be fully turned in one month. The spring of 1996 will be the first time that refiners have to produce Phase 2 RFG and carriers have to distribute the cleaner gasoline. The recent implementation of the reformulated diesel fuel regulations has shown that supply disruptions can occur in connection with the introduction of new fuel standards. Retailers and end-users concerned that gasoline on hand does not meet all of the new cap limits could increase their purchases during the latter part of the transition period, putting strains on the distribution system. The occasional need to remove non-complying gasoline from retail or end-user storage tanks could divert important resources during the transition. There could be similar occurrences at bulk plants, which are intermediate facilities supplied only by cargo tank trucks. Based on discussions with carriers and refiners, we believe the allowance of approximately 45 days for

tanks at terminals to turnover, and an additional 45 days for full turnover at bulk plants and service stations, should be sufficient to provide a smooth implementation of the Phase 2 RFG regulations.

We are also proposing an amendment making the cap limits inapplicable to sales or supplies of gasoline from a retail outlet or bulk purchaser-consumer facility where it is shown by affirmative defense that the exceedance of a cap limit was caused by gasoline delivered prior to April 15, 1996 (or from a bulk plant prior to June 1). This amendment is intended to provide relief for low-throughput facilities that may not receive sufficient deliveries of Phase 2 RFG to turn their tanks by June 1. Such relief is intentionally limited, however, and the retailer or other end-user would have the burden of demonstrating that a cap violation was caused by gasoline delivered when suppliers were not required to meet the cap limits.

While we expect that the proposed amendments will help to smooth the transition to Phase 2 RFG, we emphasize that the March 1, 1996 compliance date for gasoline shipped from production and import facilities would not change. The March 1 upstream compliance date, coupled with the fact that in most cases the cap limits are less stringent than the limits applicable to gasoline leaving production and import facilities, should mean that by April 15 most gasoline in the distribution system should comply with the cap limits. Although gasoline sold from a service station would not need to comply with the cap limits until June 1, 1996, gasoline delivered to service stations will have to meet the cap limits starting April 15, except for deliveries from bulk plants. We request comments on whether additional transition provisions are necessary to assure compliance with these requirements.

2. Notification by Producers of the Volumes of Final Blends of Gasoline Subject to Designated Alternative Limits

The Phase 2 RFG regulations contain notification requirements that apply when a producer ships gasoline subject to a designated alternative limit (DAL) from the production facility. The producer is required to notify the ARB's Executive Officer of the shipment before the producer starts to physically transfer the gasoline from the refinery, and in no case less than 12 hours before the producer completes physical transfer or commingles the final blend. The notification is to include the assigned DAL and the volume of the final blend {section 2264(a)(2)(A)}.

The regulations also provide that where a batch of gasoline has an assigned DAL that is less stringent than the averaging limit for the property, the actual volume of gasoline shipped cannot be greater than the volume reported by the producer. Where a batch of gasoline has an assigned DAL that is more stringent than the averaging limit, the actual volume of gasoline shipped cannot be less than the volume reported by the producer {section 2264(b)}. These requirements are necessary to assure that all batches of gasoline exceeding an averaging standard are fully offset by batches cleaner than the averaging standard. We anticipated that ARB compliance personnel inspecting refineries would verify whether the actual volumes of reported final blends met these requirements. There was no provision for revising the originally reported volumes because that would lessen the deterrent effect of the ARB inspections.

However, refiners have pointed out that it will be extremely difficult to comply with the volume restrictions on DAL final blend when there is no allowance for corrections to initially reported volumes. This is because a given batch may have a DAL for one property that is more stringent than the averaging limit, at the same time it has DAL for another property that is less stringent than the averaging limit. Refiners do not expect to know the precise volume of gasoline in the batch until they have completed the shipment.

Accordingly, we are proposing an amendment to section 2264(a)(2)(A) that will permit a refiner reporting a batch of gasoline with an assigned DAL to initially report the estimated volume. The refiner will be permitted to revise the originally reported volume, as long as the revised volume is reported no later than 48 hours after completion of shipment of the gasoline. This amendment will assure that refiners can report accurate volumes. Maintaining a requirement that the estimated volume be included in the original notification will be helpful when ARB field inspectors visit refineries to monitor compliance with the averaging requirements.

3. Election of and Switching Between Flat and Averaging Limits

The Phase 2 RFG regulations allow an averaging compliance option for six properties--sulfur, aromatic hydrocarbon, olefin, and benzene content, and T50 and T90. In each case, the regulations require refiners wishing to use the averaging option to elect it on a calendar-year basis. The initial election for 1996 must be made by November 1, 1995, and subsequent annual elections are to be made by October 1 of the previous year. This structure was based on the fact that the applicable limits under the averaging option were more stringent than the flat limits, and on the need for advance notice to enable the ARB to plan its enforcement efforts.

Refiners have commented that the advance election requirements substantially and unnecessarily limit the usefulness of the averaging option. We have concluded that the enforcement benefits of the election provisions do not justify the resulting reduction in flexibility. We are therefore proposing deletion of the annual election provisions. With the two limitations described below, we propose that refiners be permitted to switch between the flat limit and averaging compliance options on a batch-by-batch basis, as long as they provide notice in the same manner as is required for assigning DALs. The primary rationale for notification requirements is the need to assure that ARB inspectors visiting a refinery will know with certainty the limits applicable to the finished gasoline being supplied from the refinery. At this time, we believe the requirement that notification be given before the producer starts to physically transfer the gasoline from the refinery, and in no case less than 12 hours before the producer completes physical transfer or commingles the gasoline, will be sufficient for this purpose.

Under the proposed amendments, switching between averaging and flat limits would be subject to two restrictions. First, a refiner would not be permitted to switch from an averaging limit to a flat limit for a given property if there are outstanding deficits for that property that need to be offset. Second, once a refiner elects to switch from the averaging option to the flat limit for a property, the refiner will not be permitted to use any previously

accumulated credits to provide offsets after a subsequent switch back to the averaging option. These requirements stem from the fact that the numerical limit under the averaging option is more stringent than the flat limit. For example, the flat limit for benzene content is 1.00 volume percent, and the limit under the averaging option is 0.80 volume percent. A refiner would have a natural incentive to always select the flat option for batches between 0.80 and 1.00 percent, and to select averaging only for those batches over 1.00 percent or under 0.80 percent. If this were allowed, it would reduce the effectiveness of the regulations. Accordingly, the proposed amendments limit the refiner's ability to switch back to flat limits. This restriction is essential to maintain the integrity of the spread between the flat and averaging limits. In essence, the proposed amendments require that the refiner "close its averaging books" before switching to the flat limits.

4. Treatment of Imported Gasoline

Under the current Phase 2 RFG regulations, every time gasoline is imported into California to be sold for use in motor vehicles, the importer is subject to requirements analogous to those applicable to California refiners. These requirements apply when gasoline is shipped from another state as well as from outside the United States. Gasoline importers must assure that the gasoline complies either with the flat limits or the averaging limits if elected. Whenever a DAL is assigned for a property, the importer must sample and analyze the gasoline with respect to that property. This approach should be workable when gasoline is imported in large batches, whether by marine tanker or barge, or by pipeline. However, the requirements could be very burdensome when Phase 2 RFG is brought into the state in small batches by cargo tank trucks. Accordingly, we are proposing amendments regarding imported gasoline to lessen the burdens where appropriate.

Virtually all of the gasoline brought into border areas of California by cargo tank truck from out-of-state terminals and bulk plants was originally refined in California. This is expected to occur an even greater percentage of the time once California gasoline is required to meet the Phase 2 RFG standards, because most out-of-state refineries will not have the capability to produce significant quantities of fully complying gasoline. We are proposing that where gasoline is produced in California, and the producer should reasonably know that the gasoline will be offered for sale at an out-of-state terminal or bulk plant at which it is identified as gasoline produced in California and suitable for sale as a motor vehicle fuel in California, the gasoline will not be treated as imported gasoline. Instead, the California refiner would be responsible for complying with the producer limits when the gasoline is initially shipped from the California refinery.

We believe this approach will provide benefits to both the California refiners and to distributors. When trucking in gasoline from an appropriately labeled Phase 2 RFG rack at an out-of-state terminal, the distributor would not have to meet the importer requirements. The only applicable standard at that time would be the cap limits. At the same time, the California refiner would be better equipped than the downstream distributor to comply with the producer/importer limits, especially if the averaging compliance option is to be used. Such a treatment cannot be applied to out-of-state refiners, because they are not subject to the California refiner requirements.

Apart from this specific proposal, various parties have raised concerns that a substantial price difference between California Phase 2 RFG and out-of-state conventional gasoline could provide an incentive for unscrupulous operators to truck significant quantities of noncomplying gasoline into the state, particularly during the initial transition period. The proposed amendments regarding imported gasoline that originates in California should not result in limiting the oversight applied to imported gasoline, generally. Rather, the amendments should help ARB enforcement personnel to focus on the instances where violations involving imported gasoline are most likely. We request comment on whether additional safeguards such as reporting requirements are necessary to assure that cargo tank truck imports of noncomplying gasoline are deterred.

5. Number of Significant Digits for Aromatic Hydrocarbon Limit

The Phase 2 RFG regulations define the flat, averaging, and cap limits for aromatic hydrocarbons at 25, 22, and 30 volume percent , respectively. We are proposing to redefine the flat, averaging and cap limits for aromatic hydrocarbons to 25.0, 22.0, and 30.0 volume percent, respectively. We are proposing this change to give the producers additional flexibility in meeting an averaging limit using the California predictive model. By adding one significant digit, as proposed, producers would be able to report batches to the tenth of a volume percent. Producers have indicated that having the ability to report batches to the tenth of a percent (i.e., 24.6 instead of 25), will significantly increase the usefulness of the averaging compliance option. Currently, there are test methods that can be used to verify aromatic hydrocarbon content to the tenth of a volume percent.

6. Other Amendments

The amendments include minor changes to the section 2270 provisions on testing and recordkeeping requirements. A provision on the presumed properties of gasoline claimed by the producer, not to be gasoline for use in motor vehicles in California, was moved to assure that the provision was not limited to properties that would be subject to the averaging compliance option. Modifications are also proposed to clarify the requirements for collecting and analyzing representative samples of gasoline.

V.

IMPACTS AND ALTERNATIVES

A. EMISSIONS IMPACTS

Use of the predictive model will allow producers to comply with the Phase 2 RFG requirements by producing gasoline to specifications slightly different from the specifications set forth in the regulations. However, producers must demonstrate that the alternative Phase 2 RFG specifications will result in equivalent or lower emissions compared to Phase 2 RFG specifications. Further, the cap limits must be met for all gasoline formulations, even alternative formulations allowed under the predictive model. Therefore, we do not anticipate any increase in emissions due to use of the predictive model. Our analysis of the emissions impact of the predictive model option is set forth in more detail in Chapter I. C. 3 and Chapter III. D.

Emissions from refineries could decrease due to the use of the predictive model. Gasoline formulations that do not comply with the Phase 2 RFG specifications for a particular property could be found acceptable under the predictive model. To the extent this occurs, emissions from reprocessing the non-complying fuel would be avoided.

We do not anticipate any significant increases in emissions due to the proposed amendments pertaining to implementation of the Phase 2 RFG regulations. Very small increases in emissions may occur during March 1 to June 1, 1995, due to the proposal to extend the cap limit compliance date for terminals by 15 days (from April 1 to April 15), and to extend the cap limit compliance date for bulk plants and service stations by 61 days (from April 1 to June 1). We believe that the emission increases due to the proposed changes will be insignificant since all gasoline leaving refineries and imported into California will have to meet the Phase 2 RFG limits beginning March 1, 1996.

B. OTHER ENVIRONMENTAL IMPACTS

The October 1991 staff report prepared in connection with the adoption of the Phase 2 RFG regulations identified a number of potential environmental impacts apart from emissions from the combustion and evaporation of gasoline. We do not expect that the amendments now being proposed will adversely affect any such impacts, or result in any additional adverse environmental impacts.

C. SOCIOECONOMIC IMPACTS

1. Costs to Businesses

Availability of the predictive model will not increase the compliance costs of producers or gasoline retailers. Since use of the predictive model is optional, no entity would be required to seek approval for an alternative Phase 2 RFG formulation under the predictive model.

The proposed predictive model is expected to lower producers' and gasoline suppliers' costs to comply with the Phase 2 RFG regulations. We assume that producers would seek approval for an alternative Phase 2 RFG formulation if it can be produced at a lower cost than meeting the Phase 2 RFG specifications. By providing an option for alternative Phase 2 RFG formulations, the predictive model should encourage the development of less costly gasoline and lessen the compliance costs and indirect costs of the Phase 2 RFG regulations.

The proposed amendments pertaining to implementation of the Phase 2 RFG regulations should reduce the cost to businesses by providing increased flexibility. Refiners will be allowed to switch more frequently between flat limits and averaging limits. This flexibility will allow refiners to maximize their production capabilities and better address changing conditions. Consequently, the proposed amendments should help to avoid disruption in gasoline supply and thus avoid price increases due to real or perceived fuel shortages.

The proposed amendments may also reduce the cost for terminals, bulk plants and service stations by providing additional time to comply. The proposed amendments will decrease the need to remove non-complying gasoline during the program start-up period.

2. Costs for Compliance

Some investment will be required in order for refineries to develop alternative Phase 2 RFG formulations for the utilization of the predictive model. The cost is not anticipated to be any higher to comply with an alternative gasoline formulation than to comply with the specifications set forth in the Phase 2 RFG regulations. Any investment would be voluntary, and would only be pursued if the producer believed that the cost would be outweighed by the

increase in flexibility and cost savings. If the cost of producing an alternative Phase 2 RFG formulation based on the predictive model is not less than complying with the Phase 2 RFG specifications, producers may not choose to use the model.

The proposed amendments to Phase 2 RFG regulations should reduce the cost of compliance by providing increased flexibility in choosing the most cost-effective compliance option for a particular facility. The extent of any such reduction in the cost to produce Phase 2 RFG will not be known until producers have had an opportunity to fully evaluate the benefits of using the predictive model for their facility.

3. Indirect Costs

Indirect costs may result from the requirements for recordkeeping and/or reporting required by use of the predictive model. However, the costs are not expected to be any higher than that incurred in compliance with the current Phase 2 RFG regulations and should be outweighted by the increased flexibility afforded to producers using the predictive model.

4. Costs to Government

The ARB will be the responsible agency for the monitoring and enforcement of the Phase 2 RFG regulations and the use of the predictive model by gasoline producers and importers. Adoption of the predictive model and the amendments to the Phase 2 RFG regulations are not expected to significantly increase the cost of monitoring or enforcing the Phase 2 RFG regulations.

5. Costs to Consumers

The reduction in cost to consumers due to the adoption of the predictive model and the amendments to the Phase 2 RFG regulations are difficult to predict. Adoption of the predictive model should lower the cost to produce and increase the supply of Phase 2 RFG. The predictive model will provide an opportunity for producers to make alternative Phase 2 RFG formulations at a lower cost than gasoline meeting the Phase 2 RFG specifications. The predictive model allows the producer to develop formulations which best suit the configuration of their refinery. This flexibility should then translate to increased production of gasoline at a lower cost.

D. IMPACTS ON COMPETITIVENESS

1. Intrastate

Beginning March 1, 1996, all gasoline produced in California is subject to the Phase 2 RFG regulations. With the exception of small refiners, all producers must meet the same limits for the eight regulated gasoline properties. Producers have the same opportunity to use the predictive model. The procedures for approval of an alternative Phase 2 RFG

formulation under the predictive model are the same for all producers. The amendments to the Phase 2 RFG regulations apply equally to all producers and distributors. Thus, we do not anticipate that the proposed action will have any impact on intrastate competitiveness for producers or distributors.

We also do not anticipate that there will be any significant impact on intrastate competitiveness for the users of Phase 2 RFG. Any reductions in the cost of gasoline based on increased availability of fuel or decreased production costs should be uniformly distributed to all gasoline users. To the extent that businesses use gasoline versus other fuels, and to the extent that the purchase of gasoline is a major part of expenses, there may be a small, but unquantifiable benefit on the competitiveness of these businesses.

2. Interstate

All gasoline imported for sale in California must meet the Phase 2 RFG regulations. Any producer or importer may use the predictive model for approval of an alternative Phase 2 RFG formulation. Since the requirements are identical for all producers and importers, we do not believe that the proposed regulatory action will provide any advantages with respect to interstate competitiveness. To the extent to which the proposed regulations result in the production of gasoline at a lower cost, California businesses would experience a small but unquantifiable beneficial impact on competitiveness. We do not expect that the proposed regulations will have any adverse impacts on interstate competitiveness of California businesses.

E. IMPACTS ON JOBS

No person is required by law or regulation to attempt to gain approval for an alternative Phase 2 RFG formulation. If a refiner elects not to use the California predictive model, the status quo is maintained and there is no increase or decrease in jobs based on the proposed regulatory action. If a producer elects to use the California predictive model, they would presumely do so because they believe that an alternative Phase 2 RFG formulation would reduce the cost of producing Phase 2 RFG and may convince them to stay in the California market.

To the extent that using the California predictive model and the amendments to the Phase 2 RFG provide cost savings to producers, this should provide a small but unquantifiable positive impact on jobs.

F. ALTERNATIVES

Prior to selecting the California predictive model, we evaluated several alternatives. These alternatives are the United States Environmental Protection Agency (USEPA) complex model, a modified USEPA approach that we refer to as a "Hybrid" model, and the California

predictive model without random balance. Appendix E describes the alternatives in greater detail. Appendix E also discusses the methods we used to evaluate the models and the reasons we rejected the various alternatives.

The USEPA used a different approach to develop its complex model. The approach does not consider the interactions that result from the random errors occurring due to the individual effects of the vehicles. The USEPA complex model also excluded certain terms prior to conducting the statistical analysis (pre-exclusion of terms), included several techniques designed to eliminate outlier data, and used a mathematical technique designed to simplify the model. This later technique is referred to as a random balance. In addition, the USEPA complex model was developed for the emission control technologies used for the 1990 model year vehicles. Finally, it includes separate models for exhaust emissions from normal-emitting and high-emitting vehicles and for evaporative emissions.

The Hybrid model differs from the USEPA complex model in several areas. It uses a different statistical approach than we used to develop the proposed California predictive model. It also uses the California working database (which is somewhat larger than the USEPA database), applies to the same vehicle technology classes as the California predictive model, and uses slightly different initial assumptions relative to pre-excluding various statistical terms from the statistical analysis.

We also evaluated a version of the California predictive model that did not incorporate the random balance. After evaluating the random balance, we found that this was an appropriate and beneficial technique to simplify the model without sacrificing the explanatory power of the model. Therefore, our final proposed California predictive model incorporates random balance.

We found that all of the models fit the data reasonably well. No procedure can guarantee that it will include the "best" choice of variables; thus, there is no "best" model. However, we believe that our approach is the best technical approach because it considers fixed effects due to changes in fuel properties and random effects due to vehicle and vehicle by fuel interactions. In addition, we have included an evaluation of all possible second-order terms in the model and have used the most extensive database available. Therefore, we believe that the California predictive model is likely to yield relationships that are very close to the most satisfactory relationships that can be achieved.

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APPENDIX A

PROPOSED REGULATION ORDER

PROPOSED REGULATION ORDER

Amend Title 13, California Code of Regulations, section 2260, to read as follows:

Section 2260. Definitions

(a) For the purposes of this article, the following definitions apply:

(1) "Alternative gasoline formulation" means a blend of gasoline meeting all of the specifications identified in a certification issued by the Executive Officer pursuant to the "California Test Procedures for Evaluating Alternative Specifications for Gasoline", adopted September 18, 1992, which is incorporated herein by reference.

(2) "Averaging compliance option" means, with respect to a specific gasoline property, the compliance option set forth in section 2262.2(c), section 2262.3(c), section 2262.4(c), section 2262.6(c) or (f), or section 2262.7(c).

~~(2)~~ (3) "ASTM" means the American Society of Testing and Materials.

~~(3)~~ (4) "Bulk purchaser-consumer" means a person that purchases or otherwise obtains gasoline in bulk and then dispenses it into the fuel tanks or motor vehicles owned or operated by the person.

(5) "Bulk plant" means an intermediate gasoline distribution facility where delivery of gasoline to and from the facility is solely by truck.

~~(4)~~ (6) "California gasoline" means:

(A) ~~g~~Gasoline sold, intended for sale, or made available for sale as a motor vehicle fuel in California; and

(B) Gasoline that is produced in California, and that the producer knows or reasonably should know will be offered for sale or supply at an out-of-state terminal or bulk plant at which it will be identified as gasoline produced in California and suitable for sale as a motor vehicle fuel in California.

~~(5)~~ (7) "Designated alternative limit" means an alternative gasoline specification limit, expressed in the nearest part per million by weight for sulfur content, nearest ~~hundreth~~ hundredth percent by volume for

benzene content, nearest tenth percent by volume for aromatic hydrocarbon content, nearest tenth percent for olefin content, and nearest degree Fahrenheit for T90 and T50, which is assigned by a producer or importer to a final blend of California gasoline pursuant to section 2264.

~~(6)~~ (8) "Ethanol" means ethyl alcohol which meets any additional requirements for ethanol or ethyl alcohol in Health and Safety Code section 43830.

~~(7)~~ (9) "Executive Officer" means the executive officer of the Air Resources Board, or his or her designee.

~~(8)~~ (10) "Final blend" means a distinct quantity of gasoline which is introduced into commerce in California without further alteration which would tend to affect a regulated gasoline specification of the fuel.

~~(9)~~ (11) "Final distribution facility" means the stationary gasoline transfer point from which gasoline is transferred into the cargo tank truck, pipeline, or other delivery vessel from which the gasoline will be delivered to the facility at which the gasoline will be dispensed into motor vehicles; except that a cargo tank truck is the final distribution facility where the cargo tank truck is used to transport gasoline and carries written documentation demonstrating that oxygenates, in quantities that will bring the gasoline into compliance with section 2262.5(a) and (c), will be or have been blended directly into the cargo tank truck prior to delivery of the gasoline from the cargo tank truck to the facility at which the gasoline will be dispensed into motor vehicles.

(12) "Flat limit compliance option" means, with respect to a specific gasoline property, the compliance option set forth in section 2262.2(b), section 2262.3(b), section 2262.4(b), section 2262.6(b) or (e), or section 2262.7(b).

~~(10)~~ (13) "Further process" means to perform any activity on gasoline, including distillation, treating with hydrogen, or blending, for the purpose of bringing the gasoline into compliance with the standards in this subarticle.

~~(11)~~ (14) "Gasoline" means any fuel that is commonly or commercially known, sold or represented as gasoline.

(15) "Imported California gasoline" means California gasoline which is transported into California and does not meet the definition in section 2260(a)(6)(B).

~~(12)~~ (16) "Import facility" means the facility at which imported California gasoline is first received in California, including, in the case of gasoline imported by cargo tank and delivered directly to a facility for dispensing gasoline into motor vehicles, the cargo tank in which the gasoline is imported.

~~(13)~~ (17) "Importer" means any person who first accepts delivery in California of imported California gasoline.

~~(14)~~ (18) "Motor vehicle" has the same meaning as defined in section 415 of the Vehicle Code.

~~(15)~~ (19) "Oxygenate" is any oxygen-containing, ashless, organic compound, such as an alcohol or ether, which, when added to gasoline increases the amount of oxygen in gasoline.

(20) "PM alternative gasoline formulation" means a final blend of gasoline that is subject to a set of PM alternative specifications.

(21) "PM alternative specifications" means the specifications for the following gasoline properties, as determined in accordance with section 2263: maximum Reid vapor pressure, expressed in the nearest hundredth of a pound per square inch; maximum sulfur content, expressed in the nearest part per million by weight; maximum benzene content, expressed in the nearest hundredth of a percent by volume; maximum olefin content, expressed in the nearest tenth of a percent by volume; minimum and maximum oxygen content, expressed in the nearest tenth of a percent by weight; maximum T50, expressed in the nearest degree Fahrenheit; maximum T90, expressed in the nearest degree Fahrenheit; and maximum aromatic hydrocarbon content, expressed in the nearest tenth of a percent by volume.

(22) "PM averaging compliance option" means, with reference to a specific gasoline property, the compliance option for PM alternative gasoline formulations under which final blends of gasoline are assigned designated alternative limits in accordance with section 2264.

(23) "PM averaging limit" means a PM alternative specification that is subject to the PM averaging compliance option.

(24) "PM flat limit" means a PM alternative specification that is subject to the PM flat limit compliance option.

(25) "PM flat limit compliance option" means, with reference to a specific gasoline property, the compliance option under which each gallon of gasoline must meet the specification for the property contained in the PM alternative specifications.

~~(16)~~ (26) (A) "Produce" means, except as otherwise provided in section (a)(16)(B) or (a)(16)(C), to convert liquid compounds which are not gasoline into gasoline. When a person blends volumes of blendstocks which are not gasoline with volumes of gasoline acquired from another person, and the resulting blend is gasoline, the person conducting such blending has produced only the portion of the blend which was not previously gasoline. When a person blends gasoline with other volumes of gasoline, without the addition of blendstocks which are not gasoline, the person does not produce gasoline.

(B) Where a person supplies gasoline to a refiner who agrees in writing to further process the gasoline at the refiner's refinery and to be treated as the producer of the gasoline, the refiner shall be deemed for all purposes under this article to be the producer of the gasoline.

(C) Where a person blends oxygenates into gasoline which has already been supplied from a gasoline production facility or import facility, and does not alter the quality or quantity of the gasoline in any other way, the person does not produce gasoline.

~~(17)~~ (27) "Producer" means any person who owns, leases, operates, controls or supervises a California production facility.

~~(18)~~ (28) "Production facility" means a facility in California at which gasoline is produced. Upon request of a producer, the executive officer may designate, as part of the producer's production facility, a physically separate bulk storage facility which is owned and operated by the producer and which is not used to store or distribute gasoline that is not supplied from the production facility.

~~(19)~~ (29) "Qualifying volume" means, for each small refiner, the volume of gasoline equal to the average of the three highest annual production volumes of motor vehicle gasoline reported for the small

refiner's California refinery(ies) in the period 1987 through 1991, inclusive, to the California Energy Commission as required by the Petroleum Industry Information Reporting Act of 1980 (Public Resources Code Sections 25350 et seq.), deducting the volume of oxygenates in the gasoline.

~~(20)~~ (30) "Refiner" means any person who owns, leases, operates, controls or supervises a refinery.

~~(21)~~ (31) "Refinery" means a facility that produces liquid fuels by distilling petroleum.

~~(22)~~ (32) "Small refiner" means any refiner who owns or operates a refinery in California that:

(A) Has and at all times had since January 1, 1978, a crude oil capacity of not more than 55,000 barrels per stream day;

(B) Has not been at any time since September 1, 1988, owned or controlled by any refiner that at the same time owned or controlled refineries in California with a total combined crude oil capacity of more than 55,000 barrels per stream day; and

(C) Has not been at any time since September 1, 1988, owned or controlled by any refiner that at the same time owned or controlled refineries in the United States with a total combined crude oil capacity of more than 137,500 barrels per stream day.

~~(23)~~ (33) "Stream day" means 24 consecutive hours of actual operation of a refinery.

~~(24)~~ (34) "Supply" means to provide or transfer a product to a physically separate facility, vehicle, or transportation system.

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 40000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend Title 13, California Code of Regulations, section 2261 to read as follows:

Section 2261. Applicability of Standards; Additional Standards

(a) (1) Unless otherwise specifically provided, the standards in sections 2262.1(a), 2262.2(a), 2262.3(a), 2262.4(a), 2262.5(a) and (b), 2262.6(a) and 2262.7(a) shall ~~apply to California gasoline sold or supplied on or after April 1, 1996,~~ and apply: (A) starting April 15, 1996 to all sales, supplies, offers or movements of California gasoline except for transactions directly involving [i] the fueling of motor vehicles at a retail outlet or bulk purchaser-consumer facility, or [ii] the delivery of gasoline from a bulk plant to a retail outlet or bulk purchaser-consumer facility, and (B) starting June 1, 1996 to all sales, supplies, offers or movements of California gasoline, including transactions directly involving the fueling of motor vehicles at a retail outlet or bulk purchaser-consumer facility. ~~the~~ The remaining standards and requirements contained in this subarticle shall apply to all sales, supplies, or offers of California gasoline ~~sold or supplied~~ occurring on or after March 1, 1996.

(2) The standards in sections 2262.1(a), 2262.2(a), 2262.3(a), 2262.4(a), 2262.5(a) and (b), 2262.6(a) and 2262.7(a) shall not apply to transactions directly involving the fueling of motor vehicles at a retail outlet or bulk purchaser-consumer facility, where the person selling, offering, or supplying the gasoline demonstrates as an affirmative defense that the exceedance of the pertinent standard was caused by gasoline delivered to the retail outlet or bulk purchaser-consumer facility prior to April 15, 1996, or delivered to the retail outlet or bulk purchaser-consumer facility directly from a bulk plant prior to June 1, 1996.

(b) California gasoline sold or supplied on or after March 1, 1996, is also subject to section 2253.4 (Lead/Phosphorus in Gasoline), section 2254 (Manganese Additive Content), and section 2257 (Required Additives in Gasoline). California gasoline that is supplied from a small refiner's California refinery prior to March 1, 1998, and that qualifies for treatment under section 2272(a), shall also be subject to section 2250

(Degree of Unsaturation of Gasoline) and section 2252 (Sulfur Content of Gasoline).

(c) The standards contained in this subarticle shall not apply to a sale, offer for sale, or supply of California gasoline to a refiner if: (1) the refiner further processes the gasoline at the refiner's refinery prior to any subsequent sale, offer for sale, or supply of the gasoline, and (2) in the case of standards applicable only to producers or importers, the refiner to whom the gasoline is sold or supplied is the producer of the gasoline pursuant to section 2260(a)(16)(B).

(d) The prohibitions in sections 2262.2(b) and (c), 2262.3(b) and (c), 2262.4(b) and (c), 2262.5(c), 2262.6(b), (c), (e) and (f), and 2262.7(b) and (c) shall not apply to gasoline which a producer or importer demonstrates was neither produced nor imported by the producer or importer.

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Title 13, California Code of Regulations, section 2262.1 reads as follows (no amendments are being proposed):

Section 2262.1. Standards for Reid Vapor Pressure

(a) Basic Regulatory Standard.

(1) No person shall sell, offer for sale, supply, offer for supply, or transport California gasoline which has a Reid vapor pressure exceeding 7.00 pounds per square inch within each of the air basins during the regulatory period set forth in section (a)(2).

(2) Basic Regulatory Control Periods.

(A) April 1 through October 31:

South Coast Air Basin and Ventura County

San Diego Air Basin

Southeast Desert Air Basin

(B) May 1 through September 30:
Great Basin Valley Air Basin

(C) May 1 through October 31:
San Francisco Bay Area Air Basin
San Joaquin Valley Air Basin
Sacramento Valley Air Basin
Mountain Counties Air Basin
Lake Tahoe Air Basin

(D) June 1 through September 30:
North Coast Air Basin
Lake County Air Basin
Northeast Plateau Air Basin

(E) June 1 through October 31:
North Central Coast Air Basin
South Central Coast Air Basin (Excluding Ventura County)

(b) Additional Regulatory Standards for Gasoline Sold, Supplied or Transferred from a Production or Import Facility.

