

SUMMARY OF BOARD ITEM

ITEM # 00-11-4: PUBLIC HEARING TO CONSIDER PROPOSED AMENDMENTS TO THE CALIFORNIA PHASE 3 REFORMULATED GASOLINE REGULATIONS

STAFF RECOMMENDATION: Adopt the proposed amendments to the California Phase 3 Reformulated Gasoline (CaRFG3) regulations.

DISCUSSION: Air Resources Board (ARB) staff is proposing amendments to the "California Phase 3 Reformulated Gasoline" (CaRFG3) regulations. The Board approved the CaRFG3 regulations at a hearing on December 9, 1999. The CaRFG3 regulations prohibit California gasoline produced with the use of methyl tertiary butyl ether (MTBE) starting December 31, 2002, establish CaRFG3 gasoline specifications, and make various other changes. At the conclusion of the hearing, the Board adopted Resolution 99-39, in which it approved the CaRFG3 regulations with several modifications. However, a number of items could not be addressed at the December hearing and were deferred until this Board meeting.

The primary items to be addressed by these proposed amendments to the CaRFG3 regulations include:

- 1) specifications for fuel grade denatured ethanol,
- 2) amendments providing for a model to certify gasoline prior to the addition of ethanol,
- 3) amendments regarding how a gasoline storage tank may be transitioned from a fuel designed for one level of ethanol to a fuel designed for a different level of ethanol, and
- 4) other technical and clean-up changes.

Staff is also proposing changes to the Board's diesel fuel regulations to provide a mechanism for small refiners to fully mitigate any increase in emissions associated with the small refiner provisions in the CaRFG3 regulations.

The primary reasons for proposing the regulatory amendments are to provide greater flexibility for refiners to produce gasoline with ethanol in California and to ensure that existing air quality benefits are maintained.

ARB staff held six public workshops from March - September 2000, in both Sacramento and El Monte. Based on comments received as part of these workshops, staff has responded to a number of issues related to the proposed amendments of the CaRFG3 regulations. Each of the staff recommendations is based on the issues and discussions raised during this past year's public workshops.

SUMMARY AND IMPACTS: In summary, ARB staff is proposing amendments to clarify the current CaRFG3 regulations, to provide refiners with greater flexibility to comply with the CaRFG3 regulations, and to maintain the air quality benefits achieved by the CaRFG2 program as of January 1, 1999.

ARB staff believes the proposed amendments to the CaRFG3 regulations should have no significant negative economic or environmental impacts beyond the existing CaRFG3 regulations.

TITLE 13. CALIFORNIA AIR RESOURCES BOARD

NOTICE OF PUBLIC HEARING TO CONSIDER FOLLOW-UP AMENDMENTS TO THE CALIFORNIA PHASE 3 REFORMULATED GASOLINE REGULATIONS

The Air Resources Board (ARB or Board) will conduct a public hearing at the time and place noted below to consider follow-up amendments to the California Phase 3 Reformulated Gasoline (CaRFG3) regulations. The proposed amendments would establish specifications for denatured ethanol intended for blending into gasoline, establish a CARBOB model and make other changes regarding blending ethanol into gasoline, establish a mechanism under which a small refiner could alter its production of diesel fuel to provide offsets of excess emissions from gasoline subject to the small refiner CaRFG3 standards, and make various other changes.

Date: November 16, 2000

Time: 9:30 a.m.

Place: Air Resources Board
Board Hearing Room, Lower Level
2020 L Street
Sacramento, California

This item will be considered at a two-day meeting of the Board, which will commence at 9:30 a.m., on November 16, 2000, and may continue at 8:30 a.m., on November 17, 2000. This item may not be considered until November 17, 2000. Please consult the agenda for the meeting, which will be available at least 10 days before November 16, 2000, to determine the day on which this item will be considered.

This facility is accessible to persons with disabilities. If accommodation is needed, please contact ARB's Clerk of the Board by November 2, 2000, at (916) 322-5594, or Telecommunications Device for the Deaf (TDD) (916) 324-9531, or (800) 700-8326 for TDD calls for outside the Sacramento area, to ensure accommodation.

INFORMATIVE DIGEST OF PROPOSED ACTION/PLAIN ENGLISH POLICY STATEMENT OVERVIEW

Proposed Actions and Sections Affected

Proposed amendments to sections 2260, 2261, 2262.3, 2262.5, 2264, 2266.5, 2270, 2272, 2282, 2296 and 2297, and adoption of section 2262.9, title 13, California Code of Regulations (CCR). Adoption of the "Procedures for Using the California Model for California Reformulated Blendstock for Oxygenate Blending (CARBOB)," incorporated by reference in section 2266.5(a)(2)(B)1., title 13, CCR.

Background

The existing CaRFG regulations. The Phase 2 CaRFG (CaRFG2) regulations were adopted by the Board following a hearing in November 1991, and became applicable in the spring of 1996. The regulations established a comprehensive set of standards for gasoline designed to achieve the maximum feasible reductions in emissions of criteria pollutants and toxic air contaminants from gasoline-powered motor vehicles. The standards cover sulfur, benzene, olefin, oxygen, and aromatic hydrocarbon contents, the 50-percent and 90-percent distillation temperatures (T50 and T90), and summertime Reid vapor pressure (RVP).

At a December 9, 1999, hearing, the Board approved standards for CaRFG3, which gasoline producers and importers must meet starting December 31, 2002. The most prominent feature of the CaRFG3 standards was the prohibition of gasoline containing methyl tertiary-butyl ether (MTBE) – an oxygenate used in most California gasoline since 1996. Following an extensive study by University of California researchers, Governor Gray Davis had made a finding in March 1999, that there are significant risks and costs associated with water contamination from MTBE in the state's gasoline. MTBE is highly soluble in water and will transfer faster and travel farther and more easily than other gasoline constituents such as benzene when gasoline leaks from underground storage tanks or pipelines; it also degrades more slowly. The CaRFG3 standards also reflected changes from the CaRFG2 standards for several of the regulated gasoline properties. These changes were designed to maintain the emission and air quality benefits of the CaRFG2 standards while increasing refinery flexibility in producing complying gasoline without the use of MTBE.

The primary elements of both the CaRFG2 and CaRFG3 standards are sets of limits – referred to here as refiner limits – that apply to gasoline when it is first supplied from the production facility (typically a refinery) or import facility. These standards also include sets of “cap limits” that apply throughout the gasoline distribution system and are less stringent than the refiner limits.

With the exception of RVP and oxygen content, the regulations provide three compliance options for meeting the refiner limits. One option is to have the gasoline subject to either a “flat limit,” set forth in the regulations which must be met by every gallon of gasoline leaving the refinery, or a specified “averaging limit.” The averaging limits for each of the six properties are numerically more stringent than the comparable flat limits. Under averaging, a batch of gasoline with a designated alternative limit above the averaging limit must be offset by other batches with designated alternative limits below the averaging limit.

The CaRFG regulations also contain a second compliance mechanism under which a refiner may use a Phase 2 or 3 CaRFG “Predictive Model” to identify alternative flat and averaging limits applicable when gasoline is supplied from the refinery. The Predictive Model consists of mathematical equations which predict the changes in exhaust

emissions of hydrocarbons, oxides of nitrogen (NO_x), and potency weighted toxics for four toxic air contaminants in the exhaust of gasoline-powered vehicles. An alternative gasoline formulation is acceptable if there will be essentially no increase in emissions of hydrocarbons, NO_x, and potency-weighted toxics under the Predictive Model. Currently, most of the gasoline sold in California complies with the CaRFG2 regulations through the use of the Predictive Model. The third compliance option in the CaRFG regulations allows for certification of alternative gasoline formulations based on the results of vehicle emission testing.

Gasoline oxygen content is regulated somewhat differently from the other properties in that there are both minimum and maximum oxygen content standards. Oxygen is added to gasoline by blending in an oxygenate such as MTBE or ethanol. While the CaRFG2 oxygen standard is 1.8 to 2.2 percent by weight, producers and importers may use the Predictive Model to vary the applicable limit. The oxygen content may be as low as zero percent or as high as 3.5 wt. percent when the Predictive Model is used. Since adding oxygen to gasoline will reduce emissions of carbon monoxide (CO) from most vehicles now on the road, the CaRFG regulations require a minimum oxygen content of 1.8 wt. percent in the Los Angeles, Orange, Ventura, San Bernardino, Riverside and Imperial Counties in the winter months when the highest CO concentrations are experienced. California is conditionally mandated by section 211(m) of the federal Clean Air Act (FCAA) to maintain a wintertime oxygen requirement in all of these counties except Imperial.

Comparable Federal Regulations. Pursuant to the 1990 amendments to the FCAA, the U. S. Environmental Protection Agency (U.S. EPA) has adopted federal RFG regulations that apply in San Diego County, the greater Los Angeles area (Los Angeles, Orange and Ventura Counties, and parts of Riverside and San Bernardino Counties), and the greater Sacramento area (Sacramento County and parts of Yolo, Solano, Sutter, Placer, and El Dorado Counties). Together, these areas make up about 70 percent of the state's gasoline market. Both the federal and state RFG regulations apply in those areas. To avoid unnecessary duplication of the enforcement requirements, in 40 C.F.R. section 80.81, the U.S. EPA exempted California producers from many of the federal enforcement requirements.

The oxygen requirements in the federal RFG and CaRFG programs differ considerably. The FCAA requires a minimum 2.0 wt. percent oxygen requirement year-round, even when it is not needed to avoid exceedances of the ambient CO standards and formulations with less or no oxygen can achieve equivalent reductions in emissions of hydrocarbons and toxics. Thus because of federal law, California refiners must comply with the federal minimum oxygenate requirement in 70 percent of California's gasoline. For the remaining 30 percent of the state's gasoline, refiners have the flexibility to produce gasoline without oxygen if they choose, as long as minimum emissions performance required by the CaRFG regulations are met. In April 1999, Governor Davis asked the U.S. EPA to issue a waiver of the oxygenate requirement under a waiver provision in the federal law, and the ARB has furnished U.S. EPA with

substantial analyses supporting the waiver. Nevertheless, U.S. EPA has to date failed to act on the request.

Proposed Amendments

Although the Board was able to address most CaRFG3 issues at the December 1999 hearing, a few had to be deferred and will be addressed in this rulemaking.

Specifications for denatured ethanol. With the elimination of MTBE in California gasoline, the use of ethanol will become much more widespread, particularly if the federal government does not eliminate the mandate that 70 percent of California's gasoline contain at least 2.0 wt. percent oxygen. However, even with relief from the federal requirement, refiners are expected to use substantial amounts of ethanol both to meet the state requirement for oxygen in wintertime gasoline in much of Southern California and to increase octane. In the original CaRFG3 rulemaking, staff proposed specifications for denatured ethanol intended for use in California gasoline. The specifications were designed to assure a more uniform product with blending characteristics that would assist refiners in the challenging task of meeting the CaRFG3 standards and to help enable the ethanol blending requirements be streamlined. Since ethanol producers commented that some of the proposed specifications were too stringent in light of ethanol production processes and the characteristics of denaturants being used, the Board directed staff to work with interested parties and come back with a proposal for consideration at a later date.

After several workshops and exchanges of information, the staff is now proposing the following limits for denatured ethanol intended for use in California gasoline: a sulfur content of 10 parts per million, benzene content of 0.06 volume percent, olefin content of 0.5 volume percent, and aromatic hydrocarbon content of 1.7 volume percent. Sulfur content would be determined by ASTM D 5453-93. The benzene, olefin, and aromatic hydrocarbon content would be determined by analyzing the concentration of those compounds in the denaturant and then multiplying the result by 0.048. Staff is also proposing benzene, olefin and aromatic hydrocarbon limits for denaturants equal to the CaRFG3 cap limits. Persons transferring denatured ethanol intended for use in California gasoline would have to provide documentation stating that it complies with the applicable standards, and providing the name of the transferor, the facility where the ethanol was produced, the person who produced the ethanol and added the denaturant, and the nature and source of the denaturant.

Provisions pertaining to "CARBOB." When gasoline is oxygenated with ethanol, certain characteristics of the resulting blend make it generally infeasible to be transported through pipeline systems. Because of this, ethanol is typically added to gasoline at the terminal or in the delivery truck. The CaRFG regulations allow a refiner to ship non-oxygenated gasoline from the refinery without complying with the CaRFG standards if it is specially formulated to be combined with oxygenate "downstream" from the refinery and the resulting blend will meet all of the CaRFG standards. This allows

entities adding oxygen downstream from the refinery to take advantage of the contribution the oxygenate can make to complying with the CaRFG standards, particularly by diluting the concentration of compounds like benzene. The nonoxygenated blend is called "California reformulated gasoline blendstock for oxygenate blending," or "CARBOB."

Under the existing regulations, compliance of CARBOB with the CaRFG standards is determined by adding the appropriate level of oxygenate to a sample of CARBOB and comparing the results to the applicable CaRFG limits. A producer is required to conduct such tests and notify the ARB prior to supplying a final blend of CARBOB from the refinery. Whenever the CARBOB is transferred, it must be accompanied by a document identifying the oxygenate type or types and amount or range of amounts that must be added before the CARBOB is supplied from the final distribution facility.

The proposed amendments would establish a new "CARBOB Model" which would be used in connection with limits directly applicable to the CARBOB. The CARBOB model would serve as a preprocessor for the Predictive Model. The properties of the CARBOB would be used to calculate the expected properties of the finished blend. These finished blend properties would then be entered into the Predictive Model to see if the CARBOB properties result in a qualifying fuel. A refiner would have the option to use the CARBOB Model mechanism, in which case the refiner would be able to simply sample and analyze the CARBOB before it is supplied from the refinery, without having to hand-blend the ethanol into the CARBOB before analyzing the properties. However, ARB inspectors would have the option of hand-blending the CARBOB with ethanol and testing the blend.

Normally, in determining compliance the properties of the denatured ethanol would be assumed to be in the expected range reflecting the proposed specifications for denatured ethanol. But producers and imports would have the option of specifying a "cleaner" range of properties, in which case the range would have to be included in product transfer documentation and the ultimate oxygen blender would be responsible to use denatured ethanol with the specified properties.

The amendments would also add cap limits for CARBOBs designed for the three most common ranges of ethanol. These cap limits could be enforced throughout the distribution system.

The proposal would also change the current prohibition of combining CARBOB that has been shipped from the refinery with any other CARBOB, gasoline, blendstock or oxygenate, except for the oxygenate for which the CARBOB was designed, or other CARBOB for which the refiner has designated the same type and amount or range of oxygenate. Combining CARBOBs designed for different ethanol levels in a storage tank at a terminal or bulk plant would be permitted if it was part of a transition to a new type of CARBOB and certain criteria are met, including a requirement that the batch of the new CARBOB being added have a reduced sulfur content. Combining CARBOB with

California gasoline in a storage tank at a terminal or bulk plant would also be permitted if specified conditions are met. One condition would be that the resulting blend of product in the tank could only be supplied from the terminal or bulk plant when it was not subject to the RVP standards.

Providing offsets for excess emissions from small refiner CaRFG3. In the CaRFG3 rulemaking, the Board included small refiner CaRFG3 standards with less stringent flat limits for benzene and aromatics content, T50, and T90. A small refiner may only use the small refiner CaRFG3 standards, however, if it offsets the excess emissions with changes to its diesel fuel produced pursuant the ARB's regulation limiting the aromatic hydrocarbon content. The CaRFG3 regulations identify the excess emissions of hydrocarbons, NOx, and potency-weighted toxics on a per-barrel basis that must be offset, but the Board deferred establishment of the diesel fuel offset provisions until this rulemaking. A small refiner may only use the small refiner CaRFG3 standards if it produced gasoline meeting CaRFG2 standards in 1998 and 1999; Kern Oil and Refining Co. (Kern Oil) is the only refiner to meet this criterion.

The diesel aromatics regulation includes a basic aromatic hydrocarbon standard of 10 vol. percent, with a 20 vol. percent standard for small refiners, applicable to the small refiner's annual "exempt volume" (additional diesel fuel produced by the small refiner in the year is subject to the 10 percent aromatics standard). The regulation also includes a mechanism under which a refiner may certify an "alternative formulation" shown by an engine test program to achieve emissions reductions equivalent to a 10 percent aromatics diesel fuel (20 percent for small refiners).

The amendments proposed by staff would provide a small refiner with three options in producing diesel fuel in a manner that offsets the excess emissions from gasoline subject to the small refiner CaRFG3 standards in a particular year. First, the small refiner can accept a smaller annual exempt volume of diesel fuel subject to the 20 percent aromatics standard – in the case of Kern Oil, the equivalent of 2,263 barrels per day in place of 6,405 barrels per day. Second, the refiner can produce up to its annual exempt volume of diesel fuel, but subject to standards more stringent than a 20 percent aromatics standard. Third, the small refiner could opt for an exempt volume augmented by 25 percent, if emissions are reduced enough to offset emissions from the small refiner's gasoline and the augmentation of the volume. The small refiner would also have the option to use these mechanisms prior to December 31, 2002.

Other amendments. The staff is also proposing several additional amendments that would make minor changes to the CaRFG regulations, including reducing the applied reproducibility of automated RVP test methods, clarifying the method for sampling gasoline, correcting provisions on transitions to the winter oxygenates season for low-throughput stations, and clarifying that racing gasoline is not subject to the detergent additives requirements.

AVAILABILITY OF DOCUMENTS AND AGENCY CONTACT PERSON

The Board staff has prepared a Staff Report: Initial Statement of Reasons (ISOR) for the proposed regulatory action, which includes the full text of the proposed regulatory language and a summary of the environmental and economic impacts of the proposal, if any. Copies of the ISOR may be obtained from the Public Information Office, Air Resources Board, 2020 L Street, Sacramento, California 95814, (916) 322-2990, at least 45 days prior to the scheduled hearing. To obtain the Staff Report in an alternative format, please contact the Air Resources Board's Americans with Disabilities Act Coordinator at (916) 323-4916, TDD (916) 324-9531, or (800) 700-8326 for TDD calls from outside the Sacramento area. This notice, the ISOR, and all subsequent regulatory documents are being made available on the ARB Internet site for this rulemaking, <http://www.arb.ca.gov/regact/carfg300/carfg300.htm>.

The Board staff has compiled a record which includes all information upon which the proposal is based. This material is available for inspection upon request to the agency contact person identified immediately below.

The ARB has determined that it is not feasible to draft the regulation amendments in plain English due to the technical nature of the regulation; however, a plain English summary of the proposed regulation is available from the agency contact person named below, and is also contained in the ISOR for this regulatory action.

Further inquiries regarding this matter should be directed to agency contact person, Mr. Dean C. Simeroth, Chief, Criteria Pollutants Branch, Stationary Source Division, at (916) 322-6020.

COSTS TO PUBLIC AGENCIES AND TO BUSINESSES AND PERSONS AFFECTED

The determinations of the Board's Executive Officer concerning the costs or savings necessarily incurred in reasonable compliance with the proposed regulatory action are presented below.

The Executive Officer has determined that the proposed regulatory action will not create costs or savings, as defined in Government Code section 11346.5(a)(6), to any state agency or in federal funding to the state, costs or mandate to any local agency or school district whether or not reimbursable by the state pursuant to part 7 (commencing with section 17500, division 4, title 2) of the Government Code, or other nondiscretionary costs or savings to local agencies.

In preparing the regulatory proposal, the staff has considered the potential economic impacts on private persons and businesses. The Executive Officer has determined that the proposed regulatory action will not have a significant cost impact, as defined in Government Code section 11346.5(a)(9) on directly affected private persons or businesses. The amendments are generally designed to provide refiners and gasoline

distributors with more flexibility in complying with the CaRFG standards, and as such should not result in cost increases. For instance, refiners would not be expected to use the CARBOB model option if it will increase costs. The new specifications for denatured ethanol should help assure a reliable product, enabling refiners to better predict the necessary properties of the reformulated blendstock to be blended with ethanol and avoid the possibility of ethanol adding unanticipated levels of sulfur. In a survey by an ethanol producers trade association, over half of the respondents reported they currently produce denatured ethanol that meets the proposed specifications, and with careful selection of the denaturant, a significant portion of the remaining producers would be able to meet the specification.

The Executive Officer has determined that the proposed regulatory action will not have a significant adverse economic impact on businesses including the ability of California businesses to compete with businesses in other states. In accordance with Government Code section 11346.3, the Executive Officer has determined that the proposed regulatory action will not affect the creation or elimination of jobs within the State of California, the creation of new businesses or elimination of existing businesses within California, or the expansion of businesses currently doing business within California. An assessment of the economic impacts of the proposed regulatory action can be found in the Staff Report.

The Executive Officer has also determined, pursuant to Government Code section 11346.5(a)(3)(B), that the proposed regulatory action will affect small business.

Before taking action on the proposed regulatory action, the Board must determine that no alternative considered by the agency would be more effective in carrying out the purpose for which the action is proposed or would be as effective and less burdensome to affected private persons than the proposed action.

SUBMITTAL OF COMMENTS

The public may present comments relating to this matter orally or in writing at the hearing, and in writing or by e-mail before the hearing. To be considered by the Board, written submissions must be addressed to and received by the Clerk of the Board, Air Resources Board, P.O. Box 2815, Sacramento, CA 95812, or 2020 L Street, 4th Floor, Sacramento, CA 95814, no later than 12:00 noon, November 15, 2000, or received by the Clerk of the Board at the hearing. To be considered by the ARB, e-mail submissions must be addressed to crfg300@listserv.arb.ca.gov and received at the ARB no later than 12:00 noon, November 15, 2000, so that ARB staff and Board members have time to fully consider each comment.

The Board requests, but does not require, that 30 copies of any written statement be submitted and that all written statements be filed at least 10 days prior to the hearing. The Board encourages members of the public to bring to the attention of staff in

advance of the hearing any suggestions for modification of the proposed regulatory action.

STATUTORY AUTHORITY AND REFERENCES

This regulatory action is proposed under that authority granted in sections 39600, 39601, 43013, 43013.1, 43018, 43101, and 43830, Health and Safety Code, and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). This regulatory action is proposed to implement, interpret, and make specific sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, 43021, 43830, 43830.8 and 43101, Health and Safety Code, and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

HEARING PROCEDURES

The public hearing will be conducted in accordance with the California Administrative Procedure Act, title 2, division 3, part 1, chapter 3.5 (commencing with section 11340) of the Government Code.

Following the public hearing, the Board may adopt the regulatory language as originally proposed, or with nonsubstantial or grammatical modifications. The Board may also adopt the proposed regulatory language with other modifications if the text as modified is sufficiently related to the originally proposed text that the public was adequately placed on notice that the regulatory language as modified could result from the proposed regulatory action, including but not limited to other small refiner provisions; in such event the full regulatory text, with the modifications clearly indicated, will be made available to the public, for written comment, at least 15 days before it is adopted. The public may request a copy of the modified regulatory text from the Board's Public Information Office, 2020 L Street, Sacramento, California 95814, (916) 322-2990.

CALIFORNIA AIR RESOURCES BOARD



for MICHAEL P. KENNY
EXECUTIVE OFFICER

Date: September 19, 2000

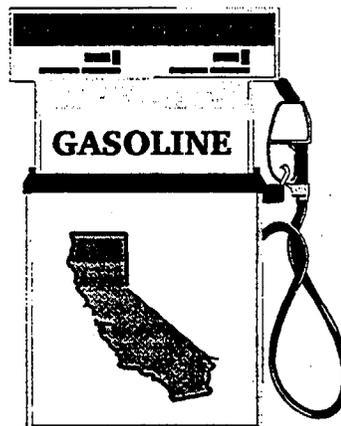
California Environmental Protection Agency

 **Air Resources Board**

Proposed Follow-up Amendments to the California Phase 3 Reformulated Gasoline Regulations

**Proposed Amendments to the California Reformulated
Gasoline Regulations Including Denatured Ethanol Specifications, Small Refiner
Provisions, CARBOB Model, and Other Changes**

STAFF REPORT: INITIAL STATEMENT OF REASONS



Release Date: September 29, 2000



State of California
California Environmental Protection Agency
AIR RESOURCES BOARD
Stationary Source Division

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

Public Hearing to Consider Amendments to the
California Reformulated Gasoline Regulations, Including Denatured
Ethanol Specifications, Small Refiner Provisions, CARBOB Model, and
Other Changes

Date of Release: September 29, 2000
Scheduled for Consideration: November 16, 2000

Location:

California Air Resources Board
Board Hearing Room, Lower Level
2020 L Street
Sacramento, California 95814

This report has been reviewed by the staff of the Air Resources Board and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. To obtain this document in an alternative format, please contact the Air Resources Board ADA Coordinator at (916) 322-4505, TDD (916) 324-9531, or (800) 700-8326 for TDD calls from outside the Sacramento area. This report is available for viewing or downloading from the Air Resources Board's Internet site; <http://www.arb.ca.gov/regact/carfg3/carfg3.htm>

Acknowledgments

This report was prepared with the assistance and support from the other divisions and offices of the Air Resources Board. In addition, we would like to acknowledge the assistance and cooperation that we have received from many individuals and organizations. In particular, we would like to thank members of the Renewable Fuels Association, the California Energy Commission, and the Western States Petroleum Association.

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Executive Summary

A. Introduction

The Air Resources Board approved the Phase 3 Reformulated Gasoline (CaRFG3) regulations at a hearing on December 9, 1999. The regulations prohibit California gasoline produced with the use of methyl tertiary-butyl ether (MTBE) starting December 31, 2002, establish CaRFG3 standards, and make various other changes. At the conclusion of the hearing, the Board adopted Resolution 99-39, in which it approved the originally proposed amendments with several modifications. A number of items that could not be addressed in December were deferred until this Board hearing.

The primary items addressed in this rulemaking include amendments to accommodate the blending of ethanol in CaRFG3, new regulations to assure consistent quality of fuel grade ethanol, proposed changes to the diesel fuel regulations to provide for offsets of the emissions associated with the small refiner CaRFG3 standards, and amendments that specify how refiners and gasoline distribution system proprietors can transition from distributing gasoline produced for one ethanol content level to a gasoline produced for another ethanol content level. Some other changes include improving the stated enforcement reproducibility of the Reid vapor pressure (RVP) test method when certain automated instruments are used.

B. Background

What were the Governor's Directives? The December 9, 1999 rulemaking was in response to Governor Davis' March 25, 1999 Executive Order D-5-99, in which he found that, on balance, there is a significant risk to the environment from using MTBE in gasoline in California. He made this finding on the basis of a University of California report (the U.C. Report) and other public input that concluded there are significant risks and costs associated with water contamination due to the use of MTBE. MTBE is highly soluble in water and will transfer faster and travel farther and more easily than other gasoline constituents such as benzene when gasoline leaks from underground storage tanks or pipelines. The Executive Order directed the California Energy Commission (CEC) to issue a timetable for the removal of MTBE from gasoline at the earliest possible date, but not later than December 31, 2002. The CEC subsequently determined that December 31, 2002 was in fact the earliest feasible time. The Executive Order also directed the ARB by December 1999 to adopt CaRFG3 regulations that will provide additional flexibility to refineries to lower or eliminate the use of oxygenates while maintaining current emissions and air quality benefits and ensuring compliance with the State Implementation Plan (SIP).

At the December 1999 public hearing, the Board approved the CaRFG3 regulations via Resolution 99-39. However, in Resolution 99-39, the Board recognized with the approval of the CaRFG3 regulations that there were items that still needed to be investigated further to fully and effectively implement the CaRFG3 regulations. As a result, in Resolution 99-39, the Board directed ARB staff to return to the Board with further amendments to the CaRFG3 regulations to address the remaining items. These included:

- ◆ Provisions to facilitate production and shipping of ethanol blendstocks (CARBOB);
- ◆ Specifications for denatured ethanol for blending in CaRFG3;
- ◆ Amendments to the ARB's diesel fuel regulations to incorporate a mechanism for small refiners to fully mitigate any increased emissions associated with the CaRFG3 small refiner provisions.

The Board directed that the proposed amendments not include changes to the CaRFG3 flat, averaging or cap limits or the Predictive Model.

How Were the Proposed Amendments Developed? To develop staff's proposed regulatory amendments, ARB staff conducted six public workshops over the past six months with representatives from the oil, automobile, ethanol industry, and other key stakeholders. Also, over the past six months, ARB staff has held numerous meetings with representatives from Western States Petroleum Association, individual refiners including small refiner Kern Oil Company, vehicle manufacturers, fuel suppliers, environmental organizations, the ethanol industry, marketing associations, and other organizations. Many of these meetings were held jointly with the staff of the California Energy Commission.

Items Deferred to Future. In Resolution 99-39, the Board directed ARB staff over the next few years to further evaluate and as appropriate develop recommendations to address potential emission increases that would result from the use of ethanol in gasoline due to material permeability and commingling of varying levels of ethanol in the gasoline distribution system. Staff was also directed to further evaluate the practicality of the allowable MTBE residual limits in the CaRFG3 regulations. The Board additionally directed staff to examine the potential to further lowering CaRFG3 sulfur levels in the future.

The Board also directed ARB staff in Resolution 99-39 to examine a number of critical issues regarding the future implementation of the CaRFG3 regulations. Staff was directed to evaluate whether the fully implemented CaRFG3 regulations maintain the CaRFG2 air quality benefits and the effective CaRFG2 Driveability Index (DI) level. Staff was also directed to monitor refiner progress in complying with the CaRFG3 regulations and to assist local governments in addressing potential impacts from diesel truck emissions.

These issues are not dealt within this proposal. Staff will return to the Board periodically on these items.

The following sections of the Executive Summary present a brief summary and discussion of the staff's proposed regulatory amendments. The text of the proposed regulatory amendments are contained in Appendix A.

C. Denatured Ethanol Specifications

The staff's originally proposed CaRFG3 amendments included proposed specifications for denatured ethanol used as an additive to California gasoline. At the December 9, 1999 hearing, ethanol producers commented that some of the proposed specifications were too stringent in light of ethanol production processes and the characteristics of denaturants now being used. The Board decided to eliminate the proposed specifications as a part of that rulemaking, and directed staff to work with interested parties and come back with a proposal for consideration by the Board at a later hearing.

Following discussions with interested parties over the last year, we are proposing limits on the sulfur, benzene, olefins, and aromatics content in denatured ethanol used as an additive in CaRFG3. Refiners could establish more stringent alternative limits, typically for use in proprietary systems.

The staff is proposing that the sulfur limit be enforced by testing the denatured ethanol, but for the other properties enforcement would be through testing the denaturant and calculating the concentrations in the denatured ethanol. This approach would require product transfer documents with a description of ethanol and denaturant properties. Table 1 lists the proposed specifications for denatured ethanol and denaturants.

Table 1
Proposed Specifications for Denatured Ethanol and Denaturants

Property	Specifications for Denatured Ethanol	Specifications for Denaturants
Sulfur, ppm	10	--
Benzene, vol.%	0.06	1.1%
Olefin, vol.%	0.50	10%
Aromatics, vol.%	1.7	35%
Others	ASTM D 4806	--

The staff's goal in developing the proposed specifications for denatured ethanol was to find the appropriate balance between ensuring that the cleanest ethanol possible is supplied for use in CaRFG3 distributed through common tankage without significantly limiting the supply of ethanol for those markets. Refiners which distribute fuel directly from refineries or through proprietary pipeline systems would be able to establish their own more stringent ethanol specifications.

D. CARBOB Provisions

The U.S. Environmental Protection Agency (U.S. EPA) structured the federal RFG regulations to allow refiners to ship non-oxygenated gasoline from the refinery that does not comply with the federal RFG standards if it is specially formulated to be combined with oxygenate "downstream" from the refinery and the resulting blend will meet all of the federal RFG standards. This allows entities wishing to oxygenate gasoline downstream from the refinery to take advantage of the contribution oxygenates can make in meeting the federal RFG standards. U.S. EPA calls the specially formulated product "Reformulated Gasoline Blendstock for Oxygen Blending," or "RBOB." In its 1995 rulemaking, the ARB amended the CaRFG2 regulations to incorporate a similar approach, allowing refiners to supply a non-oxygenated blendstock called "California reformulated gasoline blendstock for oxygen blending," or "CARBOB."

At the December 1999 hearing, the staff proposed some changes to the CARBOB regulations and was aware of additional CARBOB issues that needed to be addressed. However, the remaining issues required more time and discussions with affected parties before specific regulatory proposals could be made. The staff was directed to address these issues this year so that fuel producers and distributors would have sufficient time to make any necessary distribution system changes prior to December 31, 2002. The amendments will also facilitate the early introduction of CaRFG3, made without MTBE.

The staff is proposing adoption of a CARBOB model as an alternative to the current requirement to hand blend ethanol into CARBOB in determining the finished gasoline properties for evaluating compliance with CaRFG3 specifications. The staff is also proposing mechanisms under which gasoline suppliers may conduct a transition between finished gasoline and CARBOB, or between CARBOB intended for one ethanol content level and a CARBOB intended for another ethanol content level.

Why a CARBOB Model? The staff is proposing amendments to the CaRFG3 regulation to provide for a CARBOB model that would allow a refiner to certify a CARBOB blend that, when mixed with the specified ethanol content, is fully compliant with the CaRFG3 specifications. This provision would increase the flexibility for a refiner to produce complying CARBOB blends. The refiner would not have to hold a batch of fuel until it collects a sample, hand-blends ethanol into the sample, and then analyzes the sample to demonstrate compliance with the CaRFG3 specifications.

Development of the CARBOB Model. A CARBOB dataset was used as the basis for constructing a statistical model to predict finished fuel properties from the CARBOB properties and the expected quantity of ethanol to be blended. The linear regression procedure available from the SAS Institute Inc. was used in the model development. The basic terms included in the model are RVP, T90, T50, and ethanol content.

Use of the CARBOB Model. The CARBOB model is used in tandem with the CaRFG3 Predictive Model. The properties of the CARBOB gasoline are entered into the CARBOB model, which then calculates the expected properties for the finished blend. These finished blend properties are then entered into the CaRFG3 Predictive Model to see if they give CARBOB properties that would lead to a certifiable fuel. Details on the use of the CARBOB model are provided in Appendix B, the “Procedures for Using the California Model for California Reformulated Gasoline Blendstocks for Oxygenate Blending (CARBOB).”

E. CARBOB Tank Transition Requirements

The current CaRFG regulations generally prohibit the blending of CARBOB that is downstream from its production or import facility with other CARBOB, gasoline, blendstock or oxygenate.

The current regulations also recognize that there could be legitimate operational business reasons for mixing CARBOB with California gasoline or with other types of CARBOB during a changeover in service of a storage tank. Consequently Section 2266.5(f)(2), title 13, California Code of Regulations (CCR) allows the Executive Officer to enter into a written protocol with any person to identify conditions under which such mixing might be permitted. However, to simplify the transition from one gasoline oxygen content to another some modifications to the regulations are necessary. Staff conducted an analysis and determined that the regulations could be amended to allow transitions at the storage tank under specific conditions and constraints.

The staff is proposing options to provide flexibility on how gasoline suppliers would transition from distributing CARBOB intended for one ethanol content to another ethanol content. Specifically, staff is proposing conditions that would allow the mixing of CARBOBs intended for varying ethanol content in a manner that would not result in increased emissions. However, the mixing of nonoxygenated RFG with oxygenated RFG is more complex and would not be allowed during the RVP (summertime) control periods without a protocol between the Executive Officer and the supplier.

F. Small Refiner Provisions

The Board adopted small refiner CaRFG3 standards to provide flexibility to a small refiner provided that the small refiner fully offset the excess emissions of NO_x, hydrocarbons and potency-weighted toxics by marketing a cleaner diesel fuel. The Board directed the ARB staff to propose amendments to the ARB’s diesel fuel regulations to incorporate a mechanism for the small refiner to fully mitigate any increase in emissions from the small refiner provisions in the CaRFG3 regulations. The small refiner will be able to produce gasoline subject to the small refiner CaRFG3 standards only after the offset provisions are in place. A small refiner would be allowed this flexibility only if it produced CaRFG2 fuel in 1998 and 1999.

Small refiners are now allowed to produce diesel fuel meeting a 20 volume percent aromatic hydrocarbon content limit, while large refiners are required to meet a 10 volume percent aromatic hydrocarbon content standard. Both large and small refiners can certify alternative diesel formulations that are shown to be equivalent to their respective standard. Small refiners are also restricted to a volume cap on the total annual quantity of diesel fuel they could market subject to the small refiner standards. However, small refiners can increase their diesel production by complying with the large refiner 10 percent aromatic hydrocarbon content provisions.

The staff is proposing three options for small refiners to use in offsetting the small refiner CaRFG3 emissions. First, a small refiner can reduce the small refiner exempt volume cap to offset emissions. Second, the small refiner can produce a “cleaner” small refiner diesel fuel. Third, the small refiner can increase its exempt volume by producing an even “cleaner” small refiner diesel fuel that will result in no net increase in emissions from gasoline or diesel fuel it produces, if the small refiner also foregoes its right to market nonvehicular high sulfur diesel fuel in California and makes available a reasonable quantity of diesel fuel meeting a 30 ppm sulfur limit. None of the proposed options would prevent the small refiner from producing as much “large refiner” diesel as it chooses.

With any of these approaches, it is assumed that if the small refiner does not produce the maximum amount of small refiner diesel fuel, extra emissions benefits would be gained because the small refiner diesel would be replaced by cleaner large refiner diesel fuel. The reason staff is proposing three options is to provide the small refiner with greater flexibility in choosing how to comply with both the diesel fuel mitigation and CaRFG3 regulations, and to avoid the need in the future to make additional regulatory adjustments as other changes may occur.

G. Other Changes

The staff is also proposing a number of other changes. One change would provide that, when the RVP of a gasoline sample is determined using a specified automated instrument, the staff-determined reproducibility for that instrument will be used for enforcement purposes rather than the larger reproducibility of ASTM D323-58, the base method in the regulations. Both the staff and refiners have successfully been using automated instruments to determine RVP for a number of years. Some of the other changes are to update the designation for the test method for MTBE, ethanol and oxygen content, and authorization of protocols that will allow multiple averaging banks for operationally distinct products at a refinery or import facility.

H. Impacts of the Staff Proposal

What are the Emission Impacts of the Proposed Amendments? Staff's proposal was developed to provide greater flexibility to refiners and gasoline distribution system proprietors to comply with the CaRFG3 regulations while continuing to preserve the CaRFG2 air quality benefits and to preserve the additional emission reductions estimated

from the CaRFG3 regulations which can be applied towards the SIP. As a result, staff's proposal is emissions-neutral.

What are the Costs of the Proposed Amendments? With the greater regulatory flexibility provided by these proposed amendments, refiners and gasoline distribution system proprietors should be able to reduce costs to comply with the CaRFG3 regulations.

Staff's proposed ethanol denaturant specifications may exclude some suppliers of ethanol to the California market, which could affect supply and potentially gasoline prices in California. However, the Renewable Fuels Association (RFA) survey supports the conclusion that there should be an adequate number of ethanol suppliers for the California market that can comply with the proposed ethanol denaturant specifications. As a result, the potential impacts on supply and cost should be very small. Further, this potential impact is further limited by the fact that denaturant can only be added up to a five percent maximum to comply with federal requirements.

What is the Cost-Effectiveness of the Proposed Amendments? Staff's proposal allows those entities subject to the CaRFG3 regulations new options which could enable them to more easily implement the CaRFG3 requirements. Staff's proposal is emissions neutral as it affects the CaRFG3 regulations. Therefore, with no emissions impact or expected increase in costs there is no cost-effectiveness to calculate for these proposed amendments.

What are the Environmental Impacts of the Proposed Amendments? Staff's proposal is emissions neutral as it affects the CaRFG3 regulations. No significant environmental effects from staff's proposal are expected regarding water and air quality and greenhouse gases.

I. Recommendation

The staff recommends that the Board adopt the proposed amendments to the Board's CaRFG3 and diesel fuel regulations as contained in Appendix A, and the "Procedures for Using the California Model for California Reformulated Gasoline Blendstocks for Oxygenate Blending (CARBOB)" as contained in Appendix B, with the recognition that staff may propose some modifications to their proposal based on information and comments obtained subsequent to the release of the Staff Report and prior to the Board hearing in November 2000. Specifically, discussions are continuing with CENCO Refining Company which is asking for temporary relief from complying with the CaRFG3 regulation.

I. Introduction

The Air Resources Board approved the Phase 3 Reformulated Gasoline (CaRFG3) regulations at a hearing on December 9, 1999. The regulations prohibit California gasoline produced with the use of methyl tertiary-butyl ether (MTBE) starting December 31, 2002, establish CaRFG3 standards, and make various other changes. At the conclusion of the hearing, the Board adopted Resolution 99-39, in which it approved the CaRFG3 regulations with future actions required because a number of items could not be appropriately addressed in December.

A. Why the CaRFG3 regulations?

The CaRFG3 rulemaking was in response to Governor Davis' March 25, 1999 Executive Order D-5-99, in which he found that, on balance, there is a significant risk to the environment from using MTBE in gasoline in California. He made this finding on the basis of a University of California report (the U.C. Report) and other public input that concluded there are significant risks and costs associated with water contamination due to the use of MTBE. MTBE is highly soluble in water and will transfer faster and travel farther and more easily than other gasoline constituents such as benzene when gasoline leaks from underground storage tanks or pipelines. The Executive Order directed the California Energy Commission (CEC) to issue a timetable for the removal of MTBE from gasoline at the earliest possible date, but not later than December 31, 2002. The CEC subsequently determined that December 31, 2002 was in fact the earliest feasible time. The Executive Order also directed the ARB by December 1999 to adopt CaRFG3 regulations that will provide additional flexibility in lowering or removing the oxygen content requirement while maintaining current emissions and air quality benefits and ensuring compliance with the State Implementation Plan (SIP).

B. ARB Staff's Proposal

The ARB staff returns to the Board in this proposed rulemaking with further amendments to the CaRFG3 regulations to request the Board's consideration of:

- Provisions to facilitate production and shipping of ethanol blendstocks (CARBOB);
- Specifications for denatured ethanol for blending in CaRFG3;
- Amendments to the ARB's diesel fuel regulations to incorporate a mechanism for small refiners to fully mitigate any increased emissions associated with the CaRFG3 small refiner provisions approved herein.
- Some other changes staff are proposing include lowering the enforcement reproducibility of the RVP test method and minor changes to update test methods ASTM D4815-94 and D4815-94a to the current version.

The Board directed that the proposed amendments not include changes to the CaRFG3 flat, averaging or cap limits or the Predictive Model. The following chapters in this report present staff's proposals.

C. The Process

The process ARB staff used to develop the proposed regulatory amendments included hosting six public workshops between February and September, 2000 and holding numerous individual meetings with representatives from the oil, automobile, and ethanol industries as well as numerous other key stakeholders over the past six months.

D. Other Future Activities

At the December 1999 public hearing in Resolution 99-39, the Board also directed ARB staff to investigate a number of other CaRFG3 related items and to report back to the Board. Those items are identified below as the Board's direction to ARB staff to:

- Evaluate potential increases in hydrocarbon emissions from materials permeability associated with the use of ethanol in gasoline and provide the Board with an update and report to the Board on the results of permeability testing.
- Further evaluate the expected real-world emissions impact in 2003 and beyond of the commingling of CaRFG3 containing ethanol with CaRFG3 not containing ethanol and report the findings to the Board with any appropriate recommendations.
- Further evaluate the practicality of the allowable MTBE residual limits for CaRFG3 and report back to the Board with a recommendation on whether the limit should be revised.
- Evaluate whether CaRFG3 regulations maintain CaRFG2 air quality benefits and report to the Board by 2004 on the results of the evaluation along with appropriate recommendations.
- Evaluate the CaRFG3 Driveability Index (DI) and report back to the Board by 2004 with the results and any appropriate recommendations.
- Evaluate potential to further lower CaRFG3 sulfur levels in the future and report back to the Board.
- Monitor refiner progress to comply with CaRFG3 regulations and assist local governments to address potential impacts from diesel truck emissions.

II. Proposed Specifications for Denatured Ethanol

Because of the physical properties of ethanol, the majority of ethanol used in California gasoline will be blended into the delivery tank truck at the terminal by an oxygenate blender rather than added at the refinery. The CaRFG regulations allow a refiner to ship from its refinery a non-oxygenated gasoline blendstock called "CARBOB," which is designed to comply with the applicable CaRFG refinery limits after its is blended with ethanol or another designated oxygenate. CARBOB stands for "California reformulated blendstock for oxygenate blending." The regulations require that refiners sample each final blend of CARBOB, hand-blend in the specified amount of ethanol, analyze the oxygenated sample to determine the level of each of the properties subject to CaRFG standards, and retain the test results.

Since most gasoline in California is shipped through common pipelines, the ethanol will be blended into the non-oxygenated base fuel at a point that is beyond the control of the refiner who originally certified the fuel. Therefore, to ensure the integrity of the original certification and to preserve the emission characteristics of the oxygenated gasoline, it is necessary to limit the concentration of the compounds controlled in gasoline by the CaRFG3 regulations and in the ethanol used to provide the desired oxygen content. These compounds are sulfur, olefins, aromatics, and benzene. The concentration of sulfur must be controlled in the denatured ethanol since sulfur occurs in both the base ethanol and in the material used to denature the ethanol. However, the others can be controlled by limiting their concentrations in the denaturant. These proposed limits are presented in Table II-1.

Table II-1
Proposed Specifications for Denatured Ethanol and Denaturants

Property	Specifications for Denatured Ethanol	Specifications for Denaturants
Sulfur, ppm	10	--
Benzene, vol.%	0.06	1.1
Olefin, vol.%	0.50	10
Aromatics, vol.%	1.7	35
Others	ASTM D 4806	--

A. Background

With the phase-out of MTBE, ethanol will most likely become the only oxygenate used in California. Part of the original staff proposal for the CaRFG3 regulations was a new section 2262.9, Title 13, CCR, which established a set of specifications for denatured ethanol intended for use in California gasoline. Because of concerns about water contamination, gasoline with ethanol has historically not been shipped through the

common pipeline system. Instead, the ethanol is expected to be added to gasoline downstream at the distribution terminal.

Since ethanol is typically not added to the base gasoline until truck loading at the terminal, a set of denatured ethanol standards would provide predictable specifications that could be taken into account when refiners are producing CARBOB. The standards could also enable refiners to maximize the potential contribution that ethanol can make towards complying gasoline.

In the original CaRFG3 rulemaking, the staff proposed that the following standards be set for denatured ethanol intended for use in motor vehicles: 1 ppmw sulfur, 1 volume percent aromatics, 0.1 volume percent benzene, and 0.1 volume percent olefins. At the December 9, 1999 hearing, representatives of the ethanol industry commented that some of the proposed specifications were too stringent in light of ethanol production processes and the characteristics of denaturants now being used. The Board decided to postpone action on the proposed ethanol specifications as a part of the CaRFG3 rulemaking, and directed staff to work with stakeholders and come back with a proposal for consideration by the Board.

Beginning in March 2000, ARB staff held monthly workshops to discuss this and other issues with stakeholders. As a result of these workshops and individual meetings and discussions, the Renewable Fuels Association (RFA) conducted a survey to obtain information on the manufacture, properties and specification of denatured fuel ethanol. Based on information from the RFA study, discussion with interested stakeholders, and further analysis, the staff is proposing specifications for denatured ethanol, and for denaturants, in this rulemaking.

B. RFA's Ethanol Producers Survey

The RFA conducted a survey of ethanol producers within its membership. The objective of the survey was to obtain information regarding the sulfur content in denatured ethanol and certain hydrocarbons in the denaturants. The survey included forty-three companies that operated ethanol production facilities. Of the facilities surveyed, the RFA received data from twenty-seven that have a total production capacity of 1.42 billion gallons per year. The data covers production capacity representing 81 percent of the fuel ethanol production capacity in the United States. Table II-2 lists the results of RFA's survey.

Table II-2
Results of RFA's Ethanol Producer Survey

Property	Average	Range
Sulfur content of undenatured Ethanol	2.9 ppm	1 - 11 ppm
Sulfur content of denatured Ethanol	8.7 ppm	2.1 - 27.2 ppm
Sulfur content of the denaturant	127.7 ppm	9.1 - 733.9 ppm
Benzene content of the denaturant	0.63 vol. %	0.01 - 1.94 vol. %
Olefin content of the denaturant	0.55 vol. %	0.02 - 2.1 vol. %
Aromatic content of the denaturant	1.33 vol. %	0.05 - 6.6 vol. %

The survey data represent only one sample from each reporting producer. It is not known how much variation would occur in the reported values over an annual production period. In addition, the uncertainty in the reported sulfur results is unknown because the repeatability and reproducibility for the method used to determine sulfur levels in ethanol have not been determined. Currently, nearly 100% of the denaturants used are natural gasoline. Natural gasoline is a condensate from natural gas production. The RFA proposed that for flexibility, the benzene, olefin, and aromatics limits in fuel ethanol should be set to allow for the possibility of using CaRFG3 gasoline as a denaturant. The RFA proposed specifications for fuel ethanol intended for use to produce CARFG3 gasoline. Table II-3 lists the limits for sulfur benzene, olefins, and aromatics in fuel ethanol proposed by RFA.

Table II-3
RFA's Proposed Specifications for Fuel Ethanol

Property	Maximum Limit
Sulfur	15 ppm mass
Benzene	0.10 vol. %
Olefins	0.50 vol. %
Aromatics	1.70 vol. %

Since there are no benzene, olefins, or aromatics in undenatured ethanol and a maximum 4.8% denaturant addition level, back calculating for these compounds in the denaturant yields levels very close to the Phase 3 RFG cap limits with the exception of benzene. Based on the benzene limit proposed by the RFA, a back calculation for benzene resulted in a value greater than the CARFG3 cap limit for benzene. Ethanol denatured with a denaturant containing benzene at the CaRFG3 cap limit of 1.10 vol. % should result in a benzene content of no greater than 0.06 vol. %. The RFA survey showed that the average benzene content in the denaturants used by ethanol producers is 0.63 volume percent. This would result in a benzene content of 0.03 volume percent in the denatured ethanol.

C. ASTM Specifications for Denatured Ethanol

The current specifications of the American Society of Testing and Materials (ASTM) for "denatured fuel ethanol for blending with gasolines for use as automotive spark-ignition

engine fuel" are contained in ASTM D4806-98. These specifications require that the only denaturants used for fuel ethanol may be natural gasoline, gasoline components, or unleaded gasoline at a minimum concentration of two parts per 100 parts by volume of fuel ethanol (2.0 vol.%). The use of hydrocarbons with an end point higher than 437 °F are prohibited. The denaturant may be included as part of the 10 volume percent denatured fuel ethanol blended with a gasoline if they do not exceed five parts per 100 parts by volume of fuel ethanol (4.8 vol.%). The use of methanol, pyroles, turpentine, ketones and tars are prohibited. Denatured ethanol must conform to the performance requirements list in Table II-4 at the time of blending with a gasoline.

Table II-4
Performance Requirements for Denatured Fuel Ethanol
(ATSM D 4806)

Property	Specification
Ethanol, volume %, min.	92.1
Methanol, volume %, max.	0.5
Solvent-washed gum, mg/100 ml, max.	1
Water Content, volume %, maxim	1
Denaturant content, volume %, min.—max.	1.96 – 4.76
Inorganic chloride content, mass ppm (mg/l), max	40 (32)
Copper content, mg/kg, max.	0.1
Acidity (as acetic acid), mass % (mg/l) max.	0.007 (56)
Appearance	Visibility free of suspended or precipitated contaminants (clear and bright)

D. Proposed Test Methods and Specifications for Denatured Ethanol

Test Methods. The test method (ASTM D 5453-93) to measure sulfur in liquid hydrocarbons can be used to determine the sulfur content in ethanol. However, at this time precision for repeatability and reproducibly have not been determined for the use of this method for total sulfur content in ethanol. To facilitate the use of ASTM 5453-93 as a test method for sulfur in ethanol the staff of the ARB's Monitoring & Laboratory Division (MLD) is coordinating a round robin series of tests between participating laboratories to evaluate ASTM D5453-93 for determining the sulfur content in denatured ethanol. It is anticipated that the ASTM D5453-93 test method will be suitable to accurately measure the sulfur content in ethanol. The ARB staff is accordingly proposing that ASTM D5453-93 be the test method specified for determining the sulfur content of denatured ethanol.

There are no comparable test methods applicable to measure benzene, olefins, and aromatics at the concentration levels of these compounds that are found in denatured ethanol. The staff proposes that the concentration of these compounds in denatured ethanol be calculated using the concentration of these compounds found in the

denaturant. The test methods to be used for testing the denaturants are the ones specified in the CaRFG regulations for determining compliance with the CaRFG standards.

Proposed Specifications. The staff's goal in proposing the specifications for denatured ethanol is to find the appropriate balance between ensuring that the cleanest ethanol possible is supplied for use in CaRFG3 without significantly limiting the supply of ethanol. The ARB staff is proposing limits to the sulfur, benzene, olefins, and aromatics content in denatured ethanol used as an additive in CaRFG3. The sulfur limit would be enforced by testing the denatured ethanol. The benzene, olefins, and aromatics limits would be enforced by determining the concentrations of these compounds in the denaturant and multiplying the result by 0.048 to reflect the maximum denaturant content of the denatured ethanol.

Table II-5 lists the staff's proposed specifications for denatured ethanol. It also lists separate standards that would apply to denaturants represented as suitable for fuel ethanol. In addition, denatured ethanol must meet all of the performance requirements specified in ASTM 4806.

**Table II-5
Proposed Specifications for Denatured Ethanol and Denaturants**

Property	Specifications for Denatured Ethanol	Specifications for Denaturants
Sulfur, ppm	10	--
Benzene, vol.%	0.06	1.1%
Olefin, vol.%	0.50	10%
Aromatics, vol.%	1.7	35%
Others	ASTM D 4806-98	--

The staff is not proposing a limit on the sulfur content of the denaturant to provide more flexibility to ethanol producers. The proposed specifications would allow producers that produce undenatured ethanol with a very low sulfur content to use denaturants with a higher sulfur content. Assuming a denaturant with a sulfur content of 60 ppm (the interim CaRFG3 cap limit) and the sulfur levels normally found in undenatured ethanol, the addition of the denaturant will result in an increase in the sulfur content of the denatured ethanol by 1 ppm. Appendix C presents what the final sulfur content of denatured ethanol would be if a denaturants with 60 ppm of sulfur were used to denature the ethanol. In addition, if a producer can produce ethanol with low levels of sulfur, the producer can use denaturant with higher levels of sulfur and still meet the proposed limit of 10 ppm for denatured ethanol. For example, with ethanol that has a sulfur content of 3 ppm (the average reported in the RFA survey), the denaturant could have a sulfur content of 352 ppm and 150 ppm when it is added to ethanol at 2.0 vol.% and 4.8 % vol%, respectively. Data in Appendix C also demonstrate how the sulfur content of the denaturant used by ethanol producers could vary widely depending upon the sulfur content of the undenatured ethanol.

In addition to proposed specifications for the sulfur content, benzene content, olefin content, and aromatic content, the staff is proposing that denatured ethanol and denaturants meet the all of the specifications listed in ASTM D 4806-93.

E. Rationale for Proposed Specifications

The RFA survey data show that the sulfur content of denatured ethanol ranged from 1 ppm to 11 ppm with the average sulfur content at 2.9 ppm. Although there are no data on the distribution of the sulfur content from different producers, the available data suggest that at least half of the ethanol currently produced has a sulfur content below 3 ppm.

