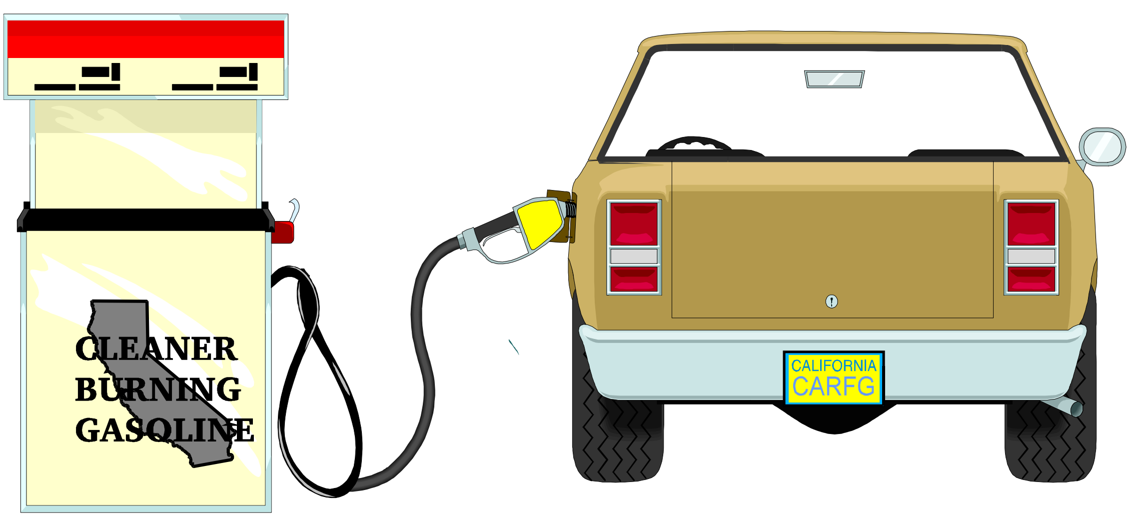
California Environmental Protection Agency

Air Resources Board

Proposed 2007 Amendments to Phase 3 California Reformulated Gasoline Regulations

Staff Report: Initial Statement of Reasons



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State of California

California Environmental Protection Agency
AIR RESOURCES BOARD
Stationary Source Division

STAFF REPORT: INITIAL STATEMENT OF REASONS PROPOSED AMENDMENTS TO CALIFORNIA PHASE 3 GASOLINE REGULATIONS

Public Hearing to Consider Amendments to the
California Reformulated Gasoline Regulations
and Other Changes

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Staff would like to pay special thanks to the working groups that helped develop the new Predictive Model.

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A. Introduction

The Air Resources Board (ARB/Board) staff is proposing to amend the California reformulated gasoline (CaRFG) regulations. Over the years, the Board has approved and amended these regulations in three phases. The most recent amendments adopted in 1999 implemented the Governor's and Legislature's direction to phase out the additive methyl-tertiary-butyl-ether (MTBE) from California gasoline. The enabling legislation also required the Board to ensure that the emission benefits of Phase 2 CaRFG (CaRFG2) were fully preserved when adopting the Phase 3 CaRFG (CaRFG3) regulations.

As part of the CaRFG3 regulatory process, the Board directed staff to investigate the potential emissions impact of adding ethanol to gasoline, specifically related to the increase in hydrocarbon emissions through permeation. Permeation refers to the diffusive process whereby fuel molecules migrate through the materials of a vehicle's fuel system. Eventually, the fuel molecules are emitted into the air where they contribute to evaporative emissions from the vehicle. Recently completed studies on on-road motor vehicles now show that ethanol increases the evaporation emissions of gasoline through permeation over that of a comparable fuel without ethanol, or with MTBE.

Based on this new information, staff is proposing amendments to mitigate the increases in evaporative emissions from on-road motor vehicles resulting from the addition of ethanol to gasoline. The staff is also proposing additional amendments to the CaRFG3 regulations to increase the flexibility, enforceability, and consistency of the regulations. The proposed regulatory amendments are in Appendix A.

B. California Reformulated Gasoline Regulations

The following section provides a brief overview of the CaRFG2 and CaRFG3 regulations, a description of the California Predictive Model, and the impacts of adding ethanol to gasoline.

1. CaRFG2

The California Clean Air Act requires the ARB to adopt regulations that produce the most cost-effective combinations of control measures on motor vehicles and motor vehicle fuels. This directive led to many actions, including the Board approval of the CaRFG2 regulations in 1992. The CaRFG2 regulations set stringent standards for California gasoline that produced cost-effective emission reductions in new and in-use gasoline-powered vehicles. The regulations set specifications for the following eight fuel properties:

sulfur	50 percent distillation temperature
aromatics	90 percent distillation temperature
oxygen	olefins
benzene	Reid vapor pressure

With the exception of oxygen, the regulations set three limits for each property: a "cap" limit that applies to all gasoline anywhere in the gasoline distribution and marketing system and does not vary; and "flat" and "averaging" limits that apply to gasoline when it is released by refiners, importers, and blenders (collectively, "producers")[1]. For oxygen, the regulations establish a range of flat limits and caps that may vary depending on the location and the specific fuel formulation.

Gasoline producers could comply with the limits in one of three ways. First, for a given property, each producer may choose to meet either the flat limit or the averaging limit. Second, a producer may use the Predictive Model to identify other sets of property limits (flat, averaging, or mixed) that can be applied to that producer's gasoline. Third, a producer may validate an alternative set of property limits through emission testing per a prescribed protocol. Whether validated by the Predictive Model or by testing, no alternative limit may exceed the cap limit for the property.

To comply with the oxygen content requirement, producers chose to use MTBE. Soon after CaRFG2 implementation, the presence of MTBE in groundwater began to be reported. An investigation and public hearings were conducted resulting in the issuance of Executive Order D-5-99 on March 25, 1999. The Executive Order directed the phase-out of MTBE in California's gasoline. In addition, the Legislature passed Senate Bill 989. Among other provisions, the bill directed the ARB to ensure that regulations adopted pursuant to the Executive Order maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999 (Health and Safety Code section 43013.1).

2. CaRFG3

In response to the Governor's and Legislature's directive, the Board approved the CaRFG3 regulations on December 9, 1999 and amended them on July 25, 2002. The CaRFG3 regulations prohibited California gasoline produced with MTBE starting December 31, 2003, established revised CaRFG3 standards, established a CaRFG3 Predictive Model, and made various other changes. The CaRFG3 regulations also placed a conditional ban, starting December 31, 2003, on the use of any oxygenate other than ethanol, as a replacement for MTBE in California gasoline. The current specifications for CaRFG3 are presented in Table ES-1.

[1] Throughout this report, we are using the producers to generally represent those that are affected by the regulations. The specific regulations, however, have requirements that sometimes differ depending on whether the affected entity is a refiner, importer, or blender. The reader is referred to the regulations for specific applicable requirements.

Table ES-1: CaRFG3 Limits and Caps

Property	Flat Limits	Averaging Limits	Cap Limits[1]
Reid vapor pressure, psi, max	7.00 or 6.90 [2]	---	6.40 - 7.20
Benzene, vol%, max	0.8	0.70	1.10
Sulfur, ppmw, max	20	15	30
Aromatic HC, vol%, max	25	22	35
Olefins, vol%, max	6.0	4.0	10
Oxygen, wt%	1.8 to 2.2	---	1.8 – 3.5[3] 0 – 3.5
T50 (temp. at 50% distilled) ^{o}F, max	213	203	220
T90 (temp. at 90% distilled) ^{o}F, max	305	295	330

(1) The "cap limits" apply to all gasoline at any place in the marketing system and are not adjustable.

(2) 6.90 psi applies when a producer is using the evaporative emissions element of CaRFG3 Predictive Model and gasoline may not exceed a cap of 7.20 psi; otherwise, the 7.00 psi limit applies.

(3) The 1.8 weight percent minimum applies only during the winter and only in certain areas.

3. California Predictive Model

Numerous studies have shown that the properties of gasoline affect motor vehicle emissions. Based on thousands of individual tests, equations have been developed that relate changes in fuel properties to changes in emissions. The Predictive Model takes advantage of these relationships to provide producers flexibility. The producers use the Predictive Model to identify alternative limits that achieve equal or better emission reductions compared to the use of the flat or averaging limits. The Predictive Model provides flexibility for the producers, while ensuring ARB's emissions reduction goals are met. This flexibility is highly valued by the producers and the vast majority of CaRFG is produced using the Predictive Model.

As originally developed for CaRFG2, the Predictive Model is a set of mathematical equations that relate emission rates of exhaust hydrocarbons, oxides of nitrogen (NOx), and combined exhaust toxic species[2] to the values of the eight regulated gasoline properties. Emissions of each pollutant type are predicted by equations formulated separately for vehicles of different technology classes.

In 1999, as part of the CaRFG3 regulations to phase-out MTBE from California gasoline, the CaRFG2 Predictive Model was revised. The new CaRFG3 Predictive Model included a limited data set for the newer class of low emission vehicles (LEVs). Also, an evaporative emissions model was incorporated to provide additional flexibility to consider both exhaust and evaporative

[2] Four toxic species are involved: benzene, 1,3-butadiene, formaldehyde, and acetaldehyde. Separate predictions for the four are combined with weights proportional to the ARB's unit-risk values for the species. The resultant sum is the "potency-weighted toxic" (PWT) emission rate.

hydrocarbon emissions. This change was done on an ozone-forming potential basis, by weighting hydrocarbon emissions using their average reactivity factors.

The equations were derived by statistical analyses applied to thousands of individual emission observations and the associated values of the fuel properties. For each pollutant, the predictions for the three vehicle classes representing groupings of vehicle technologies are combined with weights proportional to the contributions of the vehicle classes to the ARB's emission inventory for that pollutant.

The Predictive Model then allows producers to certify alternative formulations of CaRFG3 by comparing the emission predictions for a candidate set of property limits to the predictions for the flat or averaging limits. If each prediction for the candidate limit is no greater than 1.004 times the corresponding basic-limit prediction, the alternative set of limits is allowable. Separate determinations must be made for ozone-forming potential, oxides of nitrogen, and potency-weighted toxics. In effect, the model allows a producer to use one or more limits greater than the flat or averaging limits in exchange for compensating reductions in other limits. Thus, the model provides valuable flexibility to individual refiners by allowing refiners to most efficiently meet the CaRFG3 requirements, taking into consideration the configuration of the refinery.

To facilitate the use of the Predictive Model, ARB staff provide a procedures guide, "California Procedures for Evaluation Alternative Specifications for Phase 3 Reformulated Gasoline Using the California Predictive Model." The guide provides step by step instructions, including ARB staff notification requirements. Also, a computer spreadsheet is provided so that users can in effect insert the specifications for the candidate fuel and the spreadsheet will calculate if the candidate fuel passes or fails.

4. Impact of Ethanol Use

In general, oxygenates such as MTBE and ethanol are used in gasoline to reduce the exhaust emissions of hydrocarbons and carbon monoxide and improve the octane rating. It is well known that ethanol increases the vapor pressure of gasoline. For many years, blends of gasoline have had to be adjusted to ensure that the Reid vapor pressure (RVP) of the resulting blend met the limits and did not increase evaporative emissions. Available data also indicate that higher blends of ethanol increase the exhaust emissions of oxides of nitrogen.

In response to the Board's direction to investigate the impact of ethanol on permeation emissions, the ARB co-funded a research study with the Coordinating Research Council (CRC) to assess the magnitude of the permeation emissions associated with the use of ethanol in gasoline in on-road vehicles (CRC E-65 Study). Based on the study results, staff calculated the increase in evaporative emissions from on-road motor vehicles due to the presence of ethanol in gasoline to be about 18.4 tons per day of hydrocarbons in 2010. This represents a seven percent increase in evaporative emissions and a four percent increase in overall hydrocarbon (HC) emissions.

Ethanol also affects off-road gasoline-powered engines and equipment, as well as portable gas containers. Available data indicate that ethanol may reduce the exhaust emissions of hydrocarbons and carbon monoxide, but increase the evaporative emissions due to permeation. In addition, the use of ethanol may also increase oxides of nitrogen emissions. Based on very limited testing, staff calculated that the net impact may have from little, if any, effect on increasing hydrocarbon emissions to about 20 tons per day (tpd) and slightly increase oxides of nitrogen emissions by about 1 to 2 tpd.

As discussed in Chapter V, ARB staff is collaborating with the small engine manufacturers and U.S. EPA to co-fund studies at Southwest Research Institute to assess the impact of ethanol of various types of off-road sources.

Pursuant to Health and Safety Code section 43013.1(b)(1), the ARB must ensure that CaRFG3 maintains or improves upon the emissions and air quality benefits achieved by CaRFG2. The data now show that there are increased and quantifiable evaporative emissions from on-road motor vehicles due to permeation caused by ethanol. As a result, staff is proposing amendments to fully mitigate the impacts from on-road motor vehicles. Due to the limited data available, staff is not proposing any modifications at this time to address permeation emissions from off-road sources.

C. Proposed Amendments

In summary, the staff is proposing the following amendments:

- Amend the California Predictive Model to ensure that permeation emissions associated with ethanol use are mitigated and to incorporate new data;
- Add an option to use an alternative emissions reduction plan (AERP) for a limited time period to help mitigate permeation emissions;
- Decrease the sulfur cap limit from 30 parts per million by weight (ppmw) to 20 ppmw to improve enforceability and facilitate new motor vehicle emissions control technology;
- Allow emissions averaging for low level sulfur blends to provide additional flexibility for producers;
- Apply the 7.00 psi RVP limit to oxygenated gasoline to reflect that virtually all gasoline will be oxygenated and commingling emissions are not a problem for these fuels; and retain the 6.90 RVP limit for non-oxygenated gasoline to ensure that no increase in hydrocarbon emissions from commingling with oxygenated gasoline will occur;

- Allow flexibility in setting oxygen content in the Predictive Model to account for variability in test methods;
- Increase the maximum allowable amount of denaturant in ethanol to be consistent with new federal requirements; and
- Update the test method for oxygenate content of gasoline.
- Require producers to use the revised Predictive Model starting December 31, 2009, which allows for the use of alternative emission mitigations. Require the production of CaRFG compliant with the revised Predictive Model by December 11, 2011

Each of these proposed amendments is described in the following text.

1. Revise the Predictive Model

There are five aspects of the Predictive Model that the staff is proposing to add or update as shown below:

- Add permeation emissions and require they be mitigated;
- Update the motor vehicle emissions inventory vehicle mix;
- Update the reactivity adjustment factors;
- Add new motor vehicle exhaust emissions test data; and
- Update the effect of carbon monoxide on ozone-forming potential.

Staff proposes to generally use a 2015 statewide ozone planning inventory as the baseline, including passenger vehicles to light heavy-duty trucks with gross vehicle weight (GVW) less than 10,000 pounds (lbs). An inventory year of 2015 allows the model to best reflect the in-use fleet in the 2010 – 2020 timeframe, and to appropriately model those fuel specifications that are most important in maintaining the emissions performance of advanced technology vehicles.

a. Add Permeation Emissions

As discussed above, there are increases in evaporative emissions due to the effects of ethanol on permeation. To develop appropriate mitigation, the staff is proposing to add this emissions increase to the Predictive Model.

In late 2006, ARB released the latest update to California's on-road motor vehicle emissions model, referred to as EMFAC2007. This model was updated to include permeation emissions.

In addition, the staff is proposing to revise the EMFAC2007 output to reflect higher temperatures than are included as default temperatures. Typically, days with high temperatures have high ozone levels. Permeation emissions are also higher on hot days. To ensure that the Predictive Model formulas adequately mitigate the permeation emissions, it is important to use a temperature profile that recognizes this relationship. For this analysis, ARB staff is using the temperature profiles that occur when the California 8-hour ozone standard was exceeded by substantial amounts, and which have high ozone levels that would form the basis of the control strategy needed to attain the state ambient air quality standards for ozone. In general, the temperature profiles are about two to three degrees Fahrenheit higher than the default temperature profile included in EMFAC2007. The default temperature profile is represented by those temperatures where the federal 8-hour ozone standard is exceeded.

Using the EMFAC2007 model with the revised temperature profile, staff calculated the increased emissions from permeation that needed to be included in the Predictive Model. On a statewide basis in 2005, the increase in evaporative emissions due to permeation is about 28.8 tpd from on-road gasoline vehicles (GVW <10,000 lbs). The emissions increase declines to 18.4 tpd in 2010, 12.1 tpd in 2015, and 8.1 tpd in 2020. These reductions are due to a general reduction in emissions from motor vehicles.

b. Update the Motor Vehicle Emission Inventory Vehicle Mix

Using the most recent information from EMFAC2007, staff proposes to update the contribution of emissions from each vehicle technology class used in the model so that it more accurately reflects the California vehicle fleet setting in calendar year 2015. In 2015, the majority of the light-duty motor vehicles will have Tier II low emission vehicle (LEVII) and partial zero emission vehicle (PZEV) emissions control technologies.

c. Update the Reactivity Adjustment Factors

Staff proposes to update the exhaust hydrocarbons, evaporative hydrocarbons, and exhaust CO reactivity adjustment factors used in the Predictive Model. Reactivity adjustment factors are used to establish the ozone-forming potential of the gasoline formulation. Staff continues to recommend that the maximum incremental reactivity (MIR) scale developed by Dr. William Carter be used. This scale is the most appropriate for complementing California's dual program of reducing both NOx and volatile organic compounds (VOC) to control ozone and other pollutants.

In December 2003, the Board approved an updated list of reactivity values and reconfirmed the other MIR values. At that time, the MIR value for CO was updated to 0.06. Prior to Board consideration, the Reactivity Advisory Committee reviewed the list of values. After their review, the Reactivity Scientific Advisory Committee concluded that the proposed update did not substantially change the nature of the MIR values and were arrived through an appropriate scientific manner. For this update, the staff is proposing to use these MIR values.

d. Add New Motor Vehicle Exhaust Emissions Test Data

The Predictive Model is based on about 9,000 individual emissions tests showing how the exhaust emissions change with changing fuel properties. Since the last model update in 1999, there have been a number of additional tests conducted. Therefore, the staff is proposing to add about 1,000 new observations to the current database to update the Predictive Model. The new datasets reflect emissions testing of fuels in the newest class of vehicles, referred to as Tech 5 vehicles, ranging from low emission vehicles (LEV) to super low emission vehicles (SULEV).

e. Update the Effect of Carbon Monoxide on Ozone-Forming Potential

Staff proposes to update the methods used for estimating the effect of changing fuel properties on carbon monoxide (CO) in the reactivity adjusted hydrocarbons portion of the Predictive Model. The current Predictive Model only uses changes in oxygen level to calculate changes in CO emissions. The staff proposes to add to the Predictive Model a new mathematical formulation that accounts for the impact of seven properties on CO emissions. This approach for CO follows the approach taken for exhaust hydrocarbons and NOx.

2. Add an Alternative Emissions Reduction Plan

The staff is proposing to add a new provision that would allow producers to use an approved Alternative Emissions Reduction Plan (AERP) for a limited time. An AERP would allow a producer the option of creating emission reductions from other sources to fully mitigate any emissions increase from permeation not otherwise mitigated from the producer's fuel formulation. The AERP would not enable the producer to avoid meeting the majority of the CaRFG3 requirements; the producer would still have to comply with the non-permeation portion of the Predictive Model.

The addition of an AERP would enable mitigation of ethanol permeation effects more expeditiously and increase flexibility for producers to comply with the requirement to mitigate any increase in emissions associated with the use of ethanol blends. Producers will be required to certify fuel formulations or use an AERP to mitigate the increase in permeation emissions starting in December 31, 2009. Some producers may find it difficult to produce the desired amount of complying fuel without significant refinery and/or infrastructure modifications. The AERP option is proposed to be available to producers from December 31, 2009 until December 31, 2011. Producers will have four years to come into full compliance.

Staff is also proposing to allow producers to apply to the Executive Officer for a one year extension should circumstances warrant an extension. For small refiners, staff also proposes that a small refiner using the small refiner provisions be allowed to use the AERP option indefinitely.

The proposed AERP requires that emission reductions used in an AERP must come from combustion or gasoline related emission sources, such as motor vehicles, stationary or portable engines, off-road equipment, or portable fuel containers. A producer could not use emission reductions that are created at other types of sources or which are required through other programs. An AERP may not include emission reductions that may be part of on-going business practices. The producer would also need to show that emission reductions from an AERP occur in the same general region that the producer distributes fuel. Finally, the emission reductions must coincide within the applicable time period for the AERP.

3. Decrease the Sulfur Cap Limit

Staff proposes to reduce the sulfur cap limit from the current specification of 30 ppmw to 20 ppmw. Cap limits provide an upper limit for fuel properties for all compliance options and allow enforcement of the requirements throughout the gasoline distribution system.

Sulfur levels currently average about 10 ppmw, with 95 percent of production being below 18 ppmw. Staff believes that producers will significantly further reduce the sulfur content of California gasoline to certify gasoline if the proposed revisions are adopted. With the recent implementation of the federal Tier II sulfur rules for gasoline, nationwide gasoline sulfur levels must average less than 30 ppmw with a cap of 80 ppmw. The implementation of the federal Tier II sulfur rules will significantly reduce the historical difference between sulfur levels in California and those seen outside of the State.