(1) California gasoline sold, offered for sale, supplied or offered for supply by a producer or importer from its production facility or import facility in an air basin during the regulatory period specified in section (b)(2) shall have a Reid vapor pressure not exceeding 7.00 pounds per square inch. California gasoline transported directly from a production facility or import facility in an air basin during the regulatory period set forth in section (b)(2) shall have a Reid vapor pressure not exceeding 7.00 pounds per square inch.

(2) Additional Regulatory Control Periods.

(A) March 1 through March 31:
South Coast Air Basin and Ventura County
San Diego Air Basin
Southeast Desert Air Basin

(B) April 1 through April 30:
San Francisco Bay Area Air Basin
San Joaquin Valley Air Basin
Sacramento Valley Air Basin

Great Basin Valley Air Basin
Mountain Counties Air Basin
Lake Tahoe Air Basin

(C) May 1 through May 31:
North Central Coast Air Basin
South Central Coast Air Basin (Excluding Ventura County)
North Coast Air Basin
Lake County Air Basin
Northeast Plateau Air Basin

(c) Applicability

(1) Section (a) shall not apply to a transaction occurring in an air basin during the basic regulatory control period where the person selling, supplying, or offering the gasoline demonstrates as an affirmative defense that, prior to the transaction, he or she has taken reasonably prudent precautions to assure that the gasoline will be delivered to a retail service station or bulk purchaser-consumer's fueling facility when the station or facility is not subject to a basic regulatory control period.

(2) Section (b) shall not apply to a transaction occurring in an air basin during the additional regulatory control period for producers and importers where the person selling, supplying, offering or transporting the gasoline demonstrates as an affirmative defense that, prior to the transaction, he or she has taken reasonably prudent precautions to assure that the gasoline will be delivered to a retail service station or bulk purchaser-consumer's fueling facility located in an air basin not then subject to the basic regulatory control period or the additional control period for producers and importers.

(3) Section (a)(1) shall not apply to a transaction occurring in an air basin during the basic regulatory control period where the transaction involves the transfer of gasoline from a stationary storage tank to a motor vehicle fuel tank and the person selling, supplying, or offering the gasoline demonstrates as an affirmative defense that the last delivery of gasoline to the stationary storage tank occurred more than fourteen days before the start of the basic regulatory control period.

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend Title 13, California Code of Regulations, section 2262.2 to read as follows:

Section 2262.2. Standards for Sulfur Content

(a) **Maximum sulfur standard for all California gasoline.** No person shall sell, offer for sale, supply, offer for supply, or transport California gasoline which has a sulfur content exceeding 80 parts per million by weight.

(b) **Additional flat sulfur standard for producers and importers.** No producer or importer shall sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has a sulfur content exceeding 40 parts per million by weight, unless the transaction occurs during a period for which the producer or importer has elected to be subject to section (c), or unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c).

(c) **~~"Designated alternative limit"~~ option Sulfur averaging compliance option for producers and importers.** No producer or importer shall, during a period for which the producer or importer has elected to be subject to this section (c), sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has a sulfur content exceeding 30 parts per million by weight, unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c), or unless:

(1) A designated alternative limit for sulfur content has been established for the gasoline in accordance with the requirements of section 2264(a), and

(2) The sulfur content of the gasoline does not exceed the designated alternative limit, and

(3) Where the designated alternative limit exceeds 30 parts per million, the excess sulfur content is fully offset in accordance with section 2264(c).

~~(d) Election of sulfur content standard by producers and importers. On or before November 1, 1995, each producer or importer shall notify the executive officer of the party's election to be subject to section (b) or to section (c). All elections shall apply for a minimum of one calendar year and shall be effective in calendar year increments until changed by the producer or importer. A producer or importer may change or make an election for any calendar year after 1996 only by notifying the executive officer no later than October 1 of the preceding calendar year.~~

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend Title 13, California Code of Regulations, section 2262.3 to read as follows:

Section 2262.3. Standards for Benzene Content

(a) **Maximum benzene standard for all California gasoline.** No person shall sell, offer for sale, supply, offer for supply, or transport California gasoline which has a benzene content exceeding 1.20 percent by volume.

(b) **Additional flat benzene standard for producers and importers.** No producer or importer shall sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline

which has a benzene content exceeding 1.00 percent by volume, unless the transaction occurs during a period for which the producer or importer has elected to be subject to section (c), or unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c).

(c) ~~"Designated alternative limit" option~~ Benzene averaging compliance option for producers and importers. No producer or importer shall, during a period for which the producer or importer has elected to be subject to this section (c), sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has a benzene content exceeding 0.80 percent by volume, unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c), or unless:

(1) A designated alternative limit for benzene content has been established for the gasoline in accordance with the requirements of section 2264(a), and

(2) The benzene content of the gasoline does not exceed the designated alternative limit, and

(3) Where the designated alternative limit exceeds 0.80 percent by volume, the excess benzene content is fully offset in accordance with section 2264(d).

~~(d) Election of benzene content standard by producers and importers. On or before November 1, 1995, each producer or importer shall notify the executive officer of the party's election to be subject to section (b) or to section (c). All elections shall apply for a minimum of one calendar year and shall be effective in calendar year increments until changed by the producer or importer. A producer of importer may change or make an election for any calendar year after 1996 only by notifying the executive officer no later than October 1 of the preceding calendar year.~~

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515,

39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend Title 13, California Code of Regulations, section 2262.4 to read as follows:

Section 2262.4. Standards for Olefin Content

(a) **Maximum olefin standard for all California gasoline.** No person shall sell, offer for sale, supply, offer for supply, or transport California gasoline which has an olefin content exceeding 10.0 percent by volume.

(b) **Additional flat olefin standard for producers and importers.** No producer or importer shall sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has an olefin content exceeding 6.0 percent by volume, unless the transaction occurs during a period for which the producer or importer has elected to be subject to section (c), or unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c).

(c) ~~"Designated alternative limit" option~~ Olefin averaging compliance option **for producers and importers.** No producer or importer shall, during a period for which the producer or importer has elected to be subject to this section (c), sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has an olefin content exceeding 4.0 percent by volume, unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c), or unless:

(1) A designated alternative limit for olefin content has been established for the gasoline in accordance with the requirements of section 2264(a), and

(2) The olefin content of the gasoline does not exceed the designated alternative limit, and

(3) Where the designated alternative limit exceeds 4.0 percent by volume, the excess olefin content is fully offset in accordance with section 2264(e).

~~(d) Election of sulfur content standard by producers and importers. On or before November 1, 1995, each producer or importer shall notify the executive officer of the party's election to be subject to section (b) or to section (c). All elections shall apply for a minimum of one calendar year and shall be effective in calendar year increments until changed by the producer or importer. A producer or importer may change or make an election for any calendar year after 1996 only by notifying the executive officer no later than October 1 of the preceding calendar year.~~

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend Title 13, California Code of Regulations, section 2262.5 to read as follows:

Section 2262.5. Standards for Oxygen Content

(a) **Minimum wintertime oxygen content standard for all California gasoline.** (1) Within each of the air basins during the regulatory control period set forth in section (a)(2), no person shall sell, offer for sale, supply, offer for supply, or transport California gasoline unless it has an oxygen content of not less than 1.8 percent by weight.

(2) **Regulatory Control Periods.**

(A) October 1 through February 29
South Coast Air Basin and Ventura County

(B) October 1 through January 31
Sacramento Valley Air Basin

San Joaquin Valley Air Basin
San Francisco Bay Area Air Basin
Lake Tahoe Air Basin
Great Basin Valley Air Basin
Mountain Counties Air Basin
North Coast Air Basin
Lake County Air Basin
Northeast Plateau Air Basin
North Central Coast Air Basin

(C) November 1 through February 29
San Diego Air Basin
South Central Coast Air Basin (Excluding Ventura County)
Southeast Desert Air Basin

(b) **Maximum oxygen content standard for all California gasoline.** No person shall sell, offer for sale, supply, or transport California gasoline which has an oxygen content exceeding 2.7 percent by weight.

(c) **Additional oxygen content standards for producers and importers.** No producer or importer shall sell, offer for sale, supply, or offer for supply from its production or import facility California gasoline which has an oxygen content less than 1.8 percent by weight or more than 2.2 percent by weight, unless the gasoline has been reported as as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c), and complies with the standards contained in sections (a) and (b).

(d) **Restrictions on adding oxygenates to gasoline produced or imported by others.** No person may add oxygenates to California gasoline produced or imported by another person where the resulting oxygenated gasoline blend has an oxygen content exceeding 2.2 percent by weight, except where the person adding the oxygenates demonstrates that: (i) the gasoline to which the oxygenates are added has been reported pursuant to section 2266(c) as an alternative gasoline formulation and has not been commingled with other gasoline, and (ii) the person adding the oxygenates is doing so at the express request of the producer or importer of the gasoline, and (iii) the resulting oxygenated gasoline blend has an oxygen content not more than the

maximum oxygen content specification in the certification for the reported alternative gasoline formulation.

(e) **Application of prohibitions.**

(1) Sections (a) and (c) shall not apply to transactions involving gasoline not meeting the minimum oxygen content standard where the person selling, supplying, or offering the gasoline demonstrates by affirmative defense that: [i] the gasoline has not yet been supplied from the final distribution facility, and [ii] the documents accompanying such gasoline clearly state that it does not comply with the minimum oxygen content standard in sections (a) and (c), and either [iii] the person has taken reasonably prudent precautions to assure that he or she will bring the gasoline within the standards in sections (a) and (c) before it is supplied from the final distribution facility, or [iv] at or before the time of the transaction the person has obtained a written statement from the purchaser, recipient, or offeree of the gasoline stating that he or she will take reasonably prudent precautions to assure that the gasoline is brought within the standards of section (a) and (c) before it is supplied from the final distribution facility.

(2) Section (a) shall not apply to a transaction occurring in an air basin during the regulatory control period where the person selling, supplying, or offering the gasoline demonstrates as an affirmative defense that, prior to the transaction, he or she has taken reasonably prudent precautions to assure that the gasoline will be delivered to a retail service station or bulk purchaser-consumer's fueling facility when the station or facility is not subject to a regulatory control period.

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend Title 13, California Code of Regulations, section 2262.6 to read as follows:

Section 2262.6. Standards for Distillation Temperatures

(a) **Maximum distillation temperature standards for all California gasoline.** No person shall sell, offer for sale, supply, offer for supply, or transport California gasoline which has a T90 (90 percent distillation temperature) exceeding 330 degrees Fahrenheit, or which has a T50 (50 percent distillation temperature) exceeding 220 degrees Fahrenheit.

(b) **Additional flat T90 distillation temperature standards for producers and importers.** No producer or importer shall sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has a T90 (90 percent distillation temperature) exceeding 300 degrees Fahrenheit, unless the transaction occurs during a period for which the producer or importer has elected to be subject to section (c), or unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c).

(c) **T90 ~~"Designated alternative limit"~~ option averaging compliance option for producers and importers.** No producer or importer shall, during a period for which the producer or importer has elected to be subject to this section (c), sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has a T90 exceeding 290 degrees Fahrenheit, unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c), or unless:

(1) A designated alternative limit for T90, not exceeding 310 degrees Fahrenheit, has been established for the gasoline in accordance with the requirements of section 2264(a), and

(2) The T90 of the gasoline does not exceed the designated alternative limit, and

(3) Where the designated alternative limit exceeds 290 degrees Fahrenheit, the exceedance is fully offset in accordance with section 2264(f).

~~(d) Election of T90 distillation temperature standard by producers and importers. On or before November 1, 1995, each producer or importer shall notify the executive officer of the party's election to be subject to section (b) or to section (c). All elections shall apply for a minimum of one calendar year and shall be effective in calendar year increments until changed by the producer or importer. A producer or importer may change or make an election for any calendar year after 1996 only by notifying the executive officer no later than October 1 of the preceding calendar year.~~

~~(e)~~ (d) **Additional flat T50 distillation temperature standard for producers and importers.** No producer or importer shall sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has a T50 (50 percent distillation temperature) exceeding 210 degrees Fahrenheit, unless the transaction occurs during a period for which the producer or importer has elected to be subject to section (f), or unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c).

~~(f)~~ (e) **T50 ~~"Designated alternative limit"~~ option averaging compliance option for producers and importers.** No producer or importer shall, during a period for which the producer or importer has elected to be subject to this section (f), sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has a T50 exceeding 200 degrees Fahrenheit, unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c), or unless:

(1) A designated alternative limit for T50 has been established for the gasoline in accordance with the requirements of section 2264(a), and

(2) The T50 of the gasoline does not exceed the designated alternative limit, and

(3) Where the designated alternative limit exceeds 200 degrees Fahrenheit, the exceedance is fully offset in accordance with section 2264(g).

~~(g) Election of T50 distillation temperature standard by producers and importers.~~ ~~On or before November 1, 1995, each producer or importer shall notify the executive officer of the party's election to be subject to section (e) or to section (f). All elections shall apply for a minimum of one calendar year and shall be effective in calendar year increments until changed by the producer or importer. A producer or importer may change or make an election for any calendar year after 1996 only by notifying the executive officer no later than October 1 of the preceding calendar year.~~

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend Title 13, California Code of Regulations, section 2262.7 to read as follows:

Section 2262.7. Standards for Aromatic Hydrocarbon Content

(a) **Maximum aromatic hydrocarbon standard for all California gasoline.** No person shall sell, offer for sale, supply, offer for supply, or transport California gasoline which has a aromatic hydrocarbon content exceeding 30.0 percent by volume.

(b) **Additional flat aromatic hydrocarbon standard for producers and importers.** No producer or importer shall sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has a aromatic hydrocarbon content exceeding 25.0 percent by volume, unless the transaction occurs during a period for which the producer or importer has elected to be subject to section (c), or unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c).

(c) **~~"Designated alternative limit"~~ option** Aromatic hydrocarbon averaging compliance option **for producers and importers.** No producer or

importer shall, during a period for which the producer or importer has elected to be subject to this section (c), sell, offer for sale, supply, or offer for supply from its production facility or import facility California gasoline which has a aromatic hydrocarbon content exceeding 22.0 percent by volume, unless the gasoline has been reported as a PM alternative gasoline formulation pursuant to section 2265(a) or as an alternative gasoline formulation pursuant to section 2266(c), or unless:

(1) A designated alternative limit for aromatic hydrocarbon content has been established for the gasoline in accordance with the requirements of section 2264(a), and

(2) The aromatic hydrocarbon content of the gasoline does not exceed the designated alternative limit, and

(3) Where the designated alternative limit exceeds 22.0 percent by volume, the excess aromatic hydrocarbon content is fully offset in accordance with section 2264(h).

~~(d) Election of aromatic hydrocarbon content standard by producers and importers. On or before November 1, 1995, each producer or importer shall notify the executive officer of the party's election to be subject to section (b) or to section (c). All elections shall apply for a minimum of one calendar year and shall be effective in calendar year increments until changed by the producer or importer. A producer or importer may change or make an election for any calendar year after 1996 only by notifying the executive officer no later than October 1 of the preceding calendar year.~~

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

No amendments are proposed to Title 13, California Code of Regulations, section 2263 (Sampling Procedures and Test Methods).

Amend Title 13, California Code of Regulations, section 2264 to read as follows:

Section 2264. Designated Alternative Limits

(a) Assignment of a designated alternative limit.

(1) A producer or importer that has elected to be subject to sections 2262.2(c), 2262.3(c), 2262.4(c), 2262.6(c), 2262.6(f), or 2262.7(c) may assign a designated alternative limit to a final blend of California gasoline produced or imported by the producer or importer by satisfying the notification requirements in this section (a). In no case shall a designated alternative limit be less than the sulfur, benzene, olefin or aromatic hydrocarbon content, or T90 or T50, of the final blend shown by the sample and test conducted pursuant to section 2270. If a producer or importer intends to assign designated alternative limits for more than one gasoline specification to a given quantity of gasoline, the party shall identify the same final blend for all designated alternative limits for the gasoline.

(2) (A) The producer or importer shall notify the executive officer of the estimated volume (in gallons), the designated alternative limit, the blend identity, and the location of each final blend receiving a designated alternative limit. This notification shall be received by the executive officer before the start of physical transfer of the gasoline from the production or import facility, and in no case less than 12 hours before the producer or importer either completes physical transfer or commingles the final blend. A producer or importer may revise the reported estimated volume, as long as notification of the revised volume is received by the executive officer no later than 48 hours after completion of the physical transfer of the final blend from the production or import facility. If notification of the revised volume is not timely received by the executive officer, the reported estimated volume shall be deemed the reported actual volume.

(B) For each final blend receiving a designated alternative limit exceeding 0.80 percent by volume benzene content, 30 parts per million by weight sulfur content, 4.0 percent by volume olefin content, 22.0 percent

by volume aromatic hydrocarbon content, T90 of 290 degrees Fahrenheit, or T50 of 200 degrees Fahrenheit, the producer or importer shall notify the executive officer of the date and time of the start of physical transfer from the production or import facility, within 24 hours after the start of such physical transfer. For each final blend receiving a designated alternative limit less than 0.80 percent by volume benzene content, 30 parts per million by weight sulfur content, 4.0 percent by volume olefin content, 22.0 percent by volume aromatic hydrocarbon content, T90 of 290 degrees Fahrenheit, or T50 of 200 degrees Fahrenheit, the producer or importer shall notify the executive officer of the date and time of the completion of physical transfer from the production or import facility, within 24 hours after the completion of such physical transfer.

(3) If, through no intentional or negligent conduct, a producer or importer cannot report within the time period specified in (2) above, the producer or importer may notify the executive officer of the required data as soon as reasonably possible and may provide a written explanation of the cause of the delay in reporting. If, based on the written explanation and the surrounding circumstances, the executive officer determines that the conditions of this section (a)(3) have been met, timely notification shall be deemed to have occurred.

(4) The executive officer may enter into a written protocol with any individual producer or importer for the purposes of specifying how the requirements in section (a)(2) shall be applied to the producer's or importer's particular operations, as long as the executive officer reasonably determines that application of the regulatory requirements under the protocol is not less stringent or enforceable than application of the express terms of section (a)(2). Any such protocol shall include the producer's or importer's agreement to be bound by the terms of the protocol.

(5) Whenever the final blend of a producer or importer includes volumes of gasoline the party has produced or imported and volumes the party has neither produced nor imported, the producer's or importer's designated alternative limit shall be assigned and applied only to the volume of gasoline the party has produced or imported. In such a case, the

producer or importer shall report to the executive officer in accordance with section (a) both the volume of gasoline produced and imported by the party, and the total volume of the final blend. The party shall also additionally report the sulfur content, benzene content, olefin content, aromatic hydrocarbon content, T90, and T50, as applicable, of the portion of the final blend neither produced nor imported by the party, determined as set forth in section 2270(b).

(b) **Additional prohibitions regarding gasoline to which a designated alternative limit has been assigned.**

(1) No producer or importer shall sell, offer for sale, or supply California gasoline in a final blend to which the producer or importer has assigned a designated alternative limit exceeding 0.80 percent by volume benzene content, 30 parts per million by weight sulfur content, 4.0 percent by volume olefin content, 22.0 percent by volume aromatic hydrocarbon content, T90 of 290 degrees Fahrenheit, or T50 of 200 degrees Fahrenheit, where the total volume of the final blend sold, offered for sale, or supplied exceeds the volume reported to the executive officer pursuant to section (a).

(2) No producer or importer shall sell, offer for sale or supply California gasoline in a final blend to which the producer or importer has assigned a designated alternative limit less than 0.80 percent by volume benzene content, 30 parts per million by weight sulfur content, 4.0 percent by volume olefin content, 22.0 percent by volume aromatic hydrocarbon content, T90 of 290 degrees Fahrenheit, or T50 of 200 degrees Fahrenheit, where the total volume of the final blend sold, offered for sale, or supplied is less than the volume reported to the executive officer pursuant to section (a).

(c) **Offsetting excess sulfur.** Within 90 days before or after the start of physical transfer from a production or import facility of any final blend of California gasoline to which a producer has assigned a designated alternative limit for sulfur content exceeding 30 parts per million, the producer or importer shall complete physical transfer from the same production or import facility of California gasoline in sufficient quantity and with a designated alternative limit sufficiently below 30

parts per million to offset the mass of sulfur in excess of a limit of 30 parts per million.

(d) **Offsetting excess benzene.** Within 90 days before or after the start of physical transfer from a production or import facility of any final blend of California gasoline to which a producer has assigned a designated alternative limit for benzene content exceeding 0.80 percent by volume, the producer or importer shall complete physical transfer from the same production or import facility of California gasoline in sufficient quantity and with a designated alternative limit sufficiently below 0.80 percent by volume to offset the volume of benzene in excess of a limit of 0.80 percent by volume.

(e) **Offsetting excess olefins.** Within 90 days before or after the start of physical transfer from a production or import facility of any final blend of California gasoline to which a producer has assigned a designated alternative limit for olefin content exceeding 4.0 percent by volume, the producer or importer shall complete physical transfer from the same production or import facility of California gasoline in sufficient quantity and with a designated alternative limit sufficiently below 4.0 percent by volume to offset the volume of olefins in excess of a limit of 4.0 percent by volume.

(f) **Offsetting T90.** Within 90 days before or after the start of physical transfer from a production or import facility of any final blend of California gasoline to which a producer has assigned a designated alternative limit for T90 exceeding 290 degrees Fahrenheit, the producer or importer shall complete physical transfer from the same production or import facility of California gasoline in sufficient quantity and with a designated alternative limit sufficiently below 290 degrees Fahrenheit to offset the extent to which the gasoline exceeded a T90 of 290 degrees Fahrenheit .

(g) **Offsetting T50.** Within 90 days before or after the start of physical transfer from a production or import facility of any final blend of California gasoline to which a producer has assigned a designated alternative limit for T50 exceeding 200 degrees Fahrenheit, the producer or importer shall complete physical transfer from the same production or

import facility of California gasoline in sufficient quantity and with a designated alternative limit sufficiently below 200 degrees Fahrenheit to offset the extent to which the gasoline exceeded a T50 of 200 degrees Fahrenheit .

(h) **Offsetting excess aromatic hydrocarbons.** Within 90 days before or after the start of physical transfer from a production or import facility of any final blend of California gasoline to which a producer has assigned a designated alternative limit for aromatic hydrocarbon content exceeding 22.0 percent by volume, the producer or importer shall complete physical transfer from the same production or import facility of California gasoline in sufficient quantity and with a designated alternative limit sufficiently below 22.0 percent by volume to offset the volume of aromatic hydrocarbons in excess of a limit of 22.0 percent.

(i) **Designated alternative limits for PM alternative gasoline formulations.**

The producer or importer of a final blend of California gasoline that is subject to the PM averaging compliance option for one or more properties may assign a designated alternative limit to the final blend by satisfying the notification requirements of section 2264(a). The producer or importer of such a final blend shall be subject to all of the provisions of this section 2264, except that, with respect to that final blend:

(A) The PM averaging limit (if any) for benzene content shall replace any reference in this section 2264 to 0.80 percent by volume benzene content;

(B) The PM averaging limit (if any) for olefin content shall replace any reference in this section 2264 to 4.0 percent by volume olefin content;

(C) The PM averaging limit (if any) for sulfur content shall replace any reference in this section 2264 to 30 parts per million by weight sulfur content;

(D) The PM averaging limit (if any) for aromatic hydrocarbon content shall replace any reference in this section 2264 to 22.0 percent by volume aromatic hydrocarbon content;

(E) The PM averaging limit (if any) for T90 shall replace any reference in this section 2264 to T90 of 290 degrees Fahrenheit; and

(F) The PM averaging limit for T50 (if any) shall replace any reference in this section 2264 to T50 of 200 degrees Fahrenheit.

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Adopt Title 13, California Code of Regulations, section 2264.2 to read as follows:

Section 2264.2. Election of Applicable Limit for Gasoline Supplied From a Production or Import Facility

(a) Election of the averaging compliance option.

(1) A producer or importer selling or supplying a final blend of gasoline from its production or import facility may elect pursuant to this section 2264.2 to have the final blend subject to the averaging compliance option for one or more of the following properties: sulfur, benzene, olefins or aromatic hydrocarbon content, T90 or T50. Once a producer or importer has made such an election for a gasoline property, all final blends subsequently sold or supplied from the production or import facility shall be subject to the averaging compliance option for that property until the producer or importer either (A) elects in accordance with section 2264.2(b) to have a final blend at the facility subject to the flat limit compliance option for that property, or (B) elects in accordance with section 2265(a) to sell or supply a final blend at the facility as a PM alternative gasoline formulation, or (C) elects in accordance with section 2266(c) to sell or supply a final blend at the facility as an alternative gasoline formulation.

(2) In order to elect to have a final blend subject to the averaging option for a gasoline property, the producer or importer shall notify the executive officer of such election and of the information identified in

section 2264(a)(2)(A), within the time limits set forth in section 2264(a)(2)(A).

(b) **Election of flat limit compliance option.**

(1) A producer or importer selling or supplying from its production or import facility gasoline subject to the averaging compliance option for a property may elect to have a final blend subject to the flat limit compliance option in accordance with this section 2264.2(c). No such election may be made if there are outstanding requirements to provide offsets for the gasoline property at the facility pursuant to the applicable provision in section 2264(c), (d), (e), (f), (g), or (h).

(2) In order to elect to have a final blend subject to the flat limit compliance option for a gasoline property, the producer or importer shall notify the executive officer of such election and of the blend identity and the location of the final blend, within the time limits set forth in section 2264(a)(2)(A).

(3) Once a producer or importer has made an election under this section 2264.2(b) with respect to a gasoline property, all final blends subsequently sold or supplied from the production or import facility shall be subject to the flat limit compliance option for that property until the producer or importer either (A) elects in accordance with section 2264.2(a) to have a final blend at the facility subject to the averaging compliance option for that property, or (B) elects in accordance with section 2265(a) to sell or supply a final blend at the facility as a PM alternative gasoline formulation, or (C) elects in accordance with section 2266(c) to sell or supply a final blend at the facility as an alternative gasoline formulation.

(4) Once a producer or importer has made an election under this section 2264.2(b) with respect to a gasoline property of a final blend at a production or import facility, the producer or importer may not use any previously assigned designated alternative limit for that property to provide offsets pursuant to the applicable provision in section 2264(c), (d), (e), (f), (g), or (h) for any final blend sold or supplied from the production or import facility subsequently to the election.

(c) Inapplicability to elections for PM alternative gasoline formulations.

Any election for a final blend to be subject to a PM averaging compliance option or a PM flat limit compliance option shall be made in accordance with section 2265 rather than this section 2264.2.

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Adopt Title 13, California Code of Regulations, section 2265, to read as follows:

Section 2265. Gasoline Subject to PM Alternative Specifications Based on the California Predictive Model

(a) Election to sell or supply a final blend as a PM alternative gasoline formulation.

(1) In order to sell or supply from its production facility or import facility a final blend of California gasoline as a PM alternative gasoline formulation subject to PM alternative specifications, a producer or importer shall satisfy the requirements of this section (a).

(2) The producer or importer shall evaluate the candidate PM alternative specifications in accordance with the Air Resources Board's "California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model," as adopted [Insert date of adoption], which is incorporated herein by reference (hereafter the "Predictive Model Procedures"). If the PM alternative specifications meet the criteria for approval in the Predictive Model Procedures, the producer shall notify the executive officer of: (A) The identity, location, and estimated volume of the final blend; (B) the PM alternative specifications that will apply to the final blend, including for each specification whether it applies as a PM flat limit or a PM

averaging limit; and (C) the numerical values for percent change in emissions for oxides of nitrogen, hydrocarbons, and potency-weighted toxic air contaminants as determined in accordance with the Predictive Model Procedures. The notification shall be received by the executive officer before the start of physical transfer of the gasoline from the production or import facility, and in no case less than 12 hours before the producer or importer either completes physical transfer or commingles the final blend.

(3) Once a producer or importer has notified the executive officer pursuant to this section 2265(a) that a final blend of California gasoline is being sold or supplied from a production or import facility as a PM alternative gasoline formulation, all final blends of California gasoline subsequently sold or supplied from that production or import facility shall be subject to the same PM alternative specifications until the producer or importer either (A) designates a final blend at that facility as a PM alternative gasoline formulation subject to different PM alternative specifications, (B) elects in accordance with section 2264.2 to have a final blend at that facility subject to flat limit compliance options and/or averaging compliance options, or (C) elects in accordance with section 2266(c) to sell a final blend at that facility as an alternative gasoline formulation.

(b) Prohibited activities regarding PM alternative gasoline formulations.

(1) No producer or importer shall sell, offer for sale, supply, or offer for supply from its production or import facility California gasoline which is reported pursuant to section 2265(a) as a PM alternative gasoline formulation subject to PM alternative specifications if any of the following occur:

(A) The identified PM alternative specifications do not meet the criteria for approval in the Predictive Model Procedures; or

(B) The producer was prohibited by section 2265(c) from electing to sell or supply the gasoline as a PM alternative gasoline formulation; or

(C) The gasoline fails to conform with any PM flat limit in the identified PM alternative specifications; or

(D) With respect to any property for which the producer or importer has identified a PM averaging limit,

(i) the gasoline exceeds the applicable PM average limit, and no designated alternative limit for the property has been established for the gasoline in accordance with section 2264(a); or

(ii) a designated alternative limit for the property has been established for the gasoline in accordance with section 2264(a), and either of the following occur:

[a] The gasoline exceeds the designated alternative limit for the property, or

[b] Where the designated alternative limit for the property exceeds the PM averaging limit, the exceedance is not fully offset in accordance with the applicable provisions in section 2264(c) through (i).

(2) Where a producer or importer has elected to sell or supply a final blend of California gasoline as a PM alternative gasoline formulation in accordance with this section 2265, the final blend shall not be subject to section 2262.2(b) and (c), section 2262.3(b) and (c), section 2262.4(b) and (c), section 2262.5(c), section 2262.6(b), (c), (e), and (f), and section 2262.7(b) and (c).

(c) Restrictions associated with elections to sell or supply final blends as PM alternative gasoline formulations

(1) A producer or importer may not elect to sell or supply from its production or import facility a final blend of California gasoline as a PM alternative gasoline formulation if the producer or importer is subject to any outstanding requirements to provide offsets at the same production or import facility pursuant to any provision in section 2264 (c), (d), (e), (f), (g), or (h).

(2) Once a producer or importer has elected to sell or supply from its production or import facility a final blend of California gasoline as a PM alternative gasoline formulation subject to a PM averaging compliance option for one or more properties, the producer or importer may not elect any other compliance option, including another PM alternative gasoline formulation, if there are outstanding requirements to provide offsets for

such property or properties pursuant to the applicable provisions in section 2264 (c), (d), (e), (f), (g), or (h).

(3) Once a producer or importer has elected to sell or supply from its production or import facility a final blend of California gasoline as a PM alternative gasoline formulation, the producer or importer may not use any previously assigned designated alternative limit for a property to provide offsets pursuant to section 2264 (c), (d), (e), (f), (g), or (h) for any final blend sold or supplied from the production or import facility subsequent to the election.

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

No amendments are proposed to Title 13, California Code of Regulations, section 2266 (Certified Gasoline Formulations Resulting in Equivalent Emissions Reductions Based on Motor Vehicle Emission Testing), section 2267 (Exemptions), section 2268 (Liability of Persons Who Commit Violations Involving Gasoline That Has Not Yet Been Sold or Supplied to a Motor Vehicle), and section 2269 (Submittal of Compliance Plans).