The CaRFG2 averaging limit for sulfur is 30 ppm. However, data collected by the CEC showed that the average sulfur content of gasolines produced in 1998 was much lower than the averaging limit. The CaRFG3 averaging limit for sulfur is 15 ppm. If the current trend continues, refiners would likely produce gasoline with sulfur contents well below 15 ppm. Gasolines produced to meet the CaRFG3 averaging limits could have sulfur contents of 10 ppm or lower. The use of denatured ethanol with sulfur content higher than that of 10 ppm in these cases would actually increase the sulfur content of the gasoline. Table II-6 shows how the sulfur content of the denatured ethanol can affect the sulfur content of the finished gasoline containing 5.7 volume percent ethanol.

**Table II-6
Gasoline Sulfur Contents Resulting from Blending CARBOBs
and 5.7 Volume Percent of Denatured Ethanol with Different Sulfur Levels**

Sulfur Level of CARBOB	CaRFG3 with Denatured Ethanol with 10 ppm Sulfur	CaRFG3 with Denatured Ethanol with 15 ppm Sulfur
1	1.5	1.8
3	3.4	3.7
5	5.3	5.6
7	7.2	7.5
10	10.0	10.3
15	14.7	15.0

F. Rationale for Adopting the ASTM D 4806-98 Specifications

The ASTM D-4806-98 specifications are very important for the successful use of ethanol. The ASTM denaturant requirements limit the denaturant to gasoline and gasoline components with a maximum end point of 437°F. This assures that denaturants that are not compatible with vehicle components could not be used even though they are allowed by the Bureau of Alcohol, Tobacco and Firearms.

G. Rationale for Separate Standards for Products Represented as Appropriate for Use as a Denaturant in Fuel Ethanol

Although most of the ethanol used in California gasoline will probably be imported in denatured form, in some instances the denaturant will be added in the state. Since compliance with the denatured ethanol standards for benzene, olefins and aromatic hydrocarbon content will depend entirely on the composition and amount of the denaturant, it is appropriate to adopt denaturant standards for these properties. These will enable an ethanol producer or marketer to rely on the denaturant supplier to provide a product that results in compliance with the ethanol specifications.

H. Documentation Required for the Transfer of Denatured Fuel Ethanol

The proposed amendments include requirements that apply when a person transfers denatured ethanol intended for use as an additive in California gasoline. The person transferring the product would have to provide a document stating that the denatured ethanol complies with the ARB standards. Further, when the denatured ethanol is supplied from the California facility at which it was produced or imported, the supplier would have to furnish a document stating his or her name and address, the name and location of the facilities where the ethanol was produced and the denaturant added, and the name of the party who produced it and added the denaturant. This requirements would help assure refiners and others that the ethanol is in compliance and facilitate tracing back if there are problems associated with the denaturant.

III. CARBOB Model and Related Provisions

The staff is proposing amendments to the CaRFG regulations to provide for a CARBOB model that could be used to calculate the expected properties of the final oxygenated gasoline from the properties of the CARBOB itself. If the properties of the finished blend meet the criteria of the Predictive Model, then a refiner could elect to have CARBOB at the refinery directly subject to CARBOB limits, rather than being subject to the CaRFG limits after the ethanol has been hand blended into the CARBOB. This could provide refiners with operational advantages. Staff is also proposing various other amendments to make the CARBOB regulation work more effectively and efficiently.

A. Background

The U.S. EPA structured the federal RFG regulations to allow refiners to ship non-oxygenated gasoline from the refinery without complying with the federal RFG standards if it is specially formulated to be combined with oxygenate "downstream" from the refinery and the resulting blend will meet all of the federal RFG standards. This allows entities wishing to oxygenate gasoline downstream from the refinery to take advantage of the contribution oxygenates can make in meeting the federal RFG standards. U.S. EPA calls the specially formulated product "Reformulated Gasoline Blendstock for Oxygen Blending," or "RBOB." In a 1995 rulemaking, the ARB amended the CaRFG2 regulations to incorporate a similar approach, allowing refiners to supply a non-oxygenated blendstock called "California reformulated gasoline blendstock for oxygen blending," or "CARBOB."

At the December 1999 hearing, the staff proposed some changes to the existing CARBOB regulations and was aware of additional CARBOB issues that needed to be addressed. However, the remaining issues required more time and discussion with interested parties before they could be resolved. The staff committed to address these issues this year so that fuel producers and distributors would have sufficient time to make any necessary distribution system changes prior to December 31, 2002.

The staff is proposing further amendments to the CaRFG regulations to assure the practical and effective implementation of the CARBOB provisions and to facilitate the blending of ethanol in gasoline.

B. Existing CaRFG and CARBOB Requirements

Background. When gasoline is mixed with ethanol, certain characteristics of the resulting blend make it infeasible to be transported through pipeline systems. For example, if there is water in the system the ethanol will separate from the gasoline into

the water. This could lead to contamination of the gasoline or corrosion in the distribution system. Because of this, ethanol is typically added at the terminal, either in a stationary blend tank or by "splash blending" the ethanol and the non-oxygenated gasoline in the cargo tank truck that will deliver the oxygenated gasoline to service stations and other outlets. Adding the ethanol affects the properties of the resulting gasoline blend in various ways. Since denatured ethanol typically has very low levels of the compounds for which the ARB has adopted CaRFG specifications (sulfur, benzene, aromatics and olefins), adding the ethanol to gasoline may reduce the concentration of these compounds in the resulting blend by simple dilution. The addition of ethanol to a base hydrocarbon gasoline has a non-linear effect on the Reid vapor pressure (RVP), the 50 percent distillation point (T50) and, 90 percent distillation point (T90). Adding 5-10 percent ethanol will increase the RVP of the resulting blend by approximately 1.2 psi, and it will also depress T50 and, to a lesser extent, T90.

Current Requirements. The current CARBOB provisions require the producer of a batch of CARBOB to take a representative sample, add the appropriate level of oxygenate, and test the resulting blend to determine compliance with all of the properties covered by the CaRFG standards. The producer must notify the ARB about the batch of CARBOB before it is transferred from the refinery. Whenever the CARBOB is transferred, it must be accompanied by a document identifying the oxygenate type or types and amount or range of amounts that must be added before the CARBOB is supplied from the final distribution facility. Like the federal regulations, the CARBOB provisions prohibit combining CARBOB that has been shipped from the refinery with any other CARBOB, gasoline, blendstock or oxygenate, except for the oxygenate for which the CARBOB was designed, or other CARBOB for which the refiner has designated the same type and amount or range of oxygenate.

C. Development of the Model for the Certification of a Gasoline Blend Prior To The Addition of Ethanol (CARBOB Model)

The staff is proposing amendments that would establish a new "CARBOB model" which would be used in connection with limits directly applicable to the CARBOB being supplied from a production or import facility. The CARBOB model would serve as a preprocessor for the Predictive Model. The refiner's proposed CARBOB properties would be used to calculate the expected properties of the finished oxygenated blend. These finished blend properties would then be entered into the Predictive Model to see if the CARBOB properties result in a qualifying fuel. If the finished blend properties do qualify, then the refiner electing the CARBOB model option could compare the test results of the CARBOB directly against the CARBOB limits, rather than go through the step of hand blending ethanol to produce a finished blend.

CARBOB Model Dataset. To develop the CARBOB model, it was necessary to assemble a dataset of fuel properties before the ethanol was added to the blend and after the ethanol was blended. The amount of ethanol added is also a necessary value to have. Sierra Research Inc. in Sacramento, California was contracted by the Western States Petroleum Association (WSPA) to collect and assemble all the available information into

a computer readable datafile. This data is available through the ARB web page. For sulfur, benzene, aromatics, and olefins the resulting fuel property could be calculated by scaling the initial fuel property by the amount of denatured ethanol to be added and the concentration of the specific fuel property in the denatured ethanol. After a preliminary analysis, it was found that the important properties for predicting an effect on RVP, T50, and T90 are RVP, T50, T90, and the volume of ethanol. To that end, the assembled dataset only contains the amount of denatured ethanol added and the values for RVP, T50, and T90, both before and after the blending of the ethanol. Table III-1 presents a summary of the dataset assembled for the construction of the CARBOB model.

Table III-1
Summary of CARBOB Dataset

	Minimum	Mean	Maximum
RVP Before (psi.)	5.3	8.2	15.4
T50 Before, °F	160	210	253
T90 Before, °F	278	325	368
Ethanol (vol%)	4.6	7.4	15
RVP After, (psi.)	6.0	9.2	16.0
T50 After, °F	140	196	250
T90 After, °F	275	321	362

Model Development. The CARBOB dataset was used as the basis for constructing a statistical model to predict finished fuel properties from the CARBOB properties and the expected quantity of ethanol to be blended. The linear regression procedure available from the SAS Institute Inc. was used in the model development. An automated stepwise model selection procedure was used to generate a candidate model. The stepwise procedure, at each step tests each term not already in the model to see if including the term will make the model better. In this case, the most significant term meeting the 95 percent significance level was added at each step and the coefficients were recalculated. If an included term ceased to be significant at the 95 percent level after a new term was added, it was then removed and the coefficients for the regression model were recalculated.

The pool of candidate terms included the first order terms: RVP, T50, T90, and the amount of ethanol to be blended. Also, included were all second order terms that could be created from the four first order terms. The stepwise procedure starts with all first order terms forced into the model. Then the second order terms are entered by the stepwise procedure. Once the stepwise procedure has stopped and there are no more statistically significant terms not added to the model, then any first order term that is not significant at the 95 percent level and not part of a second order term is removed from the model and the regression coefficients are then recalculated.

During the model development, it was found some models fit better over some ranges of the independent variable than others. The RVP model was found to be very close to

being linear over the range where the base RVP was less than or equal to 9.0 psi and the ethanol blend amounts were between 4 percent by volume and 10 percent by volume. The T90 model was fit across all the data. The T50 model as constructed by partitioning the data set into two parts and fitting different models to each part. The two partitions were based on ethanol between 4 percent by volume and 9 percent by volume and ethanol between 9 percent by volume and 10 percent by volume. Table III-2 presents the list of terms included in each model. Details of each model are provided in Appendix D.

Table III-2
Terms Included as Part of Each Statistical Model

Variable Modeled	First Order Terms	Second Order Terms
RVP	RVP	None
T90	T90, T50, EtOH	None
T50 (4% ≥ Ethanol < 9%)	RVP, T90, T50, Ethanol	EtOH*EtOH, RVP*EtOH, T50*EtOH, T90*EtOH, RVP*T90
T50 (9% ≥ Ethanol < 10%)	RVP, T90, T50	T50*T50, T50*RVP, T90*RVP

D. Use of the CARBOB Model

Proposed amendments to the CARBOB regulation (section 2266.5, title 13, CCR) would allow producers and importers to elect to have the CARBOB model used in determining whether a final blend designated as CARBOB complies with the standards applicable to gasoline when it is supplied from the production or import facility. In doing so, they would use the new “Procedures for Using the California Model for California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB)” as shown in Appendix B.

A producer or importer using the CARBOB model option would select a single volume of ethanol to be added, and an oxygen content range to serve as the oxygen input for the Predictive Model. Staff is proposing that the oxygen content range be permitted to be no greater than 0.4 wt.% when the CARBOB model is used. This is analogous to the approach in the current Predictive Model procedures. Under those procedures, where a refiner selects an oxygen range of 1.8-2.2 wt.%, one Predictive Model evaluation is conducted, with an oxygen content of 2.0 wt.%. Similarly, selection of an oxygen range of 2.5-2.9 wt.% results in one Predictive Model evaluation with oxygen set at 2.7 wt.%. These are the two most commonly expected ranges to be specified, because of the tax structure for ethanol blending. To obtain optimal tax benefits, the refiner would be expected to specify either 5.7 vol.% or 2.7 vol.% ethanol, which typically translates to 2.0 or 2.7 wt.% oxygen, so it is appropriate to use the single mid-range value. Where a wider oxygen content range is identified, however, the Predictive Model procedures require that two sets of specifications must pass the Predictive Model – one with the minimum amount of oxygen and one with the maximum amount. Limiting the oxygen range to 0.4

wt.% when the CARBOB Model is used will avoid a situation where the oxygenate value used in the CARBOB Model to identify the CARBOB limits does not closely reflect the amount of oxygen that may ultimately be added to the CARBOB downstream.

Amendments to the sampling and testing requirements in the CARBOB regulation would provide that a refiner selecting the CARBOB model would directly analyze the sample of CARBOB rather than going through the step of hand blending the ethanol into the CARBOB and then analyzing the oxygenated blend. Refiners see this as the primary advantage of the CARBOB model mechanism, because the analysis can be conducted more quickly and a protocol for in-line blending could theoretically be established under the appropriate circumstances.

Notification requirements. A producer or importer supplying CARBOB from its production or import facility has been required to notify the executive officer of specified information before it starts physical transfer of the final blend of CARBOB, and at least 12 hours before physical transfer is completed or the final blend is commingled. Where the producer is using the CARBOB model, the notification would have to include a statement of that election and each of the CARBOB alternative specifications that apply to the final blend. The notice would also include the information that is required when the Predictive Model is being used, i.e. the Predictive Model alternative specifications. The proposed amendments would provide that once the producer has provided notice regarding a final blend of CARBOB, the reported properties will continue to apply to subsequent shipments of CARBOB or gasoline until the producer provides a superceding notification. This is similar to the provisions that have applied to final blends of CaRFG being supplied from the refinery, and assures that there is a clear compliance option that applies to each batch of gasoline or CARBOB being shipped from the refinery.

Compliance determinations by ARB inspectors. The proposed amendments provide that where a refiner has elected to use the CARBOB model, ARB inspectors still would have the option to demonstrate a violation by taking a sample of the CARBOB, hand blending in the appropriate amount of ethanol, and testing the blended product against the applicable CaRFG flat or averaging standards. Refiners have argued strenuously that such a provision substantially reduces the usefulness of the CARBOB model, and could cause refiners not to use the mechanism at all. Staff believes the requirement provides a backup mechanism if serious shortcomings with the CARBOB model become apparent. However, it is the staff's intent during initial implementation of the amendments that, where a refiner has elected to use the CARBOB model, violations will only be pursued where tests show that the CARBOB limits have been exceeded. Staff anticipates that it will also conduct tests based on hand blending during implementation, to augment the database for evaluating the effectiveness of the CARBOB model. Staff also anticipates that refiners will participate in a testing program to expand the available data for further verifying the CARBOB model. If significant shortcomings of the CARBOB model, staff expects to work with refiners and other interested parties to make sure that a vigorous enforcement program is maintained for shipments of CARBOB.

The existing regulations prohibit the supply of CARBOB from a production facility where the sulfur, benzene, olefin and aromatic hydrocarbon content of the CARBOB would necessarily result in a sulfur, benzene, olefin or aromatic hydrocarbon content value in the blended gasoline which exceeds the applicable limit for that property. For example, where the oxygenate will make up 5.4 percent of the oxygenated blend, the measured CARBOB properties for sulfur, benzene, olefins, and aromatics could be diluted to 94.6 percent of the original concentration (assuming the denatured ethanol contains none of any of those compound). This is calculated by multiplying the concentrations of sulfur, benzene, olefins, and aromatics 0.946. Any CARBOB found to be out of compliance under this mathematical adjustment would necessarily be out of compliance after the minimum designated amount of oxygenate is added, since for these four properties the only effects adding the oxygenate is expected to have are dilution and the possible introduction of impurities. This provides ARB inspectors with a useful compliance tool and would be retained where the producer or importer has not elected to use the CARBOB model.

E. Cap Limits for Downstream CARBOB

Under the existing regulations, the only way that ARB inspectors can determine whether CARBOB at terminals meets the CaRFG2 or CaRFG3 cap limits is by hand blending the ethanol and analyzing the resulting blend. Staff is proposing amendments that would establish cap limits that would apply directly to the CARBOB, so hand blending would not be necessary. Table III-3 presents the proposed CARBOB cap limits as calculated using the CARBOB model and the existing CaRFG3 cap limits. There would be three sets of CARBOB cap limits, applicable to the ethanol ranges that would encompass the three levels of ethanol most likely to be used because of the tax structure for ethanol blending. The ranges would start with 2.0 vol.% ethanol, because by that point the RVP response has become flat.

In the CARBOB model, the RVP, T50, and T90 of the final blend are a function of the RVP, T50, and T90 of the CARBOB fuel and of the ethanol content. CARBOB cap limits for T50 and T90 are a function of the target ethanol concentration and the possible range of values for the other properties in the CARBOB model. The RVP of the final blend is only a function of the initial RVP of the CARBOB blend. It should be noted that the RVP portion of the CARBOB model is only applicable between 4 and 10 percent ethanol content.

Table III-3
CARBOB Cap Limits
Calculated by the CARBOB Model

Property	CARBOB Cap Limits					
	2.0 - 5.8 vol.% Ethanol Range		5.9 - 7.8 vol.% Ethanol Range		7.9 - 10 vol.% Ethanol Range	
	CaRFG2	CaRFG3	CaRFG2	CaRFG3	CaRFG2	CaRFG3
RVP ¹ , psi	5.78	5.99	5.78	5.99	5.78	5.99
Sulfur ² , ppmw	85	63 / 31	86	64 / 32	89	66 / 32
Benzene, vol%	1.27	1.16	1.30	1.19	1.33	1.22
Aromatics, vol%	31.7	37.0	32.4	37.8	33.1	38.7
Olefins, vol%	10.6	10.6	10.8	10.8	11.1	11.1
T50, °F	226	226	228	228	226	226
T90, °F	333	333	334	334	335	335

1. The Reid vapor pressure standards apply only during the warmer weather months identified in section 2262.4.
2. The CaRFG Phase 3 CARBOB cap limits for sulfur are phased in starting December 31, 2002, and December 31, 2004, in accordance with section 2261(b)(1)(A).

F. Other Changes Pertaining to CARBOB

Level of oxygenate used in hand blending. The current CARBOB regulation provides that when hand blending is conducted to convert a sample of CARBOB into finished gasoline, the smallest amount of oxygenate is to be added where an oxygen range has been specified. This was because adding the smallest amount of oxygenate would provide the minimum amount of dilution possible. Staff is proposing revised language that would call for 5.7 vol.% ethanol when an oxygen range of 1.8-2.2 wt.% is specified, and 7.7 vol.% ethanol when the oxygen range is 2.5-2.9 wt.%. This makes the approach more consistent with the features of the Predictive Model procedures discussed in III.D. above.

Properties of the ethanol used in hand blending. The existing CARBOB regulation provides that the oxygenate used for hand blending at the refinery be representative of the oxygenate that will ultimately be added at the terminal or elsewhere. It requires a refiner planning to produce CARBOB to enter into a protocol with the Executive Officer on how representativeness will be assured. One of the advantages of adopting specifications for denatured ethanol is that they can be used to set the specifications for ethanol used in hand blending at the refinery. The proposed amendments eliminate the "representativeness" and protocol requirements, and substitute the following specifications for the ethanol used in refinery hand blending: a sulfur content of 3-10 ppm, a benzene content of 0-0.06 vol.%, an olefins content of 0-0.05 vol.%, and an aromatic hydrocarbons content of 0-1.70 vol.%. The minimum sulfur level is required because denatured ethanol will normally have some amount of sulfur.

Designating “cleaner” specifications for the denatured ethanol used in blending.

The amendments also permit a refiner to designate a “cleaner” set of denatured ethanol specifications for the ethanol that will ultimately be added at the terminal. In this case, there is a mechanism for those specifications to be reflected in the ethanol used for hand blending at the refinery. There are also provisions that would assure that the ultimate oxygenate blender knows what specifications the ethanol ultimately added must meet.

Alternative means for determining whether are final blend of CARBOB complies with the standards for California gasoline. Along with hand blending and the option of the CARBOB Model, the amendments authorize a producer or importer to enter into a protocol with the Executive Officer identifying a different way of determining compliance for CARBOB. Such a protocol would only be permitted if the Executive Officer reasonably determines that its application will be no less stringent or enforceable than application of the express regulatory provisions.

IV. Transition from Gasoline with One Ethanol Content to Another

The staff is proposing amendments that would permit the mixing of CARBOBs designed for different oxygen levels as part of a change of service of a terminal tank, as long as certain conditions are met. Also proposed are amendments allowing the mixing of CARBOB and CaRFG in such tanks, as long as conditions are met including a prohibition to the RVP standards. Staff has conducted an emissions analysis indicating no significant emission increases in these circumstances.

A. Background

The current CaRFG regulations prohibit the blending of CARBOB that is downstream from its production or import facility with other CARBOB, gasoline, blendstock or oxygenate. (2266.5(h).) Downstream CARBOB may only be combined with other CARBOB that has been designed to have the same type and amount (or range of amounts) of oxygenate added and with the type and amount of oxygenate for which it is designed. Once the CARBOB has been oxygenated and converted to CaRFG, there are no restrictions on blending it with other CaRFG, as long as the blend continues to comply with the cap limits.

When ethanol is added to gasoline, the RVP of the gasoline is increased, and this will result in increased evaporative emissions. Also, two CARBOB's that are to be blended with different ethanol contents cannot be mixed because it becomes difficult to determine the appropriate amount of ethanol to add; consequently, the final blend may not comply with the regulations.

The regulations also recognize that there could be operational business reasons for mixing CARBOB with California gasoline or other CARBOB during a changeover in service of a storage tank. Consequently, section 2266.5(f)(2) allows the Executive Officer to enter into a written protocol with any person to identify conditions under which such mixing would be permitted. However, to simplify the transition from one gasoline oxygen content to another, it is preferable to have the regulations identify the conditions under which the mixing of two products will always be permitted. Staff conducted an analysis and determined that the regulations could be modified to allow transitions at the storage tank under specific conditions and constraints that would preserve emissions benefits.

B. Staff Analysis

The primary objectives of the staff's analysis were to determine any potential adverse effect on emissions with a refinery transitioning from a CARBOB designed for one level of ethanol to another level of ethanol or to non-oxygenated RFG. The staff analysis also identified the types of transitions where the RVP cap limit could be exceeded. The

properties of the blends were calculated for each turnover of the terminal tank, service station tank, and vehicle tank, and the changes were evaluated using the CaRFG3 Predictive Model to estimate the effect on emissions. Staff's analysis addressed only RVP and evaporative and exhaust emissions, other constraints, such as minimum octane requirements, will need be considered by refiners.

Changing the amount of ethanol added at a terminal leads to changes in products at the service station tanks and in the vehicle tanks. The term "transition" refers to sufficient tank turnovers such that the gasoline used at the vehicle meets the predictive model requirements. When a refiner is changing from one product to another, we refer to the limit applicable to the new product as the "target" properties. Table IV-1 summarizes the possible transitions

**Table IV-1
Possible Transitions**

Possible Transitions at the Terminal	Corresponding Transitions at Service Station or Vehicle Tank
Zero Oxygen RFG to CARBOB	Zero Oxygen RFG to Ethanol Fuel
CARBOB to Zero Oxygen RFG	Ethanol Fuel to Zero Oxygen RFG
CARBOB (A) to CARBOB (B)	Ethanol Fuel (A) to Ethanol fuel (B)

Note: A and B are the ethanol volume concentrations for which the CARBOBs were designed.

A transition at the terminal is complete when the target fuel or CARBOB properties are attained. The fuels properties after each tank turnover were calculated until the gasoline in the vehicle tank met the CaRFG3 predictive model requirements for a complying gasoline. This process generally required more than one terminal tank turnover before sufficient mixing occurred downstream so that the predicted emissions would not increase. In some cases, the blends downstream of the refinery would not meet the CaRFG predictive model requirements.

In conducting the analysis, the staff made several assumptions. The staff evaluated the effect on emissions at three different heel amounts at the terminal tank (10 percent, 25 percent and 50 percent) for six gasolines. It was assumed that the service station tank had an average heel of 20 percent and the vehicle tank had an average heel of 25 percent. The analysis only varied the terminal tank heel amount because that is the only tank turnover that can be practically controlled by the supplier. Also, it was assumed that the properties of the CaRFG that would be produced at the terminal, prior to the transition, were the same as the properties of the heel at the service station and vehicle tank.

It was also assumed that the terminal tank would undergo one turnover per week, the service station tank two turnovers per week, and the vehicle tank one turnover per week. The analysis also assumed that in each week, half of the vehicles would refuel with the mixture resulting from the first turnover at the station while the remaining half of the vehicles would refuel with the mixture resulting from the second turnover at the station.

The increase in emissions was calculated by averaging the total emissions exceeding the Predictive Model standard for each fuel blend in a four week period. Appendix E contains a detailed description of the fuels and methodology used to calculate the effect on emissions.

C. Effect on Emissions

The staff's analysis showed that the emissions impact of the tank transitions depended on at least three factors:

- ◆ the relative magnitude of the fuel remaining in the terminal tank (the heel) at each tank turnover,
- ◆ whether the oxygen content increased or decreased with the transition, and
- ◆ the CaRFG properties

The detailed results of the staff analysis are contained in Appendix E. A summary is presented in Table IV-2 and discussed below under four types of terminal tank transitions:

- ◆ from CARBOB to CARBOB with increasing oxygen content,
- ◆ from CARBOB to CARBOB with decreasing oxygen content,
- ◆ from non-oxygenated fuel to CARBOB, and
- ◆ from CARBOB to non-oxygenated fuel.

Terminal Tank Transitions From CARBOB to CARBOB With Increasing Oxygen Content. These transitions at the terminal result in service station and vehicle tank transitions from an ethanol fuel of one oxygen content to an ethanol fuel with a higher oxygen content. These transitions could increase NO_x emissions from the vehicle tailpipe. However, the adverse emissions impacts can be minimized by controlling the tank heel at each turnover and by changing the properties of the target fuel at the first terminal tank turnover. The staff's analysis shows that emissions increases can be prevented if the following is done:

- ◆ the terminal tank heel is not allowed to exceed 10 percent during any of the tank turnovers required to complete the transition, and
- ◆ the sulfur content of the target fuel is reduced for at least the first turnover.

Transitions From CARBOB to CARBOB With Decreasing Oxygen Content. This transition at the terminal results in a transition at the service station and vehicle from an ethanol fuel of one oxygen content to an ethanol fuel with a lower oxygen content. These transitions can increase total hydrocarbon emissions from the vehicle. Emissions increases can be prevented if the following is done:

- ◆ the terminal tank heel is not allowed to exceed 10 percent during any of the tank turnovers required to complete the transition, and
- ◆ the sulfur content of the target fuel is reduced for at least the first turnover.

Transitions From Non-Oxygenated Fuel to CARBOB. The transition from non-oxygenated CaRFG to a CARBOB (designed to be blended with ethanol) at the terminal causes commingling of non-oxygenated CaRFG and CaRFG with ethanol at the service station and in the vehicle tank. The staff's analysis indicates that for the three terminal heels investigated, there would be an increase in evaporative hydrocarbon emissions and an increase in RVP above the cap limit. This would not be a problem, however, if the combined product is only supplied from the terminal when it is not subject to the seasonal RVP standard.

Transitions From CARBOB to Non-Oxygenated Fuel. A transition from a CARBOB (originally intended for ethanol to be added) and non-oxygenated CaRFG at the terminal causes commingling of non-oxygenated and ethanol fuels in the service station tank and the vehicle tank. The staff's analysis predicts that for all three possible terminal transitions and for all three terminal tank heels investigated, there would be an increase in evaporative hydrocarbon emissions and an increase in RVP above the cap limit. Again, this would not be a problem if the combined product is only supplied from the terminal when it is not subject to the seasonal RVP standard.

D. Staff Recommendations

In light of this analysis, the staff is proposing adoption of new subsections 2266.5(f)(1)(C) and (D), identifying situations in which – without the need for a protocol – parties would be permitted to mix different CARBOBs and CARBOB with nonoxygenated CaRFG downstream from the refinery or import facility, as part of a change in service of a storage tank.

First, the mixing of two different CARBOBs designed for different oxygen levels in a storage tank at a terminal or bulk plant would be permitted where the party combining the products can demonstrate that the following conditions are met:

1. The ratio of the initial CARBOB remaining in the storage tank to the new CARBOB added to the tank is 1 to 9 or less;
2. The sulfur content on the new CARBOB added to the tank in the first turnover of the transition is no more than 12 ppm sulfur;
3. The change in ethanol content will not exceed 3 percent of the oxygenated gasoline blend; and
4. The change in service is for legitimate operational reasons and is not for the purpose of combining the different types of CARBOB.

Second, the changing from CaRFG to CARBOB, or from CARBOB to CaRFG, as the product stored in a storage tank at a terminal or bulk plant would be permitted where the party combining the products can demonstrate that the following conditions are met:

1. If CARBOB is being added to CaRFG, the ratio of the initial CARBOB remaining in the storage tank to the new CARBOB added to the tank is 1 to 9 or less;
2. The resulting blend of product in the tank is supplied from the terminal or bulk plant during a time that it is not subject to the RVP standards;
3. The change in service is for legitimate operational reasons and is not for the purpose of combining the different types of CARBOB.

Under either of these scenarios, the party doing the mixing would be required to notify the ARB prior to commencement of the mixing. As long as the conditions are met, the product in the storage tank after the fuel is mixed will be treated as the new type of product.

**Table IV-2
Staff Recommendations for Tank Transitions to Change Ethanol Content of
CaRFG3 and Mitigation of Emissions Impact**

Transition From	Potential Emission Impact	Conditions to Prevent Emissions Increases
CARBOB to CARBOB (increasing oxygen by no more than 3%)	NOx increase	1. Sulfur of target fuel to be no more than 12 ppmw for 1 st tank turnover of the transition. 2. Heel at terminal not to exceed 10% for each tank turnover during the transition
CARBOB to CARBOB (decreasing oxygen by no more than 3%)	HC increase	1. Sulfur of target fuel to be no more than 12 ppmw for 1 st tank turnover of the transition. 2. Heel at terminal not to exceed 10% for each tank turnover during the transition
Non-Oxygenated to Oxygenated RFG	HC increase and likely RVP violation downstream of refinery	None known for summer. Allow transition during non-RVP season
Oxygenated RFG to Non-Oxygenated	HC increase and possible RVP violation downstream of refinery	None known for summer. Allow transition during non-RVP season.

V. Small Refiner Offset Provisions

A. Background

In approving the CaRFG3 regulations in December 1999, the Board found it not economically feasible for small refiners that had been producing CaRFG2 to phase out MTBE and meet the CaRFG3 specifications. Because of the disparate costs, and preexisting investments made to comply with CaRFG2, the Board adopted less stringent CaRFG3 standards for small refiners provided that any increased emissions would be offset by changes to the small refiner diesel fuel specifications or production. Table V-1 compares the CaRFG3 specifications for small refiners and large refiners. The flat limits for benzene, aromatics, T50, and T90 were relaxed. These changes result in increases of hydrocarbon, NOx and toxic emissions that have to be offset. The Board did not change the CaRFG3 cap limits for small refiners so that the small refiner provisions will not adversely affect downstream enforcement.

Table V-1
The California Reformulated Gasoline Phase 3 Standards

Property	Flat Limits		Cap Limits
	Small Refiner	Large Refiner	All Refiners
RVP ¹ , psi	7.00 or 6.90 ²	7.00 or 6.90 ²	6.40 -7.20
Sulfur, ppmw	20	20	60-30 ³
Benzene, vol%	1.0	0.80	1.10
Aromatics, vol%	35.0	25.0	35.0
Olefins, vol%	6.0	6.0	10.0
T50., °F	220	213	220
T90, °F	312	305	330
Oxygen, wt%	1.8 - 2.2	1.8 - 2.2	0 ⁴ -3.5 ⁵

1. The Reid vapor pressure standards apply only during the warmer weather months identified in section 2262.4.
2. The 6.90 psi standard applies only when a producer or importer is using the evaporative emissions model element of the CaRFG Phase 3 Predictive Model.
3. The CaRFG Phase 3 sulfur content cap limits of 60 and 30 parts per million are phased in starting December 31, 2002, and December 31, 2004, respectively, in accordance with section 2261(b)(1)(A)
4. The 1.8 percent by weight minimum oxygen content cap only applies during specified winter months in the areas identified in section 2262.5(a).
5. If the gasoline contains more than 3.5 percent by weight oxygen but no more than 10 volume percent ethanol, the maximum oxygen content cap is 3.7 percent by weight.

The current CaRFG3 regulations identify the pounds of excess emissions that must be offset per barrel of gasoline subject to the small refiner CaRFG3 flat limits – 0.0206 pounds of exhaust hydrocarbons per barrel, 0.0322 pounds of NO_x per barrel, and the potency-weighted toxic emissions equivalent of 0.0105 pounds of benzene per barrel.

B. Proposed Small Refiner Mechanism to Offset Emissions Increases

The staff is proposing modifications to the small refiner provisions of the diesel fuel regulations to ensure that a small refiner utilizing the small refiner provision of the CaRFG3 regulations will fully offset the emissions increase.

Small refiners are now allowed to produce diesel fuel meeting a 20 volume percent aromatic hydrocarbon content limit, while large refiners are required to meet a 10 volume percent aromatic hydrocarbon content standard. Both large and small refiners can certify alternative diesel formulations that are shown to be equivalent to their respective standards. Small refiners are also restricted to an annual volume cap on the total quantity of diesel fuel they can supply subject to the small refiner standard. Small refiners can increase their diesel production by complying with the large refiner 10 percent aromatic hydrocarbon content provisions.

The staff is proposing several options for small refiners to use in offsetting the small refiner CaRFG3 emissions. First, a small refiner can reduce its diesel fuel exempt volume cap to provide the needed offsets. Second, the small refiner can produce a “cleaner” small refiner diesel fuel. Third, the small refiner can increase their exempt volume by producing an even “cleaner” small refiner diesel fuel that will result in no net increase in emissions from gasoline or diesel fuel produced by them if they also forego their right to market high sulfur diesel fuel in California. Under each of the options, the small refiner would also have to make available up to 100 barrels per day of diesel fuel having a sulfur content not exceeding 30 ppm and an aromatic hydrocarbon content not exceeding 20 percent, to the extent there are buyers wishing to acquire that diesel fuel on commercially reasonable terms. None of the proposed options would prevent the small refiner from producing as much “large refiner” diesel as it chooses.

The staff is proposing several options to provide flexibility in meeting the regulations. Also, refinery operations are likely to change in the future and the regulations could become unnecessarily restrictive if only one option is provided.

Kern Oil and Refining Co. (Kern) is the only small refiner that qualifies for the CaRFG3 small refiner provisions at this time, because is the only small refiner that produced California gasoline subject to the CaRFG2 standards in 1998 and 1999. The exempt volume cap for Kern is currently 6,405 barrels per day for small refiner diesel fuel.

Under option one, Kern could reduce its small refiner exempt volume cap from 6405 bpd to 2,263 bpd, and sell or supply 100 bpd of diesel fuel with a sulfur content not exceeding 30 ppm. This would reduce the total amount of small refiner diesel sold in California.

With option two, Kern could keep its small refiner exempt volume cap at 6405 bpd and provide the offsets by reducing the aromatic hydrocarbon content of its small refiner diesel alternative formulation by 2 volume percent and increasing the cetane number by 0.7. Any small refiner diesel fuel it sells or supplies which is not designated as a certified alternative formulation must have an aromatic hydrocarbon content not exceeding 18 weight percent. Also, Kern would be required to sell or supply 100 bpd of diesel fuel with a sulfur content not exceeding 30 ppm.

With option three, Kern could give up the small refiner diesel exempt volume entirely in exchange for an exempt volume of a "cleaner" small refiner diesel fuel that is 125% higher than the current 6,405 bpd limit on the condition that they no longer market, in California, diesel fuel that does not meet the California motor vehicle diesel fuel requirements. For Kern, its exempt volume would be capped at 8,006 barrels per day and would be required to meet the following conditions:

- ◆ A reduced aromatic hydrocarbon content of 3.5 volume percent, a 0.5 number increase in cetane and an increase in additive of .02 percent for diesel fuel meeting a small refiner certified alternative diesel fuel formulation, or
- ◆ An aromatic hydrocarbon content not greater than 14 volume percent for small refiner diesel
- ◆ sell or supply 100 bpd of diesel fuel with a sulfur content not exceeding 30 ppm.

The staff calculations for Kern's situation are presented in Appendix F and demonstrate that either of the three options offset the emissions increase associated with the production of small refiner CaRFG3 and any increased emissions from increasing the diesel fuel exempt volume.

With any of these approaches, it is assumed that if the small refiner does not produce the maximum amount of small refiner diesel fuel extra emissions benefits would be gained because their small refiner diesel would be replaced by cleaner large refiner diesel fuel.

VI. Other Proposed Amendments

Staff is proposing several additional amendments to make the regulations work more effectively, provide additional flexibilities where feasible, and correct errors.

A. Reproducibility of RVP Test Method Using Automated Instruments

Until adoption of the Phase 1 CaRFG (CaRFG1) regulations, the sole test method designated for determining compliance with the ARB's standards for the RVP of gasoline was ASTM D 323-58, which had a stated reproducibility of 0.3 psi. The reproducibility of a particular test method represents the maximum difference between two single and independent test results obtained by different operators working in different laboratories on identical material that one would expect to occur in no more than in one case in twenty. When conducting tests to determine whether gasoline complies with an ARB standard, the Compliance Division only takes enforcement action when its test shows the gasoline exceeds the applicable standard plus the reproducibility. Thus, where the RVP standard is 7.00 psi and the test method reproducibility is 0.3 psi, the Compliance Division will only pursue a violation where the ARB's test results show an RVP exceeding 7.30 psi (staff also routinely notifies parties of test results exceeding the standard but within the range of reproducibility, in order for the party to consider corrective actions in the future).

As part of the CaRFG1 rulemaking in 1990 – and at the request of industry – the ARB adopted an alternative method for measuring RVP, in order to accommodate testing with automated instruments. The test method was named the ARB's "Test Method for the Determination of the Reid Vapor Pressure Equivalent Using an Automated Pressure Testing Instrument," and was adopted as section 2297, title 13, CCR. The ARB method was based on ASTM Emergency Standard 15. The method identifies calibration equations for three different automated instruments: (1) Grabner Instruments Model CCA-VP (the laboratory Grabner), (2) Grabner Instruments Model CCA-VPS (the portable Grabner), and (3) the Stanhope-Seta Setavap model. In a round-robin testing process involving various laboratories including the ARB's and those of WSPA members, the ARB staff identified the following reproducibilities for the three instruments: 0.13 psi for the laboratory Grabner, 0.21 psi for the portable Grabner, and 0.32 psi for the Setavap. However, because ASTM D323-58 was still the regulatory base method, the Board adopted staff's recommendation for the regulation to state that, for compliance purposes, the reproducibility for all automated instruments would be treated as 0.3 psi. Attachment G contains the staff's 1990 report on the ARB test method using automated instruments, including the analysis supporting the instrument-specific reproducibilities identified above.

Since the early 1990's, Compliance Division inspectors have used the portable Grabner instrument for all RVP testing, with excellent results. The staff has issued advisories to

the industry, announcing the instrument being used for testing each regulated gasoline property. Refiners and others have almost always used an automated instrument to analyze for RVP, achieving reproducibilities significantly better than is stated in the regulation. Staff is accordingly proposing that the RVP test method regulation be amended to eliminate the blanket 0.3 psi reproducibility value that had been based on the original D 323-58 method. Instead, the regulation would specify that, for each of the three instruments with assigned calibration equations, the reproducibility value will be the value identified in the staff's 1990 round-robin analysis and set forth in the preceding paragraph. Similarly, the lower repeatability values for the three instruments identified in the 1990 round-robin analysis would substitute for the regulation's current 0.20 psi repeatability value derived from the ASTM D323-58 test method.

After this amendment becomes effective, the ARB plans to continue testing with the portable Grabner instrument, and to apply the proposed 0.21 psi reproducibility value in taking enforcement action. This will enhance the ARB's RVP enforcement program at the same time that the RVP cap limit is being raised to 7.2 psi to accommodate the evaporative model for the CaRFG3 standards. The amendment will not reduce refiner flexibility because refiners are already conducting their own RVP tests with the automated instruments having better reproducibilities than has been stated in the test method regulation.

B. Other Changes

Exemption For Gasoline Used In Racing Vehicles. A proposed amendment to section 2261(f) corrects an oversight in the provision that exempts gasoline used only in racing vehicles from the ARB's gasoline regulations. This provision has reflected the ARB's longstanding interpretation that, since racing vehicles are exempted by Health and Safety Code section 43001(a) from the vehicular air pollution control statutes, fuel used in racing vehicles is exempt from the ARB's motor vehicle fuels regulations. The amendment adds the detergent additives regulation to the others covered by the exemption.

Winter Oxygenates Requirements At Low-Throughput Stations. Staff proposes an amendment to section 2262.5(e)(2), which authorizes a defense to the wintertime oxygenates requirements at the beginning of the winter season for low-throughput stations that have not received a gasoline delivery to a particular tank since 14 or more days before start of the season. The amendment would correct a misalignment of this provision with the elimination of October from the South Coast oxygenates season starting in 2003.

Test Method For Determining Oxygen, Ethanol And MTBE Content. The staff is proposing nonsubstantive amendments to sections 2263(b), 2273(b)(1) and 2273(d)(1) that will result in having the same test method version identified in all references to determining oxygen, MTBE and ethanol content. Each reference currently identifies the basic ASTM D4815 method, the Standard Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C1 to C4 Alcohols in Gasoline by Gas

Chromatography. However, while the method for determining oxygen content is identified as ASTM D4815-94, the method for determining MTBE and ethanol is identified as ASTM D4815-94a. The amendments would substitute uniform references to ASTM D4815-99, the most recent version of the method. This change would simply keep the test method designations current, and would eliminate the potentially confusing references to two different methods. The only differences between the three version of the method are editorial, so this change will have no substantive effect.

Protocol For Multiple Averaging Banks At Refinery Or Import Facility. A proposed amendment to section 2264(c) would allow a producer or importer to enter into a protocol with the Executive Officer allowing up to three separate averaging banks at a single production or import facility, applicable to operationally distinct products such as different grades of gasoline or oxygenated and unoxxygenated. The averaging provisions currently require that the shipment of any "debit" batch of gasoline at the facility be offset by the shipment from the same facility of sufficient "credit" batches within specified time periods, and this has not permitted a protocol allowing multiple averaging banks to apply to a single facility. At least one refiner has indicated that the ability to have two or three simultaneous averaging banks at a facility for distinct products would provide additional useful flexibility. The Compliance Division has already entered into protocols that allow all shipments of one grade of gasoline to be subject to a particular set of Predictive Model flat limits while shipments of a different grade are subject to a different set of Predictive Model flat limits. As long as the different averaging banks are applied to clearly distinct product streams, compliance determinations for two or three banks should still be manageable. The offset requirements would apply independently to each bank. Once averaging is selected for a particular product, the refiner could change to a different compliance option only if all of the preexisting requirements for such a change were met for that product.

Staff proposes amendments to sections 2266.5(c)(2) and 2270(a)(3) regarding an importer's obligation to sample and test gasoline it has imported. Just as the flat and averaging CaRFG limits apply to each "final blend" that is supplied from a refinery, those limits also apply to each final blend that is supplied from the import facility. Regulatory requirements for sampling and testing each imported shipment would accordingly be amended so that they apply to each final blend of gasoline or CARBOB the importer has imported, rather than each shipment. This will make the batch that is sampled identical to the batch that is subject to the regulations.

Gasoline Sampling Procedures. An amendment is also proposed for the tap sampling element of the motor fuel sampling procedures in section 2296, which is ambiguous on the need for a cooling bath as part of the tap sampling. The amendment would insert a note which had been in the ASTM procedure from which the ARB's sampling procedure was derived. The note indicates that a cooling bath is to be used only if the RVP is over 16 psi.

VII. Economic Effects of the Proposed Amendments to the CaRFG3 Regulations

This chapter presents a summary of the staff analysis regarding the economic effects of the staff's proposal. Overall, the proposed changes to the CaRFG3 regulations are designed to provide clarity and enhance the flexibility of the current regulations. The staff does not anticipate there should be any adverse economic effect associated with the staff proposal.

A. Background

The primary issues that are to be addressed by this proposed rulemaking include amendments to accommodate the blending of ethanol in CaRFG3, new regulations to assure consistent quality of fuel grade ethanol, proposed changes to the diesel fuel regulations to offset the emissions from the small refiner provisions specified for CaRFG3, and amendments that specify how refiners are to transition from distributing gasoline produced for one ethanol content to a different ethanol content. Some other changes include lowering the enforcement reproducibility of the RVP test method when specified automatic instruments are used.

B. CARBOB Model

The CARBOB model will increase the flexibility for refiners to produce complying CaRFG3 gasoline. The CARBOB model will allow refiners to certify CARBOB blends without having to hand blend ethanol into the CARBOB and then send the sample to a laboratory to determine if the resulting blend is a complying fuel. This will decrease the time for a refiner to produce and ship CARBOB gasoline from the refinery. This increase in flexibility should not result in a negative economic impact.

C. Provisions to Switch from One CARBOB to Another or to a Non-oxygenated CaRFG

The current regulations impose restrictions on how one CARBOB and another may be combined downstream from the production or import facility. Downstream of a refinery, a CARBOB can only be commingled with other CARBOB that has been designed to have the same type and amount of oxygenate added. Once the CARBOB has been oxygenated and converted to CaRFG, there are no restrictions on blending it with other CaRFG, as long as the blend continues to comply with the cap limits. These restrictions

limit the ability of gasoline distribution system proprietors to change the type of fuel in a storage tank.

The CARBOB tank transition provisions are intended to provide a mechanism for gasoline distribution system proprietors to transition their gasoline storage tanks from CARBOB blends requiring one level of ethanol to a different level of ethanol without having to pump the storage container dry prior to the introduction of a different CARBOB. These transitions include going from CARBOB to complying gasoline, and from complying gasoline to CARBOB, outside of the RVP season. Having to empty a storage container to comply with current regulations is time-consuming and expensive. Therefore, the staff's proposal would result in an increase in flexibility and potential cost savings and not result in a negative economic impact.

D. Denatured Ethanol Specifications

The proposed denatured ethanol specifications will help ensure that when ethanol is blended with CARBOB at a gasoline terminal, the ethanol does not contribute to an exceedance of the applicable CaRFG3 limits for sulfur, benzene, aromatic, and olefin content. Suppliers will be able to specify alternative denatured ethanol specifications, most likely for use in proprietary systems. With the phase-out of MTBE from California gasoline, it is expected that by 2003, California would consume about one third of the existing United States ethanol production. Based on the results of the RFA survey, currently over half of all producers responding to their survey produce denatured ethanol that meets the proposed specification, and with careful selection of the denaturant, a significant portion of the remaining producers would be able to meet the proposed specifications for denatured ethanol.

For those few producers that currently do not meet the proposed specifications, they could use a denaturant with a lower sulfur content than they currently use. Given the small amount of denaturant that is added to ethanol, relatively small increases in the cost of the denaturant should have small impacts on the cost of the denatured ethanol. For example, an ethanol producer who wishes to meet the California specifications for denatured ethanol may need to purchase a denaturant that costs 10 cents per gallon more than its previous purchase price. At the ASTM upper limits of 4.8 percent volume denaturant, the added cost is less than a half cent per gallon (0.48 cent per gallon) of denatured ethanol. At the Bureau of Alcohol, Tobacco and Firearms lower limit for denaturant volume of 2 percent, the added cost is only 0.2 cents per gallon. This is significantly less than the expected transportation cost of about 10 to 15 cents per gallon when shipping ethanol to California. Therefore, the staff's proposal for denatured ethanol specifications should not have a significant negative economic impact.

E. Small Refiner Provisions

In Resolution 99-29, the ARB found that the cost of compliance with the CaRFG3 standards for small refiners now producing CaRFG2, and the additional capital expenditures to enable them to meet the CaRFG3 standards, would be substantially

greater on a per-gallon basis than the comparable cost for large California refiners. Given the disparate costs and preexisting investments made to comply with the CaRFG2 standards, the ARB approved a set of alternative CaRFG3 flat limits for small refiners. The staff's proposal would put into place a mechanism for qualifying small refiners to fully mitigate any emissions increase associated with the small refiner CaRFG3 standards, and as such, are not expected to have a significant negative economic impact.

F. Other Changes

The staff's proposal to lower the enforcement reproducibility for the RVP test method when specified automated instruments are used should not result in a significant adverse economic method. Most if not all refiners are already using the same sorts of automated instruments as are used by ARB inspectors, and are presumably not supplying gasoline for which test results exceed the RVP standard, even if within the range of reproducibility.

G. Economic Effects on Small Business

Government Code section 11346.2(b)(4)(B) requires the ARB to describe any alternatives it has identified that would lessen any adverse impact on small business. In defining small business, Government Code section 11342(h) explicitly excludes refiners from the definition. Also, the definition includes only businesses that are independently owned and, if in retail trade, gross less than \$2,000,000 per year.

The staff's proposed amendments to the CaRFG3 regulations are designed to assure the practical and effective implementation of the provisions on CARBOB and to provide a mechanism for small refiners to fully mitigate any increased emissions associated with the CaRFG3 small refiner provisions. These provisions are expected to increase the flexibility for refiners and gasoline distribution system proprietors to remove MTBE from California gasoline.

The current regulations prohibit the mixing of CARBOB designed for one level of ethanol with a CARBOB designed for another level of ethanol. This could be a significant burden to the smaller gasoline marketers and fuel distribution system proprietors. The staff proposal is designed to increase the flexibility for gasoline marketers and distribution system proprietors to make transitions from a CARBOB designed for one level of ethanol to a CARBOB designed for another level of ethanol. The staff proposal also includes provisions for transitioning between a complying CaRFG3 gasoline with ethanol and a non-oxygenated gasoline. These amendments are designed to provide clarity and enhance the flexibility of the current regulations, and as such, should not have a negative economic impact.

The remaining provisions are clean-up changes, clarifications, and small technical modifications to the current regulations. Therefore, the staff does not anticipate there should be any significant additional adverse economic effect upon small businesses associated with the staff proposal.

VIII. Environmental Effects of the Proposed Amendments to the CaRFG3 Regulations

This chapter presents a summary of the results of the analysis of the environmental effects of the staff's proposal.

A. Background on the Staff's Proposal and Existing Environmental Requirements

The staff's proposal will amend the CaRFG3 regulations to provide greater flexibility and guidance for refiners to produce and distribute gasoline meeting the CaRFG3 regulations without the use of MTBE. The changes include conditions that could allow CARBOBs intended for different oxygen contents to be mixed without increasing emissions. These proposed amendments are consistent with the Board's intent when the CaRFG3 Regulations were approved in December 1999. The proposed amendments do not effect the requirements specified in Senate Bill (SB) 989 or SB 529, nor do they present any issues that were not anticipated during the review by the Environmental Policy Council.

SB 989. Senate Bill 989 (Sher) was signed by the Governor on October 10, 1999. This legislation requires that the ARB ensure that the CaRFG3 regulations maintain or improve upon emissions and air quality benefits achieved by CaRFG2 as of January 1, 1999, and to provide additional flexibility to reduce or remove oxygen from motor vehicle fuel.

SB 529. Senate Bill 529 (Bowen) also was signed by the Governor on October 10, 1999. It established a mechanism for conducting environmental assessments of revisions to the ARB's CaRFG standards proposed before January 1, 2000, and was the mechanism used in connection with the December, 1999 CaRFG3 rulemaking.

California Environmental Policy Council Review. SB 529 also requires the California Environmental Policy Council (CEPC) to review the environmental assessments prepared on ARB's motor vehicle fuels regulations and to determine whether any significant environmental impacts would occur from regulatory amendments. Based on the CaRFG3 environmental assessments, the CEPC met on January 18, 2000, and determined that there will be not be a significant adverse environmental impact on public health or the environment, including any impact on air, water, or soil, that is likely to result from the change in gasoline that is expected to be implemented to meet the CaRFG3 regulations approved by the ARB. Further, it concluded that the CaRFG3 regulations will comply with all of the requirements of SB 989 and SB 529.

Below is additional discussion of potential individual environmental media effects regarding the staff's proposal and the modifications to the CaRFG3 regulations.

B. Effects on Water Quality

The staff's proposal would not change any of the CaRFG2 or CaRFG3 standards, and would not create changes to the CaRFG3 regulations that would have environmental impacts on water quality.

C. Effects on Air Quality

The staff's proposal is designed to facilitate the transition to and production of CaRFG3 without affecting emissions. This proposal includes amendments to the CaRFG3 regulations to assure the practical and effective implementation of the provisions on CARBOB, including tank transitions from one ethanol content to another and a CARBOB model. This proposal also includes a mechanism for small refiners to fully mitigate any increased emissions associated with the CaRFG3 small refiner provisions. The staff proposal also includes other technical changes that do not materially effect emissions. As such, these provisions are not expected to result in any increase in emissions. The staff's proposal would not create a change to the intent of the CaRFG3 regulations when approved in 1999 and would have no effect regarding environmental impacts on air quality.

Use of CARBOB Model and Air Quality Impacts. The CARBOB model will increase the flexibility for refiners to produce CARBOB blends and complying CaRFG3 gasoline. The staff's proposal and modifications to the CaRFG3 regulations will have no net effect on emissions as refiners will still be required to meet the CaRFG3 specifications either by complying with specified CaRFG3 flat or averaging limits or through the use of the ARB Predictive Model. Therefore, the staff's proposal and additional regulatory flexibility provided in the CaRFG3 regulations will not have a negative effect on air quality.

Denatured Ethanol Specifications and Air Quality Impacts. The staff's proposal for specifications for fuel grade denatured ethanol would provide greater predictability for refiners, oxygen blenders, and gasoline distribution system proprietors. The increased flexibility and predictability for the blending of ethanol would not have a negative environmental impact.

Small Refiner Provisions and Air Quality Impacts. The staff's proposal would put into place a mechanism for small refiners to fully mitigate any emissions increase associated with the use of complying CaRFG3 made to the small refiner specifications, and as such, are not expected to have a negative environmental impact.

Tank Transition Provisions and Air Quality Impacts. The tank transition provisions are intended to provide a mechanism for gasoline distribution system proprietors to transition their gasoline storage tanks from CARBOB blends requiring one level of ethanol to a different level of ethanol without having pump all storage tanks dry prior to the introduction of a different CARBOB. These transitions include transitioning from CARBOB to non-oxygenated gasoline and from non-oxygenated gasoline to CARBOB

blends outside the RVP season. The intent of staff's proposal is to increase flexibility when transitions to different ethanol contents are needed without resulting in any increases in air emissions or other negative environmental impact.

D. Effects of the Staff's Proposal on Greenhouse Gas (GHG) Emissions

The staff's proposal is not expected to increase emissions of greenhouse gases that may contribute to global warming and do not effect the original finding that there is essentially no difference in GHG emissions between reformulated gasoline produced with MTBE versus gasoline blended with corn-derived ethanol.

E. Effects of Proposed CaRFG3 Regulations on Allowable Emissions

The proposed amendments to the CaRFG3 regulations will maintain the emissions benefits gained in the existing CaRFG2 program as required by SB 989 and the Governor's Executive D-5-99. Therefore, there should be no increase in allowable emissions associated with the staff's proposal to amend the CaRFG3 regulations.

APPENDICES

Appendix A – Proposed Regulation Order -- Follow-up Amendments to the CaRFG3 Regulations

Appendix B – Procedures for Using the California Model for California Reformulated Gasoline Blendstocks for Oxygenate Blending (CARBOB)

Appendix C – Denatured Ethanol

Appendix D – Development of the CARBOB Model

Appendix E -- Effect of Transitions to Different Ethanol Contents

Appendix F -- Small Refiner Emissions Offsets

Appendix G -- RVP Test Method and Reproducibility

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Appendix A

Proposed Regulation Order
Follow-up Amendments to the CaRFG3 Regulations

PROPOSED REGULATION ORDER

FOLLOW-UP AMENDMENTS TO THE

CALIFORNIA PHASE 3 REFORMULATED GASOLINE REGULATIONS

Add section 2260(a)(6.7), title 13, California Code of Regulations, to read as follows:

Section 2260. Definitions.