Lowering the sulfur cap to 20 ppmw is not expected to significantly affect flexibility to make complying fuels, but will increase the enforceability of the program and help to protect the performance of sulfur-sensitive emissions control components. Staff believes that it will not be practical for producers to certify alternative formulations with sulfur levels above 20 ppmw. Staff believes that the sulfur cap should be set at the lowest level possible that does not significantly reduce production flexibility. From this perspective, the current cap of 30 ppmw is much higher than necessary.

The Alliance of Automobile Manufacturers and individual vehicle manufacturers have indicated that before lean burn gasoline technology can be successfully introduced, they need assurance that sulfur content will be less than 20 ppmw. A sulfur cap of 20 ppmw will provide this assurance. This new technology has the potential to improve the feasibility of gasoline engines that have higher efficiencies and less greenhouse gas emissions per mile traveled.

4. Allow Emissions Averaging for Low Level Sulfur Blends

Staff expects producers will very likely choose to increase the use of ethanol in gasoline to offset the increase in permeation emissions. The addition of ethanol increases the oxygen content in the fuel blend. While this generally reduces the exhaust emissions of hydrocarbons and carbon monoxide, emissions of NOx increase. In many cases, this increase in NOx would, if not mitigated through some other fuel property, result in a non-complying blend. Staff expects producers to use sulfur as a lever to lower NOx emissions in their fuel formulations. Such action could result in sulfur levels below 10 ppmw in most CaRFG3 formulations.

At these low sulfur levels, the compliance margin for refiners is small and slight unexpected deviations in the refinery process could easily cause a batch to become non-compliant. Staff anticipates that it will be very difficult to blend a slightly higher than needed sulfur level batch to a compliant blend using the existing sulfur averaging provisions because it becomes increasingly more and more difficult to average out sulfur when the levels are very near the bottom of the range. Therefore, for a producer that experiences a problem with the sulfur content when blending a particular batch of gasoline, staff is proposing to add a compliance option that would permit that producer to use an averaging option that is based on emissions. Emissions must be mitigated within 90 days by subsequent cleaner than required blends. Any additional emissions reductions achieved under the emissions averaging provision may not be banked. In addition, this emissions averaging option can only be triggered by unexpected high sulfur levels.

Without such a flexibility provision, such batches would likely need to be shipped out-of-state at significant expense while reducing supplies of available product. Unlike most other fuel properties governed by the CaRFG3 rules, increases in sulfur levels in individual batches do not result in immediate emission increases in vehicles using the batch. Sulfur degrades catalyst performance, but the effect is reversible. Given this situation, staff believes it is reasonable to infrequently allow batches with slightly higher sulfur levels to be used, so long as the impacts of the higher sulfur batch are fully mitigated in the near future through subsequent batches.

5. Adjust the RVP for Oxygenated Fuels

When non-oxygenated and oxygenated fuels are mixed together in a vehicle fuel tank, the evaporative emissions of the blend increase due to an increase in RVP. This effect is referred to as commingling. In the existing CaRFG3 regulations, provisions were included to help mitigate any commingling that could have occurred as MTBE was phased out. Specifically, the RVP flat limit was reduced by 0.10 psi and set at 6.90 psi for producers that used the evaporative emissions portion of the Predictive Model. However, virtually all gasoline has been blended with ethanol; therefore, the commingling impact has been negligible.

As a result of federal policies requiring ethanol use, and the likelihood that increases in oxygen content will be used to mitigate permeation, staff expects almost all fuel produced in California will continue to be blended with ethanol. Therefore, the required use of 6.90 psi rather than the original 7.00 psi reference level for RVP for ethanol blends is no longer needed. As such, staff is proposing to restore a flat limit of 7.00 psi for blends that use ethanol. This change will provide some additional flexibility for producers while preserving the emissions benefits.

While we expect that gasoline produced in California will be blended with ethanol, it is possible that some amount of non-oxygenated fuels could be introduced in the future. In this case, emissions could increase due to commingling. Therefore, to mitigate any potential increase in emissions associated with the commingling of non-oxygenated fuels with fuels containing ethanol, the non-oxygenated fuels will be required to be based on a flat limit of 6.90 psi RVP.

6. Allow Flexibility in Setting the Oxygen Content in the Predictive Model

In the Predictive Model, oxygen is specified in the form of a range. There are usually two candidate fuel specifications for oxygen, the upper end of the range (maximum) and the lower end of the range (minimum). This range generally represents the difficulty in precisely measuring oxygen content and was incorporated into the CaRFG3 Predictive Model as a flexibility provision. If the oxygen range of the candidate fuel specifications is within the range of 1.8 to 2.2 percent by weight, the oxygen content of the candidate fuel specifications is assumed to be 2.0 percent by weight (5.7 percent by volume). If the oxygen range of the candidate fuel specification is within the range of 2.5 to 2.9 percent by weight, the oxygen content of the candidate fuel specifications is assumed to be 2.7 percent by weight (7.7 percent by volume).

Staff proposes to allow the candidate fuel specification for oxygen to be evaluated at the midpoint of the minimum and the maximum oxygen values entered into the Predictive Model if the range between the minimum and the maximum oxygen value is 0.4 percent or less. This proposed change will provide flexibility for refiners to blend ethanol at any levels other than 5.7 percent, 7.7 percent, and 10 percent.

7. Increase the Maximum Allowable Amount of Denaturant

A denaturant is added to ethanol to ensure that it cannot be ingested. The CaRFG3 regulations include a requirement that all reformulated blendstocks for oxygenate blending contain no more than 4.76 percent by volume denaturant. This specification is based on earlier versions of the American Society of Testing and Materials (ASTM) standard specification for denatured fuel ethanol for blending with gasoline (ASTM Method D 4806-99).

ASTM recently changed the maximum amount of denaturant to 5.00 percent by volume (ASTM D 4806-06c). Therefore, the staff proposes to change the maximum denaturant content specification from 4.76 percent by volume to 5.00 percent by volume to be consistent with the recent change in ASTM D4806-06c and to update the appropriate references to the latest ASTM method. This change will align California fuel regulations with federal fuel regulations, and will create less confusion to suppliers. As a result, the proposed amendment will increase the supply of denatured ethanol available to be imported into California.

8. Adopt Current Version of ASTM D4815-04

Section 2263(b) lists ASTM D4815-99 as the test method for determining the oxygen content, ethanol content, MTBE content, and oxygenate content of gasoline. The designation "-99" means the 1999 version of the test method. Every 5 years or when the need arises, ASTM reviews its test methods and either amends or re-approves them. Staff proposes to change the test method to the current version (the 2004 version) which is labeled ASTM D4815-04.

D. Implementation of the Proposed Amendments

Staff is proposing that the proposed amendments would affect fuels produced on or after December 31, 2009. Producers that are unable to fully comply through the use of the Predictive Model may choose to offset any unmitigated permeation emissions associated with ethanol in gasoline through the use of an Alternative Emissions Reduction Plan. Starting December 31, 2011, producers will be required to fully offset the increase in emissions associated with ethanol in gasoline through the use of the Predictive Model. As mentioned above, the staff is proposing to allow a one year extension provided that any emissions increases associated with permeation are mitigated through an approved AERP. In addition, the start has added provisions that allow for early use of the new Predictive Model under specified conditions.

E. Development of the Proposed Amendments

In developing the proposal, staff hosted 14 workshops and public consultation meetings in 2006 and 2007. ARB staff and stakeholders also created four subgroups to investigate and make recommendations regarding changes to the reformulated gasoline regulations. The subgroups were made of individuals with expertise in the following areas: 1) statistics, 2) emissions inventories, 3) hydrocarbon reactivity, and 4) refinery production. The subgroups reported on progress at various workshops. Staff also held individual meetings and conference calls with various stakeholders regarding individual concerns and created a Predictive Model website to ensure that information used to update the Predictive Model is available to all stakeholders. The Fuels Program e-mail listserver was used to notify interested parties when information became available. The Fuels Program e-mail listserver is a self subscription list with over one thousand individual e-mail addresses.

F. Economic Impacts of the Proposed Amendments

This section summarizes the overall costs of producing compliant fuels, as well as potential economic impacts on businesses and consumers. The costs are generally associated with modifications necessary to mitigate the permeation emissions through the use of the Predictive Model. To mitigate these emissions, staff believes that producers will likely reduce sulfur levels, increase oxygen levels, and reduce vapor pressure levels of the blends. These changes will likely require some refinery and infrastructure modifications. In addition, the use of ethanol will also result in a small decrease in fuel economy. In developing its cost estimates, staff has consulted with producers, pipeline distributors, California Energy Commission (CEC) staff, and other stakeholders.

1. Overall Costs

Staff estimates that the proposed amendments to the CaRFG3 regulations will increase gasoline production costs by between 0.3 to 0.8 cents per gallon of gasoline. These cost estimates are generally based on:

- Recovery of $200 to $400 million of collective capital improvement costs associated with all refinery modifications and increased costs associated with increased ethanol usage, including capital expenditures at pipeline terminals and ethanol off-loading sites for the handling and storage of increased amounts of ethanol; and
- Annual operating and maintenance costs of $20 to $80 million.

About 900 million gallons per year of ethanol is currently used in CaRFG3. The proposed amendments are expected to increase ethanol consumption in California from 300 to 600 million additional gallons per year, at an estimated cost of $600 to $1,200 million annually based on average spot market prices and ethanol subsidies. Note that the producers would most likely have met most of their ethanol needs via contracts, often at much lower costs than spot prices.

However, the use of ethanol will displace an equal volume of gasoline blendstocks, and therefore, the costs must be compared to the costs of equivalent volumes. On average, ethanol costs have, after adjusting for the favorable tax treatment given to ethanol, been lower per gallon than gasoline blendstocks. Provided this price advantage continues, staff expects there to be a small cost advantage to using ethanol relative to gasoline production based on the spot market prices of gasoline.

2. Costs of the Alternative Emissions Reduction Plan

Staff believes that the AERP will not result in a significant increase in cost to producers compared to simple compliance with the proposed rule. Staff calculated the potential costs to the industry if all participants used an accelerated vehicle retirement program for an AERP. Staff estimates it would take approximately 290,000 retired vehicles to offset the 18.4 tpd of hydrocarbons (51 tpd of ozone-forming potential). At a cost of $750 per vehicle, the total AERP cost would be about $220 million. Taking into account that the credits are good for 3 years and spreading the cost over 16 billion gallons of gasoline consumed a year in California leads to producer costs of about 0.5 cents per gallon. This estimate could be substantially higher or lower depending on the funding needed to scrap vehicles.

3. Impacts on Consumers

There is a fuel economy penalty associated with increasing ethanol in gasoline. Ethanol has about 31 percent less energy per gallon than reformulated gasoline. Therefore, increasing the amount of ethanol in gasoline decreases the energy density of the blend and ultimately the fuel economy of the vehicle. Switching from a current fuel that contains 5.7 percent by volume ethanol to a fuel that contains 10 percent by volume ethanol results in a 1.3 percent fuel economy penalty.

For a typical consumer that drives 15,000 miles per year in a car with a fuel economy of 20 miles per gallon and gas prices at $3.00 a gallon, the effective cost of using a 10 percent ethanol blend would be about 0.20 cents per mile or $30 per year. The costs to the end user of increases in gasoline production costs range up to $6 per year. Combining the fuel economy penalty and the high end cost of production, staff estimates that the total cost to the end user will be about $36 per year or about 1.3 percent of total annual fuel costs for a typical California driver.

If all gasoline were to be produced at the E10 level rather than the current E6, total fuel use would increase by about 200 million gallons per year. If gasoline retails at $3.00 per gallon, net expenditures for fuel would increase by about $600 million per year.

4. Impacts on Small Refiners

Small refiners will be expected to offset the increase in evaporative emissions due to permeation. Small refiners will not be required to offset the permeation increase through fuel formulations changes, but will be allowed to use the AERP indefinitely. This would lead to small refiner costs of about 0.5 cents per gallon as discussed above.

5. Effects on Production from the Proposed Changes on CaRFG3

Staff has discussed with producers and CEC staff the impact on production that could result from implementation of the proposed amendments. In the short term production capability would be impacted by the proposed changes. For example, if producers were required to fully comply with the requirements in 2010 using newly required fuel formulations, many producers would not be able to comply while maintaining current refining capacity. In this scenario, staff estimates that there could be a five to 10 percent gasoline production loss at California refiners for one to two years. During this period, greater use of imports of gasoline or gasoline blending components would be needed. However, producers would be able to produce a complying alternative fuel formulation beginning in 2012 with no loss in production due to the completion of appropriate refinery projects.

As discussed above, producers have the option of using an AERP during the transition period from 2010 until 2012. Therefore, staff anticipates that emissions increases due to permeation can be mitigated by 2010 without production losses during this period when refinery changes are underway.

G. Environmental impacts of the Proposed Amendments

This section summarizes the expected environmental impacts of the proposed amendments. The summary addresses the need for a multimedia evaluation and impacts on air quality, greenhouse gases, water quality, and community health and environmental justice.

As mentioned above, Health and Safety Code section 43013.1 requires that CaRFG3 preserve the emission benefits of CaRFG2. These benefits include emission reductions for pollutants, including precursors, identified in the State Implementation Plan for ozone, and emission reductions in potency-weighted air toxics compounds. The staff does not anticipate any significant adverse environmental impacts associated with the proposed amendments. However, as discussed below, the proposed amendments do not fully comply with the requirements of Health and Safety Code section 43013.1 in that potential emission increases associated with off-road sources are not fully mitigated.

1. Multimedia Evaluation

Health and Safety Code section 43830.8, enacted in 1999 (Stats. 1999, ch. 813; S.B. 529, Bowen) generally prohibits ARB from adopting a regulation establishing a specification for motor vehicle fuel unless the regulation is subject to a multimedia evaluation by the California Environmental Policy Council (CEPC). A multimedia evaluation is the identification and evaluation of any significant adverse impact on public health or the environment, including air, water, or soil, that may result from the production, use, or disposal of the motor vehicle fuel that may be used to meet the state board's motor vehicle fuel specifications. The statute provides that the Board may adopt a regulation that establishes a specification for motor vehicle fuel without the proposed regulation being subject to a multimedia evaluation if the CEPC, following an initial evaluation of the proposed regulation, conclusively determines that the regulation will not have any significant adverse impact on public health or the environment.

The proposed amendments do not substantially change specifications of CaRFG3 gasoline and will not require a gasoline ingredient to be added or removed beyond what is allowed by the existing regulations or is currently already used to produce gasoline for sale in California. Therefore, staff believes that the proposed amendments to the CaRFG3 regulations are not subject to the requirement for a multimedia evaluation.

2. Air Quality

This section presents the air quality impacts of the proposed amendments.

a. Emissions Associated with the Replacement of MTBE with Ethanol

The proposed amendments are generally designed to address the emissions impacts associated with the replacement of MTBE with ethanol pursuant to the provisions of Health and Safety Code section 43013.1. Among other provisions, this section requires that CaRFG3 must maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999, including emission reductions for all pollutants identified in the State Implementation Plan for ozone, and emissions reductions in potency-weighted air toxic compounds.

In approving the CaRFG3 regulations in late 1999, it was found that CaRFG3 maintained or improved upon the CaRFG2 regulations as required by Section 43013.1 except for increases in hydrocarbon permeation emissions associated with the use of ethanol.

As discussed in Chapter II, the addition of ethanol increases permeation emissions from both on-road and off-road sources.

(1) Impact on On-road Sources

The proposed amendments are specifically designed to mitigate the increase of permeation emissions from on-road sources. The estimated increase of permeation emissions is 28.8 tpd in 2005, 18.4 tpd in 2010, 12.1 tpd in 2015 and 8.1 tpd in 2020. The mitigation is provided through the use of alternative fuel formulations or, for a limited time for most producers, through the use of an AERP. The mitigation begins no later than December 31, 2009. This date was chosen as the earliest practical date to implement either alternative fuel formulations or AERPs.

(2) Impact on Off-road Sources

The proposed amendments may not fully mitigate the impact of permeation on off-road sources. Off-road gasoline applications include sources such as lawnmowers, string trimmers, airport ground equipment, recreational equipment (snowmobiles, pleasure craft), and portable gas containers.

As discussed previously, the addition of ethanol is likely to reduce the exhaust emissions of hydrocarbons and carbon monoxide, but will likely increase permeation emissions. At higher levels of ethanol, the emissions of oxides of nitrogen may increase. However, staff is unable to define a method that ensures permeation effects in off-road sources are fully mitigated at this time. Available data are not sufficient to reasonably quantify the effect that ethanol in gasoline has on permeation emissions or the effect of fuel property changes on the exhaust emissions from off-road sources.

Based on limited test programs, staff estimates for 2015 that the addition of ethanol to gasoline will increase evaporative hydrocarbon emissions by about 15 to 39 tpd. Similarly, staff estimates that the use of additional ethanol in gasoline could decrease the exhaust emissions of hydrocarbons by 15 to 21 tpd and increase slightly the exhaust emissions of NOx by about 1 to 2 tpd. Further work is needed to determine the emission impacts of greater ethanol use and to define what additional mitigation, if any, is necessary.

To improve the data and enable the design of an effective mitigation strategy, staff is developing an emissions test program to provide enough information to reasonably quantify the impacts of ethanol on the emissions from off-road sources. This will allow a mitigation program, if appropriate, to be developed. Impacts on permeation due to ethanol blending, engine exhaust emissions, changes due to increased oxygenates, and benefits of catalysts on reducing engine emissions will be studied.

b. Impact on the State Implementation Plan

The ARB's 2007 State Implementation Plan (SIP) proposal is a comprehensive strategy designed to attain federal air quality standards as quickly as possible through a combination of technologically feasible, cost-effective, and far reaching measures. The total magnitude of the reductions to be achieved through new actions is primarily driven by the scope of the air quality problems in the San Joaquin Valley and South Coast Air Basin.

When introduced in 1996, gasoline meeting the CaRFG2 specifications was estimated to produce about a 15 percent overall reduction (300 tons per day) in ozone precursor emissions from motor vehicles. These emission reductions were equivalent to removing 3.5 million vehicles from California's roads. The CaRFG2 program is also a major component of the California SIP. In 1996, the CaRFG2 program accounted for 25 percent of the ozone precursor emission reductions in the SIP. The CaRFG3 regulations, approved by the Board in 1999, removed MTBE from California gasoline, however, the substitute oxygenate, ethanol, has resulted in increased evaporative emissions due to fuel system permeation. This proposed measure would make modifications to the CaRFG3 program to eliminate or offset all ethanol permeation effects from motor vehicles and a significant portion of the permeation effect from off-road applications.

3. Greenhouse Gas Emissions

Staff expects that the CaRFG3 amendments would ultimately result in a small (less than one percent)[3] net decrease in CO_2 equivalent greenhouse gas emissions from California gasoline production and use. This is due to the expected increase in ethanol blending ratio from 5.7 to as high as 10 percent by volume.[4] As currently produced in the U.S., ethanol creates about zero to 30 percent less CO_2 equivalent greenhouse gases (GHG) per unit of energy output than would occur from the gasoline displaced due to ethanol use[5].

In January 2007, the Governor's Executive Order S-01-07 required a Low Carbon Fuel Standard (LCFS) for transportation fuels be established for California. This first of–its-kind standard will support the AB 32 climate change emissions target as part of California's overall strategy to fight global warming. ARB is expected to initiate rulemaking activities for the LCFS in July 2007. The proposed changes to the CARFG3 rules are expected to provide additional flexibility for producers to comply with the LCFS.

Expected changes to the production of California gasoline are expected to result in an additional but much less significant change in CO_2 equivalent emissions.

[3] The actual benefits will depend greatly on how ethanol used in California is produced.
[4] This would be an ethanol energy content increase from about 3.9 percent to about 6.9 percent.
[5] http://www.energy.ca.gov/ab1007/documents/2007-03-02_joint_workshop/presentations/TIAX-2_2007-03-02.PDF

This is due to the need to use more energy in the production of lower sulfur feedstocks. The expected reduction in sulfur content could cause small (less than 0.01 percent)[6] net increases in CO_2 equivalent emissions. Generally, the more hydrotreating required in producing a given type of fuel, the more CO_2 equivalent GHGs are emitted in the production of the fuel.

4. Water Quality

The proposed amendments do not change either the flat limits or averaging limits or cause any fuel property to exceed the cap limits. Staff expects that there will be a reduction in sulfur content and an increase in the volume of ethanol. These potential fuel formulation changes are not expected to have any significant effect on the quality of both ground and surface water beyond what is currently allowed.