Amend Title 13, California Code of Regulations, section 2270 to read as follows:

Section 2270. Testing and Recordkeeping.

(a) (1) The requirements of this section (a) shall apply to each producer and importer that has elected to be subject to sections 2262.2(c), 2262.3(c), 2262.4(c), 2262.6(c), 2262.6(f), or 2262.7(c), or to a PM averaging limit. The references to sulfur content shall apply to each producer or importer that has elected to be subject to section 2262.2(c), or to a PM averaging limit for sulfur. The references to benzene content shall apply to each producer or importer that has elected to be subject to

section 2262.3(c), or to a PM averaging limit for benzene. The references to olefin content shall apply to each producer or importer that has elected to be subject to section 2262.4(c), or to a PM averaging limit for olefin content. The references to T90 shall apply to each producer or importer that has elected to be subject to section 2262.6(c), or to a PM averaging limit for T90. The references to T50 shall apply to each producer or importer that has elected to be subject to section 2262.6(f), or to a PM averaging limit for T50. The references to aromatic hydrocarbon content shall apply to each producer or importer that has elected to be subject to section 2262.7(c), or to a PM averaging limit for olefin content.

(2) Each producer shall sample and test for the sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90 in each final blend of California gasoline which the producer has produced, ~~in accordance with an applicable test method identified~~ by collecting and analyzing a representative sample of gasoline taken from the final blend, using the methodologies specified in section 2263. If a producer blends gasoline components directly to pipelines, tankships, railway tankcars or trucks and trailers, the loading(s) shall be sampled and tested for the sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90 by the producer or authorized contractor. The producer shall maintain, for two years from the date of each sampling, records showing the sample date, identity of blend sampled, container or other vessel sampled, final blend volume, sulfur, aromatic hydrocarbon olefin and benzene content, T50 and T90. ~~In the event a producer sells, offers for sale, or supplies gasoline which the producer claims is not California gasoline and which has a sulfur, aromatic hydrocarbon, olefin or benzene content, T50 and t90 exceeding the standards specified in sections 2262.2(c), 2262.3(c), 2262.4(c), 2262.6(c), 2262.6(f), and 2262.7(c), such producer shall maintain, for two years from the date of any sale or supply of the gasoline, records demonstrating that the gasoline was not California gasoline when it was sold or supplied by the producer.~~ All gasoline produced by the producer and not tested as California gasoline by the producer pursuant to as required by this section shall be deemed to have a sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90

exceeding the standards specified in sections 2262.2(c), 2262.3(c), 2262.4(c), 2262.6(c), 2262.6(f), and 2262.7(c), or exceeding the comparable PM averaging limits if applicable, unless the producer demonstrates that the gasoline meets those standards and limits.

(3) Each importer shall sample and test for the sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90 in each shipment of California gasoline which the importer has imported by tankship, pipeline, railway tankcars, trucks and trailers, or other means, ~~in accordance with an applicable test method identified~~ by collecting and analyzing a representative sample of the gasoline, using the methodologies specified in section 2263. The importer shall maintain, for two years from the date of each sampling, records showing the sample date, product sampled, container or other vessel sampled, the volume of the shipment, sulfur content, aromatic hydrocarbon, olefin and benzene content, T50 and T90. All gasoline imported by the importer and not tested as California gasoline by the importer ~~pursuant to~~ as required by this section shall be deemed to have a sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90 exceeding the standards specified in sections 2262.2(c), 2262.3(c), 2262.4(c), 2262.6(c), 2262.6(f), and 2262.7(c), or exceeding the comparable PM averaging limit(s) if applicable, unless the importer demonstrates that the gasoline meets those standards and limit(s).

(4) A producer or importer shall provide to the executive officer any records required to be maintained by the producer or importer pursuant to this section within 20 days of a written request from the executive officer if the request is received before expiration of the period during which the records are required to be maintained. Whenever a producer or importer fails to provide records regarding a final blend of California gasoline in accordance with the requirements of this section, the final blend of gasoline shall be presumed to have been sold by the producer or importer in violation of the standards in sections 2262.2(c), 2263.3(c), 2262.4(c), 2262.6(c), 2262.6(f), and 2262.7, or the PM averaging limit(s), to which the producer or importer has elected to be subject.

(5) The executive officer may enter into a protocol with any producer or importer for the purpose of specifying alternative sampling, testing,

recordkeeping, or reporting requirements which shall satisfy the provisions of sections (a)(2) or (a)(3). The executive officer may only enter into such a protocol if s/he reasonably determines that application of the regulatory requirements under the protocol will be consistent with the state board's ability effectively to enforce the provisions of sections 2262.2(c), 2262.3(c), 2262.4(c), 2262.6(c), 2262.6(f), and 2262.7(c), and the PM averaging limit(s). Any such protocol shall include the producer's or importer's agreement to be bound by the terms of the protocol.

(b) (1) For each final blend which is sold or supplied by a producer or importer from the party's production facility or import facility, and which contains volumes of gasoline that party has produced and imported and volumes that the party neither produced nor imported, the producer or importer shall establish, maintain and retain adequately organized records containing the following information:

(A) The volume of gasoline in the final blend that was not produced or imported by the producer or importer, the identity of the persons(s) from whom such gasoline was acquired, the date(s) on which it was acquired, and the invoice representing the acquisition(s).

(B) The sulfur, benzene, aromatic hydrocarbon, olefin and benzene content, T50 and T90 of the volume of gasoline in the final blend that was not produced or imported by the producer or importer, determined either by (A) sampling and testing, by the producer or importer, of the acquired gasoline represented in the final blend, or (B) written results of sampling and test of the gasoline supplied by the person(s) from whom the gasoline was acquired.

(2) A producer or importer subject to this section (b) shall establish such records by the time the final blend triggering the requirements is sold or supplied from the production or import facility, and shall retain such records for two years from such date. During the period of required retention, the producer or importer shall make any of the records available to the executive officer upon request.

(c) In the event a producer or importer sells, offers for sale, or supplies, in California, gasoline which the producer claims is not California gasoline, such gasoline shall be presumed to exceed the

standards that would be applicable pursuant to this subarticle if it was California gasoline. The producer or importer shall maintain, for two years from the date of any sale or supply of such gasoline, records demonstrating that the gasoline was not California gasoline, or that it complied with all of the standards of this subarticle 2, when it was sold or supplied by the producer.

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43016, 43018, and 43101, Health and Safety Code; and Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

No amendments are proposed to Title 13, California Code of Regulations, sections 2271 (Variances) and 2272 (Gasoline Produced by Small Refiners).

APPENDIX B

CALIFORNIA PROCEDURES FOR EVALUATING ALTERNATIVE SPECIFICATIONS FOR PHASE 2 REFORMULATED GASOLINE USING THE CALIFORNIA PREDICTIVE MODEL

State of California
California Environmental Protection Agency
AIR RESOURCES BOARD

California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model

Adopted: [ ]

Note: This is a new document proposed for adoption by the Air Resources Board.

California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model

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I. INTRODUCTION

A. Purpose and Applicability

1. The predictive model prescribed in this document may be used to evaluate gasoline specifications as alternatives to the gasoline specifications set forth in Title 13, California Code of Regulations (13 CCR), sections 2262.1 through 2262.7.

   This procedure:

   - prescribes the range of specifications that may be utilized to select a set of candidate Phase 2 RFG alternative gasoline specifications for evaluation,
   - defines the Phase 2 RFG reference specifications,
   - prescribes the calculations to be used to predict the emissions from the candidate specifications and the reference Phase 2 RFG specifications,
   - prescribes the calculations to be used to compare the emissions resulting from the candidate specifications to the reference Phase 2 RFG specifications,
   - establishes the requirements for the demonstration and approval of the candidate specifications as an alternative Phase 2 RFG formulation, and
   - establishes the notification requirements.

2. Gasoline properties for which alternative gasoline specifications may be set by this procedure include all eight Phase 2 RFG properties, except Reid vapor pressure (RVP).

3. The Phase 2 RFG specifications, established in 13 CCR, sections 2262.1 through 2262.7, are shown in Table 1.

Table 1
Properties and Specifications for Phase 2 Reformulated Gasoline

Fuel Property	Units	Flat Limit	Averaging Limit	Cap Limit
Reid vapor pressure (RVP)	psi, max.	7.00[1]	none	7.00
Sulfur (SUL)	ppmw,	40	30	80
Benzene (BENZ)	vol.%, max.	1.00	0.80	1.20
Aromatic HC (AROM)	vol.%, max.	25.0	22.0	30.0
Olefin (OLEF)	vol.%, max.	6.0	4.0	10
Oxygen (OXY)	wt. %	1.8 (min) 2.2 (max)	none	1.8(min)[2] 2.7(max)
Temperature at 50% distilled (T50)	deg. F,	210	200	220
Temperature at 90% distilled (T90)	deg. F,	300	290	330

[1] Applicable during the summer months identified in 13 CCR, sections 2262.1 (a) and (b).
[2] Applicable during the winter months identified in 13 CCR, section 2262.5 (a) .

4. The pollutant emissions addressed by these procedures and the units of measurement are shown in Table 2.

Table 2
Predictive Model Pollutants and Units of Measurement

Pollutant Emissions	Units
Oxides of Nitrogen (NOx)	gm/mile
Hydrocarbons (HC)	gm/mile
Potency-weighted Toxics (PWT)	mg/mile

B. Synopsis of Procedure

The predictive model is used to compare the exhaust emissions predicted for gasoline meeting the Phase 2 RFG specifications (reference specifications) to the exhaust emissions predicted for gasoline meeting the alternative gasoline specifications (candidate specifications).

The predictive model is made up of several sub-models. The sub-models are equations which relate gasoline specifications for certain properties to the exhaust emissions that result when the gasoline is burned in a motor vehicle. The gasoline properties included in the model are those properties that are regulated by the California Phase 2 RFG regulations (See Table 1).

Twelve separate sub-models have been developed for six pollutants (NOx, HC, benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) and two sub-models, per pollutant, for each vehicle emissions technology "Tech" class (Tech 3 and Tech 4). The predicted emissions for each Tech class are adjusted using Tech class emission-weighting factors for NOx and HC. Toxic emissions (benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) are adjusted using VMT (vehicle miles traveled) weighting factors and a potency weighting factor.

The sub-models are used to predict the emissions from the Phase 2 RFG specifications and the alternative specifications. The emissions are expressed in the units identified in Table 2. If for each pollutant (NOx, HC, and potency-weighted toxics), the percent change in emissions between the candidate specifications and the reference Phase 2 RFG specifications, is equal to or less than 0.04%, then the candidate specifications are deemed acceptable as equivalent to Phase 2 RFG. If the percent change in emissions between the candidate specifications and the reference Phase 2 RFG specifications, is equal to or greater than 0.05%, then the candidate specifications are deemed unacceptable and may not be a substitute for Phase 2 RFG.

C. Definitions

1. **Alternative gasoline formulation** means a final blend of gasoline that is subject to a set of alternative specifications deemed acceptable pursuant to the California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model.

2. **Alternative specifications** means the specifications for the following gasoline properties, as determined in accordance with 13 CCR, section 2263:

   - maximum Reid vapor pressure, expressed in the nearest hundredth of a pound per square inch;
   - maximum sulfur content, expressed in the nearest parts per million by weight;
   - maximum benzene content, expressed in the nearest hundredth of a percent by volume;
   - maximum olefin content, expressed in the nearest tenth of a percent by volume;
   - minimum and maximum oxygen content, expressed in the nearest

tenth of a percent by weight;
- maximum T50, expressed in the nearest degree Fahrenheit;
- maximum T90, expressed in the nearest degree Fahrenheit; and
- maximum aromatic hydrocarbon content, expressed in the nearest tenth of a percent by volume.

3. **Applicant** means the party seeking approval of alternative gasoline specifications and responsible for the demonstration described herein.

4. **Aromatic hydrocarbon content (Aromatic HC, AROM)** means the amount of aromatic hydrocarbons in the fuel expressed to the nearest tenth of a percent by volume in accordance with 13 CCR, section 2263.

5. **ASTM** means the American Society of Testing and Materials.

6. **Averaging Limit** means a limit for a fuel property that must be achieved in accordance with 13 CCR, sections 2264.

7. **Benzene content (BENZ)** means the amount of benzene contained in the fuel expressed to the nearest hundredth of a percent by volume in accordance with 13 CCR, section 2263.

8. **Candidate fuel or candidate specifications** means the fuel or set of specifications which are being evaluated for its emission performance using these procedures.

9. **Cap limit** means a limit that applies to all California gasoline throughout the gasoline distribution system, in accordance with 13 CCR, sections 2262.1 (a), 2262.2 (a), 2262.3 (a), 2262.4 (a), 2262.5 (a) and (b), 2262.6 (a), and 2262.7 (a).

10. **EMFAC/BURDEN 7F** means the motor vehicle emission inventory and emissions calculation system maintained by the ARB.

11. **Executive Officer** means the executive officer of the Air Resources Board, or his or her designee.

12. **Flat limit** means a single limit for a fuel property that applies to all California gasoline sold or supplied from a California production facility or import facility.

13. **Intercept** means the average vehicle effect for a particular Tech class and a particular pollutant. The intercept represents the average emissions across vehicles in the Tech class, for a fuel with properties equal to the average values of all fuels in the data base for that Tech class.

14. **Olefin content (OLEF)** means the amount of olefins in the fuel expressed in the nearest tenth of a percent by volume in accordance with 13 CCR, section 2263.

15. **Oxygen content (OXY)** means the amount of oxygen contained in the fuel expressed in the nearest tenth of a percent by weight in accordance with 13 CCR, section 2263.

16. **Phase 2 reformulated gasoline (Phase 2 RFG)** means gasoline meeting the flat or averaging limits of the Phase 2 RFG regulations.

17. **Potency-weighted toxics (PWT)** means the mass exhaust emissions of benzene, 1,3-butadiene, formaldehyde, and acetaldehyde multiplied by the relative potency with respect to 1,3-butadiene.

18. **Predictive model** means a set of equations that relate the properties of a particular gasoline formulation to the predicted emissions that result when that gasoline is combusted in a motor vehicle engine.

19. **Reference fuel or reference specification** means a gasoline meeting the flat or average specifications of the Phase 2 RFG.

20. **Reid vapor pressure (RVP)** means the vapor pressure of the fuel expressed in the nearest hundredth of a pound per square inch in accordance with 13 CCR, section 2263.

21. **Sulfur content (SUL)** means the amount of sulfur contained in the fuel expressed in the nearest part per million in accordance with 13 CCR, section 2263.

21. **Technology class (Tech 3, Tech 4)** means a classification of vehicles by model year based on what technology is used to control gasoline exhaust emissions.

22. **50% distillation temperature (T50)** means the temperature at which 50% of the fuel evaporates expressed in the nearest degree Fahrenheit in accordance with 13 CCR, section 2263.

23. **90% distillation temperature (T90)** means the temperature at which 90% of the fuel evaporates expressed in the nearest degree Fahrenheit in accordance with 13 CCR, section 2263.

24. **Toxic air contaminants** means exhaust emissions of benzene, 1,3-butadiene, formaldehyde, and acetaldehyde.

II. VEHICLE TECHNOLOGY CLASS AND WEIGHTING FACTORS

A. Vehicle Technology Classes

For the purpose of these procedures, sub-models have been developed for two categories of light-duty vehicles (passenger cars and light-duty trucks) using the vehicle model year as an indicator of the type of emission controls used. Table 3 shows the two vehicle categories.

Table 3
Vehicle Categories

Technology Class	Model Year	Emission Controls
Tech 3	1981-1985	older closed-loop three-way catalyst
Tech 4	1986-1995	closed-loop three-way catalyst

B. Emission-weighting Factors

Emission-weighting factors are used to weight the relative contribution of the model-predicted NOx and HC emissions in each Technology class. These weightings represent the average fractional contribution that vehicles in the particular Tech class make to the total on-road motor vehicle emissions of a particular pollutant from gasoline-fueled light duty vehicles in the years 1996, 2000, and 2005. These values were calculated using the information in EMFAC/BURDEN 7F. The emission-weighting factors (EWF) are shown in Table 4 and are used in the evaluation of NOx and HC emissions.

Table 4
Emission-weighting Factors

Pollutant	Tech 3	Tech 4
NOx	0.174	0.826
HC	0.198	0.802

C. VMT Weighting Factors

Vehicle miles traveled (VMT) weighting factors are used to weight the relative contribution of the model-predicted toxic air contaminant emssions in each technology class. These weightings represent the average fractional contribution to VMT that vehicles in the particular Tech class make to the total VMT from vehicles in all technology classes used in the model. The values were calculated by identifying the

VMT fraction(s) for Tech class 3 and 4 vehicles for 1996, 2000, and 2005, summing these values by Tech class, and calculating the arithmetic average. The VMT data were obtained from EMFAC/BURDEN 7F. The VMT weighting factors (VMTWFs) are shown in Table 5 and are used in the evaluation of toxic air contaminants.

Table 5

Vehicle Miles Traveled Weighting Factors (VMTWFs)

Pollutant	Tech 3	Tech 4
Benzene	0.089	0.911
1,3-Butadiene	0.089	0.911
Formaldehyde	0.089	0.911
Acetaldehyde	0.089	0.911

III. GENERAL EQUATIONS FOR CALCULATING PERCENT CHANGE IN EMISSIONS

A. Summary and Explanation

- The applicant will select a candidate specification for each property, and will identify whether the specification represents a flat limit or an averaging limit. The Phase 2 RFG reference specification is identified, for each property, using the compliance option selected for the corresponding candidate specification. (See III.B.)

- The selected candidate specifications and the comparable Phase 2 RFG reference specifications are inserted into the predictive model equations to determine the predicted candidate and reference emissions by Tech Class. (See III.C.)

- For NOx and HC, the ratio of the predicted emissions for the candidate specifications to the predicted emissions for the reference specifications is emissions weighted according to the relative contribution of each technology class. These emissions-weighted ratios are summed, reduced by 1, and multiplied by 100 to represent the percent change in emissions. The resulting values represent the percent change in NOx or HC emissions between the candidate specifications and reference specifications. (See III.D.)

- For toxic air contaminants, the predicted emissions for the candidate specifications (for each pollutant and each Tech Class) are VMT weighted and potency-weighted. The VMT/potency-weighted sums for the candidate specifications are divided by the VMT/potency-weighted sums for the reference specifications. This ratio is reduced by 1 and then multiplied by 100. The resulting value represents the percent change in potency-weighted toxic emission between the candidate specifications and reference specifications. (See III.D.)

B. Selection by Applicant of Candidate and Reference Specifications

The applicant shall select a candidate specification and for each property shall identify whether the specification represents a flat limit or an averaging limit. The Phase 2 RFG reference specifications are identified using, for each property, the compliance option selected for the corresponding candidate specification. Table 7 provides an optional worksheet to assist the applicant in selecting the candidate and reference specifications.

1. Identify the value of the candidate specifications for each fuel property and insert the values into Table 7. The candidate specifications may have any value for sulfur, benzene, aromatic hydrocarbons, olefins, oxygen, T50, and T90 as long as each specification is less than or equal to the cap limits shown in Table 1. The RVP value for the reference and candidate specifications is always 7.00. The appropriate values for oxygen content are shown in Table 6.

Table 6
Candidate and Reference Specifications for Oxygen

Oxygen Content for Candidate Fuel		Number of Reference vs Candidate Comparisons Required	Values to be Used in Comparison in Equations	
minimum	**maximum**		**Candidate**	**Reference**
≥ 1.8	≤ 2.2	1	2.0	2.0
≥ 1.8, ≤ 2.2	> 2.2	2	minimum	minimum
			maximum	2.0
< 1.8	≥ 1.8, ≤ 2.2	2	minimum	2.0
			maximum	maximum
> 2.2	> 2.2	2	minimum	2.0
			maximum	2.0

2. Identify for each specification for a property other than RVP and oxygen if the compliance option will represent a flat limit or an averaging limit.

3. Identify the reference specifications based on the compliance options selected in step 2. Circle the appropriate flat or average limit for the reference fuel in Table 7. The circled values are the reference specifications which will be used in the predictive model. Write in the appropriate reference specifications for oxygen content based on the information in Table 6.

Example:

If you elect to meet a sulfur limit of 20 for the candidate fuel and elect to comply with a flat limit, the reference fuel sulfur limit would be 40. However, if you elect to meet a sulfur limit of 20 on average, the reference fuel sulfur limit would be 30.

Table 7
Optional Worksheet for Candidate and Reference Fuel Specifications

Fuel Property	Candidate Fuel[1]: Specifications	Compliance Option: Flat or Average	Reference Fuel: Phase 2 RFG Specifications (Circle Option Chosen)	
			Flat	Average
RVP[2]	7.0	Flat	7.0	None
Sulfur			40	30
Benzene			1.00	0.80
Aromatic			25.0	22.0
Olefin			6.0	4.0
Oxygen[3]	(min)	Flat-Range	(min)	None
	(max)		(max)	
T50			210	200
T90			300	290

1 The fuel property value must be less than or equal to the cap limit.

2 The candidate fuel RVP values should be reported as 7.0 even if measured value is below 7.0.

3 If the oxygen content range for the candidate fuel is ≥ 1.8 and ≤ 2.2, the candidate fuel and reference fuel oxygen value used in the predictive model equation is 2.0. For all other cases, see Table 6, Candidate and Reference Specifications for Oxygen.

C. General Equations for Calculating Emissions by Pollutant and by Technology Class

The selected candidate specifications and set reference specifications are inserted into the predictive model equations to determine the predicted pollutant emissions generated from each fuel formulation by Tech Class. The following is the general form of the equations used to calculate emissions of the candidate and reference specifications for each pollutant and for each technology class.

$$ln\ y_{Tech} = \text{intercept} + \Sigma\ [(\text{fuel effects coefficient}) \times (\text{standardized fuel property})]$$

or

$$y_{Tech} = \text{Exp}\ \{\text{intercept} + \Sigma\ [(\text{fuel effects coefficient}) \times (\text{standardized fuel property})]\}$$

where

ln is the natural logarithm.

Exp is the inverse of the natural logarithm.

y_{Tech} is the emission in grams or milligrams per mile of a particular pollutant (NOx, HC, benzene, 1,3-butadiene, formaldehyde, and acetaldehyde) and for a particular technology class. (Note: $y_{Tech\text{-}REF}$ is the emissions for the reference specifications and $y_{Tech\text{-}CAND}$ is the emissions for the candidate specifications.)

intercept represents the average vehicle effect for a particular Tech class and a particular pollutant. The intercepts are provided in Table 11, Coefficients for NOx and HC Equations, and Table 12, Coefficients for Toxics Equations.

fuel effects coefficient represents the average fuel effects across all vehicles in the database for a particular Tech class and a particular pollutant. The fuel effect is provided in Table 11, Coefficients for NOx and HC Equations, and Table 12, Coefficients for Toxics.

standardized fuel property is defined as:

$$\text{standardized fuel property} = \frac{[(\text{actual fuel property}) - (\text{mean fuel value})]}{\text{standard deviation of the value for the fuel property}}$$

actual fuel property represents the candidate or reference fuel property selected by the applicant in Table 7, Worksheet for Candidate and Reference Specifications.

mean fuel value represents the average fuel values from all data that are used in developing the California Predictive Model. The mean and standard deviation are provided in Table 10, Standardization of Fuel Properties-Mean and Standard Deviation.

standard deviation of the value for the fuel property is the standard deviation from all data that are used in developing the California Predictive Model.

D. General Equations for Calculating Percent Change of Emissions Between Candidate and Reference Specifications

The ratio of the predicted emissions for the candidate specifications to the predicted emissions from reference specifications is multiplied by the technology class emission-weighting factors for NOx and HC and by the VMT and potency-weighting factors for the toxic pollutants. These weighted ratios are summed. The sum is reduced by 1 and multiplied by 100 to give the percent change in emission for a particular pollutant. The following is the general form of the equations used to calculate percent change in emissions between the candidate and reference specifications relative to the reference specifications for each pollutant.

% Change in NOx and HC Emissions:

%CE = change in emissions =

$$\left(\left[\frac{y_{TECH\,3\text{-}CAND}}{y_{TECH\,3\text{-}REF}} (EWF_{3q}) \right] + \left[\frac{y_{TECH\,4\text{-}CAND}}{y_{TECH\,4\text{-}REF}} (EWF_{4q}) \right] - 1 \right) 100$$

where

$y_{Tech\,3}$ and $y_{Tech\,4}$ are the pollutant emissions in grams per mile of a particular pollutant and particular Tech class

$y_{Tech\text{-}CAND}$ is the emissions for the candidate specifications
$y_{Tech\text{-}REF}$ is the emissions for the reference specifications

EWF_{3q} and EWF_{4q} are the technology class 3 and technology class 4 weighting factor for the particular pollutant q. The Vehicle Technology Class Weighting Factors are provided in Table 4.

% Change in Potency-weighted Toxic (PWT) Emission:

Step 1. Calculation of VMT and potency-weighted emissions for candidate and reference specifications

$CE_{PWT\text{-}CAND}$ = change in PWT emissions for candidate specifications =

$$\sum\left[\left(\left[(y_{TECH3q\text{-}CAND})\,x\,(VMTWF_3)\right]+\left[(y_{TECH4q\text{-}CAND})\,x\,(VMTWF_4)\right]\right)x\,(PWT_q)\right]$$

$CE_{PWT\text{-}REF}$ = change in PWT emissions for reference specifications =

$$\sum\left[\left(\left[(y_{TECH3q\text{-}REF})\,x\,(VMTWF_3)\right]+\left[(y_{TECH4q\text{-}REF})\,x\,(VMTWF_4)\right]\right)x\,(PWT_q)\right]$$

where

$(y_{Tech\ 3q})$ and $(y_{Tech\ 4q})$ are the emissions in milligrams per mile for each toxic air contaminant for Tech class 3 or 4.

$y_{Tech\text{-}CAND}$ is the emissions for the candidate specifications
$y_{Tech\text{-}REF}$ is the emissions for the reference specifications

$VMTWF_3$ and $VMTWF_4$ are the VMT weighting factors for Tech class 3 and Tech class 4 vehicles, respectively. These values are shown in Table 5.

PWF_q is the potency-weighting factor for each toxic air contaminant q provided in Table 8.

Step 2. Calculation of percent change in potency-weighted toxic (PWT) emissions.

% CE_{PWT} = percent change in the sum of the PWT emissions =

$$\left[\frac{CE_{PWT\text{-}CAND}}{CE_{PWT\text{-}REF}} - 1\right] x\ (100)$$

where

$CE_{PWT\text{-}CAND}$ is the change in the sum of PWT emissions for candidate specifications from Step 1 above.

$CE_{PWT\text{-}REF}$ is the change in the sum of PWT emissions for reference specifications from Step 1 above.

Table 8
Toxic Air Contaminant Potency-weighting Factors

Pollutant	Potency-weighting Factor
Benzene	0.17
1,3-Butadiene	1
Formaldehyde	0.035
Acetaldehyde	0.016

IV. OXIDES OF NITROGEN (NOx) EXHAUST EMISSIONS CALCULATIONS

A. NOx Emissions by Technology Class

The property values from the Table 7 worksheet are used to calculate NOx emissions for the candidate and reference specifications.

1. NOx Emissions for Tech 3

The NOx emissions for the candidate ($y_{\text{Tech 3-CAND}}$) and reference ($y_{\text{Tech 3-REF}}$) specifications for Tech 3 are calculated as follows:

NOx emissions Tech 3 = $y_{\text{Tech 3}}$ =

Description	Equation	
	Exp	
intercept	{-0.15597638	+
RVP	(-0.01671797) $\frac{(\text{RVP} - 8.651419)}{0.580438}$	+
Sulfur	(0.01785987) $\frac{(\text{SULFUR} - 193.574245)}{130.374657}$	+
Aromatic HC	(0.05428291) $\frac{(\text{AROM} - 30.967805)}{9.491877}$	+
Olefin	(0.02292342) $\frac{(\text{OLEF} - 8.34672)}{5.873768}$	+
Oxygen	(0.01439508) $\frac{(\text{OXY} - 0.912512)}{1.249609}$	+
T50	(-0.01161378) $\frac{(\text{T50} - 211.338086)}{17.374327}$	+
T90	(0.00341764) $\frac{(\text{T90} - 315.839826)}{25.694736}$	+
T50T90	(0.00857682) $\frac{(\text{T50} - 211.338086)}{17.374327}$ $\frac{(\text{T90} - 315.839826)}{25.694736}$	+

AROT90	(-0.0097818) (ARO - 30.967805) / 9.491877	(T90 - 315.839826) / 25.694736 }

where

RVP, SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the value limits for the candidate and reference specifications identified in the Table 7 worksheet.

2. NOx Emissions for Tech 4

The NOx emissions for the candidate ($y_{\text{Tech 4-CAND}}$) and reference ($y_{\text{Tech 4-REF}}$) specifications for Tech 4 are calculated as follows:

NOx emissions Tech 4 = $y_{\text{Tech 4}}$ =

Description	Equation	
	Exp	
intercept	{-0.58546115	+
RVP	(0.03005909) (RVP - 8.707348) / 0.52813	+
Sulfur	(0.050086115) (SULFUR - 174.036113) / 137.356549	+
Aromatic HC	(0.004154304) (AROM - 28.604566) / 7.848674	+
Olefin	(0.025949698) (OLEF - 7.001772) / 4.988003	+
Oxygen	(0.011321599) (OXY - 1.266843) / 1.310604	+
T50	(0.00195233) (T50 - 208.186678) / 18.149553	+
T90	(-0.00820391) (T90 - 311.36879) / 22.988439	+

AROOXY (-0.00579379) $\frac{(AROM - 28.604566)}{7.848674}$ $\frac{(OXY - 1.266843)}{1.310604}$ +

RVPOXY (0.006283521) $\frac{(RVP - 8.707348)}{0.52813}$ $\frac{(OXY - 1.266843)}{1.310604}$ +

OXYOXY (0.013486985) $\frac{(OXY - 1.266843)}{1.310604}$ $\frac{(OXY - 1.266843)}{1.310604}$ }

where

RVP, SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the values for the candidate and reference specifications in the Table 7 worksheet.

B. Percent Change in NOx Emissions

The percent change in NOx emissions between the candidate specifications and the reference specifications is calculated as follows:

$$\%CE = \left[\left[\left[\frac{(y_{TECH3\text{-}CAND})}{(y_{TECH3\text{-}REF})} \times EWF_{3\text{-}NOx}\right] + \left[\frac{(y_{TECH4\text{-}CAND})}{(y_{TECH4\text{-}REF})} \times EWF_{4\text{-}NOx}\right]\right] - 1\right] \times 100$$

where

$y_{Tech\ 3\text{-}CAND}$ and $y_{Tech\ 4\text{-}CAND}$ are the NOx emissions for the candidate specifications in grams per mile for Tech 3 and Tech 4, respectively.

$y_{Tech\ 3\text{-}REF}$ and $y_{Tech\ 4\text{-}REF}$ are the NOx emissions for the reference specifications in grams per mile for Tech 3 and Tech 4, respectively.

NOx emissions for Tech 3 are calculated according to the equations in section V. A. 1.

NOx emissions for Tech 4 are calculated according to the equations in section V. A. 2.

$EWF_{3\text{-}NOx}$ and $EWF_{4\text{-}NOx}$ are the emission-weighting factors for NOx as shown in Table 4.