* * * *

(a) (6.7) “CARBOB alternative specifications” means, for a final blend of CARBOB, CARBOB specifications that identify all of the properties identified in a set of PM alternative specifications, expressed at the same level of precision.

* * * *

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend section 2261(f) to read as follows:

Section 2261. Applicability of Standards; Additional Standards.

* * * *

(f) This subarticle 2, section 2253.4 (Lead/Phosphorus in Gasoline), and section 2254 (Manganese Additive Content), and section 2257 (Required Additives in Gasoline) shall not apply to gasoline where the person selling, offering or supplying the gasoline demonstrates as an affirmative defense that the person has taken reasonably prudent precautions to assure that the gasoline is used only in racing vehicles.

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, 43101, and 43830.8, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend the title of section 2262.3, title 13, California Code of Regulations as follows:

Section 2262.3 Compliance With the CaRFG Phase 2 and CaRFG Phase 3 Standards for Sulfur, Benzene, Aromatic Hydrocarbons, Olefins, T50, and T90 and DI.

* * * *

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, 43101, and 43830.8, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend section 2262.5(e)(2), title 13, California Code of Regulations as follows:

Section 2262.5. Compliance With the Standards for Oxygen Content.

(a) *Compliance with the minimum oxygen content cap limit standard in specified areas in the wintertime.*

(1) Within the areas and periods set forth in section (a)(2), no person shall sell, offer for sale, supply, offer for supply, or transport California gasoline unless it has an oxygen content of not less than the minimum oxygen content cap limit in section 2262.

(2) (A) *November 1 through February 29 (of any year) and October 1 through October 31 (in 1996 through 2002):*

South Coast Area

(B) *October 1, 1998 through January 31, 1999 and October 1, 1999 through January 31, 2000:*

Fresno County
Madera County

(C) *October 1, 1998 through January 31, 1999:*

Lake Tahoe Air Basin

(D) *November 1 through February 29 (of any year):*

Imperial County

* * * *

(e) *Application of prohibitions.*

- (1) Section (a) shall not apply to a transaction occurring in the areas and periods shown in (a)(2) where the person selling, supplying, or offering the gasoline demonstrates as an affirmative defense that, prior to the transaction, he or she has taken reasonably prudent precautions to assure that the gasoline will not be delivered to a retail service station or bulk purchaser-consumer's fueling facility in the areas and periods shown in (a)(2).
- (2) (A) Section (a) shall not apply to a transaction occurring in the South Coast Air Basin in October 2000, 2001, or 2002, where the transaction involves the transfer of gasoline from a stationary storage tank to a motor vehicle fuel tank and the person selling, supplying, or offering the gasoline demonstrates as an affirmative defense that the last delivery of gasoline to the stationary storage tank occurred no later than September 16 of that year.
- (B) Section (a) shall not apply to a transaction occurring in an area shown in (a)(2) in November either in Imperial County or, starting in 2003, in the South Coast Control Area, where the transaction involves the transfer of gasoline from a stationary storage tank to a motor vehicle fuel tank and the person selling, supplying, or offering the gasoline demonstrates as an affirmative defense that the last delivery of gasoline to the stationary storage tank occurred no later than October 17 of that year.

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, 43101, and 43830.8, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Add section 2262.9, title 13, California Code of Regulations, to read as follows:

Section 2262.9. Requirements Regarding Denatured Ethanol Intended For Use as an Additive in California Gasoline

(a) Standards.

- (1) Standards for denatured ethanol.** Starting December 31, 2002, no person shall sell, offer for sale, supply or offer for supply denatured ethanol intended for blending with CARBOB or California gasoline fails to comply with the following standards:

(A) Standards for properties regulated by the CaREG Phase 3 standards.

- 1. A sulfur content not exceeding 10 parts per million;**
- 2. A benzene content not exceeding 0.06 percent by volume; or**

3. An olefin content not exceeding 0.5 percent by volume; or
4. An aromatic hydrocarbon content not exceeding 1.7 percent by volume.

(B) Standards based on ASTM D 4806-98.

<i>Specification</i>	<i>Value</i>	<i>Test method</i>
Ethanol, vol.%, min.	92.1	ASTM D 5501
Methanol, vol.%, max.	0.5	
Solvent-washed gum, mg/100 ml, max.	5.0	ASTM D 381, air jet apparatus
Water content, vol.%, max.	1	ASTM E 203 or E 1064
Denaturant content, vol.%, min; vol.% max. (Note 1)	1.96 4.76	
Inorganic Chloride content, mass ppm (mg/l), max.	40 (32)	Modification of ASTM D512, Procedure C (Note 2)
Copper content, mg/kg, max.	0.1	Modification of ASTM D1688, Procedure D (Note 3)
Acidity (as acetic acid), mass % (mg/l), max.	0.007 (56)	ASTM D 1613
Appearance	Visibly free of suspended or precipitated contaminants (clean and bright)	Determined at indoor ambient temperature unless otherwise agreed upon between the supplier and purchaser

Note 1: The only denaturants used shall be natural gasoline, gasoline components, or unleaded gasoline at a minimum concentration of two parts by volume per 100 parts by volume of fuel ethanol, as defined by Formula CDA 20 of the Bureau of Alcohol, Tobacco, and Firearms (BATE) of the U.S. Treasury Department.

Note 2: The modification of ASTM D 512, Procedure C consists of using 5 ml of sample diluted with 20 ml of water in place of the 25 ml sample specified in the standard procedure. The water shall meet ASTM D 1193, Type II. The volume of the sample prepared by this modification will be slightly larger than 25 ml. to allow for the dilution factor, report the chloride ion present in the fuel ethanol sample as the chloride ion present in the diluted sample multiplied by five.

Note 3: The modification of ASTM D 1688, Procedures D (atomic absorption) consists of mixing reagent grade ethanol (which may be denatured according to the BATE Formula 3A or 30) in place of reagents and standard solutions. However, this must not be done to prepare the stock copper solution described in 38.1 of ASTM D 1688.

Because a violent reaction may occur between the acid and the ethanol, use water, as specified, in the acid solution part of the procedure to prepare the stock copper solution. Use ethanol for the rinse and dilution only.

(2) Standards for products represented as appropriate for use as a denaturant in ethanol. Starting December 31, 2002, no person shall sell, offer for sale, supply or offer for supply a product represented as appropriate for use as a denaturant in ethanol intended for blending with CARBOB or California gasoline, if the denaturant has:

(A) A benzene content exceeding 1.1 percent by volume; or

(B) An olefins content exceeding 10 percent by volume; or

(C) An aromatic hydrocarbon content exceeding 35 percent by volume;

(b) Test Methods. In determining compliance with the standards in this section,

(1) The sulfur content of denatured ethanol shall be determined by ASTM D 5453-93.

(2) The aromatic hydrocarbon, benzene and olefins content of denatured ethanol shall be determined by sampling the denaturant and using the methods specified in section 2263 to determine the content of those compounds in the denaturant, and then multiplying the result by 0.048.

(3) The sulfur, aromatic hydrocarbon, benzene and olefins content of the denaturant shall be determined by the methods specified in section 2263 for determining the content of those compounds in gasoline.

(c) Documentation required for the transfer of denatured ethanol intended for use as an additive in California gasoline.

(1) On each occasion when any person transfers custody or title of denatured ethanol intended for use as an additive in California gasoline, the transferor shall provide the transferee a document that prominently states that the denatured ethanol complies with the standards for denatured ethanol intended for use as an additive in California gasoline.

(2) Any person who sells or supplies denatured ethanol intended for use as an additive in California gasoline from the California facility at which it was imported or produced, or who produces it in California, shall provide the purchaser or recipient a document that identifies:

(A) The name and address of the person selling or supplying the denatured ethanol;

(B) The name and location of the facility(ies) at which the ethanol was produced and at which the denaturant was added to the ethanol; and

(C) The name and address of the person(s) who produced the ethanol and who added the denaturant to the ethanol.

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, 43101, and 43830.8, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend section 2263(b), title 13, California Code of Regulations, to read as follows:

Section 2263. Sampling Procedures and Test Methods

- (a) ***Sampling Procedures.*** In determining compliance with the standards set forth in this subarticle 2, an applicable sampling methodology set forth in 13 C.C.R. section 2296 shall be used.
- (b) ***Test Methods.***
- (1) In determining compliance with the standards set forth in this subarticle 2, the test methods presented in Table 1 shall be used. All identified test methods are incorporated herein by reference.

Table 1

<i>Section-</i>	<i>Gasoline Specification</i>	<i>Test Method</i> ^a
2262	Reid Vapor Pressure	ASTM D 323-58 ^b or 13 C.C.R. Section 2297
2262	Sulfur Content	ASTM D 2622-94 ^{c,d} or ASTM D 5453-93
2262	Benzene Content	ASTM D 5580-95 ^e
2262	Olefin Content	ASTM D 1319-95a ^f
2262	Oxygen Content	ASTM D 4815-94a99
2262	T90 and T50	ASTM D 86-90
2262	Aromatic Hydrocarbon Content	ASTM D 5580-95 ^g
2262.5(b)	Ethanol Content	ASTM D 4815-94a99
2262.6	MTBE Content	ASTM D 4815-94a99

* * * *

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

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

Section 2264. Designated Alternative Limits.

(a) Assignment of a designated alternative limit.

- (1) A producer or importer that has elected to be subject to an averaging limit specified in section 2262 may assign a designated alternative limit to a final blend of California gasoline produced or imported by the producer or importer by satisfying the notification requirements in this section (a). In no case shall a designated alternative limit be less than the sulfur, benzene, olefin or aromatic hydrocarbon content, or T90 or T50, of the

final blend shown by the sample and test conducted pursuant to section 2270, or section 2266.5(a), as applicable. If a producer or importer intends to assign designated alternative limits for more than one gasoline specification to a given quantity of gasoline, the party shall identify the same final blend for all designated alternative limits for the gasoline.

- (2) (A) The producer or importer shall notify the executive officer of the estimated volume (in gallons), the designated alternative limit, the blend identity, and the location of each final blend receiving a designated alternative limit. This notification shall be received by the executive officer before the start of physical transfer of the gasoline from the production or import facility, and in no case less than 12 hours before the producer or importer either completes physical transfer or commingles the final blend. A producer or importer may revise the reported estimated volume, as long as notification of the revised volume is received by the executive officer no later than 48 hours after completion of the physical transfer of the final blend from the production or import facility. If notification of the revised volume is not timely received by the executive officer, the reported estimated volume shall be deemed the reported actual volume.
- (B) For each final blend receiving a designated alternative limit exceeding an applicable averaging limit in section 2262, the producer or importer shall notify the executive officer of the date and time of the start of physical transfer from the production or import facility, within 24 hours after the start of such physical transfer. For each final blend receiving a designated alternative limit less than an applicable averaging limit in section 2262, the producer or importer shall notify the executive officer of the date and time of the completion of physical transfer from the production or import facility, within 24 hours after the completion of such physical transfer.
- (3) If, through no intentional or negligent conduct, a producer or importer cannot report within the time period specified in (a)(2) above, the producer or importer may notify the executive officer of the required data as soon as reasonably possible and may provide a written explanation of the cause of the delay in reporting. If, based on the written explanation and the surrounding circumstances, the executive officer determines that the conditions of this section (a)(3) have been met, timely notification shall be deemed to have occurred.
- (4) The executive officer may enter into a written protocol with any individual producer or importer for the purposes of specifying how the requirements in sections (a)(2) and (c) through (i) shall be applied to the producer's or importer's particular operations, as long as the executive officer reasonably determines that application of the regulatory requirements under the protocol is not less stringent or enforceable than application of the express terms of sections (a)(2) and (c) through (i). Any such protocol shall include the producer's or importer's agreement to be bound by the terms of the protocol.

- (5) Whenever the final blend of a producer or importer includes volumes of gasoline the party has produced or imported and volumes the party has neither produced nor imported, the producer's or importer's designated alternative limit shall be assigned and applied only to the volume of gasoline the party has produced or imported. In such a case, the producer or importer shall report to the executive officer in accordance with section (a) both the volume of gasoline produced and imported by the party, and the total volume of the final blend. The party shall also additionally report the sulfur content, benzene content, olefin content, aromatic hydrocarbon content, T90, and T50, as applicable, of the portion of the final blend neither produced nor imported by the party, determined as set forth in section 2270(b), or section 2266.5(a)(2), as applicable.
- (b) ***Additional prohibitions regarding gasoline to which a designated alternative limit has been assigned.***
- (1) No producer or importer shall sell, offer for sale, or supply California gasoline in a final blend to which the producer or importer has assigned a designated alternative limit exceeding an applicable averaging limit in section 2262, where the total volume of the final blend sold, offered for sale, or supplied exceeds the volume reported to the executive officer pursuant to section (a).
- (2) No producer or importer shall sell, offer for sale or supply California gasoline in a final blend to which the producer or importer has assigned a designated alternative limit less than an applicable averaging limit in section 2262, where the total volume of the final blend sold, offered for sale, or supplied is less than the volume reported to the executive officer pursuant to section (a).
- (c) ***Offsetting exceedances of an applicable averaging limit.***
- (1) With respect to each property for which a producer or importer has elected to be subject to the averaging limit in section 2262, within 90 days before or after the start of physical transfer from a production or import facility of any final blend of California gasoline to which a producer has assigned a designated alternative limit for the property exceeding the applicable averaging limit in section 2262, the producer or importer shall complete physical transfer from the same production or import facility of California gasoline in sufficient quantity and with a designated alternative limit sufficiently below the applicable averaging limit in section 2262 to fully offset the extent to which the gasoline exceeded the applicable averaging limit in section 2262. In the case of benzene, olefins, or aromatic hydrocarbons, the total volume of benzene, olefins, or aromatic hydrocarbons in excess of the averaging limit must be offset within the specified time period; the mass of sulfur and the degree gallons of T50 and T90 in excess of the averaging limit must be similarly offset.

For example, within 90 days before or after the start of physical transfer from a production or import facility of any final blend of California gasoline to which a producer

has assigned a designated alternative limit for olefin content exceeding 4.0 percent by volume, the producer or importer shall complete physical transfer from the same production or import facility of California gasoline in sufficient quantity and with a designated alternative limit sufficiently below 4.0 percent by volume to offset the volume of olefins in excess of a limit of 4.0 percent by volume.

(2) A producer or importer may enter into a protocol with the Executive Officer under which the producer or importer is allowed to have up to three separate averaging banks at a single production or import facility, applicable to operationally distinct products (e.g. different grades of gasoline or oxygenated and nonoxygenated). The offset requirements will apply independently for each separate averaging bank. Once averaging is selected for a particular product, the compliance scheme for that product may only be changed if the change meets the applicable criteria and conditions in sections 2264.2 and 2265(c) with respect to that product. The protocol shall specify how the requirements in section (a)(2) and (c)(1) will be applied to the producer's or importer's particular operations and the separate averaging banks. In order to enter into the protocol, the Executive Officer must determine that application of the requirements under the protocol will not be less stringent or enforceable than application of the express terms of sections (a)(2) and (c). Any such protocol shall include the producer's or importer's agreement to be bound by the terms of the protocol.

(d) ***Designated alternative limits for PM alternative gasoline formulations.*** The producer or importer of a final blend of California gasoline that is subject to the PM averaging compliance option for one or more properties may assign a designated alternative limit to the final blend by satisfying the notification requirements of section 2264(a). The producer or importer of such a final blend shall be subject to all of the provisions of this section 2264, except that, with respect to that final blend, the PM averaging limit (if any) for each property subject to the PM averaging compliance option shall replace any reference in this section 2264 to the averaging limit specified in section 2262.

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend section 2266.5, title 13, California Code of Regulations to read as follows:

Section 2266.5. Requirements Pertaining to California Reformulated Gasoline Blendstock for Oxygen Blending (CARBOB) and Downstream Blending.

(a) Application of the California gasoline standards to CARBOB.

(1) **Applicability of standards and requirements to CARBOB.** All of the standards and requirements in sections 2261, 2262, 2262.3, 2262.4, 2262.5(a), (b), (c) and (e), 2262.6, 2264, 2264.2, ~~2264.4~~, 2265, 2266, 2267, 2268, 2270(b) and (c), 2271 and 2272 pertaining to California gasoline or transactions involving California gasoline also apply to CARBOB or transactions involving CARBOB. Whenever the term "California gasoline" is used in the sections identified in the preceding sentence, the term means "California gasoline or CARBOB." Whenever the term "gasoline" is used in section 2265(b)(1), the term means "California gasoline or CARBOB."

(2) **Determining whether a final blend of CARBOB complies with the standards for California gasoline.**

(A) General.

1. Where a producer or importer has designated a final blend as CARBOB and has complied with all applicable provisions of this section 2266.5, the properties of the final blend for purposes of compliance with sections 2262, 2262.3, 2262.4, 2262.5, and 2262.6, 2265 and 2266 shall be determined in accordance with section (a)(2)(B) or (a)(2)(C) as applicable. ~~by adding the specified type and amount of oxygenate to a representative sample of the CARBOB and determining the properties and characteristics of the resulting gasoline in accordance with an applicable test method identified in section 2263(b) or permitted under section 2263(c). Where the producer or importer has in accordance with section (b)(1)(C) designated a range of amounts of oxygenate, or more than one oxygenate type, to be added to the CARBOB, the minimum designated amount of the oxygenate having the smallest designated volume shall be added to the CARBOB when determining the properties and characteristics of the final blend.~~
2. If the producer or importer has not complied with any all applicable provisions of this section 2266.5, the properties of the final blend for purposes of the producer's or importer's compliance with the limits for sulfur, benzene, aromatic hydrocarbons, olefins, T50, T90, and oxygen required by sections 2262.3, and 2262.5, 2265 and 2266 shall be determined without adding oxygenate to the gasoline, and compliance with the flat limits for Reid vapor pressure and oxygenates required by sections 2262.4, 2262.6, 2265 and 2266 shall be determined in accordance with section (a)(2)(B) or (a)(2)(C) as applicable.

(B) Determining whether a final blend of CARBOB complies with the standards for California gasoline by use of the CARBOB Model.

1. A producer or importer may elect to have the CARBOB model used in determining whether a final blend designated as CARBOB complies with the standards applicable to California gasoline when it is supplied from the production facility or import facility, by providing the notice in section (b)(1)(C). In this case, the CARBOB alternative specifications for the final blend shall be determined in accordance with the "Procedures for Using the California Model for California Reformulated Blendstock for Oxygenate Blending (CARBOB)," as adopted *[Insert date of adoption]*. The final blend's compliance with the assigned CARBOB alternative specification for a property shall constitute the final blend's compliance with that property's assigned PM flat limit, designated alternative limit, or (if no designated alternative limit has been established) PM averaging limit.
2. Notwithstanding section (a)(2)(B)1., where a final blend of CARBOB is sampled and analyzed by a state board inspector in accordance with section 2263 using the methodology in (a)(2)(C), the results may be used to establish a violation of applicable standards for California gasoline.

(C) Determining whether a final blend of CARBOB complies with the standards for California gasoline by oxygenate blending and testing.

1. **Oxygenate blending and testing.** Except as otherwise provided in section (a)(2)(B), the properties of a final blend of CARBOB shall be determined for purposes of compliance with sections 2262, 2262.3, 2262.4, 2262.5, 2262.6, 2265 and 2266 by adding the specified type and amount of oxygenate to a representative sample of the CARBOB and determining the properties and characteristics of the resulting gasoline in accordance with an applicable test method identified in section 2263(b) or permitted under section 2263(c). Where the producer or importer has in accordance with section (b)(1)(C) designated a range of amounts of oxygenate, or more than one oxygenate type, to be added to the CARBOB, the minimum designated amount of the oxygenate having the smallest designated volume shall be added to the CARBOB when determining the properties and characteristics of the final blend. However, where the designated range for oxygen from ethanol is between 1.8 wt.% and 2.2 wt.% and includes 2.0 wt.%, 5.7 vol.% ethanol shall be added, and where the designated range for oxygen from ethanol is between 2.5 wt.% and 2.9 wt.% and includes 2.7 wt.%, 7.7 vol.% ethanol shall be added.

~~(B) In determining whether CARBOB complies with the standards for California gasoline, the oxygenate added must be representative of the oxygenate the producer or importer reasonably expects will be subsequently added to the final blend. Prior to~~

supplying CARBOB from a production or import facility, the producer or importer must enter into a protocol with the executive officer setting forth how the representativeness of the oxygenate will be determined:

2. Characteristics of denatured ethanol used in determining whether a final blend of CARBOB complies with the standards for California gasoline.

- a. Except as provided in section (a)(2)(C)2.b., in determining whether CARBOB complies with the standards applicable to California gasoline when it is supplied from the production facility or import facility, denatured ethanol used as the oxygenate must have the following properties:

<u>Sulfur content:</u>	<u>3 - 10 parts per million</u>
<u>Benzene content:</u>	<u>0 - 0.06 volume percent</u>
<u>Olefin content:</u>	<u>0 - 0.05 volume percent</u>
<u>Aromatic hydrocarbon content:</u>	<u>0 - 1.70 volume percent</u>

- b. A producer or importer may elect to specify the properties of the oxygenate used in determining whether a final blend of CARBOB complies with the standards applicable to California gasoline when it is supplied from the production facility or import facility, by providing the notice in section (b)(1)(D). In this case, the oxygenate must meet the ranges of specifications identified in the section (b)(1)(D) notification.
- c. A producer or importer who is electing to specify the properties of the oxygenate used in a final blend in accordance with the preceding section (a)(2)(C)2.b. must maintain at the production or import facility, while the final blend is at the facility, quantities of oxygenate meeting the specifications that are sufficient to enable state board inspectors to use the oxygenate in compliance determinations.

(D) Protocol for Determining whether a final blend of CARBOB complies with the standards for California gasoline. The executive officer may enter into a written protocol with any individual producer or importer for the purpose of specifying a alternative method for determining whether a final blend of CARBOB complies with the standards for California gasoline, as long as the executive officer reasonably determines that application of the protocol is not less stringent or enforceable than application of the express terms of section (a)(2)(A)-(C). Any such protocol shall include the producer's or importer's agreement to be bound by the terms of the protocol.

- (3) Calculating the volume of a final blend of CARBOB.** Where a producer or importer has designated a final blend as CARBOB and has complied with all applicable provisions of this section 2266.5, the volume of a final blend shall be calculated for all purposes under

section 2264 by adding the minimum designated amount of the oxygenate having the smallest volume designated by the producer or importer. If the producer or importer has not complied with any applicable provisions of this section 2266.5, the volume of the final blend for purposes of the refiner or producer's compliance with sections 2262, 2262.3, 2262.4, 2262.5, and 2262.6, 2265 and 2266 shall be calculated without adding the amount of oxygenate to the CARBOB.

(4) **Specifications for a final blend of CARBOB when the CARBOB model is not being used.** No A producer or importer who has not elected to use the CARBOB model pursuant to section (a)((2)(B) with regard to a final blend of CARBOB may not sell, offer for sale, supply or offer for sale a that final blend of CARBOB from its production facility or import facility where the sulfur, benzene, olefin or aromatic hydrocarbon content of the CARBOB, when multiplied by (1 - the designated minimum volume the oxygenate will represent, expressed as a decimal fraction, after it is added to the CARBOB), results in a sulfur, benzene, olefin or aromatic hydrocarbon content value exceeding the applicable limit for that property under section (a)(2).

(5) **Determining whether downstream CARBOB complies with the cap limits for California Gasoline.**

(A) **Application of CARBOB cap limits derived from the CARBOB Model.** No person may sell, offer for sale, supply, offer for supply, or transport CARBOB that is designated for blending with the following ranges of ethanol and has been supplied from its production or import facility, where the CARBOB exceeds the following CARBOB cap limits:

<i>Property</i>	<i>CARBOB Cap Limits</i>					
	<i>2.0 - 5.8 vol.% Ethanol Range</i>		<i>5.9 - 7.8 vol.% Ethanol Range</i>		<i>7.8 - 10 vol.% Ethanol Range</i>	
	<i>CaRFG2</i>	<i>CaRFG3</i>	<i>CaRFG2</i>	<i>CaRFG3</i>	<i>CaRFG2</i>	<i>CaRFG3</i>
Reid Vapor Pressure ¹ (pounds per square inch)	5.78	5.99	5.78	5.99	5.78	5.99
Sulfur Content (parts per million by weight)	85	63 ²	86	65 ²	89	66 ²
		31 ²		32 ²		32 ²
Benzene Content (percent by volume)	1.27	1.16	1.30	1.19	1.33	1.22
Aromatics Content (percent by volume)	31.7	37.0	32.4	37.8	33.1	38.7
Olefins Content (percent by volume)	10.6	10.6	10.8	10.8	11.1	11.1
T50 (degrees Fahrenheit)	226	226	228	228	226	226
T90 (degrees Fahrenheit)	333	333	334	334	335	335

¹ The Reid vapor pressure standards apply only during the warmer weather months identified in section 2262.4.
² The CaRFG Phase 3 CARBOB cap limits for sulfur are phased in starting December 31, 2002, and December 31, 2004, in accordance with section 2261(b)(1)(A).

(B) Determining whether downstream CARBOB complies with the cap limits for California gasoline by oxygenate blending and testing. No person may sell, offer for sale, supply, offer for supply, or transport CARBOB that has been supplied from the production or import facility and that exceeds an applicable cap limit set forth in section 2262. To determine whether the cap limit is exceeded, the specified type and amount of oxygenate is added to a representative sample of the CARBOB and the properties and characteristics of the resulting gasoline are determined in accordance with an applicable test method identified in section 2263(b) or permitted under section 2263(c). Where the CARBOB has been designated for a range of amounts of oxygenate, or more than one oxygenate type, to be added, the minimum designated amount of the oxygenate having the smallest designated volume is to be added to the CARBOB when determining the properties and characteristics of the final blend. Denatured ethanol used as the oxygenate must have the properties set forth in section (a)(2)(C)2.a.

(C) A person may enter into a protocol with the Executive Officer for the purpose of identifying more stringent specifications for the denatured ethanol used pursuant to section (a)(5)(B), or different CARBOB cap limits under section (a)(5)(A), if the Executive Officer reasonably determines that the specifications or cap limits are reasonably premised on the person's program to assure that the denatured ethanol added to the CARBOB by oxygenate blenders will meet the more stringent specifications.

(b) Notification regarding the supply of CARBOB from the facility at which it was produced or imported.

(1) A producer or importer supplying a final blend of CARBOB from the facility at which the producer or importer produced or imported the CARBOB must notify the executive officer of the information set forth below. The notification must be received by the executive officer before the start of physical transfer of the final blend of CARBOB from the production or import facility, and in no case less than 12 hours before the producer or importer either completes physical transfer or commingles the final blend.

(A) The identity and location of the final blend;

(B) The designation of the final blend as CARBOB;

(C) If the producer or importer is electing to use the CARBOB model to determine whether the final blend complies with the standards applicable to California gasoline when it is supplied from the production facility or import facility, a statement of that election and each of the CARBOB alternative specifications that will apply to the final blend (along with the information required under section 2265(a)(2));

(D) If the producer or importer is electing to specify the properties of the oxygenate to be used in determining whether the final blend complies with the standards applicable to California gasoline when it is supplied from the production facility or import facility, a statement of that election, the type of oxygenate, and the oxygenate's specifications for the following properties (not to exceed the limits set forth in section 2262.9(a)(1)):

<u>Sulfur content:</u>	<u>Within a range of 5 parts per million</u>
<u>Benzene content:</u>	<u>Within a range of 0.06 volume percent</u>
<u>Olefin content:</u>	<u>Within a range of 0.10 volume percent</u>
<u>Aromatic hydrocarbon content:</u>	<u>Within a range of 1.00 volume percent</u>

~~(E)~~(E) The designation of each oxygenate type or types and amount or range of amounts to be added to the CARBOB. The amount or range of amounts of oxygenate to be added shall be expressed as a volume percent of the gasoline after the oxygenate is added, in the nearest tenth of a percent. For any final blend of CARBOB except one that is subject to PM alternative specifications or is reported as an alternative

formulation in accordance with section 2266(c), the amount of oxygenate to be added must be such that the resulting California gasoline will have a minimum oxygen content no lower than 1.8 percent by weight and a maximum oxygen content no greater than 2.2 percent by weight. For a final blend of CARBOB that is subject to PM alternative specifications, the amount of oxygenate to be added must be such that the resulting California gasoline has a range of oxygen content that is identical to the oxygen content PM alternative specification for the final blend. For a final blend of CARBOB that is reported as an alternative formulation in accordance with section 2266(c), the amount or range of amounts of oxygenate to be added must be such that the resulting California gasoline has an amount or range of oxygen content that is identical to the oxygen content alternative specification identified in the certification order for the formulation;

~~(D)~~(F) Where the producer or importer is using an averaging compliance option or a PM averaging compliance option for any property, the estimated volume of the final blend of CARBOB, and of the California gasoline that will result when the minimum specified amount of oxygenate is added to the final blend of CARBOB. A producer or importer may revise the reported estimated volume, as long as notification of the revised volume is received by the executive officer no later than 48 hours after completion of the physical transfer of the final blend from the production or import facility. If notification of the revised volume is not timely received by the executive officer, the reported estimated volume shall be deemed the reported actual volume.

(2) Applicability of notification to subsequent final blends. The notification a producer or importer provides pursuant to section (b)(1) for a final blend of CARBOB shall apply to all subsequent final blends of CARBOB or California gasoline supplied by the producer or importer from the same production or import facility until the producer or importer designates a final blend at that facility as either (a) California gasoline rather than CARBOB, or (B) CARBOB subject to a new notification made pursuant to section (b)(1).

~~(2)~~(3) If, through no intentional or negligent conduct, a producer or importer cannot report within the time period specified in (b)(1) above, the producer or importer may notify the executive officer of the required data as soon as reasonably possible and may provide a written explanation of the cause of the delay in reporting. If, based on the written explanation and the surrounding circumstances, the executive officer determines that the conditions of this section ~~(b)(2)~~(3) have been met, timely notification shall be deemed to have occurred.

~~(3)~~(4) The executive officer may enter into a written protocol with any individual producer or importer for the purpose of specifying how the requirements in section (b)(1) shall be applied to the producer's or importer's particular operations, as long as the executive officer reasonably determines that application of the regulatory requirements under the protocol is not less stringent or enforceable than application of the express terms of

section (b)(1). Any such protocol shall include the producer's or importer's agreement to be bound by the terms of the protocol.

(c) *Sampling, testing and recordkeeping by producers and importers of CARBOB.*

- (1) Each producer of CARBOB shall sample and test for the sulfur, aromatic hydrocarbon, olefin, oxygen and benzene content, T50, T90, and, during the regulatory control periods identified in section 2262.4(a)(2) and (b)(2), the Reid vapor pressure, of each final blend of CARBOB that the producer has produced, by collecting and analyzing a representative sample of CARBOB taken from the final blend, ~~in accordance with section (a). a producer who is electing to use the CARBOB model in determining compliance shall analyze the CARBOB without adding oxygenate. In all other cases, the producer or importer shall oxygenate and analyze the CARBOB in accordance with section (a)(2)(C).~~ If a producer blends CARBOB directly to pipelines, tankships, railway tankcars or trucks and trailers, the loading(s) shall be sampled and tested by the producer or authorized contractor.
- (2) Each importer of CARBOB shall sample and test for the sulfur, aromatic hydrocarbon, olefin, oxygen and benzene content, T50, T90, and, during the regulatory control periods identified in section 2262.4(a)(2) and (b)(2), the Reid vapor pressure, of each ~~shipment final blend~~ of CARBOB which the importer has imported by tankship, pipeline, railway tankcars, trucks and trailers, or other means, by collecting and analyzing a representative sample of CARBOB taken from the ~~shipment final blend at its import facility, in accordance with section (a). An importer who is electing to use the CARBOB model in determining compliance shall analyze the CARBOB without adding oxygenate. In all other cases, the importer shall oxygenate and analyze the CARBOB in accordance with section (a)(2)(C).~~
- (3) Each producer or importer required to sample and analyze a final blend or shipment of CARBOB pursuant to this section (c) shall maintain, for two years from the date of each sampling, records showing the sample date, identify of blend or product sampled, container or other vessel sampled, the final blend or shipment volume, and the sulfur, aromatic hydrocarbon, olefin, oxygen and benzene content, T50, T90, and Reid vapor pressure as determined in accordance with section (a)(2). All CARBOB produced or imported by the producer or importer and not tested as required by this section shall be deemed to have a Reid vapor pressure, sulfur, aromatic hydrocarbon, olefin, oxygen and benzene content, T50 and T90 exceeding the applicable flat limit or averaging limit standards specified in section 2262, unless the importer demonstrates that the CARBOB meets those standards and limit(s).
- (4) a producer or importer shall provide to the executive officer any records required to be maintained by the producer or importer pursuant to this section (c) within 20 days of a written request from the executive officer if the request is received before expiration of the period during which the records are required to be maintained. Whenever a producer

or importer fails to provide records regarding a final blend or shipment of CARBOB in accordance with the requirements of this section, the final blend or shipment of CARBOB shall be presumed to have been sold by the producer or importer in violation of the applicable flat limit or averaging limit standards and compliance requirements in sections 2262, 2262.3(b) or (c), 2262.4(b), or 2262.5(c), unless the importer demonstrates that the CARBOB meets those standards and limit(s).

- (5) The executive officer may enter into a protocol with any producer or importer for the purpose of specifying alternative sampling, testing, recordkeeping, or reporting requirements which shall satisfy the provisions of sections (c)(1) or (c)(2). The executive officer may only enter into such a protocol if s/he reasonably determines that application of the regulatory requirements under the protocol will be consistent with the state board's ability effectively to enforce the provisions of sections 2262, 2262.3(b) or (c), 2262.4(b), or 2262.5(c), and the PM averaging limit(s). Any such protocol shall include the producer's or importer's agreement to be bound by the terms of the protocol.

(d) Documentation required when CARBOB is transferred.

- (1) On each occasion when any person transfers custody or title of CARBOB, the transferor shall provide the transferee a document that prominently:
- (a) states that the CARBOB does not comply with the standards for California gasoline without the addition of oxygenate, and
 - (B) identifies, consistent with the notification made pursuant to section (b), the oxygenate type or types and amount or range of amounts that must be added to the CARBOB to make it comply with the standards for California gasoline. Where the producer or importer of the CARBOB has elected to specify the properties of the oxygenate pursuant to section (b)(1)(D), the document must also prominently identify the maximum permitted sulfur, benzene, olefin and aromatic hydrocarbon contents — not to exceed the maximum levels in the section (b)(1)(D) notification — of the oxygenate to be added to the CARBOB.
- (2) a pipeline operator may comply with this requirement by the use of standardized product codes on pipeline tickets, where the code(s) specified for the CARBOB is identified in a manual that is distributed to transferees of the CARBOB and that sets forth all of the required information for the CARBOB.

(e) Restrictions on transferring CARBOB.

- (1) No person may transfer ownership or custody of CARBOB to any other person unless the transferee has agreed in writing with the transferor that either:

(a) The transferee is a registered oxygenate blender and will add oxygenate of the type(s) and amount (or within the range of amounts) designated in accordance with section (b) before the CARBOB is transferred from a final distribution facility, or

(B) The transferee will take all reasonably prudent steps necessary to assure that the CARBOB is transferred to a registered oxygen blender who adds the type and amount (or within the range of amounts) of oxygenate designated in accordance with section (b) to the CARBOB before the CARBOB is transferred from a final distribution facility.

(2) No person may sell or supply CARBOB from a final distribution facility where the type and amount or range of amounts of oxygenate designated in accordance with section (b) has not been added to the CARBOB.

(f) ***Restrictions on blending CARBOB with other products.***

(1) No person may combine any CARBOB that has been supplied from the facility at which it was produced or imported with any other CARBOB, gasoline, blendstock or oxygenate, except:

(a) ***The specified oxygenate.*** Oxygenate of the type and amount (or within the range of amounts) specified by the producer or importer at the time the CARBOB was supplied from the production or import facility, or

(B) ***Identically-specified CARBOB.*** Other CARBOB for which the same oxygenate type and amount (or range of amounts) was specified by the producer or importer at the time the CARBOB was supplied from the production or import facility.

(C) ***CARBOB specified for different ethanol level.*** Where a person is changing from an initial to a new type of CARBOB stored in a storage tank at a terminal or bulk plant, and the conditions below are met; in this case, the CARBOB in the tank after the new type of CARBOB is added will be treated as that new type of CARBOB.

1. The change in service is for legitimate operational reasons and is not for the purpose of combining the different types of CARBOB;

2. The initial and new CARBOBs are designated for blending with different amounts (or ranges of amounts) of ethanol, and the change in ethanol content will not exceed 3 percent of the oxygenated gasoline blend;

3. Prior to adding the new CARBOB, the volume of the initial CARBOB in the tank is drawn down to no more than 10 percent, and

4. The volume of the new CARBOB that is added to the tank is as large as possible taking into account availability of the new CARBOB, and
5. The sulfur content of the new CARBOB added to the tank is no more than 12 parts per million.

(D) California gasoline not subject to RVP standard. Where a person is changing from California gasoline to CARBOB, or from CARBOB to California gasoline, as the product stored in a storage tank at a terminal or bulk plant and the conditions below are met; in this case the product in the tank, pipe or manifold after the new product is added will be treated as the new type of product.

1. The change in service is for legitimate operational reasons and is not for the purpose of combining the California gasoline and CARBOB;
2. If the person is adding CARBOB to California gasoline,
 - a. Prior to adding the CARBOB, the volume of the California gasoline in the tank is drawn down to no more than 10 percent, and
 - b. The volume of CARBOB that is added to the tank is as large as possible taking into account availability of that type of CARBOB;
3. The resulting blend of product in the tank is supplied from the terminal or bulk plant during a time that it is not subject to the standards for Reid vapor pressure under section 2262.4.

(2) Notwithstanding section (f)(1), the executive officer may enter into a written protocol with any person to identify conditions under which the person may lawfully combine CARBOB with California gasoline or other CARBOB during a changeover in service of a storage tank for a legitimate operational business reason. The executive officer may only enter into such a protocol if he or she reasonably determines that commingling of the two products will be minimized as much as is reasonably practical. Any such protocol shall include the person's agreement to be bound by the terms of the protocol.

(g) Requirements for oxygenate blenders.

(1) Registration and Certification.

- (a) Any oxygen blender must register with the executive officer by March 1, 1996, or at least 20 days before blending oxygenates with CARBOB, whichever occurs later. Thereafter, a oxygenate blender must register with the executive officer annually by January 1. The registration must be addressed to the attention of the Chief,

Compliance Division, California Air Resources Board, P.O. Box 2815, Sacramento, CA, 95812.

(B) The registration must include the following:

1. The oxygen blender's contact name, telephone number, principal place of business which shall be a physical address and not a post office box, and any other place of business at which company records are maintained.
2. For each of the oxygen blender's oxygenate blending facilities, the facility name, physical location, contact name, and telephone number.

(C) The executive officer shall provide each complying oxygen blender with a certificate of registration compliance no later than June 30. The certification shall be effective from no later than July 1, through June 30 of the following year. The certification shall constitute the oxygen blender's certification pursuant to Health and Safety Code section 43021.

(D) Any oxygen blender must submit updated registration information to the executive officer at the address identified in section (h)(g)(1)(a) within 30 days of any occasion when the registration information previously supplied becomes incomplete or inaccurate.

(2) **Requirement to add oxygenate to CARBOB.** Whenever an oxygenate blender receives CARBOB from a transferor to whom the oxygenate blender has represented that he/she will add oxygenate to the CARBOB, the oxygenate blender must add to the CARBOB oxygenate of the type(s) and amount (or within the range of amounts) identified in the documentation accompanying the CARBOB. If the documentation identifies the permitted maximum sulfur, benzene, olefin and aromatic hydrocarbon contents of the oxygenate, the oxygenate blender must add an oxygenate that does not exceed the maximum permitted levels.

(3) **Additional requirements for terminal blending.** Any oxygenate blender who makes a final blend of California reformulated gasoline by blending any oxygenate with any CARBOB in any gasoline storage tank, other than a truck used for delivering gasoline to retail outlets or bulk purchaser-consumer facilities, shall, for each such final blend, determine the oxygen content and volume of the final blend prior to its leaving the oxygen blending facility, by collecting and analyzing a representative sample of gasoline taken from the final blend, using methodology set forth in section 2263.

(h) ***Downstream blending of California gasoline with nonoxygenate blendstocks.***

- (1) No person may combine California gasoline which has been supplied from a production or import facility with any nonoxygenate blendstock, other than vapor recovery condensate, unless the person can affirmatively demonstrate that (1) the blendstock that is added to the California gasoline meets all of the California gasoline standards without regard to the properties of the gasoline to which the blendstock is added, and (2) the person meets with regard to the blendstock all requirements in this subarticle applicable to producers of California gasoline.
- (2) Notwithstanding section (i)(1), the executive officer may enter into a written protocol with any person to identify conditions under which the person may lawfully blend transmix into California gasoline which has been supplied from its production or import facility. The executive officer may only enter into such a protocol if he or she reasonably determines that alternatives to the blending are not practical and the blending will not significantly affect the properties of the California gasoline into which the transmix is added. Any such protocol shall include the person's agreement to be bound by the terms of the protocol.
- (3) Notwithstanding section (i)(1), a person may add nonoxygenate blendstock to California gasoline that does not comply with one or more of the applicable cap limits contained in section 2262, where the person obtains the prior approval of the executive officer based on a demonstration that adding the blendstock is a reasonable means of bringing the gasoline into compliance with the cap limits.

(i) ***Restrictions During the RVP Season on Blending Gasoline Containing Ethanol With California Gasoline Not Containing Ethanol.***

- (1) Within each air basin during the Reid vapor pressure cap limit periods specified in section 2262.4(a)(2), no person may combine California gasoline produced using ethanol with California gasoline produced without using ethanol, unless the person can affirmatively demonstrate that: (a) the resulting blend complies with the cap limit for Reid vapor pressure set forth in section 2262, or (B) the person has taken reasonably prudent precautions to assure that the gasoline is not subject to the Reid vapor pressure cap limit either because of sections 2261(d) or (f) or 2262.4(c)(1) or (c)(3), or because the gasoline is no longer California gasoline.
- (2) Section 2266.5(i)(1) does not apply to combining California gasolines that are in a motor vehicle's fuel tank.

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend section 2270(a), title 13, California Code of Regulations, to read as follows:

Section 2270. Testing and Recordkeeping.

- (a) (1) The requirements of this section (a) shall apply to each producer and importer that has elected to be subject to an averaging limit in section 2262, or to a PM averaging limit. The references to sulfur content shall apply to each producer or importer that has elected to be subject to section 2262.2(c), or to a PM averaging limit for sulfur. The references to benzene content shall apply to each producer or importer that has elected to be subject to section 2262.3(c), or to a PM averaging limit for benzene. The references to olefin content shall apply to each producer or importer that has elected to be subject to the section 2262 averaging limit for olefin content, or to a PM averaging limit for olefin content. The references to T90 shall apply to each producer or importer that has elected to be subject to the section 2262 averaging limit for T90, or to a PM averaging limit for T90. The references to T50 shall apply to each producer or importer that has elected to be subject to the section 2262 averaging limit for T50, or to a PM averaging limit for T50. The references to aromatic hydrocarbon content shall apply to each producer or importer that has elected to be subject to the section 2262 averaging limit for aromatic hydrocarbon content, or to a PM averaging limit for aromatic hydrocarbon content.
- (2) Each producer shall sample and test for the sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90 in each final blend of California gasoline which the producer has produced, by collecting and analyzing a representative sample of gasoline taken from the final blend, using the methodologies specified in section 2263. If a producer blends gasoline components directly to pipelines, tankships, railway tankcars or trucks and trailers, the loading(s) shall be sampled and tested for the sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90 by the producer or authorized contractor. The producer shall maintain, for two years from the date of each sampling, records showing the sample date, identity of blend sampled, container or other vessel sampled, final blend volume, sulfur, aromatic hydrocarbon olefin and benzene content, T50 and T90. All gasoline produced by the producer and not tested as California gasoline by the producer as required by this section shall be deemed to have a sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90 exceeding the applicable averaging limit standards specified in section 2262, or exceeding the comparable PM averaging limits if applicable, unless the producer demonstrates that the gasoline meets those standards and limits.
- (3) Each importer shall sample and test for the sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90 in each shipment final blend of California gasoline which the importer has imported by tankship, pipeline, railway tankcars, trucks and trailers, or other means, by collecting and analyzing a representative sample of the gasoline, using the methodologies specified in section 2263. The importer shall maintain, for two years

from the date of each sampling, records showing the sample date, product sampled, container or other vessel sampled, the volume of the shipment final blend, sulfur content, aromatic hydrocarbon, olefin and benzene content, T50 and T90. All gasoline imported by the importer and not tested as California gasoline by the importer as required by this section shall be deemed to have a sulfur, aromatic hydrocarbon, olefin and benzene content, T50 and T90 exceeding the applicable averaging limit standards specified in section 2262, or exceeding the comparable PM averaging limit(s) if applicable, unless the importer demonstrates that the gasoline meets those standards and limit(s).

* * * *

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 39515, 39516, 41511, 43000, 43013, 43013.1, 43016, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend section 2272(c)(5), title 13, California Code of Regulations, to read as follows:

Section 2272. CaRFG Phase 3 Standards for Qualifying Small Refiners.

* * * *

(c) **Criteria for qualifying gasoline.** Gasoline shall only be subject to treatment under this section if the small refiner demonstrates all of the following:

* * * *

(5) The excess emissions of hydrocarbons, oxides of nitrogen, and potency-weighted toxics are offset pursuant to section 2282, title 13, California Code of Regulations. The excess emissions from gasoline subject to the small refiner CaRFG Phase 3 standards are: 0.0206 pounds of exhaust hydrocarbons per barrel, 0.0322 pounds of oxides of nitrogen per barrel, and the potency-weighted toxic emissions equivalent of 0.0105 pounds of benzene per barrel. (Note: ~~At the time this section 2272(d)(5) was adopted in June 2000, section 2282 did not include a mechanism for offsetting excess emissions from gasoline subject to the small refiner CaRFG Phase 3 standards. As such, a qualifying small refiner accordingly may not elect to have its gasoline subject to the small refiner CaRFG Phase 3 standards until section 2282 is amended to provide a mechanism for offsetting the excess emissions and those amendments become operative. The Air Resources Board intends to consider such amendments in a Fall 2000 rulemaking.~~)

* * * *

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

Amend section 2273, title 13, California Code of Regulations, to read as follows:

Section 2273. Labeling of Equipment Dispensing Gasoline Containing MTBE.

* * * *

(b) Residual levels of MTBE.

- (1) The labeling requirements in section 2273(a) do not apply to equipment dispensing gasoline from a storage tank containing gasoline having an MTBE content of less than 0.6 percent by volume, as determined by American Society of Testing and Materials (ASTM) Test Method D 4815-94a99, which is incorporated herein by reference, or any other test method determined by the executive officer to give equivalent results.

* * * *

(d) Deliveries of gasoline to retail outlets.

- (1) Any person delivering gasoline to a retail gasoline outlet shall provide to the outlet operator or responsible employee, at time of delivery of the fuel, an invoice, bill of lading, shipping paper, or other documentation which states whether the gasoline does or does not contain 0.6 percent by volume or more MTBE, and which may identify the volumetric amount of MTBE in the gasoline. For purposes of determining compliance with this section 2273(d), the volumetric MTBE content of gasoline shall be determined by ASTM Test Method D 4815-94a99, which is incorporated herein by reference, or any other test method determined by the executive officer to give equivalent results.

* * * *

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

Amend section 2282(e), title 13, California Code of Regulations, to read as follows:

Section 2282. Aromatic Hydrocarbon Content of Diesel Fuel

* * * *

(e) *Small Refiner Diesel Fuel.*

- (1) The provisions of subsection (a)(1)(a), (B) and (C) shall not apply to the diesel fuel that is produced by a small refiner at the small refiner's California refinery and that is first consecutively supplied from the refinery as vehicular diesel fuel in each calendar year, up to the small refiner's exempt volume (up to one quarter of the small refiner's exempt volume for the period from October 1, 1993-December 31, 1993). Diesel fuel which is designated by the small refiner as not exempt under this section (e), and which is reported to the executive officer pursuant to a protocol entered into between the small refiner and the executive officer, shall not be counted against the exempt volume and shall not be exempt under this subsection (e). This exemption shall not apply to any diesel fuel supplied from a small refiner's refinery in any calendar quarter in which less than 25 percent of the diesel fuel supplied from the refinery was produced from the distillation of crude oil at the refinery. The foregoing notwithstanding, in the case of any small refiner that pursuant to subsection (a)(4) has not been subject to subsection (a)(1) until October 1, 1994, all vehicular diesel fuel produced by the small refiner at the small refiner's California refinery and supplied from the refinery from October 1, 1994 through December 31, 1994, shall be exempt from the provisions of subsection (a)(1)(a), (B) and (C), up to the quarterly volume limits imposed by the executive officer in connection with issuance of suspension orders pursuant to section 2281(g). These quarterly volume limits are as follows: Kern Oil & Refining, 714,100 barrels; Paramount Petroleum, 1,064,700 barrels; and Powerine Oil Company, 1,419,600 barrels.
- (2) To qualify for an exemption under this subsection (e), a refiner shall submit to the executive officer an application for exemption executed in California under penalty of perjury, on the Air Resources Board's ARB/SSD/CPB Form 89-9-1, for each of the small refiner's California refineries. The application shall specify the crude oil capacity of the refinery at all times since January 1, 1978, the crude oil capacities of all the refineries in California and the United States which are owned or controlled by, or under common ownership or control with, the small refiner since September 1, 1988, data demonstrating that the refinery has the capacity to produce liquid fuels by distilling petroleum, and copies of the reports made to the California Energy Commission as required by the Petroleum Industry Reporting Act of 1980 (Public Resources Code sections 25350 et seq.) showing the annual production volumes of distillate fuel at the small refiner's California refinery for 1983 through 1987. Within 90 days of receipt of the application, the executive officer shall grant or deny the exemption in writing. The exemption shall be granted if the executive officer determines that the applicant has demonstrated that s/he meets the provisions of subsection (b)(19), and shall identify the small refiner's

exempt volume. The exemption shall immediately cease to apply at any time the refiner ceases to meet the definition of small refiner in subsection (b)(19).

(3) In addition to the requirements of subsection (f) below, each small refiner who is covered by an exemption shall submit to the executive officer reports containing the information set forth below for each of the small refiner's California refineries. The reports shall be executed in California under penalty of perjury, and must be received within the time indicated below:

(a) The quantity, ASTM grade, aromatic hydrocarbon content, and batch identification of all diesel fuel, produced by the small refiner, that is supplied from the small refinery in each month as vehicular diesel fuel, within 15 days after the end of the month;

(B) For each calendar quarter, a statement whether 25 percent or more of the diesel fuel transferred from the small refiner's refinery was produced by the distillation of crude oil at the small refiner's refinery, within 15 days after the close of such quarter;

(C) The date, if any, on which the small refiner completes transfer from its small refinery in a calendar year of the maximum amount of vehicular diesel fuel which is exempt from subsection (a)(1)(a) and (B) pursuant to subsection (e), within 5 days after such date;

(D) Within 10 days after project completion, any refinery addition or modification which would affect the qualification of the refiner as a small refiner pursuant to subsection (b)(19); and

(E) Any change of ownership of the small refiner or the small refiner's refinery, within 10 days after such change of ownership.

(4) Whenever a small refiner fails to provide records identified in subsection(e)(3)(a) or (B) in accordance with the requirements of those subsections, the vehicular diesel fuel supplied by the small refiner from the small refiner's refinery in the time period of the required records shall be presumed to have been sold or supplied by the small refiner in violation of section (a)(1)(a).

(5) Offsetting Excess Emissions From Gasoline Subject to the Small Refiner CaREG Phase 3 Standards.

(a) Annual elections. No later than December 22 of each calendar year starting with 2002, a small refiner who is also a qualifying small refiner as defined in the CaREG regulations (section 2260(a)(28.5)) may make the following elections:

1. Whether the small refiner elects to produce gasoline subject to the small refiner CaREG Phase 3 standards in section 2272(a) in the coming year;

2. If electing to produce small refiner CaRFG Phase 3, whether the refiner elects the option of accepting a reduced exempt volume in the coming year to offset the excess emissions;
3. If electing to produce small refiner CaRFG Phase 3 but not to accept a reduced exempt volume, the refiner must elect for the coming year either (i) to produce offset small refiner diesel fuel with an exempt volume determined in accordance with section (b)(4), or (ii) to produce cleaner offset small refiner diesel fuel with an exempt volume expanded by 25 percent and restrictions on sales of high-aromatics California nonvehicular diesel fuel.

(B) Effect of election.

1. **Election not to produce small refiner CaRFG Phase 3.** If a small refiner does not elect to produce gasoline subject to the small refiner CaRFG Phase 3 standards for a particular year, no gasoline sold or supplied from the small refiner's refinery in that year will qualify for the small refiner CaRFG Phase 3 standards in section 2272(a).
2. **Election to accept a reduced exempt volume for small refiner diesel fuel.** If a small refiner elects to accept a reduced exempt volume under section (f)(5)(a), the Executive Officer shall assign a substitute exempt volume for the year that is reduced sufficiently to offset the excess emissions of hydrocarbons, oxides of nitrogen, and potency-weighted toxics that would result from production of the small refiner's full qualifying volume of gasoline subject to the CaRFG Phase 3 standards. In the case of Kern Oil and Refining Co., its reduced exempt volume of small refiner diesel fuel would be 825,995 barrels per year (equal to 2263 bpd; 828,258 in leap years) in place of 2,337,825 barrels per year (equal to 6405 bpd; 2,344,230 in leap years).
3. **Election to retain the preexisting exempt volume and produce offset small refiner diesel fuel.** If the small refiner elects to be subject to the exempt volume determined in accordance with section (b)(4), the Executive Officer shall adjust the aromatics and cetane number of the standards applicable to the small refiner sufficient to offset the potential increased emissions identified pursuant to section 2272(c)(5). In the case of Kern Oil and Refining Co., its exempt volume for the year would be 2,337,825 barrels per year (equivalent to 6405 bpd; 2,344,230 in leap years). Any small refiner diesel fuel it sells or supplies as a certified alternative formulation equivalent to a 20 percent aromatics reference fuel must have an aromatic hydrocarbon content that is 2 percentage points lower, and a cetane number that is 0.5 higher, than is specified for the alternative formulation. Any small refiner diesel fuel it sells or supplies which is not designated as a certified alternative formulation must have an aromatic hydrocarbon content not exceeding 18 percent.

4. Election of expanded exempt volume with requirement for cleaner offset small refiner diesel fuel. If the small refiner elects to produce offset small refiner diesel fuel with an expanded exempt volume, its exempt volume for the year will be 125 percent of its exempt volume determined in accordance with section (b)(4). The Executive Officer shall adjust the aromatics and cetane number of the standards applicable to the potential volume of small refiner sufficient to offset the potential increased emissions identified pursuant to section 2272(c)(5). The small refiner will be prohibited during the year from selling or supplying diesel fuel that it has produced and is intended for nonvehicular applications in California unless the fuel meets the U.S. EPA's standards for diesel fuel for use in motor vehicles in 40 CFR sec. 80.29 as it existed July 1, 2000. In the case of Kern Oil and Refining Co., its exempt volume for the year would be 2,922,190 barrels per year (equivalent to 8006 bpd; 2,930,196 in leap years). Any small refiner diesel fuel it sells or supplies in the year as a certified alternative formulation equivalent to a 20 percent aromatics reference fuel must have an aromatic hydrocarbon content that is 3.5 percentage points lower, and a cetane number that is 0.5 higher, and an additive content that is 0.02 percentage higher, than is specified for the alternative formulation. Any small refiner diesel fuel it sells or supplies which is not designated as a certified alternative formulation shall have an aromatic hydrocarbon content not exceeding 14 percent.