5. Community Health and Environmental Justice

Environmental justice is a core consideration in ARB's efforts to provide clean air for all California communities (CARB 2001, i.e. Policies and Actions for Environmental Justice, PTSD, 2001). The increased ethanol required for blending would require additional number of trucks delivering ethanol to pipeline terminals. Staff has estimated that to supply the necessary additional ethanol to the distribution terminals there will likely be about an additional 8300 miles driven each day by heavy duty diesel trucks. This represents about 0.02 percent of the total miles driven each day by heavy duty diesel trucks (38,204,000 miles per day in 2006-source: ARB EMFAC 2007). The impacts of this however, could be localized near blending terminals. To accommodate the additional ethanol most of the terminals must have their ethanol storage and blending equipment upgraded; this will be subject to local permitting requirements and California Environmental Quality Act (CEQA), and any significant increases in emissions must be mitigated. Also, the expansion of hydrotreating capacity at producer facilities and other associated changes will require either new permits or amendments to existing permits. Again, increases in emissions must be mitigated.

H. Alternatives to the Proposed Amendments

1. Alternatives Related to the Predictive Model

Staff believes that it is appropriate to update the Predictive Model to add the permeation emissions, update the motor vehicle emissions inventory vehicle mix, update the reactivity adjustment factors, add the new motor vehicle exhaust emissions test data, and update the effect of carbon monoxide on ozone-forming potential. During the development of these proposed amendments to the Predictive Model, stakeholders proposed alternatives related to the general

[6] See ARB staff report, Appendix J, "Effect of Low Sulfur Diesel Fuel on Greenhouse Gas Emissions," June 6, 2003.

construction of the Predictive Model. These proposed alternatives consisted of issues such as reactivity values for CO and dividing the vehicle datasets in the Predictive Model. Stakeholders also proposed the inclusion of off-road emissions into the Predictive Model.

Staff reviewed the stakeholder proposed alternatives related to the general construction of the Predictive Model and determined that the related data and information conclusively supported staff's suggested revisions to the Predictive Model. A detailed description and analysis of the proposed alternatives related to the Predictive Model is contained in Chapter VI.

a. Incorporate Off-Road Emissions Into the Predictive Model

The CaRFG program was adopted to reduce emissions from motor vehicles. The data developed to support this rulemaking came from studies that related fuel properties to on-road motor vehicle emissions. Then, as now, adequate emission studies do not exist to allow inclusion of off-road emissions into the CaRFG program including the Predictive Model. This is due in part to low consumption of fuels in off-road applications, less than five percent of total gasoline. Emission studies are being implemented to provide the necessary data to allow an assessment to be made of the appropriateness of incorporating off-road emissions into the CARFG program.

2. Alternatives Related to the Alternative Emission Reduction Plan

There are two basic alternatives related to the AERP. The first alternative would be to extend the AERP to address off-road emissions. As discussed in Chapter V, there are insufficient data available to reliably estimate the impact of the addition of ethanol to gasoline. Staff has initiated several new studies designed to provide the data necessary to make further improvements to the off-road emissions estimates. Also, once these studies are complete, staff proposes to return with appropriate mitigation approaches and/or changes in the Predictive Model.

The second alternative would be to allow the use of the AERP indefinitely. As proposed, the AERP can only be used by the large producers until December 31, 2011. Small producers can use the AERP indefinitely. Staff does not support the use of the AERP beyond the sunset date. While it is expected that an AERP can provide emission mitigation, only fully complying fuel can ensure that the full benefits are obtained. Small producers supply less than 5 percent of gasoline consumed in the State and the risk by allowing them access to the AERP on an ongoing basis is limited.

3. Alternatives Related to the Change in Specifications

There were four staff proposals related to specification changes. These proposals were relating to denatured ethanol, the modeling of oxygen content, adjusting the RVP limit, and lowering the sulfur cap. Regarding the first three, no alternatives exist that would provide an acceptable alternative. A detailed description and analysis of the proposed alternatives related to specification changes is contained in Chapter VI.

a. Sulfur Cap

The first alternative is to lower the sulfur cap limit even further than 20 ppmw. Lowering the sulfur cap limit below 20 ppmw would make sense, if the current CaRFG flat limit is also changed to be below 20 ppmw. Lowering both the sulfur cap and the flat limits would decrease flexibility for refiners to make compliant CaRFG. This lack of flexibility could adversely affect the supply of gasoline in California, and would severely limit the options available to producers to use higher oxygen level to mitigate permeation emissions.

The second alternative is to leave the sulfur cap at 30 ppmw. Given the implementation of the new federal Tier II sulfur limits for federal gasoline, it would make it more difficult to enforce the requirement that only complying California Phase 3 reformulated gasoline be sold for use in California. No alternative considered by the agency would be more effective in carrying out the purpose for which the regulation is proposed or would be as effective and less burdensome to affected stakeholders than the proposed regulation.

4. Alternatives Related to Implementation Dates

Staff considered alternative implementation dates for producers to certify fuel formulations that mitigate the increase in permeation emissions. Staff also considered alternative dates for the use of the AERP option, including implementing the requirements sooner. After discussions, with stakeholders, staff determined that December 31, 2009 was a sufficient date for producers to certify fuel formulations that mitigate the increase in permeations along with the option using the AERP option. Staff was also able to determine that the producers would have sufficient time to certify formulations that could fully mitigate permeation emissions with the use of the AERP option by December 31, 2011.

I. Recommendations

The staff recommends that the Board adopt the following proposed amendments to the California Reformulated Gasoline regulations.

1. Update the Predictive Model and the CaRFG3 performance standards to require the mitigation of increases in permeation emissions due to the use of ethanol. Require mitigation of these emissions no later than the 2010 smog season.

2. Between 2010 and 2012, allow producers to utilize an Alternative Emissions Reduction Plan to mitigate emissions associated with permeation, thus allowing additional flexibility to come into compliance at an earlier date or more time to offset emissions, if needed. In general, sunset this provision after 2012, but provide for a one year extension under specified situations.
3. Lower the sulfur cap limit from 30 ppmw to 20 ppmw and restore the RVP flat limit of 7.00 psi allowed in CaRFG2 when using the evaporative emissions portion of the Predictive Model to certify ethanol blends. Maintain the requirement to use 6.90 psi RVP as the flat limit for non-oxygenated blends, adopted originally to mitigate the effects of commingling.
4. Allow refiners the option of averaging emissions associated with unexpected high sulfur levels over a period no more than 90 days. This is a modification of the current averaging provisions, which will allow flexibility while preserving emission benefits.
5. Approve other miscellaneous changes to increase enforceability, flexibility, and consistency of the regulations.

Chapter I. Introduction

This report presents the Initial Statement of Reasons in support of proposed amendments to the California reformulated gasoline (CA RFG) regulations. Over the years, the Air Resources Board (ARB/Board) developed and amended these regulations in three phases. The most recent amendments implemented the Governor's and Legislature's directions to phase out methyl-tertiary-butyl-ether (MTBE) from California gasoline. Legislation, Senate Bill 989, establishing Heath and Safety Code Section 43013.1 requires the Board to preserve the air quality benefits of the existing reformulated gasoline program as it existed in 1999.

The purpose of the proposed amendments is to address increases in emissions resulting from the addition of ethanol to gasoline. Ethanol replaced MTBE to ensure that the oxygen requirements of the federal regulations were met. However, recently completed studies on on-road motor vehicles now show that ethanol increases the evaporation emissions of gasoline through a process known as permeation. Permeation refers to the diffusive process whereby fuel molecules migrate through the polymeric material of a vehicle's fuel system. Eventually the fuel molecules are emitted into the air where they contribute to evaporative emissions from the vehicle. Permeation emissions are higher with ethanol blended gasoline than with a comparable fuel without ethanol, or with MTBE.

To address the permeation emissions, the staff is proposing several amendments. The most significant change is to the California Predictive Model. The gasoline producers use the Predictive Model to establish alternative formulations that are most cost-effective for their specific situation, while ensuring that the emissions benefits of the fuel are achieved. A description of the Predictive Model is presented in the next chapter. The proposed amendments are presented in Chapter III. Additional amendments are proposed to lower the maximum allowable sulfur content of the fuel, provide additional flexibility to the producers in blending very low sulfur fuels, and add conforming changes throughout the regulations.

The proposed amendments will not result in any additional environmental impacts. However, ethanol also affects off-road gasoline-powered engines and equipment, as well as portable gas containers. This includes lawnmowers and other types of gasoline-powered lawn and garden equipment. Available data indicate that ethanol may reduce the exhaust emissions of hydrocarbons and carbon monoxide, but increase the evaporative emissions due to permeation. However, there are limited data available to accurately quantify this impact. Therefore, the staff is conducting an emissions test program that will provide the data necessary to quantify the impacts and will return to the Board in about 18 months with additional proposed amendments, if necessary, to fully mitigate the impacts of ethanol on off-road sources. Additional details on costs to producers and consumers are provided in Chapter IV.

The proposed amendments will result in additional costs to the producers, as the new requirements will likely require lower sulfur limits than are produced today. In addition, the blends are likely to have higher ethanol content. Because, the energy value of ethanol is lower than gasoline, a small decrease in the average fuel economy is expected. These costs are discussed in Chapter V.

In developing the proposed amendments, the ARB staff hosted 14 workshops and public consultation meetings in 2006 and 2007. ARB staff and stakeholders also created four subgroups to investigate and make recommendations regarding changes to the reformulated gasoline regulations. The subgroups were made of individuals with expertise in the areas being investigated. The areas covered by the subgroups were: statistics; emissions inventories; hydrocarbon reactivity; and refinery production. The subgroups reported on progress at various workshops. The individuals participating in the subgroups are listed in the acknowledgements.

Staff also held individual meetings and conference calls with various stakeholders regarding individual concerns. ARB staff created a Predictive Model website to ensure that information used to update the Predictive Model is available to all stakeholders. ARB staff used the Fuels Program e-mail listserver to notify interested parties when information becomes available. The Fuels Program e-mail listserver is a self subscription list with over one thousand individual e-mail addresses.

Chapter II. Reformulated Gasoline Programs

This chapter presents a brief overview of the United States Environmental Protection Agency's (U.S. EPA) Reformulated Gasoline (U.S. EPA RFG) program and California's Reformulated Gasoline (CaRFG) program. As part of this overview, a description of the California Predictive Model is presented. In addition, the Chapter presents background information on current gasoline consumption, the average fuel properties of California gasoline, and the impact that the use of ethanol has had in California.

A. Federal Reformulated Gasoline Program

The 1990 Federal Clean Air Act required the U.S. EPA to establish reformulated gasoline regulations. The Clean Air Act requires areas with high ozone concentrations to use U.S. EPA RFG. Nationally, about 30 percent of the gasoline produced must meet these requirements. These regulations impose emission performance standards for reducing volatile organic compounds (VOCs) and toxic air contaminants (air toxics). In addition, the regulations imposed a ban on heavy metals and a limit on benzene content.

Phase I U.S. EPA RFG regulations (1995-1999) set 15 percent emission reduction performance requirement for VOCs and air toxics against baseline emissions. The baseline emissions are the emissions of 1990 model year vehicles operated on a specified baseline fuel. Phase II U.S. EPA RFG (2000-present) specifies that the VOC and air toxics performance standards must meet a 25 percent reduction from the baseline. In California, fuel sold in the South Coast, San Diego, San Joaquin Valley, and the Sacramento regions must meet federal U.S. EPA RFG requirements, but can do so through the use of CaRFG because the California program produces significantly greater emission reductions than the Federal RFG program. These regions account for about 80 percent of the gasoline sold in California.

The U.S. EPA RFG requirements mandated the use of a minimum average oxygen content (2.0 percent by weight) year-round in U.S. EPA RFG areas. However, the Energy Policy Act of 2005 (EPAct), among other things, authorized the U.S. EPA to lift the reformulated gasoline oxygen content requirement. The removal of the two percent oxygen content requirement for U.S. EPA RFG took effect nationwide May 6, 2006. Instead of a minimum oxygen content requirement, the EPAct established a renewable fuels standard that requires increasing quantities of renewable fuels be consumed each year. Beginning in 2006, the renewable fuels standard requires that 4 billion gallons of renewable fuel be consumed with the amount increasing annually up to 7.5 billion gallons of renewable fuel consumed in 2012. The phase-in schedule is shown in Table 1.

Table 1: National Renewable Fuels Standard

Year	Renewable Fuels (billions of gallons)
2006	4.0
2007	4.7
2008	5.4
2009	6.1
2010	6.8
2011	7.4
2012	7.5

In 2004, the U.S. EPA implemented Tier II vehicle emissions and gasoline sulfur standards. The U.S. EPA set the refinery sulfur average at 30 parts per million by weight (ppmw), with a corporate average of 90 ppmw and a cap of 300 ppmw. A cap standard cannot be exceeded anywhere in the distribution system. Both of the average standards could be met with use of credits generated by other refiners who reduced sulfur levels early. In 2006, refiners were required to meet a 30 ppmw average sulfur level with a maximum cap of 80 ppmw.

In February 2007, EPA finalized a rule to reduce hazardous air pollutants from mobile sources. The rule requires that, beginning in 2011, refiners must meet an annual average gasoline benzene content standard of 0.62 percent by volume (vol%) on all their gasoline, both reformulated and conventional, nationwide. The national benzene content of gasoline today is about 1.0 vol%. Gasoline sold in California will not be covered because California has already implemented more stringent standards similar to those the U.S. EPA has established.

The regulations include a nationwide averaging, banking, and trading program. In addition to the 0.62 vol% standard, refiners must also meet a maximum average benzene standard of 1.3 vol% beginning on July 1, 2012, which acts as an upper limit on gasoline benzene content when credits are used to meet the 0.62 vol% standard. A refinery's or importer's actual annual average gasoline benzene levels may not exceed this maximum average standard.

B. California Reformulated Gasoline Program

California Health and Safety Code section 43018 requires the Air Resources Board (ARB or Board) to achieve the maximum feasible reductions from motor vehicles and motor vehicle fuels. In carrying out this requirement, ARB is to adopt standards and regulations that produce the most cost-effective combination of control measures on all classes of motor vehicles and motor vehicles fuels, including the specification of vehicular fuel composition. In response, the Board has adopted numerous regulations, including the California Reformulated Gasoline Program (CaRFG).

The CaRFG program is a vital part of ARB's strategy to address motor vehicles and fuels as a system by combining cleaner fuels and motor vehicle controls to achieve the maximum emission reductions at the lowest cost. CaRFG also substantially reduced emissions from existing vehicles. The Board initially adopted the CaRFG program in two phases. Phase 1 of the program required changes to gasoline that could be made in a short time frame and only required small investments by producers and importers (Note: Producers from this point forward will refer to both producers and importers, unless otherwise specified) . Phase 2 was significantly more complex and achieved more emissions reductions. Phase 3 implemented the Governor's and Legislature's direction to remove MTBE from California gasoline. Each of these phases is discussed in more detail below.

1. Phase 1

The Phase 1 CaRFG regulations (CaRFG1) were approved in 1990 and implemented in 1992. CaRFG1 lowered the limit on Reid vapor pressure (RVP), required the addition of deposit control additives, and eliminated leaded gasoline. CaRFG1 resulted in a reduction in vehicle emissions of 210 tons per day of VOC emissions, about a 10 percent reduction of this pollutant. These standards were implemented relatively quickly as they did not require significant producer facility modifications.

2. Phase 2

The Board approved CaRFG2 in 1992; the requirements were implemented in 1996. For the first time, the Board considered the vehicle and the fuel as a system. This action not only achieved emission reductions from new and existing vehicles, but ensured the fuel vehicle manufacturers needed to employ better emission control techniques for future vehicles. CaRFG2 compliant fuel reduced emissions of ozone precursors from motor vehicles by about 15 percent, or 300 tons per day (tpd), and reduced air toxic emissions by 40 percent. These emission reductions were equivalent to removing approximately 3.5 million vehicles from California's fleet.

CaRFG2 set limits for the eight gasoline properties shown below:

RVP	90% distillation temperature (T90)
Sulfur	50% distillation temperature (T50)
Benzene	Aromatic Hydrocarbons
Olefins	Oxygen

With the exception of oxygen, the regulations set three limits for each property: a "cap" limit that applies to all gasoline anywhere in the gasoline distribution and marketing system and does not vary; and "flat" and "averaging" limits that apply to gasoline when it is released by refiners, importers, and blenders (collectively, “producers”). In actual use, the flat and averaging limits are adjustable by gasoline producers through the use of the Predictive Model, as explained below. Gasoline producers could comply with the producer limits in one of three ways. First, for a given property, each producer may choose to meet either the flat limit or the averaging limit. Any gallon of gasoline released for sale by the producer may not exceed the flat limit (if used). If the averaging limit is used for a property, the producer assigns a “Designated Alternative Limit” (DAL) to each batch of gasoline and all batches with a DAL over the averaging limit must be offset by batches with lower DALs that are shipped from the production facility within 90 days before or after the high DAL batch. Second, a producer may use the Predictive Model to identify other sets of property limits (flat, averaging, or mixed) that can be applied to that producer’s gasoline. Third, a producer may validate an alternative set of property limits through emission testing per a prescribed protocol. Whether validated by the Predictive Model or by testing, no alternative limit may exceed the cap limit for the property.

To comply with the oxygen content requirement, producers chose to use MTBE. Soon after CaRFG2 implementation, the presence of MTBE in groundwater began to be reported. An investigation and public hearings were conducted resulting in the issuance of Executive Order D-5-99 on March 25, 1999. The Executive Order directed the phase-out of MTBE in California’s gasoline. In addition, the Legislature passed Senate Bill 989. Among other provisions, the bill directed the ARB to ensure that regulations adopted pursuant to the Executive Order maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999 (Health and Safety Code section 43013.1).

3. Phase 3

The Board approved the CaRFG3 regulations on December 9, 1999. The CaRFG3 regulations prohibited California gasoline produced with MTBE starting December 31, 2002, established CaRFG3 standards applicable the same date, established a CaRFG3 Predictive Model, and made various other changes. The CaRFG3 standards modify the specifications for five of the eight gasoline properties regulated by CaRFG2, with the objective of providing additional flexibility in lowering or removing the oxygen content requirement while maintaining current emissions and air quality benefits.

The CaRFG3 regulations also placed a conditional ban, starting December 31, 2002, on the use of any oxygenate other than ethanol, as a replacement for MTBE in California gasoline. No other oxygenate may be used unless a multimedia evaluation is conducted, and the California Environmental Policy Council has determined that its use will not have a significant adverse impact on the public health or the environment. To date, no other oxygenate has been approved for use in California gasoline.

Originally, the CaRFG3 regulations banned gasoline produced with the use of MTBE, for all California gasoline supplied from production and import facilities starting December 31, 2002 and established a three-stage schedule for reducing residual MTBE levels. Subsequent data indicated that the timetable for removal of MTBE would not satisfy the directive of Executive Order D-5-99 that there be an adequate supply and availability of gasoline for California consumers. At that time, there was still uncertainty regarding the supply and availability of ethanol necessary to meet California's requirements.

Therefore, on March 14, 2002, Governor Davis issued Executive Order D-52-02, which directed the ARB to take the necessary actions, by July 31, 2002, to postpone for one year the prohibitions of the use of MTBE and other specified oxygenates in California gasoline, and the related requirements for California Phase 3 reformulated gasoline. The Governor found that it was not possible to eliminate use of MTBE starting December 31, 2002 without significantly risking disruption of the availability of gasoline in California. Such disruption would substantially increase prices, harm California's economy, and impose an unjustified burden upon California motorists.

Therefore, the Board approved amendments to the CaRFG3 regulations on July 25, 2002. In this rulemaking, the Board approved the following amendments consistent with the Governor's Executive Order D-52-02, along with a few other amendments designed to ensure that the regulations work effectively.

- The amendments postponed the prohibition of the use of MTBE and other oxygenates other than ethanol in California gasoline from December 31, 2002 to December 31, 2003, with the downstream phase-in requirements also postponed by one year. Similarly, the schedule for reducing residual levels of MTBE in CaRFG3 would be postponed one year. Starting December 31, 2003, California gasoline could not contain more than 0.30 volume percent MTBE. This residual limit of 0.15 volume percent MTBE would apply starting December 31, 2004, with the 0.05 volume percent residual limit starting December 31, 2005.

- The amendments also postponed the imposition of the CaRFG3 standards for gasoline properties from December 31, 2002 to December 31, 2003. With the delay in the prohibition of the MTBE prohibition, it was appropriate to allow refiners to meet the CaRFG2 standards for an additional year for producing gasoline oxygenated with MTBE. The amendments also delayed for one year (from December 31, 2004 to December 31, 2005) the reduction of the CaRFG3 sulfur content cap limit from 60 ppmw to 30 ppmw.

The CaRFG3 limits now in effect are shown in Table 2.

Table 2: CaRFG Limits and Caps

Property	Flat Limits	Averaging Limits	Cap Limits[(1)]
Reid vapor pressure, psi, max	7.00 or 6.90 [(2)]	---	6.40 - 7.20
Benzene, vol%, max	0.8	0.70	1.10
Sulfur, ppmw, max	20	15	30
Aromatic HC, vol%, max	25	22	35.0
Olefins, vol%, max	6.0	4.0	10.0
Oxygen, wt%	1.8 to 2.2	---	1.8 – 3.5[(3)] 0 – 3.5
T50 (temp. at 50% distilled) ^{o}F, max	213	203	220
T90 (temp. at 90% distilled) ^{o}F, max	305	295	330

(1) The "cap limits" apply to all gasoline at any place in the marketing system and are not adjustable.
(2) 6.90 psi applies when a producer is using the evaporative emissions element of CaRFG3 Predictive Model and gasoline may not exceed a cap of 7.20 psi; otherwise, the 7.00 psi limit applies.
(3) The 1.8 weight percent minimum applies only during the winter and only in certain areas.