V. HYDROCARBONS (HC) EXHAUST EMISSIONS CALCULATIONS

A. HC Emissions by Technology Class

The property values from the Table 7 worksheet are used to calculate HC emissions for the candidate and reference specifications.

1. HC Emissions for Tech 3

The HC emissions for the candidate ($y_{\text{Tech 3-CAND}}$) and reference ($y_{\text{Tech 3-REF}}$) specifications for Tech 3 are calculated as follows:

HC emissions Tech 3 = $y_{\text{Tech 3}}$ =

Description	Equation	
	Exp	
intercept	{-0.79454695	+
RVP	(0.004470126) (RVP - 8.651419) / 0.580438	+
Sulfur	(0.001933575) (SULFUR - 193.574245) / 130.374657	+
Aromatic HC	(-0.03844685) (AROM - 30.967805) / 9.491877	+
Olefin	(-0.02100516) (OLEF - 8.34672) / 5.873768	+
Oxygen	(-0.02735656) (OXY - 0.912512) / 1.249609	+
T50	(0.010253527) (T50 - 211.338086) / 17.374327	+
T90	(0.017858355) (T90 - 315.839826) / 25.694736	+

RVPT50 $(-0.01626671)\ \frac{(RVP - 8.651419)}{0.580438}\ \frac{(T50 - 211.338086)}{17.374327}$ +

SULARO $(-0.04053717)\ \frac{(SULFUR - 193.574245)}{130.374657}\ \frac{(AROM - 30.967805)}{9.491877}$ +

AROT90 $(0.018225949)\ \frac{(AROM - 30.967805)}{9.491877}\ \frac{(T90 - 315.839826)}{25.694736}$ }

where

RVP, SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the value limits for the candidate and reference specifications identified in the Table 7 worksheet.

2. HC Emissions for Tech 4

The HC emissions for the candidate ($y_{\text{Tech 4-CAND}}$) and reference ($y_{\text{Tech 4-REF}}$) specifications for Tech 4 are calculated as follows:

HC emissions Tech 4 = $y_{\text{Tech 4}}$ =

Description	Equation	
	Exp	
intercept	{-1.18303868	+
RVP	$(-0.00850444)\ \frac{(RVP - 8.707348)}{0.52813}$	+
Sulfur	$(0.116903682)\ \frac{(SULFUR - 174.036113)}{137.356549}$	+
Aromatic HC	$(0.001368326)\ \frac{(AROM - 28.604566)}{7.848674}$	+

Olefin (-0.0068737) $\frac{(OLEF - 7.001772)}{4.988003}$ +

Oxygen (-0.01035001) $\frac{(OXY - 1.266843)}{1.310604}$ +

T50 (0.076436841) $\frac{(T50 - 208.186678)}{18.149553}$ +

T90 (0.038947849) $\frac{(T90 - 311.36879)}{22.988439}$ +

AROARO (-0.01197286) $\frac{(AROM - 28.604566)}{7.848674}$ $\frac{(AROM - 28.604566)}{7.848674}$ +

AROT90 (0.012076013) $\frac{(AROM - 28.604566)}{7.848674}$ $\frac{(T90 - 311.36879)}{22.988439}$ +

OXYT90 (0.015107193) $\frac{(OXY - 1.266843)}{1.310604}$ $\frac{(T90 - 311.36879)}{22.988439}$ +

T50T50 (0.025807977) $\frac{(T50 - 208.186678)}{18.149553}$ $\frac{(T50 - 208.186678)}{18.149553}$ +

T90T90 (0.018209586) $\frac{(T90 - 311.36879)}{22.988439}$ $\frac{(T90 - 311.36879)}{22.988439}$ }

where

RVP, SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the values for the candidate and reference specifications in the Table 7 worksheet.

B. Percent Change in HC Emissions

The percent change in HC emissions between the candidate specifications and the reference specifications is calculated as follows:

$$\%CE = \left[\left[\left[\frac{(y_{TECH\,3\text{-}CAND})}{(y_{TECH\,3\text{-}REF})} \times EWF_{3\text{-}VOC}\right] + \left[\frac{(y_{TECH\,4\text{-}CAND})}{(y_{TECH\,4\text{-}REF})} \times EWF_{4\text{-}VOC}\right]\right] - 1\right] \times 100$$

where

$y_{Tech\ 3\text{-}CAND}$ and $y_{Tech\ 4\text{-}CAND}$ are the HC emissions for the candidate specifications in grams per mile for Tech 3 and Tech 4, respectively.

$y_{Tech\ 3\text{-}REF}$ and $y_{Tech\ 4\text{-}REF}$ are the HC emissions for the reference specifications in grams per mile for Tech 3 and Tech 4, respectively.

HC emissions for Tech 3 are calculated according to the equations in section V. A. 1.

HC emissions for Tech 4 are calculated according to the equations in section V. A. 2.

$EWF_{3\text{-}HC}$ and $EWF_{4\text{-}HC}$ are the emission-weighting factors for HC as shown in Table 4.

VI. POTENCY-WEIGHTED TOXICS (PWT) EXHAUST EMISSIONS CALCULATIONS

A. Mass Emissions of Toxics by Technology Classa

The property values from the Table 7 worksheet are used to calculate mass toxic emissions for the candidate and reference specifications.

1. Mass Emissions for Tech 3

The mass emissions for each toxic for Tech 3 are calculated as follows:

a. Benzene mass emissions Tech 3 = $y_{\text{Tech 3}}$ =

Description	Equation	
	Exp	
intercept	{2.98444988	+
RVP	(0.00012084)(RVP - 8.651419) / 0.580438	+
Sulfur	(0.06702145)(SULFUR - 193.574245) / 130.374657	+
Aromatic HC	(0.11271704) (AROM - 30.967805) / 9.491877	+
Olefin	(0.0262828)(OLEF - 8.34672) / 5.873768	+
Oxygen	(0.00010461)(OXY - 0.912512) / 1.249609	+
T50	(0.07400871)(T50 - 211.338086) / 17.374327	+
T90	(-0.03666419)(T90 - 315.839826) / 25.694736	+

BENZ	$(0.13158634)\left(\frac{BENZ - 1.365963}{0.444768}\right)$	}

b. 1,3-Butadiene mass emissions Tech 3 = $y_{Tech\ 3}$ =

Description	Equation	
	Exp	
intercept	{0.55265837	+
RVP	$(-0.11048744)\left(\frac{RVP - 8.651419}{0.580438}\right)$	+
Sulfur	$(0.12662294)\left(\frac{SULFUR - 193.574245}{130.374657}\right)$	+
Aromatic HC	$(0.04922477)\left(\frac{AROM - 30.967805}{9.491877}\right)$	+
Olefin	$(0.12457297)\left(\frac{OLEF - 8.34672}{5.873768}\right)$	+
Oxygen	$(-0.01861222)\left(\frac{OXY - 0.912512}{1.249609}\right)$	+
T50	$(-0.04669652)\left(\frac{T50 - 211.338086}{17.374327}\right)$	+
T90	$(0.1898306)\left(\frac{T90 - 315.839826}{25.694736}\right)$	}

c. Formaldehyde mass emissions Tech 3 = $y_{Tech\ 3}$ =

Description	Equation	
	Exp	
intercept	{2.06596608	+
RVP	(0.02179558)(RVP - 8.651419) / 0.580438	+
Sulfur	(-0.18622636)(SULFUR - 193.574245) / 130.374657	+
Aromatic HC	(-0.1265364)(AROM - 30.967805) / 9.491877	+
Olefin	(0.00492199)(OLEF - 8.34672) / 5.873768	+
Oxygen	(0.17601939)(OXY - 0.912512) / 1.249609	+
T50	(0.06301058)(T50 - 211.338086) / 17.374327	+
T90	(-0.04218807)(T90 - 315.839826) / 25.694736	}

d. Acetaldehyde mass emissions Tech 3 = $y_{\text{Tech 3}}$ =

Description	Equation
	Exp
intercept	{0.99348033 +
RVP	(0.00386954)(RVP - 8.651419) / 0.580438 +
Sulfur	(0.04468183)(SULFUR - 193.574245) / 130.374657 +
Aromatic HC	(-0.14176068)(AROM - 30.967805) / 9.491877 +
Olefin	(0.03247264)(OLEF - 8.34672) / 5.873768 +
Oxygen	(0.11153843)(OXY - 0.912512) / 1.249609 +
T50	(0.10500375)(T50 - 211.338086) / 17.374327 +
T90	(-0.02459286)(T90 - 315.839826) / 25.694736 }

where

RVP, SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the value limits for the candidate and reference specifications identified in the Table 7 worksheet.

2. Mass Emissions for Tech 4

The mass emissions for each toxic for Tech 4 are calculated as follows:

a. Benzene mass emissions Tech 4 = $y_{Tech\ 4}$ =

Description	Equation	
	Exp	
intercept	{2.07694733	+
RVP	(0.0205809(RVP - 8.707348) / 0.52813	+
Sulfur	(0.14014755)(SULFUR - 174.036113) / 137.356549	+
Aromatic HC	(0.17375044)(AROM - 28.604566) / 7.848674	+
Olefin	(0.02072724)(OLEF - 7.001772) / 4.988003	+
Oxygen	(0.02074571)(OXY - 1.266843) / 1.310604	+
T50	(0.04810616)(T50 - 208.186678) / 18.149553	+
T90	(0.00084762)(T90 - 311.36879) / 22.988439	+
BENZ	(0.14364029)(BENZ - 1.092985) / 0.563303 }	

b. 1,3-Butadiene mass emissions Tech 4 = $y_{\text{Tech 4}}$ =

Description	Equation	
	Exp	
intercept	{-0.12216754	+
RVP	$(0.0235653)\left(\frac{RVP - 8.707348}{0.52813}\right)$	+
Sulfur	$(0.05667595)\left(\frac{SULFUR - 174.036113}{137.356549}\right)$	+
Aromatic HC	$(-0.04969117)\left(\frac{AROM - 28.604566}{7.848674}\right)$	+
Olefin	$(0.13697093)\left(\frac{OLEF - 7.001772}{4.988003}\right)$	+
Oxygen	$(0.00190223)\left(\frac{OXY - 1.266843}{1.310604}\right)$	+
T50	$(0.05848709)\left(\frac{T50 - 208.186678}{18.149553}\right)$	+
T90	$(0.08820685)\left(\frac{T90 - 311.36879}{22.988439}\right)$ }	

c. Formaldehyde mass emissions Tech 4 = $y_{Tech\ 4}$ =

Description	Equation	
	Exp	
intercept	{0.57054336	+
RVP	(0.00037903(RVP - 8.707348) / 0.52813	+
Sulfur	(-0.04718751)(SULFUR - 174.036113) / 137.356549	+
Aromatic HC	(-0.07461695)(AROM - 28.604566) / 7.848674	+
Olefin	(0.01552007)(OLEF - 7.001772) / 4.988003	+
Oxygen	(0.07852942)(OXY - 1.266843) / 1.310604	+
T50	(0.00214242)(T50 - 208.186678) / 18.149553	+
T90	(0.08066587)(T90 - 311.36879) / 22.988439 }	

d. Acetaldehyde mass emissions Tech 4 = $y_{\text{Tech 4}}$ =

Description	Equation	
	Exp	
intercept	{-0.30025158	+
RVP	(0.05984811)(RVP - 8.707348) / 0.52813	+
Sulfur	(0.00342614)(SULFUR - 174.036113) / 137.356549	+
Aromatic HC	(-0.0799839)(AROM - 28.604566) / 7.848674	+
Olefin	(0.01920116)(OLEF - 7.001772) / 4.988003	+
Oxygen	(0.12257203)(OXY - 1.266843) / 1.310604	+
T50	(0.11079701)(T50 - 208.186678) / 18.149553	+
T90	(0.06243205)(T90 - 311.36879) / 22.988439	+
BENZ	(0.08929885)(BENZ - 1.092985) / 0.563303 }	

where

RVP, SULFUR, AROM, OLEF, OXYGEN, T50, and T90 are the values for the candidate and reference specifications in the Table 7 worksheet.

B. Percent Change in Potency-weighted Toxic Emissions

1. Calculation of VMT and Potency-weighted Emissions for Candidate Specifications

$$CE_{PWT\text{-}CAND} =$$

$$\left[\left(\left[(y_{BZ\text{-}TECH3})(VMTWF_3)\right]+\left[(y_{BZ\text{-}TECH4})(VMTWF_4)\right]\right)x\,(PWT_{BZ})\right]+$$

$$\left[\left(\left[(y_{BD\text{-}TECH3})(VMTWF_3)\right]+\left[(y_{BD\text{-}TECH4})(VMTWF_4)\right]\right)x\,(PWT_{BD})\right]+$$

$$\left[\left(\left[(y_{FOR\text{-}TECH3})(VMTWF_3)\right]+\left[(y_{FOR\text{-}TECH4})(VMTWF_4)\right]\right)x\,(PWT_{FOR})\right]+$$

$$\left[\left(\left[(y_{ACE\text{-}TECH3})(VMTWF_3)\right]+\left[(y_{ACE\text{-}TECH4})(VMTWF_4)\right]\right)x\,(PWT_{ACE})\right]$$

where

$CE_{PWT\text{-}CAND}$ is the change in PWT emissions for the candidate specifications.

$y_{BZ\text{-}TECH}$ is the benzene emission for Tech 3 or Tech 4
$y_{BD\text{-}TECH}$ is the 1,3-butadiene emission for Tech 3 or Tech 4
$y_{FOR\text{-}TECH}$ is the formaldehyde emission for Tech 3 or Tech 4
$y_{ACE\text{-}TECH}$ is the acetaldehyde emission for Tech 3 or Tech 4

$VMTWF_3$ and $VMTWF_4$ are the VMT weighting factors for Tech class 3 and Tech class 4 vehicles, respectively. These values are shown in Table 5.

PWF_q is the potency weighting factor for toxic pollutant q provided in Table 8.

2. Calculation of VMT and Potency-weighted Emissions for Reference Specifications

$CE_{PWT\text{-}REF}$ =

$$\left[\left(\left[(y_{BZ\text{-}TECH3})(VMTWF_3)\right]+\left[(y_{BZ\text{-}TECH4})(VMTWF_4)\right]\right)x\,(PWT_{BZ})\right]+$$

$$\left[\left(\left[(y_{BD\text{-}TECH3})(VMTWF_3)\right]+\left[(y_{BD\text{-}TECH4})(VMTWF_4)\right]\right)x\,(PWT_{BD})\right]+$$

$$\left[\left(\left[(y_{FOR\text{-}TECH3})(VMTWF_3)\right]+\left[(y_{FOR\text{-}TECH4})(VMTWF_4)\right]\right)x\,(PWT_{FOR})\right]+$$

$$\left[\left(\left[(y_{ACE\text{-}TECH3})(VMTWF_3)\right]+\left[(y_{ACE\text{-}TECH4})(VMTWF_4)\right]\right)x\,(PWT_{ACE})\right]$$

where

$CE_{PWT\text{-}REF}$ is the change in PWT emissions for the reference specifications.

$y_{BZ\text{-}TECH}$ is the benzene emission for Tech 3 or Tech 4
$y_{BD\text{-}TECH}$ is the 1,3-butadiene emission for Tech 3 or Tech 4
$y_{FOR\text{-}TECH}$ is the formaldehyde emission for Tech 3 or Tech 4
$y_{ACE\text{-}TECH}$ is the acetaldehyde emission for Tech 3 or Tech 4

$VMTWF_3$ and $VMTWF_4$ are the VMT weighting factors for Tech class 3 and Tech class 4 vehicles, respectively. These values are shown in Table 5.

PWF_q is the potency-weighting factor for toxic pollutant q provided in Table 8.

3. Calculation of Percent Change in Emissions

% CE_{PWT} = percent change in potency-weighted toxic emissions

$$\%CE_{PWT}=\left[\frac{CE_{PWT\text{-}CAND}}{CE_{PWT\text{-}REF}}-1\right]x\,(100)$$

VII. DETERMINATION OF ACCEPTABILITY

If for each pollutant (NOx, HC, and potency-weighted toxics), the percent change in emissions between the candidate specifications and the reference Phase 2 RFG specifications is equal to or less than 0.04%, then the candidate specifications are deemed acceptable as an alternative to Phase 2 RFG. The candidate specifications must pass for all three categories -- NOx, HC, and PWT -- to be acceptable as an alternative Phase 2 RFG formulation;

$$\%CE_{NOx} \leq 0.04\%, \text{ and}$$
$$\%CE_{HC} \leq 0.04\%, \text{ and}$$
$$\%CE_{PWT} \leq 0.04\%.$$

If the percent change in emission between the candidate specifications and the reference Phase 2 RFG specifications is equal to or greater than 0.05%, then the candidate specifications are deemed unacceptable and may not be a substitute for Phase 2 RFG.

If the candidate specifications are deemed acceptable, the property values and the compliance options of the candidate specifications become the property values and compliance options for the alternative gasoline formulation.

VII. NOTIFICATION OF INTENT TO OFFER AN ALTERNATIVE GASOLINE FORMULATION

A producer or importer intending to sell or supply an alternative gasoline formulation of California gasoline from its production facility or import facility shall notify the executive officer in accordance with 13 CCR, section 2265(a).

Table 9, Alternative Specifications for Phase 2 RFG Using the California Predictive Model Notification has been provided as an example of the minimum information required.

Table 9
Alternative Specifications for Phase 2 RFG
Using California Predictive Model Notification

Name of Producer/Importer: _____ Facility Location: _____

Name of Person Reporting: _____ Telephone No.: _____

Date/Time of This Report: _____ I.D. of 1st Batch with this Specification: _____

☞*All California gasoline transfered from this facility will meet the specifications listed below until the next Alternative Specifications report to the ARB.*

☞*Fuel properties that will be averaged will report the "Designated Alternative Limit and volume of gasoline report" separately to the ARB.*

Fuel Property:	Candidate Fuel: Fuel Property Value	Compliance Option: Flat or Average	Reference Fuel: Phase 2 RFG Property Value	
			Flat	Average
RVP	7.00	Flat	7.00	None
Sulfur			40	30
Benzene			1.00	0.80
Aromatic HC			25.0	22.0
Olefin			6.0	4.0
Oxygen[1]	(min.)	Flat Range	(min.)	None
	(max.)		(max.)	
T50			210	200
T90			300	290

[1] If the oxygen content range for the candidate specification is ≥ 1.8 and ≤ 2.2, the candidate and reference oxygen property value used in the predictive model equation is 2.0. For all other cases, see Table 6 in the Predictive Model Procedures.

Pollutant[1]	Percent Change in Emissions $\left[\left(\frac{\%CE_{CAND}}{\%CE_{REF}}\right)-1\right](100)$
Oxides of Nitrogen	
Hydrocarbons	
Potency-weighted Toxics	

[1] If one or both oxygen specifications are outside the 1.8-2.2 volume percent range, a %CE must be reported for both the minimum and maximum specifications.

☎ *Please FAX this reports to the ARB at (916)445-5745* ☎

Table 10
Standardization of Fuel Properties - Mean and Standard Deviation

Fuel Property	Tech 3		Tech 4	
	Mean	Std. Dev.	Mean	Std. Dev.
RVP	8.651419	0.580438	8.707348	0.52813
Sulfur	193.574245	130.374657	174.036113	137.356549
Aromatic HC	30.967805	9.491877	28.604566	7.848674
Olefin	8.34672	5.873768	7.001772	4.988003
Oxygen	0.912512	1.249609	1.266843	1.310604
T50	211.338086	17.374327	208.186678	18.149553
T90	315.839826	25.694736	311.36879	22.988439
Benzene	1.365963	0.444768	1.092985	0.563303

Table 11
Coefficients for NOx and HC Equations

Pollutant Emission	Tech 3		Tech 4	
	NOx	HC	NOx	HC
Intercept	-0.15597638	-0.79454695	-0.58546115	-1.18303868
RVP	-0.01671797	0.004470126	0.03005909	-0.00850444
Sulfur	0.01785987	0.001933575	0.050086115	0.116903682
Aromatic HC	0.05428291	-0.03844685	0.004154304	0.001368326
Olefin	0.02292342	-0.02100516	0.025949698	-0.0068737
Oxygen	0.01439508	-0.02735656	0.011321599	-0.01035001
T50	-0.01161378	0.010253527	0.00195233	0.076436841
T90	0.00341764	0.017858355	-0.00820391	0.038947849
RVPT50		-0.01626671		
RVPOXY			0.006283521	
SULARO		-0.04053717		
AROARO				-0.01197286
AROOXY			-0.00579379	
AROT90	-0.0097818	0.018225949		0.012076013
OXYOXY			0.013486985	
OXYT90				0.015107193
T50T50				0.025807977
T50T90	0.00857682			
T90T90				0.018209586

Table 12
Coefficients for Toxics Equations

Pollutant Emission	Tech 3			
	Benzene	Butadiene	Formaldehyde	Acetaldehyde
Intercept	2.98444988	0.55265837	2.06596608	0.99348033
RVP	0.00012084	-0.11048744	0.02179558	0.00386954
Sulfur	0.06702145	0.12662294	-0.18622636	0.04468183
Aromatic HC	0.11271704	0.04922477	-0.1265364	-0.14176068
Olefin	0.0262828	0.12457297	0.00492199	0.03247264
Oxygen	0.00010461	-0.01861222	0.17601939	0.11153843
T50	0.07400871	-0.04669652	0.06301058	0.10500375
T90	-0.03666419	0.1898306	-0.04218807	-0.02459286
Benzene	0.13158634			
Pollutant Emission	**Tech 4**			
	Benzene	Butadiene	Formaldehyde	Acetaldehyde
Intercept	2.07694733	-0.12216754	0.57054336	-0.30025158
RVP	0.0205809	0.0235653	0.00037903	0.05984811
Sulfur	0.14014755	0.05667595	-0.04718751	0.00342614
Aromatic HC	0.17375044	-0.04969117	-0.07461695	-0.0799839
Olefin	0.02072724	0.13697093	0.01552007	0.01920116
Oxygen	0.02074571	0.00190223	0.07852942	0.12257203
T50	0.04810616	0.05848709	0.00214242	0.11079701
T90	0.00084762	0.08820685	0.08066587	0.06243205
Benzene	0.14364029			0.08929885

APPENDIX C

DESCRIPTION OF EMISSIONS TEST PROGRAMS INCLUDED IN THE CALIFORNIA PREDICTIVE MODEL WORKING DATABASE

DESCRIPTION OF EMISSIONS TEST PROGRAMS INCLUDED IN THE CALIFORNIA PREDICTIVE MODEL WORKING DATABASE

This Appendix describes the emission test programs that were included in the California predictive model working database. The purpose of these test programs was to determine the effect of fuel property changes on vehicle exhaust emissions. All of the studies involved actual vehicle tests in which vehicles fueled with gasolines of known composition were driven at prescribed conditions over prescribed driving schedules. Emissions were measured and fuel property effects were estimated using standard mathematical analytical techniques. The fuel properties varied in the test gasolines included the Reid vapor pressure (RVP), sulfur, aromatic hydrocarbons, olefins, benzene, T50 and T90 distillation temperatures, and oxygen. The vehicles tested were representative of the four Tech classes, described in Chapter I, Table 1, of the staff report. The majority of the vehicles tested were in the Tech 3 and 4 classes. Table 1, at the end of this Appendix, lists the emission test programs and the number of data points within each Tech class.

1. USEPA-Emission Factors

The USEPA Emission Factor Database contains test results that were accumulated on a continuous basis for a period of several years. The database contains the results of tests that were primarily conducted to investigate the effects of RVP, different oxygenates, and oxygen content on emissions. The results were used to develop the USEPA's analysis of the effects on emissions of using oxygenate gasoline blends in non-attainment areas. The test results were also used in the development of USEPA's vehicle emissions model.

Vehicles were removed from service and tested on various commercial unleaded gasolines, certification fuels, and oxygenated blends. The oxygenated blends contained ethanol, methyl-tert-butyl-ether (MTBE), and ethyl-tert-butyl-ether (ETBE). The oxygen content of the oxygenated blends ranged from about 2.0 to 3.7 weight percent. Vehicles of all emission control technology classes were included in the testing. Recently, USEPA has focused its testing on vehicles with the adaptive control systems. Currently there are over 1,500 observations in the USEPA emission factor database.

2. Auto/Oil Program AMOT Study

This testing program consisted of two stages. The first stage evaluated late model vehicles; the second stage evaluated older model vehicles.

The purpose of the first stage of this testing program was to determine the effects of gasoline aromatic hydrocarbon content, olefin content, oxygen content, and T90 on emissions

from late model year vehicles. Exhaust emissions (including detailed emissions speciation profiles) were measured as a function of gasoline composition in a fleet of 20, 1989 model year vehicles. The 20 car fleet was comprised of two cars from each of ten different vehicle models.

A total of 18 different gasolines were tested. The 18 gasolines consisted of 16 gasolines in a 2x2x2x2 factorial experimental design, a gasoline representative of the current industry average gasoline, and a gasoline representing new vehicle certification fuel. The fuel parameters in the 2x2x2x2 factorial design were aromatic hydrocarbon content, olefin content, MTBE content, and T90. Other fuel parameters thought to influence emissions were held approximately constant. For the fuels that make up the factorial design, the high values for the aromatic hydrocarbon content, olefin content, MTBE content, and T90 were 45 volume percent, 20 volume percent, 15 volume percent, and 330 degrees fahrenheit (°F), respectively. The design low values for these four parameters were 20 volume percent, five volume percent, zero volume percent, and 280°F, respectively. The sulfur and benzene contents for the fuels that make up the factorial design were about 300 parts per million by weight (ppmw) and 1.43 volume percent, respectively.

The purpose of the second stage of the testing program was to determine the effects of gasoline aromatic content, olefin content, oxygen content, and T90 on emissions from older model year vehicles. The fuel matrix used in this test program was the same as that used in the first stage described above. The test fleet consisted of 16 vehicles. The model years of these vehicles were 1983, 1984, and 1985. The fleet was composed of two vehicles from each of eight different models. Detailed emissions speciation profiles were measured in this test program also.

3. Auto/Oil-Sulfur-Phase 1

The purpose of this testing program was to investigate the influence of gasoline sulfur content on emissions. Ten of the vehicles tested in the Auto/Oil Current Fleet program were tested on two gasolines having sulfur contents of 466 ppmw and 49 ppmw. Other properties of the fuels considered to be important from an emissions standpoint were held approximately constant. Aromatics content was about 26.5 volume percent, olefin content was about 2.5 volume percent, T90 was about 318°F, and RVP was about 8.8 pounds per square inch (psi).

4. Auto/Oil-Sulfur-Phase 2

The purpose of this testing program was to investigate the effects of fuel sulfur content on exhaust emissions, toxics emissions, and ozone-forming potential of emissions. Ten of the vehicles tested in the Auto/Oil Program AMOT Study (Stage 1) were tested on five gasolines with variable sulfur contents. The vehicle test fleet was composed of the same vehicles that were tested in the Phase 1 program. Emissions of criteria pollutants (including speciated profiles) and toxics were measured.

The five gasolines had sulfur contents of 44 ppmw, 138 ppmw, 258 ppmw, 350 ppmw, and 443 ppmw respectively. The testing of five fuels with variable sulfur levels allowed a more accurate response curve to be developed than in the Phase 1 sulfur test program. Non-linear responses due to sulfur changes were able to be detected. All other fuel parameters considered to be important from an emissions standpoint were approximately constant. Aromatics were about 25 volume percent, MTBE was about 11 volume percent, olefins were about 1.1 volume percent, T90 was about 300°F, and RVP was about 8.9 psi.

5. Auto/Oil Low Sulfur

The purpose of this testing program was to investigate the influence of low sulfur levels on emissions. The vehicle test fleet consisted of ten 1985 model year cars, and ten cars that had been tested in the Auto/Oil Program AMOT Study (Stage 1). The three different levels of sulfur used were 11 ppmw, 28 ppmw, and 50 ppmw. Other properties of the fuels considered to be important from an emissions standpoint were held approximately constant. The values of the other properties were: (1) RVP of 9.3 psi; (2) T50 of 167°F; (3) T90 of 303°F; (4) aromatics hydrocarbons of 24.5 volume percent; (5) olefins of five volume percent; and (6) no oxygen.

6. Auto/Oil-RVP/Oxygenates

This study evaluated the effects of reducing RVP one psi and individually adding the oxygenates ethanol, MTBE, and ETBE. The effects of aromatic hydrocarbon content, RVP, and oxygenate content on emissions of toxics and criteria pollutants were evaluated for the fleet of 20 current model year vehicles. These were the same vehicles used in the Auto/Oil Program AMOT Study (Stage 1).

A total of 11 fuels were included in the test program. Four fuels contained no oxygen and were considered to be base fuels. These four fuels were arranged in a 2x2 factorial design with aromatic hydrocarbon content at 32 and 20 volume percent and RVP at eight and nine psi. Four fuels contained ten volume percent ethanol. These four fuels were arranged in a 2x2 factorial design with aromatics at 32 and 20 percent and RVP at nine and ten psi. Two fuels contained 15 volume percent MTBE and 20 volume percent aromatic hydrocarbons, and RVP of eight and nine psi. The final fuel had an RVP of nine, and contained 17 volume percent ETBE and with 20 volume percent aromatic hydrocarbons. The sulfur contents of the fuels varied from about 250 ppmw to about 360 ppmw. Emissions of criteria pollutants and toxics were measured. Emissions speciation profiles were also obtained.

7. Auto/Oil-MTBE and TAME

The objectives of this study were to compare the effects of MTBE and tert-amino-methyl-ether (TAME) on hydrocarbons, carbon monoxide, oxides of nitrogen, toxic air

pollutants, and exhaust emissions; and to compare the effects on ozone-forming potential and the specific reactivity of exhaust and evaporative emissions.

Test fuels containing 11.5 volume percent of MTBE or 12.7 volume percent of TAME (both are approximately equivalent to 2.9 weight percent oxygen in the fuel) were evaluated in ten vehicles used in the Auto/Oil Program AMOT Study (Stage 1). The fuels were blended in a base fuel representing Federal emission certification fuel. The base fuel was the same as that used in the Auto/Oil sulfur studies.

8. Auto/Oil Heavy T90 - Heavy Hydrocarbons

The objective of this testing program was to look at the effect of T90 on emissions. Analyses were performed on emissions from cars running on gasolines with heavy hydrocarbons. The three objectives of this study were: (1) to investigate whether the T90 effect is due to distillation properties or compositional changes which affect distillation properties, (2) to determine whether the T90 effect observed in the original two-level study is linear or nonlinear, and (3) to design the experiment such that the results would be relevant to current refinery technology while also providing information of a more fundamental nature that could be applied to future refinery technology.

The vehicle fleet consisted of ten 1989 model year vehicles operating on 26 fuels of differing heavy hydrocarbon composition.

9. GM/CARB/WSPA-Driveability

This testing program was a cooperative effort between the Air Resources Board (ARB), the Western States Petroleum Association (WSPA), and General Motors (GM). The objective of the program was to investigate the independent effects of RVP and Driveability Index (DI) on emissions. Tests were conducted at two different temperatures. Exhaust emissions, including emissions speciation, were measured.

Twenty cars were tested on six gasolines. The 20 cars consisted of five cars from each of four different emissions control technology groups. The four groups were pre-1975 non-catalyst vehicles; 1975-1982 oxidation catalyst vehicles; 1981-1985 three-way catalyst vehicles without adaptive learning; and 1987-1990 three-way catalyst vehicles with adaptive learning.