5. Additional requirement to sell or supply ultra-low sulfur diesel fuel. In addition to the requirements in section (f)(5)(B)1. through (f)(5)(B)4., a small refiner that elects to produce gasoline subject to the CaRFG Phase 3 standards for a year must sell or supply in that year up to 100 bpd of diesel fuel having a sulfur content not exceeding 30 ppm and an aromatic hydrocarbon content not exceeding 20 percent, to the extent there are buyers wishing to acquire that diesel fuel on commercially reasonable terms.

(C) Early opt-in to produce small refiner CaRFG Phase 3. To the extent that the sale of supply of gasoline subject to the CaRFG Phase 3 standards before December 31, 2002 is permitted by section 2261(b)(3), a qualifying small refiner may elect to have to option of producing gasoline subject to the small refiner CaRFG Phase 3 standards for a full year or the remainder of a year prior to December 31, 2002. In that case, section (e)(5)(B)2.-5. would apply on a pro rata basis to the portion of the year on and after the effective date of the election, and the preexisting requirements would apply on a pro rata basis to the portion of the year prior to the effective date of the election.

* * * *

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

Amend section 2296(k)(2), title 13, California Code of Regulations, as follows:

§ 2296. Motor Fuel Sampling Procedures.

* * * *

(k) "Sampling procedures."

* * * *

- (2) "Tap sampling." The tap sampling procedure is applicable for sampling liquids of 26 pounds (1.83 kgf/cm²) RVP or less in tanks which are equipped with suitable sampling taps or lines. This procedure is recommended for volatile stocks in tanks of the breather and balloon roof type, spheroids, etc. (Samples may be taken from the drain cocks of gage glasses, if the tank is not equipped with sampling taps.) When obtaining a sample for RVP distillation analysis, use the assembly as shown in Figure 3. When obtaining a sample for other than RVP or distillation analysis, the assembly as shown in Figure 3 need not be provided.

NOTE: If RVP is more than 16 pounds (1.12 kgf/cm²) but not more than 26 pounds (1.83 kgf/cm²) a cooling bath as shown in section (l)(6), Figure 5, shall be used between the tank tap and the sample container to cool the sample and prevent volatilization of low-boiling components.

* * * *

NOTE: Authority cited: sections 39600, 39601, 43013, 43013.1, 43018, 43101 and 43830, Health and Safety Code. Reference: sections 39000, 39001, 39002, 39003, 39010, 39500, 41511, 43000, 43013, 43018, 43101, and 43830, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Amend section 2297(k), title 13, California Code of Regulations, to read as follows:

§ 2297. Test Method for the Determination of the Reid Vapor Pressure Equivalent Using an Automated Vapor Pressure Test Instrument.

* * * *

(k) *Precision and Bias*

- (1.0) *Precision* — The precision of this test method as determined by the statistical examination of interlaboratory test results is as follows:

(1.1) **Repeatability** — The difference between successive test results obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the correct operation of the test method exceed the following value only in one case in twenty. The repeatability values for the specific automated vapor pressure test instruments listed in section (i)(1.0) were equal to or less than 0.2 psi. For the purposes of determining compliance with sections 2251 and 2252.5, the repeatability value for this method shall be 0.20 psi. are:

1. <u>Grabner Instruments,</u> <u>Model: CCA-VP (laboratory Grabner)</u>	0.84 psi
2. <u>Grabner Instruments,</u> <u>Model: CCA-VPS (portable Grabner)</u>	0.84 psi
3. <u>Stanhope-Seta Limited</u> <u>Model: Setavap</u>	0.10 psi

(1.2) **Reproducibility** — The difference between two single and independent test results obtained by different operators working in different laboratories using the same make and model test instrument on identical test material would, in the long run, in the correct operation of the test method exceed the following value only in one case in twenty. The reproducibility values for the specific automated vapor pressure test instruments listed in section (i)(1.0) were equal to or less than 0.3 psi. For the purposes of determining compliance with sections 2251 and 2252.5, the reproducibility value for this method shall be 0.30 psi. are:

1. <u>Grabner Instruments,</u> <u>Model: CCA-VP (laboratory Grabner)</u>	0.13 psi
2. <u>Grabner Instruments,</u> <u>Model: CCA-VPS (portable Grabner)</u>	0.21 psi
3. <u>Stanhope-Seta Limited</u> <u>Model: Setavap</u>	0.32 psi

(2.0) **Bias** — a relative bias was observed between the total pressure obtained using this test method and the Reid vapor pressure obtained using ASTM Test Method D 323-58. This bias is corrected by the use of the calibration equation in section (i)(1.0) which calculates a Reid vapor pressure equivalent value from the observed total pressure.

NOTE: Authority cited: sections 39600, 39601, 43013, 43018, and 43101, and 43830, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975). Reference: sections 39000, 39001, 39002, 39003, 39500, 43000, 43013, 43018, 43101, and 43830, Health and Safety Code; and *Western Oil and Gas Ass'n. v. Orange County Air Pollution Control District*, 14 Cal.3d 411, 121 Cal.Rptr. 249 (1975).

Appendix B

Procedures for Using the California Model for California Reformulated Gasoline Blendstocks for Oxygenate Blending (CARBOB)

State of California
California Environmental Protection Agency
AIR RESOURCES BOARD

**Procedures for Using the California Model for
California Reformulated Gasoline Blendstocks
for Oxygenate Blending (CARBOB)**

Adopted:

**Procedures for Using the California Model for
California Reformulated Gasoline Blendstocks
for Oxygenate Blending (CARBOB)**

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1 INTRODUCTION AND BACKGROUND

The procedures in this document describe how to use the ARB's model for California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB). The procedures are applicable when ethanol is being blended into California Reformulated Gasoline (RFG). The procedures can be used to comply with either the Phase 2 or Phase 3 gasoline regulations. For simplicity, the procedures described in this document will be referred to as the CARBOB procedures. CARBOB is the gasoline blendstock that, when blended with ethanol, results in a finished gasoline which meets the requirements of the Phase 2 or Phase 3 California Reformulated Gasoline (RFG) Regulations. The CARBOB procedures in this document are to be used in combination with the California Procedures for Evaluating Alternative Specifications for Phase 2 Reformulated Gasoline Using the California Predictive Model or with the California Procedures for Evaluating Alternative Specifications for Phase 3 Reformulated Gasoline Using the California Predictive Model (i.e., "The Predictive Model Procedures"). The Predictive Model Procedures implement Section 2265 of the California Code of Regulations, Gasoline Subject to PM Alternative Specifications Based on the California Predictive Model. The principal element of the Predictive Model Procedures is the Phase 2 or Phase 3 predictive model which is used to evaluate the emissions equivalency of alternative complying gasolines that producers wish to produce.

Under the predictive model provisions of the Phase 2 and Phase 3 RFG regulations, the refiner inputs into the predictive model equations the fuel properties of the gasoline he is interested in producing, referred to as the predictive model candidate gasoline. The predicted emissions associated with the candidate gasoline's properties are compared to the predicted emissions for a gasoline meeting either the Phase 2 or Phase 3 limits adopted by the Air Resources Board. If the predicted emissions for the refiner's predictive model candidate gasoline are equivalent to the predicted emissions for a gasoline meeting the appropriate reformulated gasoline limits (either Phase 2 or Phase 3), the predictive model candidate gasoline is allowed to be produced as an alternative complying gasoline.

Section 2266.5, Requirements Pertaining to California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB) and Downstream Blending contains the requirements governing the production and blending of CARBOB. These CARBOB procedures implement the use of the CARBOB model, which is the principle element of these procedures. The CARBOB model is a set of equations which predict the properties of the finished gasoline (gasoline after the addition of ethanol), given the properties of the CARBOB, the properties of the ethanol blended into the CARBOB, and the ethanol content of the finished gasoline. The CARBOB properties, the ethanol properties, and the ethanol content of the finished gasoline are inputs to the CARBOB model, and the properties of the finished gasoline are outputs. The finished gasoline outputs from the CARBOB model are then input into either the Phase 2 or Phase 3 predictive model (depending on which regulations are applicable), as the predictive model candidate gasoline, and the emissions equivalency of the predictive model candidate gasoline is evaluated in accordance with the Predictive Model Procedures.

Thus, the properties of the finished predictive model candidate gasoline can be determined without actually blending the ethanol into the CARBOB.

The purposes of CARBOB model are to facilitate the enforcement of the RFG regulations and to reduce the sampling and testing demands on the refiners in ensuring that gasolines containing ethanol meet the requirements of the RFG regulations. Enforcement is facilitated by allowing the enforcement staff to sample and test CARBOB and to compare the measured CARBOB properties to the properties reported to the ARB. The enforcement staff does not necessarily have to blend into the CARBOB ethanol in order to determine if the finished gasoline complies.

2. GENERAL USE OF THE CARBOB MODEL

As discussed above, the CARBOB model is a set of equations which relate the properties of finished gasoline (gasoline containing ethanol) to the properties of the CARBOB, the properties of the ethanol blended into the CARBOB, and the amount of ethanol that is blended. The CARBOB model uses these inputs to estimate the properties of the finished gasoline, which are then input into either the Phase 2 or Phase 3 Predictive Model. The Predictive Model then evaluates whether the finished gasoline meets the emissions equivalency requirements applicable to gasolines subject to the predictive model alternative specifications of the Phase 2 or Phase 3 gasoline regulations. Figure 1 illustrates schematically how the inputs and outputs to the CARBOB model are used in combination with the Predictive Model.

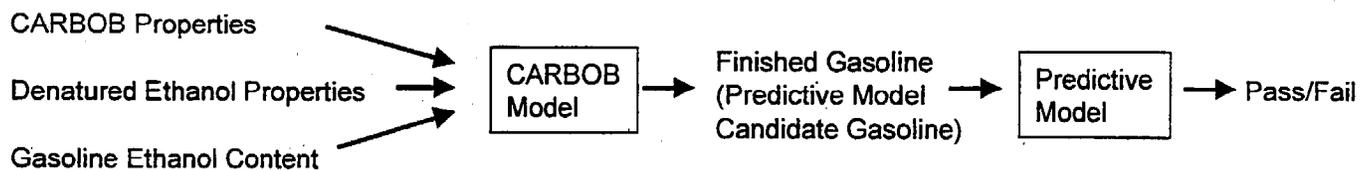
With the exception of the T50 distillation temperature and the oxygen content, the CARBOB model contains one equation for each fuel property regulated under the Phase 2 and Phase 3 RFG regulations. In the case of T50, there are two equations. There is one equation for T50 when the ethanol content of the gasoline is greater than or equal to 4.0 percent and less than 9.0 percent, and another equation when the ethanol content is from 9.0 to 10.0 percent (inclusive). If the ethanol content of the finished gasoline is less than 4.0 percent, the CARBOB model cannot be used. The CARBOB model does not contain an input for the oxygen content. The oxygen content of the predictive model candidate gasoline is input directly into either the Phase 2 or Phase 3 predictive model.

In using the CARBOB model, the user first indicates whether he intends to input into the CARBOB model proprietary values for the aromatics, olefins, sulfur, and benzene contents of the ethanol that is to be blended into the CARBOB. The presence of these compounds in the ethanol generally results from the use of a denaturant. If the user does not intend to use proprietary values for the aromatics, olefins, sulfur, and benzene contents, default values are used.

The user then enters into the CARBOB model the values of the CARBOB properties, and the amount of ethanol that is to be blended into the gasoline. The CARBOB model outputs the properties of the finished (ethanol-containing gasoline). The properties of the finished gasoline are input into either the Phase 2 or Phase 3

predictive model (whichever regulatory limits are appropriate) as the properties of the predictive model candidate gasoline. The emissions equivalency of the predictive model candidate gasoline is evaluated by the predictive model in accordance with the provisions of the Predictive Model Procedures.

Figure 1
Schematic Showing the Integration of the CARBOB Model with the Predictive Model



3. CARBOB MODEL EQUATIONS

The equations which constitute the CARBOB model are shown below:

A. RVP Model

$$RVP_{FG} = 1.446 + 0.961 \cdot RVP_{CARBOB} \quad \text{where,}$$

RVP_{FG} is the RVP of the finished gasoline, in psi.

RVP_{CARBOB} is the RVP of the CARBOB, in psi.

B. T50 Models

There are two CARBOB models for T50. The first is for a finished gasoline ethanol content of greater than or equal to 4.0 percent, but less than 9.0 percent. The second is for a finished gasoline ethanol content of greater than or equal to 9.0 percent, but less than or equal to 10.0 percent.

i. Model for $4\% \leq \text{EtOH} < 9\%$

$$\begin{aligned} T50_{FG} = & 21.93 + 14.875 \cdot \text{EtOH} - 10.238 \cdot RVP_{CARBOB} + \\ & 0.672 \cdot T50_{CARBOB} + 0.02579 \cdot T90_{CARBOB} - 0.8313 \cdot \text{EtOH}^2 - \\ & 0.3103 \cdot RVP_{CARBOB} \cdot \text{EtOH} + 0.06623 \cdot T50_{CARBOB} \cdot \text{EtOH} - \\ & 0.05519 \cdot T90_{CARBOB} \cdot \text{EtOH} + 0.03607 \cdot RVP_{CARBOB} \cdot T90_{CARBOB} \end{aligned}$$

where,

$T50_{FG}$ is the T50 of the finished gasoline, in degrees F,

EtOH is the ethanol content of the finished gasoline, including the denaturant, in vol.%,

RVP_{CARBOB} is the RVP of the CARBOB, in psi,

$T50_{CARBOB}$ is the T50 of the CARBOB, in psi,

$T90_{CARBOB}$ is the T90 of the CARBOB, in psi.

ii. Model for $9\% \leq \text{EtOH} \leq 10\%$

$$\begin{aligned} T50_{FG} = & 559.276 - 0.5431 \cdot RVP_{CARBOB} - 4.1884 \cdot T50_{CARBOB} - \\ & 0.3957 \cdot T90_{CARBOB} + 0.01482 \cdot T50_{CARBOB}^2 - \\ & 0.05309 \cdot T50_{CARBOB} \cdot RVP_{CARBOB} + \\ & 0.02884 \cdot T90_{CARBOB} \cdot RVP_{CARBOB} \end{aligned}$$

where,

$T50_{FG}$ is the T50 of the finished gasoline, in degrees F,

EtOH is the ethanol content of the finished gasoline, including the denaturant, in vol.%,

RVP_{CARBOB} is the RVP of the CARBOB, in psi,
 T50_{CARBOB} is the T50 of the CARBOB, in psi,
 T90_{CARBOB} is the T90 of the CARBOB, in psi.

Note that there is a T50 CARBOB model only for CARBOB ethanol contents greater than or equal to 4.0 percent. If the ethanol content of the CARBOB is less than 4.0 percent the CARBOB model can not be used.

C. T90 Model

$T90_{FG} = 1.493 + 0.964 * T90_{CARBOB} + 0.0468 * T50_{CARBOB} - 0.473 * EtOH$
 where,

T90_{FG} is the T90 of the finished gasoline, in degrees F,
 T90_{CARBOB} is the T90 of the CARBOB, in psi,
 T50_{CARBOB} is the T50 of the CARBOB, in psi,
 EtOH is the ethanol content of the finished gasoline, including the denaturant, in vol.%.

D. Aromatic Content Model

$AROM_{FG} = ((1 - (EtOH * 0.01)) * AROM_{CARBOB}) + (EtOH * 0.01 * AROM_{EtOH})$
 where,

AROM_{FG} is the aromatic content of the finished gasoline, in vol.%,
 EtOH is the ethanol content of the finished gasoline, including the denaturant, in vol.%,
 AROM_{CARBOB} is the aromatic content of the CARBOB, in vol.%,
 AROM_{EtOH} is the aromatic content of the ethanol, in vol.%.

E. Olefin Content Model

$OLEF_{FG} = ((1 - (EtOH * 0.01)) * OLEF_{CARBOB}) + (EtOH * 0.01 * OLEF_{EtOH})$
 where,

OLEF_{FG} is the olefin content of the finished gasoline, in vol.%,
 EtOH is the ethanol content of the finished gasoline, including the denaturant, in vol.%,
 OLEF_{CARBOB} is the olefin content of the CARBOB, in vol.%,
 OLEF_{EtOH} is the olefin content of the ethanol, in vol.%.

F. Benzene Content Model

$$\text{BENZ}_{\text{FG}} = ((1 - (\text{EtOH} \cdot 0.01)) \cdot \text{BENZ}_{\text{CARBOB}}) + (\text{EtOH} \cdot 0.01 \cdot \text{BENZ}_{\text{EtOH}})$$

where,

BENZ_{FG} is the benzene content of the finished gasoline, in vol.%,
 EtOH is the ethanol content of the finished gasoline, including the denaturant, in vol.%,

$\text{BENZ}_{\text{CARBOB}}$ is the benzene content of the CARBOB, in vol.%,

$\text{BENZ}_{\text{EtOH}}$ is the benzene content of the ethanol, in vol.%.

G. Sulfur Model

$$\text{SULF}_{\text{FG}} = \{((1 - (\text{EtOH} \cdot 0.01)) \cdot \text{SULF}_{\text{CARBOB}} \cdot 0.718) + (\text{EtOH} \cdot 0.01 \cdot \text{SULF}_{\text{EtOH}} \cdot 0.788)\} / \{((1 - (\text{EtOH} \cdot 0.01)) \cdot 0.718) + (\text{EtOH} \cdot 0.01 \cdot 0.788)\}$$

where,

SULF_{FG} is the sulfur content of the finished gasoline, in ppm,
 EtOH is the ethanol content of the finished gasoline, including the denaturant, in vol.%,

$\text{SULF}_{\text{CARBOB}}$ is the sulfur content of the CARBOB, in ppm by wt.,

$\text{SULF}_{\text{EtOH}}$ is the sulfur content of the ethanol, in ppm by wt.

4. DETAILED APPLICATION OF THE CARBOB MODEL EQUATIONS

This section will provide a step-by-step explanation of how the CARBOB model equations are used and how the outputs from the CARBOB model are input into the Predictive Model equations.

The first step in the process is for the user to decide if he is interested in using the evaporative emissions model element of the Phase 3 predictive model (if he is complying with the Phase 3 regulations). If the Phase 2 regulations are applicable, this step is not applicable because there is no evaporative emissions element associated with the Phase 2 predictive model. The user generally will not be interested in using the evaporative emissions model element of the Phase 3 predictive model if he is interested in complying with a flat 7.0 psi RVP limit instead of a limit less than 6.9 psi, or greater than 7.0 psi.

The next step in the use of the CARBOB model is for the user to specify the properties of the ethanol that is to be blended into the CARBOB. The ethanol properties to be specified are: 1) the aromatic content (vol.%), 2) the olefin content (vol.%), 3) the sulfur content (wt. ppm), and 4) the benzene content (vol.%). If the user does not specify values for the ethanol properties, the CARBOB model uses default property values. The default property values are shown in Table 1 below. If the user specifies

values for the ethanol properties, they are to be specified to the same number of decimal places as is shown for the default properties.

Table 1
Default Ethanol Properties Values Used in the CARBOB Model

Property	Default Property
Aromatic content	1.7 vol. %
Olefin content	0.5 vol. %
Sulfur content	10 ppmw
Benzene content	0.06 vol. %

After the user specifies the ethanol properties (or elects to use the default ethanol property values), he specifies the values of the properties of the CARBOB and the ethanol content (including the denaturant) of the finished gasoline. The values of the CARBOB properties and ethanol content are specified to the number of decimal places shown in Table 2.

Table 2
Fuel Properties Specified in CARBOB Model

Fuel Property	Units	Decimal Places
Reid vapor pressure (RVP)	psi, max.	0.01
T50 Distillation Temperature (T50)	deg. F, max.	1.0
T90 Distillation Temperature (T90)	deg. F, max.	1.0
Aromatics Content	vol. %, max.	0.1
Olefin Content	vol. %, max.	0.1
Ethanol Content	vol. %, max.	0.1
Sulfur Content	ppmw, max.	1.0
Benzene Content	vol. %, max.	0.01

The user then uses the CARBOB model equations shown in Section 3 above and the values for each CARBOB property, ethanol property, and the ethanol content of the finished gasoline, to compute, for each property for which there is a CARBOB model, the corresponding property for the finished gasoline. The value for each property of the finished gasoline is then input into either the Phase 2 or Phase 3 predictive model as the predictive model candidate gasoline. The use of the Phase 2 or Phase 3 predictive model is dictated by which regulations are in effect or applicable to the user at the time. The applicable Predictive Model then evaluates the emissions equivalency of the predictive model candidate gasoline in accordance with the process described in the Phase 2 and Phase 3 Predictive Model Procedures.

Shown in Table 3 on the next page is a worksheet which includes a step-by-step process to illustrate the use of the CARBOB procedures and to assist the user in using the CARBOB model. The worksheet in Table 3 assumes that the user is complying with the Phase 3 regulations, but the same process would be used if the user were

complying with the Phase 2 regulations. Only Step 5 in the process shown in Table 3 would be different if the user were complying with the Phase 2 gasoline regulations. In that case, the user would compare his predictive model candidate gasoline to the applicable Phase 2 limits instead of the Phase 3 limits.

Table 3
Worksheet for Computing Finished Gasoline Properties from CARBOB Properties

Step 1: Do you elect to use the evaporative emissions model element of the Phase 3 Predictive Model? Yes (Y) or No (N) _____

Step 2: Specify the properties of the ethanol, or use the default values in the table below.

Property	Specified Value	Default Value
Aromatic content (vol.%)		1.7
Olefin content (vol.%)		0.5
Sulfur content (ppmw)		10
Benzene content (vol.%)		0.06

Step 3: Specify the ethanol content, including the denaturant, in volume percent, of the finished gasoline. Ethanol content = _____ vol. percent.

Step 4: Enter in the table below the values of the CARBOB properties. For these CARBOB property values, and the ethanol properties specified in Step 2, and the ethanol content specified in Step 3, use the CARBOB model equations shown in Section 3 to compute the properties of the finished gasoline. Enter both the CARBOB values and the predicted finished gasoline values in the table below.

Property	CARBOB Value	Predicted Finished Gasoline Value
RVP (psi)		
T50 (deg. F)		
T90 (deg. F)		
Aromatics (vol.%)		
Oxygen as Ethanol (max.) (vol.%)	Not Specified by User	
Oxygen as Ethanol (min.) (vol.%)	Not Specified by User	
Sulfur (ppmw)		
Benzene (vol.%)		

Step 5: Complete Table 7 of the Phase 3 Predictive Model Procedures by entering into column 2 (Candidate Fuel Specifications) of Table 7 of the Phase 3 Predictive Model Procedures the predicted finished gasoline property values from Step 4. For convenience, Table 7 of the Phase 3 Predictive Model Procedures is shown on the next page. Proceed with the evaluation of the candidate fuel in accordance with the requirements specified in the Phase 3 predictive model Procedures.

Table 4
(Table 7 of Predictive Model Procedures)
Optional Worksheet for Candidate and Reference Fuel Specifications

Does the applicant wish to use the evaporative HC emissions model and the CO adjustment factor in the evaluation of the equivalency of the candidate fuel specifications? YES ___ NO ___

If the above question is answered yes, the flat RVP limit is 6.90 psi and the RVP cap is 7.20 psi. If the above question is answered no, 7.00 psi is the flat RVP limit and the candidate fuel RVP specification.

Fuel Property	Candidate Fuel ¹ : Specifications	Compliance Option: Flat or Average	Reference Fuel: Phase 3 RFG Specifications	
			(Circle Option Chosen)	
			Flat	Average
RVP		Flat	6.90 ⁵ / 7.00	None
Sulfur			20	15
Benzene			0.80/1.00 ⁶	0.70
Aromatic			25.0/35.0 ⁶	22.0
Olefin			6.0	4.0
Oxygen ² (Total)	(min)	Flat-Range	(min)	None
	(max)		(max)	
Oxygen ³ (as MTBE)	(min)	Not Applicable	Not Applicable	None
	(max)			
Oxygen ⁴ (as EtOH)	(min)	Not Applicable	Not Applicable	None
	(max)			
T50			213/220 ⁶	203
T90			305/312 ⁶	295

note: Footnotes are on the next page

Footnotes for Table 4

- 1 The fuel property value must be within or equal to the cap limit.
- 2 If the oxygen content range for the candidate fuel is 1.8 and 2.2, the candidate fuel and reference fuel oxygen value used in the predictive model equation is 2.0. For all other cases, see Table 6, Candidate and Reference Specifications for Oxygen.
- 3 The oxygen content (as MTBE) is reported because the hot soak evaporative benzene emissions model includes an MTBE content term (See VIII.A.2).
- 4 The oxygen content (as EtOH) is reported because the exhaust formaldehyde and the exhaust acetaldehyde models include EtOH content terms for the predictions for the candidate fuel specifications (See VI.A.1.c & d., VI.A.2.c & d., VI.A.3.c & d.). The EtOH content term is not included in the exhaust formaldehyde and acetaldehyde predictions for the reference fuel specifications because it is assumed that, for the reference fuel specifications, MTBE is the oxygenate used to meet the oxygen requirement.
- 5 If the applicant elects to use the evaporative HC emissions models, the flat RVP limit is 6.90. That is, all predictions for evaporative emissions increases or decreases are made relative to 6.90 psi. If the applicant has elected not to use the evaporative HC emissions models, the flat RVP limit is 7.00. The exhaust models contain an RVP term, but this term has been made constant by fixing the RVP for both the reference and candidate fuels at 7.00 psi in the calculation of the standardized RVP values used in the exhaust emissions equations. This fixing of the RVP takes RVP out of the exhaust models as a fuel property which effects exhaust emissions.
- 6 The higher value is the small refiner CaRFG flat limit for qualifying small refiners only, as specified in section 2272.

Table 3 shows that the oxygen content is not specified in the CARBOB model by the user. The user specifies only the ethanol content of the finished gasoline, which is used in the CARBOB model equations to calculate the properties of the finished gasoline. As shown by the CARBOB model equations shown in Section 3, the ethanol content of the finished gasoline is used in all the CARBOB model equations except RVP.

The oxygen content of the finished gasoline is specified by the user when using either the Phase 2 or the Phase 3 predictive model. The user specifies in the predictive model an oxygen content range. The oxygen content range is specified when all other properties of the predictive model candidate fuel are specified, as shown in Table 4 above. For a more detailed discussion of the specification of the oxygen content range for predictive model candidate fuels, see the Predictive Model Procedures document.

After the CARBOB model predictions have been made and entered into the predictive model, all evaluations of the finished gasoline predictive model candidate fuel are made in accordance with the provisions of the Predictive Model Procedures.

Appendix C

Denatured Ethanol

PROPOSED SPECIFICATIONS FOR DENATURED ETHANOL

A. RFA's Ethanol Producers Survey

The Renewable Fuels Association (RFA) has conducted a survey of ethanol producers within its membership. The objective of the survey was to obtain information regarding the sulfur content in denatured ethanol and certain hydrocarbons in the denaturants. The survey included forty-three companies that operated ethanol production facilities. Of the facilities surveyed, the RFA received data from twenty-seven that have a total production capacity of 1.42 billion gallons per year. The data covers production capacity representing 81 percent of the fuel ethanol production capacity in the United States. RFA presented its findings from its survey at the June 15, 2000, workshop on relating issue to the California Phase 3 reformulated gasoline regulations. A copy of the RFA's reports on the ethanol producer survey has been included as part of this appendix. Also included is the information the manufacture, properties and specifications of denatured ethanol presented by the RFA at the May 4, 2000 public workshop.

B. ASTM Specifications for Denatured Ethanol

ASTM D4806 requires that the only denaturants used for fuel ethanol shall be natural gasoline, gasoline components, or unleaded gasoline at a minimum concentration of two parts by volume per 100 parts by volume of fuel ethanol (2.0 volume percent). The use of hydrocarbons with an end point higher than 437 °F are prohibited. The denaturants permitted may be included as part of the 10 volume percent denatured fuel ethanol blended with a gasoline if they do not exceed five parts per volume 100 parts by volume (4.8 volume percent) of fuel ethanol. The use of methanol, pyrroles, turpentine, ketones and tars are prohibited. Denatured ethanol must conform to the performance requirements specified in ASTM D 4806-99.

C. Test Methods

There currently is a test method for sulfur in ethanol and no test methods for measuring benzene, olefins, or aromatics. The ARB's Monitoring & Laboratory Division (MLD) is coordinating a robin round series of tests between participating laboratories to evaluate ASTM D5453 for determining the sulfur content in denatured ethanol. It is anticipated that ASTM D5453 test method will be suitable to accurately measure the sulfur content in ethanol. However, because there are no comparable test methods applicable to measure benzene, olefins, and aromatics at the concentration levels of these compounds that are found in denatured ethanol. Therefore, it has been suggested that the concentration of these compounds in denatured ethanol will be calculated using the concentration of these compounds found in the denaturant. The test methods to be used for testing the denaturants are the ones specified in the CaRFG regulations for determining compliance. Table C-1 lists the test method currently available for determining compliance to the proposed specifications for denatured ethanol and denaturants.

**Table C-1
Test Methods**

Specification	Test Method
Sulfur in Ethanol	ASTM D 5453-00
Benzene in Denaturant	ASTM D 5580-00
Olefins in Denaturant	ASTM D 6550-00
Aromatics in Denaturant	ASTM D 5580-00

D. Proposed Specifications

The staff is not proposing to set a limit on the sulfur of the denaturant to provide more flexibility to the ethanol producers. The result of the RFA survey shows that the sulfur contents in undenatured ethanol ranged from 1 ppm to 11 ppm. The specifications would allow producers that have lower sulfur content in the undenatured ethanol to use denaturants with high sulfur content. Table C-2 shows what the sulfur content of denatured ethanol would be if a denaturant with 60 ppm sulfur were used to denature the ethanol.

**Table C-2
Final Sulfur Levels in Denatured Ethanol
For Different Addition Levels of Denaturant**

Undenatured Ethanol (Sulfur Content, ppm)	Denatured Ethanol ¹ (Sulfur Content, ppm)	
	2.0% Denaturant ²	4.8% Denaturant ²
8	9	10
9	10	11
10	11	12
11	12	13
12	13	14
13	14	15

1. Assumes that the denaturant has a sulfur level of 60 ppm.

2. Federal regulations and ASTM standards require a minimum denaturant concentration of 2 vol.% and a maximum concentration of 4.8 vol.%

Table C-3 demonstrates that the sulfur content of the denaturant used by ethanol producers could vary widely depending upon the sulfur content of the undenatured ethanol.

Table C-3
Amount Of Sulfur in Denaturant For Different Addition Rates
Without Exceeding the 10 or 15 ppm Limit for Denatured Ethanol

Sulfur Content of Undenatured Ethanol	Sulfur Content of Denaturant to Produce a Denatured Ethanol with 10 ppm Sulfur Content		Sulfur Content of Denaturant to Produce a Denatured Ethanol with 15 ppm Sulfur Content	
	2.0% Denaturant	4.8% Denaturant	2.0% Denaturant	4.8% Denaturant
1	451	189	701	293
2	402	169	652	273
3	352	149	603	253
4	304	129	554	233
5	255	109	505	213
6	206	89	456	194
7	157	70	407	174
8	108	50	358	154
9	59	30	309	134
10	10	10	260	114
11	--	--	211	90
12	--	--	162	75
13	--	--	113	55
14	--	--	64	35
15	--	--	15	15

**DENATURED FUEL ETHANOL
MANUFACTURE, PROPERTIES AND
SPECIFICATIONS**

**PRESENTED AT THE CALIFORNIA PHASE 3
REFORMULATED GASOLINE REGULATIONS WORKSHOP**

MAY 4, 2000

Carl F. Reeder

Archer Daniels Midland Co.

Chairman, Renewable Fuels Association Technical Committee

U. S. FUEL ETHANOL PRODUCTION

12 Corn Wet Milling Plants

31 Corn Dry Milling Plants

9 Other Sources (Wheat, cheese whey,
potato, beverage and wood waste)

Wet Mills - 63 % of Production

Dry Mills - 35 % of Production

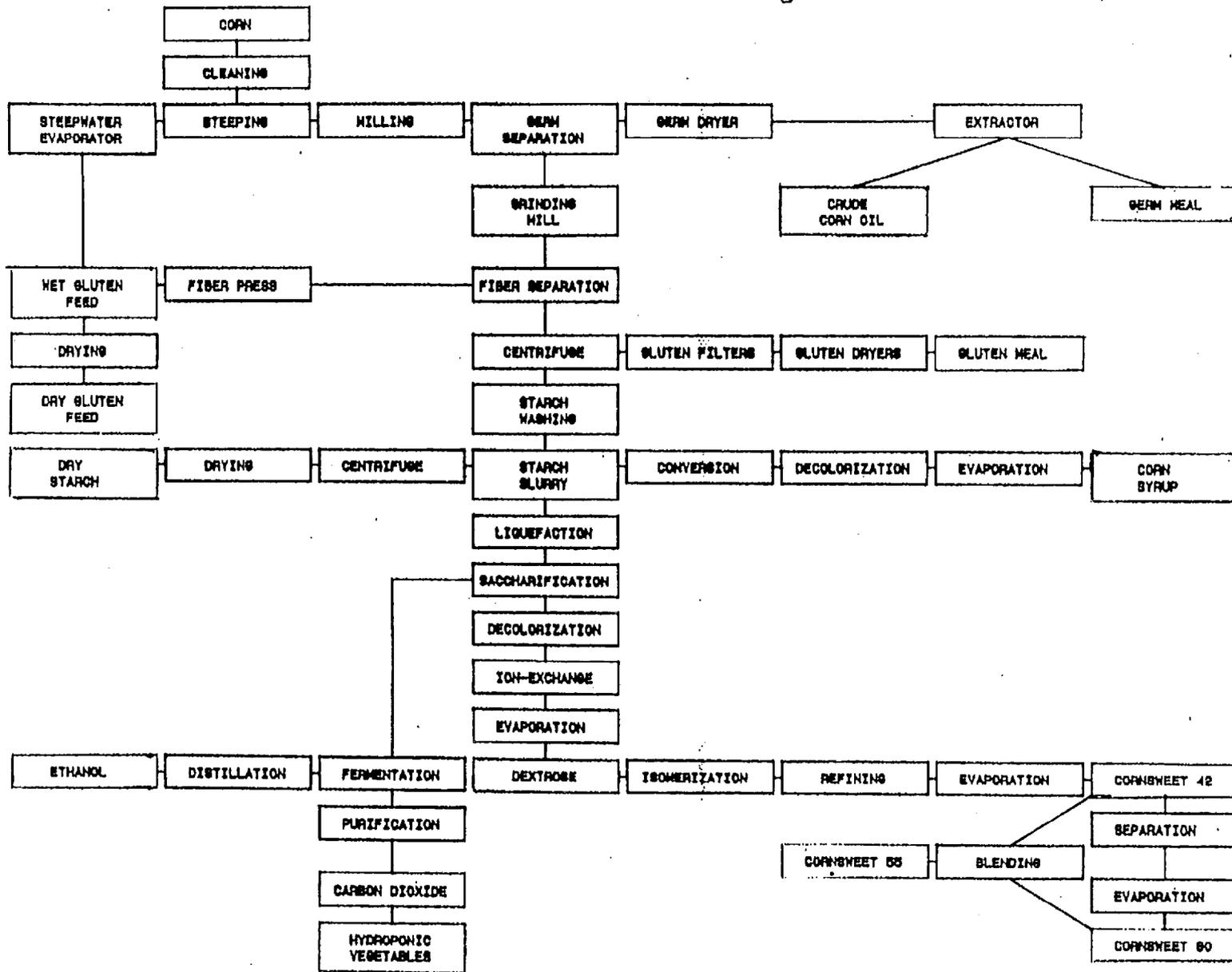
Other - 2 % of Production

SULFUR IN FUEL ETHANOL

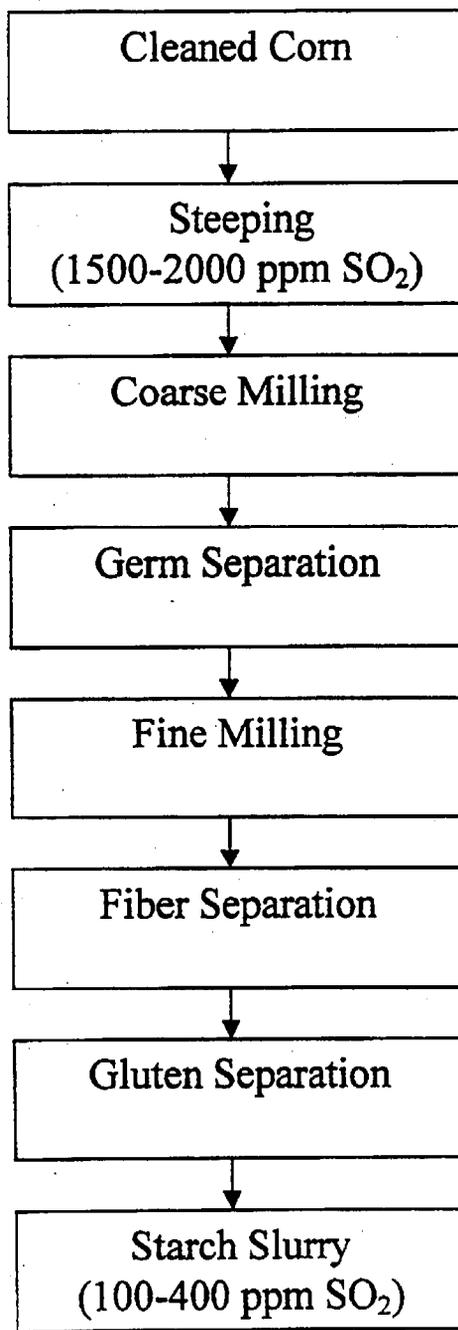
SOURCES OF SULFUR

1. Ethanol Production Process
2. Denaturant

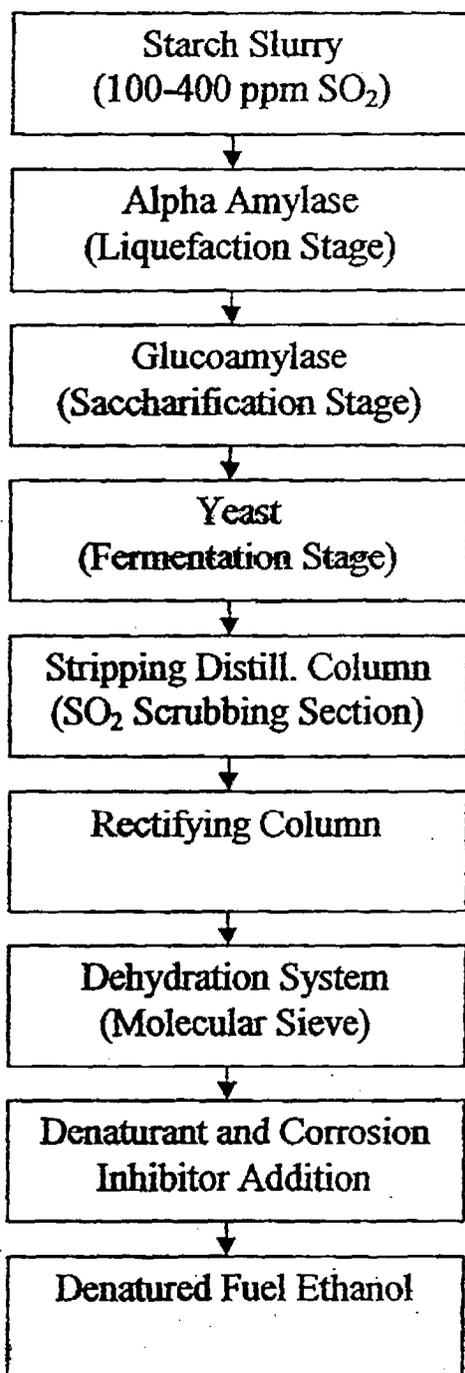
Corn Wet Milling Process



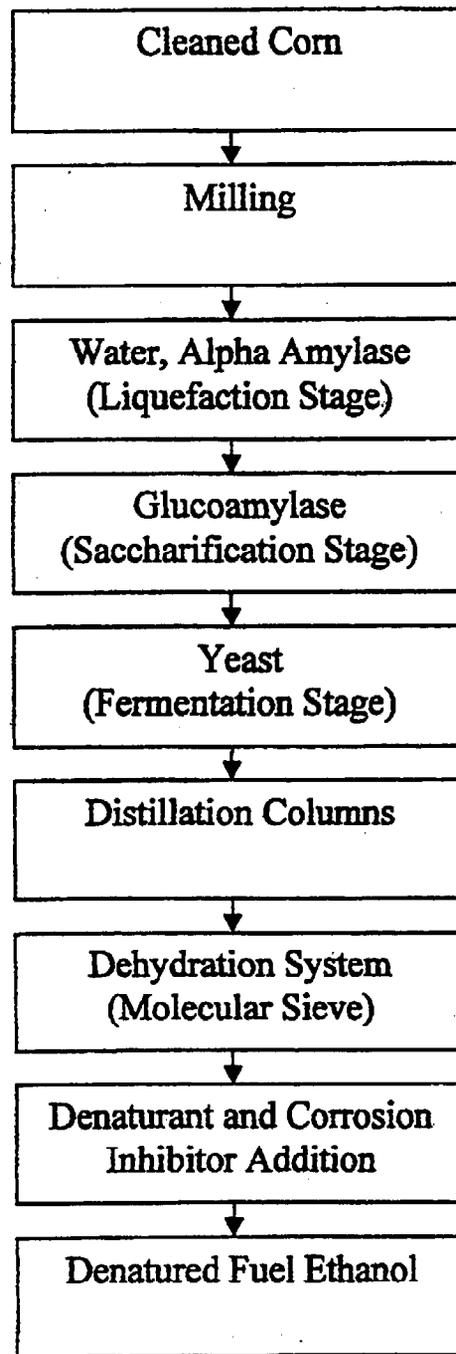
Corn Wet Milling Process



Corn Wet Milling Ethanol Process



Corn Dry Milling Ethanol Process



**DENATURED FUEL ETHANOL
TYPICAL COMPOSITION**

Ethanol, volume %	94.5
Other Fermentation Alcohols, volume %	0.3
Denaturant, volume %	4.6
Water, volume %	0.6
Acidity (as acetic acid) mass %	0.004
Solvent Washed Gum, mg/100mL	2
pHe	7.0
Chloride Content, mg/L, max.	2
Copper Content, mg/kg, max.	Not Detectable
Appearance	Clear and Bright
Corrosion Inhibitor	20 to 30 lbs/1000 bbl

CORROSION INHIBITOR IN DENATURED ETHANOL

The Renewable Fuels Association (RFA) recommends that all fuel ethanol producers add a corrosion inhibitor to all of their fuel ethanol production.

OBJECT: To provide corrosion protection from points of distribution and storage to final ethanol/gasoline use.

USAGE: The corrosion inhibitors approved by the RFA provide fuel ethanol a B+ or better rust rating when tested by NACE TM-01-72 method.

SUMMARY: Field surveys show that the industry is producing ethanol with virtually 100% having NACE rust ratings of A. No samples are below B+ rating.

DENATURED FUEL ETHANOL**TYPICAL PROPERTIES**

Gravity, API	47.5
Specific Gravity, 60°F	0.7905
Pounds/Gal., 60°F	6.58
Vapor Pressure, 100°F, psi	4.0
Blending Vapor Pressure, 5.7 to 10% in gasoline, psi	18
Oxygen Content, wt. %	33
Color	Colorless
Appearance	Clear, Free of Suspended Matter

FUEL ETHANOL DENATURANTS

Denaturant Definition Specific to D4806 - natural gasoline, gasoline components, unleaded gasoline or toxic or noxious materials added to fuel ethanol to make it unsuitable for beverage use but not unsuitable for automotive use.

**PROPERTIES OF NATURAL GASOLINE
HISTORICALLY AVAILABLE FOR
DENATURING OF ETHANOL**

Color, Saybolt	+25 to +30
API Gravity	80 - 85
RVP @ 100°F, psi	13 - 14
Sulfur, ppm	60 - 160
Research octane number	76
Motor octane number	74
Distillation °F, Typical	
1 BP - 92	
10% - 105	
20% - 110	
50% - 125	
90% - 185	
FBP - 265	
Benzene, volume %	0.3 - 0.5
Olefins, volume %	0.1 - 0.8
Aromatics, volume %	1.0 - 2.6

**FUEL ETHANOL PRODUCERS' RESPONSE
TO CaRFG3 PROPOSED SPECIFICATION**

1. The ARB & industry need to review test methods associated with the proposed aromatic, benzene and olefin limits.
2. The ethanol industry is anxious to work with CARB and ASTM to verify an appropriate test method for sulfur in fuel ethanol.
3. It is inappropriate for the ethanol industry to commit to a sulfur specification today. Data from the supplier survey is scattered, the test methods are not known, denaturant sulfur levels are not known and several of the producers have not responded to the survey.
4. We cannot comment today on a sulfur specification until the second RFA survey is completed. We can respond at the next CARB workshop.

REPORT ON ETHANOL PRODUCERS SURVEY

**PRESENTED AT THE CALIFORNIA PHASE 3
REFORMULATED GASOLINE REGULATION WORKSHOP**

JUNE 15, 2000

Carl F. Reeder

Archer Daniels Midland Co.

Chairman, Renewable Fuels Association Technical Committee

ETHANOL PRODUCERS SURVEY

Requested by the Board of Directors of the Renewable Fuels Association (RFA).

Objective: To ascertain from producer reports the sulfur content of ethanol and certain hydrocarbons in the denaturants. This information will provide a basis for responding to the establishment of specifications for fuel ethanol by regulatory agencies.

Survey conducted during May and June, 2000 by Edward D. Heffernan, General Counsel of the RFA. There is a possibility of receiving additional reports and as they are received minor modifications will be made in the data.

All data reported has remained proprietary. Test results have been reported by the producer only to Mr. Heffernan who summarized the data and reported it to the RFA office.

ETHANOL PRODUCERS SURVEY

A questionnaire was sent to 43 companies that operate single or multiple fuel ethanol plants.

The questionnaire form asked for the sulfur content of the producer's undenatured and denatured ethanol. The sulfur, benzene, olefin and aromatic content of the denaturant used by the producer was also requested.

The respondents to the survey form sent single samples of undenatured ethanol, denatured ethanol and the denaturant to independent petroleum testing laboratories for analysis.

Test results were reported by the testing laboratory to the producer who then reported them to Mr. Heffernan.

ETHANOL PRODUCERS SURVEY

Test Methods:

Sulfur in Ethanol	-----	ASTM D5453
Sulfur in Denaturant	-----	ASTM D2622
Benzene in Denaturant	-----	ASTM D3606 or IR
Olefins in Denaturant	-----	ASTM D1319
Aromatics in Denaturant	-----	ASTM D5769

The information shown in the following table is based upon data received from 27 plants that have a total production capacity of 1.42 billion gal/yr. This response represents 81% of the 1.75 billion gallons of yearly production capacity of the ethanol industry.

INFORMATION REPORTED BY PRODUCERS

<u>Information Requested</u>	<u>Average</u>	<u>Range</u>
Sulfur content of the undenatured ethanol	2.9 ppm mass	1 -11 ppm mass
Sulfur content of the denatured ethanol	8.7 ppm mass	2.1 - 27.2 ppm mass
Sulfur content of the currently used denaturant	127.7 ppm mass	9.1-733.9 ppm mass
Benzene content of the denaturant	0.63 vol. %	0.01 - 1.94 vol. %
Olefin content of the denaturant	0.55 vol. %	0.02 - 2.1 vol. %
Aromatic content of the denaturant	1.33 vol. %	0.05 - 6.6 vol. %

Note: The above represents 81% of 1.75 billion gallons of yearly production capacity in the ethanol industry.

ETHANOL PRODUCERS SURVEY

The ethanol industry requires flexibility in the choice of denaturants. Currently nearly 100% of the denaturant used is natural gasoline. Other denaturants may be options in the future.

CaRFG3 gasoline is proposed to have a cap limit of 1.10% benzene, 10% olefins and 35% aromatics.

For producer flexibility, the benzene, olefin and aromatic limits in fuel ethanol should be set to allow for the possibility of using CaRFG3 gasoline as a denaturant.

ETHANOL PRODUCERS SURVEY

COMMENTS AND SUMMARY:

The Renewable Fuels Association has completed a survey of the U.S. fuel ethanol producers. The RFA response to proposed specifications of key properties is based upon replies from companies representing 81% of the current fuel ethanol production capacity.

The test data reported represents only one sample from each reporting producer. It is not known how much variation in the reported values there would be over a long production period.

Also, the test method for sulfur ASTM D5453, does not include ethanol in the scope of applicability. Therefore, no precision for repeatability and reproducibility has been determined for the use of this method for total sulfur content in ethanol.

CARB is considering setting a lower sulfur standard for ethanol than for gasoline on the basis that ethanol is not a motor fuel but a fuel component. However, with Ed-85, ethanol is the motor fuel and gasoline is the blend component. It is appropriate that the sulfur standard (flat limit) for ethanol be the same as the average limit for gasoline.

A degree of tolerance must be incorporated into specifications based upon the reported numbers because of the lack of analytical data on multiple production samples and lack of precision information on the D5453 test method. Uniformity of the gasoline and ethanol specifications is also a factor.