C. The California Predictive Model

Numerous studies have shown that the properties of gasoline affect motor vehicle emissions. Based on thousands of individual tests, equations have been developed that relate changes in fuel properties to changes in emissions. The Predictive Model takes advantage of these relationships to provide producers flexibility. The producers use the Predictive Model to identify alternative limits that achieve equal or better emission reductions compared to the use of the flat or averaging limits. The Predictive Model provides flexibility for the producers, while ensuring California's emissions reduction goals are met. This flexibility is highly valued by the producers and the vast majority of CaRFG is produced using the Predictive Model.

As originally developed for CaRFG2, the Predictive Model is a set of mathematical equations that relate emission rates of exhaust hydrocarbons, oxides of nitrogen (NOx), and combined exhaust toxic species[7] to the values of the eight regulated gasoline properties. Emissions of each pollutant type are predicted by equations formulated separately for vehicles of different technology classes.

The CaRFG2 Predictive Model divides vehicles into five basic emissions control technology groups. Table 3 shows the vehicle technology group definition used in the development of the Predictive Model. Each group represents a different emissions standard required on California fleet vehicles. The contribution of

[7] Four toxic species are involved: benzene, 1,3-butadiene, formaldehyde, and acetaldehyde. Separate predictions for the four are combined with weights proportional to the ARB's unit-risk values for the species. The resultant sum is the "potency-weighted toxic" (PWT) emission rate.

each group changes with time as older vehicles are retired, or new vehicles met more stringent standards. Regression equations were derived from vehicle emission observations associated with fuel property changes. The limited data for older vehicles prevented the construction of Tech 1 and Tech 2 models; originally, there were no data available to construct the Tech 5 model in 1994.

Table 3: Vehicle Technology Groups

Tech Group	Vehicle MY	Emissions Control Technology
Tech 1	Pre-1975	Non-Catalysts
Tech 2	1975-1980	Open-Loop Oxidizing Catalysts
Tech 3	1981-1985	Closed-Loop Three-Way Catalysts
Tech 4	1986-1995	Advanced Closed-Loop Three-Way Catalysts
Tech 5	1996 and newer	Low Emission Vehicles (LEV, ULEV, SULEV, and PZEV)

The equations were derived by statistical analyses applied to thousands of individual emissions observations and the associated values of the fuel properties. For each pollutant, the predictions for the three classes are combined with weights proportional to the contributions of the vehicle classes to the ARB's emission inventory for that pollutant.

The Predictive Model then allows producers to certify alternative formulations of CaRFG2 by comparing the emission predictions for a candidate set of property limits to the predictions for the flat or averaging limits. If each prediction for the candidate limit is no greater than 1.004 times the corresponding basic-limit prediction, the alternative set of limits is allowable. In effect, the model allows a producer to use one or more limits greater than flat or averaging limits in exchange for compensating reductions in other limits. Thus, the model provides valuable flexibility to individual refiners by allowing refiners to most efficiently meet the CaRFG2 requirements, taking into consideration the configuration of the refinery. The CaRFG2 Predictive Model did not allow for the RVP limit to be adjusted, thus there was no evaporative emissions component.

In 1999, as part of the CaRFG3 regulations to phase-out MTBE from California gasoline, the CaRFG2 Predictive Model was revised. Also, an evaporative emissions model was incorporated to provide additional flexibility to offset emissions, by allowing tradeoffs between exhaust and evaporative HC emissions based on their ozone forming potential differences estimated by using reactivity weighting factors.

To facilitate the use of the Predictive Model, ARB staff provide a procedures guide, "California Procedures for Evaluation Alternative Specifications of Phase 3 Reformulated Gasoline Using the California Predictive Model." The guide provides step by step instructions, including ARB staff notification requirements. Also, a computer spreadsheet is provided so that users can in effect insert the specifications for the candidate fuel and the spreadsheet will calculate if the candidate fuel passes or fails.

D. Impact of Ethanol Use

In general, oxygenates such as MTBE and ethanol are used in gasoline to reduce the exhaust emissions of hydrocarbons and carbon monoxide and improve the octane rating. It is well known that ethanol increases the vapor pressure of gasoline. For many years, blends of gasoline have had to be adjusted to ensure that the RVP of the resulting blend met the limits and did not increase evaporative emissions. Available data also indicate that higher blends of ethanol increase the exhaust emissions of oxides of nitrogen.

When the Board approved CaRFG3 in 1999, if recognized that there was another potential source of evaporative emissions associated with the use of ethanol, referred to as permeation, and directed the staff to investigate. Permeation refers to the diffusive process whereby fuel molecules migrate through the polymeric material of a vehicle's fuel system. Eventually the fuel molecules are emitted into the air where they contribute to evaporative emissions from the vehicle. Permeation emissions were suspected of being higher with ethanol blended gasoline than with a comparable fuel without ethanol, or with MTBE. At the time, however, there was insufficient data available to quantify the impact of permeation on evaporative emissions.

To investigate, the ARB co-funded a research study with the Coordinating Research Council (CRC) to assess the magnitude of the permeation emissions associated with the use of ethanol in gasoline in on-road vehicles (CRC E-65 Study). Based on the study results, staff calculated the increase in evaporative emissions from on-road motor vehicles due the presence of ethanol in gasoline to be about 18 tons per day of hydrocarbons in 2010. Additional detail is presented in Chapter III. Appendix B provides the calculations supporting the emissions inventory.

Ethanol also affects off-road gasoline-powered engines and equipment, as well as portable gas containers. This includes lawnmowers and other types of gasoline-powered lawn and garden equipment. Available data indicate that ethanol reduces the exhaust emissions of hydrocarbons and carbon monoxide, but increase the evaporative emissions due to permeation. However, data available are too limited to accurately quantify this impact. As discussed in Chapter V, ARB staff is collaborating with the small engine manufacturers and U.S. EPA to co-fund studies at Southwest Research Institute to assess the impact of ethanol of various types of off-road sources, including portable gas containers. Appendix C presents additional details on the status of testing on off-road sources.

Pursuant to Health and Safety Code section 43013.1(b)(1), the ARB must ensure that CaRFG3 maintains or improves upon the emissions and air quality benefits achieved by CaRFG2. The data now show that there are increased evaporative emissions from on-road motor vehicles due to permeation caused by ethanol. As a result, staff is proposing amendments to fully mitigate the impacts from on-road motor vehicles.

E. California Gasoline Consumption

As shown in Table 4, the consumption of gasoline in California has steadily increased from the inception of the CaRFG program in 1992 through at least 2004. This increase was a result of various factors, such as population growth, longer commutes to work, and an increase in the number of vehicles per family. Also, the recent public preference for sport utility vehicles, vans, and trucks with lower fuel economy ratings has had an impact on the consumption of gasoline. In 2006, gasoline consumption was about 15.8 billion gallons per day.

Historically, gasoline consumption in California has been relatively price inelastic. This means that increases in price have relatively little impact on demand. Gasoline prices have exceeded three dollars a gallon in 2006 and have continued to hover around that level today (see Figure 1). As a result, the impact of even the relatively small price elasticity seems to have appeared in the gasoline market, as gasoline consumption decreased in 2006 from 2005 by 0.6 percent. Figure 1 shows the recent flat trend in gasoline consumption with increasing gasoline prices.

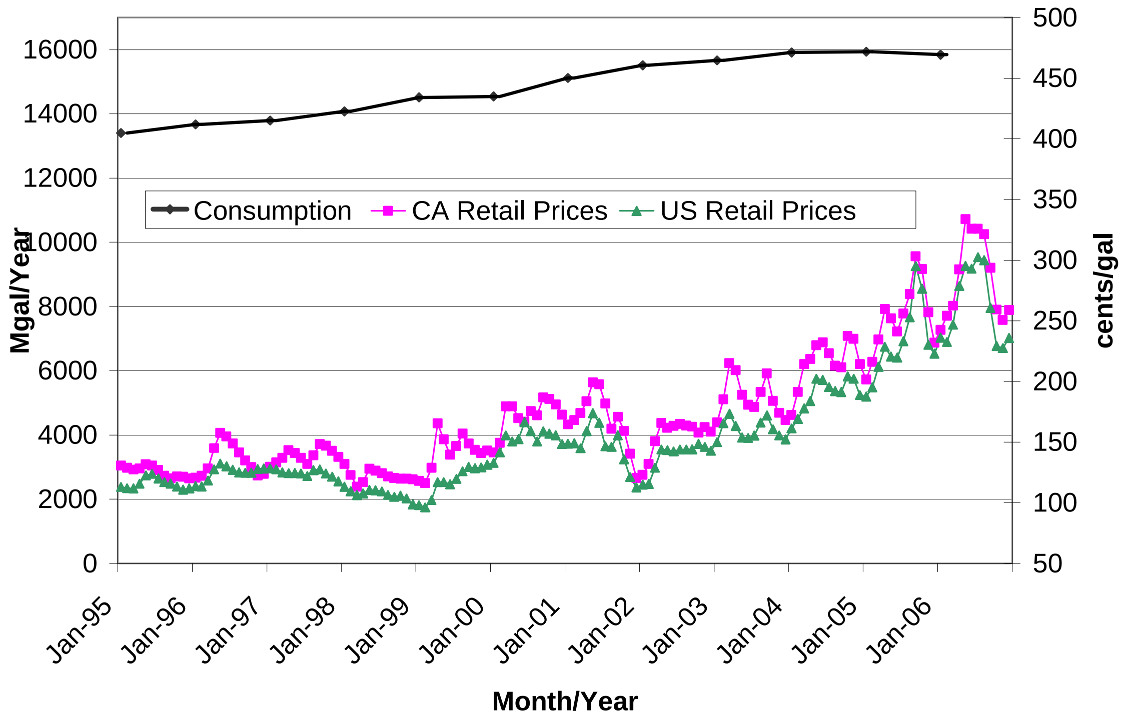
California refineries are producing gasoline very near their maximum production capability. Between 1999 and today, average demand in the markets supplied by California producers has exceeded production capacities, and imports have been increasing into California of finished gasoline and gasoline blending components.

Table 4: Gasoline Consumption in California

Year	Consumption (billion gallons/year)
1990	13.4
1991	13.2
1992	13.1
1993	13.2
1994	13.3
1995	13.4
1996	13.5
1997	13.8
1998	13.9
1999	14.5
2000	14.5
2001	15.1
2002	15.5
2003	15.7
2004	15.9
2005	15.9
2006	15.8

Source: State of California Board of Equalization Tax Tables

Figure 1: California Gasoline Consumption vs. Retail Price



F. CaRFG3 Properties and Composition

The staff analyzed the available information regarding the fuel properties for 2005 and 2006 to determine average in-use fuel properties. The staff used a database of 2005 and 2006 fuel properties reported by each producer certifying alternative formulations using the Predictive Model, as well as the results of ARB tests of fuel samples taken from refineries for 2003 through the first half of 2006.

Producers make fuels with properties that are less than what they report to the ARB. If ARB staff tests a fuel and it is above the reported values, it may be subject to enforcement action. Therefore, producers typically allow themselves a "safety or compliance margin" between their own measurements of a property and the limit they provide to ARB. The staff has estimated the typical margin for each property by averaging the mean difference between the ARB's Enforcement Division staff measurements of samples taken at refineries in 2005 and 2006 and the limits that applied to the gasoline batches that were sampled. The results are presented in Table 5.

Table 5: Weighted Averages of Predictive Model Reported Values and ARB Measured Values at California Refineries

Gasoline Property	RVP controlled (summer)			RVP uncontrolled (winter)		
	Average of Reported PM Results	Average Measured	Apparent Compliance Margin	Average of Reported PM Results	Average Measured	Apparent Compliance Margin
Aromatics (vol%)	24.2	22.8	1.4	24.6	24.0	0.6
Benzene (vol%)	0.67	0.55	0.12	0.69	0.54	0.15
Olefins (vol%)	7.9	5.3	2.6	7.2	4.9	2.3
Sulfur (ppmw)	13	10	3	15	11	4
T50 (^oF)	213	212	1	206	200	6
T90 (^oF)	313	308	5	316	308	8
RVP (psi)	6.95	6.83	0.12	-	11.00	-
Ethanol (vol%)	5.28	5.45	-0.17	5.27	5.23	0.04
No. of samples	3,945	344	-	2,095	140	-

Source: ARB Enforcement Division

The predictive model has an option which allows the producers to elect to use an evaporative hydrocarbon emissions model. Of the summer samples, the producers chose to use this option 39 percent of the time. Six percent of the summer samples and sixteen percent of the winter samples had a sulfur concentration greater than 20 ppm.

Data collected from fuel sampling at production and importation points, performed by ARB Enforcement Division staff during the period of January 2003 through June 2006 and shown in Tables 6 and 7. Fuel analyses were performed by ARB Monitoring and Laboratory Division staff. For all data, the tabulated averages and numbers of samples have been weighted as ninety percent regular grade and ten percent non-regular grade. The total (regular plus non-regular) numbers of samples are shown in parentheses. The non-regular grade samples are almost all premium grade with a few middle grade samples included. The volume-weighted averages incorporate production volumes provided by the CEC staff for the period January 2003 through August 2006.

Table 6: Properties and Composition of Summer CaRFG3 2003 through mid-2006 (1)

Gasoline Property	No. of Samples	Average	Volume-Weighted Average	Maximum	95th Percentile	5th Percentile	Minimum
Aromatics (vol. %)	225 (344)	22.3	22.8	34.8	31.5	14.3	10.5
Benzene (vol. %)	225 (344)	0.53	0.55	0.86	0.71	0.23	0.07
Olefins (vol. %)	225 (344)	4.9	5.3	10.3	8.5	0.4	0.0
Sulfur (ppmw)	224 (342)	10	10	33	18	2	1
T50 (°F)	230 (352)	212	212	230	220	203	195
T90 (°F)	230 (352)	307	308	328	321	293	219
RVP (psi)	230 (352)	6.83	6.83	7.23	7.08	6.53	6.38
Ethanol (vol. %)	230 (352)	5.52(2)	5.45(1)	7.40	5.70	5.69	0.00

1) Source: ARB Enforcement Division
2) The fuels used to calculate the mean include non-oxygenated fuels. The average percent volume for fuels containing ethanol is 5.7 vol%

Table 7: Properties and Composition of Winter CaRFG3 2003 through mid-2006 (1)

Gasoline Property	No. of Samples	Average	Volume-Weighted Average	Maximum	95th Percentile	5th Percentile	Minimum
Aromatics (vol. %)	129 (185)	25.7	24.0	36.5	31.9	17.1	10.8
Benzene (vol. %)	128 (184)	0.48	0.54	0.97	0.75	0.22	0.12
Olefins (vol. %)	127 (181)	3.5	4.9	10.5	8.4	0.0	0.0
Sulfur (ppmw)	125 (180)	8	11	32	18	1	1
T50 (°F)	114 (161)	197	200	222	216	183	150
T90 (°F)	126 (180)	305	308	330	322	288	218
RVP (psi)	100 (140)	10.81	11.00	14.50	14.11	8.51	8.40
Ethanol (vol. %)	141 (197)	3.77(1)	5.23(1)	8.26	5.70	0.00	0.00
DI	99 (139)	1069	1077	1163	1142	1003	868

1) The fuels used to calculate the mean include non-oxygenated fuels. The average percent volume for fuels containing ethanol is 5.7%.

Chapter III. Proposed Amendments to the CaRFG3 Regulations

This chapter presents the staff's proposal to amend the CaRFG3 regulations. In summary, the staff is proposing the following amendment:

- Amend the California Predictive Model to ensure that permeation emissions associated with ethanol use are mitigated and to incorporate new data;
- Add an option to use an alternative emissions reduction plan for a limited time period to help mitigated permeation emissions;
- Decrease the sulfur cap limit from 30 ppmw to 20 ppmw to improve enforceability and facilitate new motor vehicle emissions control technology;
- Allow emissions averaging for low level sulfur blends to provide additional flexibility for producers;
- Apply the 7.00 psi RVP limit to oxygenated CaRFG to reflect that virtually all CaRFG will be oxygenated and commingling emissions are not a problem for these fuels; and retain the 6.90 RVP limit for non-oxygenated CaRFG to ensure that no increase in hydrocarbon emissions from commingling with oxygenated CaRFG will occur;
- Allow flexibility in setting oxygen content in the Predictive Model to account for variability in test methods;
- Increase the maximum allowable amount of denaturant in ethanol to be consistent with new federal requirements;
- Update the test method for oxygenate content of gasoline; and
- Require producers use the revised Predictive Model starting in December 31, 2009, which allows for use of alternative emission mitigations. Required the production of CaRFG complaint with the revised Predictive Model by December 31, 2011.

These proposed amendments are presented in strike out underline form in appendix in Appendix A.

A. Revise the Predictive Model

There are five aspects of the Predictive Model that the staff is proposing to add or update as shown below:

- Add permeation emissions and require they be mitigated;
- Update the motor vehicle emissions inventory vehicle mix;
- Update the reactivity adjustment factors;
- Add new motor vehicle exhaust emissions test data; and
- Update the effect of carbon monoxide on ozone-forming potential.

In order to develop a new Predict Model and to ensure interactions between staff and stakeholders, staff formed working subgroups on statistics, emissions inventory, reactivity, and producer production. These workgroups provided valuable feedback throughout the development process.

Staff proposes to generally use a 2015 statewide ozone planning inventory as the baseline, including passenger vehicles to light heavy-duty trucks with gross vehicle weight (GVW) less than 10,000 pounds. An inventory year of 2015 allows the model to best reflect the in-use fleet in the 2010 – 2020 timeframe, and to appropriately model those fuel specifications that are most important in maintaining the emissions performance of advanced technology vehicles.

A more detailed discussion regarding each section can be found in the Appendices provided at the end of this report.

1. Add Permeation Emissions

As discussed in the previous chapter, there are increases in evaporative emissions due to the effects of ethanol on permeation. CRC Report No. E-65 and CRC Report No. E-65-3 concluded that the use of ethanol fuel increased permeation emissions by about 1.40 grams/day or 65 percent more than MTBE fuel. Therefore, the staff is proposing to add an element that ensures that permeation emissions associated with ethanol use in on-road motor vehicles are mitigated.

In late 2006, the ARB released the latest update to California's on-road motor vehicle emissions model, referred to as EMFAC2007. This model was updated to include permeation emissions. Typically, days with high temperatures have high ozone levels. Permeation emissions are also higher on hot days. To ensure that the CaRFG Predictive Model formulas adequately mitigate the permeation emissions, it is important to use a temperature profile that recognizes this relationship. For this analysis, ARB staff is using the temperature profiles that occur when the California 8-hour ozone standard was exceeded. Details are provided in Appendix B. In general, the temperature profiles are about 2-3 degrees Fahrenheit higher than the default temperature profile included in EMFAC2007. The default temperature profile is represented by those temperatures where the federal 8 hour ozone standard is exceeded.

On a statewide basis in 2005, the increase in evaporative emissions due to permeation is about 28.8 tpd from all on-road gasoline vehicles. The emissions increase declines to 18.4 tpd in 2010, 12.1 tpd in 2015 and 8.1 tpd in 2020. These reductions are due to a general reduction in emissions from motor vehicles. The detailed emission calculations are presented in Appendix B.

The Predictive Model includes three different regression models for evaporative emissions, representing the different processes: diurnal/resting losses; hot soak, and running losses. Using the emissions results, staff proposes to update the three evaporative emission regression models. For non-oxygenated fuel, staff assumes the evaporative emissions are the same as the MTBE emissions. Therefore, the non-oxygenated regression models are identical to the MTBE models. Appendix D provides staff's statistical work on the evaporative models.

2. Update the Motor Vehicle Emission Inventory Vehicle Mix

Using the most recent information from EMFAC2007, the staff proposes to update the contribution of emissions from each vehicle technology class used in the model so that it more accurately reflects the California vehicle fleet setting in calendar year 2015. In 2015, the majority of the light-duty motor vehicles will have LEVII and PZEV emissions control technologies.

The fraction of emissions contributed by each vehicle class is referred to as a weighting factor. The weighting factors are used in two portions of the Predictive Model. The first is to reflect the relative contribution of each vehicle technology group to overall emissions, and the second is to do the same for the reactivity-weighted hydrocarbons that will be discussed in the following section.

As discussed, staff proposes to use the 2015 statewide ozone planning inventory as the baseline, again using the California 8-hour temperature profile. The exhaust hydrocarbons, NOx, CO, and potency-weighted toxics emissions inventory weighting factors for each vehicle class are shown in Table 8.