The six gasolines consisted of four gasolines described by a 2x2 factorial design with RVP and DI as variables, one base gasoline, and one high DI gasoline. The four gasolines in the 2x2 factorial matrix had design RVP levels of about 7.7 psi and 6.9 psi and design DI levels of about 1090 and 1020. Actual values for these parameters were slightly different from the design values. The base gasoline had properties similar to unleaded gasoline currently being used in California and had a DI of about 1200. The high DI gasoline had a DI of approximately 1266. The four gasolines in the 2x2 matrix had about 11 volume percent MTBE, 24 volume percent aromatic hydrocarbons, and 1.2 volume percent benzene. The

high DI gasoline also had about 11 volume percent MTBE. The base gasoline and the high DI gasoline had aromatic hydrocarbons contents of about 35 percent. All gasolines in the test program had sulfur contents of about 200 ppmw.

10. API RVP/Oxygenate Program

The purpose of this testing program was to investigate the influence of RVP, oxygenates, and ambient temperature on emissions. Eleven cars, eleven fuels, and three temperatures were included in the test matrix. The fuel matrix consisted of four 13 psi RVP fuels, five nine psi RVP fuels, one ten psi RVP fuel, and one seven psi RVP fuel. The 13 and nine RVP groups of fuels included a non-oxygenated base fuel, a ten volume percent ethanol blend, a 15 volume percent MTBE blend, and a 7.5 volume percent MTBE blend. One nine RVP fuel was a 17.1 volume percent ETBE blend. The fuels with RVP values at seven and ten psi contained no oxygen. Other important fuel properties varied little among the fuels.

Nine of the 11 vehicles were three-way catalysts and two were oxidation catalysts. Seven of the three-way catalyst vehicles were closed loop, and two were open loop. Tests were conducted at 80°F, 55°F, and 35°F. Tests with all fuels except the ten psi RVP fuel were conducted at 80°F. Tests with all fuels except the 17.1 volume percent ETBE fuel were conducted at 55°F. Tests with all fuels except the 7.5 volume percent MTBE fuels, the 17.1 percent ETBE fuel, and the 7 RVP fuel were conducted at 35°F.

11. API-Aromatic Hydrocarbons

This study investigated the effects of a number of fuel properties on emissions. Ten cars were tested on nine fuels in this study. All of the cars tested were post-1985 model year cars (Tech 4 cars). None of the fuels tested contained oxygenates. The RVP's of the fuels in this study ranged from 8.1 to 8.9 psi, the aromatics contents ranged from 32 to 37 volume percent, the olefins contents ranged from five to nine volume percent, the sulfur contents ranged from 42 ppmw to 339 ppmw, the T50's ranged from 218°F to 243°F, and the T90's ranged from 313°F to 353°F.

12. Chevron-Distillation

Chevron has conducted four test programs to investigate the effects of fuel properties on emissions. These four test programs were primarily designed to investigate the effects of distillation properties on emissions. However, other fuel properties were varied in these tests, and the results provided insight to the effects on emissions of these other properties.

The first program conducted by Chevron investigated the effects of large differences in the distillation characteristics of gasolines. This program was primarily intended to serve as a screening program and as a guide in the planning of future test programs.

The first program tested six fuels in two cars. The first fuel was a totally paraffinic gasoline with an RVP of about 7.3 psi. The DI of this fuel was about 1122. The second fuel was made by adding 30 volume percent toluene to the first fuel. The total aromatic content of this fuel was about 32 volume percent and the DI was about 1107. The RVP of this fuel was about 8.5 psi. The distillation properties of the first two gasolines were similar throughout much of the distillation range. A third gasoline was created by replacing half the toluene in the second fuel with a heavy reformate stream. As a result of this addition, the RVP decreased to about 8.0 psi and the DI increased to about 1237. Most of the DI increase occurred in the mid and heavy portions of the distillation curve. The fourth fuel tested was the certification fuel indolene. The fifth fuel was a commercial unleaded gasoline. The sixth fuel was made by removing from the fourth fuel the gasoline portion which boiled above 270°F. As a result, the sixth fuel had a very low DI (approx. 931). The test fleet consisted of one 1987 and one 1989 model year vehicle.

The second test program tested seven fuels in five vehicles. This program was designed to investigate the independent effects on emissions of gasoline aromatics content and DI. A seven fuel matrix was created in which these two fuel parameters were varied independently. Four of the fuels in the matrix were represented by a 2x2 matrix with design aromatics levels of 20 and 40 volume percent and design DI levels of about 1000 and 1250. Actual values differed slightly from these levels. The fifth fuel was indolene. The sixth fuel was a low aromatics (5.2 volume percent) high DI (1218) fuel. The seventh fuel was a low aromatics (10.5 volume percent), low DI (1090) fuel with 11 volume percent MTBE. Four 1989 model year vehicles and one 1987 model year vehicle were tested in this program.

The third program tested two fuels in 20 vehicles. The two fuels included a premium unleaded fuel representative of unleaded fuel used in Southern California during the summer and a reformulated gasoline designed to reduce exhaust and evaporative emissions. The reformulated gasoline contained 11 volume percent MTBE, had a lower RVP (7.5 psi vs. 8.5 psi), and a lower DI (1125 vs. 1232) than the Southern California unleaded gasoline. The 20 vehicles consisted of five vehicles from each of four categories represented by different exhaust emissions control technologies. The four categories were non-catalyst, oxidation catalyst, three-way catalyst, and three-way catalyst with adaptive learning.

The fourth program tested four fuels in eight vehicles. Two of the fuels were the same two fuels used in the third program. The third fuel was a standard FTP emissions test fuel. The fourth fuel was similar to the reformulated gasoline used in the third test program, except that the reformulated gasoline used in this test program did not contain any oxygenated compounds. The eight vehicles tested in this program were a subset of the 20 vehicles tested in the third program. Two cars from each of the four technology groups were tested.

13. Unocal-RFG

There were three objectives of the UNOCAL program. These were to: 1) determine which fuel properties influence emissions; 2) develop a mathematical relationship between

emissions and fuel properties; and 3) verify the predictive ability of the relationship on an independent sample of vehicles. The UNOCAL testing program was conducted in three phases to address each of the three objectives.

Initial testing was performed on one car to determine the fuel properties that influence emissions. Testing was then performed on ten cars to develop a predictive model. Finally, tests were performed on 13 cars to verify the predictive ability of the model.

In the single car test program, a 1988 vehicle was tested on 15 gasolines in which ten properties were independently varied. These properties were aromatic hydrocarbon content, olefin content, paraffin content, MTBE content, research octane number, motor octane number, ten percent distillation temperature, T50, T90, and RVP. For this car, correlations were developed between emissions and fuel properties.

In the ten car test program, 1984 -1990 model year vehicles were tested. The ten cars were tested on 15 different gasolines in which ten fuel parameters were independently varied. The varied parameters were the same as the ones that were varied in the single car test program. The actual properties of the gasolines were different from those in the single car test program.

The 13 car test program was conducted to verify the predictive ability of the regressions developed from the ten car program. A reformulated gasoline was produced which, according to regression predictions, would result in a 15 percent reduction in hydrocarbon emissions compared with the Federal Clean Air Act reference gasoline. The 13 cars were then tested on these two gasolines to determine if the hydrocarbon emissions reductions predicted by the regressions would result. The fleetwide average hydrocarbon emissions and carbon monoxide emissions were reduced about 13 percent and 15 percent. No statistically significant change in NOx emissions was observed.

14. Niper-Benzene

The purpose of this testing program was to investigate the influence on emissions of benzene and other aromatic compounds in gasoline. The test program was conducted in three phases. Five cars were tested in each phase.

Phase 1 tests were conducted to determine if individual aromatic species influenced benzene emissions. Six fuels were tested in Phase 1. These fuels included an aromatic-free, alkylate stock and five aromatic hydrocarbon blends made by blending the alkylate stock with the individual aromatic hydrocarbon streams of five volume percent benzene, ten volume percent toluene, five volume percent ethyl benzene, ten volume percent oxylene, and ten percent reformate containing mostly C9 and higher aromatic hydrocarbons.

Phase 2 tests were conducted to develop predictive equations that relate benzene emissions to the presence of various aromatic compounds in gasoline. Nine fuels were tested

in the Phase 2 tests. The nine fuels were made by blending into the alkylate stock various amounts of the four individual aromatic hydrocarbon streams used in the Phase 1 tests. The experimental design represented by the blends was a fractional factorial with four factors (aromatic compounds) each at three levels. The three levels for the four aromatic hydrocarbon streams were: benzene of 1,2,3 volume percent; toluene of 5,10,15 percent; ethyl benzene of 1,3,5 percent; and xylenes of 5,10,15, volume percent. Each of the nine fuels contained ten percent C9 and higher aromatic hydrocarbons. Total aromatic hydrocarbons ranged from 22 to 46 volume percent.

Phase 3 tests were conducted to validate the predictive ability of the regressions developed in Phase 2. Four fuels were tested in Phase 3. These fuels included the certification fuel indolene, two commercial gasolines, and a fuel made at NIPER. The four fuels had a wide range of the five aromatic streams included in the Phase 1 and 2 tests. Total aromatic hydrocarbons ranged from 23.6 to 47.8 volume percent.

15. CARB/ATL-Oxygenates

The purpose of this testing program was to investigate the effects of oxygenates, ambient temperature, and driving cycle on emissions. Thirteen vehicles, ten fuels, three ambient temperatures, and three driving cycles were included in this program. The fuel matrix included five summertime and five wintertime fuels.

The summertime fuels consisted of a nominal 7.6 psi RVP non-oxygenated industry average base fuel and four oxygenated blends. Two of the fuels were nominal 7.6 RVP, 2.0 weight percent oxygen, MTBE and ETBE blends, blended from the base fuel. The other two summertime blends were a nominal 7.6 psi RVP, 2.0 weight percent oxygen ethanol blends, blended from the base fuel, and a nominal 8.8 psi RVP, 2.0 weight percent oxygen ethanol blend, splash blended from the base fuel.

The wintertime fuels consisted of a nominal 9.7 psi RVP fuel and four oxygenate blends. Two of the blends were nominal 9.7 psi RVP, 2.7 volume percent oxygen MTBE and ETBE blends, blended from the base fuel. The other two wintertime blends were a nominal 9.7 psi RVP, 2.7 weight percent oxygen ethanol blends, blended from the base fuel, and a nominal 11 psi RVP, 2.7 weight percent oxygen blend, splash blended from the base fuel.

The vehicle fleet consisted of one flexible-fueled vehicle with multi-port fuel injection, closed-loop three-way catalyst with adaptive learning system and two vehicles from each of the following six emissions control technology groups: 1) pre-1975 model year (non-catalyst vehicles); 2) 1975-1978 carbureted, open loop, oxidation catalyst vehicles; 3) post 1981, carbureted, closed loop, three-way catalyst vehicles; 4) post 1981, throttle body injected, closed loop, three-way catalyst vehicles; 5) post 1987, closed loop, multi-port fuel injected, three way-catalyst vehicles; and 6) post 1987, closed loop, multi-port fuel injected, three-way catalyst vehicles with adaptive learning.

Tests with all 13 cars, using the wintertime fuels, were conducted at 50°F and 75°F. Tests with all 13 cars using the summertime fuels were conducted at 75°F and 95°F.

Three driving cycles were used in this test program. These cycles were the Federal test procedure (FTP), the highway fuel economy test (HFET), and the New York City Cycle (NYCC). These cycles differ mainly in the accelerations, decelerations, and average speeds. Each of the tests specified in the test matrix were conducted using each of the three test cycles.

16. Arco-EC-X

The ARCO test program was conducted as the basis for the development of ARCO's EC-X reformulated gasoline. ARCO conducted an independent analysis of the test results from the Auto/Oil test program to determine the properties that have the greatest influence on emissions. Based on its analysis and on the results of a refinery planning model used to predict future refinery configurations and gasoline pool compositions, ARCO developed four different reformulated gasolines which were expected to result in lower emissions. All four gasolines had lower aromatic hydrocarbons contents, RVP, olefin content, T90, and sulfur content than the baseline gasoline which represented the industry average gasoline. All four gasolines contained MTBE in levels from 13.8 to 15.4 volume percent. ARCO then tested the four reformulated gasolines and the reference gasoline on a fleet of ten, 1990 model year vehicles. Speciated emissions results were obtained.

17. Arco T50/T90 Study

The purpose of this testing program was to investigate the influence of varying levels of T50 and T90 on emissions. Aromatics, MTBE, olefins and RVP were held constant. Sulfur levels varied between 50-110 ppmw, T50 between 186-207°F, and T90 between 288-316°F. The vehicle fleet consisted of nine different cars tested on four different fuels.

18. Auto/Oil Methanol

This study evaluated the effects of methanol/gasoline mixtures on vehicle emissions from a fleet of 19 pre-1990 prototype flexible/variable-fueled vehicles. A set of three fuels comprised of Auto/Oil industry-average gasoline and two methanol/gasoline blends (M10 and M85) containing ten volume percent and 85 volume percent methanol (M10 and M85) were used. An Auto/Oil industry average gasoline fleet was used as the gasoline reference fleet. Fuels used in this fleet were Auto/Oil industry average gasoline and research reformulated gasolines. Exhaust, evaporative and running loss emissions were measured and used in air quality models to calculated impacts on ozone and toxic air pollutants.

19. USEPA/ATL-Phase I/II Reformulated Gasoline/Oxygenated Blend Study

The purpose of this program was to investigate the effects of oxygen content, reduced RVP, reduced T90, and reduced sulfur content on emissions. In this program, 34 vehicles were tested on nine gasolines. The fuel matrix include three baseline fuels and six reformulated fuels. The baseline fuels were an industry average (non-oxygenated) gasoline, an indolene fuel, and a high sulfur (210 ppmw) indolene fuel. Five of the six oxygenated gasolines contained a nominal 11 volume percent MTBE. The other oxygenated fuel contained ten volume percent ethanol. In the five MTBE blend group, one fuel had a low RVP (8.1 psi), one fuel had a low T90 (278°F), one fuel had low sulfur (61 ppmw), one fuel had low RVP, T90, and sulfur (7.9 psi, 274°F, 81 ppmw), and one fuel had RVP, T90, and sulfur values typical of existing MTBE blends outside of California (i.e. 8.8 psi, 330°F, 275 ppmw). The aromatics and olefin contents of all oxygenated fuels were approximately constant at the Federal Clean Air Act specifications.

All of the vehicles tested in this program were 1987 or later model-year vehicles. Twenty-two of the vehicles were considered to be normal emitters, three were considered to be high emitters, eight were considered to be very high emitters, and one was considered to be a super high emitter. All vehicles, except five of the normal emitters, were three-way catalyst vehicles.

20. ARB/GM Confirmation

The ARB, in cooperation with GM, conducted a test program designed to confirm the results of ARCO's EC-X test program. In this test program, nine cars were tested on ARCO's EC-X and on the reference fuel A (RF-A) of the Auto/Oil test program. Exhaust emissions, including emissions speciation, were measured. The nine cars were from four different model year groups: pre-75, 1975-1980, 1981-1985, and 1986-1990. Except for the 1975-1980 group, each group contained two cars. The 1975-1980 group contained three cars.

Table C-1

List of Emission Test Studies

TUDY	EPA DATA BASE # of datapoints	ARB DATABASE # of datapoints				TOTAL
		Tech 4	Tech 3	Tech 2	Tech 1	
1. USEPA Emission Factors - designed to examine the effect of oxygenates on emissions.	860	1172	340	0	0	1512
2. Auto/Oil Program AMOT Study - designed to examine the effects of aromatics, olefins, T90, and oxygen on emissions. Ref: Tech Bulletin #1	865	962	698	0	0	1660
3. Auto/Oil-Sulfur-Phase I - designed to examine the sulfur effects for Phase 1 Ref: Tech Bulletin #2	270	300	0	0	0	300
4. Auto/Oil -Sulfur-Phase II - designed to examine the sulfur effects for Phase 2 Ref: Tech Bulletin #8	201	224	0	0	0	224
5. Auto/Oil Low Sulfur		109	0	0	0	109
6. Auto/Oil-RVP/Oxygenates - designed to isolate the effects of MTBE, ETBE, and ethanol at different RVP vels on emissions ef: Tech Bulletin #6	425	471	0	0	0	471
7. Auto/Oil-MTBE TAME - designed to investigate the effects on emissions when using TAME as the oxygenate. Ref: Tech Bulletin #9	72	80	0	0	0	80
8. Auto/Oil-Hvy T90-Heavy Hydrocarbons - which were designed to investigate the effects of E200 and E300 on exhaust emissions.	556	617	0	0	0	617
9. GM/WSPA/CARB Driveability - examined effects of RVP, the driveability index, and different oxygenates on emissions.	30	60	60	60	54	234
10. API RVP/Oxygenate - designed to determine the effect of RVP, different oxygenates, and temperature variation on emissions.	34	112	42	0	0	154
11. API/Aromatics Hydrocarbons - designed to analyze the effects of different types of aromatics on emissions.	230	212	0	0	0	212
12. Chevron Distillation - examined the effects of T90, T50, T10, driveability index, aromatics, and RVP on emissions.	270	306	69	54	20	449
13. Unocal-RFG - designed to study the effects of T10, 50, T90, fuel octane, oxygen content, paraffins, olefins, VP and aromatics on emissions.	462	452	176	67	49	744

STUDY	EPA DATA BASE # of datapoints	ARB DATABASE # of datapoints				TOTAL
		Tech 4	Tech 3	Tech 2	Tech 1	
14. NIPER-Benzene Precursor Study-investigate the influence on emissions of benzene and other aromatic compounds in gasoline		72	18	0	0	90
15. CARB/ATL-Oxygenates - Designed to investigate the effects of oxygen and oxygenates at different temperatures		139	60	39	19	257
16. ARCO EC-X	138	138	0	0	0	138
17. ARCO T50/T90	73	73	0	0	0	73
18. Auto/Oil Methanol		39	0	0	0	39
19. EPA/ATL-Phase I/II	960 (I-280 II-680)	278	0	0	0	278
20. ARB/GM Confirmation		24	24	18	17	83
TOTALS	**5446**	5840	1487	238	159	7724

APPENDIX D

DEVELOPMENT OF THE CALIFORNIA PREDICTIVE MODEL

DEVELOPMENT OF THE CALIFORNIA PREDICTIVE MODEL

This Appendix describes in detail the California predictive model. We will discuss the following topics: (1) the statistical approach used to develop the model, (2) how we combine the individual equations to develop the final equations for hydrocarbons, oxides of nitrogen, and toxic air contaminants, (3) how we use the final equations, and (4) how we evaluated the model.

A. BACKGROUND

The California predictive model is based on statistical analysis of the Air Resources Board's (ARB) working database. A set of equations was developed using standard statistical techniques to relate specific properties of the gasoline used in vehicle tests to exhaust emissions. Each equation represents a "best-fit" line or curve explaining the relationship between the fuel properties and exhaust emissions.

We developed equations for six different pollutants for each of two different classes of vehicles. The first class of vehicles represents the 1981 through 1985 model years. The second class of vehicles represents 1986 through 1995 model years. Of the four technology classes, the data that makes up these two technology classes were the most extensive and best represent the effects alternative gasoline formulations will have on the emissions from future gasoline-powered low-emission vehicles. Table D-1 identifies the individual equations that were developed.

Individual equations were combined to yield three final equations. The first equation will determine the change in exhaust emissions of hydrocarbons, the second will determine the change in exhaust emissions of oxides of nitrogen, and the third will determine the change in the combined exhaust emissions of four toxic air contaminants. Collectively, we refer to these three equations as the California predictive model. The method used to combine the individual equations into the final equations is discussed in Section C of this Appendix.

Table D-1

Summary of Individual Equations Developed

Pollutant	Individual Equations Developed	
	Tech Class 3	Tech Class 4
Hydrocarbons	X	X
Oxides of Nitrogen	X	X
Benzene	X	X
1,3-Butadiene	X	X
Formaldehyde	X	X
Acetaldehyde	X	X

B. STATISTICAL APPROACH

The statistical approach involves defining the mathematical form of the equations, estimating the regression coefficients, and simplifying the equations.

1. What is the mathematical form of each equation?

The California predictive model is a set of linear equations. A linear regression equation approximates the unknown underlying process represented by the data. The linear regression equation is the most common type of statistical approximation used to estimate emissions based on fuel properties. Each linear regression equation is used to estimate the emissions from an average motor vehicle given specified fuel properties. In mathematical notation, a linear regression equation may be written as:

$$E = A0 + A1*P1 + A2*P2 + ... + Am*Pm$$

In this equation, "E" represents the vehicle emissions and is the "dependent" variable. The dependent variable is estimated from the values of one or more "independent" variables. In this case, the independent variable is the fuel property (P1, P2...Pm). The regression coefficients (A1, A2, ... Am) are estimated from a maximum likelihood-best fit to the data and best explains the relationship between the emissions and the fuel properties.

Linear regressions and other types of statistical relationships are often referred to as "models." In our statistical approach, we considered a model that includes both "fixed" effects and "random" effects. The following discussion explains what these terms mean and why we believe it is important to consider both effects.

We know that the emissions from a motor vehicle will change if you change the value of an individual fuel property. If there were no other variability except that associated with the change in the fuel property, we would be able to accurately determine what that effect was if we tested the entire population of vehicles. This response would be the average response of the population. The average response is called a "fixed" effect. The regression coefficients in the linear regression equation are our best estimates of the fixed effects. In other words, these regression coefficients are our best estimates of the average responses of a class of vehicles to a unit change in a fuel property.

We also know that the emissions from individual vehicles have relationships with fuel properties that may differ substantially from the average relationship. For example, we know that the general levels of emissions vary from vehicle to vehicle and are not necessarily representative of the population average response. In addition, we know that the effect on emissions of changing a fuel property may differ from vehicle to vehicle. We refer to these effects as "random" effects because the results are dependent upon the selection of vehicles used to test. Selection of a different set of vehicles may result in different responses. Since it is impractical to test all vehicles, it is important to account for "random" effects.

We selected a statistical approach that considers both fixed-effects and random effects. This model is called a "mixed-effects" model. There are several advantages to the use of the mixed-effects model. First, the mixed-effects model contains both fixed terms which represent the population average response and random terms which represent the variability between individual vehicle's average levels of emissions. Including random terms improves the ability of the model to explain the data.

Second, using a mixed-effects model instead of a fixed-effects model yields more accurate estimates of the standard deviations of the fixed effects' regression coefficients. The increased accuracy improves the ability to estimate the statistical significance of the regressions coefficients and properly include terms that are significant. In addition, tests for the overall significance of the regression are made more accurate by using estimates from the mixed-effects model.

2. What fuel property terms did we consider including in each equation?

The starting point for the analysis is the identification of the possible independent variables in the model. In our analysis, we used linear terms and second-order terms. Linear terms represent a linear relationship between the emissions and the change in fuel properties. As shown in Table D-2, there are seven possible linear terms.

There are two types of second-order terms. Squared terms consider the effects that the square of a fuel property value may have on emissions. Interaction terms consider the effects that the product of two different fuel property values may have on emissions. There are seven possible squared terms and 21 possible interaction terms. These possible terms are also shown in Table D-2.

Table D-2

Independent Variables Evaluated for Significance in the Linear Regression Equations

Linear Terms	Squared Terms	Interaction Terms		
Reid Vapor Pressure (RVP)	RVP*RVP	RVP*SUL	SUL*OLE	ARO*T90
Sulfur (Sul)	SUL*SUL	RVP*ARO	SUL*OXY	OLE*OXY
Aromatic Hydrocarbons (ARO)	ARO*ARO	RVP*OLE	SUL*T50	OLE*T50
Olefins (Ole)	OLE*OLE	RVP*OXY	SUL*T90	OLE*T90
Oxygen (Oxy)	OXY*OXY	RVP*T50	ARO*OLE	OXY*T50
T50	T50*T50	RVP*T90	ARO*OXY	OXY*T90
T90	T90*T90	SUL*ARO	ARO*T50	T50*T90

3. What is the form of each linear regression equation?

Expressed as an equation including all the candidate variables potentially considered for inclusion, the most general form of the linear regression equation is:

Natural logarithm (emissions) =

A0 + A1*RVP + A2*SUL + A3*ARO + ... + A7*T9 [Linear Terms]

+ A8*RVP*RVP + A9*SUL*SUL + ... +A14*T90*T90 [Squared Terms]

+ A15*RVP*SUL + A16*RVP*ARO + ... + A20*RVP*T90 [Interaction Terms]

+ A21*SUL*ARO + ... + A35*T50*T90

The linear terms in the above equation are actually "standardized" values of the fuel properties, and the second-order terms are squares and products of these standardized values. These standardized values have statistical and computational advantages over non-standardized values. For example, using standardized values simplifies the calculations by accounting for the fact that different fuel properties have different units of measurement. Standardized values are dimensionless. To standardize the fuel properties, we calculated the average value and the standard deviation of that value for all of the available data points. All standardized fuel properties have a mean of zero and a standard deviation of one. The formula for the standardized value is:

$$\text{Standardized Value} = \frac{\text{(actual value of a fuel property - average fuel property value)}}{\text{(standard deviation of the fuel property value)}}$$

Note that the dependent variable of each linear regression is expressed as the natural logarithm of emissions. Inspection of the data showed that the variability of emissions from approximately identical fuels increased with increasing average level of emissions. This violates the equal-variability assumption of regression models. The variability of natural logarithms of emissions are more nearly constant and better satisfy this assumption, thereby improving the explanatory power of the model.

4. How did we develop the equations for hydrocarbons and oxides of nitrogen?

We used the SAS Institute's Mixed Model Procedure to perform the analysis. The SAS Mixed Model Procedure uses a maximum likelihood-based estimate for the regression coefficients for each of the independent variables included in the equation as well as the standard error for each regression coefficient.

All linear terms and second-order terms are entered as candidate terms into the SAS Mixed Model Procedure's model statements. A vehicle by study classification term is included as a "class" variable. This term uniquely identifies each vehicle in each study. The analysis treats the same vehicle used in two different studies as different vehicles. The class variable is identified as the data set "subject." In this analysis, the subject is specified to nest all effects in the random statement within the subject effect.

Once the SAS statements are written, the analysis to determine which terms to include in each of the linear regression equations can begin. All first-order terms are included as part of the model because these fuel properties are controlled by the Phase 2 RFG regulations.

The first step in the analysis is to run the SAS Mixed Model Procedure 28 times. In each run, a different second order term is added to the seven linear terms. After completing the analysis of all 28 runs, the most significant term is selected for inclusion in the equation if the term is significant at least at the five percent level.

The second step of the analysis is to run the SAS Mixed Model Procedure 27 times. In each run, a different second order term is added to the seven linear terms plus the one significant term from the first step. Again, the second order term that is the most significant is selected for inclusion in the equation if the term is significant at least at the five percent level. Note that if the second order term found to be significant at the five percent level during an earlier run is found to no longer be significant at the five percent level, then the term is removed from the equation and reentered into the list of candidate terms for inclusion in the equation.

Stepwise analysis is repeated until there are no candidate second order terms found to meet the five percent significance level criteria for inclusion in the equation and all second order terms already in the model remain significant at the five percent level. The second order terms included in the models computed by this procedure are tabulated in Table D-3.

The regression coefficients for the intercept and each term currently part of the equation are then used in the equation with the standardized value of the fuel property to estimate emissions.

There is a variety of possible and feasible statistical procedures for computing regression relationships between emissions and fuel parameters. No procedure can guarantee that it will yield the "best" choice of variables to include, and there is no "best" model. However, we believe that the above procedure for computing regression relationships is likely to yield relationships that are very close to the most satisfactory relationships that can be fitted. The procedure explores a very wide range of possibilities, does not arbitrarily exclude variables that may contribute significantly to estimating emissions, and generally lets the data speak for themselves.

Table D-3

Summary of Second-Order Terms in the Equations For Hydrocarbons and Oxides of Nitrogen by Technology Class

Second-Order Interaction Term	Hydrocarbons		Oxides of Nitrogen	
	Tech Class 3	Tech Class 4	Tech Class 3	Tech Class 4
RVP*RVP		X		X
SUL*SUL		X		
ARO*ARO		X		
OXY*OXY				X
T50*T50		X		
T90*T90		X		
RVP*OXY				X
RVP*T50	X			
SUL*ARO	X			
SUL*T90		X		X
ARO*OLE	X			
ARO*OXY				X
ARO*T90	X	X	X	
OLE*T90	X			
OXY*T90		X		
T50*T90			X	

5. How did we develop the equations for toxic air contaminants?

The equations for the toxic air contaminants do not contain any second-order terms. We did not include second-order terms because of the limited data available to estimate emissions of toxic air contaminants. Therefore, we did not have to do a stepwise procedure.

To determine the regression coefficients, we used the SAS Mixed Model Procedure. We also added benzene as an additional linear term to each model. However, we eliminated benzene from any equation where the results indicated it was not statistically significant. Thus, a benzene term is only included in the benzene equation for Tech class 3 and Tech class 4 and the acetaldehyde equation for the Tech class 4.

6. How did we simplify the equations?

The linear regression equations used for predicting the hydrocarbon and oxides of nitrogen appear to be very complex because they contain many terms. The equations are used for predicting the emissions from the combined effect of seven different fuel properties. Therefore, one would expect that the models would not necessarily be simple.

The ARB working database has fuels from many studies that were conducted for many different reasons. As a result, the data used to develop the equations are usually outside the range of specifications for Phase 2 RFG. We are interested in the results of the equations within the Phase 2 RFG region. Therefore, the objective is to evaluate whether we can accurately approximate the results of the original equations in the Phase 2 RFG region with simpler equations.

As discussed in Section B, we chose to retain all of the linear terms in the equations whether or not they were statistically significant because these fuel properties are controlled by the Phase 2 RFG regulations. There is still a possibility of simplifying the equations by removing some squared terms and interaction terms that have satisfied the statistical significance criterion for inclusion in the equations, yet have limited influence on the equations' predictions within the Phase 2 RFG region. Simplifying the equations makes them easier to interpret and use.

The presence of squared and interaction terms in the regression equations causes the regression equations to have local maximums or minimums. Some of these extreme values may appear to be implausible because studies of gasoline combustion may suggest that the true emissions would not have a maximum or minimum at these values. However, the quadratic regression function approximating the true emissions as a function of the fuel properties does have a maximum or minimum. Simplifying equations by removing squared and interaction terms may have an added benefit of eliminating some implausible maximums and minimums from the fitted regressions.

To simplify the equations, we used the random balance developed by Dr. H. T. McAdams of the Advanced Computing Center of Argenta. Again, simpler is defined as having fewer second-order terms.

The random balance is used to approximate the original regression equations. This is accomplished by randomly generating a large set of fictitious fuels inside a defined region of fuel properties and calculating the resultant emissions using the regression equations. The random fuels are generated so the individual fuel property terms are nearly orthogonal. Orthogonality allows the sum of the squares to be additive for each term in the model. The resulting set of random fuels and estimated emissions then can be assembled so that a standard statistical procedure can be used to estimate the contribution of each term to the overall fit of the equations within the defined region of fuel properties. Once it is determined which terms contribute minimally to the overall explanatory ability of the model, they can be removed from the equations without losing significant explanatory power.