Based upon the foregoing, the RFA suggests the following specifications for fuel ethanol that is blended to produce CaRFG3 gasoline:

Sulfur, max.	—————	15 ppm mass
Benzene, max.	—————	0.10 vol. %
Olefins, max.	—————	0.50 vol. %
Aromatics, max.	—————	1.70 vol. %

Appendix D

Development of the CARBOB Model

Development of the CARBOB Model
Example Computer Code and Output for the Development of the CARBOB Model

1. Example Computer Code
2. Example Output

Example Computer Code

```

libname data 'c:\sas\sasprogs\carbob';
options nodate pageno=1 ps=500;
data temp;
input Fuel $ RVPBase T10Base T50Base T90Base RVP EtOH T10 T50 T90;
cards;
1      11.4000 107.000 215.00 329.00 12.300 5.4300 108.00 199.00 324.00
2      11.3000 104.000 217.00 311.00 11.900 5.300 103.00 208.00 311.00
3      11.9000 107.000 205.00 317.00 12.500 5.5500 112.00 202.00 320.00
4      11.5000 110.000 191.00 305.00 12.300 5.3200 109.00 182.00 305.00
5      7.3300 126.600 200.600 310.600 8.4100 5.200 132.200 195.800 311.100
6      7.4700 143.00 236.00 315.00 8.5300 5.1100 130.00 231.00 312.00
7      7.4600 134.900 202.200 320.100 8.5200 5.1700 126.00 195.00 318.00
8      7.5900 137.400 232.500 309.900 8.4800 5.2500 126.100 226.400 307.000
9      7.0000 138.200 213.900 314.600 8.0500 4.7100 127.700 207.100 311.700
10     7.8400 127.400 232.500 317.400 8.8100 5.300 124.300 229.600 315.500
11     7.2200 130.000 204.000 320.000 8.3600 5.1700 123.000 197.000 318.000
12     7.7100 134.900 204.400 315.800 8.9500 4.6900 119.400 194.900 312.000
13     7.1600 149.000 242.900 318.900 8.1900 4.9700 132.600 237.200 316.700
14     7.6000 134.200 209.300 324.600 8.5800 4.8500 125.700 203.300 322.500
15     7.4600 137.100 232.500 311.300 8.5300 4.600 126.300 228.200 308.300
16     6.6300 136.500 204.900 314.900 7.6200 4.7900 130.400 201.500 314.400
17     7.1400 137.400 213.000 314.700 8.1200 5.1800 129.900 210.000 315.600
18     7.1700 137.800 223.100 315.300 8.1600 5.2500 129.300 215.600 313.100
19     7.6700 132.400 221.100 315.800 8.5900 5.5500 124.100 214.100 313.300
20     7.0700 142.100 240.600 321.000 8.2900 5.1300 129.300 231.800 316.700
21     7.2200 133.300 203.100 312.600 8.3100 5.4400 124.100 191.400 307.900
22     7.7600 133.700 205.500 317.300 8.7400 5.300 122.100 195.200 314.600
23     7.4000 133.100 193.600 312.400 8.5200 5.3100 125.400 186.200 310.800
24     7.5900 132.800 207.800 312.600 8.7800 5.3100 125.000 199.000 310.400
25     7.2700 134.700 204.200 313.500 8.5200 5.1900 126.100 195.600 311.100
26     7.7200 130.200 197.400 312.000 8.7300 5.300 122.300 189.800 309.700
27     8.0600 140.000 238.000 335.000 8.8600 5.4800 128.800 231.800 332.600
28     7.8800 134.600 229.200 332.400 8.700 5.3800 127.400 221.300 330.000
29     7.4300 138.300 233.700 325.700 8.4100 5.4600 130.600 228.000 324.500
30     7.6600 140.000 237.900 328.200 8.600 5.3400 132.000 233.700 329.500
31     7.9400 138.700 246.300 325.700 8.7800 5.3900 131.500 238.100 323.700
32     6.9000 149.700 245.100 333.800 8.3200 4.5600 133.800 239.500 331.300
33     7.4900 135.800 230.900 330.600 8.2900 5.8400 131.100 224.900 330.400
34     6.9100 139.100 217.500 321.900 7.8800 5.6900 130.400 211.200 321.200
35     7.0900 136.900 214.500 322.500 8.2100 5.300 127.900 209.300 320.300
36     7.3100 136.900 218.800 323.700 8.3400 5.2800 124.300 203.100 317.800
37     8.0700 136.500 227.600 331.100 8.8800 5.0800 129.300 222.000 328.800
38     7.8900 131.500 225.600 342.500 8.800 5.3500 126.500 219.500 342.800
39     14.3300 95.000 187.000 307.000 14.9400 9.400 96.000 152.000 296.000
40     14.1100 92.000 184.000 321.000 14.8200 9.400 97.000 151.000 315.000
41     14.2700 96.000 183.000 316.000 14.9400 9.300 99.000 150.000 312.000
42     14.0400 93.000 184.000 295.000 14.7700 9.500 99.000 150.000 282.000
43     13.5000 100.000 192.000 305.000 14.2700 9.400 101.000 153.000 298.000
44     14.1100 98.000 183.000 303.000 15.0300 9.300 98.000 150.000 296.000
45     14.2100 93.000 179.000 310.000 14.9700 9.600 96.000 148.000 298.000
46     14.0000 100.000 205.000 332.000 14.8200 9.300 97.000 159.000 329.000
47     11.5200 97.000 173.000 319.000 12.4700 9.200 107.000 148.000 316.000
48     13.8800 98.000 176.000 295.000 14.4900 9.000 96.000 147.000 289.000
49     11.8100 107.000 226.000 313.000 12.500 9.000 110.000 209.000 310.000
50     11.4600 105.000 182.000 303.000 12.2700 9.200 105.000 147.000 297.000
51     11.8500 102.000 179.000 327.000 12.6300 9.300 106.000 149.000 325.000

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52	12.8500	97.000	207.000	339.000	13.500	9.600	98.000	164.000	339.000
53	11.7900	103.000	186.000	329.000	12.600	9.600	107.000	151.000	322.000
54	12.4200	101.000	197.000	345.000	13.1300	9.600	102.000	156.000	341.000
55	12.4300	101.000	195.000	343.000	13.2400	9.200	101.000	152.000	336.000
56	11.3900	103.000	179.000	337.000	12.3100	9.300	106.000	149.000	335.000
57	6.5000	137.000	219.000	324.000	7.6600	9.100	132.000	208.000	322.000
58	6.6600	139.000	214.000	308.000	8.1200	9.400	131.000	201.000	302.000
59	6.7200	143.000	217.000	319.000	7.8800	9.400	132.000	206.000	315.000
60	6.7000	142.000	218.000	319.000	7.8600	8.800	131.000	202.000	314.000
61	6.1100	146.000	219.000	315.000	7.5300	9.100	134.000	209.000	312.000
62	6.7300	140.000	215.000	325.000	7.9200	9.400	127.000	190.000	321.000
63	6.8300	139.000	208.000	324.000	8.0500	8.900	127.000	188.000	319.000
64	6.8700	139.000	211.000	329.000	8.0600	9.300	127.000	184.000	316.000
65	6.4700	139.000	221.000	339.000	7.6900	9.100	132.000	204.000	336.000
66	6.4500	141.000	210.000	335.000	7.8600	9.000	130.000	188.000	327.000
67	6.6300	139.000	208.000	333.000	7.9500	9.000	129.000	187.000	327.000
68	6.2800	141.000	218.000	340.000	7.5600	9.000	130.000	204.000	333.000
69	6.3500	137.000	213.000	344.000	7.7600	9.300	132.000	200.000	338.000
70	6.8900	134.000	206.000	349.000	8.1500	9.100	128.000	184.000	345.000
71	6.7600	137.000	207.000	329.000	7.9500	9.200	130.000	188.000	320.000
72	6.7600	131.000	208.000	349.000	7.9500	9.000	127.000	190.000	345.000
73	6.5600	133.000	211.000	352.000	8.1400	8.800	127.000	184.000	346.000
74	6.4000	137.000	222.000	356.000	7.7600	9.200	127.000	198.000	350.000
75	7.0300	134.000	217.000	365.000	8.0900	9.600	127.000	197.000	355.000
76	6.5400	147.000	220.000	355.000	7.8200	9.200	129.000	203.000	351.000
77	6.7400	135.000	216.000	355.000	7.8900	8.800	129.000	199.000	347.000
78	6.5400	130.000	206.000	352.000	7.6600	9.700	141.000	222.000	356.000
79	6.4300	132.000	213.000	352.000	7.8800	9.000	129.000	195.000	347.000
80	6.7000	140.000	215.000	345.000	7.9500	9.400	129.000	195.000	339.000
81	6.7000	135.000	213.000	346.000	8.0500	9.500	127.000	197.000	346.000
82	6.7000	135.000	221.000	354.000	7.9600	9.300	128.000	200.000	350.000
83	6.4700	139.000	223.000	353.000	7.9200	8.900	130.000	202.000	349.000
84	7.1100	133.000	209.000	356.000	8.4600	9.200	125.000	177.000	347.000
85	6.7400	137.000	208.000	321.000	7.9800	9.000	129.000	191.000	318.000
86	6.5700	135.000	209.000	335.000	7.9300	9.400	127.000	184.000	332.000
87	6.5700	138.000	218.000	354.000	7.900	9.000	128.000	195.000	346.000
88	6.5400	139.000	215.000	344.000	7.9300	9.600	127.000	192.000	338.000
89	6.6100	138.000	211.000	332.000	7.8900	9.100	128.000	184.000	329.000
90	6.4700	135.000	215.000	352.000	7.8800	8.800	127.000	191.000	346.000
91	6.6100	136.000	216.000	348.000	7.8500	9.300	127.000	185.000	343.000
92	6.8700	133.000	212.000	352.000	8.0100	9.600	126.000	180.000	348.000
93	6.5100	138.000	212.000	339.000	7.7900	9.500	127.000	188.000	333.000
94	6.5800	132.000	217.000	349.000	7.7900	9.500	123.000	184.000	347.000
95	6.6700	132.000	208.000	337.000	7.9200	10.000	124.000	176.000	340.000
96	6.4500	128.000	211.000	355.000	7.7700	9.800	126.000	197.000	352.000
97	6.4500	134.000	217.000	352.000	7.800	9.400	128.000	190.000	344.000
98	6.5700	134.000	212.000	348.000	7.8200	9.800	129.000	190.000	342.000
99	6.4000	133.000	216.000	354.000	7.800	9.700	129.000	198.000	346.000
100	6.4300	132.000	208.000	348.000	8.0900	9.800	126.000	188.000	347.000
101	6.3100	138.000	221.000	357.000	7.8300	9.700	129.000	199.000	345.000
102	6.4100	142.000	217.000	352.000	7.700	8.500	130.000	197.000	345.000
103	6.5000	134.000	214.000	352.000	7.7900	9.600	127.000	187.000	346.000
104	6.5000	136.000	215.000	351.000	7.8500	9.500	128.000	192.000	348.000
105	6.4100	135.000	215.000	346.000	7.7900	9.700	128.000	193.000	344.000
106	6.2500	141.000	217.000	316.000	7.6900	9.300	131.000	204.000	313.000
107	6.3800	137.000	219.000	358.000	7.800	9.000	129.000	199.000	353.000
108	6.2500	128.000	217.000	349.000	7.400	9.400	129.000	209.000	351.000
109	9.3600	119.000	220.000	353.000	10.400	9.500	116.000	188.000	346.000
110	9.5900	117.000	203.000	330.000	10.7600	9.300	112.000	161.000	324.000

111	8.7200	124.000	227.000	349.000	9.7500	9.800	119.000	206.000	343.000
112	12.2100	105.000	215.000	338.000	13.0500	9.800	105.000	174.000	335.000
113	12.2300	101.000	191.000	334.000	12.9700	9.300	106.000	153.000	326.000
114	11.3400	111.000	188.000	303.000	12.3600	9.300	110.000	153.000	298.000
115	11.8900	104.000	184.000	335.000	12.9800	9.600	105.000	150.000	329.000
116	12.1700	105.000	186.000	344.000	13.0400	9.500	104.000	150.000	337.000
117	13.9200	99.000	182.000	308.000	14.7900	9.800	96.000	149.000	300.000
118	13.9200	93.000	176.000	311.000	14.7700	9.700	96.000	146.000	301.000
119	14.2300	93.000	179.000	354.000	14.9100	10.000	97.000	149.000	348.000
120	14.4500	92.000	195.000	344.000	14.9400	9.600	99.000	155.000	340.000
121	13.8700	94.000	165.000	291.000	14.6200	9.100	102.000	144.000	285.000
122	13.8700	92.000	186.000	297.000	14.8500	9.800	98.000	152.000	293.000
123	13.8700	97.000	166.000	317.000	14.5000	9.800	98.000	141.000	310.000
124	14.2400	95.000	175.000	361.000	14.8400	9.000	96.000	145.000	355.000
125	13.7900	95.000	180.000	340.000	14.6800	10.000	98.000	150.000	335.000
126	13.8900	94.000	172.000	338.000	14.8700	9.600	96.000	146.000	331.000
127	14.0500	90.000	176.000	352.000	14.7100	10.000	99.000	148.000	343.000
128	14.1400	93.000	179.000	340.000	14.8800	10.000	98.000	149.000	334.000
129	14.2400	96.000	175.000	339.000	14.8500	9.900	96.000	147.000	331.000
130	14.2900	92.000	171.000	345.000	14.9400	10.000	96.000	146.000	339.000
131	13.6600	97.000	166.000	312.000	14.4600	9.600	99.000	143.000	303.000
132	14.0400	91.000	165.000	346.000	14.7500	9.500	97.000	144.000	335.000
133	14.1400	96.000	169.000	340.000	14.8500	9.300	100.000	145.000	332.000
134	13.9700	97.000	181.000	346.000	14.6200	9.600	99.000	149.000	339.000
135	13.4600	98.000	170.000	298.000	14.1600	9.700	100.000	145.000	292.000
136	13.5800	96.000	189.000	342.000	14.6100	9.700	98.000	152.000	337.000
137	14.0300	98.000	176.000	294.000	14.8100	9.200	95.000	148.000	287.000
138	13.4900	97.000	182.000	345.000	14.2600	9.700	98.000	150.000	339.000
139	14.0700	96.000	180.000	340.000	14.7700	9.700	96.000	150.000	334.000
140	14.0000	95.000	184.000	344.000	14.5300	9.500	98.000	150.000	338.000
141	14.3300	93.000	181.000	348.000	14.9800	9.500	95.000	150.000	343.000
142	14.0000	96.000	181.000	326.000	14.8400	9.700	97.000	147.000	320.000
143	12.7300	102.000	200.000	352.000	13.4000	9.400	101.000	153.000	344.000
144	14.2400	92.000	212.000	307.000	14.8200	9.500	100.000	172.000	295.000
145	13.7900	95.000	209.000	339.000	14.2400	9.400	101.000	174.000	336.000
146	14.2300	93.000	212.000	342.000	14.7100	9.400	97.000	169.000	334.000
147	14.0400	94.000	213.000	337.000	14.6100	9.400	86.000	172.000	332.000
148	14.3900	93.000	204.000	307.000	14.9800	9.100	98.000	164.000	306.000
149	14.0700	94.000	212.000	328.000	14.7500	9.700	103.000	169.000	322.000
150	14.2600	94.000	210.000	324.000	14.9500	9.400	97.000	166.000	316.000
151	12.6300	101.000	227.000	352.000	13.3600	9.600	106.000	213.000	347.000
152	14.0800	96.000	215.000	338.000	14.8100	10.000	101.000	193.000	330.000
153	14.3900	93.000	209.000	320.000	14.9500	9.500	97.000	167.000	313.000
154	14.2300	91.000	212.000	327.000	14.8200	9.200	100.000	170.000	321.000
155	14.1000	92.000	211.000	325.000	14.7700	9.100	99.000	165.000	318.000
156	13.0000	104.000	173.000	317.000	13.8400	9.700	104.000	173.000	317.000
157	11.2300	109.000	213.000	309.000	12.1500	9.500	115.000	194.000	301.000
158	12.3400	104.000	220.000	334.000	13.0000	9.200	107.000	191.000	330.000
159	12.4000	99.000	220.000	352.000	13.0200	9.600	108.000	205.000	349.000
160	11.4700	109.000	220.000	350.000	12.4300	9.600	109.000	205.000	344.000
161	12.5500	104.000	223.000	352.000	13.0500	8.900	107.000	204.000	342.000
162	6.9000	144.000	219.000	306.000	7.9200	9.000	137.000	217.000	314.000
163	5.9600	154.000	226.000	327.000	7.1600	9.300	135.000	214.000	318.000
164	7.1400	141.000	222.000	331.000	8.5300	9.500	132.000	214.000	324.000
165	7.0800	142.000	228.000	333.000	8.1500	9.300	132.000	221.000	328.000
166	6.6000	148.000	221.000	316.000	7.9200	9.400	135.000	214.000	311.000
167	6.8500	144.000	219.000	305.000	7.9500	9.500	136.000	213.000	295.000
168	6.2900	146.000	224.000	338.000	7.5900	9.100	136.000	218.000	337.000
169	6.4100	154.000	227.000	343.000	7.6000	9.400	137.000	218.000	338.000

170	6.2900	148.000	222.000	330.000	7.5400	9.400	130.000	215.000	323.000
171	6.5300	138.000	219.000	331.000	7.6600	9.000	129.000	214.000	321.000
172	6.2400	146.000	221.000	339.000	7.4800	9.100	136.000	215.000	332.000
173	6.7200	141.000	222.000	342.000	7.900	9.100	136.000	214.000	336.000
174	6.4800	138.000	218.000	311.000	7.7700	9.100	136.000	210.000	306.000
175	6.3500	150.000	220.000	314.000	7.6100	8.900	139.000	214.000	310.000
176	6.6100	149.000	219.000	310.000	7.8200	9.600	136.000	212.000	305.000
177	6.6400	145.000	220.000	319.000	7.8600	9.700	130.000	211.000	316.000
178	6.4300	143.000	216.000	310.000	7.7500	9.700	137.000	211.000	307.000
179	6.7900	145.000	217.000	321.000	7.9800	9.200	131.000	200.000	311.000
180	6.2200	153.000	214.000	289.000	7.5700	9.300	137.000	207.000	282.000
181	6.9200	143.000	225.000	329.000	7.9300	9.000	132.000	215.000	323.000
182	6.5300	145.000	220.000	344.000	7.7500	9.300	137.000	218.000	336.000
183	6.5400	144.000	219.000	326.000	7.9200	9.700	136.000	214.000	321.000
184	6.4500	150.000	223.000	337.000	7.6700	9.200	137.000	216.000	334.000
185	6.5100	147.000	214.000	308.000	7.8900	9.500	134.000	206.000	299.000
186	6.3800	154.000	227.000	355.000	7.700	9.800	137.000	221.000	352.000
187	6.4300	148.000	223.000	339.000	7.5400	9.600	135.000	218.000	334.000
188	5.8200	145.000	222.000	338.000	7.2200	8.500	138.000	212.000	332.000
189	6.3100	139.000	226.000	334.000	7.7300	9.800	130.000	212.000	329.000
190	6.3700	145.000	222.000	328.000	7.3700	9.700	135.000	215.000	325.000
191	6.5400	149.000	224.000	345.000	7.500	9.500	135.000	216.000	336.000
192	6.4100	148.000	227.000	350.000	7.6700	9.400	135.000	218.000	344.000
193	6.2400	144.000	227.000	339.000	7.5100	9.800	136.000	221.000	337.000
194	10.1400	115.000	216.000	315.000	11.0700	9.400	112.000	199.000	314.000
195.1	6.9000	141.000	198.600	333.100	8.000	1.1600	128.600	195.400	327.000
195.2	6.9000	141.000	198.600	333.100	8.200	3.2300	126.100	192.300	326.100
195.3	6.9000	141.000	198.600	333.100	8.100	5.300	126.600	189.300	323.900
195.4	6.9000	141.000	198.600	333.100	8.100	9.3300	125.000	151.500	298.500
196.1	6.3000	145.900	208.700	278.700	7.400	1.3900	135.800	207.800	279.600
196.2	6.3000	145.900	208.700	278.700	7.500	3.4100	131.100	205.500	275.100
196.3	6.3000	145.900	208.700	278.700	7.600	5.2500	132.200	204.000	278.000
196.4	6.3000	145.900	208.700	278.700	7.500	9.6600	133.100	198.100	276.000
197.1	5.5000	157.100	224.200	296.900	6.700	1.1500	142.800	223.700	295.100
197.2	5.5000	157.100	224.200	296.900	6.700	3.500	137.600	222.400	296.900
197.3	5.5000	157.100	224.200	296.900	6.800	5.100	137.800	220.800	292.800
197.4	5.5000	157.100	224.200	296.900	6.800	9.8500	139.200	220.100	294.000
198.1	6.9000	139.600	194.900	302.500	7.900	1.2800	129.500	193.600	299.800
198.2	6.9000	139.600	194.900	302.500	8.000	3.3500	126.600	191.300	299.100
198.3	6.9000	139.600	194.900	302.500	8.000	5.4300	127.500	188.200	299.300
198.4	6.9000	139.600	194.900	302.500	8.000	9.8500	128.600	164.400	296.000
199.1	6.1000	147.900	211.200	315.800	7.100	1.4100	136.900	209.400	314.400
199.2	6.1000	147.900	211.200	315.800	7.200	3.4800	131.500	206.600	310.600
199.3	6.1000	147.900	211.200	315.800	7.300	5.5400	132.600	205.500	313.700
199.4	6.1000	147.900	211.200	315.800	7.200	9.6200	133.800	196.500	309.700
200.1	5.7000	154.500	225.100	286.700	6.700	1.2800	143.000	224.900	287.200
200.2	5.7000	154.500	225.100	286.700	6.800	3.3500	137.600	224.000	286.700
200.3	5.7000	154.500	225.100	286.700	6.900	5.3100	137.100	222.600	284.700
200.4	5.7000	154.500	225.100	286.700	6.900	9.8100	139.400	221.700	284.500
201.1	6.9000	140.000	196.300	317.300	7.800	1.4700	130.200	193.400	315.500
201.2	6.9000	140.000	196.300	317.300	7.900	3.4400	127.200	191.600	311.500
201.3	6.9000	140.000	196.300	317.300	7.900	5.6100	127.000	188.700	311.500
201.4	6.9000	140.000	196.300	317.300	7.900	9.7700	128.300	164.800	309.500
202.1	6.0000	148.400	211.600	295.700	7.000	1.2500	137.400	210.700	296.600
202.3	6.0000	148.400	211.600	295.700	7.100	3.2100	132.800	209.300	292.800
202.3	6.0000	148.400	211.600	295.700	7.200	5.3900	133.500	206.600	293.900
202.4	6.0000	148.400	211.600	295.700	7.200	9.6700	134.000	197.400	293.100
203.1	5.8000	151.300	223.800	292.200	6.700	1.3900	140.900	223.100	290.800
203.2	5.8000	151.300	223.800	292.200	6.900	3.2800	135.500	221.700	290.300

203.3	5.8000	151.300	223.800	292.200	6.900	5.4800	136.000	219.300	289.400
203.4	5.8000	151.300	223.800	292.200	6.900	9.7700	137.100	215.700	290.800
204.1	5.6000	149.000	202.000	307.000	6.7200	5.5800	134.000	199.000	302.000
204.2	5.6000	149.000	202.000	307.000	6.7200	6.7300	134.000	198.000	305.000
205.1	5.6500	150.000	202.000	311.000	6.7400	1.000	135.000	197.000	303.000
205.2	5.6500	150.000	202.000	311.000	6.5100	2.000	140.000	201.000	310.000
205.3	5.6500	150.000	202.000	311.000	6.8600	5.4500	133.000	197.000	307.000
205.4	5.6500	150.000	202.000	311.000	6.8500	6.7600	133.000	195.000	306.000
205.5	5.6500	150.000	202.000	311.000	6.7300	8.500	134.000	193.000	308.000
205.6	5.6500	150.000	202.000	311.000	6.700	10.000	134.000	191.000	308.000
206.1	5.5500	149.000	201.000	323.000	5.9800	1.000	144.000	204.000	322.000
206.2	5.5500	149.000	201.000	323.000	6.2700	2.000	138.000	204.000	317.000
206.3	5.5500	149.000	201.000	323.000	6.7700	5.3300	134.000	197.000	321.000
206.4	5.5500	149.000	201.000	323.000	6.800	6.6400	133.000	194.000	320.000
206.5	5.5500	149.000	201.000	323.000	6.5400	8.500	134.000	195.000	320.000
206.6	5.5500	149.000	201.000	323.000	6.500	10.000	135.000	195.000	320.000
207.1	5.6700	152.000	216.000	317.000	6.7700	5.5200	136.000	211.000	314.000
207.2	5.6700	152.000	216.000	317.000	6.8300	6.7900	135.000	210.000	314.000
207.3	5.6700	152.000	216.000	317.000	6.6300	8.500	135.000	198.000	313.000
207.4	5.6700	152.000	216.000	317.000	6.6100	10.000	135.000	193.000	313.000
208.1	5.6600	148.000	205.000	305.000	6.2400	1.000	142.000	204.000	304.000
208.2	5.6600	148.000	205.000	305.000	6.5700	2.000	140.000	205.000	305.000
208.3	5.6600	148.000	205.000	305.000	6.8600	5.5500	134.000	201.000	304.000
208.4	5.6600	148.000	205.000	305.000	6.8500	6.6700	134.000	199.000	303.000
208.5	5.6600	148.000	205.000	305.000	6.1900	8.500	143.000	201.000	310.000
208.6	5.6600	148.000	205.000	305.000	6.700	10.000	135.000	191.000	302.000
209.1	5.6400	145.500	209.000	321.600	6.900	5.200	131.600	205.500	318.700
209.2	5.6400	145.500	209.000	321.600	6.9300	6.400	131.700	202.800	318.000
210.1	5.6100	149.900	207.700	315.800	6.8600	5.200	133.300	203.800	315.500
210.2	5.6100	149.900	207.700	315.800	6.900	6.400	133.400	201.500	314.800
211.1	5.7400	150.000	207.200	311.100	6.9500	9.400	133.600	193.500	306.000
211.2	5.7400	150.000	207.200	311.100	6.9800	10.000	134.500	191.700	306.700
212.1	5.7200	149.700	205.500	304.900	6.9600	5.200	134.800	202.600	303.700
212.2	5.7200	149.700	205.500	304.900	6.9600	6.400	135.000	201.800	303.700
214.1	5.3100	154.000	213.000	305.800	6.5600	9.400	136.900	202.700	303.000
214.1	5.3100	154.000	213.000	305.800	6.5400	10.000	137.600	202.900	303.700
215.1	5.8300	147.800	207.300	317.900	6.9800	5.200	132.400	203.300	314.600
215.2	5.8300	147.800	207.300	317.900	6.9600	6.400	133.000	201.300	314.600
216.1	5.6800	149.100	207.200	315.400	6.9500	5.200	132.500	201.700	311.300
216.2	5.6800	149.100	207.200	315.400	6.9500	6.400	132.900	201.800	311.300
217.1	5.5700	153.100	202.600	290.500	6.7700	5.200	137.400	198.400	286.600
217.2	5.5700	153.100	202.600	290.500	6.8600	7.800	135.800	195.700	285.700
218.1	5.5500	151.400	211.500	317.400	6.7400	5.200	134.200	205.300	316.300
218.2	5.5500	151.400	211.500	317.400	6.8300	6.400	134.500	204.300	314.900
219.1	5.6700	150.200	203.700	300.800	6.900	5.200	135.500	201.200	298.800
219.2	5.6700	150.200	203.700	300.800	6.9200	7.800	135.500	197.700	296.600
220.1	8.7000	122.300	201.100	316.300	9.7900	5.200	116.600	193.800	316.600
220.2	8.7000	122.300	201.100	316.300	9.7900	6.400	117.400	189.300	316.900
221.1	9.8200	120.200	205.700	320.100	10.7800	5.200	118.400	200.900	317.000
221.2	9.8200	120.200	205.700	320.100	10.7300	6.400	117.300	194.700	317.300
222.1	6.5200	145.700	205.500	306.700	7.5600	5.200	132.400	201.300	305.200
222.2	6.5200	145.700	205.500	306.700	7.6600	6.400	132.200	197.000	303.600
223.1	10.3400	112.000	190.700	315.300	11.4100	5.200	110.400	184.200	315.500
223.2	10.3400	112.000	190.700	315.300	11.4300	6.400	112.200	179.800	313.300
224.1	11.2300	114.400	205.400	313.900	11.9800	5.200	108.900	199.000	309.100
224.2	11.2300	114.400	205.400	313.900	11.9700	6.400	113.200	191.500	307.400
225.1	10.2300	119.900	209.000	315.400	11.1200	5.200	119.300	204.200	313.900
225.2	10.2300	119.900	209.000	315.400	11.1100	6.400	117.600	201.800	313.700
226.1	9.9900	120.100	202.500	318.800	10.9600	5.200	116.500	197.500	319.300

226.2	9.9900	120.100	202.500	318.800	10.9100	6.400	117.200	194.700	317.400
227.1	9.1700	121.300	206.200	311.600	10.1800	5.200	117.300	198.300	308.600
227.2	9.1700	121.300	206.200	311.600	10.2200	7.800	117.300	186.100	308.800
228.1	5.6100	147.900	211.500	316.400	6.8300	5.200	133.000	206.400	313.600
228.2	5.6100	147.900	211.500	316.400	6.8200	6.400	133.800	204.500	313.500
229.1	5.5400	152.000	209.000	311.600	6.8600	5.200	135.000	204.400	309.000
229.2	5.5400	152.000	209.000	311.600	6.9200	7.200	134.300	198.700	310.100
230.1	5.5900	149.200	210.800	305.900	6.800	5.200	134.200	207.900	305.100
230.2	5.5900	149.200	210.800	305.900	6.8500	6.300	133.700	205.600	303.500
231.1	5.4500	149.300	207.000	310.600	6.6300	5.200	134.400	202.400	307.400
231.2	5.4500	149.300	207.000	310.600	6.6700	7.200	134.700	199.000	307.400
232.1	5.5700	146.800	210.000	319.200	6.8200	5.200	133.600	206.200	318.700
232.2	5.5700	146.800	210.000	319.200	6.8300	6.400	134.100	204.700	318.300
233.1	5.5600	155.800	214.600	311.000	6.6700	5.200	137.600	212.300	310.000
233.2	5.5600	155.800	214.600	311.000	6.7200	6.2500	137.800	211.600	309.600
234.1	5.6000	152.300	206.000	308.800	6.7300	5.200	136.200	204.100	307.000
234.2	5.6000	152.300	206.000	308.800	6.7400	6.400	136.100	202.100	305.900
235.1	5.5900	150.000	202.400	315.300	6.7300	5.200	133.700	197.200	310.800
235.2	5.5900	150.000	202.400	315.300	6.8200	6.400	132.900	194.500	309.300
236.1	5.6100	150.600	200.600	311.100	6.8700	5.200	133.300	197.000	310.200
236.2	5.6100	150.600	200.600	311.100	6.8600	6.400	133.300	195.300	310.900
237.1	5.5700	150.200	204.300	306.300	6.7700	5.200	134.600	200.800	304.700
237.2	5.5700	150.200	204.300	306.300	6.8200	6.400	134.900	199.400	304.700
238.1	5.5500	148.800	201.000	323.400	6.7700	5.200	133.600	197.000	320.800
238.2	5.5500	148.800	201.000	323.400	6.800	6.400	133.200	193.800	320.400
239.1	5.6600	148.000	205.000	305.000	6.8600	5.200	134.000	201.000	304.000
239.2	5.6600	148.000	205.000	305.000	6.8500	6.400	134.000	199.000	303.000
240.1	5.6500	150.000	202.000	311.000	6.8600	5.200	133.000	197.000	307.000
240.2	5.6500	150.000	202.000	311.000	6.8500	6.400	133.000	195.000	306.000
242.1	5.6000	149.000	202.000	307.000	6.7200	4.800	134.000	199.000	302.000
242.2	5.6000	149.000	202.000	307.000	6.7200	5.900	134.000	198.000	305.000
243	9.5500	123.000	191.000	335.000	10.600	10.000	113.000	150.000	325.000
244	8.3500	123.000	183.000	327.000	10.400	10.000	117.000	147.000	321.000
245	8.6500	127.000	198.000	336.000	9.5500	10.000	123.000	162.000	330.000
246	15.0000	98.000	169.000	325.000	15.8500	10.000	97.000	145.000	312.000
247	14.8000	100.000	169.000	332.000	15.5500	10.000	99.000	145.000	325.000
248	14.6000	98.000	183.000	337.000	15.400	10.000	101.000	151.000	332.000
249	15.0000	97.000	191.000	339.000	15.6500	10.000	100.000	152.000	333.000
250	9.6000	120.000	175.000	339.000	10.5500	10.000	117.000	147.000	328.000
251	10.5000	121.000	186.000	323.000	11.400	10.000	114.000	149.000	318.000
252	10.5000	121.000	193.000	336.000	11.0500	10.000	117.000	153.000	314.000
253	9.8500	123.000	194.000	319.000	10.7500	10.000	119.000	157.000	300.000
254	15.0500	96.000	160.000	334.000	15.9500	10.000	96.000	140.000	324.000
255	15.2000	98.000	174.000	340.000	15.7500	10.000	97.000	146.000	334.000
256	15.3500	98.000	181.000	342.000	15.9500	10.000	98.000	149.000	334.000
257	15.2000	97.000	189.000	343.000	15.800	10.000	100.000	153.000	343.000
258	.	131.000	210.000	341.000	.	5.7500	123.000	206.000	341.000
259	8.9800	128.000	211.000	299.000	9.9300	5.7500	118.000	202.000	338.000
260	.	140.000	233.000	325.000	.	5.7500	130.000	230.000	322.000
261	.	126.000	209.000	341.000	.	5.7500	127.000	229.000	323.000
262	.	125.000	206.000	337.000	.	5.7500	120.000	201.000	335.000
263	.	128.000	212.000	335.000	.	5.7500	125.000	209.000	334.000
264	.	135.000	211.000	333.000	.	5.7500	125.000	207.000	333.000
265	.	123.000	206.000	345.000	.	5.7500	122.000	204.000	344.000
266	.	134.000	213.000	339.000	.	5.7500	123.000	207.000	338.000
267	.	129.000	208.000	342.000	.	5.7500	124.000	202.000	339.000
268	.	141.000	231.000	322.000	.	5.7500	132.000	229.000	318.000
269	9.0400	123.000	214.000	341.000	9.7600	5.7600	120.000	210.000	342.000
270	.	130.000	216.000	342.000	.	5.7500	125.000	212.000	338.000

271	.	132.000	216.000	344.000	.	5.7500	123.000	207.000	338.000
272	.	133.000	217.000	341.000	.	5.7500	126.000	211.000	338.000
273	7.5800	134.000	213.000	344.000	8.5500	5.7600	128.000	208.000	340.000
274	6.9300	162.000	244.000	327.000	7.9700	5.7500	145.000	245.000	323.000
275	7.1100	139.000	217.000	337.000	8.1500	5.7500	128.000	210.000	332.000
276	7.4200	131.000	209.000	336.000	8.6400	5.7500	126.000	206.000	341.000
277	.	150.000	241.000	321.000	.	5.7500	137.000	239.000	321.000
278	7.1600	136.000	208.000	348.000	8.3800	5.7500	128.000	204.000	342.000
279	6.7800	143.000	213.000	337.000	8.0600	5.7500	132.000	211.000	343.000
280	7.0200	136.000	213.000	324.000	8.0200	5.7500	130.000	213.000	322.000
281	6.9600	140.000	218.000	345.000	8.3400	5.7500	125.000	210.000	333.000
282	7.1500	140.000	208.000	344.000	8.4900	5.8200	128.000	201.000	339.000
283	7.1200	157.000	248.000	345.000	8.1700	5.6700	140.000	244.000	343.000
284	7.3200	136.000	205.000	344.000	8.6500	5.0000	125.000	199.000	340.000
285	7.0300	163.000	252.000	349.000	8.2400	5.7400	138.000	246.000	343.000
286	7.3200	138.000	209.000	343.000	8.6400	5.7600	128.000	202.000	339.000
287	7.4900	135.000	208.000	341.000	8.5500	6.2700	127.000	203.000	340.000
288	6.9100	158.000	241.000	337.000	8.2900	5.9100	138.000	234.000	328.000
289	7.2100	140.000	216.000	344.000	8.4400	5.7200	129.000	211.000	342.000
290	7.0400	155.000	242.000	335.000	8.1000	5.9800	137.000	235.000	332.000
291	7.3600	140.000	213.000	346.000	8.2400	6.1200	128.000	208.000	343.000
292	6.9800	142.000	222.000	348.000	8.4600	5.7100	130.000	217.000	344.000
293	7.1500	157.000	235.000	331.000	8.2500	5.8400	140.000	234.000	328.000
294	6.8000	138.000	222.000	346.000	8.1100	5.8400	133.000	224.000	349.000
295	7.2400	140.000	222.000	347.000	8.2100	5.3000	130.000	217.000	344.000
296	7.3200	143.000	225.000	346.000	8.4400	5.7200	131.000	218.000	345.000
297	7.5000	151.000	235.000	328.000	8.5900	6.0800	140.000	236.000	329.000
298	7.3900	138.000	223.000	349.000	8.4700	5.7800	129.000	216.000	345.000
299	7.3400	139.000	222.000	347.000	8.4000	6.1700	128.000	213.000	347.000
300	7.3800	138.000	219.000	343.000	8.4900	6.2200	129.000	215.000	346.000
301	7.4500	139.000	215.000	347.000	8.5600	6.1900	127.000	209.000	347.000
302	7.5900	138.000	217.000	348.000	8.6200	5.8000	127.000	210.000	346.000
303	10.6800	121.000	207.000	333.000	11.4800	6.0600	117.000	199.000	329.000
304	.	153.000	253.000	334.000	.	6.0000	140.000	250.000	337.000
305	11.2300	138.000	249.000	339.000	11.7000	5.9100	132.000	246.000	333.000
306	10.0700	124.000	210.000	330.000	11.0900	5.9200	121.000	206.000	329.000
307	10.3800	144.000	243.000	332.000	10.7500	6.2000	134.000	240.000	330.000
308	10.2700	123.000	203.000	326.000	11.2500	5.9800	119.000	198.000	326.000
309	10.5400	136.000	240.000	325.000	11.3700	6.0700	128.000	238.000	324.000
310	10.0800	123.000	206.000	327.000	11.1700	6.0400	121.000	200.000	323.000
311	9.8900	127.000	211.000	331.000	10.9300	5.9700	122.000	205.000	329.000
312	10.3600	136.000	238.000	327.000	10.6500	5.8300	130.000	238.000	331.000
313	8.9700	128.000	216.000	329.000	9.9800	5.8900	122.000	211.000	327.000
314	8.2600	132.000	212.000	323.000	9.3500	5.9300	125.000	208.000	325.000
315	.	126.000	204.000	319.000	.	5.9500	120.000	198.000	318.000
316	9.2500	131.000	218.000	326.000	10.2800	5.9700	124.000	212.000	323.000
317	.	128.000	213.000	314.000	.	5.8500	123.000	211.000	317.000
318	9.3300	126.000	208.000	326.000	10.3600	5.9300	121.000	203.000	323.000
319	.	120.000	242.000	334.000	.	5.9700	117.000	235.000	323.000
320	.	122.000	206.000	324.000	.	5.9300	118.000	199.000	322.000
321	11.9000	120.000	238.000	321.000	12.6500	5.9600	112.000	226.000	313.000
322	9.9400	122.000	198.000	319.000	10.9600	5.9400	118.000	194.000	319.000
323	10.9200	130.000	237.000	319.000	11.7700	6.0900	123.000	234.000	314.000
324	.	126.000	208.000	327.000	.	5.9000	119.000	199.000	324.000
325	.	121.000	194.000	323.000	.	5.9400	115.000	185.000	317.000
326	.	123.000	196.000	321.000	.	6.1100	117.000	188.000	316.000
327	10.1900	121.000	193.000	317.000	11.0500	5.8800	116.000	187.000	315.000
328	.	124.000	209.000	322.000	.	5.9700	120.000	202.000	322.000
329	.	125.000	238.000	321.000	.	5.9300	121.000	235.000	318.000

330	.	121.000	207.000	334.000	.	5.7500	117.000	200.000	336.000
331	.	119.000	204.000	336.000	.	5.900	116.000	199.000	335.000
332	10.3500	123.000	206.000	331.000	11.2900	5.8700	115.000	195.000	325.000
333	.	121.000	232.000	317.000	.	6.0700	126.000	234.000	318.000
334	.	124.000	231.000	338.000	.	6.2300	123.000	224.000	334.000
335	.	122.000	199.000	330.000	.	5.9600	120.000	195.000	331.000
336	.	120.000	202.000	336.000	.	5.8500	120.000	200.000	339.000
337	.	121.000	204.000	327.000	.	5.9400	121.000	202.000	330.000
338	.	120.000	207.000	334.000	.	5.8600	118.000	200.000	332.000
339	.	121.000	199.000	329.000	.	5.7400	119.000	192.000	329.000
340	.	120.000	196.000	328.000	.	6.5700	116.000	187.000	326.000
341	.	120.000	207.000	325.000	.	5.9400	117.000	200.000	321.000
342	.	126.000	239.000	322.000	.	6.000	129.000	243.000	331.000
343	.	135.000	247.000	336.000	.	5.900	121.000	234.000	318.000
344	.	120.000	196.000	326.000	.	5.8300	119.000	190.000	323.000
345	.	131.000	206.000	331.000	.	6.1800	118.000	189.000	318.000
346	.	120.000	197.000	323.000	.	5.8600	115.000	190.000	320.000
347	.	126.000	208.000	310.000	.	5.9300	120.000	198.000	308.000
348	.	117.000	192.000	307.000	.	5.7200	117.000	194.000	306.000
349	.	123.000	206.000	323.000	.	5.8700	118.000	199.000	321.000
350	.	118.000	194.000	327.000	.	5.7600	114.000	188.000	326.000
351	.	121.000	195.000	331.000	.	5.9100	114.000	182.000	323.000
352	.	121.000	208.000	327.000	.	5.9300	115.000	198.000	320.000
353.1	7.0675	141.400	219.450	329.300	8.42250	5.000	128.7900	213.8300	326.6900
353.2	7.0675	141.400	219.450	329.300	8.32875	10.000	130.82500	201.900	326.500
353.3	7.0675	141.400	219.450	329.300	8.19750	15.000	132.200	161.9500	321.77500
354.1	7.2200	148.100	232.450	323.200	8.41750	5.000	133.62500	229.100	321.200
354.2	7.2200	148.100	232.450	323.200	8.26125	10.000	134.52500	223.07500	319.5500
354.3	7.2200	148.100	232.450	323.200	8.1500	15.000	135.77500	180.3500	316.57500
355.1	6.6800	143.0500	213.650	342.800	8.26250	5.000	128.07500	207.42500	338.800
355.2	6.6800	143.0500	213.650	342.800	8.18750	10.000	130.17500	196.2500	337.8500
355.3	6.6800	143.0500	213.650	342.800	8.14250	15.000	130.62500	159.47500	335.07500
356.1	6.7050	140.3000	229.100	362.8500	8.07375	5.000	128.72500	221.62500	359.87500
356.2	6.7050	140.3000	229.100	362.8500	8.1800	10.000	130.37500	207.42500	358.67500
356.3	6.7050	140.3000	229.100	362.8500	8.0750	15.000	131.87500	162.5500	355.97500
357.1	8.6050	140.3000	229.100	362.8500	9.8850	5.000	128.72500	221.62500	359.87500
357.2	8.6050	140.3000	229.100	362.8500	9.8150	10.000	130.37500	207.42500	358.67500
357.3	8.6050	140.3000	229.100	362.8500	9.6900	15.000	131.87500	162.5500	355.97500
358.1	8.0825	135.5500	228.300	343.700	9.47625	5.000	123.4500	218.9500	339.4500
358.2	8.0825	135.5500	228.300	343.700	9.36875	10.000	126.97500	212.32500	337.07500
358.3	8.0825	135.5500	228.300	343.700	9.26500	15.000	128.57500	165.07500	333.6500
359.1	6.1600	154.83333	231.89882	327.00385	7.55375	5.000	136.9500	230.300	326.0750
359.2	6.1600	154.83333	231.89882	327.00385	7.47875	10.00	138.400	226.625	325.525
359.3	6.1600	154.83333	231.89882	327.00385	7.46750	15.000	139.62500	190.650	321.950
360.1	8.200	139.4500	223.6500	326.300	9.62500	5.000	126.72500	218.92500	320.400
360.2	8.200	139.4500	223.6500	326.300	9.55125	10.000	129.97500	216.72500	325.150
360.3	8.200	139.4500	223.6500	326.300	9.1500	15.000	131.12500	177.37500	324.375
361.1	11.4500	113.0500	230.100	335.3500	12.53750	5.000	115.775	227.575	333.825
361.2	11.4500	113.0500	230.100	335.3500	12.64125	10.000	118.600	222.4500	331.550
361.3	11.4500	113.0500	230.100	335.3500	12.26875	15.000	120.850	167.975	326.975
362.1	8.1925	133.1500	226.700	342.200	9.44250	5.000	123.350	219.6750	337.875
362.2	8.1925	133.1500	226.700	342.200	9.45875	10.000	126.800	215.075	338.375
362.3	8.1925	133.1500	226.700	342.200	9.29125	15.000	128.775	166.975	335.700
363	.	124.000	176.000	319.000	.	10.000	119.000	146.000	316.000
364	.	121.000	181.000	315.000	.	10.000	119.000	149.000	312.000
365	.	122.000	184.000	328.000	.	10.000	120.000	152.000	333.000
366	.	125.000	185.000	335.000	.	10.000	120.000	149.000	333.000
367	.	124.000	189.000	368.000	.	10.000	120.000	152.000	362.000
368	.	127.000	193.000	312.000	.	10.000	120.000	152.000	307.000

369	.	124.000	196.000	317.000	.	10.000	120.000	155.000	313.000
370	.	121.000	200.000	336.000	.	10.000	119.000	162.000	331.000
371	.	124.000	201.000	320.000	.	10.000	120.000	170.000	315.000
372	.	129.000	201.000	314.000	.	10.000	122.000	163.000	312.000
373	.	138.000	209.000	313.000	.	10.000	129.000	191.000	312.000
374	.	115.000	211.000	324.000	.	10.000	113.000	155.000	324.000
375	.	120.000	212.000	317.000	.	10.000	123.000	193.000	317.000
376	5.5100	148.500	214.400	313.200	6.6400	5.200	135.300	210.400	310.800
377	5.6200	147.400	214.500	313.600	6.8300	5.200	134.400	211.200	312.500
378	5.6200	151.700	218.100	307.600	6.8300	7.000	136.000	213.400	303.600
379	5.8100	149.300	214.400	311.500	7.000	5.3100	132.900	209.200	308.600
380	5.700	146.900	204.500	315.500	6.7700	5.200	133.400	202.100	315.600
381	5.5500	147.600	208.800	311.900	6.8600	7.000	134.100	203.200	311.100
382	5.6100	149.200	208.300	319.400	6.7600	5.100	132.900	203.000	316.000
383	5.6100	148.600	216.000	318.200	6.8900	5.100	133.800	212.300	314.100
384	5.6200	151.200	209.100	313.200	6.7900	7.400	135.400	202.800	311.400
385	5.7500	151.100	213.700	315.700	6.9200	7.400	135.500	211.500	315.200
386	10.1200	120.400	201.100	313.600	11.0400	7.200	116.300	188.800	313.200
387	7.4700	133.000	195.200	317.400	8.5600	5.400	124.900	192.300	313.800
388	9.9100	137.900	218.500	308.000	10.6200	5.400	127.500	216.200	303.000
389	11.8800	114.000	205.200	313.800	12.7500	7.200	109.500	187.300	310.700
390	11.9700	113.600	215.200	316.600	12.5600	5.400	115.700	211.100	314.000
391	11.3500	110.000	214.000	310.200	12.1500	5.400	107.200	201.000	305.300
392	10.6700	122.800	211.600	306.200	11.3600	7.200	117.800	206.000	304.300
393	9.6800	120.100	220.800	315.700	10.6900	5.500	114.800	211.700	312.400
394	8.0400	133.800	213.400	314.200	8.9900	5.500	124.500	211.100	313.500
395	6.3200	157.700	217.900	301.200	7.4500	7.200	138.300	215.500	301.900
396	5.5900	151.000	207.300	316.300	6.7900	5.500	134.700	203.100	314.800
397	5.500	154.400	215.300	307.600	6.6700	7.200	137.800	211.300	307.600
398	5.4100	155.300	211.900	313.400	6.6400	5.500	137.400	209.000	309.800
399	5.8200	156.000	206.400	316.100	6.9200	5.500	134.200	202.400	314.300
400	5.5800	149.100	209.900	321.400	6.7900	7.000	133.400	201.800	316.100
401	5.6800	145.900	203.900	321.600	6.9800	5.500	131.200	198.900	319.600
402	5.5100	148.500	214.400	313.200	6.6600	6.400	134.500	207.200	310.300
403	5.6200	147.400	214.500	313.600	6.8500	6.400	134.700	209.900	311.600
404	5.6200	151.700	218.100	307.600	6.800	7.800	136.200	213.000	305.900
405	5.8100	149.300	214.400	311.500	6.9600	8.100	134.400	205.400	308.400
406	5.700	146.900	204.500	315.500	6.8600	8.100	132.700	197.500	314.400
407	5.5500	147.600	208.800	311.900	6.8500	7.800	134.400	203.200	310.600
408	5.6100	149.200	208.300	319.400	6.8600	8.100	133.200	198.000	312.600
409	5.6100	148.600	216.000	318.200	6.7300	8.100	134.700	209.000	314.200
410	5.6200	151.200	209.100	313.200	6.7900	7.800	134.600	200.400	310.900
411	5.7500	151.100	213.700	315.700	6.900	7.800	135.200	207.700	311.700
412	10.1200	120.400	201.100	313.600	10.8300	7.800	117.100	188.100	312.500
413	7.4700	133.000	195.200	317.400	8.6600	7.800	125.700	184.300	315.400
414	9.9100	137.900	218.500	308.000	10.6300	7.800	129.000	213.000	302.300
415	11.8800	114.000	205.200	313.800	12.6900	7.800	109.800	185.000	312.000
416	11.9700	113.600	215.200	316.600	12.5300	7.800	114.700	211.400	315.700
417	11.3500	110.000	214.000	310.200	12.1800	7.800	108.400	180.400	306.500
418	10.6700	122.800	211.600	306.200	11.4900	7.800	119.800	205.100	302.200
419	9.6800	120.100	220.800	315.700	10.6600	7.800	115.700	201.900	312.200
420	8.0400	133.800	213.400	314.200	9.0800	7.800	125.300	206.900	312.800
421	6.3200	157.700	217.900	301.200	7.4800	7.800	137.900	214.400	298.800
422	5.5900	151.000	207.300	316.300	6.8200	7.800	134.800	198.400	312.200
423	5.500	154.400	215.300	307.600	6.6900	7.800	137.200	211.000	306.000
424	5.4100	155.300	211.900	313.400	6.7400	7.800	137.800	207.700	311.900
425	5.8200	156.000	206.400	316.100	6.8600	7.800	135.000	199.300	312.100
426	5.5800	149.100	209.900	321.400	6.7700	7.800	133.500	200.200	315.600
427	5.6800	145.900	203.900	321.600	6.9300	7.800	132.600	193.000	318.100

```

;
run;

data data.total;
  set temp;

  RVP_2 = RVPBase * RVPBase;
  T10_2 = T10Base * T10Base;
  T50_2 = T50Base * T50Base;
  T90_2 = T90Base * T90Base;
  EtOH_2 = EtOH * EtOH ;
  RVPT10 = RVPBase * T10Base;
  RVPT50 = RVPBase * T50Base;
  RVPT90 = RVPBase * T90Base;
  RVPEtOH = RVPBase * EtOH ;
  T10T50 = T10Base * T50Base;
  T10T90 = T10Base * T90Base;
  T10EtOH = T10Base * EtOH ;
  T50T90 = T50Base * T90Base;
  T50EtOH = T50Base * EtOH ;
  T90EtOH = T90Base * EtOH ;

run;

title1 'T50 Models';
title2 'Low Ethanol';

data regthree;
  set data.total;
  if EtOH ge 4.0 and EtOH lt 9.0;

run;

proc reg;
  model T50 = EtOH T50Base RVPBase T90Base
            RVP_2   T50_2   T90_2   EtOH_2
            RVPT50  RVPT90  RVPEtOH
            T50T90  T50EtOH
            T90EtOH

            /include=4 selection=stepwise sle=.05 sls=.05;

run;

title2 'High Ethanol';

data regfour;
  set data.total;
  if EtOH ge 9.0 and EtOH le 10.0;
  if fuel = '78' then delete;
  if fuel = '156' then delete;

run;

proc reg;
  model T50 = T50Base RVPBase T90Base
            RVP_2   T50_2   T90_2
            RVPT50  RVPT90
            T50T90