Table 8: Exhaust Emission Weighting Factors by Vehicle Technology Group Statewide 2015 (GVW < 10,000 lbs)

Tech Group	Model Years	Weighting Factors (Fraction of Emissions)			
		THC/TOG	NOx	CO	Toxics
Tech 3	1981-1985	0.075	0.052	0.063	0.075
Tech 4	1986-1995	0.380	0.325	0.288	0.380
Tech 5	1996-2015	0.546	0.622	0.649	0.546
Total*		1.000	1.000	1.000	1.000

Source: EMFAC2007
***May not add to 1.000 due to rounding

As expected, in 2015, Tech 5 vehicles are responsible for the majority of emissions for each of the pollutant categories. The EMFAC model does not directly estimate emissions for the potency-weighted air toxics. However, the four potency-weighted toxics (1,3-butadiene, benzene, formaldehyde, and acetaldehyde) are all hydrocarbons. Therefore, staff proposes to use the exhaust hydrocarbons weighting factors for air toxics.

3. Update the Reactivity Adjustment Factors

Staff proposes to update the exhaust hydrocarbons, evaporative hydrocarbons, and exhaust CO reactivity adjustment factors used in the Predictive Model. Staff continues to recommend that the maximum incremental reactivity (MIR) scale developed by Dr. William Carter be used. This scale is the most appropriate for complementing California's dual program of reducing both NOx and VOC to control ozone and other pollutants

Dr. Carter's MIR scale is defined in terms of environmental conditions in which ozone production is most sensitive to changes in hydrocarbon emissions and, therefore, represents conditions where hydrocarbon controls are most effective. As such, it complements ARB's NOx control program which is designed to reduce ozone under conditions that are sensitive to NOx reductions. Staff believes that Dr. Carter's MIR scale is the most appropriate scale to be used for assessing the relative contribution of various hydrocarbons and CO to ozone formation.

In December 2003, the Board approved an updated list of reactivity values and reconfirmed the other MIR values. At that time, the MIR value for CO was updated to 0.06. Prior to Board consideration, the Reactivity Advisory Committee reviewed the list of values. After their review, the Reactivity Scientific Advisory Committee concluded that the proposed update did not substantially change the nature of the MIR values and were arrived at in an appropriate scientific manner. For this update, the staff is proposing to use these MIR values. A listing of the specific MIR values is presented in Appendix E.

These values were applied to speciated emission data from ARB's Vehicle Surveillance Program to calculate average specific reactivity values for exhaust hydrocarbon emissions, and diurnal/resting and hot soak evaporative hydrocarbon emissions. The running loss reactivity adjustment factor needed to be a calculated value because of a lack of testing data available on running loss hydrocarbon emissions. The surveillance data were collected in 2004-2006. As virtually all gasoline sold in that period was CaRFG3 containing ethanol, staff believes these data are the most appropriate for updating the reactivity methodology in the Predictive Model.

Table 9 presents the reactivity factors proposed to be used in the Predictive Model update. Appendix E details the calculations for the reactivity adjustment factors. Using these average specific reactivity adjustment factors, Tables 10a and 10b show how hydrocarbons and CO combine to form total ozone forming potential for the baseline gasoline with MTBE and ethanol, respectively.

Table 9: Average Reactivity Adjustment Factor

Pollutant	Average Specific Reactivity ($g\ O_3/g$ TOG)
Exhaust TOG	4.01
Evap TOG:	
Diurnal	2.74
Hot Soak	3.12
Running Loss	2.73
CO	0.06

Table 10: On-Road Vehicles Ozone Forming Potential Emissions Statewide 2015 (Tech 1-5, GVW < 10,000 lbs)

(a) Baseline Gasoline Containing MTBE

Pollutant	Emissions (tpd)*	MIR (tons O3/ tons TOG)	OFP (tpd)
Exhaust TOG	156	4.01	627
Evap TOG:			
Diurnal/Resting	60	2.74	164
Hot Soak	39	3.12	121
Running Loss	107	2.73	292
Carbon Monoxide	3,082	0.06	185
Total			**1,389**

(b) Current In-use Gasoline Containing Ethanol

Pollutant	Emissions (tpd)*	MIR (tons O3/ tons TOG)	OFP (tpd)
Exhaust TOG	156	4.01	627
Evap TOG:			
Diurnal/Resting	69	2.74	189
Hot Soak	40	3.12	125
Running Loss	109	2.73	297
Carbon Monoxide	3,082	0.06	185
Total			**1,422**

*Source: EMFAC2007, including permeation

There are five emission categories in the reactivity weighted hydrocarbons model: exhaust CO, exhaust hydrocarbons, diurnal and resting loss, hot soak, and running loss emissions. Table 11 shows the weighting factors for these five emission categories in 2015.

Table 11: Weighting Factors for Reactivity-Weighted Hydrocarbons Statewide 2015 (GVW < 10,000 lbs)

Pollutant	Weighting Factors
Exhaust TOG	0.0454
Evap TOG:	
Diurnal/Resting	0.0174
Hot Soak	0.0113
Running Loss	0.0310
CO	0.8949
Total*	1.0000

Source: EMFAC2007
*May not add to 1.0000 due to rounding

4. Add New Motor Vehicle Exhaust Emissions Test Data

The Predictive Model is based on thousands of individual emissions tests showing how the exhaust emissions change with changing fuel properties. Since the last model update in 1999, there have been a number of additional tests conducted. This section describes the new data sets and how these new data sets were used.

The CaRFG2 Predictive Model was constructed from about 7,000 data points that were compiled from 20 vehicle/fuel studies. These studies involved 250 different fuels and over 1,000 California certified vehicles. The effect of fuel properties on emissions is a function of emissions control technology. As a result, separate equations were developed within the Predictive Model to take into account these differences. Due to limited testing of other vehicle types, the CaRFG2 Predictive Model developed in 1994 included equations for Tech 3 and Tech 4 vehicles only.

In 1999, the Predictive Model was revised and updated as part of the effort to reflect new data, facilitate the removal of MTBE from California gasoline, and increase flexibility to use ethanol while preserving the emission benefits of the CaRFG2 program. Several new studies were added to the CaRFG2 database and reflected in the model. These studies formed the basis for the addition of Tech 5 group in the CaRFG3 Predictive Model (Appendix B)

a. New Tech 5 Test Results

In the current rulemaking, staff proposes to add about 1,000 new observations to the current database to update the CaRFG3 Predictive Model. Table 12 presents a summary of the Predictive Model database. The new datasets reflect emissions testing of fuels in Tech 5 vehicles, ranging from low emission vehicles (LEV) to super low emission vehicles (SULEV). The new data are weighted more toward LEVs and limited to several fuel property effects, such as oxygen and sulfur, that most impact Tech 5 vehicle emissions. A summary of the new datasets added to the Predictive Model database is presented in Table 13. Details of staff's work on statistical modeling are given in Appendix D.

Table 12: Summary of CaRFG Predictive Model Database

Description	CaRFG2 (Adopted 1994)	CaRFG3 (Adopted 1999)	Revised CaRFG3 (Being Proposed)
# Studies	20	35	40
# Observations	6,900	9,000	10,000
# Fuels	250	290	320
# Vehicles	1,100	1,280	1,320
Vehicle Added (Model Year)	California Certified (1981-1992)	California Certified (1983-1997)	California Certified (1998-2003)

Table 13: New Tech 5 Datasets Added to the Predictive Model

Study	Emission Class (MY)	# Observations	# Cars	# Fuels
AAM/AIAM/Honda	LEV, ULEV, SULEV (MY Unknown)	323	13	6
Toyota	LEV, TLEV, ULEV (MY Unknown)	33	9	2
CRC E-60	LEV, ULEV, SULEV (2000-2001)	201	14	3
CRC E-67	LEV, ULEV, SULEV (2001-2003)	326	12	12
ExxonMobil	LEV, ULEV (1998-1999)	42	5	4

b. Tech 5 Response to Sulfur

In the CaRFG3 Predictive Model, the emissions response of Tech 5 vehicles to sulfur was based on a limited data set. The modeled emissions response to changing sulfur concentrations for the Tech 5 vehicles was based on the two studies available at that time: "AAMA/AIAM Study on the Effects of Fuel Sulfur on Low Emission Vehicle Criteria Pollutants (1997)" and "CRC Sulfur/LEV Program (CRC E-42, 1997)". In the current update, two more sulfur studies have been added to the Predictive Model database: "Sulfur Oxygen Vehicle Emissions Test Program (AAM/AIAM, 2001)" and "The Effect of Fuel Sulfur on NH3 and Other Emissions from 2000-2001 Model Year Vehicles (CRC E-60, 2003)."

Staff believes these two later studies are much more relevant to both the actual California vehicle mix and in-use fuels and is, therefore, proposing to only use these two studies to estimate the average Tech 5 vehicle response to changes in fuel sulfur concentrations in 2015. Our rationale is based on several considerations. Staff believes that using all four datasets to calculate the Tech 5 portion of the Predictive Model would significantly over represent the LEV I and earlier vehicle emissions control technologies.

Table 14 summarizes the Tech 5 vehicles included in all four studies and the range of fuel sulfur content. Unlike the two earlier studies, the two new studies included testing with fuel sulfur levels in the CaRFG3 range of sulfur concentrations; that is, 0 to 30 ppmw. The average sulfur concentration in California for CaRFG3 is about 10 ppmw. Use of the previous studies necessitated extrapolation of data from levels many times higher that the CaRFG3 cap limit and was based on an assumption that responses to sulfur at very low levels is the same as that at high levels.

Table 14: Tech 5 Vehicles by Emissions Control Technology and Sulfur Levels Tested

Study	# Vehicles						S Levels Tested (ppmw)	# Obs
	LEV 1 and older	ULEV 1	SULEV 1	Euro 3	LEV 2	T o t		
Existing Studies:								
AAMA/AIAM Study (1997)	21	0	0	0	0	21	40 - 600	105
CRC Sulfur/LEV Program (1997)	22	0	0	0	0	22	30 - 630	168
New Studies:								
AAM/AIAM Study (2001)	10	3	0	0	0	13	1 -100	65
CRC E-60 (2003)	4	6	2	2	0	14	5 - 150	84

The older two sulfur studies, which focused on the early LEV emission control technologies, included about 43 different vehicle identifiers and about 275 observations. The two newer studies focused on a much broader range of vehicle emissions control technologies, including LEV, ULEV, and SULEV, and contained only about half the number of vehicles (27) and observations (150). Using the combined dataset biases the results of the sulfur effect towards the dataset dominated by over 80 percent LEV I vehicles and earlier emission control technologies. Using the data on the sulfur effects from the two newer studies leads to a dataset with about 50 percent LEV Is and earlier emissions control technologies, with the rest being made up of ULEV and SULEVs.

By 2015, as shown in Table 15, emissions in Tech 5 will be dominated by LEV I and newer technology vehicles. The table presents the predictive proportions of vehicle population, vehicle-miles-traveled (VMT), and NOx emissions for the Tech 5 vehicle group in 2015 based on EMFAC 2007. Only about 25 percent of the vehicles on the road in 2015 are projected to have LEV I or earlier emissions control technologies. The majority of vehicle population and VMT is associated with the newer or more advanced technology vehicles (i.e. lowest emission technologies). It is these advanced technology vehicles that are more sensitive to sulfur, that should be represented in the Predictive Model to properly reflect sulfur level effect on their high control efficiencies. This is also critical for enabling even more sophisticated vehicle technology that are about to be introduced, such as lean burn gasoline engines.

Table 15: Tech 5 Vehicles (1996 or newer, GVW < 10,000 lbs.)
2015 Statewide

Emissions Control Technology (NOx Standard, g/mi)	2015 (%)		
	Population	VMT	NOx Emissions
Older Tech (1 or greater)	4.9	3.1	17.0
Early LEVs			
TLEV (0.2 PC/LDT; 0.7 Others)	0.4	0.2	1.2
LEV I (0.2 PC/LDT; 0.6 Others)	19.7	14.9	44.0
Subtotal	**20**	**15.1**	**45.2**
ULEV (0.2 PC/LDT; 0.4 Others)	3.3	2.5	7.4
LEV II (0.07 PC/LDT; 0.2 Others)	17.1	17.5	10.7
ULEV (0.07 PC/LDT; 0.2 Others)	15.1	16.8	8.5
SULEV (0.02 PC/LDT; 0.1 Others)	34.5	38.9	9.9
PZEV (0.02 PC/LDT; 0.1 Others)	5.1	5.9	1.2
Subtotal	**75.1**	**81.6**	**37.7**
T o t a l*	**100**	**100**	**100**

Note: 2015: Pop = 24 million (90% of Tech 3-5); VMT = 875 million mi/d (94%); NOx = 175 tpd (62%)
***May not add up to 100 due to rounding errors

Table 16 combines Tables 14 and 15 together to illustrate the emission inventory breakdown and the vehicle study breakdown in terms of LEV and earlier technology and ULEV and newer technology. This table clearly illustrates that if all 4 studies are included in the sulfur response, this approach disproportionately represents early LEVs and other older technology 81 percent to 19 percent for the newer technology, where the LEVs and earlier technology represent only 25 percent of the estimated vehicle population. The inclusion of just the two new studies better represents the future California vehicle population. Using all four studies to the sulfur response skews the response towards early LEVs and other older technologies. Successive years after 2015 would continue to see the older technologies disappear from the vehicle population and the newer technology vehicle population increase. As a result, staff concluded that the two most recent studies best represent the emission response in the expected fleet composition in 2015 and beyond.

Table 16: Summary of Sulfur Studies

Vehicle Emission Control Technology	2015 California Vehicle Population (%)	2015 VMT (%)	2015 NOx Emissions (%)	All 4 Studies Vehicle Breakdown (%)	2 New Studies Vehicle Breakdown (%)
≤ LEV	25	18	62	81	52
≥ ULEV and LEV II	75	82	38	19	48

Recent conversations with representatives of the automobile manufacturers further support the premise that the NOx emissions from the newer vehicle emission control technologies are expected to be more sensitive to changes in sulfur concentration than the older Tech 5 vehicles. To investigate this differential, staff estimated the reduction in NOx emissions associated with reducing fuel sulfur levels from 20 ppmw to 10 ppmw with three different datasets of Tech 5 sulfur data: the two older datasets, all four datasets combined, and the two newer datasets. Table 16 presents the results of this analysis.

As shown in Table 17, the percent change in NOx emissions associated with reducing fuel sulfur levels from 20 ppmw to 10 ppmw is significantly larger for the vehicles in the two newer datasets (-6.2 percent) than the older datasets (-2.9 percent) or the combined datasets (-3.0 percent). This result is consistent with the information provided by representatives of the automobile industry. When all four datasets are combined, the response is very similar to the response from using only the two older datasets. Staff believes that this occurs because the two older datasets have significantly more observations across a much wider range of sulfur levels, well above the CaRFG3 sulfur cap limit. Staff believes the preponderance of LEV I vehicles and vehicles with earlier emission control technologies, along with the assumption that the sulfur response is linear from very high to very low levels, are “masking” the response from the newer vehicles in the two new studies. Therefore, staff believes that the best way to model the likely NOx response to changes in sulfur level for the Tech 5 vehicles in 2015 is to use only the two newer datasets.

Table 17: Estimated Tech 5 NOx Response Associated with Changing Fuel Sulfur Levels from 20 to 10 ppmw (All Other Fuel Properties @ Flat Limits)

Studies (Year)	Percent Change in NOx Emissions
AAMA/AIAM Study (1997); CRC Sulfur/LEV Program (1997)	-2.9
AAMA/AIAM Study (1997); CRC Sulfur/LEV Program (1997); AAM/AIAM Study (2001); CRC E-60 (2003)	-3.0
AAM/AIAM Study (2001); CRC E-60 (2003)	-6.2

To gain an additional perspective on this issue, ARB staff compared these results to results that recently became available from a joint U.S. EPA/Automobile Industry study of fuel effects in federal Tier 2 vehicles. In this study, nine Tier 2 compliant vehicles, MY 2004-2007 meeting approximately the Tier 2 Bin 5 emission standards (NOx limit of 0.07 grams per mile equivalent to LEV II standards) were tested on chassis dynamometers at three industry labs and the U.S. EPA's National Vehicle Fuels and Emissions Laboratory. These vehicles were equipped with laboratory-aged catalysts to simulate a service life of approximately 120,000 miles.

One of the comparisons was between a fuel with 6 ppmw sulfur and the same fuel with the sulfur level increased to 32 ppmw. The results of this comparison indicate that increasing the sulfur level from 6 ppmw to 32 ppmw increased NOx emissions by about 45 percent. Further, these results indicate that, for the sampled fleet, decreasing fuel sulfur levels from 20 ppmw to 10 ppmw would lead to about a 14 percent reduction in NOx emissions. The U.S. EPA results are consistent with the staff conclusion that the Tech 5 emissions/sulfur response is best modeled using the two newer datasets.

For a comparison, staff calculated the percent change in NOx emissions for changes from 20 ppmw to 10 ppmw if the existing sulfur studies results (i.e. LEV and earlier technology vehicle studies) were combined with the U.S. EPA results (i.e. ULEV and newer technology). Table 18 shows these calculated results. Combining the existing studies and U.S. EPA's results showed a decrease of NOx emissions by about seven percent. This closely follows the six percent NOx emissions decrease estimated by the two most recent sulfur studies. Whereas the two exiting studies and the two recent studies combined gave a three percent NOx emissions decrease.

Table 18: **Estimated Tech 5 NOx Response Associated with Changing Fuel Sulfur Levels from 20 to 10 ppmw for U.S EPA and Existing Studies Combined**

Studies	Emission Control Technology in studies	EMFAC NOx Emissions	Percent Change in NOX Emissions	Weighted Percent Change in NOX Emissions
AAMA/AIAM Study (1997); CRC Sulfur/LEV Program (1997)	≤ LEV	0.62	-3	-1.86
U.S. EPA	≥ ULEV	0.38	-14	-5.32
		Total NOx Emission Change		**-7.18**

5. Update the Effect of Carbon Monoxide on Ozone-Forming Potential

Staff proposes to update the methods used for estimating the effect of changing fuel properties on CO in the reactivity adjusted hydrocarbons portion of the Predictive Model. The current model only uses changes in oxygen level to calculate changes in CO emissions. The staff proposes to use a new model that accounts for all seven properties. This modeling approach for CO follows the approaches taken for the exhaust HC and NOx models.

B. Add an Alternative Emissions Reduction Plan

1. Description of the Alternative Emissions Reduction Plan

The staff is proposing to add a new provision that would allow producers to use an approved Alternative Emissions Reduction Plan (AERP) for a limited time. An AERP would allow a producer the option of creating emission reductions from other sources to fully mitigate any emissions increase from permeation not otherwise mitigated from the producer's fuel formulation. The AERP would not enable the producer to avoid meeting the majority of the CaRFG3 requirements; the producer would still have to comply with the non-permeation portion of the Predictive Model.

The addition of an AERP would enable mitigation of ethanol permeation effects more expeditiously and increase flexibility for producers to comply with the requirement to mitigate any increase in emissions associated with the use of ethanol blends. Producers will be required to certify fuel formulations that mitigate the increase in permeation emissions starting in December 31, 2009. Some producers may find it difficult to produce the desired amount of complying fuel without significant production facility and/or infrastructure modifications. The

AERP option is proposed to be available to producers from December 31, 2009 until December 31, 2011. This will allow producers four years to produce fuels that will offset the permeation impact of ethanol. Permeation emissions will have to be compensated for during the RVP regulatory period. Producers typically begin producing summer CaRFG blends beginning March 1 to comply with the RVP regulatory period. The RVP regulatory period typically begins in April and ends in October. The RVP regulatory period varies slightly in each air basin. (See page 26, section 2262.4 of the CaRFG regulations for explicit dates.)

Staff is also proposing to allow producers to apply for a one year extension should circumstances warrant an extension. For small refiners, staff also proposes that a small refiner using the small refiner provisions be allowed to use the AERP option indefinitely.

The proposed AERP requires that all emission reductions used in an AERP must come from combustion or gasoline related emission sources, such as motor vehicles, stationary or portable engines, off-road equipment, or portable fuel containers. A producer could not use emission reductions that are created at other types of sources or which are required through other programs. An AERP may not include emission reductions that may be part of on-going business practices. The producer would also need to show that emission reductions from an AERP occur in the same general region that the producer distributes fuel. The emission reductions must coincide within the applicable time period for the AERP.   Emission reductions may not be banked for future time periods.

The main focus of the AERPs will be to mitigate NOx and hydrocarbons. Air toxics are not a focus of the AERP because staff believes that air toxic emissions will track OFP and NOx and separate actions are not required.

2. Description of the Alternative Emissions Reduction Plan

A producer will enter the desired fuel formulation into the Predictive Model and calculate the necessary OFP and NOx emissions that must be offset through an AERP from the emission debits predicted. The producer will then describe and demonstrate the type of program that will provide the necessary emission credits to offset the debit of emissions produced by the fuel formulation.