The random balance program was written using the SAS computer language. The sum of squares for all first order terms and each second order terms are sorted by magnitude. A cumulative sum is calculated starting with the term with the largest sum of the squares. Once the cumulative sum of the squares exceeds 99 percent, all remaining second order terms that did not contribute to the 99 percent are considered insignificant can be removed from the final equation. The final coefficients are generated as part of the random balance procedure.

As previously mentioned, the random balance requires a defined set of fuels. The goal is to define the boundaries by the levels at which gasoline properties will likely be when the Phase 2 RFG regulations take effect. The region bounded by the boundaries is called the "box" and is presented in Table D-4.

The random balance was applied to the hydrocarbons and oxides of nitrogen models for both Tech class 3 and Tech class 4. Table D-5 lists the terms of the final model after the random balance was applied. The random balance was not applied to the models for the toxic air contaminants because there were no second-order terms included in these models.

Table D-4

Range of Values ("Box") Used for Simplifying the California Predictive Model Using the Random Balance

Property	Units	Lower Limit	Upper Limit
Reid Vapor Pressure	psi	6.5	7.5
Sulfur	ppmw	0	80
Aromatic Hydrocarbons	% vol.	10	30
Olefins	% vol.	0	10
Oxygen	% wt.	0	2.7
50% Distillation Temperature	deg. F	160	220
90% Distillation Temperature	deg. F	260	330
Benzene	% wt.	0	1.2

Table D-5

Summary of Second-Order Terms in the Equations For Hydrocarbons and Oxides of Nitrogen by Technology Class After Application of the Random Balance

Second-Order Interaction Term	Hydrocarbons				Oxides of Nitrogen			
	Tech Class 3		Tech Class 4		Tech Class 3		Tech Class 4	
	Before Random Balance	After Random Balance	Before Random Balance	After Random Balance	Before Random Balance	After Random Balance	Before Random Balance	After Random Balance
RVP*RVP			X				X	
SUL*SUL			X					
ARO*ARO			X	X				
OXY*OXY							X	X
T50*T50			X	X				
T90*T90			X	X				
RVP*OXY							X	X
RVP*T50	X	X						
SUL*ARO	X	X						
SUL*T90			X				X	
ARO*OLE	X							
ARO*OXY							X	X
ARO*T90	X	X	X	X	X	X		
OLE*T90	X							
OXY*T90			X	X				
T50*T90					X	X		

C. METHOD FOR COMBINING THE INDIVIDUAL EQUATIONS AND USING THE FINAL EQUATIONS

As mentioned earlier, a separate equation is developed for Tech class 3 and Tech class 4 and for each emissions criterion. To develop a single equation for each of the three emissions criteria, the Tech class 3 and Tech class 4 results must be combined. The method used to combine the results is called the technology class weighting.

As discussed in Section A of this Appendix, the California predictive model is based on an analysis of vehicle emission tests for two different classes of vehicles. Tech class 3 represents model years 1981 through 1985 motor vehicles and Tech class 4 represents model years 1986 through 1995 motor vehicles. Each class consists of vehicles with similar exhaust emission control technologies.

1. How did we combine the individual equations for hydrocarbons and oxides of nitrogen?

To calculate the composite of the emissions within the California predictive model, the individual equations for each Tech class must be combined using weighting factors. For oxides of nitrogen and hydrocarbons emissions, we selected weighting factors based on emissions because we are comparing fuels based on the percent change in emissions. Therefore, the Tech classes should be weighted by their contribution to the total emissions. The following procedure was used to combine the individual equations for hydrocarbons and oxides of nitrogen.

1. The vehicle fleet is divided into two technology classes. Each Tech class is comprised of vehicles with similar exhaust emission control technologies and identified by vehicle model year. The two technology classes are defined as Tech class 3 - 1981 through 1985 model year vehicles and Tech class 4 - 1986 through 1995 model year vehicles.

2. The EMFAC7F/BURDEN7F statewide ozone planning emissions inventory reports were run for the years 1996, 2000, and 2005 assuming Phase 2 RFG is used in 1996 (See Attachment 1 for copies of these reports). The on-road motor vehicle emissions for 1996, 2000, and 2005 were grouped by Tech class. For example, the emissions inventory report for 1996 - Tech class 3, listed the exhaust and evaporative emissions for hydrocarbons and oxides of nitrogen due to 1981 through 1985 model year vehicles. For determining the emissions weighting-factor for the California predictive model, we were only interested in the exhaust emissions.

3. For 1996, 2000, and 2005, the total exhaust emissions for each Tech class were calculated by adding the "total exhaust" values from the emission inventory reports for "light-duty passengers-cat" and "light duty trucks-cat." Values were calculated for hydrocarbons and oxides of nitrogen.

4. Emission weighting factors were calculated by taking the exhaust emissions for the pollutant and Tech class of interest and dividing this value by the total exhaust emissions from both Tech class 3 and 4. Values were calculated for hydrocarbons and oxides of nitrogen, for both Tech classes and for the years 1996, 2000, and 2005. The average emission weighting factor for each Tech class was calculated by summing the 1996, 2000, and 2005 emission weighting factors for each Tech class and pollutant and dividing by three. Table D-6 shows the emission weighting factors for Tech class 3 and 4 for 1996, 2000, and 2005 and the average for the three years combined. The average values were selected for use in the California predictive model.

Table D-6

Technology Class Weightings for Hydrocarbons and Oxides of Nitrogen Based on Emissions

Pollutant and Tech Class	Percent Weighting by Inventory Year			Average
	1996	2000	2005	
Hydrocarbons a/				
Tech Class 3	24.5	16.2	18.6	19.8
Tech Class 4	75.5	83.8	81.4	80.2
Oxides of Nitrogen a/				
Tech Class 3	22.3	14.4	15.6	17.4
Tech Class 4	77.7	85.6	84.4	82.6

a/ Weightings based on emissions inventory.

2. How did we combine the individual equations for the toxic air contaminants?

For the toxic air contaminants, we used the vehicle-miles-traveled (VMT) as the weighting factors because we are comparing fuels based on the percent change in potential cancers. For a toxic air contaminant, the absolute magnitude of emissions needs to be considered and not just the percent change in emissions. For example, the change in potential cancers is quite different for a change in emissions from four milligrams per mile (mg/mile) to two mg/mile as compared to a change in emissions from 0.5 mg/mile to 0.25 mg/mile. However, both represent a 50 percent change in emissions.

The following procedure was used to combine the individual equations for hydrocarbons and oxides of nitrogen.

1. The same EMFAC/BURDEN 7F Statewide Ozone Planning emissions inventory reports described above were used to calculate the VMT weighting factor.

2. For 1996, 2000, and 2005, the daily VMT for each Tech class was calculated by adding the "daily VMT" values from the emission inventory report for "light-duty passengers-cat" and "light duty trucks-cat."

3. VMT weighting factors were calculated by taking the daily VMT for each Tech class, and dividing this value by the total daily VMT from both Tech class 3 and Tech class 4. Values were calculated for both Tech classes and for the years 1996, 2000, and 2005. Average VMT weighting factors were calculated by summing the 1996, 2000, and 2005 daily VMT for the Tech class and dividing by three. Table D-7 shows the VMT weighting factors for Tech class 3 and 4 for 1996, 2000, and 2005 and the average for the three years combined. The average values were selected for use in the California predictive model.

We are also proposing to weight the mass of toxic air contaminants by the potential to cause cancer. The proposed California predictive model evaluates the percent difference between the potency-weighted emissions of the alternative gasoline formulation and the Phase 2 RFG reference fuel. In developing regulations to control emissions of toxic air contaminants, the ARB's policy is to consider the potency-weighted emissions of the particular toxic air contaminant. The ARB has identified benzene, 1,3-butadiene, formaldehyde and acetaldehyde as toxic air contaminants.

Table D-7

Technology Class Weightings for the Toxic Air Contaminants Based on the Fraction of Vehicle-Miles Travelled

Tech Class	Percent Weighting by Inventory Year			Average
	1996	2000	2005	
Tech Class 3	10.9	8.3	7.4	8.9
Tech Class 4	89.1	91.7	92.6	91.1

a/ Weightings based on vehicle-miles travelled.

Table D-8 lists the relative potencies of 1,3-butadiene, benzene, formaldehyde, and acetaldehyde. The relative potencies of these toxic compounds are based on cancer potency values provided by the Office of Environmental Health Hazard Assessment (OEHHA). The cancer potency value for each pollutant has been divided by the cancer potency value for 1,3-butadiene. If the model evaluated toxics on a mass basis, the relative impact of a milligram/mile reduction of formaldehyde would be equal to a milligram/mile reduction of 1,3-butadiene. This approach does not consider the potential cancer risk associated with each pollutant. As shown in Table D-8, the potential cancer risk associated with 1,3-butadiene is 62.5 times that of acetaldehyde. We believe the model should take this into account when evaluating the equivalency of two fuels.

Table D-8

Potency Weighting Factors (relative to 1,3-Butadiene)

Toxic Air Contaminant	Unit Risk $(\mu g/m^3)^{-1}$	Relative Potency
1,3-Butadiene	1.7E-4	1.0
Benzene	2.9E-5	0.17
Formaldehyde	6.0E-6	0.035
Acetaldehyde	2.7E-6	0.016

Reference: California Air Pollution Control Officers Association, Air Toxics Hot Spots Program, Revised 1992 Risk Assessment Guidelines, October 1993

3. How do we use the combined equations?

For an alternative gasoline formulation to be acceptable, the percent difference in emissions of hydrocarbons, oxides of nitrogen, and potency-weighted toxic air contaminants for the alternative gasoline specifications compared to the Phase 2 RFG reference specifications must be less than or equal to 0.04 percent for all pollutants.

The method used for hydrocarbons and oxides of nitrogen is straightforward. The percent difference between the predicted values for the alternative gasoline specifications and the Phase 2 RFG reference specifications is calculated. If the percent difference in emissions of hydrocarbons or oxides of nitrogen for the alternative gasoline specification compared to the Phase 2 RFG reference specifications is greater than 0.04 percent then the alternative gasoline formulation is not acceptable as an alternative Phase 2 RFG.

For the potency-weighted toxic air contaminants, there are eight different equations that must be combined (four toxic air contaminants and two Tech classes). There is also not an emissions inventory for the toxic air contaminants from mobile sources. Therefore, the comparison between two fuels is based on assuring that there is no increase in the relative potential number of cancer cases. This comparison is accomplished using the following procedure.

Step 1. Begin with the Phase 2 RFG reference specifications. For each Tech class by toxic air contaminant, multiply the fractional VMT (See Table D-7) times the predicted emissions (mg/mile) times the relative potency (See Table D-8).

Step 2. Sum all values to yield the total relative potential cancers for the Phase 2 RFG reference fuel.

Step 3. Repeat steps 1 - 2 for the proposed alternative gasoline specifications.

Step 4. Calculate the percent difference between the alternative gasoline specifications and the Phase 2 RFG reference specifications. If the difference is greater than 0.04 percent, the fuel is not acceptable as an alternative to Phase 2 RFG.

D. EVALUATION OF THE CALIFORNIA PREDICTIVE MODEL

We used two different approaches to determine if the California Predictive Model yields reasonable results. The first approach is to compare the results of the individual equations with selected observations from individual studies. The second approach is to produce and review linear plots of the results.

1. How well do the California predictive model predictions compare with observation?

The best approach for determining how well the California predictive model performs is to compare the model's predictions to the results of a study that is not part of the database. Unfortunately, there is no such study available at this time. As an alternative, we have selected certain studies that are part of the ARB working database to compare predictions versus observations. Two groups of studies were selected. The first group represented well-designed studies that tested fuels that were outside the Phase 2 region (most fuel property values are well above Phase 2 limits). For this group, the Auto/Oil AMOT (study 2 in Appendix C) and the Auto/Oil T90 (study 8 in Appendix C) studies were selected. The second group represented well-designed studies that tested fuels that were within the Phase 2 region (most fuel property values meet the Phase 2 limits). For this group, we selected the ARCO-EC-X (study 16 in Appendix C), ARB/GM-Confirmation (study 20 in Appendix C) and the GM/WSPA/CARB (study 9 in Appendix C) studies.

For each fuel in each study, we determined the average percent change in the observed emissions between the studies' reference fuel and each fuel tested. The reference fuel for the Auto/Oil studies was a gasoline meeting the nationwide average specifications. The reference fuel for the second group of studies approximated California Phase 1 gasoline for most properties. We then used the California predictive model to predict the percent change between the reference fuel and each fuel tested. Finally, we compared the observed percent change to the predicted percent change for each set of fuels.

Figure D-1 shows that for the two Auto/Oil studies (fuels outside the Phase 2 region), the number of times that the predicted percent change in emissions was within zero and five percent, five to 10 percent, and greater than 10 percent of the observed percent change. For example, if the observed percent change was five percent, predicted values of between plus 15 percent and minus five percent would be considered within 10 percent of the observed value. Figure D-2 shows similar predictions for the three studies with fuels in the Phase 2 region. These two graphs show that the California predictive model predictions are generally within 10% of the observed values. The model appears to predict better for fuels in the Phase 2 region and does better in predicting the percent change in hydrocarbons than oxides of nitrogen. These two points support the use of the California predictive model. Alternative gasoline specifications should be close to Phase 2 values where the model predicts better. Variability in emissions measurements are greater with hydrocarbons as compared to oxides of nitrogen. This favors the selection of a model that predicts better for hydrocarbons than for the oxides of nitrogen.

2. What do the linear plots show?

We developed 22 linear plots of the data to provide a visual indication of the performance of the model. The plots were useful in identifying unexpected behavior and as a quality control check on the coefficients in the model. For example, the linear plots were useful in identifying an unexpected response to olefins in the Tech class 3. Because the

plots generally do not recognize the interaction terms, they cannot be used to reach any conclusions on which model provides the best estimate.

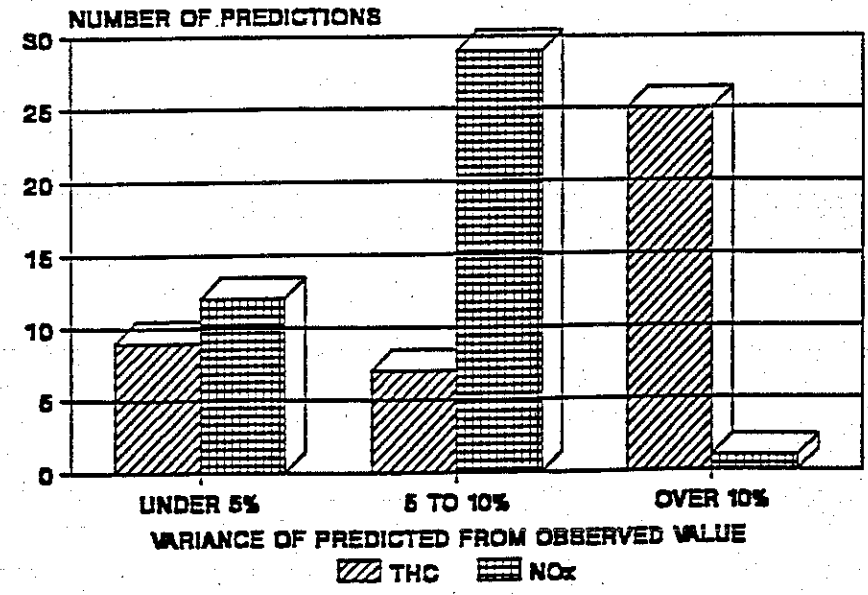
The following graphed results of the California predictive model are available from the Air Resources Board upon request. They may be obtained by containing the Public Information Office at (916) 322-2990.

California predictive model: Tech 3, Tech 4, and composite

Effect on hydrocarbons, oxides of nitrogen, and potency weighted toxics by varying fuel properties of Phase 2 "Flat Limit" gasoline [22 graphs].

Figure D-1

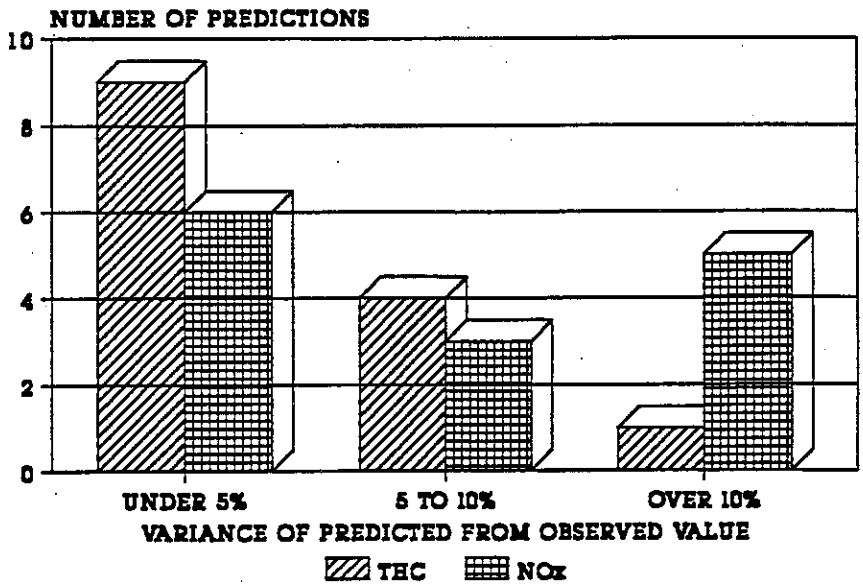
Model Predictions Versus Observed Results
of Fuels Outside the Phase 2 Region



*AUTO/OIL TSC & AMOT STUDIES

Figure D-2

Model Predictions Versus Observed Results
of Fuels in the Phase 2 Region



*ARCO-EC-X, ARB/GM CONFIRM., GM/WSPA/ARB

ATTACHMENT 1

EMISSIONS INVENTORY PRINTOUTS

PREDICTED CALIFORNIA VEHICLE EMISSIONS
OZONE PLANNING INVENTORY

RUNDATE: 3/10/1994

YEAR: 1996 -- MODEL YEARS 1981 TO 1985 INCLUSIVE

1996 Technology Class 3

EMISSION UNIT: TONS PER DAY

E7F/PHS2/1981 19/DAILY EMISSIONS/STATE

	LIGHT DUTY PASSENGERS				LIGHT DUTY TRUCKS				MEDIUM DUTY TRUCKS			--- HEAVY DUTY TRUCKS --- ----- GASOLINE TRUCKS -----			DIESEL	TOTAL HD	URBAN	MOTOR-	ALL
	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	TOTAL	NON-CAT	CAT	TOTAL	TRUCKS	TRUCKS	BUSES	CYCLES	VEHICLES
NO. OF IN USE VEHS	0	2375799	87179	2462978	0	710864	34913	745777	4145	183047	187192	97009	0	97009	32666	129675	1435	23364	3550421
DAILY VMT (X 1000)	0	47088	1712	48801	0	14037	601	14638	59	3097	3156	2280	0	2280	3445	5725	166	44	72530
NO. OF HOT TRIPS	0	2411265	87698	2498963	0	664944	28478	693422	4248	146675	150921	331261	0	331261	0	331261	0	3300	3677867
NO. OF COLD TRIPS	0	3693822	134340	3828162	0	1017075	43561	1060636	2877	224383	227260	216358	0	216358	0	216358	0	2240	5334656
NO. OF DAILY TRIPS	0	6105087	222038	6327125	0	1682019	72039	1754058	7123	4736051	4743174	547619	0	547619	0	547619	0	5540	13383056
TOTAL ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	35.13	0.64	35.77	0.00	20.51	0.22	20.73	0.08	6.93	7.01	7.47	0.00	7.47	10.62	18.09	0.78	0.22	82.61
COLD START EXHAUST	0.00	25.61	0.07	25.69	0.00	8.08	0.05	8.11	0.05	2.05	2.09	0.00	0.00	0.00	0.00	0.00	0.00	0.04	35.93
HOT START EXHAUST	0.00	1.35	0.01	1.36	0.00	0.20	0.01	0.21	0.01	0.09	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.03	1.70
TOTAL EXHAUST	0.00	82.09	0.73	82.82	0.00	28.77	0.28	29.05	0.14	9.06	9.20	7.47	0.00	7.47	10.62	18.09	0.78	0.30	120.24
DIURNAL EVAPORATION	0.00	8.72	0.00	8.72	0.00	2.88	0.00	2.88	0.04	0.77	0.81	0.25	0.00	0.25	0.00	0.25	0.00	0.13	12.79
HOT SOAK EVAPORATION	0.00	6.64	0.00	6.64	0.00	2.25	0.00	2.25	0.03	0.57	0.60	0.42	0.00	0.42	0.00	0.42	0.00	0.01	9.92
RUNNING LOSSES	0.00	13.00	0.00	13.00	0.00	3.15	0.00	3.15	0.01	0.67	0.68	0.43	0.00	0.43	0.00	0.43	0.00	0.00	17.27
RESTING LOSSES	0.00	10.15	0.00	10.15	0.00	3.04	0.00	3.04	0.02	0.78	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.00
TOTAL TOG EMISSION	0.00	100.61	0.73	101.34	0.00	40.10	0.28	40.37	0.24	11.86	12.10	8.57	0.00	8.57	10.62	19.19	0.78	0.43	174.22
REACTIVE ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	30.08	0.63	30.71	0.00	17.58	0.21	17.77	0.08	5.93	6.00	6.89	0.00	6.89	10.37	17.25	0.77	0.20	72.71
COLD START EXHAUST	0.00	21.93	0.07	22.00	0.00	6.90	0.05	6.95	0.04	1.75	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.04	30.78
HOT START EXHAUST	0.00	1.15	0.01	1.17	0.00	0.17	0.01	0.18	0.01	0.08	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.03	1.46
TOTAL EXHAUST	0.00	53.16	0.71	53.87	0.00	24.63	0.27	24.90	0.13	7.76	7.89	6.89	0.00	6.89	10.37	17.25	0.77	0.27	104.96
DIURNAL EVAPORATION	0.00	8.72	0.00	8.72	0.00	2.88	0.00	2.88	0.04	0.77	0.81	0.25	0.00	0.25	0.00	0.25	0.00	0.13	12.79
HOT SOAK EVAPORATION	0.00	6.64	0.00	6.64	0.00	2.25	0.00	2.25	0.03	0.57	0.60	0.42	0.00	0.42	0.00	0.42	0.00	0.01	9.92
RUNNING LOSSES	0.00	13.00	0.00	13.00	0.00	3.15	0.00	3.15	0.01	0.67	0.68	0.43	0.00	0.43	0.00	0.43	0.00	0.00	17.27
RESTING LOSSES	0.00	10.15	0.00	10.15	0.00	3.04	0.00	3.04	0.02	0.78	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.00
TOTAL ROG EMISSION	0.00	91.68	0.71	92.39	0.00	35.95	0.27	36.23	0.23	10.55	10.78	7.99	0.00	7.99	10.37	18.35	0.77	0.41	158.93
CARBON MONOXIDE EMISSIONS																			
RUNNING EXHAUST	0.00	338.33	2.51	340.85	0.00	156.04	0.86	156.90	1.15	40.57	41.72	190.40	0.00	190.40	40.45	230.85	3.73	0.65	776.69
COLD START EXHAUST	5.00	269.38	1.14	275.52	0.00	78.17	0.30	78.47	0.18	21.15	21.34	0.00	0.00	0.00	0.00	0.00	0.00	0.11	375.44
HOT START EXHAUST	0.00	54.07	0.35	54.42	0.00	17.27	0.13	17.40	0.09	2.96	3.06	0.00	0.00	0.00	0.00	0.00	0.00	0.04	74.91
TOTAL CO EMISSION	5.00	661.78	4.00	670.79	0.00	253.48	1.30	254.77	1.44	64.69	66.12	190.40	0.00	190.40	40.45	230.85	3.73	0.80	1227.05
OXIDES OF NITROGEN EMISSIONS																			
RUNNING EXHAUST	0.00	58.88	2.95	61.84	0.00	24.73	0.97	25.69	0.12	10.03	10.16	20.44	0.00	20.44	66.99	87.43	4.39	0.05	189.55
COLD START EXHAUST	0.00	13.11	0.03	13.14	0.00	3.29	0.05	3.35	0.01	1.16	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.66
HOT START EXHAUST	0.00	5.51	0.00	5.51	0.00	1.71	0.02	1.74	0.02	0.68	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.94
TOTAL NOX EMISSION	0.00	77.50	2.98	80.48	0.00	29.73	1.04	30.78	0.16	11.87	12.02	20.44	0.00	20.44	66.99	87.43	4.39	0.05	215.15
PARTICULATE MATTER EMISSIONS																			
EXHAUST	0.01	0.52	0.99	1.51	0.00	0.15	0.34	0.49	0.00	0.03	0.03	0.01	0.00	0.01	12.23	12.23	0.85	0.00	15.12
TIRE-WEAR	0.00	10.37	0.38	10.75	0.00	3.09	0.13	3.22	0.01	0.68	0.70	0.83	0.00	0.83	2.50	3.33	0.12	0.00	18.13
TOTAL PM EMISSION	0.01	10.88	1.38	12.26	0.00	3.25	0.47	3.72	0.01	0.72	0.73	0.84	0.00	0.84	14.73	15.57	0.97	0.01	33.25
LEAD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OXIDES - SULFUR	0.00	0.06	0.01	0.07	0.00	0.02	0.00	0.02	0.00	0.01	0.01	0.00	0.01	0.01	0.28	0.30	0.01	0.00	0.41
FUEL CONSUMED IN 1000 GALLONS																			
GASOLINE	12.69	292.14		304.83	1.78	88.46		90.25	1.52	46.56	48.07	15.68	36.18	51.84		51.84		1.02	496.02
DIESEL			1.43	1.43			0.52	0.52							80.20	80.20	1.78		83.94

PREDICTED CALIFORNIA VEHICLE EMISSIONS
OZONE PLANNING INVENTORY

1996 Technology Class 4

RUNDATE: 3/10/1994

YEAR: 1996 -- MODEL YEARS 1986 TO 1995 INCLUSIVE

EMISSION UNIT: TONS PER DAY

E7I/PHS2/1986 I9/DAILY EMISSIONS/STATE

	LIGHT DUTY PASSENGERS				LIGHT DUTY TRUCKS				MEDIUM DUTY TRUCKS			--- HEAVY DUTY TRUCKS ---						ALL VEHICLES
	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	TOTAL	GASOLINE TRUCKS NON-CAT	GASOLINE TRUCKS CAT	GASOLINE TRUCKS TOTAL	DIESEL TRUCKS	TOTAL HD TRUCKS	URBAN BUSES	MOTOR-CYCLES	
NO OF EN USE VEHS	0	12774701	45560	12820261	0	2919989	21171	2941160	0	973973	973973	66514	324759	391273	133676	524949	4026	646372	17910741
DAILY VMT (X 1000)	0	404857	1196	406053	0	85595	456	86051	0	32510	32510	2680	15401	18081	30052	48133	582	3144	586473
NO. OF HOT TRIPS	0	20731152	61283	20792435	0	4528444	21631	4550075	0	1539707	1539707	389420	1465613	1855033	0	1855033	0	234193	28971443
NO. OF COLD TRIPS	0	31758112	93876	31851988	0	6926548	33088	6959636	0	2355435	2355435	254344	2233362	2487706	0	2487706	0	158995	43813760
NO OF DAILY TRIPS	0	52489264	155159	52644423	0	11454992	54719	11509711	0	4736051	4736051	643764	3698975	4342739	0	4342739	0	393188	74019300
TOTAL ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	70.64	0.34	70.99	0.00	26.48	0.13	26.60	0.00	15.77	15.77	3.29	9.59	12.88	65.11	77.99	2.41	7.59	201.34
COLD START EXHAUST	0.00	134.51	0.04	134.55	0.00	33.20	0.03	33.23	0.00	14.63	14.63	0.00	0.00	0.00	0.00	0.00	0.00	1.53	183.94
HOT START EXHAUST	0.00	11.93	0.01	11.93	0.00	3.44	0.01	3.44	0.00	2.07	2.07	0.00	0.00	0.00	0.00	0.00	0.00	1.23	18.68
TOTAL EXHAUST	0.00	217.08	0.39	217.47	0.00	63.12	0.16	63.28	0.00	32.46	32.46	3.29	9.59	12.88	65.11	77.99	2.41	10.35	403.97
DIURNAL EVAPORATION	0.00	24.99	0.00	24.99	0.00	6.19	0.00	6.19	0.00	1.86	1.86	0.13	0.53	0.65	0.00	0.65	0.00	0.61	34.30
HOT SOAK EVAPORATION	0.00	15.87	0.00	15.87	0.00	4.03	0.00	4.03	0.00	1.02	1.02	0.42	2.26	2.68	0.00	2.68	0.00	0.21	23.81
RUNNING LOSSES	0.00	78.58	0.00	78.58	0.00	13.58	0.00	13.58	0.00	4.51	4.51	0.36	1.98	2.34	0.00	2.34	0.00	0.00	99.01
RESTING LOSSES	0.00	19.45	0.00	19.45	0.00	4.98	0.00	4.98	0.00	1.42	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.85
TOTAL TOG EMISSION	0.00	355.97	0.39	356.36	0.00	91.80	0.16	92.05	0.00	41.29	41.29	4.19	14.36	18.58	65.11	83.67	2.41	11.16	586.94
REACTIVE ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	60.48	0.33	60.82	0.00	22.67	0.12	22.79	0.00	13.50	13.50	3.03	8.22	11.25	63.53	74.78	2.35	7.00	181.24
COLD START EXHAUST	0.00	115.17	0.04	115.21	0.00	28.43	0.03	28.45	0.00	12.53	12.53	0.00	0.00	0.00	0.00	0.00	0.00	1.41	157.60
HOT START EXHAUST	0.00	10.21	0.01	10.22	0.00	2.94	0.01	2.95	0.00	1.77	1.77	0.00	0.00	0.00	0.00	0.00	0.00	1.14	16.07
TOTAL EXHAUST	0.00	185.86	0.38	186.25	0.00	54.04	0.15	54.20	0.00	27.80	27.80	3.03	8.22	11.25	63.53	74.78	2.35	8.54	354.92
DIURNAL EVAPORATION	0.00	24.99	0.00	24.99	0.00	6.19	0.00	6.19	0.00	1.86	1.86	0.13	0.53	0.65	0.00	0.65	0.00	0.61	34.30
HOT SOAK EVAPORATION	0.00	15.87	0.00	15.87	0.00	4.03	0.00	4.03	0.00	1.02	1.02	0.42	2.26	2.68	0.00	2.68	0.00	0.21	23.81
RUNNING LOSSES	0.00	78.58	0.00	78.58	0.00	13.58	0.00	13.58	0.00	4.51	4.51	0.36	1.98	2.34	0.00	2.34	0.00	0.00	99.01
RESTING LOSSES	0.00	19.45	0.00	19.45	0.00	4.98	0.00	4.98	0.00	1.42	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.85
TOTAL ROG EMISSION	0.00	324.75	0.38	325.14	0.00	82.82	0.15	82.97	0.00	36.62	36.62	3.94	12.98	16.92	63.53	80.45	2.35	10.36	537.89
CARBON MONOXIDE EMISSIONS																			
RUNNING EXHAUST	0.00	1024.18	1.31	1025.48	0.00	325.24	0.48	325.72	0.00	103.97	103.97	53.53	144.16	197.69	289.56	487.25	11.42	37.05	1990.90
COLD START EXHAUST	5.00	1430.75	0.57	1436.31	0.00	374.79	0.17	374.96	0.00	177.83	177.83	0.00	0.00	0.00	0.00	0.00	0.00	7.59	1996.70
HOT START EXHAUST	0.00	219.98	0.17	220.16	0.00	59.76	0.07	59.83	0.00	19.70	19.70	0.00	0.00	0.00	0.00	0.00	0.00	3.26	302.95
TOTAL CO EMISSION	5.00	2674.91	2.05	2681.96	0.00	759.80	0.72	760.51	0.00	301.51	301.51	53.53	144.16	197.69	289.56	487.25	11.42	47.90	4290.54
OXIDES OF NITROGEN EMISSIONS																			
RUNNING EXHAUST	0.00	194.35	1.62	195.98	0.00	69.28	0.61	69.89	0.00	45.18	45.18	20.83	85.93	106.76	388.00	494.76	11.76	3.35	820.91
COLD START EXHAUST	0.00	65.01	0.02	65.03	0.00	18.06	0.03	18.09	0.00	10.28	10.28	0.00	0.00	0.00	0.00	0.00	0.00	0.12	93.52
HOT START EXHAUST	0.00	20.90	0.00	20.90	0.00	6.14	0.01	6.15	0.00	3.70	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.15	30.90
TOTAL NOX EMISSION	0.00	280.26	1.64	281.90	0.00	93.48	0.66	94.13	0.00	59.16	59.16	20.83	85.93	106.76	388.00	494.76	11.76	3.62	945.33
PARTICULATE MATTER EMISSIONS																			
EXHAUST	0.51	4.46	0.39	5.35	0.06	1.05	0.14	1.26	0.05	0.36	0.40	0.52	1.36	1.88	37.47	39.35	1.33	0.03	47.72
TIRE-WEAR	0.00	89.18	0.26	89.44	0.00	21.06	0.10	21.16	0.00	7.16	7.16	0.97	5.60	6.57	21.84	28.42	0.42	0.35	146.84
TOTAL PM EMISSION	0.51	93.63	0.65	94.78	0.06	22.11	0.24	22.41	0.05	7.52	7.56	1.49	6.95	8.45	59.31	67.78	1.75	0.38	194.66
LEAD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OXIDES - SULFUR	0.23	4.50	0.36	5.08	0.03	1.37	0.13	1.53	0.03	0.78	0.80	0.26	0.64	0.90	20.12	21.02	0.45	0.02	28.90
FUEL CONSUMED IN 1000 GALLONS																			
GASOLINE	900.65	18135.91		19036.57	127.04	5502.30		5629.33	100.51	3114.06	3214.56	1035.26	2570.67	3605.93		3605.93		83.70	31550.08
DIESEL			101.61	101.61			37.07	37.07							5691.23	5691.23	126.47		5956.38