            /include=3 selection=stepwise sle=.05 sls=.05;

run;

```

Example Output

T50 Models
Low Ethanol

1

The REG Procedure
Model: MODEL1
Dependent Variable: T50

Stepwise Selection: Step 0

First 4 Vars Entered: R-Square = 0.9259 and C(p) = 76.3519

Analysis of Variance

Source	DF	Squares	Sum of Square	Mean F Value	Pr > F
Model	4		39183	9795.79536	740.44 <.001
Error	237		3135.42855	13.22966	
Corrected Total	241		42319		

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	17.76883	5.99026	116.40568	8.80	0.0033
* ETOH	-2.09554	0.21686	1235.33346	93.38	<.001
* T50BASE	1.06163	0.02150	32261	2438.50	<.001
* RVPBASE	-0.64256	0.12696	338.87270	25.61	<.001
* T90BASE	-0.06280	0.01824	156.79340	11.85	0.007

* Forced into the model by the INCLUDE= option
Bounds on condition number: 1.2169, 17.951

Stepwise Selection: Step 1

Variable ETOH_2 Entered: R-Square = 0.9352 and C(p) = 39.7260

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5		39576	7915.18857	681.08 <.001
Error	236		2742.66716	11.62147	
Corrected Total	241		42319		

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-35.09066	10.68630	125.31098	10.78	0.0012
* ETOH	12.99965	2.60454	289.50894	24.91	<.001
* T50BASE	1.06884	0.02019	32577	2803.16	<.001

* RVPBASE	-0.72101	0.11976	421.24232	36.25	<.001
* T90BASE	-0.05258	0.01719	108.78186	9.36	0.0025
ETOH_2	-1.13231	0.19477	392.76139	33.80	<.001

* Forced into the model by the INCLUDE= option
 Bounds on condition number: 167.1, 1688.5

Stepwise Selection: Step 2

Variable T90ETOH Entered: R-Square = 0.9383 and C(p) = 28.6652

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	39709	6618.12491	595.92	<.001
Error	235	2609.86053	11.10579		
Corrected Total	241	42319			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-111.65019	24.48017	231.01459	20.80	<.001
* ETOH	23.90945	4.05411	386.27529	34.78	<.001
* T50BASE	1.06071	0.01987	31634	2848.41	<.001
* RVPBASE	-0.71634	0.11708	415.75284	37.44	<.001
* T90BASE	0.22640	0.08241	83.82464	7.55	0.0065
ETOH_2	-0.86495	0.20550	196.73945	17.72	<.001
T90ETOH	-0.04500	0.01301	132.80663	11.96	0.006

* Forced into the model by the INCLUDE= option
 Bounds on condition number: 480.67, 6785.1

Stepwise Selection: Step 3

Variable RVPT90 Entered: R-Square = 0.9410 and C(p) = 19.3463

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	39824	5689.12059	533.62	<.001
Error	234	2494.76589	10.66139		
Corrected Total	241	42319			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-36.91953	33.05473	13.30022	1.25	0.2652

* ETOH	24.27119	3.97370	397.74658	37.31	<.001
* T50BASE	1.05139	0.01968	30435	2854.71	<.001
* RVPBASE	-11.42072	3.25994	130.85216	12.27	0.006
* T90BASE	-0.009527	0.10617	0.000859	0.00	0.9993
ETOH_2	-0.83863	0.20151	184.65823	17.32	<.001
RVPT90	0.03367	0.01025	115.09464	10.80	0.0012
T90ETOH	-0.04713	0.01277	145.33686	13.63	0.003

* Forced into the model by the INCLUDE= option
 Bounds on condition number: 936.34, 20614

Stepwise Selection: Step 4

Variable RVPETOH Entered: R-Square = 0.9429 and C(p) = 13.6007

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	39903	4987.82544	481.03	<.001
Error	233	2416.00647	10.36913		
Corrected Total	241	42319			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-29.83827	32.69961	8.63385	0.83	0.3625
* ETOH	24.82750	3.92405	415.08724	40.03	<.001
* T50BASE	1.05059	0.01941	30382	2930.04	<.001
* RVPBASE	-10.84524	3.22172	117.50152	11.33	0.009
* T90BASE	-0.06515	0.10733	3.82107	0.37	0.5444
ETOH_2	-0.86050	0.19889	194.10249	18.72	<.001
RVPT90	0.03761	0.01021	140.75985	13.57	0.003
RVPETOH	-0.28857	0.10471	78.75942	7.60	0.0063
T90ETOH	-0.04162	0.01275	110.55093	10.66	0.0013

* Forced into the model by the INCLUDE= option
 Bounds on condition number: 955.03, 24262

Stepwise Selection: Step 5

Variable T50ETOH Entered: R-Square = 0.9446 and C(p) = 8.4154

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	39976	4441.74071	439.82	<.001
Error	232	2342.94362	10.09889		
Corrected Total	241	42319			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	21.93025	37.57434	3.44016	0.34	0.5600
* ETOH	14.87544	5.35601	77.89872	7.71	0.0059
* T50BASE	0.67204	0.14204	226.08683	22.39	<.001
* RVPBASE	-10.23835	3.18746	104.19438	10.32	0.0015
* T90BASE	0.02579	0.11119	0.54354	0.05	0.8167
ETOH_2	-0.83126	0.19658	180.58467	17.88	<.001
RVPT90	0.03607	0.01009	129.08374	12.78	0.004
RVPETOH	-0.31029	0.10365	90.50906	8.96	0.0031
T50ETOH	0.06623	0.02462	73.06285	7.23	0.0077
T90ETOH	-0.05519	0.01355	167.45473	16.58	<.001

* Forced into the model by the INCLUDE= option
 Bounds on condition number: 958.1, 39387

 All variables left in the model are required or significant at the 0.0500 level.
 No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	ETOH_2	5	0.0093	0.9352	39.7260	33.80	<.001	
2	T90ETOH	6	0.0031	0.9383	28.6652	11.96	0.006	
3	RVPT90	7	0.0027	0.9410	19.3463	10.80	0.0012	
4	RVPETOH	8	0.0019	0.9429	13.6007	7.60	0.0063	
5	T50ETOH	9	0.0017	0.9446	8.4154	7.23	0.0077	

T50 Models High Ethanol 2

The REG Procedure
 Model: MODEL1
 Dependent Variable: T50

Stepwise Selection: Step 0

First 3 Vars Entered: R-Square = 0.8999 and C(p) = 214.1396

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	119607	39869	545.43	<.001
Error	182	13304	73.09648		
Corrected Total	185	132911			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	9.44114	15.28139	27.90097	0.38	0.5375
* T50BASE	1.10400	0.05011	35475	485.32	<.001
* RVPBASE	-1.92383	0.26197	3942.09448	53.93	<.001
* T90BASE	-0.10694	0.03525	672.83924	9.20	0.0028

* Forced into the model by the INCLUDE= option
 Bounds on condition number: 2.1592, 15.922

Stepwise Selection: Step 1

Variable T50_2 Entered: R-Square = 0.9462 and C(p) = 34.6326

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	125765	31441	796.39	<.001
Error	181	7145.83219	39.47974		
Corrected Total	185	132911			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	804.73601	64.66301	6114.61646	154.88	<.001
* T50BASE	-6.85904	0.63867	4553.47362	115.34	<.001
* RVPBASE	-2.09884	0.19304	4667.23131	118.22	<.001
* T90BASE	-0.12787	0.02596	957.94780	24.26	<.001
T50_2	0.01997	0.00160	6157.72797	155.97	<.001

* Forced into the model by the INCLUDE= option
 Bounds on condition number: 649.33, 5189.2

Stepwise Selection: Step 2

Variable RVPT90 Entered: R-Square = 0.9509 and C(p) = 18.2437

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	126389	25278	697.64	<.001
Error	180	6521.97627	36.23320		
Corrected Total	185	132911			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
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Intercept	910.35225	66.97259	6694.70447	184.77	<.001
* T50BASE	-7.04531	0.61349	4778.42967	131.88	<.001
* RVPTBASE	-11.59827	2.29679	923.95588	25.50	<.001
* T90BASE	-0.39270	0.06850	1190.90960	32.87	<.001
T50_2	0.02043	0.00154	6414.96938	177.05	<.001
RVPT90	0.02885	0.00695	623.85592	17.22	<.001

* Forced into the model by the INCLUDE= option
 Bounds on condition number: 652.82, 9829.6

Stepwise Selection: Step 3

Variable RVPT50 Entered: R-Square = 0.9544 and C(p) = 6.6447

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	126850	21142	624.42	<.001
Error	179	6060.62421	33.85824		
Corrected Total	185	132911			

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	559.27611	115.05160	800.07660	23.63	<.001
* T50BASE	-4.18839	0.97504	624.75892	18.45	<.001
* RVPTBASE	-0.54307	3.72812	0.71845	0.02	0.8843
* T90BASE	-0.39571	0.06622	1209.05786	35.71	<.001
T50_2	0.01482	0.00212	1648.44077	48.69	<.001
RVPT50	-0.05309	0.01438	461.35206	13.63	0.003
RVPT90	0.02884	0.00672	623.54777	18.42	<.001

* Forced into the model by the INCLUDE= option
 Bounds on condition number: 1764.7, 28462

All variables left in the model are required or significant at the 0.0500 level.
 No other variable met the 0.0500 significance level for entry into the model.

Summary of Stepwise Selection

Step	Variable Entered	Variable Removed	Number Vars In	Partial R-Square	Model R-Square	C(p)	F Value	Pr > F
1	T50_2		4	0.0463	0.9462	34.6326	155.97	<.001
2	RVPT90		5	0.0047	0.9509	18.2437	17.22	<.001
3	RVPT50		6	0.0035	0.9544	6.6447	13.63	0.003

Appendix E

Effect of Transitions to Different Ethanol Contents

Transition from Gasoline with One Ethanol Content to Another

A. Introduction

When ethanol is added to gasoline, the Reid vapor pressure of the gasoline is increased and increased evaporative emissions will result. Also, when two CARBOB's designed for different ethanol concentrations are mixed, it becomes very difficult to determine the proper amount of ethanol to be added to the CARBOB mixture.

Changing the amount of ethanol added at a terminal, leads to changes at the service station tanks and in the vehicle tank. The term "transition" refers to this changeover in the distribution system. Table 1 summarizes the possible transitions. Transitions at the terminal tank include changes from one CARBOB to another, from non-oxygenated fuel to CARBOB, and from CARBOB to non-oxygenated fuel. Transitions at the service station tanks and the vehicle tank involve only changes from one fuel to another.

A transition from one CARBOB to another at a terminal tank results in a transition at the service station tank and in the vehicle tank between fuels with different ethanol content. A transition from a CARBOB to non-oxygenated fuel or vice versa at the terminal tank results in a transition in the service station tank and in the vehicle tank between oxygenated and non-oxygenated fuel.

Table 1
Possible Transitions

Possible Transitions at the Terminal	Corresponding Transitions at Service Station or Vehicle Tank
Zero Oxygen RFG to CARBOB	Zero Oxygen RFG to Ethanol fuel
CARBOB to Zero Oxygen RFG	Ethanol fuel to Zero Oxygen RFG
CARBOB (A) to CARBOB (B)	Ethanol fuel (A) to Ethanol fuel (B)

Note: A and B are the ethanol volume concentrations for which the CARBOBs were designed.

A transition at the terminal is complete when the target fuel or CARBOB properties are attained. This process generally requires more than one tank turnover. Therefore, fuels blended during the intermediate stages of the transition will be different from the original target complying fuel. If no adjustments were made, refiners could ship this intermediate product to the service stations for eventual use in the vehicle even though in some cases the blends downstream of the refinery may not meet CaRFG predictive model requirements.

The primary objective of the ARB's analysis was to determine the effect on emissions of a refinery transition from a gasoline with one ethanol content to another with a different ethanol content. The staff analysis also identified transitions where the RVP cap limit could be exceeded.

B. CARBOBs and Fuels Used in the Analysis

Six CaRFG formulations were evaluated in the staff analysis. The starting points and targets for all transitions were complying fuels or CARBOBS that will produce complying fuels after

blending with ethanol at the target concentration. Table 2 lists the CaRFG formulations used in the analysis and as indicated in Table 3, all of the formulations met the CaRFG predictive model requirements.

Table 4 shows a CARBOB for each of the ethanol CaRFG formulations listed in Table 2. For each of the formulations, a CARBOB was obtained by entering the properties of the formulations into the CARBOB model (version dated July 21, 2000) to get the CARBOB properties. Since the fuels at the start and end of the transition were all complying fuels, any increase in emissions during the transition period could only be due to the use of the fuel mixtures from the intermediate stages of the transition.

Properties of the fuel mixtures were calculated for each turnover of the terminal tank, service station tank, and vehicle tank and then evaluated using the CaRFG Predictive Model to determine the effect on emissions of oxides of nitrogen (NOx), total hydrocarbons and carbon monoxide (THC), and potency weighted Toxics (TOX).

Table 2

**CaRFG Formulations Used to Evaluate Potential Emissions Increases
from Transitions from One Fuel to Another**

Fuel Properties	0-OXY CaRFG	5.7 vol% Ethanol FUEL	5.7 vol% Ethanol Fuel (L)	7.7 vol% Ethanol FUEL	7.7 vol% Ethanol Fuel (L)	10 vol% Ethanol FUEL
Aromatics, vol%	25.0	25.1	26.0	25.1	26.9	24.6
Benzene, vol%	0.6	0.76	0.73	0.70	0.77	0.69
Olefins, vol%	6.0	6.0	5.6	4.0	4.2	1.0
Sulfur, ppm	10	20	14.1	14	11.8	5
T50, deg. F	210	214	214	206	211	214
T90, deg. F	305	305	310	310	312	310
Ethanol, vol. %	0.0	5.7	5.7	7.7	7.7	9.6
Oxygen	0.0	2.1	2.1	2.8	2.8	3.5
RVP, psi	6.80	6.83	6.83	7.16	7.02	7.16

Note:

All of the formulations except those designated with (L) are the ones used by ARB in a December 1999 letter to EPA to support California's request of a waiver of the federal RFG year-round oxygen mandate

The formulations designated with (L) are based on those presented in the MathPro analysis of the expected costs to produce Phase 3 gasoline.

Table 3

**Expected Change in Emissions Using the CaRFG3
Predictive Model for the CaRFG Formulations Used in the Analysis**

Fuel Properties	0-OXY CaRFG	5.7 vol% Ethanol FUEL	5.7 vol% Ethanol Fuel (L)	7.7 vol% Ethanol FUEL	7.7 vol% Ethanol Fuel (L)	10 vol% Ethanol FUEL
NOx	-3.51%	-0.03%	-0.87%	-0.10%	-0.16%	-0.08%
Exhaust THC	-1.02%	-0.40%	-0.67%	-2.88%	-0.80%	-1.08%
Evap. THC	-2.35%	-1.65%	-1.65%	-6.55%	-2.94%	-6.55%
CO (Reactivity weighted)	0%	0%	0%	-0.09%	-0.09%	-0.19%
Total THC + CO	-0.07%	-0.25%	-0.08%	-0.51%	-0.31%	-0.18%
Pot. Wt. Toxics	-4.86%	-0.80%	-0.20%	-4.39%	-0.06%	-5.95%

Table 4

CARBOBs Predicted to Give the Target Fuels After Oxygenation with Ethanol

CARBOB Properties	5.7 vol% Ethanol FUEL	5.7 vol% Ethanol Fuel (L)	7.7 vol% Ethanol FUEL	7.7 vol% Ethanol Fuel (L)	10 vol% Ethanol FUEL
Aromatics, vol%	26.5	27.5	27.0	29.0	27.0
Benzene, vol%	0.80	0.77	0.75	0.83	0.75
Olefins, vol%	6.3	5.9	4.3	4.5	1.0
Sulfur, ppm	20	14	14	12	4
T50, deg. F	217	218	213	217	221
T90, deg. F	307	312	313	315	314
RVP, psi	5.6	5.6	6.0	5.8	6.0

C. Assumptions

1. Emission calculations are based on a four week transition period.
2. The terminal tank heel amount would be the only heel amount varied because that is the only tank turnover that can be practically controlled by the supplier. The terminal tank heel amounts would be 10 percent, 25 percent and 50 percent.
3. The service station tank and vehicle tank would have average heels of 20 percent and 25 percent of capacity, respectively.
4. For terminal tank transitions from one CARBOB to another, the starting fuel and the target fuel for the underground tank transition and the vehicle tank transition would have the same properties as the ethanol fuels for which the starting and target CARBOBs were designed.
5. For terminal tank transitions from a CARBOB to non-oxygenated fuel, the starting fuel for the underground tank transition and the vehicle tank transition would have the same

properties as the ethanol fuel for which the starting CARBOB was designed and the target fuel would have the same properties as the target non-oxygenated fuel at the terminal tank.

6. For terminal tank transitions from non-oxygenated fuel to CARBOB, the starting fuel for the underground tank transitions and the vehicle tank transitions would have the same properties as the starting non-oxygenated fuel at the terminal tank and the target fuels would have the same properties as the ethanol fuels for which the target CARBOBs were designed.
7. For terminal tank transitions from one CARBOB to another, and transitions from non-oxygenated fuel to CARBOB, the CARBOB mixture from each tank turnover would be blended at the terminal with ethanol at the concentration of the target fuel.
8. The calculation of oxygen concentration of the fuels would use the same assumptions as those used in the CARBOB model dated July 21, 2000, namely a fuel density of 0.718 g/cc, ethanol density of 0.794 g/cc, and ethanol purity of 95 percent. For ethanol concentrations of 5.7, 7.7 and 9.6 volume percents, the respective weight percent values for oxygen were 2.1, 2.7 and 3.5.
9. The terminal tank would undergo one turnover per week, the service station tank two turnovers per week and the vehicle tank one turnover per week (Figure E-1). This means that during the four week transition period, the terminal tank would undergo a total of four turnovers, the service station tank a total of eight turnovers, and the vehicle tank a total of four turnovers.
10. In each week of the four-week transition period, half of the vehicles would refuel with the fuel mixture resulting from the first turnover at the service station while the remaining half of the vehicles would refuel with the fuel mixture resulting from the second turnover at the service station (Figure E-1). The calculated change in vehicle emissions would be the average for the two sets of vehicles

D. Properties of Fuel Mixtures

With one exception, a linear model (Equation E-1) was used to calculate the values for properties of the mixtures produced with each turnover. The exception was the calculation of RVP when the turnover involved commingling of non-oxygenated gasoline and ethanol fuel.

The linear model assumes that in a mixture of two CARBOBs, or a mixture of CARBOB and non-oxygenated fuel, each component in the mixture will contribute to the properties of the mixture in proportion to the volume fraction of the individual component in the mixture.

Equation E-1

$$P_{mix} = X P_1 + (1 - X) P_2$$

Where:

- P_{mix} = Value for the property in the mixture of CARBOBs or fuels
 P_1 = Value of the same property in component #1 before mixing
 P_2 = Value of the same property in component #2 before mixing
 X = Volume fraction of component #1 in the mixture of components #1 and #2

RVP of Commingled Fuels

Commingling of non-oxygenated CaRFG and ethanol fuel will occur only in the service station underground storage tank and the vehicle tank. For such ethanol gasoline mixtures, all properties except RVP were calculated according to the linear model (Equation E-1). The RVP boost and the RVP of the commingled fuels were calculated using Equations E-2 and E-3, respectively.

Equation E-2

$$\Delta RVP = \left(\frac{1}{1.11} + 1.845516 E - 0.76405 E^2 + 0.837258 E^3 \right)^{-1} \left(\frac{1.11 + 0.05(8.4 - B)}{1.11} \right)$$

Equation E-3

$$RVP_{com} = X (B + \Delta RVP) + (1 - X) RVP_{EtOH}$$

Where:

- E = Ethanol concentration (percent) of commingled fuel
 B = Base RVP of non-oxygenated fuel
 RVP_{com} = RVP of commingled fuels
 X = Fraction of fuel mixture that is non-oxygenated fuel
 RVP_{EtOH} = RVP of ethanol fuel in mixture

Equation E-2 was proposed by Rocke (1999). This equation is different from the CARBOB model equation but it applies to the range of ethanol concentrations from 0 to 10 percent whereas the CARBOB model equation does not apply when ethanol concentrations are lower than 4 percent. For ethanol concentration ranges applicable to both the CARBOB and Rocke equations, the estimated RVP values are similar.

E. Estimation of Emission Impacts

When the product of a tank turnover was a mixture of fuels, the properties of the fuel mixture were entered directly into the CaRFG Predictive Model to determine whether the fuel complied with the predictive model standards. When the product of a tank turnover was a CARBOB mixture, the CARBOB model was used to predict the properties of the fuel that would result after blending the CARBOB mixture with the appropriate amount of ethanol. The ethanol concentration entered into the CARBOB model was the target concentration for the transition.

The fuel properties predicted by the CARBOB model were then entered into the CaRFG predictive model for evaluation.

Each terminal tank turnover results in a different fuel blend in the vehicle tank. An example of the transition from one ethanol fuel to another is shown in Figure E-1 (the assumptions used in the analysis were described earlier in Section C). Using the predictive model, the expected change in emissions were determined for each fuel blend obtained with each vehicle tank turnover. An examples of the spreadsheet analysis for one transition is shown in Tables 15 to 18. A complete set of the calculations is available on request (see list of references).

For each terminal tank transition starting with a given heel, there were four emissions values for each vehicle. An average value for the emissions change during each terminal tank transition starting with a given heel was obtained by averaging the eight emissions values for the two vehicles. This change in emissions was also reported as a percentage of RFG2 benefits for that pollutant using Equation E-4.

Equation E-4

$$RFG = \frac{(28 \times EMS \times EXH)}{365 \times Ben} \times 100\%$$

Where:

RFG	=	Change in emissions as a percentage of RFG2 benefits
Ben	=	RFG 2 benefit for pollutant (190 tpd for HC and 110 tpd for NO _x)
EMS	=	Expected percent change in emissions using the CaRFG Predictive Model
EXH	=	Statewide exhaust emissions for pollutant (tpd) from EMFAC ver. 7G (997 tpd for HC and 1318 tpd for NO _x)

F. Results

Tables 5 through 13 summarize the results of the staff analysis. Tables 5 through 7 show the number of tank turnovers at the three locations (terminal, service station, and vehicle) that did not produce a fuel that met the predictive model standards. A value of zero for a transition at a given location (terminal, service station, or vehicle) means that there would be no increase in emissions with any fuel mixture resulting from any of the tank turnovers at that location. The tables also identify the pollutants for which there were emissions increases and the tank turnovers that resulted in RVPs that exceeded the cap limits.

The predictive model estimates the emissions changes which result when a gasoline is consumed in a motor vehicle. So, the emissions results shown in Tables 5 and 6 for the terminal and service station were calculated as if the fuel were directly consumed in a vehicle even though the fuel undergoes further mixing as it passes through the distribution system to the vehicle. The staff analysis assumed that there would be no emissions impact except at the vehicle and consequently any constraints on terminal tank operations would be based on the results for the vehicle tank turnovers.

The predicted changes in exhaust emissions are shown in Tables 8 to 11 for each of the fuel mixtures obtained with the vehicle tank turnovers during the four week transition period. The complete set of emissions data for the target pollutants are reported in Tables 8 to 10. Table 11 shows the emissions results only for those transitions for which there was an increase in emissions with any of the three tank heels considered. The predicted change is reported as an average for the transition period. This average is also expressed as a percent change in RFG Phase 2 benefits as described in Section E.

The staff's analysis showed that the emissions impact of the tank transitions depended on at least three factors:

- ◆ the relative amount of the fuel remaining in the terminal tank (the heel) at each tank turnover,
- ◆ whether the oxygen content increased or decreased with the transition, and
- ◆ the CaRFG properties

The results of the staff analysis are summarized under four types of terminal tank transitions:

- ◆ from CARBOB to CARBOB with increasing oxygen content,
- ◆ from CARBOB to CARBOB with decreasing oxygen content,
- ◆ from non-oxygenated fuel to CARBOB, and
- ◆ from CARBOB to non-oxygenated fuel.

Terminal Tank Transitions from CARBOB to CARBOB with increasing oxygen content

These transitions at the terminal result in service station and vehicle tank transitions from an ethanol fuel of one oxygen content to an ethanol fuel with a higher oxygen content. These transitions could increase NOx emissions from the vehicle tailpipe.

The analysis predicts that NOx emissions will increase as the terminal tank heel increases. At the larger tank heels, a larger fraction of the CARBOB mixture will be contributed by the CARBOB designed for a lower ethanol concentration than the concentration at which the mixture will be blended. Therefore, over oxygenation and NOx emissions are expected to be greater at the larger tank heels.

The transition from 5.7 to 7.7 % ethanol with the higher sulfur content fuels was the only transition in this group that resulted in an increase in NOx emissions when the terminal tank heel was 10 percent. However, when the sulfur content of the fuels was decreased, there was no increase in emissions with the transition from 5.7 to 7.7 volume percent ethanol fuel.

The results of the analysis indicate that the adverse emissions impacts can be minimized by controlling the tank heel at each turnover and by changing the properties of the target fuel at the first terminal tank turnover. The staff's analysis shows that emissions increases can be prevented if the following is done:

- ◆ the terminal tank heel is not allowed to exceed 10 percent during any of the tank turnovers required to complete the transition, and
- ◆ the sulfur content of the target fuel is reduced for at least the first turnover.

Transitions from CARBOB to CARBOB with decreasing oxygen content

This transition at the terminal results in a transition at the service station and vehicle from an ethanol fuel of one oxygen content to an ethanol fuel with a lower oxygen content. These transitions can increase hydrocarbon emissions from the vehicle tailpipe. There was no emissions increase when the terminal tank heel was 10 percent. The analysis predicts that hydrocarbon emissions will increase as the terminal tank heel increases. The staff's analysis shows that emissions increases can be prevented if the following is done:

- ◆ the terminal tank heel is not allowed to exceed 10 percent during any of the tank turnovers required to complete the transition, and
- ◆ the sulfur content of the target fuel is reduced for at least the first turnover.

Transitions from non-oxygenated fuel to CARBOB

This transition at the terminal results in commingling of non-oxygenated and ethanol fuels in the service station tank and the vehicle tank. The analysis predicts that this commingling will cause an increase in evaporative hydrocarbon emissions and an increase in RVP above the cap limits at all three possible terminal tank transitions and at all three terminal tank heels investigated.

The results of the analysis (Tables 11 and 12) indicate that hydrocarbon emissions and RVP will increase as the terminal tank heel increases. With a larger terminal tank heel, a larger percentage of the fuel blend would be the zero oxygen fuel which has a higher RVP than the CARBOB. Therefore the resulting RVP after blending with alcohol will be higher than the RVP for the smaller terminal tank heel.

Hydrocarbon emissions also increased as the difference in oxygen content between the starting and target fuel increased (Table 11).

Transitions from CARBOB to non-oxygenated fuel

This transition at the terminal also results in commingling of non-oxygenated and ethanol fuels in the service station tank and the vehicle tank. The analysis predicts that for all three possible terminal tank transitions and for all three terminal tank heels investigated, there would be an increase in evaporative hydrocarbon emissions at the vehicle and an increase in RVP above the cap limits at the service station and the vehicle.

The analysis predicts that hydrocarbon emissions and RVP will decrease as the terminal tank heel increases. As the terminal tank heel increases, a larger percentage of the RVP of the fuel mixture is contributed by the CARBOB which has a lower RVP than the non-oxygenated fuel. Consequently, the RVP increase with commingling at the station will be smaller as the terminal tank heel increases. Since the first fuelling of the vehicle will involve mixing of ethanol fuels, there is no RVP boost and the RVP of the mixture is a linear blend of the RVPs of the two fuels. As a result, the RVP shows the same trend at the terminal and the station.

Hydrocarbon emissions increased as the difference in oxygen content between the starting and target fuel increased (Table 11). For example, for a 10 percent terminal tank heel, the hydrocarbon emissions were expected to increase by 0.85 percent for the transition from 5.7% ethanol to zero oxygen fuel. However, the emissions were expected to increase by 0.95 percent

for the transition from 7.7 percent ethanol and by 1.15 percent for the transition from 10 percent ethanol.

RVP Effects

Tables 12 and 13 report the RVP values at all locations during any week that the RVP cap limits were exceeded. These tables may be compared with Tables 5 to 7 which show the number of tank turnovers where the RVP exceeded the cap limits.

The RVP results for the transitions between zero oxygen fuel and the 7.7 and 10 percent ethanol fuels were combined (Tables 12 and 13) because the RVP results were nearly identical. The two ethanol fuels had the same RVP (7.16 psi). The ethanol concentrations in the blended fuels were different for the two transitions but the commingling effect was nearly identical and since the blending ratios were the same at the service station tank and the vehicle, the calculated RVPs for the two transitions were identical.

Tables 12 and 13 also show the number of weeks that the RVP cap limit was exceeded. The RVP effect was present only in the first week for the transition from oxygenated to non-oxygenated fuels. For the transition from non-oxygenated to oxygenated fuels, the change in ethanol content and the magnitude of the terminal tank heel determined the length of the period during which the RVP cap limit was exceeded. This period increased as the difference in ethanol content increased and as the magnitude of the terminal tank heel increased.

Summary

The staff's findings are summarized in Table 14. Transitions from a fuel designed for one level of ethanol to a fuel designed for a different level of ethanol are not expected to increase emissions when:

1. the ratio of the "remaining" fuel to the "added" fuel is 1 to 9 or less, and
2. the added fuel contains no more than 12 ppm sulfur for the first turnover of the transition, and
3. the change in ethanol content is less than 3 percent.

Any other transition is expected to result in an increase in emissions. The staff analysis suggests that the mixing of oxygenated and non-oxygenate blends would result in the RVP cap being exceeded.

G. Octane Considerations

The staff's analysis was concerned only with RVP and emissions increases but refiners must also consider octane levels during transitions that decreases ethanol levels or during transitions to non-oxygenated fuel. One method of ensuring adequate octane would be to blend the CARBOB to full octane strength. Other procedures proposed by the refiners could increase RVP and tailpipe emissions of hydrocarbons because they add more oxygenate to the CARBOB than the concentration for which it was designed. Staff did not consider the effect this over-oxygenation but it is expected to worsen the problems already identified in the staff analysis.

Table 5

**Number of Terminal Tank Turnovers that Would not Comply
Based on Use of the Predictive Model**

Transition from:	Terminal Heel Amount					
	10%		25%		50%	
0 to 5.7 vol%	HC 1		HC 1		HC >4 RVP 2	
0 to 7.7 vol%	HC 1	RVP 1	HC 1	RVP 1	HC 3	RVP >4
0 to 10 vol%	NOx 1	RVP 1	HC 1	RVP 2	NOx 3	RVP >4
					HC 1	
5.7 to 7.7 vol% (H)	NOx 1		NOx 1		NOx 3	
5.7 to 7.7 vol% (L)	0		0		NOx 1	
5.7 to 10 vol%	NOx 1		NOx 2		NOx >4	
7.7 to 10 vol%	NOx 1		NOx 1		NOx >4	
7.7 to 5.7 vol% (H)	0		0		HC 1	
7.7 to 5.7 vol% (L)	HC 1		HC 1		HC >4	
10 to 5.7 vol%	0		HC 1		HC 3	
10 to 7.7 vol%	0		0		HC 1	
5.7 to 0 vol%	0		0		0	RVP 1*
7.7 to 0 vol%	0		0		0	RVP 1*
10 to 0 vol%	0		0		0	RVP 1*

Note:
H refers to 5.7 and 7.7 vol% ethanol fuels with 20 and 14 ppmw sulfur, respectively
L refers to 5.7 and 7.7 vol% ethanol fuels with 14 and 12 ppmw sulfur, respectively
* RVP lower than 6.4 psi

Table 6
Number of Gasoline Station Tank Turnovers that Would not Comply
Based on Use of the Predictive Model

Transition from:	Terminal Heel Amount					
	10%		25%		50%	
0 to 5.7 vol%	HC 2		HC 3	RVP 1	HC 7	RVP 2
0 to 7.7 vol%	HC 2	RVP 2	HC 3	RVP 3	HC 6	RVP 8
0 to 10 vol%	HC 2	RVP 2	HC 2	RVP 4	NOx 6 HC 3	RVP 8
5.7 to 7.7 vol% (H)	NOx 2		NOx 3		NOx 6	
5.7 to 7.7 vol% (L)	0		0		NOx 2	
5.7 to 10 vol%	NOx 1		NOx 4		NOx >8	
7.7 to 10 vol%	NOx 1		NOx 3		NOx 6	
7.7 to 5.7 vol% (H)	0		0		HC 3	
7.7 to 5.7 vol% (L)	HC 1		HC 3		HC 7	
10 to 5.7 vol%	HC 1		HC 2		HC 6	
10 to 7.7 vol%	0		HC 1		HC 3	
5.7 to 0 vol%	HC 2	RVP 1	HC 1	RVP 1	HC 1	RVP 1
7.7 to 0 vol%	HC 3	RVP 1	HC 2	RVP 1	HC 1	RVP 1
10 to 0 vol%	HC 3	RVP 1	HC 3	RVP 1	HC 2	RVP 1

Note:
H refers to 5.7 and 7.7 vol% ethanol fuels with 20 and 14 ppmw sulfur, respectively
L refers to 5.7 and 7.7 vol% ethanol fuels with 14 and 12 ppmw sulfur, respectively

Table 7

**Number of Vehicle Tank Turnovers that Would not Comply
Based on Use of the Predictive Model**

Transition from:	Terminal Heel Amount					
	10%		25%		50%	
0 to 5.7 vol%	HC 2	RVP 1	HC 3 (2)	RVP 1 (0)	HC >4	RVP 2
0 to 7.7 vol%	HC 2	RVP 2	HC 2	RVP 3	HC 3	RVP >4
0 to 10 vol%	HC 3	RVP 2	HC 3	RVP 3	HC >4	RVP >4
5.7 to 7.7 vol% (H)	NOx 2		NOx 2		NOx >4	
5.7 to 7.7 vol% (L)	0		NOx 1		NOx 1	
5.7 to 10 vol%	0		NOx 2		NOx >4	
7.7 to 10 vol%	0		NOx 2		NOx 4	
7.7 to 5.7 vol% (H)	0		0		HC 1	
7.7 to 5.7 vol% (L)	HC 1 (0)		HC 2		HC 4	
10 to 5.7 vol%	0		HC 1 (2)		HC 3	
10 to 7.7 vol%	0		0		HC 2	
5.7 to 0 vol%	HC 3 (2)	RVP 1 (0)	HC 2 (0)	RVP 1	HC 1 (0)	
7.7 to 0 vol%	HC 3 (2)	RVP 1	HC 3 (1)	RVP 1	HC 2 (0)	RVP 1
10 to 0 vol%	HC 3 (2)	RVP 1	HC 3 (1)	RVP 1	HC 2 (1)	RVP 1

Note:

H refers to 5.7 and 7.7 vol% ethanol fuels with 20 and 14 ppmw sulfur, respectively

L refers to 5.7 and 7.7 vol% ethanol fuels with 14 and 12 ppmw sulfur, respectively

The number in parentheses applies only when the number of tank turnovers that would not comply is different for the second vehicle than it is for the first vehicle.

Table 8
Predicted Percent Change in Total Hydrocarbon Emissions
for Fuel Mixtures in Vehicle Tank

Transition from:	Terminal Tank Heel	Vehicle 1				Vehicle 2				Average Change During Transition
		Predicted change for each turnover				Predicted change for each turnover				
0 to 5.7 vol%	10%	3.79	0.55	-0.14	-0.32	2.63	0.26	-0.22	-0.35	0.78%
	25%	4.45	1.01	0.05	-0.25	3.38	0.66	-0.06	-0.29	1.12%
	50%	5.63	2.23	0.88	0.23	4.74	1.86	0.70	0.14	2.05%
0 to 7.7 vol%	10%	4.18	0.74	-0.29	-0.46	3.06	0.08	-0.37	-0.48	0.81%
	25%	4.69	1.11	-0.13	-0.40	3.65	0.41	-0.23	-0.43	1.08%
	50%	5.58	2.08	0.56	0.01	4.69	1.36	0.40	-0.07	1.83%
0 to 10 vol%	10%	4.70	1.08	0.22	0.01	3.10	0.70	0.12	-0.02	1.24%
	25%	4.79	1.06	0.19	-0.01	3.18	0.66	0.09	-0.03	1.24%
	50%	5.07	1.19	0.16	-0.07	3.50	0.75	0.05	-0.09	1.32%
5.7 to 7.7 vol% (H) (Sulfur 20 to 14)	10%	-0.83	-0.76	-0.60	-0.54	-1.08	-0.69	-0.57	-0.53	-0.70%
	25%	-0.98	-0.90	-0.68	-0.56	-1.26	-0.82	-0.62	-0.55	-0.80%
	50%	-1.20	-1.23	-0.94	-0.74	-1.55	-1.16	-0.88	-0.71	-1.05%
5.7 to 7.7 vol% (L) (Sulfur 14 to 12)	10%	-0.54	-0.61	-0.49	-0.47	-0.82	-0.57	-0.49	-0.47	-0.56%
	25%	-0.66	-0.72	-0.55	-0.49	-0.97	-0.67	-0.53	-0.48	-0.63%
	50%	-0.86	-0.98	-0.77	-0.62	-1.22	-0.93	-0.72	-0.60	-0.84%
5.7 to 10 vol%	10%	-0.61	-0.32	-0.13	-0.08	-0.61	-0.26	-0.12	-0.08	-0.28%
	25%	-1.03	-0.69	-0.33	-0.15	-1.11	-0.60	-0.26	-0.13	-0.54%
	50%	-1.71	-1.57	-1.02	-0.58	-1.93	-1.49	-0.91	-0.52	-1.22%
7.7 to 10 vol%	10%	-0.60	-0.30	-0.16	-0.08	-0.57	-0.24	-0.11	-0.08	-0.27%
	25%	-0.93	-0.61	-0.28	-0.14	-0.98	-0.53	-0.24	-0.12	-0.48%
	50%	-1.45	-1.31	-0.86	-0.51	-1.60	-1.25	-0.78	-0.46	-1.03%
7.7 to 5.7 vol% (L) (Sulfur 12 to 14)	10%	-0.27	0.12	0.03	0.00	-0.19	0.08	0.02	0.00	-0.03%
	25%	-0.14	0.23	0.09	0.02	-0.03	0.18	0.06	0.01	0.05%
	50%	0.09	0.50	0.30	0.14	0.24	0.45	0.24	0.12	0.26%
7.7 to 5.7 vol% (H) (Sulfur 14 to 20)	10%	-0.59	-0.25	-0.38	-0.38	-0.54	-0.29	-0.36	-0.38	-0.40%
	25%	-0.42	-0.13	-0.31	-0.36	-0.34	-0.18	-0.32	-0.36	-0.30%
	50%	-0.13	0.19	-0.10	-0.22	0.00	0.13	-0.11	-0.24	-0.06%
10 to 5.7 vol%	10%	-0.32	-0.37	-0.27	-0.36	-0.18	-0.08	-0.31	-0.37	-0.24%
	25%	0.05	-0.07	-0.11	-0.30	0.26	0.19	-0.19	-0.33	-0.06%
	50%	0.68	0.66	0.38	0.03	1.00	0.92	0.31	-0.03	0.49%
10 to 7.7 vol%	10%	-0.35	-0.27	-0.44	-0.50	-0.40	-0.34	-0.47	-0.51	-0.41%
	25%	-0.15	-0.11	-0.40	-0.47	-0.15	-0.20	-0.41	-0.49	-0.30%
	50%	0.21	0.30	-0.09	-0.30	0.27	0.21	-0.14	-0.33	0.02%
5.7 to 0 vol%	10%	5.07	1.17	0.22	0.00	0.40	0.02	-0.05	-0.07	0.85%
	25%	4.39	0.70	0.01	-0.08	-0.24	-0.38	-0.23	-0.13	0.51%
	50%	3.35	-0.36	-0.79	-0.59	-1.17	-1.37	-0.96	-0.59	-0.31%
7.7 to 0 vol%	10%	5.53	1.25	0.24	0.00	0.59	0.07	-0.04	-0.06	0.95%
	25%	5.03	0.91	0.09	-0.05	0.11	-0.22	-0.17	-0.11	0.70%
	50%	4.23	0.11	-0.50	-0.42	-0.62	-0.97	-0.70	-0.44	0.09%
10 to 0 vol%	10%	6.16	1.46	0.30	0.02	1.09	0.22	0.00	-0.06	1.15%
	25%	5.86	1.27	0.21	-0.01	0.86	0.06	-0.07	-0.08	1.01%
	50%	5.42	0.88	-0.08	-0.21	0.55	-0.27	-0.34	-0.25	0.71%

Table 9
Predicted Percent Change in NOx Emissions for Fuel Mixtures in Vehicle Tank

Transition from:	Terminal Tank Heel	Vehicle 1				Vehicle 2				Average Change During Transition
		Predicted change for each turnover				Predicted change for each turnover				
0 to 5.7 vol%	10%	-2.04	-0.29	-0.11	-0.07	-1.55	-0.22	-0.09	-0.06	-0.55%
	25%	-2.22	-0.43	-0.18	-0.09	-1.75	-0.35	-0.15	-0.08	-0.66%
	50%	-2.50	-0.78	-0.45	-0.26	-2.10	-0.70	-0.40	-0.23	-0.93%
0 to 7.7 vol%	10%	-2.38	-0.66	-0.08	-0.08	-1.79	-0.08	-0.08	-0.08	-0.65%
	25%	-2.40	-0.67	-0.08	-0.08	-1.81	-0.08	-0.09	-0.08	-0.66%
	50%	-2.44	-0.69	-0.10	-0.09	-1.85	-0.10	-0.10	-0.09	-0.68%
0 to 10 vol%	10%	-3.23	-1.15	-0.45	-0.27	-2.38	-0.84	-0.37	-0.25	-1.12%
	25%	-3.02	-0.95	-0.36	-0.23	-2.11	-0.67	-0.30	-0.22	-0.98%
	50%	-2.66	-0.48	0.00	-0.01	-1.67	-0.19	0.05	-0.02	-0.62%
5.7 to 7.7 vol% (H) (Sulfur 20 to 14)	10%	0.17	0.17	-0.07	-0.07	0.54	0.09	-0.04	-0.07	0.09%
	25%	0.32	0.29	-0.04	-0.04	0.72	0.21	0.01	-0.05	0.18%
	50%	0.57	0.61	0.24	0.10	1.03	0.52	0.23	0.08	0.42%
5.7 to 7.7 vol% (L) (Sulfur 14 to 12)	10%	-0.35	-0.08	-0.14	-0.19	0.10	-0.11	-0.17	-0.19	-0.14%
	25%	-0.28	-0.02	-0.13	-0.18	0.19	-0.06	-0.15	-0.18	-0.10%
	50%	-0.17	0.13	-0.07	-0.11	0.33	0.09	-0.05	-0.12	0.00%
5.7 to 10 vol%	10%	-0.12	-0.14	-0.13	-0.20	-0.06	-0.15	-0.19	-0.20	-0.15%
	25%	0.26	0.19	-0.06	-0.14	0.40	0.15	-0.06	-0.16	0.07%
	50%	0.91	0.99	0.54	0.23	1.19	0.96	0.50	0.18	0.69%
7.7 to 10 vol%	10%	0.03	-0.10	-0.26	-0.20	0.03	-0.13	-0.18	-0.20	-0.13%
	25%	0.27	0.10	-0.05	-0.16	0.31	0.06	-0.11	-0.17	0.03%
	50%	0.67	0.59	0.28	0.07	0.79	0.55	0.24	0.03	0.40%
7.7 to 5.7 vol% (L) (Sulfur 12 to 14)	10%	-0.63	-1.15	-1.06	-1.04	-0.74	-1.11	-1.05	-1.04	-0.98%
	25%	-0.70	-1.20	-1.07	-1.05	-0.82	-1.16	-1.08	-1.05	-1.02%
	50%	-0.81	-1.34	-1.12	-1.11	-0.96	-1.30	-1.17	-1.10	-1.11%
7.7 to 5.7 vol% (H) (Sulfur 14 to 20)	10%	-0.05	-0.30	-0.20	-0.07	-0.07	-0.22	-0.09	-0.06	-0.13%
	25%	-0.20	-0.42	-0.22	-0.09	-0.25	-0.34	-0.14	-0.08	-0.22%
	50%	-0.46	-0.74	-0.49	-0.24	-0.56	-0.65	-0.37	-0.21	-0.47%
10 to 5.7 vol%	10%	-0.38	-0.21	-0.24	-0.09	-0.56	-0.50	-0.17	-0.08	-0.33%
	25%	-0.78	-0.55	-0.32	-0.16	-1.04	-0.81	-0.30	-0.13	-0.51%
	50%	-1.45	-1.38	-1.09	-0.55	-1.84	-1.64	-0.89	-0.48	-1.17%
10 to 7.7 vol%	10%	-0.22	-0.47	-0.15	-0.11	-0.19	-0.36	-0.16	-0.10	-0.22%
	25%	-0.46	-0.68	-0.36	-0.15	-0.49	-0.54	-0.24	-0.13	-0.38%
	50%	-0.87	-1.18	-0.69	-0.39	-0.97	-1.05	-0.59	-0.34	-0.76%
5.7 to 0 vol%	10%	-2.49	-3.23	-3.43	-3.49	-2.80	-3.31	-3.46	-3.50	-3.21%
	25%	-2.30	-3.07	-3.36	-3.46	-2.57	-3.17	-3.40	-3.47	-3.10%
	50%	-1.99	-2.68	-3.06	-3.28	-2.20	-2.78	-3.12	-3.31	-2.80%
7.7 to 0 vol%	10%	-3.06	-3.46	-3.50	-3.51	-3.31	-3.48	-3.50	-3.51	-3.42%
	25%	-3.03	-3.43	-3.46	-3.50	-3.27	-3.45	-3.49	-3.50	-3.39%
	50%	-2.98	-3.36	-3.42	-3.46	-3.20	-3.37	-3.44	-3.47	-3.34%
10 to 0 vol%	10%	-3.98	-3.84	-3.60	-3.53	-4.13	-3.74	-3.57	-3.52	-3.74%
	25%	-4.21	-4.02	-3.69	-3.57	-4.40	-3.91	-3.64	-3.55	-3.87%
	50%	-4.59	-4.48	-4.03	-3.78	-4.85	-4.37	-3.96	-3.74	-4.23%

Table 10
Predicted Percent Change in Toxic Emissions for Fuel Mixtures in Vehicle Tank

Transition from:	Terminal Tank Heel	Vehicle 1				Vehicle 2				Average Change During Transition
		Predicted change for each turnover				Predicted change for each turnover				
0 to 5.7 vol%	10%	-1.91	-1.46	-1.09	-0.99	-1.82	-1.31	-1.05	-0.97	-1.33%
	25%	-2.49	-1.92	-1.31	-1.07	-2.50	-1.74	-1.23	-1.04	-1.66%
	50%	-3.47	-3.07	-2.17	-1.60	-3.66	-2.89	-2.03	-1.51	-2.55%
0 to 7.7 vol%	10%	-4.06	-4.50	-4.52	-4.49	-4.34	-4.59	-4.51	-4.49	-4.43%
	25%	-4.47	-4.83	-4.68	-4.55	-4.83	-4.89	-4.64	-4.53	-4.68%