The AERP approval process would require a refiner to submit an application that would provide the following information:

- The company name, address, phone number, and contact information,
- The producer’s or importer’s name, batch name, number or other identification, grade of California gasoline, and other information that uniquely identify the California gasoline subject to the AERP,

- An explanation describing why the producer or importer cannot eliminate the emissions associated with permeation by reformulation or reprocessing its gasoline,
- The total emissions of oxides of nitrogen (NOx), total ozone forming potential, and potency-weighted toxics that would be associated with the use of California gasoline were the producer or importer to eliminate the emissions associated with permeation from its gasoline,
- Documentation, calculations, emissions test data, or other information that establishes the amount of NOx and associated with the producer's or importer's gasoline,
- The emission reduction strategy(ies) for the AERP and the date(s) that the offsets will accrue and expire for each strategy,
- The applicant's market share for the fuel produced under the AERP,
- Demonstration that the emission reduction strategy(ies) in the AERP will result in equivalent or better emission benefits for NOx, total ozone forming potential, and potency-weighted toxics than would be achieved through elimination of emissions associated with permeation from the gasoline for the same affected region and for the period the AERP will be in effect, during and outside the RVP regulatory control periods in section 2262.4(b)(2),
- Demonstration that the emission reductions are achieved in the general region where the fuel is sold,
- The proposed recordkeeping, reporting, monitoring, and testing procedures that the applicant plans to use to demonstrate continued compliance with the AERP and achievement of each increment of progress toward compliance,
- Adequate enforcement provisions,
- For each final blend of California gasoline to which the AERP applies, the NOx, total ozone forming potential, and potency-weighted toxics emission limits during the period the AERP will be in effect,
- The projected volume of each final blend of California gasoline subject to the AERP during the period the AERP will be in effect,
- The period that the AERP will be in effect,
- A compliance plan that includes increments of progress (specific events and dates) that describe periodic, measurable steps toward compliance during the proposed period of the AERP,
- The date by which the producer or importer plans to discontinue using the AERP,
- A statement, signed by a legal representative for the producer or importer that all information submitted with the AERP application is true and correct, and
- The producer's or importer's agreement to be bound by the terms of the AERP.

Once the staff determines that the submitted application is complete, the application package will be made available to all interested parties for public

comments for a period of 30 days. An optional public meeting may be held to accept public comment on the application. After the 30 day comment period, the executive officer will either approve or deny the application. The notice of approval or denial will then be made available to interested parties.
A producer using the AERP would have to submit an update on progress towards compliance each year the AERP is in effect.

3. AERP Examples

This section provides two examples of how an applicant might calculate the amount of mitigation necessary to offset excess emissions not mitigated through fuel formulations. This section also provides example costs that may occur if accelerated vehicle retirement were used in an AERP. The first example shows the amount of mitigation required and the associated AERP costs if a producer uses the flat limits for their fuel formulation and does not choose to mitigate any increased permeation emissions through an alternative fuel formulation. The second example shows the mitigation requirement and AERP costs for the situation where a producer chooses to mitigate some of the increased emissions using an alternative fuel formulation. In the second example, the basic fuel formulation is the same except the oxygen content is increased from 2.0 percent by weight to 3.5 percent by weight and the sulfur content is decreased from 20 ppmw to 10 ppmw.

To determine the amount of mitigation required, the following equations can be used:

$$\text{OFP mitigation} = \frac{\Delta OFP}{2.39} * 18.4 * MarketShare\% * 2.80$$

$$\text{NOx mitigation} = \frac{\Delta NOx}{100} * 427.8 * MarketShare\%$$

Where:

- OFP mitigation = amount of ozone forming potential that must be mitigated by the AERP in tons per day
- NOx mitigation = amount of oxides of nitrogen that must be mitigated by the AERP in tons per day
- ΔOFP = percent change in ozone forming potential output from Predictive Model. This is variable and is dependent on the fuel formulation entered into the Predictive Model.
- ΔNOx = percent change in NOx output from Predictive Model. This is variable and is dependent on the fuel formulation entered into the Predictive Model.
- MarketShare% = individual producer’s market share expressed as a percentage of gasoline supplied to California that is subject to the AERP.

- The evaporative hydrocarbons due to permeation are based on the emissions inventory year of 2010 and are equal to 18.4 tons per day. This is a constant.
- The NOx emissions are also based on the emissions inventory year of 2010 and are equal to 427.8 tons per day. This is constant
- The 2010 emission inventory was used because the AERPs would most likely be between in 2009 and 2012.
- The calculated average maximum incremental reactivity factor or evaporative emissions is 2.80. This is a constant

a. Example 1 – All Mitigation Provided Through the AERP

Assume a producer is responsible for eight percent of the gasoline supplied in California and decides to produce gasoline at the CaRFG3 flat limits while improvements are being made to meet the December 31, 2011 deadline for compliant gasoline. The following analysis shows the amount and cost of emissions reductions that must be mitigated by an AERP. Table 19 shows the output from the revised predictive model in a producer or refiner enters the CaRFG3 flat limits for the eight specified fuel properties.

Table 19: Example 1 - Flat Limit Fuel Percent Change in Emissions Output from the CaRFG3 Predictive Model

Predictive Model Results	Percent
%Change in NOx Emissions (ΔNOx)	0.00
%Change in Ozone Forming Potential (ΔOFP)	2.39

Using mitigation equations, the amount of mitigation required by the AERP can be calculated as shown below:

$$\frac{2.39}{2.39} * 18.4 * 0.08 * 2.80 = 4.12 \text{ tpd of OFP}$$

$$\frac{0.00}{100} * 427.8 * 0.08 = 0.00 \text{ tpd of NOx}$$

As shown above, the producer would be required to obtain 4.1 tons per day of hydrocarbons emission reductions.

Staff used the ARB report, The Carl Moyer Program Guidelines, 2006 Project Criteria for Light-Duty Vehicles to determine emission benefits from the use of the accelerated vehicle retirement. Table 20 below shows the amount of emissions reductions for the retirement of model year vehicles between the years

1980 and 1985. Staff is assuming that the vehicles that will be retired will be from vehicles that are from model years 1980-1985.

Table 20: Accelerated Vehicle Retirement Emissions Reductions (Total Pounds per Vehicle over 3 Years Credit Life)

Model Year	Emissions Reductions Per Vehicle (lbs/Vehicle over 3 years)						
	Total ROG	NOx	CO	PM10	ROG Exhaust	ROG Evap	OFP [1]
80	122	74	1,195	0.74	58	64	484
81	104	56	928	1.00	45	59	402
82	102	60	912	0.92	43	58	390
83	93	63	791	0.84	34	58	347
84	100	63	751	0.84	32	68	364
85	95	57	499	0.89	25	70	327

[1] OFP is calculated as (CO)*(CO MIR)+(ROG Exhaust)*(ROG Exhaust MIR)+(ROG Evap)* (ROG Evap MIR), where CO MIR= 0.06, ROG MIR=4.01, ROG Evap MIR=2.80

To determine number of vehicles needed to be retired to offset the emissions not mitigated by refiner X's fuel formulation, we first need to calculate the average OFP and NOx emission reduction values for vehicles that would be retired in tpd. We begin by determining the average emissions reductions for NOx and OFP in pounds per year (lbs/yr).

$$\text{Average OFP (1980-1985)} = \frac{484+402+390+347+364+327}{5} = 385 \text{ lbs/3yr}$$

$$= \frac{385}{3} = 128 \text{ lbs/yr}$$

$$\text{Average NOx (1980-1985)} = \frac{74+56+60+63+63+57}{5} = 62$$

$$= \frac{62}{3} = 21 \text{ lbs/yr}$$

Next we convert lbs/yr to tpd:

$$\text{OFP emission reductions} = 128 \text{ lbs/yr} * \frac{1ton}{2000lbs} * \frac{1yr}{365days} = 1.75\text{e-4 tpd}$$

To determine the number of vehicles needed to offset the emissions not mitigated by refiner X's fuel formulation we divide the OFP mitigation by the OFP emission reductions.

$$\text{Number of retired vehicles needed} = \frac{4.12}{.000175} = 23{,}543 \text{ vehicles}$$

Table 20 shows the estimated costs and cost per gallon that a producer could incur in an example where all of the emissions increases associated with permeation are mitigated with an AERP. In this example, an accelerated vehicle retirement approach was used assuming a total annual gasoline use of 16 billion gallons. Also, the cost was spread over the 3 years life of the emission credit

Table 21 shows the emission mitigation costs for vehicle retirement costs of $500, $750, and $1000. The total costs are estimated to be between $11.8 million to $23.5 million, which equates to about 0.46 to 0.92 cents per gallon over the three year life of the emission credits. Note that this option will lead to an additional reduction in NOx emissions of 0.68 tpd.

Table 21: Estimated Total Costs and Cost Per Gallon to Mitigate Permeation Emissions in Example 1

# of Retired Vehicles	Estimated Vehicle Cost ($)	Total Mitigation Cost ($)	Cost Per Gallon (cents/gallon)
23,543	$500	$11,800,000	0.3
23,543	$750	$17,700,000	0.5
23,543	$1,000	$23,500,000	0.6

Note: 16 billion gallons was used as the estimated total gasoline consumption in California for this calculation. Also, the cost was spread over the 3 years life of the emission credit.

b. Example 2- Partial Mitigation Provided by the AERP

Again assume that a producer is responsible for eight percent of the gasoline supplied in California. In this example, the producer determines that an alternative fuel formulation using 3.5 percent oxygen (10 percent ethanol) and 10 ppmw sulfur can be produced by December 31, 2009. All the rest of the gasoline properties are the same as in example 1. Refinery modifications are necessary to meet the December 31, 2011 deadline for compliant gasoline. The following example shows the amount of mitigation required to be provided through the AERP. Table 22 presents the predictive model results.

Table 22: Example 2 - Flat Limit Fuel Percent Change in Emissions Output from the CaRFG3 Predictive Model

Predictive Model Results	Percent
%Change in NOx Emissions (ΔNOx)	0.61
%Change in Ozone Forming Potential (ΔOFP)	0.40

Apply the same formulas as in Example 1 and get:

$$\frac{0.40}{2.39} * 18.41 * 0.08 * 2.80 = 0.69 \text{ tpd of OFP}$$

$$\frac{0.61}{100} * 427.8 * 0.08 = 0.21 \text{ tpd of NOx}$$

In this example, the producer would have to provide 0.69 tpd of hydrocarbon emission reductions and 0.21 tpd of NOx through the use of an AERP. To determine the number of retired vehicles needed to offset Example 2, the limiting emission factor must be determined:

$$\text{No. of retired vehicles needed to offset OFP} = \frac{0.69}{.000175} = 3{,}942 \text{ vehicles}$$

$$\text{No. of retired vehicles needed to offset NOx} = \frac{0.21}{.0000287} = 7{,}317 \text{ vehicles}$$

Therefore, the limiting determinant is NOx and 7,317 vehicles would need to be retired to mitigate the emissions from the fuel formulation in Example 2.

Table 22 shows the estimated costs and cost per gallon that a producer could incur in an example where only a portion of the emissions increases associated with permeation are mitigated with an AERP. As with example 1, an accelerated vehicle retirement approach was used assuming a total annual gasoline use of 16 billion gallons. Also, the cost was spread over the 3 years life of the emission credit.

As shown in Table 23, the total costs are estimated to be between $3.7 million to $7.3 million, which equates to about 0.1 to 0.3 cents per gallon depending on the cost to retire a vehicle. This option will lead to an additional reduction in ozone forming potential emissions of 1.04 tpd.

Table 23: Estimated Total Costs and Cost Per Gallon to Mitigate Permeation Emissions in Example 2

# of Replacement Vehicles	Estimated Vehicle Cost ($)	Total Mitigation Cost ($)	Cost Per Gallon (cents/gallon)
7,317	$500	$3,700,000	0.1
7,317	$750	$5,500,000	0.2
7,317	$1,000	$7,300,000	0.3

C. Decrease the Sulfur Cap Limit

Staff proposes to reduce the sulfur cap limit from the current specification of 30 ppmw to 20 ppmw. Cap limits provide an upper limit for fuel properties for all compliance options and allow enforcement of the requirements throughout the gasoline distribution system.

As presented in Chapter II, sulfur levels currently average about 10 ppmw, with 95 percent of production being below 18 ppmw. Staff believes that producers will significantly further reduce the sulfur content of California gasoline to certify gasoline if the proposed revisions are adopted. With the recent implementation of the federal Tier II sulfur rules for gasoline, nationwide gasoline sulfur levels must average less than 30 ppmw with a cap of 80 ppmw. The implementation of the federal Tier II sulfur rules will significantly reduce the historical difference between sulfur levels in California and those seen outside of the State.

Lowering the sulfur cap to 20 ppmw is not expected to significantly affect flexibility to make complying fuels, but will increase the enforceability of the program and help to protect the performance of sulfur-sensitive emissions control components. Staff believes that it will not be practical for producers to certify alternative formulations with sulfur levels above 20 ppmw. Staff believes that the sulfur cap should be set at the lowest level possible that does not significantly reduce production flexibility. From this perspective, the current cap of 30 ppmw is much higher than necessary.

The Alliance of Automobile Manufacturers and individual vehicle manufacturers have indicated that before lean burn gasoline technology can be successfully introduced, they need assurance that sulfur content will be less than 20 ppmw. A sulfur cap of 20 ppmw will provide this assurance. This new technology has the potential to improve the feasibility of gasoline engines that have higher efficiencies and less greenhouse gas emissions per mile traveled.

D. Allow Emissions Averaging for Low Level Sulfur Blends

1. Description of the Emissions Averaging Option

Staff expects producers will very likely change to increase the use of ethanol in gasoline to offset the increase in permeation emissions. The addition of ethanol increases the oxygen content in the fuel blend. While this generally reduces the exhaust emissions of hydrocarbons and carbon monoxide, emissions of NOx increase. In many cases, this increase in NOx would, if not mitigated through some other fuel property, result in a non-complying blend. Staff expects producers to use sulfur as a lever to lower NOx emissions in their fuel formulations. Such action would result in sulfur levels below 10 ppmw in most CaRFG3 formulations.

At these low sulfur levels, the compliance margin for refiners is small and slight unexpected deviations in the refinery process could result in a non-compliant batch due to slightly elevated sulfur. Staff anticipates that it will be very difficult to blend a slightly higher than needed sulfur level batch to a compliant blend using the existing sulfur averaging provisions because it becomes increasingly more and more difficult to average out sulfur when the levels are very near the bottom of the range. Therefore, for a producer that experiences a problem with the sulfur content when blending a particular batch of gasoline, staff is proposing to add a compliance option that would permit that producer to use an averaging option that is based on emissions. The emissions must be mitigated within 90 days by subsequent cleaner than required blends. Any additional emissions reductions achieved under the emissions averaging provision may not be banked. In addition, this emissions averaging option can only be triggered by unexpected high sulfur levels.

Without such a flexibility provision, such batches would likely need to be shipped out-of-state at significant expense and reduction in supplies of available product. Unlike most other fuel properties governed by the CaRFG3 rules, increases in sulfur levels in individual batches do not result in immediate emission increases in vehicles using the batch. Sulfur degrades catalyst performance, but the effect is reversible. Given this situation, staff believe t is reasonable to infrequently allow batches with slightly higher sulfur levels to be used, so long as the emission impacts of the higher sulfur batch are fully mitigated in the near future through subsequent batches.

2. Application Process

If a producer determines that the final batch of gasoline has a sulfur level that is too high to certify, the producer may request to the ARB’s Enforcement Division to initiate the emissions averaging option. The producer must demonstrate that there exists a sulfur limit, and other property limits, that would have led to the batch being certified. The calculated emissions percentages for ozone-forming potential, NOx, and potency-weighted toxics for the complying formulation become the reference baseline for estimating the increase in emissions. This reference baseline also becomes the reference point for calculating emissions and volume to be credited against the initial emissions increase. Alternative formulations certified under this provision could not exceed the cap limit for sulfur.

Any producer entering into an emissions averaging option must report all relevant and necessary information to the ARB’s Enforcement Division, such as batch number, volume, and alternative formulation and any other information requested by the Enforcement Division. A producer may have subsequent requests to enter into emissions averaging for other batches, but each batch reported as initiating the averaging provision must be fully mitigated within the designated time limit. This provision requires that the producer maintain some of that fuel in the tank for at least 12 hours after sending the notification to the ARB so that an ARB inspector has the opportunity to sample and test the fuel for compliance.

3. Example of an Emissions Averaging Option

Table 24 provides an example of how the emissions account may be calculated. Column 1 presents the alternative formula that the refiner was targeting; this is the reference batch. Column 2 presents the resulting alternative formulation that would not be certified due to excess emissions associated with higher than intended sulfur concentrations and volume that would be reported to the ARB under the emissions offsetting provisions. Columns 3 through 8 present examples of candidate formulations and volumes that could result in the cumulative emissions being reduced to a level that would terminate the emissions offsetting provision. To generate offsetting emissions reductions the offsetting batches must result in emissions that are less than the reference batch.

Table 24: Example of Emissions Averaging Triggered by an Inadvertently High Sulfur Fuel

	Complying Reference Specs	Non-complying Batch #0 Specs	Offsetting Batch #1 Specs	Offsetting Batch #2 Specs	Offsetting Batch #3 Specs	Offsetting Batch #4 Specs	Offsetting Batch #5 Specs	Offsetting Batch #6 Specs
Volume (gals)	NA	215,000	210,000	220,000	205,000	215,000	210,000	200,000
RVP (psi)	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
T50 (ºF)	213	213	213	213	213	213	213	213
T90 (ºF)	305	305	305	305	305	305	305	305
Arom. (vol. %)	23	23	21	21	21	21	21	21
Olefin (vol. %)	6	6	6	6	6	6	6	6
O (wt. %), max	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
S (ppmw)	5	10	5	5	5	5	5	5
C_6H_6 (vol. %)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Emissions (percent)								
NOx	-0.03	2.11	-0.42	-0.42	-0.42	-0.42	-0.42	-0.42
O_3 Potential	-0.37	-0.17	-1.01	-1.01	-1.01	-1.01	-1.01	-1.01
Pot. Wt'd Toxic	-2.77	-2.64	-4.03	-4.03	-4.03	-4.03	-4.03	-4.03
Cumulative Emissions (percent)[1]								
NOx	NA	2.14	1.76	1.36	0.99	0.6	0.22	-0.15
O_3 Potential	NA	0.2	-0.43	NA	NA	NA	NA	NA
Pot. Wt'd Toxic	NA	0.13	-1.1	NA	NA	NA	NA	NA

[1] Cumulative Emissions (%) = [Batch #0 Emissions (%) – Reference Emissions (%)]
+ [Batch #1 Emissions (%) – Reference Emissions (%)] × Batch #1 Volume ÷ Batch #0 Volume+
[Batch #2 Emissions (%) – Reference Emissions (%)] × Batch #2 Volume ÷ Batch #0 Volume+
[Batch #3 Emissions (%) – Reference Emissions (%)] × Batch #3 Volume ÷ Batch #0 Volume

E. Adjust the RVP for Oxygenated Fuels

When non-oxygenated and oxygenated fuels are mixed together in a vehicle fuel tank, the evaporative emissions of the blend increase due to an increase in RVP. This effect is referred to as commingling. In the existing CaRFG3 regulations, provisions were included to help mitigate any commingling that could have occurred as MTBE was phased out. Specifically, the RVP flat limit was reduced by 0.10 psi and set at 6.90 psi for producers that used the evaporative emissions portion of the Predictive Model. However, virtually all gasoline has been blended with ethanol; therefore, the commingling impact has been negligible.

As a result of federal policies requiring ethanol use, and the likelihood that increases in oxygen content will be used to mitigate permeation, staff expects almost all fuel produced in California will continue to be blended with ethanol. Therefore, the required use of 6.90 psi rather than the original 7.00 psi reference level for RVP for ethanol blends is no longer needed. As such, staff is proposing to restore a flat limit of 7.00 psi for blends that use ethanol. This change will provide some additional flexibility for producers while preserving the emissions benefits.

While we expect that gasoline produced in California will be blended with ethanol, it is possible that some amount of non-oxygenated fuels could be introduced in the future. In this case, emissions could increase due to commingling. Therefore, to mitigate any potential increase in emissions associated with the commingling of non-oxygenated fuels with fuels containing ethanol, the non-oxygenated fuels will be required to be based on a flat limit of 6.90 psi RVP.

The staff proposes to keep the cap limit, of 6.40 to 7.20 psi for RVP.

F. Allow Flexibility in Setting the Oxygen Content in the Predictive Model

In the Predictive Model, oxygen is specified in the form of a range. There are usually two candidate fuel specifications for oxygen, the upper end of the range (maximum) and the lower end of the range (minimum). This is to allow for variation in the blending of ethanol into CaRFG. The weight of oxygen being added depends on the density of the CaRFG the ethanol is being added to and this varies from batch to batch. Usually, this range represents the reproducibility of the test method for oxygen which is 0.4 percent by weight. If the oxygen range of the candidate fuel specifications is within the range of 1.8 to 2.2 percent, and 2.5 to 2.9 percent, and 3.3 to 3.7 percent by weight, the oxygen content of the candidate fuel specifications is assumed to be 2.0 percent, 2.7 percent, and 3.5 percent by weight respectively. Producers can enter any range they choose but the wider the range, the more difficult it is to produce complying fuels.