PREDICTED CALIFORNIA VEHICLE EMISSIONS
OZONE PLANNING INVENTORY

RUNDATE: 3/10/1994

YEAR: 2000 -- MODEL YEARS 1981 TO 1985 INCLUSIVE

2000 Technology Class 3

EMISSION UNIT: TONS PER DAY

E7F/PHS2/1981 I9/DAILY EMISSIONS/STATE

	LIGHT DUTY PASSENGERS				LIGHT DUTY TRUCKS				MEDIUM DUTY TRUCKS			--- HEAVY DUTY TRUCKS --- GASOLINE TRUCKS						
	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	TOTAL	NON-CAT	CAT	TOTAL	DIESEL TRUCKS	TOTAL HD TRUCKS	URBAN BUSES	MOTOR-CYCLES	ALL VEHICLES
NO. OF IN USE VEHS	0	1262957	46378	1309335	0	223013	11128	234141	2499	113906	116405	72609	0	72609	25487	98096	413	0	1758390
DAILY VMT (X 1000)	0	22108	734	22842	0	3407	164	3571	26	1431	1457	1211	0	1211	1931	3142	41	0	31053
NO. OF HOT TRIPS	0	1105577	36738	1142315	0	156755	7554	164309	1858	65879	67737	179035	0	179035	0	179035	0	0	1553396
NO. OF COLD TRIPS	0	1693640	56286	1749926	0	239767	11562	251329	1258	100783	102041	116934	0	116934	0	116934	0	0	2220230
NO. OF DAILY TRIPS	0	2799217	93024	2892241	0	396522	19116	415638	3116	5187088	5190204	295969	0	295969	0	295969	0	0	8794052
TOTAL ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	19.39	0.29	19.68	0.00	5.87	0.08	5.93	0.04	3.51	3.56	4.22	0.00	4.22	6.14	10.35	0.21	0.00	39.72
COLD START EXHAUST	0.00	12.89	0.03	12.92	0.00	2.09	0.01	2.10	0.02	0.99	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.03
HOT START EXHAUST	0.00	0.64	0.01	0.65	0.00	0.05	0.00	0.05	0.01	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74
TOTAL EXHAUST	0.00	32.93	0.32	33.25	0.00	8.00	0.08	8.08	0.07	4.55	4.62	4.22	0.00	4.22	6.14	10.35	0.21	0.00	56.50
DIURNAL EVAPORATION	0.00	5.51	0.00	5.51	0.00	1.10	0.00	1.10	0.03	0.58	0.61	0.21	0.00	0.21	0.00	0.21	0.00	0.00	7.42
HOT SOAK EVAPORATION	0.00	3.97	0.00	3.97	0.00	0.70	0.00	0.70	0.02	0.33	0.35	0.24	0.00	0.24	0.00	0.24	0.00	0.00	5.25
RUNNING LOSSES	0.00	7.90	0.00	7.90	0.00	1.00	0.00	1.00	0.01	0.40	0.41	0.30	0.00	0.30	0.00	0.30	0.00	0.00	9.60
RESTING LOSSES	0.00	5.40	0.00	5.40	0.00	0.96	0.00	0.96	0.01	0.49	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.86
TOTAL ROG EMISSION	0.00	55.70	0.32	56.02	0.00	11.75	0.08	11.83	0.13	6.35	6.48	4.98	0.00	4.98	6.14	11.10	0.21	0.00	85.63
REACTIVE ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	16.60	0.28	16.89	0.00	5.02	0.06	5.08	0.04	3.01	3.05	3.89	0.00	3.89	5.99	9.88	0.20	0.00	35.09
COLD START EXHAUST	0.00	11.04	0.03	11.07	0.00	1.79	0.01	1.80	0.02	0.85	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.74
HOT START EXHAUST	0.00	0.55	0.01	0.55	0.00	0.04	0.00	0.04	0.01	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64
TOTAL EXHAUST	0.00	28.19	0.32	28.51	0.00	6.85	0.08	6.92	0.06	3.89	3.96	3.89	0.00	3.89	5.99	9.88	0.20	0.00	49.47
DIURNAL EVAPORATION	0.00	5.51	0.00	5.51	0.00	1.10	0.00	1.10	0.03	0.58	0.61	0.21	0.00	0.21	0.00	0.21	0.00	0.00	7.42
HOT SOAK EVAPORATION	0.00	3.97	0.00	3.97	0.00	0.70	0.00	0.70	0.02	0.33	0.35	0.24	0.00	0.24	0.00	0.24	0.00	0.00	5.25
RUNNING LOSSES	0.00	7.90	0.00	7.90	0.00	1.00	0.00	1.00	0.01	0.40	0.41	0.30	0.00	0.30	0.00	0.30	0.00	0.00	9.60
RESTING LOSSES	0.00	5.40	0.00	5.40	0.00	0.96	0.00	0.96	0.01	0.49	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.86
TOTAL ROG EMISSION	0.00	50.96	0.32	51.28	0.00	10.60	0.08	10.67	0.13	5.69	5.82	4.63	0.00	4.63	5.98	10.62	0.20	0.00	78.59
CARBON MONOXIDE EMISSIONS																			
RUNNING EXHAUST	0.00	187.57	1.16	188.73	0.00	46.46	0.28	46.71	0.57	21.15	21.72	109.47	0.00	109.47	23.44	132.91	0.99	0.00	391.06
COLD START EXHAUST	2.56	134.75	0.54	137.84	0.00	20.13	0.09	20.21	0.09	10.09	10.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	168.23
HOT START EXHAUST	0.00	27.90	0.16	28.06	0.00	4.46	0.04	4.50	0.04	1.49	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.09
TOTAL CO EMISSION	2.58	350.22	1.86	354.63	0.00	71.05	0.38	71.43	0.70	32.73	33.43	109.47	0.00	109.47	23.44	132.91	0.99	0.00	593.38
OXIDES OF NITROGEN EMISSIONS																			
RUNNING EXHAUST	0.00	31.06	1.32	32.38	0.00	8.88	0.28	7.13	0.08	5.02	5.08	11.29	0.00	11.29	39.47	50.76	1.17	0.00	96.52
COLD START EXHAUST	0.00	6.38	0.01	6.39	0.00	0.85	0.01	0.86	0.01	0.54	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.80
HOT START EXHAUST	0.00	2.79	0.00	2.79	0.00	0.46	0.01	0.47	0.01	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.60
TOTAL NOX EMISSION	0.00	40.23	1.33	41.57	0.00	8.17	0.30	8.48	0.07	5.89	5.96	11.29	0.00	11.29	39.47	50.76	1.17	0.00	107.92
PARTICULATE MATTER EMISSIONS																			
EXHAUST	0.00	0.24	0.44	0.69	0.00	0.04	0.10	0.13	0.00	0.02	0.02	0.00	0.00	0.00	8.67	8.67	0.29	0.00	9.79
TIRE-WEAR	0.00	4.87	0.16	5.03	0.00	0.75	0.04	0.79	0.01	0.32	0.32	0.44	0.00	0.44	1.40	1.84	0.03	0.00	8.01
TOTAL PM EMISSION	0.00	5.11	0.60	5.72	0.00	0.79	0.13	0.92	0.01	0.33	0.34	0.44	0.00	0.44	10.07	10.51	0.32	0.00	17.80
LEAD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OXIDES - SULFUR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FUEL CONSUMED IN 1000 GALLONS																			
GASOLINE	0.00	22.77		22.77	0.00	3.75		3.75	0.06	1.80	1.86	0.74	0.00	0.74		0.74		0.00	29.12
DIESEL			0.00	0.00			0.00	0.00							0.00	0.00	0.00		0.00

PREDICTED CALIFORNIA VEHICLE EMISSIONS
OZONE PLANNING INVENTORY

2000 Technology Class 4

RUNDATE: 3/10/1994

YEAR: 2000 - MODEL YEARS 1986 TO 1995 INCLUSIVE

EMISSION UNIT: TONS PER DAY

E7F/PH52/1986 19/DAILY EMISSIONS/STATE

	LIGHT DUTY PASSENGERS				LIGHT DUTY TRUCKS				MEDIUM DUTY TRUCKS			--- HEAVY DUTY TRUCKS --- ----- GASOLINE TRUCKS -----						ALL
	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	TOTAL	NON-CAT	CAT	TOTAL	DIESEL TRUCKS	TOTAL HD TRUCKS	URBAN BUSES	MOTOR-CYCLES	VEHICLES
NO OF IN USE VEHS	0	9354683	26708	9381391	0	2821056	11533	2832589	0	665708	665708	49602	249961	299563	105718	405281	4125	274977	13364071
DAILY VMT (X 1000)	0	247371	512	247883	0	69843	197	70140	0	16653	16653	1437	8470	9907	17566	27473	541	996	363686
NO OF HOT TRIPS	0	12370498	25602	12396100	0	3217887	9058	3226945	0	766483	766483	212523	820212	1032735	0	1032735	0	73750	17496013
NO OF COLD TRIPS	0	18950412	39224	18989636	0	4921959	13864	4935823	0	1172571	1172571	138806	1249879	1388685	0	1388685	0	50067	26536802
NO OF DAILY TRIPS	0	31320930	64826	31385756	0	8139846	22922	8162768	0	5187088	5187088	351329	2070091	2421420	0	2421420	0	123817	47404666
TOTAL ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	58.08	0.16	58.24	0.00	23.22	0.06	23.28	0.00	10.08	10.08	2.07	6.79	8.87	41.66	50.52	2.56	3.51	148.19
COLD START EXHAUST	0.00	91.82	0.02	91.83	0.00	26.91	0.01	26.92	0.00	8.87	8.87	0.00	0.00	0.00	0.00	0.00	0.00	0.68	128.30
HOT START EXHAUST	0.00	8.50	0.00	8.51	0.00	2.88	0.00	2.88	0.00	1.26	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.54	13.19
TOTAL EXHAUST	0.00	158.40	0.18	158.57	0.00	53.01	0.07	53.08	0.00	20.21	20.21	2.07	6.79	8.87	41.66	50.52	2.56	4.73	289.68
DIURNAL EVAPORATION	0.00	22.84	0.00	22.84	0.00	6.70	0.00	6.70	0.00	1.63	1.63	0.12	0.54	0.65	0.00	0.65	0.00	0.26	32.08
HOT SOAK EVAPORATION	0.00	15.18	0.00	15.18	0.00	4.22	0.00	4.22	0.00	0.89	0.89	0.25	1.44	1.69	0.00	1.69	0.00	0.07	22.04
RUNNING LOSSES	0.00	85.94	0.00	85.94	0.00	20.38	0.00	20.38	0.00	5.14	5.14	0.37	2.33	2.70	0.00	2.70	0.00	0.00	114.16
RESTING LOSSES	0.00	13.19	0.00	13.19	0.00	3.81	0.00	3.81	0.00	0.94	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.94
TOTAL ROG EMISSION	0.00	295.55	0.18	295.72	0.00	88.12	0.07	88.19	0.00	28.80	28.80	2.81	11.10	13.92	41.66	55.57	2.56	5.05	475.90
REACTIVE ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	49.73	0.15	49.88	0.00	19.88	0.06	19.94	0.00	8.63	8.63	1.91	5.82	7.73	40.65	48.38	2.50	3.23	132.56
COLD START EXHAUST	0.00	78.61	0.02	78.63	0.00	23.04	0.01	23.05	0.00	7.59	7.59	0.00	0.00	0.00	0.00	0.00	0.00	0.63	109.90
HOT START EXHAUST	0.00	7.28	0.00	7.28	0.00	2.46	0.00	2.47	0.00	1.08	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.50	11.33
TOTAL EXHAUST	0.00	135.62	0.17	135.79	0.00	45.39	0.07	45.46	0.00	17.30	17.30	1.91	5.82	7.73	40.65	48.38	2.50	4.36	253.79
DIURNAL EVAPORATION	0.00	22.84	0.00	22.84	0.00	6.70	0.00	6.70	0.00	1.63	1.63	0.12	0.54	0.65	0.00	0.65	0.00	0.26	32.08
HOT SOAK EVAPORATION	0.00	15.18	0.00	15.18	0.00	4.22	0.00	4.22	0.00	0.89	0.89	0.25	1.44	1.69	0.00	1.69	0.00	0.07	22.04
RUNNING LOSSES	0.00	85.94	0.00	85.94	0.00	20.38	0.00	20.38	0.00	5.14	5.14	0.37	2.33	2.70	0.00	2.70	0.00	0.00	114.16
RESTING LOSSES	0.00	13.19	0.00	13.19	0.00	3.81	0.00	3.81	0.00	0.94	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.94
TOTAL ROG EMISSION	0.00	272.77	0.17	272.94	0.00	80.49	0.07	80.56	0.00	25.89	25.89	2.65	10.12	12.78	40.65	53.43	2.50	4.68	440.01
CARBON MONOXIDE EMISSIONS																			
RUNNING EXHAUST	0.00	879.91	0.64	880.55	0.00	307.52	0.23	307.75	0.00	79.15	79.15	31.50	93.51	125.01	184.90	309.91	11.67	13.01	1602.04
COLD START EXHAUST	2.56	988.88	0.28	991.72	0.00	308.98	0.08	309.06	0.00	109.28	109.28	0.00	0.00	0.00	0.00	0.00	0.00	2.40	1412.46
HOT START EXHAUST	0.00	159.24	0.09	159.33	0.00	50.49	0.03	50.52	0.00	13.37	13.37	0.00	0.00	0.00	0.00	0.00	0.00	0.89	224.11
TOTAL CO EMISSION	2.56	2028.04	1.01	2031.60	0.00	666.99	0.35	667.33	0.00	201.80	201.80	31.50	93.51	125.01	184.90	309.91	11.67	16.30	3238.61
OXIDES OF NITROGEN EMISSIONS																			
RUNNING EXHAUST	0.00	147.45	0.74	148.19	0.00	62.84	0.27	63.11	0.00	29.17	29.17	12.15	52.70	64.85	246.78	311.63	12.08	1.06	565.24
COLD START EXHAUST	0.00	42.89	0.01	42.90	0.00	14.70	0.01	14.71	0.00	5.90	5.90	0.00	0.00	0.00	0.00	0.00	0.00	0.04	63.55
HOT START EXHAUST	0.00	15.26	0.00	15.26	0.00	5.42	0.01	5.43	0.00	2.30	2.30	0.00	0.00	0.00	0.00	0.00	0.00	0.05	23.03
TOTAL NOX EMISSION	0.00	205.60	0.74	206.35	0.00	82.96	0.30	83.26	0.00	37.36	37.36	12.15	52.70	64.85	246.78	311.63	12.08	1.15	651.82
PARTICULATE MATTER EMISSIONS																			
EXHAUST	0.08	2.72	0.18	2.99	0.00	0.77	0.07	0.84	0.01	0.18	0.19	0.11	0.75	0.86	29.40	30.25	1.73	0.01	36.01
TIRE WEAR	0.00	54.49	0.11	54.60	0.00	15.41	0.04	15.45	0.00	3.67	3.67	0.52	3.08	3.60	12.77	16.37	0.39	0.11	90.59
TOTAL PM EMISSION	0.08	57.21	0.30	57.58	0.00	16.18	0.11	16.29	0.01	3.85	3.86	0.63	3.82	4.46	42.18	46.62	2.12	0.12	126.60
LEAD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OXIDES - SULFUR	0.03	1.38	0.05	1.47	0.00	0.43	0.01	0.44	0.00	0.25	0.25	0.05	0.22	0.28	6.28	6.56	0.13	0.00	8.86
FUEL CONSUMED IN 1000 GALLONS																			
GASOLINE	138.87	5672.12		5811.00	4.25	1751.83		1756.09	12.03	1011.84	1023.87	219.53	903.50	1123.03		1123.03		20.25	9734.23
DIESEL			13.18	13.18			4.03	4.03							1777.40	1777.40	36.88		1831.49

PREDICTED CALIFORNIA VEHICLE EMISSIONS
OZONE PLANNING INVENTORY

RUNDATE: 3/10/1994

YEAR: 2005 -- MODEL YEARS 1981 TO 1985 INCLUSIVE

2005 Technology Class 3

EMISSION UNIT: TONS PER DAY

E7:/PH52/1981 19/DAILY EMISSIONS/STATE

	LIGHT DUTY PASSENGERS				LIGHT DUTY TRUCKS				MEDIUM DUTY TRUCKS			--- HEAVY DUTY TRUCKS ---						ALL VEHICLES
	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	TOTAL	----- GASOLINE TRUCKS ----- NON-CAT	CAT	TOTAL	DIESEL TRUCKS	TOTAL HD TRUCKS	URBAN BUSES	MOTOR-CYCLES	
NO. OF IN USE VEHS	0	595782	22293	818075	0	170412	9078	179490	2574	88656	91230	60608	0	60608	18615	79223	203	0	968221
DAILY VMT (X 1000)	0	8758	322	10080	0	2229	124	2353	30	1006	1036	789	0	789	1151	1940	16	0	15425
NO. OF HOT TRIPS	0	475200	15710	490910	0	99411	5557	104968	2025	44891	46916	118933	0	118933	0	118933	0	0	761727
NO. OF COLD TRIPS	0	727952	24063	752015	0	152051	8498	160549	1365	68673	70038	77681	0	77681	0	77681	0	0	1060283
NO. OF DAILY TRIPS	0	1203152	39773	1242925	0	251462	14055	265517	3390	5664120	5667510	196614	0	196614	0	196614	0	0	7372566
TOTAL ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	10.09	0.13	10.22	0.00	4.87	0.05	4.92	0.05	2.80	2.85	3.05	0.00	3.05	3.77	6.82	0.09	0.00	24.90
COLD START EXHAUST	0.00	6.05	0.01	6.07	0.00	1.50	0.01	1.51	0.03	0.68	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.29
HOT START EXHAUST	0.00	0.28	0.00	0.28	0.00	0.02	0.00	0.02	0.01	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
TOTAL EXHAUST	0.00	16.43	0.15	16.57	0.00	6.38	0.06	6.44	0.08	3.52	3.61	3.05	0.00	3.05	3.77	6.82	0.09	0.00	33.54
DIURNAL EVAPORATION	0.00	3.14	0.00	3.14	0.00	1.03	0.00	1.03	0.04	0.55	0.59	0.19	0.00	0.19	0.00	0.19	0.00	0.00	4.95
HOT SOAK EVAPORATION	0.00	2.21	0.00	2.21	0.00	0.58	0.00	0.59	0.02	0.30	0.32	0.17	0.00	0.17	0.00	0.17	0.00	0.00	3.29
RUNNING LOSSES	0.00	4.48	0.00	4.48	0.00	0.83	0.00	0.83	0.01	0.36	0.37	0.24	0.00	0.24	0.00	0.24	0.00	0.00	5.92
RESTING LOSSES	0.00	2.55	0.00	2.55	0.00	0.73	0.00	0.73	0.01	0.38	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.68
TOTAL ROG EMISSION	0.00	28.81	0.15	28.98	0.00	9.56	0.08	9.62	0.16	5.12	5.28	3.65	0.00	3.65	3.77	7.42	0.09	0.00	51.38
REACTIVE ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	8.64	0.13	8.77	0.00	4.17	0.05	4.22	0.05	2.39	2.44	2.81	0.00	2.81	3.68	6.49	0.09	0.00	22.00
COLD START EXHAUST	0.00	5.18	0.01	5.20	0.00	1.28	0.01	1.28	0.02	0.59	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.10
HOT START EXHAUST	0.00	0.24	0.00	0.24	0.00	0.02	0.00	0.02	0.01	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
TOTAL EXHAUST	0.00	14.08	0.14	14.21	0.00	5.47	0.06	5.53	0.08	3.02	3.09	2.81	0.00	2.81	3.68	6.49	0.09	0.00	29.41
DIURNAL EVAPORATION	0.00	3.14	0.00	3.14	0.00	1.03	0.00	1.03	0.04	0.55	0.59	0.19	0.00	0.19	0.00	0.19	0.00	0.00	4.95
HOT SOAK EVAPORATION	0.00	2.21	0.00	2.21	0.00	0.59	0.00	0.59	0.02	0.30	0.32	0.17	0.00	0.17	0.00	0.17	0.00	0.00	3.29
RUNNING LOSSES	0.00	4.48	0.00	4.48	0.00	0.83	0.00	0.83	0.01	0.36	0.37	0.24	0.00	0.24	0.00	0.24	0.00	0.00	5.92
RESTING LOSSES	0.00	2.55	0.00	2.55	0.00	0.73	0.00	0.73	0.01	0.38	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.68
TOTAL ROG EMISSION	0.00	26.45	0.14	26.59	0.00	8.64	0.06	8.70	0.16	4.61	4.77	3.41	0.00	3.41	3.68	7.09	0.09	0.00	47.25
CARBON MONOXIDE EMISSIONS																			
RUNNING EXHAUST	0.00	98.89	0.56	99.44	0.00	39.03	0.21	39.24	0.71	19.28	19.99	81.34	0.00	81.34	14.58	95.92	0.43	0.00	255.03
COLD START EXHAUST	0.81	63.34	0.26	64.40	0.00	14.24	0.07	14.31	0.10	7.10	7.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.90
HOT START EXHAUST	0.00	13.50	0.08	13.58	0.00	2.99	0.03	3.02	0.05	0.97	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.62
TOTAL CO EMISSION	0.81	175.73	0.89	177.42	0.00	56.26	0.31	56.57	0.85	27.35	28.20	81.34	0.00	81.34	14.58	95.92	0.43	0.00	358.55
OXIDES OF NITROGEN EMISSIONS																			
RUNNING EXHAUST	0.00	15.50	0.61	16.11	0.00	5.42	0.22	5.64	0.07	3.74	3.80	7.68	0.00	7.68	24.90	32.58	0.50	0.00	58.64
COLD START EXHAUST	0.00	2.92	0.01	2.93	0.00	0.81	0.01	0.82	0.01	0.39	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.95
HOT START EXHAUST	0.00	1.34	0.00	1.34	0.00	0.36	0.00	0.36	0.01	0.25	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.96
TOTAL NOX EMISSION	0.00	19.76	0.62	20.38	0.00	6.39	0.24	6.63	0.08	4.38	4.47	7.68	0.00	7.68	24.90	32.58	0.50	0.00	64.55
PARTICULATE MATTER EMISSIONS																			
EXHAUST	0.00	0.11	0.20	0.31	0.00	0.02	0.07	0.10	0.00	0.01	0.01	0.00	0.00	0.00	5.08	5.08	0.15	0.00	6.64
TIRE WEAR	0.00	2.15	0.07	2.22	0.00	0.49	0.03	0.52	0.01	0.22	0.23	0.29	0.00	0.29	0.84	1.12	0.01	0.00	4.10
TOTAL PM EMISSION	0.00	2.26	0.27	2.53	0.00	0.52	0.10	0.62	0.01	0.23	0.24	0.29	0.00	0.29	5.91	7.20	0.16	0.00	10.75
LEAD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OXIDES - SULFUR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FUEL CONSUMED IN 1000 GALLONS																			
GASOLINE	0.00	12.39		12.39	0.00	3.18		3.18	0.08	1.60	1.68	0.60	0.00	0.60		0.60		0.00	17.84
DIESEL			0.00	0.00			0.00	0.00							0.00	0.00	0.00		0.00

PREDICTED CALIFORNIA VEHICLE EMISSIONS
OZONE PLANNING INVENTORY

RUNDATE: 3/10/1994

YEAR: 2005 -- MODEL YEARS 1986 TO 1995 INCLUSIVE

2005 Technology Class 4

EMISSION UNIT: TONS PER DAY

E7F/PHS2/1986 I9/DAILY EMISSIONS/STATE

	LIGHT DUTY PASSENGERS				LIGHT DUTY TRUCKS				MEDIUM DUTY TRUCKS			--- HEAVY DUTY TRUCKS --- GASOLINE TRUCKS			DIESEL	TOTAL HD	URBAN	MOTOR-	ALL
	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	DIESEL	TOTAL	NON-CAT	CAT	TOTAL	NON-CAT	CAT	TOTAL	TRUCKS	TRUCKS	BUSES	CYCLES	VEHICLES
NO. OF IN USE VEHS	0	5024088	11705	5035793	0	1347370	2984	1350354	0	376260	376260	33030	169165	202195	69658	271863	2117	44856	7081243
DAILY VMT (X 1000)	0	104703	182	104885	0	28439	41	28480	0	6521	6521	626	3734	4360	7598	11958	244	96	152184
NO. OF HOT TRIPS	0	5098406	8905	5107311	0	1267985	1858	1269843	0	290976	290976	94140	368586	462926	0	462926	0	7039	7138095
NO. OF COLD TRIPS	0	7810166	13640	7823806	0	1939400	2841	1942241	0	445124	445124	61617	561670	623287	0	623287	0	4779	10839237
NO. OF DAILY TRIPS	0	12908572	22545	12931117	0	3207385	4699	3212084	0	5664120	5664120	155957	930256	1086213	0	1086213	0	11818	22917170
TOTAL ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	31.11	0.06	31.18	0.00	8.85	0.01	8.86	0.00	4.59	4.59	1.04	3.62	4.66	19.61	24.27	1.33	0.44	71.67
COLD START EXHAUST	0.00	42.55	0.01	42.56	0.00	10.98	0.00	10.99	0.00	3.84	3.84	0.00	0.00	0.00	0.00	0.00	0.00	0.08	57.46
HOT START EXHAUST	0.00	4.05	0.00	4.05	0.00	1.19	0.00	1.19	0.00	0.55	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.06	5.85
TOTAL EXHAUST	0.00	77.72	0.07	77.79	0.00	22.02	0.02	22.04	0.00	8.98	8.98	1.04	3.62	4.66	19.61	24.27	1.33	0.59	134.99
DIURNAL EVAPORATION	0.00	15.38	0.00	15.38	0.00	4.07	0.00	4.07	0.00	1.17	1.17	0.09	0.45	0.54	0.00	0.54	0.00	0.04	21.20
HOT SOAK EVAPORATION	0.00	9.40	0.00	9.40	0.00	2.21	0.00	2.21	0.00	0.51	0.51	0.12	0.71	0.84	0.00	0.84	0.00	0.01	12.97
RUNNING LOSSES	0.00	58.96	0.00	58.96	0.00	14.30	0.00	14.30	0.00	3.59	3.59	0.27	1.78	2.04	0.00	2.04	0.00	0.00	78.89
RESTING LOSSES	0.00	6.59	0.00	6.59	0.00	1.54	0.00	1.54	0.00	0.52	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.65
TOTAL TOG EMISSION	0.00	166.05	0.07	166.12	0.00	44.15	0.02	44.17	0.00	14.77	14.77	1.52	6.56	8.08	19.61	27.68	1.33	0.63	256.71
REACTIVE ORGANIC GAS EMISSIONS																			
RUNNING EXHAUST	0.00	26.64	0.06	26.70	0.00	8.43	0.01	8.45	0.00	3.83	3.83	0.98	3.10	4.08	19.13	23.18	1.30	0.41	63.98
COLD START EXHAUST	0.00	38.43	0.01	38.44	0.00	9.40	0.00	9.41	0.00	3.29	3.29	0.00	0.00	0.00	0.00	0.00	0.00	0.08	48.21
HOT START EXHAUST	0.00	3.47	0.00	3.47	0.00	1.02	0.00	1.02	0.00	0.47	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.06	5.02
TOTAL EXHAUST	0.00	68.54	0.07	68.61	0.00	18.86	0.02	18.87	0.00	7.69	7.69	0.98	3.10	4.08	19.13	23.18	1.30	0.54	118.20
DIURNAL EVAPORATION	0.00	15.38	0.00	15.38	0.00	4.07	0.00	4.07	0.00	1.17	1.17	0.09	0.45	0.54	0.00	0.54	0.00	0.04	21.20
HOT SOAK EVAPORATION	0.00	9.40	0.00	9.40	0.00	2.21	0.00	2.21	0.00	0.51	0.51	0.12	0.71	0.84	0.00	0.84	0.00	0.01	12.97
RUNNING LOSSES	0.00	58.96	0.00	58.96	0.00	14.30	0.00	14.30	0.00	3.59	3.59	0.27	1.78	2.04	0.00	2.04	0.00	0.00	78.89
RESTING LOSSES	0.00	6.59	0.00	6.59	0.00	1.54	0.00	1.54	0.00	0.52	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.65
TOTAL ROG EMISSION	0.00	156.88	0.07	156.94	0.00	40.98	0.02	41.00	0.00	13.48	13.48	1.44	8.04	7.48	19.13	26.61	1.30	0.59	239.92
CARBON MONOXIDE EMISSIONS																			
RUNNING EXHAUST	0.00	481.01	0.26	481.28	0.00	133.47	0.06	133.53	0.00	39.50	39.50	15.00	47.06	62.06	86.77	148.83	5.89	1.39	810.40
COLD START EXHAUST	0.81	462.35	0.11	463.27	0.00	124.45	0.02	124.46	0.00	47.52	47.52	0.00	0.00	0.00	0.00	0.00	0.00	0.23	635.48
HOT START EXHAUST	0.00	77.13	0.03	77.17	0.00	20.36	0.01	20.37	0.00	6.16	6.16	0.00	0.00	0.00	0.00	0.00	0.00	0.07	103.78
TOTAL CO EMISSION	0.81	1020.49	0.40	1021.70	0.00	278.28	0.08	278.36	0.00	93.18	93.18	15.00	47.06	62.06	86.77	148.83	5.89	1.69	1549.66
OXIDES OF NITROGEN EMISSIONS																			
RUNNING EXHAUST	0.00	75.62	0.28	75.90	0.00	29.53	0.06	29.59	0.00	13.40	13.40	5.67	25.31	30.98	115.22	146.20	6.04	0.10	271.23
COLD START EXHAUST	0.00	19.60	0.00	19.60	0.00	6.45	0.00	6.45	0.00	2.49	2.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.55
HOT START EXHAUST	0.00	7.51	0.00	7.51	0.00	2.50	0.00	2.50	0.00	1.02	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.04
TOTAL NOX EMISSION	0.00	102.74	0.28	103.02	0.00	38.48	0.06	38.54	0.00	16.91	16.91	5.67	25.31	30.98	115.22	146.20	6.04	0.11	310.82
PARTICULATE MATTER EMISSIONS																			
EXHAUST	0.00	1.15	0.07	1.23	0.00	0.31	0.02	0.33	0.00	0.07	0.07	0.01	0.33	0.34	16.89	17.22	0.97	0.00	19.82
TIRE-WEAR	0.00	23.06	0.04	23.10	0.00	6.26	0.01	6.27	0.00	1.44	1.44	0.23	1.36	1.58	5.52	7.11	0.18	0.01	38.11
TOTAL PM EMISSION	0.00	24.22	0.11	24.33	0.00	6.58	0.02	6.60	0.00	1.51	1.51	0.24	1.69	1.92	22.41	24.33	1.15	0.01	57.93
LEAD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OXIDES - SULFUR	0.00	0.13	0.00	0.13	0.00	0.04	0.00	0.04	0.00	0.02	0.02	0.00	0.02	0.03	0.60	0.63	0.01	0.00	0.84
FUEL CONSUMED IN 1000 GALLONS																			
GASOLINE	3.97	811.61		815.57	0.00	183.73		183.73	0.07	103.91	103.97	15.48	93.01	108.49		108.49		1.98	1013.75
DIESEL			0.50	0.50			0.14	0.14							170.16	170.16	3.25		174.06

APPENDIX E

ALTERNATIVES TO THE CALIFORNIA PREDICTIVE MODEL

ALTERNATIVES TO THE CALIFORNIA PREDICTIVE MODEL

This Appendix discusses the alternatives that we evaluated prior to selecting the California predictive model. These alternatives are the United States Environmental Protection Agency (USEPA) complex model, a modified USEPA approach that we refer to as a "Hybrid" model, and the California predictive model without random balance.