	50%	-5.18	-5.67	-5.30	-4.93	-5.67	-5.73	-5.22	-4.88	-5.32%
0 to 10 vol%	10%	-5.19	-5.98	-6.04	-6.04	-5.71	-6.03	-6.04	-6.03	-5.88%
	25%	-5.75	-6.46	-6.27	-6.12	-6.38	-6.47	-6.23	-6.10	-6.22%
	50%	-6.68	-7.61	-7.15	-6.68	-7.49	-7.63	-7.05	-6.60	-7.11%
5.7 to 7.7 vol% (H) (Sulfur 20 to 14)	10%	-3.02	-4.09	-4.44	-4.45	-3.48	-4.21	-4.41	-4.46	-4.07%
	25%	-2.85	-3.94	-4.42	-4.43	-3.28	-4.08	-4.35	-4.44	-3.97%
	50%	-2.56	-3.59	-4.06	-4.26	-2.94	-3.73	-4.11	-4.29	-3.69%
5.7 to 7.7 vol% (L) (Sulfur 14 to 12)	10%	-0.45	-0.33	-0.22	-0.20	-0.50	-0.30	-0.17	-0.20	-0.30%
	25%	-0.63	-0.44	-0.24	-0.22	-0.72	-0.39	-0.21	-0.22	-0.38%
	50%	-0.94	-0.83	-0.61	-0.35	-1.09	-0.78	-0.49	-0.32	-0.68%
5.7 to 10 vol%	10%	-4.03	-5.49	-5.89	-6.00	-4.60	-5.66	-5.94	-6.01	-5.45%
	25%	-3.90	-5.39	-5.90	-5.98	-4.45	-5.57	-5.90	-5.99	-5.39%
	50%	-3.68	-5.13	-5.61	-5.86	-4.19	-5.31	-5.72	-5.89	-5.17%
7.7 to 10 vol%	10%	-5.53	-5.93	-5.96	-6.03	-5.73	-5.97	-6.02	-6.03	-5.90%
	25%	-5.64	-6.02	-5.99	-6.04	-5.86	-6.06	-6.06	-6.04	-5.96%
	50%	-5.81	-6.24	-6.18	-6.16	-6.06	-6.28	-6.22	-6.14	-6.14%
7.7 to 5.7 vol% (L) (Sulfur 12 to 14)	10%	-0.26	-0.33	-0.50	-0.47	-0.26	-0.38	-0.43	-0.48	-0.39%
	25%	-0.05	-0.05	-0.20	-0.43	-0.03	-0.09	-0.32	-0.45	-0.20%
	50%	0.28	0.34	-0.11	-0.13	0.38	0.30	-0.04	-0.15	0.11%
7.7 to 5.7 vol% (H) (Sulfur 14 to 20)	10%	-2.53	-1.34	-1.01	-0.97	-2.12	-1.22	-1.02	-0.97	-1.40%
	25%	-2.68	-1.47	-1.02	-1.00	-2.30	-1.34	-1.07	-0.98	-1.48%
	50%	-2.93	-1.78	-1.35	-1.15	-2.60	-1.65	-1.29	-1.12	-1.73%
10 to 5.7 vol%	10%	-3.27	-1.64	-1.03	-0.98	-2.64	-1.33	-1.05	-0.97	-1.50%
	25%	-3.45	-1.81	-1.05	-1.02	-2.86	-1.48	-1.11	-1.00	-1.72%
	50%	-3.76	-2.20	-1.47	-1.21	-3.23	-1.89	-1.40	-1.17	-2.04%
10 to 7.7 vol%	10%	-5.17	-4.62	-4.50	-4.49	-4.98	-4.58	-4.50	-4.49	-4.67%
	25%	-5.18	-4.64	-4.52	-4.49	-5.00	-4.59	-4.51	-4.49	-4.68%
	50%	-5.20	-4.67	-4.54	-4.51	-5.03	-4.62	-4.54	-4.50	-4.70%
5.7 to 0 vol%	10%	-1.41	-3.74	-4.46	-4.66	-3.00	-4.22	-4.59	-4.69	-3.85%
	25%	-0.82	-3.25	-4.23	-4.57	-2.32	-3.78	-4.40	-4.63	-3.50%
	50%	0.15	-2.07	-3.33	-4.01	-1.18	-2.59	-3.57	-4.12	-2.59%
7.7 to 0 vol%	10%	-3.06	-4.21	-4.59	-4.69	-4.19	-4.55	-4.68	-4.71	-4.34%
	25%	-2.62	-3.85	-4.42	-4.63	-3.68	-4.22	-4.54	-4.66	-4.08%
	50%	-1.88	-2.98	-3.76	-4.22	-2.84	-3.34	-3.92	-4.30	-3.41%
10 to 0 vol%	10%	-3.86	-4.45	-4.65	-4.71	-4.78	-4.72	-4.72	-4.73	-4.58%
	25%	-3.48	-4.16	-4.52	-4.66	-4.36	-4.45	-4.61	-4.69	-4.37%
	50%	-2.84	-3.44	-3.98	-4.33	-3.64	-3.73	-4.11	-4.39	-3.81%

Table 11
Expected Changes in Statewide Exhaust Emissions
If All California Gasoline Transitioned to Different Ethanol Content

Transition from:	Terminal Tank Heel	Pollutant Exceeded	Average Change During Transition	Percent of CaRFG Benefits
0 to 5.7 vol%	10%	HC	0.78%	0.31%
	25%	HC	1.12%	0.45%
	50%	HC	2.05%	0.83%
0 to 7.7 vol%	10%	HC	0.81%	0.33%
	25%	HC	1.08%	0.44%
	50%	HC	1.83%	0.74%
0 to 10 vol%	10%	HC	1.24%	0.50%
	25%	HC	1.24%	0.50%
	50%	HC	1.32%	0.53%
5.7 to 7.7 vol% (H) (Sulfur 20 to 14)	10%	NOx	0.09%	0.08%
	25%	NOx	0.18%	0.16%
	50%	NOx	0.42%	0.39%
5.7 to 7.7 vol% (L) (Sulfur 14 to 12)	10%	NOx	-0.14%	-0.13%
	25%	NOx	-0.10%	-0.09%
	50%	NOx	0.00%	0.00%
5.7 to 10 vol%	10%	NOx	-0.15%	-0.14%
	25%	NOx	0.07%	0.07%
	50%	NOx	0.69%	0.63%
7.7 to 10 vol%	10%	NOx	-0.13%	-0.12%
	25%	NOx	0.03%	0.03%
	50%	NOx	0.40%	0.37%
7.7 to 5.7 vol% (L) (Sulfur 12 to 14)	10%	HC	-0.03%	-0.01%
	25%	HC	0.05%	0.02%
	50%	HC	0.26%	0.10%
7.7 to 5.7 vol% (H) (Sulfur 14 to 20)	10%	HC	-0.40%	-0.16%
	25%	HC	-0.30%	-0.12%
	50%	HC	-0.06%	-0.02%
10 to 5.7 vol%	10%	HC	-0.24%	-0.09%
	25%	HC	-0.06%	-0.03%
	50%	HC	0.49%	0.20%
10 to 7.7 vol%	10%	HC	-0.41%	-0.17%
	25%	HC	-0.30%	-0.12%
	50%	HC	0.02%	0.01%
5.7 to 0 vol%	10%	HC	0.85%	0.34%
	25%	HC	0.51%	0.20%
	50%	HC	-0.31%	-0.12%
7.7 to 0 vol%	10%	HC	0.95%	0.38%
	25%	HC	0.70%	0.28%
	50%	HC	0.09%	0.03%
10 to 0 vol%	10%	HC	1.15%	0.46%
	25%	HC	1.01%	0.41%
	50%	HC	0.71%	0.29%

Table 12
Reid Vapor Pressures for Transitions from Oxygenated to Non-oxygenated fuel

Transition from:	Terminal Tank Heel	# Weeks into Transition Period ¹	Terminal	Station	Vehicle #1	Vehicle #2
5.7 to 0 vol%	10%	1	6.80	7.67	7.46	
	25%	1	6.50	7.53	7.35	
	50%	1	6.20	7.30	7.18	
7.7 to 0 vol% 10 to 0 vol%	10%	1	6.72	7.76	7.61	
	25%	1	6.59	7.66	7.54	
	50%	1	6.38	7.50	7.42	
¹ Emissions calculations were based on a four week transition period						

Table 13
Reid Vapor Pressures for Transitions from Non-oxygenated to Oxygenated Fuel

Transition from:	Terminal Tank Heel	# Weeks into Transition Period ¹	Terminal	Station	Vehicle #1	Vehicle #2	
0 to 5.7 vol%	10%	1	6.94	7.15	7.36	7.24	
				6.98			
	25%	1	7.12	7.29	7.47	7.36	
				7.15			
		50%	1	7.4	7.52	7.64	7.57
					7.43		
2	7.12	7.18	7.29	7.24			
		7.13					
0 to 7.7 vol% 0 to 10 vol%	10%	1	7.25	7.39	7.54	7.45	
				7.28			
		2	7.17	7.19	7.28	7.25	
				7.18			
	25%	1	7.37	7.49	7.62	7.54	
				7.39			
		2	7.22	7.25	7.34	7.30	
				7.22			
	3	7.18	7.19	7.22	7.21		
			7.18				
	50%	1	7.57	7.66	7.74	7.69	
				7.59			
2		7.37	7.41	7.49	7.46		
			7.38				
3	7.27	7.29	7.34	7.32			
		7.27					
4	7.22	7.23	7.25	7.24			
		7.22					
¹ Emissions calculations were based on a four week transition period							

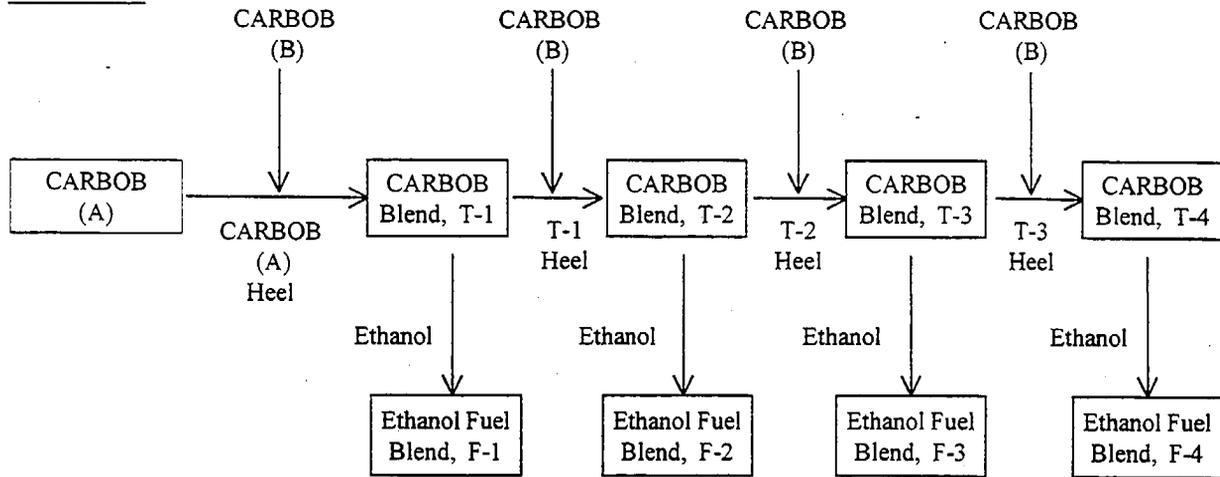
Table 14

**Staff Recommendations for Tank Transitions to Change Ethanol Content of
CaRFG3 and Mitigation of Emissions Impact**

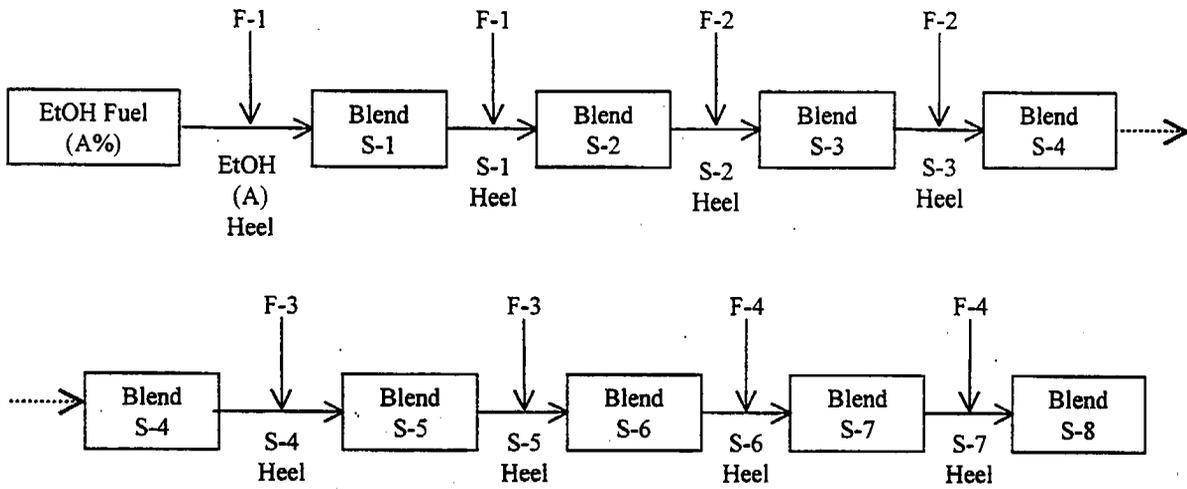
Transition From	Potential Emission Impact:	Conditions to Prevent Emissions Increases
CARBOB to CARBOB (increasing oxygen by no more than 3%)	NOx increase	1.Sulfur of target fuel to be no more than 12 ppmw for 1 st tank turnover of the transition. 2.Heel at terminal not to exceed 10% for each tank turnover during the transition
CARBOB to CARBOB (decreasing oxygen by no more than 3%)	HC increase	1.Sulfur of target fuel to be no more than 12 ppmw for 1 st tank turnover of the transition. 2.Heel at terminal not to exceed 10% for each tank turnover during the transition
Non-Oxygenated to Oxygenated RFG	HC increase and likely RVP violation downstream of refinery	None known for summer. Allow transition during non-RVP season
Oxygenated RFG to Non-Oxygenated	HC increase and possible RVP violation downstream of refinery	None known for summer. Allow transition during non-RVP season.

TRANSITION FROM ETHANOL FUEL (A) TO ETHANOL FUEL (B)

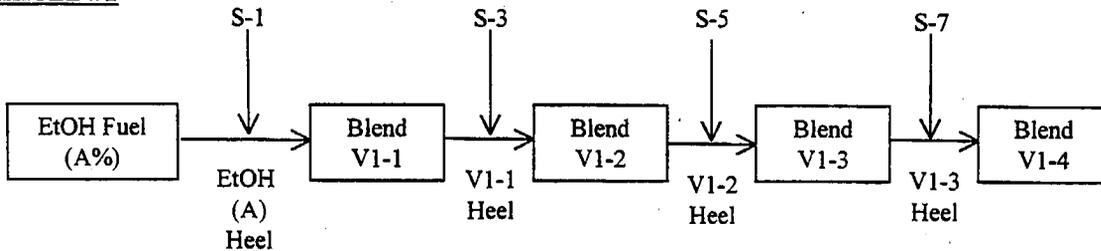
TERMINAL



SERVICE STATION



VEHICLE #1



VEHICLE #2

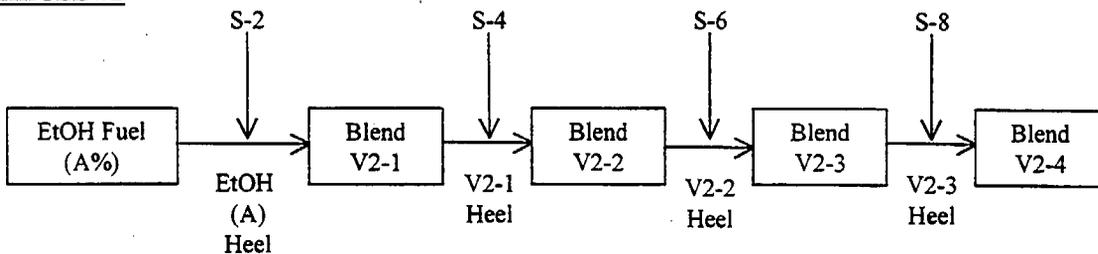


TABLE 15: EXAMPLE CALCULATION FOR TRANSITION FROM NON-OXYGENATED FUEL TO 7.7 VOL % ETHANOL FUEL

TERMINAL TANK TRANSITION: 0-OXY CaRFG TO TARGET CARBOB FOR 7.7 VOL.% EtOH

PROPERTIES OF CARBOBS AT EACH TANK TURNOVER

CARBOB Properties	0-OXY CaRFG	TARGET CARBOB (7.7 vol% EtOH)	1st Turnover CARBOB	2nd Turnover CARBOB	3rd Turnover CARBOB	4th Turnover CARBOB
Aromatics, vol%	25.0	27.0	26.8	27.0	27.0	27.0
Benzene, vol%	0.6	0.75	0.74	0.75	0.75	0.75
Olefins, vol%	6.0	4.3	4.5	4.3	4.3	4.3
Sulfur, ppm	10	14	13.6	14	14	14
T50, deg. F	210	213	213	213	213	213
T90, deg. F	305	313	312	313	313	313
Oxygen, wt. %	0.0	0	0.0	0.0	0.0	0.0
RVP, psi	6.8	6.0	6.0	6.0	6.0	6.0

PROPERTIES OF FUELS PRODUCED FROM CARBOBS

FUEL Properties	0-OXY CaRFG	TARGET FUEL from CARBOB (7.7 vol% EtOH)	FUEL from 1st Turnover CARBOB	FUEL from 2nd Turnover CARBOB	FUEL from 3rd Turnover CARBOB	FUEL from 4th Turnover CARBOB
Aromatics, vol%	25.0	25.1	24.9	25.0	25.1	25.1
Benzene, vol%	0.60	0.70	0.69	0.70	0.70	0.70
Olefins, vol%	6.0	4.0	4.2	4.0	4.0	4.0
Sulfur, ppm	10.0	14.1	13.7	14.0	14.1	14.1
T50, deg. F	210	206	206	206	206	206
T90, deg. F	305	310	309	309	310	310
Ethanol, vol.%	0.0	7.7	7.7	7.7	7.7	7.7
Oxygen	0.0	2.8	2.8	2.8	2.8	2.8
RVP, psi	6.80	7.16	7.25	7.17	7.16	7.16

NOTES: PROPERTIES OF BLENDED ETHANOL FUELS CALCULATED USING WSPA CARBOB MODEL (7/20/00)
 CARBOBS FROM TERMINAL TANK TURNOVERS BLENDED WITH ETHANOL AT TARGET CONCENTRATION OF: **7.7 VOL.% EtOH**

PROPERTIES OF FUELS EVALUATED USING THE PHASE 3 PREDICTIVE MODEL

PREDICTED PERCENT CHANGE IN EMISSIONS (CANDIDATE VS REFERENCE)

POLLUTANT	0-OXY CaRFG	TARGET FUEL from CARBOB (7.7 vol% EtOH)	FUEL from 1st Turnover CARBOB	FUEL from 2nd Turnover CARBOB	FUEL from 3rd Turnover CARBOB	FUEL from 4th Turnover CARBOB
NOX	-3.51	-0.10	-0.10	-0.09	-0.08	-0.08
EXHAUST THC	1.02	-2.88	-3.27	-2.98	-2.95	-2.95
EVAP THC (Reactivity Weighted)	-2.35	6.55	8.85	6.87	6.68	6.66
CO (Reactivity Weighted)	0.00	-0.09	-0.09	-0.09	-0.09	-0.09
TOTAL THC+CO	-0.07	-0.51	-0.06	-0.47	-0.52	-0.52
POT.TOX.	-4.86	-4.39	-4.92	-4.52	-4.48	-4.48
	PASSES	PASSES	PASSES	PASSES	PASSES	PASSES

THE CANDIDATE FUEL **PASSES** IF THE PERCENT CHANGE IN EMISSIONS BETWEEN THE CANDIDATE FUEL AND REFERENCE FUEL IS LESS THAN OR EQUAL TO 0.04%

THE CANDIDATE FUEL **FAILS** IF THE PERCENT CHANGE IN EMISSIONS BETWEEN THE CANDIDATE FUEL AND REFERENCE FUEL IS GREATER THAN OR EQUAL TO 0.05%

TERMINAL TANK TURNOVERS

1ST TERMINAL TANK TURNOVER

Heel (base CARBOB) 0-OXY CaRFG
 New batch TARGET CARBOB (7.7 vol% EtOH)

RVP = 7.25 EXCEEDS CAP

10% of tank capacity **PASSES**
 90% of tank capacity

2ND TERMINAL TANK TURNOVER

Heel 1st Turnover CARBOB
 New batch TARGET CARBOB (7.7 vol% EtOH)

10% of tank capacity **PASSES**
 90% of tank capacity

3RD TERMINAL TANK TURNOVER

Heel 2nd Turnover CARBOB
 New batch TARGET CARBOB (7.7 vol% EtOH)

10% of tank capacity **PASSES**
 90% of tank capacity

4TH TERMINAL TANK TURNOVER

Heel 3rd Turnover CARBOB
 New batch TARGET CARBOB (7.7 vol% EtOH)

10% of tank capacity **PASSES**
 90% of tank capacity

TABLE 16: EXAMPLE CALCULATION FOR TRANSITION FROM NON-OXYGENATED FUEL TO 7.7 VOL % ETHANOL FUEL UNDERGROUND TANK TRANSITION
0-OXY CaRFG TO 7.7 VOL% EtOH

NEW BATCHES OF FUELS DELIVERED TO STATION

FUEL Properties	0-OXY CaRFG	FUEL from 1st Turnover CARBOB	FUEL from 1st Turnover CARBOB	FUEL from 2nd Turnover CARBOB	FUEL from 2nd Turnover CARBOB	FUEL from 3rd Turnover CARBOB	FUEL from 3rd Turnover CARBOB	FUEL from 4th Turnover CARBOB	FUEL from 4th Turnover CARBOB
Aromatics, vol%	25.0	24.9	24.9	25.0	25.0	25.1	25.1	25.1	25.1
Benzene, vol%	0.60	0.69	0.69	0.70	0.70	0.70	0.70	0.70	0.70
Olefins, vol%	6.0	4.2	4.2	4.0	4.0	4.0	4.0	4.0	4.0
Sulfur, ppm	10	14	14	14	14	14	14	14	14
T50, deg. F	210	206	206	206	206	206	206	206	206
T90, deg. F	305	309	309	309	309	310	310	310	310
Ethanol conc., vol. %	0.0	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
Oxygen	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
RVP, psi	6.80	7.25	7.25	7.17	7.17	7.16	7.16	7.16	7.16

NOTES: FUELS DELIVERED TO STATION WERE PRODUCED BY BLENDING CARBOBS FROM TERMINAL TANK TURNS WITH ETHANOL AT:

TARGET ETHANOL CONCENTRATION OF: **7.7 VOL% EtOH**

HEEL IN UNDERGROUND TANK **20% OF TANK CAPACITY**

CARBOB HEEL IN TERMINAL TANK WAS **10% OF TANK CAPACITY**

UNDERGROUND TANK TRANSITION FROM 0-OXY CaRFG TO 7.7 vol% EtOH FUEL

FUELS PRODUCED BY MIXING UNDERGROUND TANK HEEL WITH NEW BATCH OF FUEL

FUEL Properties	0-OXY CaRFG	1st Turnover FUEL at STATION	2nd Turnover FUEL at STATION	3rd Turnover FUEL at STATION	4th Turnover FUEL at STATION	5th Turnover FUEL at STATION	6th Turnover FUEL at STATION	7th Turnover FUEL at STATION	8th Turnover FUEL at STATION	7.7 vol% EtOH FUEL
Aromatics, vol%	25.0	24.9	24.9	25.0	25.0	25.0	25.0	25.1	25.1	25.1
Benzene, vol%	0.60	0.67	0.68	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Olefins, vol%	6.0	4.5	4.2	4.1	4.0	4.0	4.0	4.0	4.0	4.0
Sulfur, ppm	10	13	14	14	14	14	14	14	14	14
T50, deg. F	210	207	206	206	206	206	206	206	206	206
T90, deg. F	305	308	309	309	309	310	310	310	310	310
Ethanol conc., vol. %	0.0	6.2	7.4	7.6	7.7	7.7	7.7	7.7	7.7	7.7
Oxygen, wt. %	0.0	2.2	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.8
RVP, psi	6.80	7.39	7.28	7.19	7.18	7.17	7.17	7.16	7.16	7.16

NOTES: HEEL IN UNDERGROUND STORAGE TANK:

20.0% of tank capacity

USE ROCKE'S EQUATION TO CALCULATE RVP BOOST FOR FIRST UNDERGROUND TANK TURNS

RVP BOOST =

1.19 psi FOR HEEL FOR FIRST UNDERGROUND TANK TURNS

PROPERTIES OF FUELS EVALUATED USING THE PHASE 3 PREDICTIVE MODEL

PREDICTED PERCENT CHANGE IN EMISSIONS (CANDIDATE VS REFERENCE)

POLLUTANT	0-OXY CaRFG	1st Turnover FUEL at STATION	2nd Turnover FUEL at STATION	3rd Turnover FUEL at STATION	4th Turnover FUEL at STATION	5th Turnover FUEL at STATION	6th Turnover FUEL at STATION	7th Turnover FUEL at STATION	8th Turnover FUEL at STATION	7.7 vol% EtOH FUEL
NOX	-3.51	-1.30	-0.09	-0.09	-0.09	-0.08	-0.08	-0.08	-0.08	-0.10
EXHAUST THC	1.02	-2.60	-3.27	-3.04	-2.99	-2.96	-2.95	-2.95	-2.95	-2.88
EVAP THC (Reactivity Weighted)	-2.35	13.01	9.66	7.42	6.98	6.74	6.69	6.66	6.66	6.55
CO (Reactivity Weighted)	0.00	-0.03	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09
TOTAL THC+CO	-0.07	2.10	0.19	-0.34	-0.45	-0.50	-0.51	-0.52	-0.52	-0.51
POT.TOX.	-4.86	-4.53	-4.89	-4.60	-4.54	-4.49	-4.49	-4.48	-4.48	-4.39
	PASSES	FAILS	FAILS	PASSES	PASSES	PASSES	PASSES	PASSES	PASSES	PASSES

UNDERGROUND TANK TRANSITION

0-OXY CaRFG

TO

7.7 VOL% EtOH

CARBOB HEEL IN TERMINAL TANK WAS

10% OF TANK CAPACITY

UNDERGROUND TANK TURNS

1ST UNDERGROUND TANK TURNS:

Heel (base fuel): **0-OXY CaRFG**
 New batch: **FUEL from 1st Turnover CARBOB**

RVP = 7.39 **EXCEEDS CAP**
 20.0% of tank capacity
 80.0% of tank capacity **FAILS**

2ND UNDERGROUND TANK TURNS:

Heel: **1st Turnover FUEL at STATION**
 New batch: **FUEL from 1st Turnover CARBOB**

RVP = 7.28 **EXCEEDS CAP**
 20.0% of tank capacity
 80.0% of tank capacity **FAILS**

3RD UNDERGROUND TANK TURNS:

Heel: **2nd Turnover FUEL at STATION**
 New batch: **FUEL from 2nd Turnover CARBOB**

20.0% of tank capacity
 80.0% of tank capacity **PASSES**

4TH UNDERGROUND TANK TURNS:

Heel: **3rd Turnover FUEL at STATION**
 New batch: **FUEL from 2nd Turnover CARBOB**

20.0% of tank capacity
 80.0% of tank capacity **PASSES**

5TH UNDERGROUND TANK TURNS:

Heel: **4th Turnover FUEL at STATION**
 New batch: **FUEL from 3rd Turnover CARBOB**

20.0% of tank capacity
 80.0% of tank capacity **PASSES**

6TH UNDERGROUND TANK TURNS:

Heel: **5th Turnover FUEL at STATION**
 New batch: **FUEL from 3rd Turnover CARBOB**

20.0% of tank capacity
 80.0% of tank capacity **PASSES**

7TH UNDERGROUND TANK TURNS:

Heel: **6th Turnover FUEL at STATION**
 New batch: **FUEL from 4th Turnover CARBOB**

20.0% of tank capacity
 80.0% of tank capacity **PASSES**

8TH UNDERGROUND TANK TURNS:

Heel: **7th Turnover FUEL at STATION**
 New batch: **FUEL from 4th Turnover CARBOB**

20.0% of tank capacity
 80.0% of tank capacity **PASSES**

THE CANDIDATE FUEL **PASSES** IF THE PERCENT CHANGE IN EMISSIONS BETWEEN THE CANDIDATE

FUEL AND REFERENCE FUEL IS LESS THAN OR EQUAL TO 0.04%

THE CANDIDATE FUEL **FAILS** IF THE PERCENT CHANGE IN EMISSIONS BETWEEN THE CANDIDATE

FUEL AND REFERENCE FUEL IS GREATER THAN OR EQUAL TO 0.05%

TABLE 17: EXAMPLE CALCULATION FOR TRANSITION FROM NON-OXYGENATED FUEL TO 7.7 VOL % ETHANOL FUEL VEHICLE TANK TRANSITION FROM 0-OXY CaRFG TO 7.7 vol% EtOH FUEL

VEHICLE #1

NEW BATCHES OF FUELS PRODUCED AT STATION WITH EACH UNDERGROUND TANK TURNOVER

FUEL Properties	0-OXY CaRFG	1st Turnover FUEL at STATION	3rd Turnover FUEL at STATION	5th Turnover FUEL at STATION	7th Turnover FUEL at STATION	7.7 vol% EtOH FUEL
Aromatics, vol%	25.0	24.9	25.0	25.0	25.1	25.1
Benzene, vol%	0.60	0.67	0.70	0.70	0.70	0.70
Olefins, vol%	6.0	4.5	4.1	4.0	4.0	4.0
Sulfur, ppm	10	13	14	14	14	14
T50, deg. F	210	207	206	206	206	206
T90, deg. F	305	308	309	310	310	310
Ethanol conc. vol. %	0.0	6.2	7.6	7.7	7.7	7.7
Oxygen, wt. %	0.0	2.2	2.8	2.8	2.8	2.8
RVP, psi	6.80	7.39	7.19	7.17	7.16	7.16

FUELS AT STATION PRODUCED BY MIXING UNDERGROUND TANK HEEL WITH NEW BATCH OF FUEL DELIVERED TO STATION
 HEEL IN UNDERGROUND TANK: 20.0% of tank capacity
 HEEL IN TERMINAL TANK: 10% of tank capacity

VEHICLE #1

FUELS IN VEHICLE TANK PRODUCED BY MIXING VEHICLE TANK HEEL WITH NEW BATCH OF FUEL AT STATION

FUEL Properties	0-OXY CaRFG	1st Turnover FUEL in VEHICLE #1	2nd Turnover FUEL in VEHICLE #1	3rd Turnover FUEL in VEHICLE #1	4th Turnover FUEL in VEHICLE #1	7.7 vol% EtOH FUEL
Aromatics, vol%	25.0	24.9	25.0	25.0	25.0	25.1
Benzene, vol%	0.60	0.65	0.68	0.70	0.70	0.70
Olefins, vol%	6.0	4.9	4.3	4.1	4.0	4.0
Sulfur, ppm	10.0	12.2	13.5	13.9	14.0	14.1
T50, deg. F	210	207	206	206	206	206
T90, deg. F	305	307	309	309	309	310
Ethanol conc. vol. %	0.0	4.6	6.9	7.5	7.6	7.7
Oxygen, wt. %	0.0	1.7	2.5	2.7	2.8	2.8
RVP, psi	6.80	7.54	7.28	7.20	7.17	7.16

NOTE: HEEL IN VEHICLE TANK: 25% of tank capacity
 HEEL IN UNDERGROUND TANK: 20% of tank capacity
 HEEL IN TERMINAL TANK: 10% of tank capacity
 RVP BOOST = 1.19 psi FOR FIRST VEHICLE TANK TURNOVER

PROPERTIES OF FUELS IN VEHICLE TANK EVALUATED USING THE PHASE 3 PREDICTIVE MODEL PREDICTED PERCENT CHANGE IN EMISSIONS (CANDIDATE VS REFERENCE)

POLLUTANT	0-OXY CaRFG	1st Turnover FUEL in VEHICLE #1	2nd Turnover FUEL in VEHICLE #1	3rd Turnover FUEL in VEHICLE #1	4th Turnover FUEL in VEHICLE #1	7.7 vol% EtOH FUEL
NOX	-3.51	-2.38	-0.66	-0.08	-0.08	-0.10
EXHAUST THC	1.02	-1.76	-2.80	-2.99	-2.96	-2.88
EVAP THC (Reactivity Weighted)	-2.35	17.37	9.80	7.49	6.87	6.55
CO (Reactivity Weighted)	0.00	0.00	-0.06	-0.09	-0.09	-0.09
TOTAL THC+CO	-0.07	4.18	0.74	-0.29	-0.46	-0.51
POT.TOX.	-4.86	-4.06	-4.50	-4.52	-4.49	-4.39
	PASSES	FAILS	FAILS	PASSES	PASSES	PASSES

THE CANDIDATE FUEL **PASSES** IF THE PERCENT CHANGE IN EMISSIONS BETWEEN THE CANDIDATE FUEL AND REFERENCE FUEL IS LESS THAN OR EQUAL TO 0.04%
 THE CANDIDATE FUEL **FAILS** IF THE PERCENT CHANGE IN EMISSIONS BETWEEN THE CANDIDATE FUEL AND REFERENCE FUEL IS GREATER THAN OR EQUAL TO 0.05%

VEHICLE TANK TURNOVERS

VEHICLE #1

1ST VEHICLE TANK TURNOVER:

Heel (base fuel):	0-OXY CaRFG	RVP = 7.54	EXCEEDS CAP
New batch	1st Turnover FUEL at STATION	25.0% of tank capacity	
		75.0% of tank capacity	FAILS

2ND VEHICLE TANK TURNOVER:

Heel:	1st Turnover FUEL in VEHICLE #1	RVP = 7.28	EXCEEDS CAP
New batch	3rd Turnover FUEL at STATION	25.0% of tank capacity	
		75.0% of tank capacity	FAILS

3RD VEHICLE TANK TURNOVER:

Heel:	2nd Turnover FUEL in VEHICLE #1	25.0% of tank capacity	
New batch	5th Turnover FUEL at STATION	75.0% of tank capacity	PASSES

4TH VEHICLE TANK TURNOVER:

Heel:	3rd Turnover FUEL in VEHICLE #1	25.0% of tank capacity	
New batch	7th Turnover FUEL at STATION	75.0% of tank capacity	PASSES

TABLE 18: EXAMPLE CALCULATION FOR TRANSITION FROM NON-OXYGENATED FUEL TO 7.7 VOL % ETHANOL FUEL VEHICLE TANK TRANSITION FROM 0-OXY CaRFG TO 7.7 vol% EtOH FUEL**VEHICLE #2****NEW BATCHES OF FUELS PRODUCED AT STATION WITH EACH UNDERGROUND TANK TURNOVER**

FUEL Properties	0-OXY CaRFG	2nd Turnover FUEL at STATION	4th Turnover FUEL at STATION	6th Turnover FUEL at STATION	8th Turnover FUEL at STATION	7.7 vol% EtOH FUEL
Aromatics, vol%	25.0	24.9	25.0	25.0	25.1	25.1
Benzene, vol%	0.60	0.68	0.70	0.70	0.70	0.70
Olefins, vol%	6.0	4.2	4.0	4.0	4.0	4.0
Sulfur, ppm	10	13.6	14.0	14.1	14.1	14
T50, deg. F	210	206	206	206	206	206
T90, deg. F	305	309	309	310	310	310
Ethanol conc., vol. %	0.0	7.4	7.7	7.7	7.7	7.7
Oxygen, wt. %	0.0	2.7	2.8	2.8	2.8	2.8
RVP, psi	6.80	7.28	7.18	7.17	7.16	7.16

FUELS AT STATION PRODUCED BY MIXING UNDERGROUND TANK HEEL WITH NEW BATCH OF FUEL DELIVERED TO STATION

HEEL IN UNDERGROUND TANK: 20.0% of tank capacity

HEEL IN TERMINAL TANK: 10% of tank capacity

VEHICLE #2**FUELS IN VEHICLE TANK PRODUCED BY MIXING VEHICLE TANK HEEL WITH NEW BATCH OF FUEL AT STATION**

FUEL Properties	0-OXY CaRFG	1st Turnover FUEL in VEHICLE #2	2nd Turnover FUEL in VEHICLE #2	3rd Turnover FUEL in VEHICLE #2	4th Turnover FUEL in VEHICLE #2	7.7 vol% EtOH FUEL
Aromatics, vol%	25.0	24.9	25.0	25.0	25.0	25.1
Benzene, vol%	0.60	0.66	0.69	0.70	0.70	0.70
Olefins, vol%	6.0	4.7	4.2	4.1	4.0	4.0
Sulfur, ppm	10	12.7	13.7	14.0	14.1	14.0
T50, deg. F	210	207	206	206	206	206
T90, deg. F	305	308	309	309	310	310
Ethanol conc. vol. %	0.0	5.5	7.2	7.6	7.7	7.7
Oxygen, wt. %	0.0	2.0	2.6	2.7	2.8	2.8
RVP, psi	6.80	7.45	7.25	7.19	7.17	7.16

NOTE: HEEL IN VEHICLE TANK: 25% of tank capacity

HEEL IN UNDERGROUND TANK: 20% of tank capacity

HEEL IN TERMINAL TANK: 10% of tank capacity

RVP BOOST = 1.19 psi FOR FIRST VEHICLE TANK TURNOVER

**PROPERTIES OF FUELS IN VEHICLE TANK EVALUATED USING THE PHASE 3 PREDICTIVE MODEL
PREDICTED PERCENT CHANGE IN EMISSIONS (CANDIDATE VS REFERENCE)**

POLLUTANT	0-OXY CaRFG	1st Turnover FUEL in VEHICLE #2	2nd Turnover FUEL in VEHICLE #2	3rd Turnover FUEL in VEHICLE #2	4th Turnover FUEL in VEHICLE #2	7.7 vol% EtOH FUEL
NOX	-3.51	-1.79	-0.08	-0.08	-0.08	-0.10
EXHAUST THC	1.02	-2.26	-3.06	-2.98	-2.95	-2.88
EVAP THC (Reactivity Weighted)	-2.35	14.73	8.85	7.22	6.80	6.55
CO (Reactivity Weighted)	0.00	0.00	-0.09	-0.09	-0.09	-0.09
TOTAL THC+CO	-0.07	3.06	0.08	-0.37	-0.48	-0.51
POT.TOX.	-4.86	-4.34	-4.59	-4.51	-4.49	-4.39
	PASSES	FAILS	FAILS	PASSES	PASSES	PASSES

THE CANDIDATE FUEL **PASSES** IF THE PERCENT CHANGE IN EMISSIONS BETWEEN THE CANDIDATE FUEL AND REFERENCE FUEL IS LESS THAN OR EQUAL TO 0.04%THE CANDIDATE FUEL **FAILS** IF THE PERCENT CHANGE IN EMISSIONS BETWEEN THE CANDIDATE FUEL AND REFERENCE FUEL IS GREATER THAN OR EQUAL TO 0.05%**VEHICLE TANK TURNOVERS****VEHICLE #2****1ST VEHICLE TANK TURNOVER:**

	0-OXY CaRFG	RVP = 7.45	EXCEEDS CAP
Heel:	0-OXY CaRFG	25.0% of tank capacity	
New batch	2nd Turnover FUEL at STATION	75.0% of tank capacity	FAILS

2ND VEHICLE TANK TURNOVER:

	0-OXY CaRFG	RVP = 7.25	EXCEEDS CAP
Heel:	1st Turnover FUEL in VEHICLE #2	25.0% of tank capacity	
New batch	4th Turnover FUEL at STATION	75.0% of tank capacity	FAILS

3RD VEHICLE TANK TURNOVER:

Heel:	2nd Turnover FUEL in VEHICLE #2	25.0% of tank capacity	
New batch	6th Turnover FUEL at STATION	75.0% of tank capacity	PASSES

4TH VEHICLE TANK TURNOVER:

Heel:	3rd Turnover FUEL in VEHICLE #2	25.0% of tank capacity	
New batch	8th Turnover FUEL at STATION	75.0% of tank capacity	PASSES

Appendix F

Small Refiner Emissions Offsets

Calculation of Emissions Offset Requirements for the Small Refiner Provisions

Introduction

Section 2272 specifies that for each barrel of gasoline produced by a small refiner to the small refiner standards, the following excess emissions would have to be offset: 0.0206 pounds of exhaust THC per barrel, 0.0322 pounds of NO_x per barrel, and potency-weighted toxics (PWT) equivalent to 0.0105 pounds per barrel of benzene. The proposed amendments to section 2282 (Aromatic Hydrocarbon Content of Diesel Fuel) describe the mechanism whereby a small refiner provides offsets for the emissions increase cited above. This mechanism includes various combinations of small refiner diesel volume reduction, aromatics content reduction, cetane number increases, and additive concentration increases.

Because Kern Oil and Refining Company (Kern) is the only small refiner currently qualifying for the small refiner provisions of the Phase 3 RFG regulations, the analysis in this section will be specific to Kern. Kern is interested in producing 8,000 barrels per day of gasoline to the small refiner RFG standards. This means that Kern is required to offset 164.8 pounds per day of exhaust THC ($8,000 \times 0.0206$), 257.6 pounds per day of NO_x ($8,000 \times 0.0322$), and 84.0 pounds per day of benzene-equivalent PWT ($8,000 \times 0.0105$).

The proposed regulations provide three different options for offsetting the excess emissions arising from compliance with the small refiner provisions of the Phase 3 gasoline regulations. These are:

- 1) An increase in the amount of diesel produced to the 20 percent aromatics standard, accompanied with a reduction in aromatic content, an increase in cetane, and an increase in additive concentration.
- 2) Retention of the existing diesel volume of diesel produced to the 20 percent aromatics standard, accompanied with reduction in the aromatics content, increases in the cetane number, and an increase in additive concentration.
- 3) A reduction in the volume of diesel produced to the 20 percent aromatics content specification of the diesel aromatics content regulation.

The emissions reductions resulting from diesel aromatics reduction and cetane increases are calculated by multiplying the diesel fuel emissions factors (in units of pounds per barrel), by the volume of diesel fuel produced, and then multiplying this product by the percent change in emissions resulting from the aromatics and cetane changes. The percent changes in emissions are calculated from regression equations which have been developed from test programs designed to investigate the effects of changing diesel fuel properties on emissions.

Methodology

Kern may consider an option to increase its diesel production by about 25 percent from its 6,405 barrel per day limit of 20 percent-equivalent alternative diesel it is allowed to produce under the small refiner provisions of Section 2282, to 8,000 barrels per day. If Kern does this, it would mean that, for 1,595 (8,000-6,405) barrels per day, the difference in emissions between a 10 percent-equivalent alternative diesel formulation and a 20 percent-equivalent alternative formulation would have to be offset by Kern. This additional excess emissions can be calculated using the diesel emissions factors (in pounds per barrel), and the incremental diesel production (1,595 barrels per day). The applicable diesel NOx emissions factors are as follows: Diesel fuel with 10 percent aromatics (or 10 percent-equivalent alternative formulations) NOx emissions are 4.719 pounds per barrel. For small refiner diesel fuel produced to the 20 percent aromatics standard (or 20 percent-equivalent alternative formulations) NOx emissions are 4.879 pounds per barrel. The applicable PM emissions factors are: 0.205 pounds per barrel for 10 percent-equivalent formulations, and 0.236 for 20 percent-equivalent formulations. The applicable THC emissions factors are: 0.462 pounds per barrel for 10 percent-equivalent formulations, and 0.499 pounds per barrel for 20 percent-equivalent formulations.

The additional excess emissions from the 1,595 barrel per day increased diesel production that would have to be offset are: NOx: 255.2 pounds per day (1,595 x (4.879-4.719)), and PM: 49.4 pounds per day (1,595 x (0.236-0.205)). There are no increased THC emissions to be offset from the increased diesel production because the diesel aromatics regulation was not adopted as a THC emission reduction measure. The table below summarizes the total offsets required from the diesel fuel that will be produced by Kern Refining Company. The first line in the table is for the case where Kern does not increase its diesel production above its current 6,405 barrel per day 20 percent-equivalent cap (that is, only the excess emissions from 8,000 bpd of gasoline would have to be offset). The last row in the table shows the offsets that would be required if Kern elects to increase its diesel fuel production to 8,000 barrels per day.

Summary of Excess Emissions for Kern Oil

Source	THC (lb/day)	NOx (lb/day)	PM (lb/day)
Small Refiner Gasoline (8,000 BPD)	164.8	257.6	84.0/10.3=8.2
Increase Diesel Production (1,595 BPD)	0	255.2	49.4
Total	164.8	512.8	57.6

In the above table, the value of the required PM offsets for the small refiner gasoline was divided by 10.3. This reflects the fact that PM emissions from diesel fuel are 10.3 times more toxic than benzene emissions (potency of 3.00×10^{-4} vs. 2.90×10^{-5}). Thus, the PM reductions are put on the basis of pounds of PM from diesel.

The regressions shown below were used to estimate the emissions reductions that would result from changing the cetane number and aromatics content of the diesel fuel produced by Kern. The regressions resulted from testing conducted by the Southwest Research Institute in 1990 and summarized in the report "Study of Fuel Cetane Number and Aromatic Content Effects on Regulated Emissions from a Heavy-Duty Diesel Engine."

$$\ln\text{THC (g/hp-hr)} = 1.015 - 0.9539 * (\ln(\text{cetane}-35))$$

$$\ln\text{NOx (g/hp-hr)} = 1.587 + 0.00296 * \text{FIA aromatics} - 0.04276 * (\ln(\text{cetane}-35))$$

$$\ln\text{PM(g/hp-hr)} = -1.439 + 0.003617 * \text{FIA aromatics} - 0.1734 * (\ln(\text{cetane}-35))$$

Using these regressions, percent emissions reductions were calculated for various levels of aromatics content and cetane number. The baseline fuel properties for these calculations were the properties of Kern's current 20 percent aromatics-equivalent alternative diesel formulation. The percent emissions changes predicted by the regressions were multiplied by Kern's anticipated diesel production and the baseline emissions factors to give the estimated reduction in emissions (on a pound per day basis) that would be available to offset the estimated excess emissions shown in the table above. The calculations were done for both diesel production volume scenarios of 6,405 barrels per day and 8,000 barrels per day. The baseline emissions factors that were used are shown below.

Baseline Emissions Factors

THC: 0.462 lbs/bbl

NOx: 4.879 lbs/bbl

PM: 0.236 lb/bbl

In addition to increases in cetane number and decreases in the aromatic content, Kern also proposed to increase the amount of the additive that it uses in diesel fuel. The additive has been shown to decrease both NOx and PM emissions. Kern proposed that the concentration of the additive in the diesel fuel be increased by 0.02 volume percent. The additive decreases NOx emissions by about 0.3 percent per 0.01 volume percent of additive, and PM emissions by about 0.565 percent per 0.01 volume percent of additive.

Using the regressions, emissions reductions estimation method, and values for the additive effectiveness shown above, the staff computed the emissions reductions that would be available to offset the excess emissions arising from the 8,000 barrels per day of gasoline produced to the small refiner standards, and to offset the emissions increase resulting from the increase in diesel production from 6,405 barrels per day to 8,000 barrels per day (for the 8,000 barrel per day diesel production scenario).

Kern may also consider a reduction in the production volume of its 20 percent-equivalent alternative diesel formulation as a means of offsetting the excess emissions from the small refiner gasoline (option 3). As with option 1, the available offsets for this option were calculated using the difference between the 20 percent-equivalent formulation

emissions factors and the 10 percent-equivalent formulation emissions factors. These differences are: for NOx: 0.16 pounds per barrel (i.e., 4.879-4.719), for PM: 0.031 pounds per barrel (i.e., 0.236-0.205), and for THC: 0.037 pounds per barrel (i.e., 0.499-0.462). The pounds per day excess emission values shown in line one (Small Refiner Gasoline) of the above table were divided by these emission factor differences to estimate the reduction in diesel volume needed to provide the necessary offsets. In the case of THC, it was also assumed that 29.5 percent of the PM reductions that are achieved could be used as THC offsets. The rationale for this is that approximately 29.5 percent of PM emissions are the soluble organic fraction (SOF), which is emitted from the engine as gaseous hydrocarbons.

Results

For the 8,000 barrel per day diesel production scenario, the aromatics content of Kern's diesel fuel would have to be reduced by 3.5 percentage points, and the cetane number would have to be increased by 0.5 number in order to provide the emissions reduction necessary to offset the excess emissions arising from the gasoline produced to the small refiner specifications, and to offset the increased emissions from the additional 1,495 barrels per day of diesel production. For the 8,000 barrel per day diesel case, Kern would have to increase the additive concentration of its diesel fuel by 0.02 volume percent. For both the 6,405 barrels per day and the 8,000 barrels per day diesel production cases, no changes to the sulfur content, nitrogen content, and poly-cyclic aromatic (PAH) content of Kern's diesel fuel would be required.

For the 6,405 barrel per day diesel production scenario, using the same basic calculations as above the staff's analysis shows that the aromatics content of Kern's diesel would have to be reduced by 2.0 percentage points and the cetane number would have to be increased by 0.5 number in order to provide the emissions reductions necessary to offset the excess emissions arising from the gasoline produced to the small refiner specifications of the Phase 3 regulations.

For the reduced production of Kern's 20% equivalent diesel fuel, to mitigate the expected increase in emissions associated with the small refiner provision of the CaRFG3 regulations, Kern would have to decrease its production to 2263 barrels per day.

References

1. Investigation of the Effects of Fuel Composition and Injection and Combustion System Type on Heavy-Duty Diesel Exhaust Emissions, Terry L. Ullman, Southwest Research Institute, under contract to the Coordinating Research Council, Inc., March, 1989.
2. Study of Fuel Cetane Number and Aromatic Content Effects on Regulated Emissions from a Heavy-Duty Diesel Engine, Terry L. Ullman, et. al., Southwest Research Institute, under contract to the Coordinating Research Council, Inc., September, 1990.

Appendix G

RVP Test Method and Reproducibility

TEST METHOD FOR THE VAPOR PRESSURE OF GASOLINE
(A supplement to the staff report on Reformulated Gasoline:
Proposed Phase 1 Specifications)

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Compliance Division
Air Resources Board

September 1990

TEST METHOD FOR THE VAPOR PRESSURE OF GASOLINE
(A supplement to the staff report on Reformulated Gasoline:
Proposed Phase 1 Specifications)

September 27, 1990
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107 South Broadway Street
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Air Resources Board
P.O. Box 2815
Sacramento, California 95812

This report has been reviewed by the staff of the California Air Resources Board and approved for release. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board.

OVERVIEW AND RECOMMENDATION

Overview

This report is a supplement to the staff report titled Reformulated Gasoline: Proposed Phase 1 Specifications. In that report the staff proposed, in part, to adopt alternative test methods for the enforcement of the Reid Vapor Pressure of Gasoline Regulation. The two methods proposed are the American Society of Testing and Materials (ASTM) Emergency Standards 14 and 15. Emergency Standards 14 and 15 cover the operation of two types of automated vapor pressure testing instruments.

The automated instruments are said to be more accurate, faster, and easier to operate than the current legal test method, ASTM D323-58. The industry already uses these instruments for informal testing of their gasoline, but are compelled to test by ASTM D323-58 for the final test before releasing the product for sale. The industry is anxious for the Air Resources Board (ARB) to adopt an automated test method so that they can rely on the automated instruments for all testing. The industry and the ARB conducted a joint vapor pressure test program to determine which automated instruments would produce test results equivalent to the current legal test method, ASTM D323-58. The details of the test program are included in this report.

The industry requested that two new instruments also be evaluated for equivalency. The new instruments operate somewhat similarly to the instruments covered by Emergency Standards 14 and 15, but are not specifically included in those methods. The test program showed that one of the new instruments met the performance standards to be an enforcement test method.

The staff made modifications to Emergency Standard 15 to include all the acceptable instruments under one test method. The new test method is named: the Air Resources Board's Test Method for the Determination of the Reid Vapor Pressure Equivalent Using an Automated Pressure Testing Instrument.

Recommendation

The staff recommends that the state board approve the amended proposal which specifies the Test Method for the Determination of the Reid Vapor Pressure Equivalent Using an Automated Vapor Pressure Test Instrument as an appropriate alternative test method for the enforcement of the RVP standards for gasoline.

BACKGROUND

The California Health and Safety Code, Section 43830, directs the California Air Resources Board (ARB) to establish Reid Vapor Pressure (RVP) standards for motor vehicle gasoline sold in the State. Section 43830 states that the RVP shall be determined by the American Society of Testing and Materials (ASTM) test method D323-58, or by an appropriate test determined by the state board. In 1971, the ARB adopted California Code of Regulations, Section 2251 (the Reid Vapor Pressure of gasoline) which cites the ASTM D323-58 as the approved test method. The Compliance Division uses the ASTM D323-58 test method when it enforces the RVP regulation.

In the past few years, equipment manufacturers have developed automated instruments claiming they perform vapor pressure measurements very accurately, faster, and more easily using modern electronics. Because of the intense demand by industry for approved test methods, the ASTM adopted two methods on an emergency basis. These were Emergency Standards 14 and 15 (abbreviated ES 14 and ES 15). ES 14 and ES 15 were adopted about a year ago and only covered the two types of instruments that were available at that time. The ASTM is currently working on expanding the scope of ES 14 and ES 15 to include newer instruments.

The staff report, Reformulated Gasoline: Proposed Phase 1 Specifications, proposed to amend the current Reid Vapor Pressure test method to include ES 14 and ES 15. The industry informed the ARB that they were interested in including the newer instruments not yet covered by ES 14 and ES 15. The staff responded by conducting a vapor pressure testing program to determine which automated test instruments were appropriate for enforcement testing. The details of the test program are included in this report. The test program showed that three instruments are appropriate for enforcement testing. However, one of the instruments is not specifically covered by ES 14 or ES 15. The staff understands that the ASTM will take about two years to update its methods to include this instrument. The staff made modifications to ES 15 to include all the acceptable instruments in one method. This method is named: the Air Resources Board's Test Method for the Determination of the Reid Vapor Pressure Equivalent Using an Automated Vapor Pressure Test Instrument.

THE VAPOR PRESSURE TEST PROGRAM

On May 1, 1990 members of the Western States Petroleum Association (WSPA) asked the ARB staff if the ARB would consider using automated test instruments when testing for compliance with the RVP regulation. The ARB staff agreed to participate in a joint vapor pressure testing program with WSPA to determine if automated test instruments are an appropriate enforcement test method.

The WSPA and ARB designed a vapor pressure test program that would compare test results obtained from the automated instruments against results from testing by the ASTM D323-58 method. The parameters of the test program were as follows: 1. At least four laboratories must volunteer the participation of a particular automated instrument (ie. the same

manufacturer and model) before that instrument type would be included in the program. 2. Six gasolines and one pure compound (neohexane) would be prepared for testing. Three containers of each type of gasoline and one container of neohexane would be provided for testing by each instrument. Two fuels would contain oxygenates; one containing MTBE and the other containing ethanol. 3. The ARB would prepare the samples by splitting them from larger containers. The ARB would keep the samples on ice and personally deliver them to each laboratory. The ARB would observe the testing at each laboratory. 4. Prior to the commencement of testing, all analytical personnel would be required to attend a workshop to ensure that each operator understood the instructions for the test instrument, is familiar and experienced in operating the equipment, and conducts the tests according to the method. 5. The ARB would conduct RVP determinations on identical samples using the ASTM D323-58 test procedure.

The schedule for the program was:

May 7--WSPA to mail a letter to membership requesting participation.

May 14--Companies to respond with their intent to participate in the program.

May 21--Begin preparing fuel samples for the test program.

June 4--Begin testing.

June 18--Begin data analysis.