Staff proposes to allow the candidate fuel specification for oxygen to be evaluated at the midpoint of the minimum and the maximum oxygen values entered into the Predictive Model if the range between the minimum and the maximum oxygen value is 0.4 percent or less, the reproducibility of the test method. Also, this allows for some variation in the densities of the different batches of CaRFG. Without this allowance it would be necessary to determine the density before a volume of ethanol could be determined to supply a known weight percent of oxygen to CaRFG. It is the weight percent of oxygen that determines the emissions impact of the oxygenate.

G. Increase the Maximum Allowable Amount of Denaturant

A denaturant is added to ethanol to ensure that it cannot be ingested. It also allows for ethanol to be transported and handled as an industrial fluid rather than a controlled substance which would place it under supervision and control of the Bureau of Alcohol Tobacco and Firearms (BATF). Typical denaturants include natural gas oils, diesel and natural gasoline**.** The CaRFG3 specifications (Title 13, California Code of Regulations, section 2262,9) include a requirement that all reformulated blendstocks for oxygenate blending contain no more than 4.76 percent by volume denaturant. This specification is based on earlier versions of the American Society of Testing and Materials (ASTM) standard specification for denatured fuel ethanol for blending with gasoline (ASTM D4806-99).

Upon consulting with the Bureau of Alcohol, Tobacco and Firearms (BATF) and the Internal Revenue Service (IRS), the maximum amount of denaturant has been increased to 5.00 percent by volume. Therefore, staff proposes to change the maximum denaturant content specification in section 2262.9 from 4.76 percent by volume to 5.00 percent by volume to be consistent with the recent change and to update the appropriate references to the latest ASTM specification (ASTM D4806-06c) which reflects the new federal limit. This change will align California fuel regulations with federal fuel regulations, and will create less confusion to suppliers. As a result, the proposed amendment will increase the supply of denatured ethanol available to be imported into California.

H. Adoption of the Current Version of ASTM D4815-04

Section 2263(b) lists ASTM D4815-99 as the test method for determining the oxygen content, ethanol content, MTBE content, and oxygenate content of gasoline. The designation “-99” means the 1999 version of the test method. Every 5 years, or sooner when the need arises, ASTM reviews its test methods and either amends or re-approves them. Staff proposes to change the test method to the current version (the 2004 version) which is labeled ASTM D4815-04.

I. Implementation of the Proposed Amendments

Staff is proposing that the proposed amendments would affect fuels produced on or after December 31, 2009. Producers that are unable to fully comply through the use of the Predictive Model may choose to offset any unmitigated permeation emissions associated with ethanol in gasoline through the use of an Alternative Emissions Reduction Plan. Starting December 31, 2011, producers will be required to fully offset the increase in emissions associated with ethanol in gasoline through the use of the Predictive Model. As mentioned above, the staff is proposing to allow a one year extension provided that any emissions increases associated with permeation are mitigated through an approved AERP. In addition, the start has added provisions that allow for early use of the new Predictive Model under specified conditions.

Chapter IV. Economic Impacts of the Proposed Amendments

This chapter presents a summary of potential effects of the proposed amendments on the production of CaRFG3 and an analysis of the costs to produce CaRFG3 gasoline in compliance with the proposed amendments. In addition, the chapter outlines potential economic impacts on businesses and consumers.

Health and Safety Code section 43013.1(b)(1) requires that CaRFG3 preserve the emission benefits of CaRFG2. The proposed amendments will result in the emissions reductions necessary to preserve the benefits associated with the use of CaRFG3 in on-road motor vehicles. The proposed amendments will require producers to mitigate the increase in evaporative emissions from permeation from on-road motor vehicles either through the use of a revised and strengthened Predictive Model or an Alternative Emissions Reduction Plan. The increase in permeation emissions associated with ethanol is estimated to be about 18.4 tpd in 2010, 12.1 tpd in 2015, and 8.1 tpd in 2020. To mitigate these emissions through the use of the Predictive Model, staff believes that producers will likely reduce sulfur levels, increase oxygen levels, and reduce vapor pressure levels of the blends.

A. Effects of the Proposed Amendments on the Production of CaRFG3

The proposed amendments to the Predictive Model ensure previous air quality benefits achieved from the CaRFG program will be restored, at least as they relate to on-road motor vehicle emissions. The proposed Predictive Model now accounts for potential increases in evaporative permeation emissions from the presence of ethanol in gasoline. Based on our current assessment, gasoline ethanol formulations blended to existing flat limit specifications will exceed allowable potential emission increases.

The proposed revisions would require all production of CaRFG that includes ethanol to be formulated with the Predictive Model. The existing flat limits did not consider permeation for gasoline blended with ethanol. However, these flat limits would serve as a baseline to ensure benefits of CaRFG2, other than permeation, are preserved.

Table 25 lists several fully compliant potential future in-use alternative gasoline formulations capable of fully mitigating on-road permeation emissions using different oxygen levels of 0, 2, 2.7 and 3.5 percent by weight. Staff chose the listed formulas to demonstrate the types of blends that can pass the proposed Predictive Model. The formulas were chosen to keep as many of the fuel properties near the average current in-use fuel properties as possible. The 3.5% oxygen content (10% ethanol) fuel required the least adjustment from the average current in-use fuel properties.

Table 25: Candidate Alternative Gasoline Model Formulations for Summertime Gasoline

Property (units)	Percent Ethanol			
	0.0%	5.7%	7.7%	10.0%
RVP* (psi)	6.60	6.91	6.92	6.99
T50 (deg. F.)	204	206	209	212
T90 (deg. F.)	315	310	313	313
Aromatic (vol.%)	25.0	25.0	25.0	25.0
Olefin (vol.%)	8.0	9.0	9.0	6.0
Total Oxygen (wt. %**)	0.0	2.0	2.7	3.5
Sulfur (ppmw)	5	5	5	5
Benzene (vol.%)	0.50	0.50	0.50	0.50
CaRFG3 Predictive Model Criteria	% Change in Emissions			
Ozone Forming Potential	-0.67	-0.38	-0.59	-0.05
Predictive Model (Pass/Fail)	Pass	Pass	Pass	Pass
% change in emissions must be < 0.04% to Pass.				
* In wintertime season (11/1 thru 2/29), there is no RVP control.				
** If wintertime season, then minimum oxygen content in ozone non-attainment area = 1.8 wt. %				
***OFP is the must limiting performance requirement				

Gasoline blends are not limited to the combinations listed above. The table is intended to demonstrate that a wide variety of California gasoline formulations can comply if the proposed Predictive Model is adopted. Producers are allowed to vary gasoline blend components as long as the product meets California requirements.

B. Costs to Produce CaRFG3 Gasoline Fuel

Based on conversations with producers, pipeline distributors, CEC staff, and other stakeholders, staff estimates that, collectively, producers will incur capital expenditures of approximately $200 million to $400 million. The cost depends on the investment choices the producers make to comply with the proposed amendments and produce CaRFG3 gasoline.

As shown in the previous section, to produce CaRFG3 gasoline with the proposed amendments, producers will most likely choose to blend in higher amounts of ethanol and decrease sulfur levels in their formulations to mitigate permeation, while still meeting required performances for NOx. Therefore, the majority of the capital expenditures are expected to go towards removing sulfur from the gasoline. These investments include increasing hydrotreating or alkylation capacity by expansion or addition of new units. These capital expenditures are considered one-time costs that will most likely be recovered over a period of time. To estimate the annualized capital costs, staff has assumed a recovery period of 10 years at an interest rate of seven percent per year. Thus, the associated annualized capital recovery cost of the proposed amendments can be determined according to the following equation:

Capital Recovery Cost = (Capital Cost) x (Capital Recovery Factor)

Where:

Capital Cost = $200 million to $400 million
Capital Recovery Factor = 14.2% (7% per year over 10 years)

This value, calculated to range from $28 to $57 million, represents the annualized capital cost to producers to upgrade producer facilities to comply with the proposed amendments.

Along with the initial capital investment, annual operating and maintenance (O&M) costs must also be considered. Usually, these are costs associated with labor, material (such as catalysts, etc.), sulfur disposal, maintenance, insurance, and repairs associated with the new or modified equipment. Staff conservatively estimated O&M costs based on the economic analysis preformed in the "Proposed Amendments to the California Diesel Fuel Regulations Staff Report: Initial Statement of Reasons (June 6, 2003)." This analysis showed that annual O&M costs would range from 10% to 20% of the capital expenditure. The O&M costs are estimated to collectively range from $20 to $80 million per year for producers.

Total annualized statewide refinery costs can be determined according to the following equation:

Annualized Statewide Refinery Cost = (*Capital Recovery Cost*)
+ (*Annual O&M Cost*)

Using this equation, the annualized statewide refinery costs of the proposed amendments are estimated to range from about $48 to $137 million.

To determine the per gallon annualized statewide refinery costs, staff used the 2005 California gasoline consumption data of approximately 15.9 billion gallons and an annual growth factor of 1 percent to grow California gasoline consumption to a 2010 level of about 16.5 billion gallons. Staff estimates that the annualized CaRFG production costs will be about 0.3 to 0.8 cent per gallon.

C. Ethanol Costs to Refiners

About 900 million gallons per year of ethanol is currently used in CaRFG3. The proposed amendments are expected to increase ethanol consumption in California from 300 to 600 million additional gallons per year, at an estimated cost of $600 to $1,200 million annually based on average spot market prices and ethanol subsidies. Note that the producers would most likely have met most of their ethanol needs via contracts, often at much lower costs than spot prices.

However, the use of ethanol will displace an equal volume of gasoline blendstocks, and therefore, the costs must be compared to the costs of equivalent volumes. On average, ethanol costs have, after adjusting for the favorable tax treatment given to ethanol, been lower per gallon than gasoline blendstocks. Provided this price advantage continues, staff expects there to be a small cost advantage to using ethanol relative to gasoline production based on the spot market prices of gasoline.

D. AERP Option Costs

Staff believes that the new alternative compliance options will not result in a significant increase in cost to producers compared to simple compliance with the proposed rule. In fact, the increased number of options will likely result in a decrease in cost for some producers to the extent that the compliance option is used. Staff calculated the potential costs to the industry if all participants used an accelerated vehicle retirement program for an AERP. This calculation is very similar to that shown in Example 1 from Chapter III, except the market share used in the calculation was 100 percent. It would take approximately 290,000 retired vehicles to offset the 18.4 tpd of HC or 51 tpd of OFP. At a cost of $750 per vehicle, the total AERP cost would be about $220 million. Taking into account the credits are good for 3 years and spreading the cost over 16 billion gallons of gasoline consumed a year in California leads to refiner costs of about 0.5 cent per gallon. This estimate could be substantially higher or lower depending on the funding needed to scrap vehicles.

E. Ethanol Fuel Economy Penalty

There is a fuel economy penalty associated with increasing ethanol in gasoline. Ethanol has about 31 percent less energy per gallon than reformulated gasoline. Therefore, increasing the amount of ethanol in gasoline decreases the energy density of the blend and ultimately the fuel economy of the vehicle. A 0.7 percent fuel penalty occurs in switching from a fuel containing about 5.7 percent by volume (E6) to a blend containing 7.7 percent by volume (E8); similarly, switching from an E6 fuel to a fuel that contains 10 percent by volume ethanol results in a 1.3 percent fuel economy penalty. For a typical consumer that drives 15,000 miles per year in a car with a fuel economy of 20 miles per gallon and gas prices at $3.00 a gallon, the effective cost of going from E6 to E8 will be 0.10 cents per mile or about $16 per year. The effective cost for going from E6 to E10 will be 0.20 cents per mile or about $30 per year.

If all gasoline were to be produced at the E10 level rather than the current E6, total fuel use would increase by about 200 million gallons per year. If gasoline retails at $3.00 per gallon, then net expenditures for fuel would increase by about $600 million per year.

F. Impact on Government Revenue

The fuel economy penalty for increasing amounts of ethanol will result in increased gasoline consumption in California. This increase in gasoline consumption will increase federal and State excise tax revenue placed on gasoline and increase sales tax revenue.

1. Federal

The federal excise tax for gasoline is 18.3 cents per gallon. However, there is an ethanol subsidy of $0.51 per gallon of ethanol. Going from E6 to E8 will result in an increase in federal excise tax revenue by about $20 million, but increase the federal ethanol subsidy cost by $168 million. The total overall cost to the federal government for going to E6 to E8 will be about $148 million. Going from E6 to E10 will result in additional $43 million in federal tax revenue, but increase the federal ethanol subsidy cost by $363 million. The total overall cost to the federal government for going from E6 to E10 will be about $320 million.

2. State

The State excise tax on gasoline is 18 cents per gallon. Going from E6 to E8 will result in an increase in State excise tax revenue by about $20 million. Going from E6 to E10 will result in additional $43 million in State tax revenue.

3. Local and State Sales Tax Revenue

In estimating the increase in sales tax revenue, staff assumed a price of $3.00 per gallon of gasoline and a sales tax rate of 7.75%, or about 23 cents per gallon. Going from E6 to E8 will result in an increase in sales tax revenue by about $26 million. Going from E6 to E10 will result in additional $56 million in sales tax revenue.

G. Small Refiners

Small refiners will be expected to offset the increase in evaporative emissions due to permeation. Small refiners will not be required to offset the permeation increase through fuel formulations changes, but will be allowed to use the AERP indefinitely. This would lead to small refiner costs of about 0.5 cent per gallon as discussed in part D above.

H. Small Business Economic Effect

Government Code sections 11342 et. seq. require the ARB to consider any adverse effects on small businesses that would have to comply with a proposed regulation. In defining small business, Government Code section 11342 explicitly excludes refiners from the definition of "small business." Also, the definition includes only businesses that are independently owned and, if in retail trade, gross less than $2,000,000 per year. Thus, our analysis of the economic effects on small business is limited to the costs to gasoline retailers and jobbers, retailers, and gasoline fuel end-users. A jobber is an individual or business that purchases wholesale gasoline and delivers and sells it to another party, usually a retailer or other end-user.

1. Jobbers and Retailers

If the wholesale price of gasoline rose as a result of additional costs to producers to comply with the production of CaRFG3 gasoline, retailers and jobbers would pay more for every gallon of gasoline that they resell in the State. Any adverse impacts on retailers and jobbers would occur only if their profits decreased as a result of the higher wholesale prices. The decrease in profits would likely only occur if retail prices did not increase by the corresponding increase in wholesale prices, or if the demand for gasoline declined as a result of higher retail prices. Historically, small changes in wholesale fuel prices have not had substantial impacts on gasoline purchases. Also, over time, changes in wholesale prices have been passed on to consumers through changes in retail prices.

2. Gasoline Fuel End-Users

The potential economic effects of the new fuel requirements are not limited to jobbers and gasoline retailers. Individual consumers who operate typical gasoline fueled vehicles could be impacted. Combining the cost to produce amended CaRFG3 fuel, the cost of ethanol, and fuel economy losses, staff estimates that total additional cost to produce CaRFG3 could cost gasoline fuel end-users about three to six cents per gallon, with approximately two to five cents per gallon of that total attributed to fuel economy loss.

To calculate total costs to the end user, staff assumed the average end user drove 15,000 miles per year with a vehicle that had a fuel economy of 20 miles per gallon. Staff also assumed an average price of gasoline of $3.00 per gallon. As discussed above, staff calculated the fuel economy cost penalty in going from E6 to E8 would be about $16 per year and going from E6 to E10 would be $30 per year.

The increased cost to produce fully complying gasoline is estimated to be about 0.3 to 0.8 cents per gallon. Using the same assumptions as above, the cost to the end user for increases in gasoline production costs are about $2 per year to $6 per year. Combining the fuel economy penalty and the cost of production, the total cost to the end user will be between $18 a year and $36 a year. Assuming the total fuel cost is approximately $2,250 per year, the increased costs are about 0.8 to 1.6 percent of total annual fuel costs.

I. Effects on Production from the Proposed Changes on CaRFG3

Staff has discussed with producers and CEC staff the impact on production that could result from implementation of the proposed amendments. In the short term production capability would be impacted by the proposed changes. For example, if producers were required to fully comply with the requirements in 2010 using newly required fuel formulations, many producers would not be able to comply while maintaining current production capacity. In this scenario, staff estimates that there could be a five to 10 percent gasoline production loss at California refiners for one to two years. During this period, greater use of imports of gasoline or gasoline blending components would be needed. However, producers would be able to produce a complying alternative fuel formulation beginning in 2012 with no loss in production due to the completion of appropriate refinery projects.

As discussed above, producers have the option of using an AERP during the transition period from 2010 until 2012. Therefore, staff anticipates that emissions increases due to permeation can be mitigated by 2010 without production losses during this period when refinery changes are underway.

Chapter V. Environmental Impacts of the Proposed Amendments

This chapter summarizes the expected environmental impacts of the proposed amendments. Health and Safety Code section 43013.1 requires that CaRFG3 preserve the emission benefits of CaRFG2. These benefits include emission reductions for all pollutants, including precursors, identified in the State Implementation Plan for ozone, and emission reductions in potency-weighted air toxics compounds. The staff does not anticipate any significant adverse environmental impacts associated with the proposed amendments. However, as discussed below, the proposed amendments do not fully comply with the requirements of Health and Safety Code section 43013.1 in that potential emission increases associated with off-road sources are not fully mitigated.

A. California Environmental Quality Act (CEQA)

CEQA and ARB policy require an analysis to determine the potential adverse environmental impacts of the proposed amendments. ARB's program involving the adoption of regulations has been approved by the Secretary of Resources (see Public Resources Code, section 21080.5). Therefore, the CEQA environmental analysis requirements are included in the ARB's Initial Statement of Reasons in lieu of preparing an environmental impact report or negative declaration. In addition, ARB will respond in writing to all significant environmental issues raised by the public during the public review period or the public Board hearing. These responses are to be contained in the Final Statement of Reasons for the proposed amendments.

Public Resources Code section 21159 requires that the environmental impact analysis conducted by the ARB include the following:

- An analysis of the reasonably foreseeable environmental impacts of the methods of compliance;
- An analysis of reasonably foreseeable mitigation measures; and
- An analysis of reasonably foreseeable alternative means of compliance with the standard.

Our analysis of the reasonable foreseeable environmental impacts of the methods of compliance and the analysis of reasonably foreseeable mitigation measures, if appropriate, are presented in the following sections. In general, ARB staff has not identified any significant environmental impacts associated with the proposed amendments and therefore, there has been no need to identify mitigation measures.

An assessment of potential alternatives to the proposed amendments is presented in Chapter VI. ARB staff has concluded there is no alternative considered by the agency that would be more effective in carrying out the purpose for which the regulation is proposed or would be as effective as and less burdensome to affected private persons than the proposed regulation.

B. Multimedia Evaluation

Health and Safety Code section 43830.8, enacted in 1999 (Stats. 1999, ch. 813; S.B. 529, Bowen) generally prohibits ARB from adopting a regulation establishing a specification for motor vehicle fuel unless the regulation is subject to a multimedia evaluation by the California Environmental Policy Council (CEPC). A multimedia evaluation is the identification and evaluation of any significant adverse impact on public health or the environment, including air, water, or soil, that may result from the production, use, or disposal of the motor vehicle fuel that may be used to meet the state board's motor vehicle fuel specifications. The statute provides that the Board may adopt a regulation that establishes a specification for motor vehicle fuel without the proposed regulation being subject to a multimedia evaluation if the CEPC, following an initial evaluation of the proposed regulation, conclusively determines that the regulation will not have any significant adverse impact on public health or the environment.

The proposed amendments do not change specifications of CaRFG3 gasoline and will not require a gasoline ingredient to be added or removed beyond what is already used to produce gasoline for sale in California. Therefore, staff believes that the proposed amendments to the CaRFG3 regulations are not subject to the requirement for a multimedia evaluation.

C. Air Quality

This section presents the air quality impacts of the proposed amendments.

1. Emissions Associated with the Replacement of MTBE with Ethanol

The proposed amendments are generally designed to address the emissions impacts associated with the replacement of MTBE with ethanol pursuant to the provisions of Health and Safety Code section 43013.1. Among other provisions, this section requires that CaRFG3 must maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999, including emission reductions for all pollutants identified in the State Implementation Plan for ozone, and emissions reductions in potency-weighted air toxic compounds.

As discussed in Chapter II, the addition of ethanol increases permeation emissions from both on-road and off-road sources.

a. Impact on On-road Sources

The proposed amendments are specifically designed to mitigate the increase of permeation emissions from on-road sources. The estimated emissions increase of permeation emissions is estimated to be 28.8 tpd in 2005, 18.4 tpd in 2010, 12.1 tpd in 2015, and 8.1 tpd in 2020. The mitigation is provided through the use of an alternative fuel formulation or, for a limited time for most producers, through the use of an AERP. The mitigation begins no later than December 31, 2009. This date was chosen as the earliest practical date to implement either alternative fuel formulations or AERPs.