The USEPA used a different statistical approach to develop its complex model. The approach does not consider the interactions that result from the random errors occurring due to the individual effects of the vehicles used in the study. The USEPA complex model also excluded certain terms prior to conducting the statistical analysis (pre-exclusion of terms), included several techniques designed to eliminate outlier data, and used a mathematical technique designed to simplify the model. This later technique is referred to as random balance. In addition, the USEPA complex model was developed for the emission control technologies used for the 1990 model year vehicles. Finally, it included separate models for exhaust emissions from normal-emitting and high-emitting vehicles and for evaporative emissions.

The Hybrid model differs from the USEPA complex model in several areas. It uses a different statistical approach than we used to develop the proposed California predictive model. It also uses the California working database (which is somewhat larger than the USEPA database), applies to the same vehicle technology classes as the California predictive model, and uses slightly different initial assumptions relative to pre-excluding various statistical terms from the statistical analysis.

We also evaluated a version of the California predictive model that did not incorporate random balance. After evaluating random balance, we found that this was an appropriate and beneficial technique to simplify the model without sacrificing the explanatory power of the model. Therefore, our final proposed California predictive model incorporates random balance.

We found that all of the models fit the data reasonably well. No procedure can guarantee that it will include the "best" choice of variables; thus, there is no "best" model. However, we believe that the California predictive model is likely to yield relationships that are very close to the most satisfactory relationships that can be achieved.

The following sections describe each alternative, identify how we evaluated the models, and provides the reasons why each alternative was not selected.

A. DESCRIPTION OF THE ALTERNATIVE MODELS

1. What is the USEPA complex model?

Shortly after the passage 1990 Amendments to the Federal Clean Air Act (FCAA), the USEPA entered into regulatory negotiation with interested parties to develop specific proposals for implementing the RFG program. From the regulatory negotiation, the USEPA agreed to utilize a complex model for certifying compliance with federal RFG standards. The USEPA complex model was first proposed in February 1993 in the Notice of Proposed Rulemaking for the Regulation of Fuels and Fuel Additives: Standards for Reformulated and Conventional Gasoline and has undergone a number of changes since first proposed. The USEPA complex model provides a method of certification based on fuel characteristics such as oxygen, benzene, aromatics, RVP, sulfur, olefins and the percent of fuel evaporated at 200 and 300 degrees Fahrenheit (E200 and E300). The USEPA utilized statistical analysis techniques to isolate the effects of fuel modifications on exhaust emissions of hydrocarbons, oxides of nitrogen, and toxic air contaminants from other factors affecting exhaust emissions. The USEPA complex model was adopted in December 1993 and is required to be used beginning January 1, 2000.

The USEPA's complex model considers both motor vehicle exhaust and evaporative emissions. The USEPA used only data from vehicles equipped with 1990 model year emission control systems. The USEPA further segregated the data into nine subgroups. Eight of the subgroups were based on differences in emissions control technologies. The ninth subgroup was based on the level of hydrocarbon emissions. This subgroup is made up of high emission vehicles (high emitters). Separate models were developed for each of the nine groups. The eight raw models for non-high emitters vehicles (normal emitters) were consolidated into one composite model. The high emitter model was not consolidated into the normal emitter model because doing so would introduce significant and unacceptable bias into the model's predictions. Therefore, the final model consists of a normal emitter model and a high emitter model. The results of these two models are consolidated into a single value using normal emitters and high emitters weighting factors.

The USEPA complex model utilized a database which excluded a number of studies. Studies were excluded if the emissions measurements were not based on the appropriate Federal Test Procedure. Studies without at least one 1990 class vehicle were excluded. Studies which did not include vehicles from more than one manufacturer were excluded and studies that did not have sufficient quality control to separate fuel effects from vehicle effects were also excluded. Some of the studies which were rejected include the NIPER study, Toyota's RFG study, and Auto/Oil's high emitter study. The USEPA complex model database included about 5000 data points.

A number of tests were also excluded from the database used to model hydrocarbon emissions. USEPA's revision of its definition of hydrocarbons to exclude methane, ethane, and various other substances resulted in an exclusion of tests which did not measure methane.

The USEPA concluded that a model based on total hydrocarbons cannot be used to estimate hydrocarbons and that a model based on non-methane hydrocarbons (NMHC) can be used to estimate hydrocarbons. Approximately 20 percent of the data available was excluded from the model because it was based on total hydrocarbons. Data from higher emitting vehicles were also excluded from the database because of variations in equivalent ratios. Finally, all data from tests on Fuel W in the USEPA's ATL-II program were excluded because its emissions effects and composition differed dramatically from the emission effects and composition of the other gasoline used in the study.

The database excluded vehicles which were not 1990 technology type vehicles. The FCAA requires that the effectiveness of the Federal RFGs be determined in reference to representative model year 1990 vehicles. The 1990 model year technology type vehicles were considered because these vehicles have similar engine designs, fuel distribution systems, and emission control and would be expected to respond similarly to fuel changes. Also, much more data is available on emission effects of fuel changes from this set of vehicles.

The USEPA used the natural logarithm (ln) of gross emissions as the dependent variable for all pollutants. This was done because it increased the explanatory power of the model by increasing the correlation coefficient between emissions and fuel parameters.

The independent fuel variables for exhaust hydrocarbons, oxides of nitrogen, and 1,3-butadiene emissions were oxygen, sulfur, aromatics, olefins, E200, E300, and RVP. The fuel components of exhaust emissions were separated into two categories. The first category consisted of effects of individual fuel parameters on emissions. The second category consisted of interactive effects between two different fuel parameters. Fuel variables were then modeled in centered form in the complex model.

The overall process used by the USEPA to arrive at the final Complex Models for hydrocarbons, oxides of nitrogen, and toxic air contaminants is summarized below.

A raw model was developed which contained all the regression terms found to be significant in a forward stepwise fit. Another re-regression was performed after deleting terms based on Mallows' Cp criterion to balance overfitting and underfitting. A re-regression was run on surviving terms after data outliers and influential points were excluded. A backwards fit to eliminate insignificant terms is then performed.

The raw model was refined by deleting terms whose contribution to the explanatory power was small. Terms which contributed less than one percent of the model's explanatory power were deleted to produce a refined model which was simpler in form without sacrificing its ability to predict the emissions impact of fuel modifications. This refined model was then simplified by consolidating the technology group specific models for normal emitters into a single model. Finally, the fuel variables were uncentered.

2. What is the Hybrid model?

We developed the Hybrid model using an approach similar to the approach the USEPA used to develop its complex model. In November 1993, WSPA requested that we develop a model using the USEPA methodology. This methodology included pre-exclusion of terms, removal of statistical outliers and influential points, and model simplification using the random balance. In December and January, we worked with the USEPA and WSPA to understand the USEPA approach and to agree upon the methodology. The main difference between the Hybrid model and the USEPA complex model is that the Hybrid approach uses the ARB working database and the SAS Mixed Model Procedure.

The Hybrid approach is essentially a fixed effect model. The statistical analysis for the Hybrid model was done under the assumption that all effects are fixed. The parameter estimation step prior to the random balance was the only part of the Hybrid model development process where the information regarding the "true" random effects for the vehicles and vehicle by fuel term interactions was considered. All assessment of the significance of the individual second order terms was done under the assumption of a fixed-only effects model. This may lead to an inappropriate choice of second order terms to be included as part of the final Hybrid model.

The following steps were taken to develop the Hybrid model.

1. Each vehicle's data in the ARB's working database was placed in one of the four vehicle technology groups.

2. The fuel parameters in the database were standardized to a mean of zero and standard deviation of one. The natural logarithm of emissions are calculated. Emissions are averaged by study, vehicle, and fuel.

3. Dummy indicator variables were included to represent each study by vehicle combination.

4. The following terms were excluded as candidates for inclusion as part of the final model.

Olefins*Sulfur	Olefins*RVP
Aromatics*T50	Olefins*T50
Aromatics*RVP	T50*RVP
T50*Sulfur	T50*T90
RVP*T90	RVP*Sulfur
T50*Oxygen	

5. A forward stepwise regression procedure was used to determine a preliminary list of candidate second order terms for inclusion as part of the final model. A significance criteria of ten percent was used both to enter terms and to remove terms from the model. All first order terms were forced into the model.

6. Once the stepwise procedure identified a preliminary list of candidate second order term to be included in the model, Mallow's C(p) criteria for inclusion was used to balance bias with overfit. The number of parameters (p) used in stepwise model construction process are plotted versus the corresponding C(p) statistic. The term where (p) first exceeds C(p) is used as the cut off point. None of the remaining second order terms were candidates for inclusion in the final model.

7. All first order terms and second order terms not removed to this point were then used to determine a candidate model. This candidate model was then used to determine outlier and influential points. Outliers are defined as any point with R Student greater than four in absolute magnitude. R Student is defined as the studentized residual with the current observation excluded from the calculations. Influential points are defined by a DFFITS statistic greater than 1.2 in absolute magnitude. DFFITS is defined as the standard influence of the observation on it's predicted value. The original data was used in the outlier analysis. Study by vehicle indicator variables were included.

8. All points where the absolute value of the R Student statistic was greater than four or where the absolute value of the DFFITS statistic was greater then 1.2, were removed from the dataset.

9. The candidate model was then subjected to a backwards stepwise regression procedure. The data set was the original data with all data identified is Step 8 removed. This step identifies any second order term that was included as a candidate for inclusion in the final model because of outliers or overly influential points. Any term removed by the backwards stepwise regression procedure was removed from the candidate final model.

10. The SAS Mixed Model Procedure was then used to estimate coefficients for all first order terms and any second order terms remaining at this point. The USEPA in their complex model construction used a standard regression procedure that estimated coefficients with no constant intercept term. The mixed model procedure was used at this point to facilitate comparison of the Hybrid model with the California predictive model. The dataset used is the original dataset with the outliers and influential points removed.

11. The random balance was then used to see if there is any simplification possible in the model. Any terms that contributed less than one percent to the explanatory power of the model were excluded.

3. What is the California predictive model without random balance?

In Chapter III and Appendix D, we discussed the development of the proposed California predictive model. The last step in the development is to use random balance to simplify the model by excluding interaction terms that do not contribute significantly to the explanatory power of the model. The California predictive model without random balance is the version of the model prior to using the random balance approach.

B. EVALUATION OF THE DIFFERENT MODELS

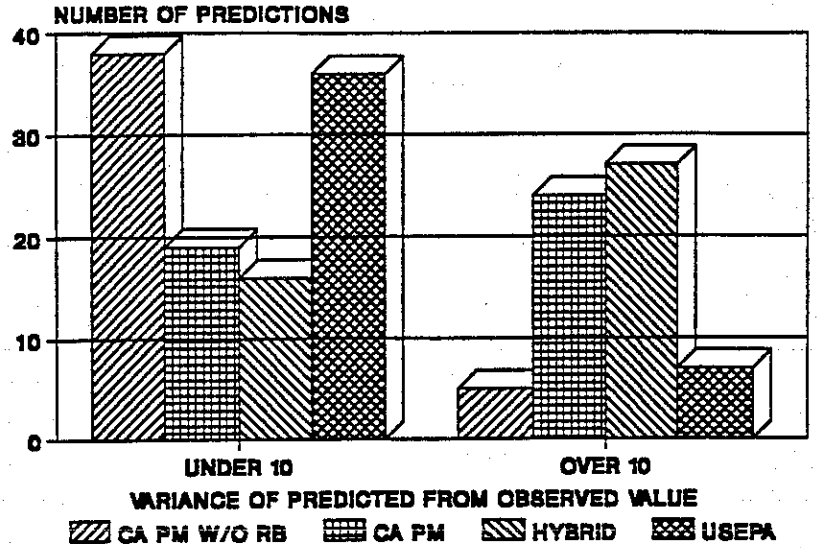
We used three different approaches to compare the different models. The first approach is to compare the results of the individual equations with selected observations from individual studies. The second approach is to produce and review linear plots of the results and evaluate the residual variance. Finally, we developed linear plots to graphically evaluate the responses.

1. How well do the results of the models compare with actual observations?

The performance evaluation procedure was similar to that discussed in Appendix D, section D. The data from five studies were used to define candidate fuel parameter values for each of the three alternatives and the California predictive model. Two of the studies represented fuels outside the Phase 2 region (Auto/Oil AMOT and Auto/Oil T90) and three of the studies represented fuels within the Phase 2 region (ARCO-EC-X, ARB/GM-Confirmation, and GM/WSPA/CARB). The predicted results from each model were compared to the observed results from each study. The results are shown in Figures E-1 through E-4. Each Figure shows the number of times the predicted value from each model falls under or over 10% of the observed percent change. As shown in Figures E-2, E-3 and E-4, all four models appear to predict equally well. However, Figure E-1 shows the California predictive model without and the USEPA complex model performing better at predicting hydrocarbon emissions for fuels outside the Phase 2 region. We believe that most candidate fuel formulations should be close to the Phase 2 region. Keeping that in mind and that the analysis illustrated in Figures E-1 through E-4 is based on a very limited number of observations, we believe the graphs show that no one model has a clear advantage over another.

Figure E-1

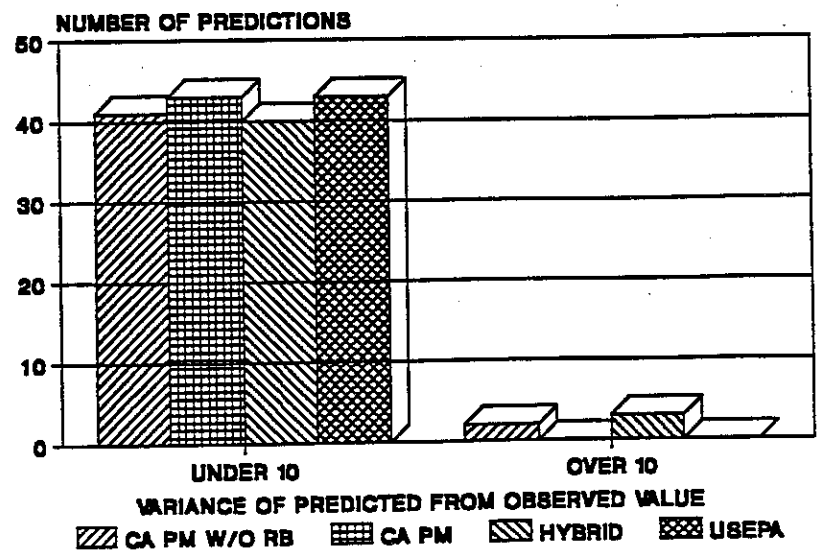
Model Predictions Versus Observed Results from Fuels Outside the Phase 2 RFG Region* (THC)



*AUTO/OIL T90 & AMOT STUDY

Figure E-2

Model Predictions Versus Observed Results from Fuels Outside the Phase 2 RFG Region* (NOx)



*AUTO/OIL T90 & AMOT STUDY

Figure E-3

Model Predictions Versus Observed Results from Fuels In the Phase 2 RFG Region* (THC)

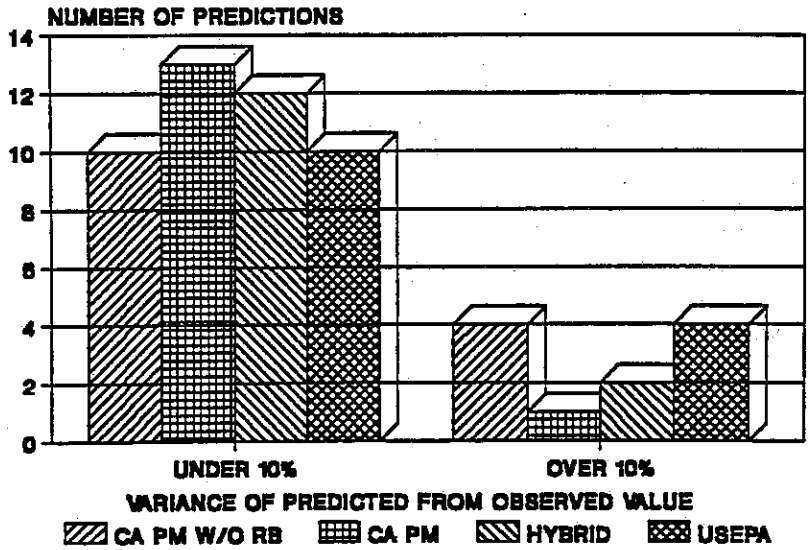
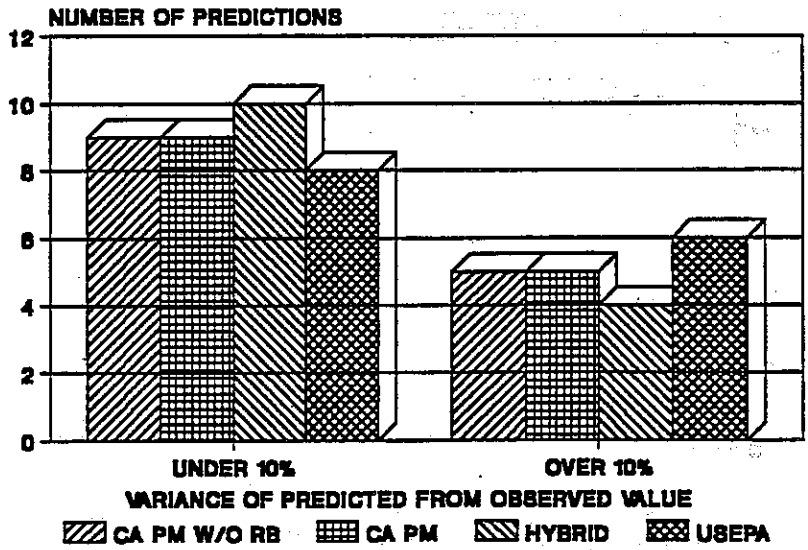


Figure E-4

Model Predictions Versus Observed Results from Fuels In the Phase 2 RFG Region* (NOx)



*ARCO-EC-X, ARB/GM CONFIRM., GM/WSPA/ARB

2. How do the different models compare using the standard deviations?

The preceding discussion of the California predictive model has discussed that there are several plausible models for predicting the same emissions from the same data. How well the different models fit the data is one way to assess which model to use. The difference between the observed emissions and the emissions estimated using the equations represents the unexplained variation in the observed emissions.

One of the simplest measures of goodness of fit is the estimated standard deviation of the variation in the data that the equations fail to explain. Equations with smaller standard deviations of unexplained variation estimate the observed emissions better on the average.

As discussed previously, the California predictive model is a mixed effects model that fits both fixed effects (population average regression coefficients) and random effects (modeling the variability of regression coefficients between cars). The California predictive model also fits an additional random effect, which is the variance of the remaining variation not explained by the effects in the model. To assess different models, we can compare the square roots of these error variances. Note that we can only make this comparison on the California predictive model and the Hybrid model. Residual standard deviations of fixed-effect models like the USEPA complex model cannot be compared to the residual standard deviations of mixed effects models, because fixed effect models apportion all the unexplained variation to a single random effect.

When comparing the California predictive model and the Hybrid model, we must keep in mind that the two models differ both in their modeling approaches and in the data sets to which the models were fitted. Outliers and high-leverage points in the California predictive model were removed from the data set for the Hybrid model, as noted in the description of the hybrid fitting method. Also, the hybrid data set contains data for high-RVP fuels which were excluded from the California predictive model.

The residual standard deviations of the California predictive model and the Hybrid model are tabulated in Table E-1. Judging by the residual standard deviations, the residual standard deviations of hydrocarbon predictions by the California predictive model are somewhat higher than those of the Hybrid model. However, they are not sufficiently higher to justify concluding that the Hybrid model is superior. The two modeling approaches predict oxides of nitrogen emissions equally well.

Table E-1

Comparison of the California Predictive Model and the ARB Hybrid Models using the Residual Standards Deviations

Emissions	Model	Standard Deviations	
		Tech Class 3	Tech Class 4
Hydrocarbons	California Predictive Model	.160	.149
	Hybrid Model	.145	.134
Oxides of Nitrogen	California Predictive Model	.093	.112
	Hybrid Model	.092	.114

3. How do the models compare based on the linear plots?

We developed a number of linear plots of the data to provide a visual indication of the performance of the models. These plots were useful in identifying unexpected behavior and as a quality control check on the coefficients in the model. These plots indicate that for the most part the results are very consistent. However, some of the model results do differ somewhat. Because these plots generally do not recognize the interaction terms, they cannot be used to reach any conclusions on which model provides the best estimate.

The following graphed results of the California predictive model, EPA complex model, and the Hybrid model are available from the Air Resources Board upon request. They may be obtained by contacting the Public Information Office at (916) 322-2990.

1) California predictive model without random balance: Tech 3, Tech 4, and composite

Effect on hydrocarbons, oxides of nitrogen, and potency weighted toxics by varying fuel properties of Phase 2 "Flat Limit" gasoline [22 graphs].

2) California predictive model vs California predictive model without random balance vs. Hybrid model vs. EPA complex model for exhaust emissions: composite

Effect on hydrocarbons, oxides of nitrogen, and potency weighted toxics by varying fuel properties of Phase 2 "Flat Limit" gasoline [22 graphs].

C. BASIS FOR REJECTING THE ALTERNATIVE MODELS

1. Why did we reject the USEPA Complex Model?

The USEPA complex model was rejected as an alternative to the California predictive model for several technical, statistical and practical reasons.

The technical basis for rejecting the USEPA complex model includes:

- o the data set contains 25 percent fewer observations than the proposed model;
- o interaction terms were pre-excluded from the model;
- o the model is based on only 1990-technology vehicles; and
- o high emitting vehicles are represented by a separate model.

The data set used to develop the USEPA complex model contains fewer observations than the data set used to generate the California predictive model. Generally, the more observations (data) used to develop a model, the more accurate the model's predictions are likely to be. The USEPA model includes about 5400 observations. The final California predictive model includes about 7300 observations. This difference is in large measure due to the USEPA's exclusion of studies in which total hydrocarbons were reported without a separate analysis of the contribution of methane. The USEPA excluded these studies because it considers methane to be non-reactive. Excluding these studies results in a loss of approximately 20 percent of the available data. We believe that the data provided in many of these studies is very important in predicting how vehicular emissions will change with changes in fuel properties.

Before any statistical analysis was done on the USEPA complex model database, 11 interaction terms were eliminated from consideration. Thus, these terms could not be included in the final model even if statistical analysis found the interactions to be significant. The reason given for pre-excluding these terms was that there was insufficient information and studies on the particular interaction. We believe this approach fails to take advantage of the fact that the pooling of data from many studies provides information on interactions that the individual studies were not specifically designed to examine.

The USEPA complex model is based on only 1990 technology vehicles. This decision eliminates from consideration the effects of fuel property change on a significant portion of the fleet. As discussed in Section III, even in 2005, about 20 percent of the vehicle fleet emissions will be from 1981-1985 model year vehicles. Since the California predictive model will need to accurately predict emissions from these vehicles, we favor a modeling approach which includes pre-1990 technologies where sufficient data is available. The California predictive model uses such an approach.

The USEPA complex model has separate sub-models for normal and high emitting vehicles. The results from these two sub-models are combined using weighting factors. Because of difficulties in predicting the contribution of high emitting vehicles, we favor the approach used in the California predictive model which does not separate out high emitting vehicles from the normal emitting vehicles.

The statistical basis for rejecting the USEPA complex model includes:

- o it does not take into consideration random vehicle effects; and
- o it excludes outliers for statistical rather than technical reasons.

The USEPA complex model take into consideration only "fixed" effects and not "random" effects. The USEPA complex model attributes changes in predicted emissions entirely to the changes in specifications for the fuel properties (fixed effect). The California predictive model attributes changes in predictive emissions to the changes in specifications for the fuel properties (fixed effect) and to random vehicle-to-vehicle variations (random effects). We believe that a model which considers both fixed and random effects will result in a more defensible predictions of the effects of changes in fuel property specifications.

In developing the USEPA complex model, the USEPA excluded data they found to be an outlier or an overly influential data using statistical tests. We believe that outlier and influential data should not be eliminated based on statistical reasons. All the data should be considered unless there was a technical problem with the test from which they were generated.

The practical basis for rejecting the USEPA complex model includes:

- o both exhaust and evaporative emissions are included.

The USEPA complex model includes both exhaust and evaporative emissions. This results in a much more complex model than the California predictive model which address evaporative effect by fixing RVP.

2. Why did we reject the Hybrid model?

The reasons for rejecting the Hybrid model are similar to those for rejecting the USEPA complex model. The Hybrid approach included the pre-exclusion of terms, and removal of statistical outliers and influential points. Further, the approach used to generative the Hybrid model is more complex than the approach used to generate the California predictive model.

As discussed previously, the Hybrid model is essentially a fixed effects model. As such, it does not appropriately consider the random effects. This may lead to an inappropriate choice of second order terms to be included in the model. The Hybrid model approaches pre-exclusion of certain second order terms. We believe none of the interaction terms should be

pre-excluded. Under the Hybrid approach, a term would be pre-excluded from the model equations if there was not sufficient information justifying that the interaction is real. In most cases, sufficient information means the existence of a study specifically designed to evaluate the particular interaction. We believe that a lack of information to verify the existence of an interaction is not reason enough to eliminate it from being considered in model development. This does not mean that we believe all interaction terms should be forced into the model. If the model shows that a term does not contribute significantly, then it can be excluded from the model.

The Hybrid model approach also includes a statistical outlier and influential point analysis. We believe removing data based on statistical tests is not appropriate. We believe all data generated from vehicles or tests that were not shown to be outliers due to technical problems should be included in model development.

The approach used to generate the Hybrid model is also much more complex than the approach used to generate the California predictive model even though the Hybrid model has about the same number of interaction terms as the California predictive model. This comparison is shown in Table E-2 and Table E-3.

Table E-2

Comparison of Interaction Terms
California Predictive Model vs Hybrid Model

Term	Hydrocarbons			
	Tech 3		Tech 4	
	Hybrid Model	California Predictive Model	Hybrid Model	California Predictive Model
ARO*ARO			X	X
ARO*OXY				
ARO*SUL		X		
ARO*T90	X	X	X	X
T50*T50			X	X
T50*RVP		X		
T90*T90	X		X	X
T90*OXY			X	X

Table E-3

Comparison of Interaction Terms
California Predictive Model vs Hybrid Model

Term	Oxides of Nitrogen			
	Tech 3		Tech 4	
	Hybrid	California Predictive Model	Hybrid	California Predictive Model
ARO*OXY				X
OXY*OXY			X	X
RVP*OXY				X
SUL*SUL				
T50*T90		X		
T90*ARO		X	X	

3. Why did we reject the version of the California predictive model without random balance?

Our decision not to recommend the version of the California predictive model without random balance is based on practical rather than statistical or technical considerations. Using random balance results in fewer interaction terms in the model. Removing interaction terms, particularly squared terms, tends to result in linear relationships between fuel property changes and changes in emissions. Refiners see this simplification as desirable. They believe that the more non-linear the relationships in the model the more problem they will have in blending to specifications. To the extent that the random balance approach does not significantly effect the predictive power of the model, we are not opposed to using the approach.

To evaluate any loss in the predictive power of the model as a result of using random balance, we looked at 68 data points that were in Phase 2 region. For each data point, we identified the observed gram per mile (g/mi) emissions reported in the particular study. Next

we determined the predicted g/mi emissions using the California predictive model with and without random balance. The numerical value of these predictions were extremely close. For all 68 data points, the predicted values for the random balanced version of the model differed from the predicted values for the version of the model without random balance by 0.001 g/mi or less for both hydrocarbons and oxides of nitrogen. This supports the conclusion that the use of random balance does not adversely effect the predictive power of the power.

Another way to compare the predictive power of the two models, is to look at the relative percent difference in the magnitude of error in the model's predictions. Error (also called residual) is measured as the difference between the observed and the predicted, squared. These values are summed and divided by the number of observations less two to determine the mean (average) square error (also called the residual mean square). Using 68 data points in the Phase 2 region, the mean square error for the Tech class 4 hydrocarbon equations without random balance is 0.0068109. The mean square error for the version of the model with random balance is 0.0067947. For the Tech class 4 oxides of nitrogen equations, the corresponding values are 0.0639975 (without random balance) and 0.0639731(with random balance), for a difference of -.04 percent. The relative percent difference between these two values is 0.24 percent. This result further supports the conclusion that there is little loss in the predictive power of the model using random balance.