Adoption of CARFG3 in 1999 to eliminate MTBE and require ethanol resulted in regulations for gasoline properties being revised. In the 1999 staff report, it was demonstrated that benefits of CARFG2 are preserved except due to permeation from use of ethanol. The limits for the fuel properties are not being changed at this point. The only change is the inclusion that an amount of hydrocarbons be mitigated equivalent to the increase related to permeation from the use of ethanol in on-road vehicles. Off-road impacts can not be quantified at this time; but once available, a mitigation proposal can be developed to address the impact from this category.

b. Impact on Off-road Sources

The proposed amendments will likely potentially mitigate, but not fully offset the impact of permeation on off-road sources. Off-road gasoline applications include sources such as lawnmowers, string trimmers, airport ground equipment, recreational equipment (snowmobiles, pleasure craft), and portable gas containers.

As discussed previously, the addition of ethanol is likely to reduce the exhaust emissions of hydrocarbons and carbon monoxide, but will likely increase permeation emissions. At higher levels of ethanol, the emissions of oxides of nitrogen may increase. However, staff is unable to define a method that ensures permeation effects in off-road sources are fully mitigated at this time. Available data are not sufficiently available to reasonably quantify the effect that ethanol in gasoline has on permeation emissions or the effect of fuel property changes on the exhaust emissions from off-road sources.

There are a few limited test programs that have addressed the impacts of fuel properties on off-road sources, including the impact of ethanol on permeation emissions. For exhaust emissions, use of 10 percent ethanol blends provided small to moderate (3 to 40 percent) reductions in hydrocarbons, and moderate to significant reductions in carbon monoxide (10 to 70 percent). Most results indicated a slight, but not statistically significant, increase in emissions of oxides of nitrogen. From studies reviewed on evaporative emission increases, staff has determined that use of ethanol blends leads to increase in evaporative emissions due to permeation. Two studies specifically conducted by the ARB on lawnmowers have provided a wide range of probable impacts that drawing any specific conclusions at this time has not been attempted. The lawnmower studies however, have been used to estimate the range of impacts for the entire off-road category. A detailed discussion of these test programs is presented in Appendix C.

Based on limited test programs, staff estimates for 2015 that the addition of ethanol to gasoline will increase evaporative hydrocarbon emissions by about 15 to 39 tpd. Similarly, staff estimates that the use of additional ethanol to gasoline could decrease the exhaust emissions of hydrocarbons by 15 to 21 tpd and increase slightly the exhaust emissions of NOx by about 1 to 2 tpd. Further work is needed to determine the emission impacts of greater ethanol use and to define what additional mitigation, if any is necessary.

To improve the data and enable the design of an effective mitigation strategy, staff is developing an emissions test program to provide enough information to reasonably quantify the impacts of ethanol on the emissions from off-road sources. This will allow a mitigation program, if appropriate, to be developed. Different off-road categories likely have different ethanol permeation rates. Therefore, staff is proposing to significantly expand the existing database of evaporative and exhaust emissions data for the off-road equipment. Impacts on permeation due to ethanol blending, engine exhaust emissions, changes due to increased oxygenates, and benefits of catalysts on reducing engine emissions will be studied.

The proposed program will be conducted in two phases. The first phase will be conducted at a Southwest Research Institute with a report made available within a year. The second phase will be conducted in-house by ARB staff and is expected to be completed in a longer time frame (2-3 years). This project will expand the number and types of engines being tested.

c. Impact on the State Implementation Plan

The ARB's 2007 State Implementation Plan (SIP) proposal is a comprehensive strategy designed to attain federal air quality standards as quickly as possible through a combination of technologically feasible, cost-effective, and far reaching measures. The total magnitude of the reductions to be achieved through new actions is primarily driven by the scope of the air quality problems in the San Joaquin Valley and South Coast Air Basin.

When introduced in 1996, gasoline meeting the CaRFG2 specifications was estimated to produce about a 15 percent overall reduction (300 tons per day) in ozone precursor emissions from motor vehicles. These emission reductions were equivalent to removing 3.5 million vehicles from California's roads. The CaRFG2 program is also a major component of the California SIP. In 1996, the CaRFG2 program accounted for 25 percent of the ozone precursor emission reductions in the SIP. The CaRFG3 regulations approved by the Board in 1999, removed MTBE from California gasoline. However, the substitute oxygenate, ethanol, has resulted in increased evaporative emissions due to fuel system permeation. This proposed measure would make modifications to the CaRFG3 program to fully mitigate ethanol permeation effects from motor vehicles and a significant portion of the permeation effect from off-road applications.

D. Greenhouse Gas Emissions

Staff expects that the CaRFG3 amendments would ultimately result in a small (less than one percent)[8] net decrease in CO_2 equivalent greenhouse gas emissions from California gasoline production and use. This is due to the expected increase in ethanol blending ratio from 5.7 to as high as 10 percent by volume.[9] As currently produced in the U.S., ethanol creates about zero to 30 percent less CO_2 equivalent greenhouse gases (GHG) per unit of energy output than would occur from the gasoline displaced due to ethanol use[10].

In January 2007, the Governor's Executive Order S-01-07 a Low Carbon Fuel Standard (LCFS) for transportation fuels be established for California. This first of–its-kind standard will support the AB 32 climate change emissions target as part of California's overall strategy to fight global warming. ARB is expected to initiate rulemaking activities for the LCFS in July 2007. The proposed changes to the CARFG3 rules are expected to provide additional flexibility for producers to comply with the LCFS.

Expected changes to the CARBOB component of California gasoline are expected to result in an additional but much less significant change in CO_2 equivalent emissions. This is due to the need to use more energy in the production of lower sulfur feedstocks. The expected reduction in sulfur content could cause small (less than 0.01 percent)[11] net increases in CO_2 equivalent emissions. Generally, the more hydrotreating required in producing a given type of fuel, the more CO_2 equivalent GHGs are emitted in the production of the fuel.

E. Water Quality

The proposed amendments do not change flat or average limits of CaRFG3 gasoline. Therefore, no major changes in fuel formulation are expected except for a small decrease in sulfur level and a likely increase in ethanol use. These expected fuel formulation changes are not expected to have a significant negative effect on the quality of both ground and surface water. The findings of the environmental fate and transport analysis and a health risk evaluation of ethanol performed in 1999 supports this analysis. In 1999, the Board approved the environmental assessment of CaRFG3 with ethanol. This assessment

[8] The actual benefits will depend greatly on how ethanol used in California is produced.
[9] This would be an ethanol energy content increase from about 3.9 percent to about 6.9 percent.
[10] http://www.energy.ca.gov/ab1007/documents/2007-03-02_joint_workshop/presentations/TIAX-2_2007-03-02.PDF
[11] See ARB staff report, Appendix J, "Effect of Low Sulfur Diesel Fuel on Greenhouse Gas Emissions," June 6, 2003.

included ethanol levels up to 10 percent by volume. In 2000, the California Environmental Policy Council approved the multimedia environmental assessment of ethanol in gasoline for ethanol levels up to 10 percent by volume.

F. Community Health and Environmental Justice

Environmental justice is a core consideration in ARB's efforts to provide clean air for all California communities (CARB 2001, i.e. Policies and Actions for Environmental Justice, PTSD, 2001). The increased ethanol required for blending would require additional number of trucks delivering ethanol to pipeline terminals. Staff has estimated that to supply the necessary additional ethanol to the distribution terminals there will likely be about an additional 8300 miles driven each day by heavy duty diesel trucks. This represents about 0.02 percent of the total miles driven each day by heavy duty diesel trucks (38,204,000 miles per day in 2006-source: ARB EMFAC 2007). The impacts of this however, could be localized near blending terminals. To accommodate the additional ethanol most of the terminals must have their ethanol storage and blending equipment upgraded; this will be subject to local permitting requirements and CEQA, and any significant increases in emissions must be mitigated. Also, the expansion of hydrotreating capacity at producer facilities and other associated changes will require either new permits or amendments to existing permits. Again, increases in emissions must be mitigated.

Chapter VI. Alternatives to the Proposed Amendments

This chapter presents an analysis of alternatives to the proposed amendments. In general, the proposed amendments are driven by the need to mitigate the impacts of ethanol permeation effects on CaRFG3, as required by Health and Safety Code section 43013.1. Therefore, there is not a “no project” alternative. As there are documented increases in permeation emissions associated with the addition of ethanol, staff believes the Board must take action to mitigate this increase. There are, however, various alternative approaches that could be taken as part of the revisions to the CaRFG3 regulations, or in establishing alternative compliance options. Based on an analysis of these alternatives, the staff has not identified any alternative that is as effective, or less burdensome, as the approach taken with the proposed amendments to the CaRFG3 regulations.

The following sections outline the different alternatives that the staff has identified or that have been discussed in the process of developing the proposed amendments. These alternatives are related to the Predictive Model, the AERP, and the proposed changes in specifications.

A. Alternatives Related to the Predictive Model

Staff believes that it is necessary and appropriate to update the Predictive Model to add the permeation emissions, update the motor vehicle emissions inventory vehicle mix, update the reactivity adjustment factors, add the new motor vehicle exhaust emissions test data, and update the effect of carbon monoxide on ozone-forming potential. During the development of these proposed amendments to the Predictive Model, one or more stakeholders introduced alternatives discussed below related to the general construction of the Predictive Model. These alternatives were related to the inclusion of off-road emissions into the Predictive Model, reactivity adjustment factors for carbon monoxide, the construction of the Tech 4 model, the studies used to evaluate the sulfur/NOx response for the Tech 5 class, and miscellaneous comments on the construction of the Predictive Model. The specific alternatives are discussed in the following sections.

1. Incorporate Off-Road Emissions Into the Predictive Model

The CaRFG program was adopted to reduce emissions from motor vehicles. The data developed to support this rulemaking came from studies that related fuel properties to on-road motor vehicle emissions. Then, as now, adequate emission studies do not exist to allow inclusion of off-road emissions into the CaRFG program including the Predictive Model. This is due in part to low consumption of fuels in off-road applications, less than five percent of total gasoline. Emission studies are being implemented to provide the necessary data to allow an assessment to be made of the appropriateness of incorporating off-road emissions into the CARFG program.

2. Reactivity Adjustment Factors for Carbon Monoxide

Some stakeholders requested that staff review submitted information regarding the MIR factor for CO. These parties believed that the MIR value for CO was too low relative to other hydrocarbons and requested that staff consider using a significantly higher value for the MIR of CO.

Staff reviewed this information and concluded that the information was insufficient to provide a basis for changing the approach used to estimate the reactivity in the Predictive Model. Staff recommends that the MIR scale developed by Dr. William Carter continues to be used. This was specifically to complement California's dual program of reducing both NOx and VOC to control ozone and other pollutants.

In 2003, the Board approved an updated list of reactivity values and reconfirmed the other MIR values. At that time, the MIR value for CO changed slightly to 0.06. Prior to Board consideration, the Reactivity Advisory Committee reviewed the list of values. After their review, the Reactivity Scientific Advisory Committee concluded that the proposed update did not substantially change the nature of the MIR values and were arrived at in an appropriate scientific manner.

3. Construction of the Tech 4 NOx Portion of the Predictive Model

During the workshop process, several stakeholders requested that the staff consider dividing the Tech 4 dataset into a higher and lower emitter group to be modeled separately, and presented the results of an analysis of dividing the datasets. The basic concept was that a Tech 4 NOx model would provide an overall higher statistical fit if the dataset were divided into two distinct vehicle groups. The cut point would be at 0.6 times the NOx emissions standard and each portion modeled separately. Proponents believe that this approach produces a much lower response of NOx to oxygen content and it would require less adjustment to other fuel properties to be able to increase the amount of ethanol into CARFG.

Staff discussed this issue with the ARB's vehicle experts and consulted representatives of the Alliance of Automobile Manufacturers and the Association of International Automobile Manufacturers. These discussions focused on determining if there was some physical design factor in vehicle emission control systems that change how they respond to fuel property changes at the levels indicated by the stakeholder analysis. Staff learned that while many manufacturers do calibrate their emission control systems to emit at levels below the actual standard, there is no physical response differences between vehicles emitting just below 0.6 times the standard and those emitting just above

0.6 times the standard. This was important because the alternative statistical method did not produce consistent results at other cut points. Lacking a technical reason for using the suggested 0.6, staff was concerned that the result was more the product of a statistical anomaly than a meaning point that defines vehicle emission performance. Staff also is concerned that the rational for the cutoff point of 0.6, applied specifically to NOx to produce an optimal statistical model, is not applicable to hydrocarbons and CO. The cutoff points that maximize the likelihood function for THC and CO are 1.0 and 1.6 times their tailpipe standard, respectively.

Staff also consulted with Dr. David Rocke of the University of California, Davis to provide comments and guidance regarding the validity of the Tech 4 NOx modeling approach proposed by the stakeholders. He concurred with staff that while the alternative approach might provide some improvement in statistical performance, other factors should be considered. In this case, it is essential that emissions modeling be consistent with sound engineering judgment and good science and have a sound basis relative to vehicle control system design and combustion chemistry. Relying on statistics as the sole guide to model construction could lead to misleading results. As a result, staff believes the suggested alternative is not appropriate and the approach taken to model Tech 4 vehicles in the previous Predictive Model modeling efforts should be maintained. This current approach was subject to independent scientific peer reviewed by appointees from the University of California in 1994 and 1999 and found to be reasonable and scientifically supportable. Appendix D presents the information provided by the stakeholders.

4. Sulfur/NOx Response for the Tech 5 Class

To provide the best representation of the Tech 5 fleet in 2015 using the available data, staff chose to use the two newest datasets for modeling the Tech 5 emissions response to changes in sulfur levels. Staff chose not to include the two older datasets because there were larger datasets that are based on emissions testing in the early LEV I vehicles and pre-LEV vehicles. In 2015, only about 25 percent of the on-road vehicles are the LEV I and earlier technologies. Using the combined dataset, with the earlier and later datasets, would lead to the modeling of a fleet with only 25 percent LEV I and earlier vehicles with a data with about 80 percent LEV I and earlier vehicles.

Stakeholders suggested that using the larger combined dataset should lead to comparable results and that the results would provide better estimates of the emissions response to changes in sulfur levels. To investigate this, staff made estimates using the larger and smaller datasets and found that including the data from the two older datasets overwhelmed the response from the two newer and smaller datasets. Staff also compared the results of this analysis with results published as part the U.S. EPA MSAT rule making where they, in conjunction with the Alliance of Automobile Manufactures, tested a low sulfur fuel (6 ppmw) sulfur fuel against the same fuel with higher sulfur levels (32 ppmw) in 9 Tier II 2003 to 2007 model year vehicles and found results that clearly indicate that in LEV II/Tier II and later emission control technology vehicles, reductions in sulfur will provide significantly higher emissions benefits than indicated by using the combined Tech 5 sulfur data to model the 2015 California light-duty vehicle fleet. These results are consistent with the staff's earlier analysis. More details are provided in Chapter III.

5. Miscellaneous Comments on the Development of the Predictive Model

a. Coefficients for Tech 5 model

Stakeholder suggested that staff should consider different methods for estimating coefficients for the Tech 5 terms in the model. Staff reviewed two other methods of estimation coefficients for the Tech 5 model: model Tech 4 first and then model Tech 5 from the residuals, and modeling the Tech 5 terms in pairs with the corresponding Tech 4 terms. Staff has worked extensively with the Statistical Working Subgroup and determined that the other methods gave essentially the same estimates within the expected uncertainty ranges associated with the coefficients being estimated while being significantly less complicated.

b. Quantification of Increases in Permeation due to Ethanol

Stakeholder suggested that staff should directly use the emissions data from the Coordinating Research Council's E-65 Fuel Permeation from Automotive Systems rather than use the percent change from a baseline fuel to the ethanol fuel. Staff believes that the method chosen best uses the limited information from the CRC E-65 study. To accurately estimate increase in permeation emissions associated with the presence of ethanol in gasoline, staff must incorporate the effect of temperatures and vehicle operations into the calculations. This is best done by incorporating the permeation by temperature response to ethanol directly into the EMFAC2007 model. Details of this effort and the resulting calculations are presented in Appendix B.

c. New Tech 6 Group

Stakeholders suggested that the staff should develop a new Tech 6 vehicle emissions technology group for modeling the Predictive Model database. This was because the stakeholders believed that vehicles produced after 2000 would respond differently than the 1994 to 2000 vehicle model portion of Tech 5. Staff worked with the stakeholders and the Statistical Working Subgroup to investigate the merits of developing a new Tech 6 vehicle emissions control group. Staff and stakeholders determined that there was insufficient data available for the newest vehicle emission control technologies to develop a new statistical response model using only most recent vehicles emissions test information.

d. *Distillation Temperature*

Stakeholders suggested that the impact of T_{50} on total organic gas should be examined. Below a T_{50} value of 190°F, emissions appear to rise as T_{50} decreases. While there are some data to support this effect, the data is not adequate to precisely determine where the upturn occurs other than it is less than 190°F. Also, it is to be expected that little or no gasoline will be produced with values below 190°F. The response should be modified to be flat below 190°F. Similarly, the impact of T_{90} on exhaust TOG should be examined. Below a T_{90} value of 305°F, the TOG emissions appear to rise as T_{90} decreases. Again, there are not adequate data to support this effect. Therefore, the response should be modified to be flat below 305°F. Staff agrees and the hydrocarbon response functions were flattened out as they were in both the CaRFG2 and CaRFG3 models.

B. Alternatives Related to the AERP

There are two basic alternatives related to the AERP. The first alternative would be to extend the AERP to address off-road emissions. As discussed in Chapter V, there is insufficient data available to reliably estimate the impact of the addition of ethanol to gasoline. Staff has initiated several new studies designed to provide the data necessary to make further improvements to the off-road emissions estimates. Also, once these studies are complete, staff proposes to return with appropriate mitigation approaches and/or changes in the Predictive Model.

The second alternative would be to allow the use of the AERP indefinitely. As proposed, the AERP can only be used by the large producers until December 31, 2011. Small producers can use the AERP indefinitely. Staff does not support the use of the AERP beyond the sunset date. While it is expected that an AERP can provide emission mitigation, only fully complying fuel can ensure that the full benefits are obtained. Small producers supply less than 5 percent of gasoline consumed in the State and the risk by allowing them access to the AERP on an ongoing basis is limited.

C. Alternatives Related to the Change in Specifications

1. *Denatured Ethanol*

The only practical alternative to the proposed amendments to section 2262.9 would be to leave the section as is. Staff recommends against this alternative. This approach would force fuel suppliers to supply California denatured ethanol that is different from the rest of the country. The best way to assure fungibility of denatured ethanol throughout the ethanol storage and distribution system is to amend section 2262.9. No alternative considered by the agency would be more effective in carrying out the purpose for which the regulation is proposed or would be as effective as and less burdensome to affected private persons than the proposed regulation.

2. *Modeling Oxygen Content*

An alternative would be to leave the oxygen flat spots as they are in the current Predictive Model. Doing this would discourage refiners from using oxygen contents other than 2 percent and 2.7 percent (5.7 percent and 7.7 percent in terms of ethanol) and decrease needed flexibility for refiners to find the optimum ethanol levels to offset the evaporative emissions due to permeation. Such an approach could have a significant negative impact on California refinery's ability to produce and supply gasoline to California's consumers.

a. RVP Limit

An alternative is to leave the RVP flat limits as they currently exist when the evaporative portion of the Predictive Model is used. However, since commingling has not occurred, there is no need to retain the lower RVP limit for oxygenated gasoline. The only other alternative is to lower the RVP limit. This was not considered because a minimum RVP of 6.4 psi is required to avoid vehicle performance problems related to cold starts. Lowering the upper limit would effectively mean that refiners would have little flexibility in producing fuels and batches of gasoline would be susceptible to being found out of specification and have to be reprocessed resulting in lost production with tight supplies and cost excursions.

b. Sulfur Cap

The first alternative is to lower the sulfur cap limit even further than 20 ppmw. Lowering the sulfur cap limit below 20 ppmw would make sense, if the current CaRFG flat limit is also changed to be below 20 ppmw. Lowering both the sulfur cap and the flat limits would decrease flexibility for refiners to make compliant CaRFG. This lack of flexibility could adversely affect the supply of gasoline in California, and would severely limit the options available to producers to use higher oxygen level to mitigate permeation emissions.

The second alternative is to leave the sulfur cap at 30 ppmw. Given the implementation of the new federal Tier II sulfur limits for federal gasoline, it would make it more difficult to enforce the requirement that only complying California Phase 3 reformulated gasoline be sold for use in California. No alternative considered by the agency would be more effective in carrying out the purpose for which the regulation is proposed or would be as effective and less burdensome to affected stakeholders than the proposed regulation.

D. Alternatives Related to Implementation Dates

Staff considered alternative dates for producers to certify fuel formulations that mitigate the increase in permeation emissions. Staff also considered alternative dates for the use of the AERP option. Based on available information, staff determined that December 31, 2009 was a sufficient date for producers to certify fuel formulations that mitigate the increase in permeations along with the option to use the AERP. Staff was also able to determine that the producers would have sufficient time to certify formulations that could mitigate permeation emissions with the use of the AERP option by December 31, 2011.

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