July 1--Data analysis completed and final report.

SOLICITING PARTICIPANTS

The WSPA solicited its members for participation in the vapor pressure test program. The solicitation resulted in 16 laboratories volunteering; operating a total of 19 automated instruments (one laboratory would test with two instruments and another laboratory would test with three instruments). The laboratories are:

- ARCO-Wilmington Refinery
- Chevron-El Segundo Refinery
- Chevron Research-Richmond (three instruments)
- Chevron-Richmond Refinery (two instruments)
- Exxon-Benicia Refinery
- Golden West-Santa Fe Springs Refinery
- Mobil-Torrance Refinery
- Santa Fe Pacific Pipeline-Concord Facility
- Saybolt-Wilmington Facility
- Shell-Long Beach Terminal
- Shell-Los Angeles Terminal
- Shell-West Sacramento Terminal
- Ultramar-Long Beach Refinery
- Unocal Research (Analytical)-Brea
- Unocal Research (Fuels)-Brea
- Unocal-Rodeo Refinery
- California Air Resources Board-Mobile Laboratory

The 19 instruments consisted of:

Stanhope-Seta Limited, Model: Setavap, five instruments participating.

Grabner Instruments, Model: CCA-VP (known as the laboratory Grabner), four instruments participating.

Grabner Instruments, Model: CCA-VPS (known as the portable Grabner), six instruments participating.

Herzog, Model: Mini Herzog, four instruments participating.

WORKSHOP

A workshop was held in Sacramento on May 25, 1990. All analytical personnel were requested to attend a workshop. The purpose of the workshop was to assure that each operator understood the instructions for the test instrument, was familiar and experienced in operating the equipment, and was conducting the tests in the same manner as other operators using the same type of instrument. Virtually all of the operators attended, and if they could not, the laboratory supervisor or a representative attended in that person's place.

The workshop activities included:

Demonstrations of the test instruments.

Dialogue between the instrument representatives, experienced users, and trainees about the procedures.

Review the existing test procedure and, if necessary, make any revisions so the instructions for this test program are very clear.

Discuss the revised test procedure with the program coordinator.

Hands-on practice with the instruments following the established test procedure.

The workshop was a very valuable part of this program since several operators had just received (or were about to receive) delivery of their automated test instruments and had very little hands-on experience with the instrument prior to that time. The workshop provided an arena for experienced operators to share their knowledge with the less experienced. It provided the opportunity for the users to give feed-back to the instrument representatives on how the instruments actually worked in a laboratory environment.

At the request of the program coordinators, each instrument representatives issued written operating instructions for their instrument which reflected the consensus of the workshop discussions. The consensus instructions included changes for clarity, for uniformity in the preparation, calibration, and operation of the instruments, and any special instructions for the test program.

SAMPLE PREPARATION

The samples were prepared at the Core Laboratory facility, located in Long Beach, on May 30 and 31, 1990. A refrigerated truck was used for cooling the gasoline, sample bottles, and all of the sampling equipment. The sample preparation also took place in the truck. The truck was kept at about 34 degrees F at all times.

The different gasolines were supplied in five gallon containers by volunteers. Each five gallon container constituted a "batch". The contents of each five gallon container were transferred to five gallon collapsible

plastic containers, from which one-quart sample bottles were filled. The use of the collapsible containers prevented the creation of additional vapor space above the liquid contents as the quart bottles were being filled. An extension tube was used at the outlet of the spigot on the collapsible container to bottom-fill the quart containers. The samples were identified with labels with a code so that the testers would not know the true identity of the samples.

Neohexane (2,2 dimethylbutane) was used for the pure compound. The vapor pressure of a pure compound is not affected by poor or improper handling of the sample; whereas with gasoline, if the sample container is left open or if the container leaks, the vapor pressure will likely decrease. Therefore, testing a pure compound along with gasoline samples often helps identify whether poor test data (if any) was a result of problems in sample preparation and handling or in the test instrument itself.

All laboratories that would be testing with the same type of automated instrument were supplied with quart bottles from the same batch. Therefore, it would not be appropriate to compare test results, for example, from gasoline B for the Setavap with gasoline B for the laboratory Grabner. The ARB was supplied with quart bottles from each batch for testing by the ASTM D323-58 so that the automated instruments' test results could be compared with ASTM D323-58 test results.

All samples were kept in an ice bath in ice chests from the time they were prepared until they were tested.

SAMPLE DELIVERY

The ARB staff personally delivered all gasoline samples to each of the laboratories. The samples designated for ARB testing were delivered in the evenings of May 30 and May 31, 1990 for testing the following day on May 31 and June 1, 1990 (respectively). The samples designated for the participating laboratories were delivered according to a prearranged schedule (between June 4 to June 15, 1990) so that the laboratory would be prepared to commence testing shortly after the samples were delivered.

TESTING

Testing commenced shortly after the samples were delivered to the laboratories. The ARB personnel observed the testing at each laboratory. The ARB observer verified that the operator at each laboratory followed the consensus test method. All testing went smoothly; there were no significant problems.

Operators were unaware of which samples were replicates of each other. The samples were tested in a specific order (see Table I).

Grabner Instruments, Model: CCA-VP (known as the laboratory Grabner),
four instruments participating.

Grabner Instruments, Model: CCA-VPS (known as the portable Grabner),
six instruments participating.

Herzog, Model: Mini Herzog, four instruments participating.

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Operators were unaware of which samples were replicates of each other. The samples were tested in a specific order (see Table I).

Table I

Sample Numbering and Run Order

Sample Number in Order

1	1	2	3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	1
X	X	F	A	A	B	C	D	E	F	E	D	C	B	A	F	E	D	C	B	A	X

Fuel

TEST DATA

The test data from the vapor pressure test program are listed in Table II. The vapor pressures data from the laboratory Grabner, the portable Grabner, and the Setavap instruments are "measured pressures", not "Reid-equivalents". The data for the mini Herzog is represented by the manufacturer of the instrument to be a "Reid" vapor pressure. The six gasolines are represented in the tables by the letters A to F. The pure compound is represented in the tables by the letter X.

Table II
Batch = S
Data in Standard Arrangement

LAB	A	B	C	D	E	F	X
1	6.80	8.10	8.45	9.55	9.15	10.25	9.95
	6.70	8.00	8.45	9.60	9.25	10.20	9.95
	6.80	7.95	8.35	9.65	9.15	10.25	10.15 r 9.90 9.90 9.85
D 323 Mean	6.767	8.017	8.417	9.600	9.183	10.233	9.910
3	7.85	9.30	9.39	10.85	10.64	11.37	11.09
	7.88	9.10	9.41	10.79	10.66	11.37	11.12
	7.80	9.21	9.46	10.81	10.56	11.41	11.19
	7.86						
5	7.64	8.95	9.10	10.61	10.30		10.96
	7.62	8.99	9.11	10.62	10.31	11.05	
	7.63	9.00	9.20	10.60	10.39	11.04	10.98
	7.67						
6	7.64	9.06	9.20	10.69	10.44	11.09	10.91
	7.66	9.04	9.22	10.67	10.44	11.13	10.92
	7.66	9.04	9.21	10.70	10.42	11.11	10.95
	7.67						
7	7.72	9.13	9.29	10.75	10.54	11.15	10.98
	7.69	9.12	9.32	10.79	10.45	11.18	11.01
	7.70	9.12	9.28	10.77	10.45	11.21	11.01
	7.70						
8	7.67	9.02	9.12	10.53	10.37	11.04	10.81
	7.64	8.97	9.08	10.68	10.38	11.08	11.62 r
	7.56	9.02	9.09	10.55	10.36	11.05	10.88
	7.63						
S Mean	7.695	9.071	9.232	10.694	10.447	11.114	10.984

Table II
Batch = L
Data in Standard Arrangement

LAB	A	B	C	D	E	F	X
1	6.95	8.15	8.50	9.85	9.15	10.20	9.90
	6.95	8.15	8.55	9.80	9.25	10.25	9.90
	6.95	8.15	8.45	9.80	9.00	10.35	9.85
							9.95
							9.95
							10.15 r
D 323							
Mean	6.950	8.150	8.500	9.817	9.133	10.267	9.910
4	7.54	8.87	9.10	10.50	10.29	10.99	10.67
	7.51	8.91	9.06	10.51	10.28	10.97	10.68
	7.57	8.93	9.06	10.52	10.31	10.99	10.64
	7.54						
9	7.58	8.89	9.07	10.47	10.22	10.94	10.63
	7.61	8.93	9.09	10.47	10.23	10.93	10.65
	7.59	8.91	9.12	10.54	10.26	10.96	10.70
15	7.48	8.91	9.03	10.45	10.26	10.93	10.58
	7.58	8.90	9.07	10.50	10.23	10.94	10.64
	7.57	8.87	9.05	10.47	10.22	10.93	10.60
	7.52						
17	7.58	8.83	9.02	10.42	10.22	10.93	10.65
	7.57	8.77	8.99	10.39	10.21	10.90	10.76
	7.51	8.84	8.96	10.35	10.16	10.89	10.63
	7.52						
L							
Mean	7.554	8.880	9.052	10.466	10.241	10.942	10.653

Table II
Batch = P
Data in Standard Arrangement

LAB	A	B	C	D	E	F	X
1	6.85	7.90	8.20	9.45	9.10	10.00	9.95
	6.80	7.85	8.20	9.50	9.15	10.00	9.95
	6.80	8.00	8.20	9.60	9.20	10.00	10.15 r 9.90 9.90 9.85
D 323 Mean	6.817	7.917	8.200	9.517	9.150	10.000	9.910
2	7.74	9.02	9.18	10.65	10.36	10.99	10.82
	7.74	9.02	9.20	10.69	10.36	11.07	10.86
	7.74	9.02	9.11	10.69	10.36	10.98	10.80
	7.74						
4	7.86	9.12	9.27	10.73	10.37	11.18	10.98
	7.89	9.17	9.28	10.69	10.34	11.11	10.92
	7.90	9.15	9.28	10.67	10.40	11.24	10.83
	7.88						
11	7.69	8.99	9.15	10.62	10.31	10.94	10.80
	7.70	8.98	9.17	10.65	10.31	11.01	10.76
	7.70	8.99	9.14	10.60	10.31	10.95	10.73
12	7.67	8.99	9.15	10.60	10.30	10.96	10.80
	7.66	8.95	9.15	10.66	10.31	11.00	10.83
	7.67	8.98	9.14	10.62	10.31	10.94	10.73
	7.69						
13	7.80	9.06	9.24	10.70	10.38	11.08	10.96
	7.79	9.06	9.20	10.73	10.31	11.05	10.86
	7.77	9.06	9.24	10.75	10.41	11.02	10.82
	7.76						
14	7.66	8.95	9.11	10.57	10.28	10.92	10.75
	7.66	8.96	9.12	10.60	10.30	10.94	10.73
	7.66	8.95	9.12	10.60	10.30	10.89	10.75
	7.66						
P Mean	7.739	9.023	9.181	10.657	10.334	11.015	10.818

Table II
Batch = H
Data in Standard Arrangement

LAB	A	B	C	D	E	F	X
1	6.85	8.00	8.30	9.85	9.25	9.80	9.95
	6.90	7.95	8.40	9.75	9.10	9.85	9.95
	6.90	8.05	8.35	9.70	9.15	9.85	10.15 r
							9.90
							9.90
							9.85
D 323 Mean	6.883	8.000	8.350	9.767	9.167	9.833	9.910
4	6.67	8.25	8.36	9.79	9.44	9.94	9.70
	6.72	8.15	8.41	9.81	9.54	9.96	9.81
	6.84	8.18	8.34	9.75	9.55	9.95	9.70
	6.77						
5	6.61	7.89	8.15	9.51	9.38	9.83	9.54
	6.76	7.91	8.26	9.34	9.25	9.56	9.81
	6.67	7.96	8.25	9.42	9.34	9.81	9.64
	6.70						
10	6.97	8.21	8.18	9.85	9.39	9.86	9.93
	6.47	8.08	8.42	9.77	9.75	9.80	9.80
	6.21	7.98	8.37	9.53	9.44	9.97	9.65
	6.50						
16	6.89	8.38	8.07	9.27	8.66	9.94	9.11
	3.73 r	7.76	7.97	9.16	8.82	9.28	9.61
	5.98	7.79	8.07	9.53	9.29	9.77	9.06
	6.36		7.99				
H Mean	6.596	8.045	8.235	9.561	9.321	9.806	9.613

ARB Testing: Laboratory 1 is the ARB. The ARB conducted ASTM D323-58 RVP analysis on three sample containers of each gasoline that was supplied for each instrument type. The "D323 Mean" listed in each table is the mean for Laboratory 1 only. The ARB conducted six RVP analysis on neohexane. These six test results were used for the comparisons with each of the four automated instruments. One of the six test results was determined by the statistician to be an outlier.

Setavap Instrument: The test data from the Setavap instruments are in Table II, Batch = S. The Setavap was used by Laboratories 3, 5, 6, 7, and 8. Three sample containers of each gasoline (gasoline types A to F) were tested by each laboratory. Each laboratory testing with the automated instruments were requested to conduct a second analysis on sample container #3, which contained gasoline A. Thus, column A contains four test results instead of three. Laboratory 5 had two test results that they were not confident with; they suspected a possible problem with the syringe. Thus, columns F and X have only two test results each. The statistician determined that there was an outlier with laboratory 8, column X. The "S Mean" is the means for the five Setavap instruments.

Laboratory Grabner: The test data from the laboratory Grabner instruments are in Table II, Batch = L. The laboratory Grabner was used in Laboratories 4, 9, 15, and 17. There were no outliers in the laboratory Grabner test data. Although each laboratory was requested to conduct a second analysis on container #3, laboratory 9 did not. Thus column A for laboratory 9 has three test results instead of four. The "L Mean" is the mean for the four laboratory Grabner instruments.

Portable Grabner: The test data from the portable Grabner instruments are in Table II, Batch = P. The portable Grabner was used in Laboratories 2, 4, 11, 12, 13, and 14. There were no outliers in the portable Grabner test data. Although each laboratory was requested to conduct a second analysis on container #3, laboratory 11 did not. Thus column A for laboratory 11 has three test results instead of four. The "P Mean" is the mean for the six portable Grabner instruments.

Mini Herzog: The test data from the mini Herzog instruments are in Table II, Batch = H. The mini Herzog was used in Laboratories 4, 5, 10, and 16. The statistician determined that there was one outlier with laboratory 16, column A. Laboratory 16 conducted a second analysis on sample 11 which contained gasoline c. That test result was used in the data, therefore column C for laboratory 16 has four test results instead of three. The "H Mean" is the mean for the four mini Herzog instruments.

DATA ANALYSIS

At the conclusion of the testing, the data was forwarded to Mr. Richard Stanley, a statistician for Chevron Research Company. Mr. Stanley has experience evaluating this type of data; he has evaluated the data for previous ASTM vapor pressure precision studies. Mr. Stanley submitted his report to the ARB and the ARB forwarded the report to all program participants on July 20, 1990. A copy of the report is found in Appendix A of this report.

Setavap Instrument: The statistical evaluation stated that the test data from the five laboratories operating the Setavap showed a repeatability of .102 psi and a reproducibility of .32 psi. (see Table III). Figure 4 shows the Setavap test data plotted against ARB's ASTM D323-58 test results. If there were complete agreement, the points would all fall on the solid line. The data from the four different of test instruments showed correctable biases, especially after removing oxygenated fuels from consideration. The Setavap data was corrected for bias. A linear calibration was estimated for the Setavap data against the ARB's ASTM D323-58 test results (see Table IV). The basic equation is in the form:

$$RVPE = a X + b,$$

where:

- "RVPE" is the vapor pressure value that would be expected from test method ASTM D323-58;
- "a" is the correlative relationship of test data (obtained during a vapor pressure test program) from the specific approved automated vapor pressure test instrument and test data from ASTM D323-58;
- "X" is the total vapor pressure value as determined by the specific approved automated vapor pressure test instrument;
- "b" is the offset of the test data between the specific approved automated vapor pressure test instrument and ASTM D323-58.

Table IV of the report shows that the calibration equation for the Setavap instrument is:

$$RVPE = (.961)X - .577$$

Laboratory Grabner: The report stated that the test data from the four laboratories operating the laboratory Grabner showed a repeatability of .084 psi. and a reproducibility of .13 psi. Figure 2 shows the laboratory Grabner test data plotted against the ARB's ASTM D323-58 test results. The laboratory Grabner data was corrected for bias. Table IV shows that the calibration equation for the laboratory Grabner is:

$$RVPE = (.965)X - .304$$

Portable Grabner: The report stated that the test data from the six laboratories operating the portable Grabner showed a repeatability of .084 psi. and a reproducibility of .21 psi. Figure 3 shows the portable Grabner test data plotted against the ARB's ASTM D323-58 test results. The portable Grabner data was corrected for bias. Table IV shows that the calibration equation for the portable Grabner is:

$$RVPE = (.972)X -.715$$

Mini Herzog: The report stated that the test data from the four laboratories operating the mini Herzog showed a repeatability of .53 psi. and a reproducibility of .70 psi. Figure 1 shows the mini Herzog test data plotted against the ARB's ASTM D323-58 test results. The mini Herzog data was corrected for bias. Table IV shows that the calibration equation for the mini Herzog is:

$$RVPE = (.968)X + .468$$

Table III

Precision Estimates

<u>Instrument</u>	<u>Repeatability</u>	<u>Reproducibility</u>
D 323-58	.158	n.a.
Mini-Herzog	.53	.70
Lab Grabner	.084	.13
Portable Grabner	.084	.21
SetaVap	.102	.32

Table IV

Estimated Calibration Equations

<u>Instrument</u>	<u>a</u>	<u>b</u>	<u>s2</u>
Mini-Herzog	.968	.468	.0151
Lab Grabner	.965	-.304	.0037
Portable Grabner	.972	-.715	.0094
SetaVap	.961	-.577	.0131
Portable Grabner/Setavap	.967	-.647	.0088

Table V

Simplified Calibration Equations

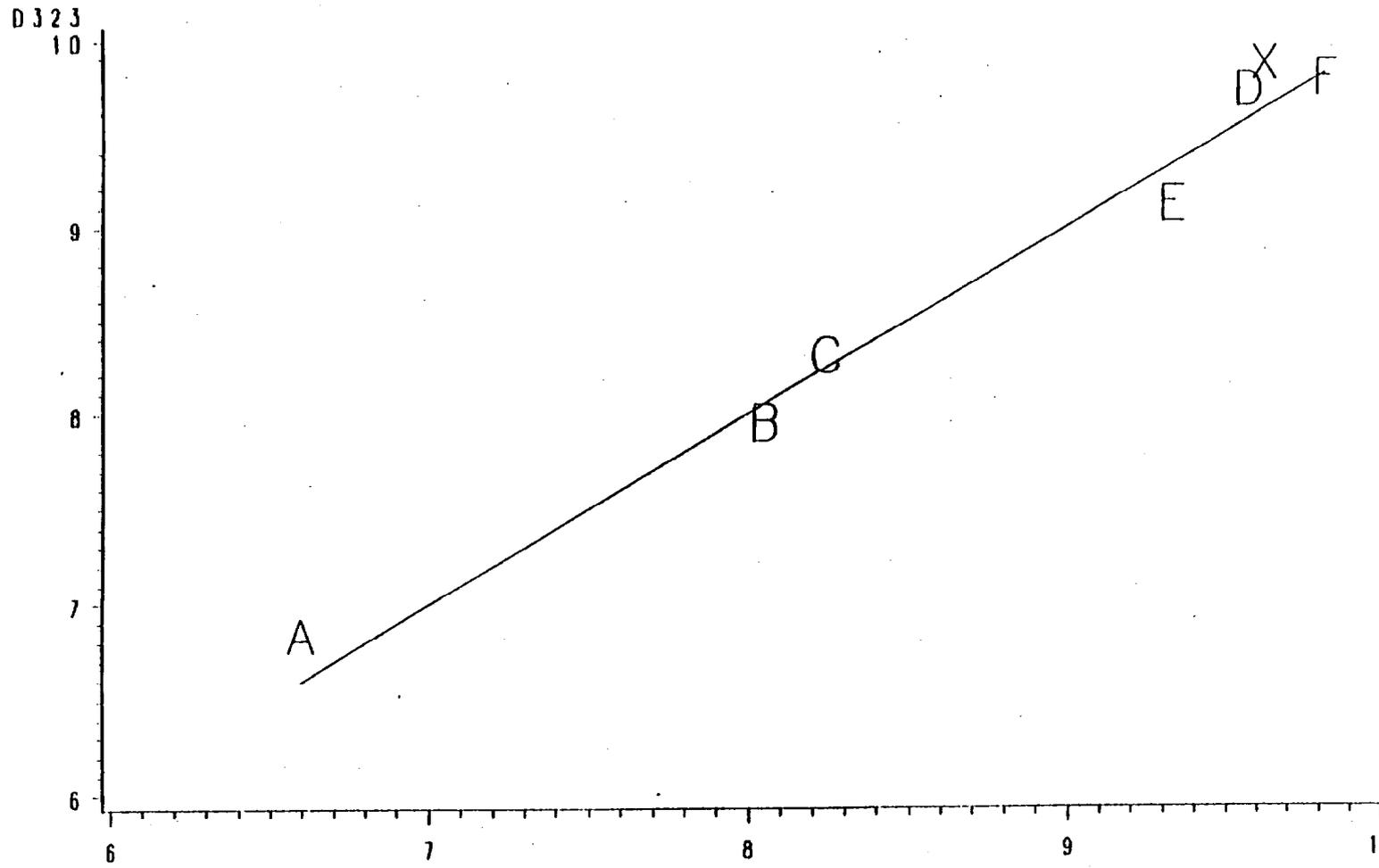
<u>Instrument</u>	<u>b</u>	<u>s2</u>
Mini-Herzog	.187	.0133
Lab Grabner	-.644	.0052
Portable Grabner/Setavap	-.979	.0099

Table VI

Reproducibility of an Automated Instrument vs. ASTM D 323-58
(Prediction Error Limits)

<u>Instrument</u>	<u>limit</u>
Mini-Herzog	.613
Lab Grabner	.183
Portable Grabner	.268
SetaVap	.363

Figure 1
 CARB Vapor Pressure Round Robin
 Calibration Curves
 BATCH=H

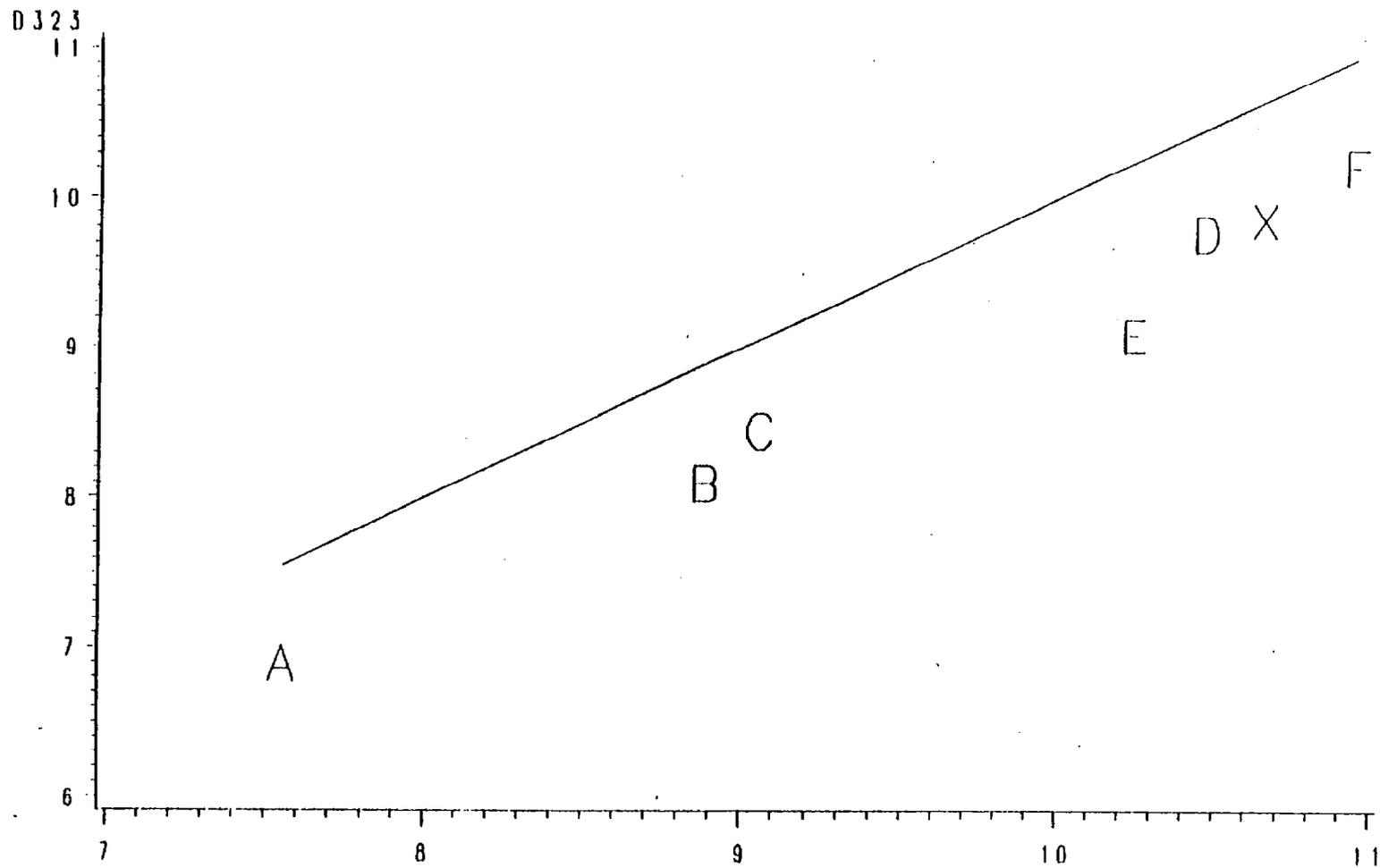


SAMPLE	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	Z
	E	E	E	E	F	F	F	F	X	X	X	X					

Figure 2

CARB Vapor Pressure Round Robin Calibration Curves

BATCH=L

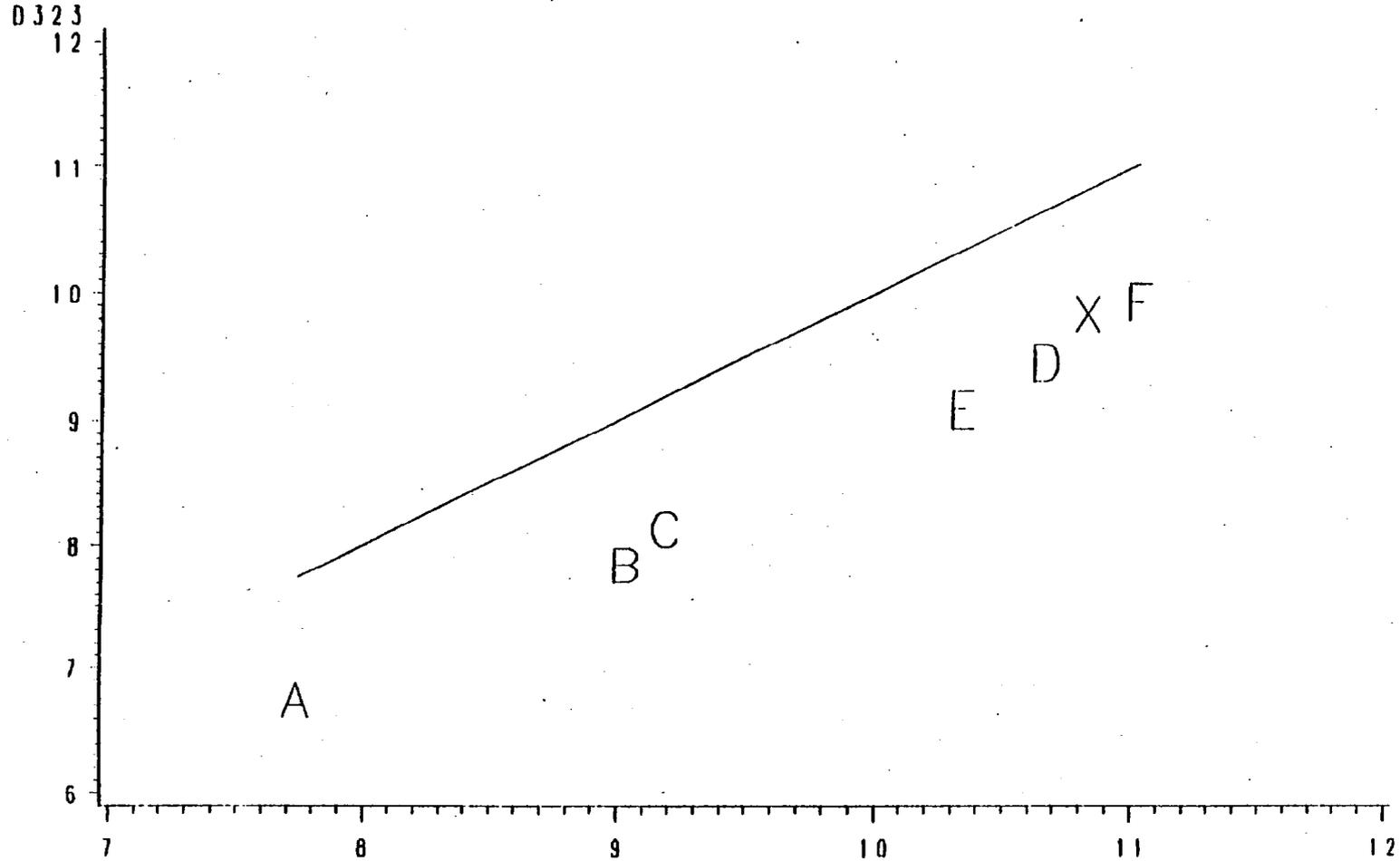


SAMPLE	A	B	C	D
	A A A A	B B B B	C C C C	D D D D
	E E E E	F F F F	X X X X	<u>D D D D</u> Z

Figure 3

CARB Vapor Pressure Round Robin Calibration Curves

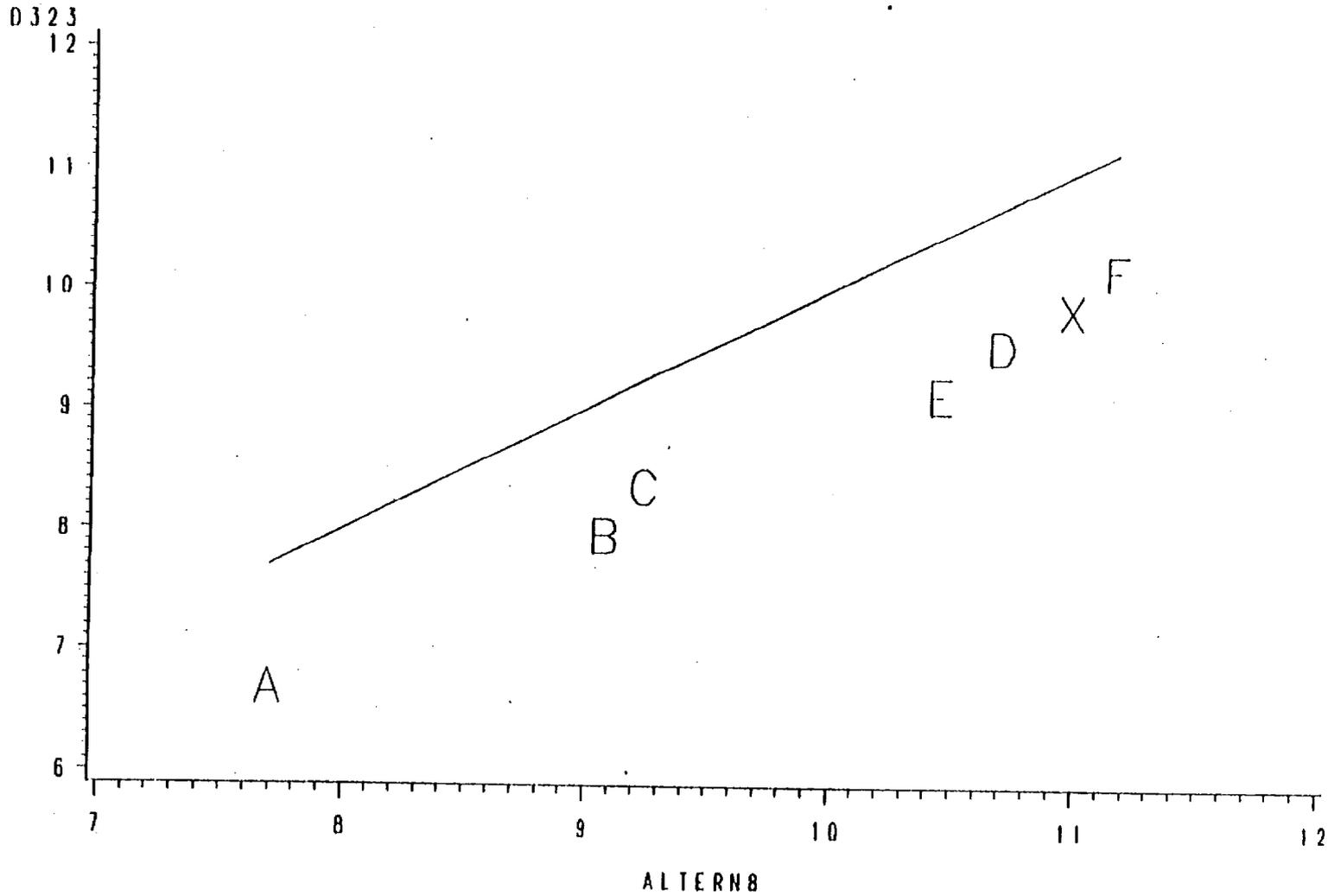
BATCH=P



SAMPLE	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	Z
	E	E	E	E	F	F	F	F	X	X	X	X					

Figure 4

CARB Vapor Pressure Round Robin
Calibration Curves
BATCH=5



SAMPLE	A A A A	B B B B	C C C C	<u>D D D D</u>
	E E E E	F F F F	X X X X	Z

The Compliance Division staff reviewed the results of the statistical report to determine if the automated instruments meet the desired performance level. That performance level is that the instrument be at least as precise as ASTM D323-58. This means that:

1. the repeatability value for the instrument must be 0.2 psi or lower; and,
2. the reproducibility value must be 0.3 psi or lower.

The Setavap, the laboratory Grabner, and the portable Grabner instruments met the required performance level.

AIR RESOURCES BOARD TEST METHOD

The ASTM adopted Emergency Standards 14 and 15 about a year ago. ES 14 covers the Southwest Research Institute instrument. ES 15 covers the Setavap and the laboratory Grabner. The portable Grabner was developed after ASTM adopted the two emergency standards, and therefore is not covered by either. The portable Grabner operates very similarly to the instruments covered in ES 15. The ARB staff understands that the ASTM will be modifying ES 15 to include that instrument. However, the ASTM may take up to two years to implement this modification.

The Compliance Division made revisions to ES 15 to include all three instruments in one test method. This revised method can no longer be referred to as ES 15 and is, therefore, named: the Air Resources Board's Test Method for the Determination of the Reid Vapor Pressure Equivalent Using an Automated Vapor Pressure Test Instrument, (see Appendix B of this report).

AMENDMENTS TO THE PROPOSED RVP REGULATION

The Stationary Source Division staff report, Reformulated Gasoline: Proposed Phase 1 Specifications, August 13, 1990, proposed, in part, to adopt ASTM Emergency Standards 14 and 15 as alternative test methods to the ASTM D323-58. The vapor pressure test program shows that automated test instruments covered by ES 15 and one additional instrument, too new to have been included in ES 15, are acceptable enforcement test methods. The Compliance Division proposes amending Paragraph (c) of Section 2251.5 to specify the Air Resources Board's Test Method for the Determination of the Reid Vapor Pressure Equivalent Using an Automated Vapor Pressure Test Instrument as the appropriate alternative test method. The proposed amendments are found in Appendix C of this report.

Because of the intense desire by industry to have automated vapor pressure testing in place as soon as possible, the Compliance Division proposes that the automated test instruments be available for enforcement testing at the beginning of the 1991 RVP season. The amendments to Section 2251, proposed by the Stationary Source Division, are now further amended to allow for the use of automated test instruments in 1991 (see Appendix D of this report).

UPDATED INFORMATION

The Stationary Source Division staff report, Reformulated Gasoline: Proposed Phase 1 Specifications, August 13, 1990, stated that the laboratory Grabner and the portable Grabner were the only instruments of the four types tested that meet the approval criteria. Further evaluation of the test data, after the August 13, 1990, publication date, shows that the difference between the 0.3 reproducibility criteria and the 0.32 reproducibility value for the Setavap instrument is insignificant with respect to denying approval. Therefore the Setavap instrument also meets the approval criteria. The Compliance Division is recommending the approval of the Setavap instrument as well.

RECOMMENDATION

The Compliance Division recommends that the state board approve the amended proposal which specifies the Test Method for the Determination of the Reid Vapor Pressure Equivalent Using an Automated Vapor Pressure Test Instrument as an appropriate alternative test method for the enforcement of the RVP standards for gasoline. The Compliance Division recommends that the test procedure be adopted into regulation.

APPENDICES

APPENDIX A

CHEVRON RESEARCH AND TECHNOLOGY COMPANY
RICHMOND, CALIFORNIACARB VAPOR PRESSURE ROUND ROBIN
DATA ANALYSIS

JULY 11, 1990

Author - R. M. Stanley

This interlab study involved the cooperation of sixteen industry laboratories with the Western States Petroleum Association (WSPA) and the California Air Resources Board (CARB) to compare four alternative instruments to ASTM D 323-58. The study was designed to meet a number of research objectives, as listed in Section I. However, this preliminary report covers only the following points:

- * Outliers. Only a small number of data were rejected. See Table II and Section III.A.
- * Precision estimates for the alternative instruments. See Table III and results section, Section III.B.
- * Calibration equations. See Tables IV and V and Sections III.C and III.D. A single calibration equation for the Setavap and the two Grabner instruments cannot be found.
- * Prediction error bounds. 95% confidence limits for predicting D 323-58 results from alternatives (corresponding to reproducibility) have been calculated. See Table VI and Section III

I. Study design.

- A. Test Methods. CARB used ASTM D 323-58. Cooperating labs used one or more of the following: Mini-Herzog (H), Laboratory Grabner (L), Portable Grabner (P), and Setavap (S).

- B. Laboratories. The following laboratories cooperated in the study:

California Air Resources Board
 ARCO-Wilmington
 Chevron-El Segundo
 Chevron Research and Technology
 (Three instruments)
 Chevron-Richmond (Two instruments)
 Exxon-Benicia
 Golden West-Santa Fe Springs
 Mobil-Torrance
 Santa Fe Pipeline-Concord
 Saybolt-Wilmington
 Shell-Long Beach
 Shell-Los Angeles
 Shell-West Sacramento
 Ultramar-Long Beach
 Unocal-Brea (#1)
 Unocal-Rodeo
 Unocal-Brea (#2)

- C. Fuels. There were six gasolines (A-F) and one pure compound (neohexane, X). Three samples of each gasoline and one sample of neohexane were provided for each lab-instrument combination. The samples were numbered as shown in Table I.

Two fuels contain oxygenates. Fuel B contains MTBE and fuel E contains ethanol.

Different batches of the gasolines were blended for each instrument type, E, L, P and S. CARB ran D 323 on three samples from each gasoline batch. CARB ran D 323 on six samples of neohexane.

- D. The measurement process. The samples were hand delivered to the laboratories by CARB. Samples were tested in a specific order (see Table I) while CARB personnel observed. Operators were unaware of which samples were replicates of each other. One measurement only was made from each sample container, except as noted in Table I. The laboratories were asked to retest the resealed, chilled retains approximately one day later in the reverse order from Table I.
- E. Data. Table II contains the data from the initial measurements. (Results from retain testing will be discussed in a later report.) The vapor pressures from the L, P and S instruments are "absolute" pressures, not "Reid-equivalent".

II. Study Objectives.

- A. Assess the precision of each instrument. The H and P instruments did not participate in the 1988 ASTM round robin. Check the precisions of L and S against the results of that study. (Note that the reproducibility of ASTM D 323-58 cannot be estimated from the data of this study.)
- B. Determine calibration lines for each instrument, for predicting D 323. (Do not include oxygenated fuels.) Determine a "universal" calibration line for L, P and S, if appropriate. Compare this to the calibration line for L and S developed in the ASTM study.
- C. After application of the calibration lines, estimate limits on the prediction error for each alternative method. Examine the components of this error.
- D. Determine whether there is either a bias or a degradation of precision in retesting the retains.

III. Results.

A. Precision Estimates.

1. Outliers. There were repeatability outliers in the sets H16 fuel A, and S8 fuel X. There was also one repeatability outlier in CARB's results on fuel X. As there were three replicates, I deleted only the one obvious offender from each group. See Table II.

In addition to the outliers removed on the basis of statistics, two data from S8 were deleted due to discrepancies noted by the operator during testing.

No reproducibility outliers were removed. My software singled out P4 as contributing more than its share to the reproducibility of the Portable Grabner. (It is generally higher than the others, but not always by the same amount.) I did not remove this instrument-lab because I was reluctant to discard so much data when there are few labs.

2. Precisions. The calculated precisions are found in Table III. The Herzog's performance was significantly less precise than the others. The two Grabner instruments precisions are comparable, and would be even closer if lab P4 had been

deleted. The reproducibility of the Grabner instruments was significantly smaller than the SetaVap's.

Compared to the 1988 ASTM round robin, the Grabner instruments performed better both in repeatability and reproducibility. The SetaVaps' repeatability was better this time, and their reproducibility somewhat worse. The Setavaps' reproducibility was largely due to consistent offsets among the instruments, i.e. calibration variation.

The precisions were calculated using all the fuels, including those containing oxygenates. The same calculations were carried out without the oxygenated fuels, and the results were essentially the same.

B. Calibration Equations.

Figures 1 through 4 show the alternative vapor pressure measurements plotted against CARB's D 323 measurements. If there were complete agreement, the points would all fall on the solid lines. All alternatives show correctable biases, especially after removing oxygenated fuels from consideration. Linear calibrations were estimated.

1. The Basic equations: the form is

$$D\ 323 = a X + b,$$

where X is the particular alternative vapor pressure. Table IV contains the estimated coefficients. The oxygenated fuels were not used in estimating the calibration coefficients.

For all of the alternative instruments, the calibrated vapor pressure is superior to the uncorrected pressure for predicting D 323 results.

The last column in Table IV is the mean-squared-error of the fit. It is the (adjusted) mean squared difference between the average D 323 measurement and the average alternative measurement for each fuel.

2. A universal calibration equation. In the 1988 ASTM study the same calibration curve was used for both the (lab) Grabner and the Setavap. For this data, the same equation cannot be used for the instruments L, P and S, but one equation can be

used for both P and S, not L. This equation is also found in Table IV.

2. simplified calibration equations. As noted above, all alternative instruments predict better with some adjustment. However both parameters are not necessary. Unadjusted data has $a=1$ and $b=0$. In all cases we find essentially equivalent calibrations if we leave $a=1$. That means we need only estimate an offset (b). These estimates are found in Table V. The simplified calibrations were used to produce the prediction error limits of the next subsection.
- C. Prediction error. Table VI contains estimates of limits on the error one should expect when using a single result from a calibrated alternative method to estimate a single result from D 323-58. These limits should be interpreted analogously to reproducibility: differences between pairs of independent results on identical material, one from D 323-58 and the other from the specific alternative method, should, in the long run, exceed the tabled number only one time in twenty.
- E. Retain testing. I haven't looked at this yet.

Table I
Sample Numbering and Run Order

Sample Number in Order

1	1	2	3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	1
X	X	F	A	A	B	C	D	E	F	E	D	C	B	A	F	E	D	C	B	A	X

Fuel

Table II
Batch = H
Data in Standard Arrangement

LAB	A	B	C	D	E	F	X
1	6.85	8.00	8.30	9.85	9.25	9.80	9.95
	6.90	7.95	8.40	9.75	9.10	9.85	9.95
	6.90	8.05	8.35	9.70	9.15	9.85	10.15 r
							9.90
							9.90
							9.85
D 323 Mean	6.883	8.000	8.350	9.767	9.167	9.833	9.910
4	6.67	8.25	8.36	9.79	9.44	9.94	9.70
	6.72	8.15	8.41	9.81	9.54	9.96	9.81
	6.84	8.18	8.34	9.75	9.55	9.95	9.70
	6.77						
5	6.61	7.89	8.15	9.51	9.38	9.83	9.54
	6.76	7.91	8.26	9.34	9.25	9.56	9.81
	6.67	7.96	8.25	9.42	9.34	9.81	9.64
	6.70						
10	6.97	8.21	8.18	9.85	9.39	9.86	9.93
	6.47	8.08	8.42	9.77	9.75	9.80	9.80
	6.21	7.98	8.37	9.53	9.44	9.97	9.65
	6.50						
16	6.89	8.38	8.07	9.27	8.66	9.94	9.11
	3.73 r	7.76	7.97	9.16	8.82	9.28	9.61
	5.98	7.79	8.07	9.53	9.29	9.77	9.06
	6.36		7.99				
H Mean	6.596	8.045	8.235	9.561	9.321	9.806	9.613

Table II
Batch = L
Data in Standard Arrangement

LAB	A	B	C	D	E	F	X
1	6.95	8.15	8.50	9.85	9.15	10.20	9.90
	6.95	8.15	8.55	9.80	9.25	10.25	9.90
	6.95	8.15	8.45	9.80	9.00	10.35	9.85
							9.95
							9.95
							10.15 r
D 323 Mean	6.950	8.150	8.500	9.817	9.133	10.267	9.910
4	7.54	8.87	9.10	10.50	10.29	10.99	10.67
	7.51	8.91	9.06	10.51	10.28	10.97	10.68
	7.57	8.93	9.06	10.52	10.31	10.99	10.64
	7.54						
9	7.58	8.89	9.07	10.47	10.22	10.94	10.63
	7.61	8.93	9.09	10.47	10.23	10.93	10.65
	7.59	8.91	9.12	10.54	10.26	10.96	10.70
15	7.48	8.91	9.03	10.45	10.26	10.93	10.58
	7.58	8.90	9.07	10.50	10.23	10.94	10.64
	7.57	8.87	9.05	10.47	10.22	10.93	10.60
	7.52						
17	7.58	8.83	9.02	10.42	10.22	10.93	10.65
	7.57	8.77	8.99	10.39	10.21	10.90	10.76
	7.51	8.84	8.96	10.35	10.16	10.89	10.63
	7.52						
L Mean	7.554	8.880	9.052	10.466	10.241	10.942	10.653

Table II
 Batch = P
 Data in Standard Arrangement

LAB	A	B	C	D	E	F	X
1	6.85	7.90	8.20	9.45	9.10	10.00	9.95
	6.80	7.85	8.20	9.50	9.15	10.00	9.95
	6.80	8.00	8.20	9.60	9.20	10.00	10.15 r
							9.90
							9.90
							9.85
D 323 Mean	6.817	7.917	8.200	9.517	9.150	10.000	9.910
2	7.74	9.02	9.18	10.65	10.36	10.99	10.82
	7.74	9.02	9.20	10.69	10.36	11.07	10.86
	7.74	9.02	9.11	10.69	10.36	10.98	10.80
	7.74						
4	7.86	9.12	9.27	10.73	10.37	11.18	10.98
	7.89	9.17	9.28	10.69	10.34	11.11	10.92
	7.90	9.15	9.28	10.67	10.40	11.24	10.83
	7.88						
11	7.69	8.99	9.15	10.62	10.31	10.94	10.80
	7.70	8.98	9.17	10.65	10.31	11.01	10.76
	7.70	8.99	9.14	10.60	10.31	10.95	10.73
12	7.67	8.99	9.15	10.60	10.30	10.96	10.80
	7.66	8.95	9.15	10.66	10.31	11.00	10.83
	7.67	8.98	9.14	10.62	10.31	10.94	10.73
	7.69						
13	7.80	9.06	9.24	10.70	10.38	11.08	10.96
	7.79	9.06	9.20	10.73	10.31	11.05	10.86
	7.77	9.06	9.24	10.75	10.41	11.02	10.82
	7.76						
14	7.66	8.95	9.11	10.57	10.28	10.92	10.75
	7.66	8.96	9.12	10.60	10.30	10.94	10.73
	7.66	8.95	9.12	10.60	10.30	10.89	10.75
	7.66						
P Mean	7.739	9.023	9.181	10.657	10.334	11.015	10.818

Table II
Batch - S
Data in Standard Arrangement

LAB	A	B	C	D	E	F	X
1	6.80	8.10	8.45	9.55	9.15	10.25	9.95
	6.70	8.00	8.45	9.60	9.25	10.20	9.95
	6.80	7.95	8.35	9.65	9.15	10.25	10.15 r
							9.90
							9.90
							9.85
D 323 Mean	6.767	8.017	8.417	9.600	9.183	10.233	9.910
3	7.85	9.30	9.39	10.85	10.64	11.37	11.09
	7.88	9.10	9.41	10.79	10.66	11.37	11.12
	7.80	9.21	9.46	10.81	10.56	11.41	11.19
	7.86						
5	7.64	8.95	9.10	10.61	10.30		10.96
	7.62	8.99	9.11	10.62	10.31	11.05	
	7.63	9.00	9.20	10.60	10.39	11.04	10.98
	7.67						
6	7.64	9.06	9.20	10.69	10.44	11.09	10.91
	7.66	9.04	9.22	10.67	10.44	11.13	10.92
	7.66	9.04	9.21	10.70	10.42	11.11	10.95
	7.67						
7	7.72	9.13	9.29	10.75	10.54	11.15	10.98
	7.69	9.12	9.32	10.79	10.45	11.18	11.01
	7.70	9.12	9.28	10.77	10.45	11.21	11.01
	7.70						
8	7.67	9.02	9.12	10.53	10.37	11.04	10.81
	7.64	8.97	9.08	10.68	10.38	11.08	11.62 r
	7.56	9.02	9.09	10.55	10.36	11.05	10.88
	7.63						
S Mean	7.695	9.071	9.232	10.694	10.447	11.114	10.984

Table III
Precision Estimates

<u>Instrument</u>	<u>Repeatability</u>	<u>Reproducibility</u>
D 323-58	.158	n.a.
Mini-Herzog	.53	.70
Lab Grabner	.084	.13
Portable Grabner	.084	.21
SetaVap	.102	.32

Table IV
Estimated Calibration Equations

<u>Instrument</u>	<u>a</u>	<u>b</u>	<u>s²</u>
Mini-Herzog	.968	.468	.0151
Lab Grabner	.965	-.304	.0037
Portable Grabner	.972	-.715	.0094
SetaVap	.961	-.577	.0131
Portable Grabner/Setavap	.967	-.647	.0088

Table V
Simplified Calibration Equations

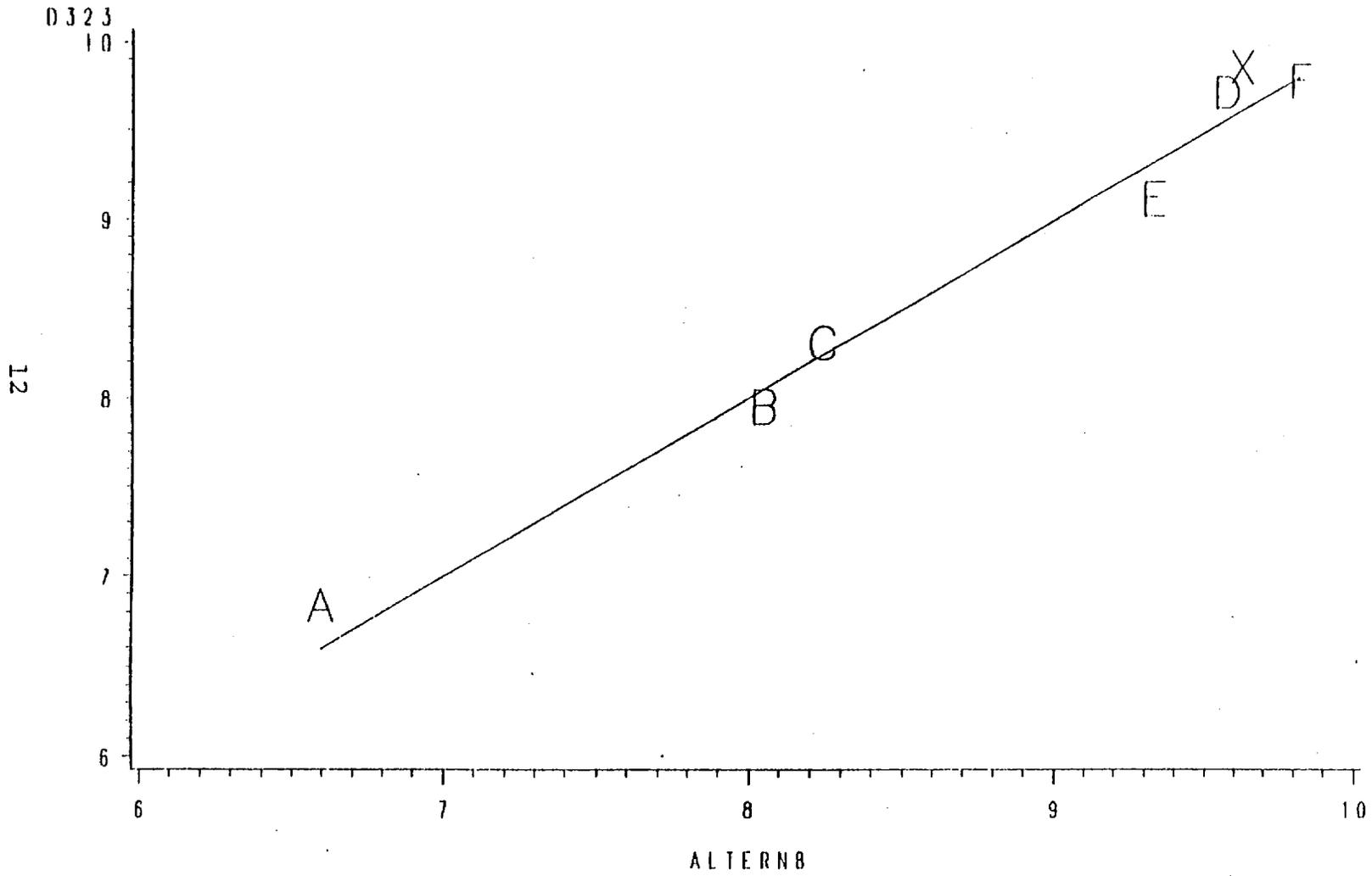
<u>Instrument</u>	<u>b</u>	<u>s²</u>
Mini-Herzog	.187	.0133
Lab Grabner	-.644	.0052
Portable Grabner/Setavap	-.979	.0099

Table VI

Reproducibility of an Automated Instrument vs. ASTM D 323-58
(Prediction Error Limits)

<u>Instrument</u>	<u>limit</u>
Mini-Herzog	.613
Lab Grabner	.183
Portable Grabner	.268
SetaVap	.363

Figure 1
 CARB Vapor Pressure Round Robin
 Calibration Curves
 BATCH=H

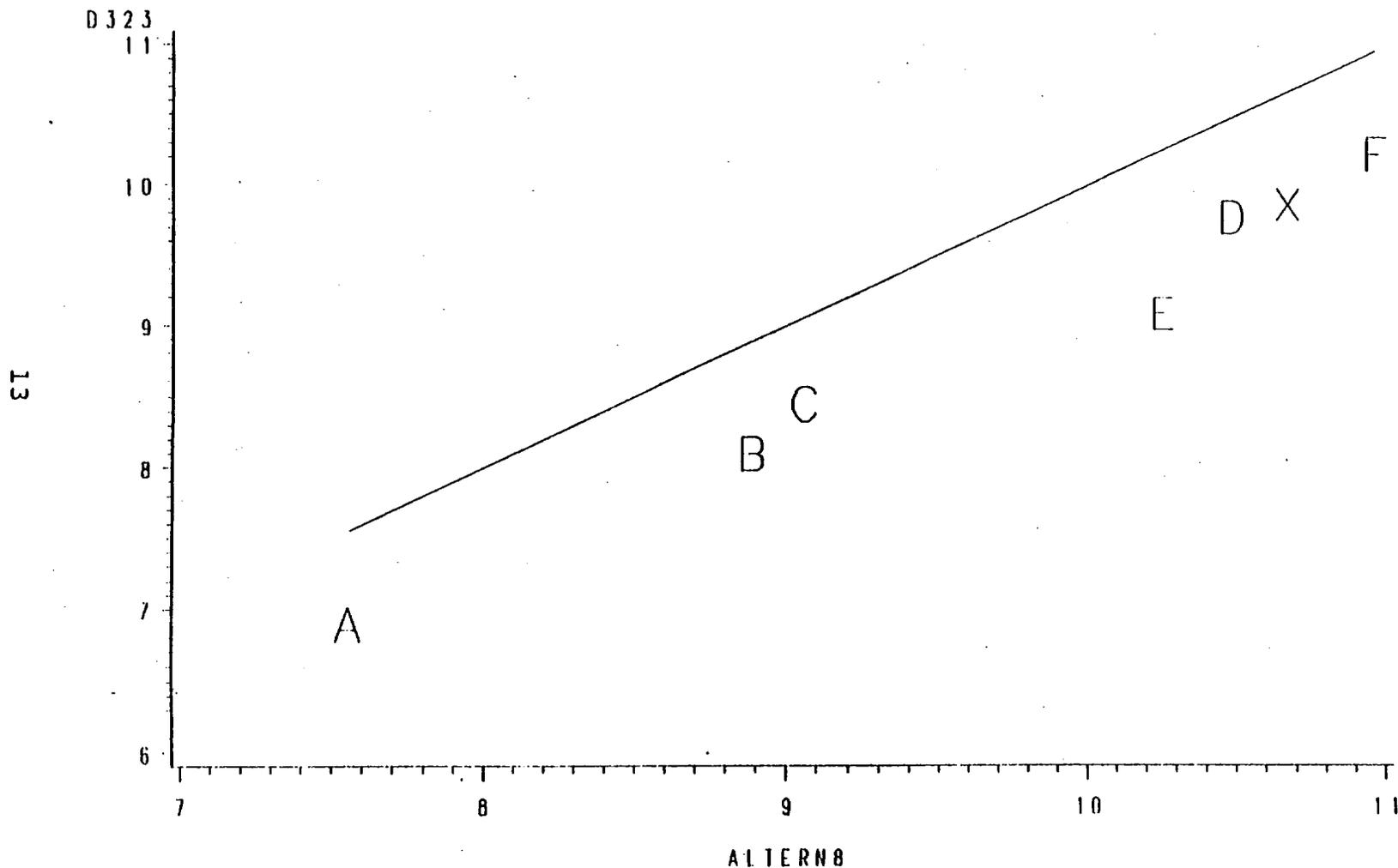


SAMPLE	A A A A	B B B B	C C C C	D D D D
	E E E E	F F F F	X X X X	----- Z

Figure 2

CARB Vapor Pressure Round Robin Calibration Curves

BATCH=L

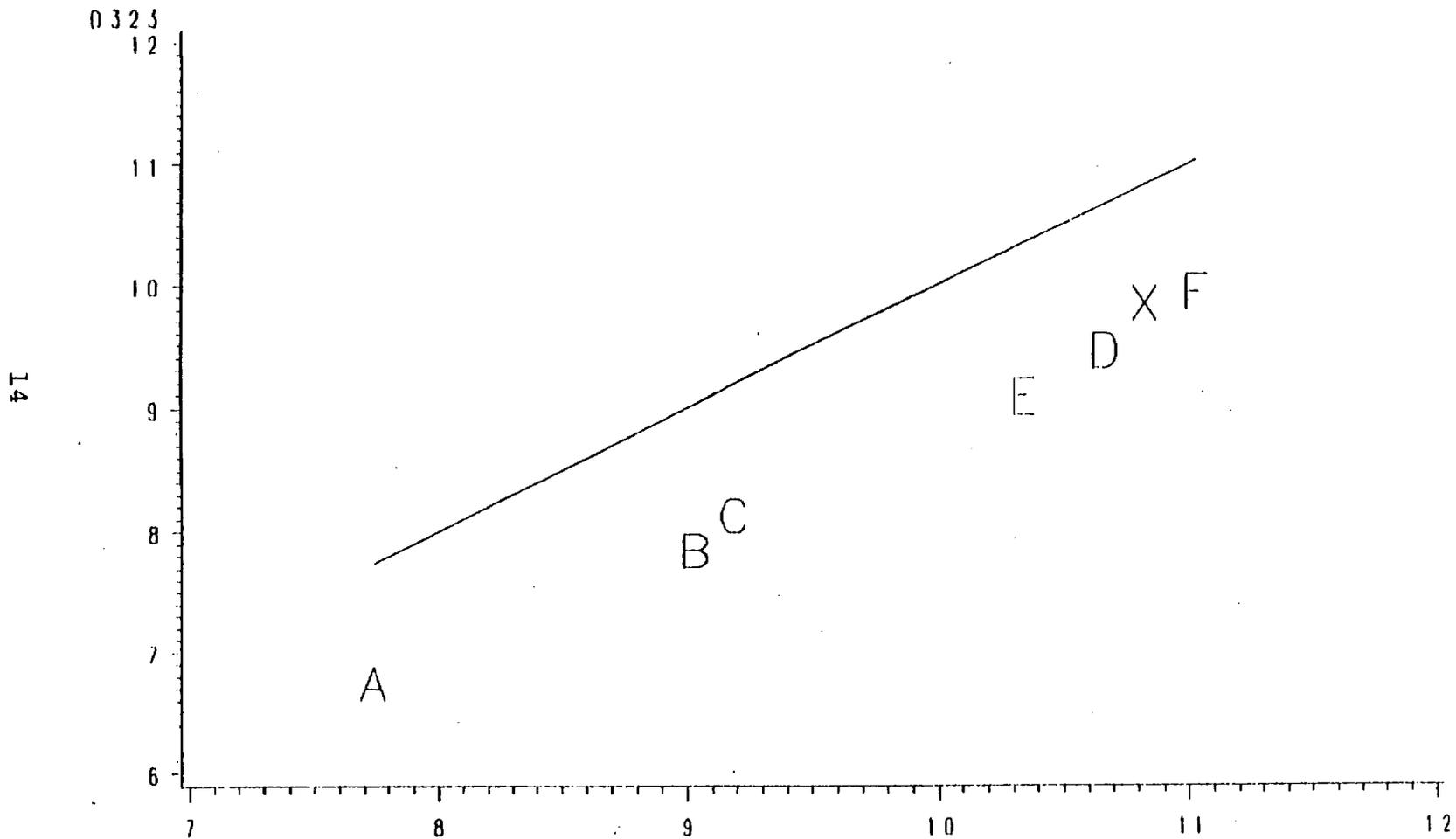


SAMPLE	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D
	E	E	E	E	F	F	F	F	X	X	X	X				Z

Figure 3

CARB Vapor Pressure Round Robin Calibration Curves

BATCH=P

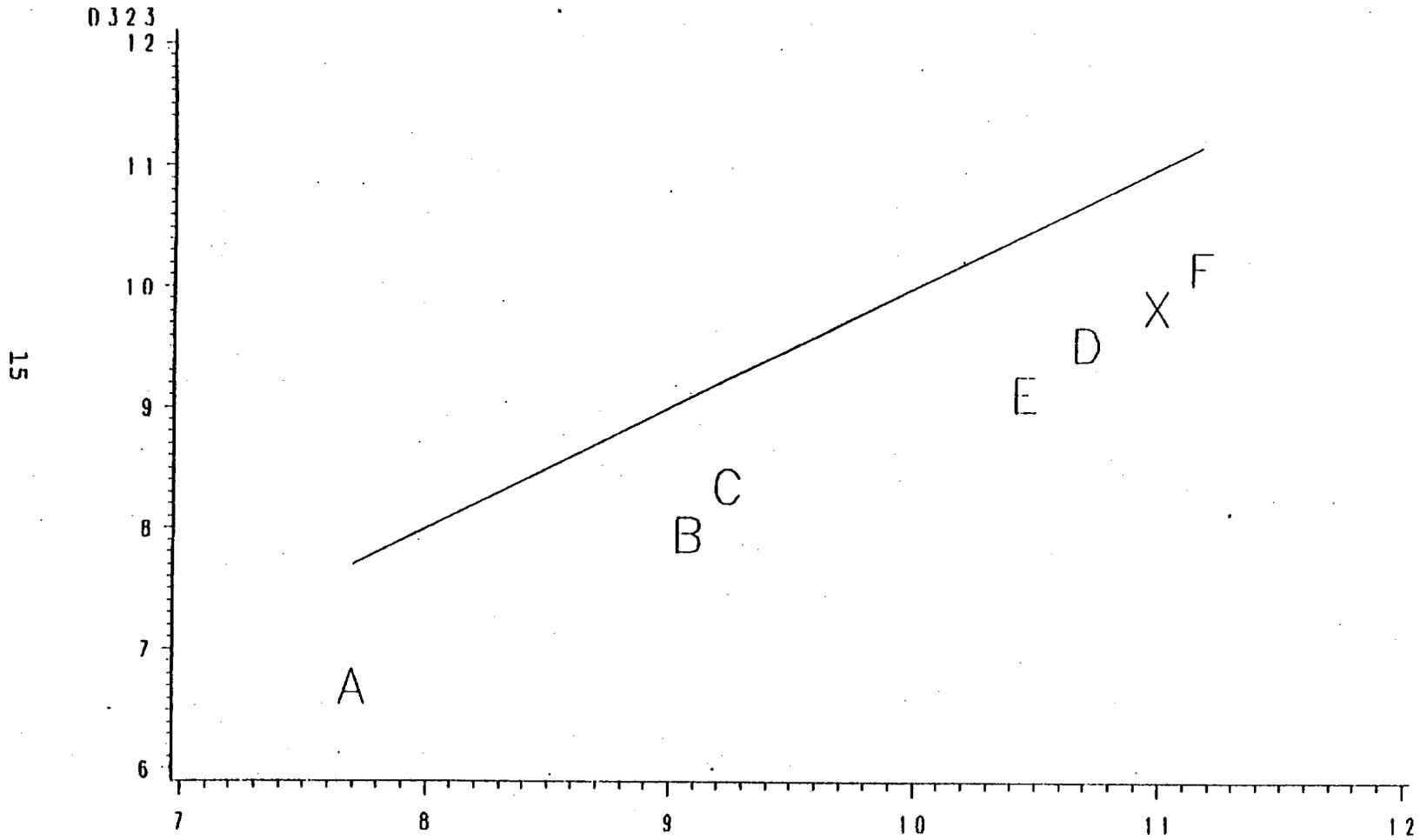


SAMPLE	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D
	E	E	E	E	F	F	F	F	X	X	X	X	<u>D</u>	<u>D</u>	<u>D</u>	<u>D</u>

Figure 4

CARB Vapor Pressure Round Robin Calibration Curves

BATCH=S



ALTERN8

SAMPLE

A A A A
E E E E

B B B B
F F F F

C C C C
X X X X

D D D D
Z

APPENDIX B

Section 2262 Test Method for the Determination of the Reid Vapor Pressure Equivalent Using an Automated Vapor Pressure Test Instrument

(a) Scope

- (1.0) This test method covers the determination of the total pressure, exerted in vacuum, by air-containing, volatile, petroleum products. The test method is suitable for testing samples with boiling points above 0° C (32°F) that exert a vapor pressure between 7 and 130 kPa (1.0 and 19 psi) at 37.8°C (100°F) at a vapor-to-liquid ratio of 4:1. The test method is suitable for testing gasoline samples which contain oxygenates. No account is made of dissolved water in the sample. (Samples can also be tested at other vapor-to-liquid ratios, temperatures and pressures, but the Precision and Bias as described in paragraph (k) do not necessarily apply.)
- (2.0) This test method covers the use of automated vapor pressure instruments that perform measurements on liquid specimen sizes in the range from 1 to 10 ml.
- (3.0) Standard values are specified in SI units (International System of Units). The values given in parentheses are provided for information purposes only.
- (4.0) This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific hazard statements, see paragraph (g)(5.0).

(b) Summary of Test Method

- (1.0) A known volume of chilled, air-saturated sample is introduced into a thermostatically controlled test chamber, the internal volume of which is five times that of the total test specimen introduced into the chamber. A vacuum is applied to the chamber in accordance with the manufacturer's instructions. After introduction into the test chamber the test specimen is allowed to reach thermal equilibrium at the test temperature, 37.8°C (100°F). The resulting rise in pressure in the chamber is measured using a pressure transducer sensor and indicator.

- (2.0) Only the sum of the partial pressure of the sample and the partial pressure of the dissolved air (commonly known as the total pressure) are used in this test method. Note that some instruments may call this pressure measurement by another term. Also note that some instruments are capable of measuring the absolute pressure of the specimen as well.
- (3.0) The measured total vapor pressure is converted to a Reid vapor pressure equivalent (RVPE) by use of a calibration equation (paragraph (i)(1.0)). This calculation converts the measured total pressure to the Reid vapor pressure (RVP) expected from the American Society of Testing and Materials (ASTM) Test Method D 323-58.

(c) Apparatus

- (1.0) Vapor Pressure Apparatus - An appropriate instrument, designed for the intended use should be selected. The minimum performance level for the automated vapor pressure test instrument is that the instrument shall perform as well as, or better than, the precision criteria set forth in the ASTM D323-58. The ASTM D323-58 states a repeatability value of 0.2 psi and a reproducibility value of 0.3 psi. The instrument shall provide accurate results which are comparable to the RVP measured by the ASTM 323-58. Typically, the type of apparatus suitable for use in this test method employs a small volume test chamber incorporating a transducer for pressure measurements and associated equipment for thermostatically controlling the chamber temperature and for evacuating the test chamber.
 - (1.1) The test chamber shall be designed to contain between 5 and 50 ml of liquid and vapor and be capable of maintaining a vapor-to-liquid ratio between 3.95 to 1.00 and 4.05 to 1.00.
 - (1.2) The pressure transducer shall have a minimum operational range from 0 to 177 kPa (0 to 25.6 psi) with a minimum resolution of 0.1 kPa (0.01 psi) and a minimum accuracy of ± 0.3 kPa (± 0.05 psi). The pressure measurement system shall include associated electronics and readout devices to display the resulting pressure reading.
 - (1.3) The thermostatically controlled heater shall be used to maintain the test chamber at $37.8 \pm 0.1^\circ\text{C}$ ($100 \pm 0.2^\circ\text{F}$) for the duration of the test.
 - (1.4) A platinum resistance thermometer shall be used for measuring the temperature of the test chamber. The minimum temperature range of the

measuring device shall be from ambient to 60°C (140°F) with a resolution of 0.1°C (0.2°F) and accuracy of 0.1°C (0.2°F).

- (1.5) The vapor pressure apparatus shall have provisions for introduction of the test specimen into the test chamber and for the cleaning or purging of the chamber following the test.
- (2.0) A vacuum pump (if required by the manufacturer's instructions) shall be capable of reducing the pressure in the test chamber to less than 0.01 kPa (0.001 psi) absolute.
- (3.0) A syringe (optional, depending on sample introduction mechanism employed with each instrument) shall be gas-tight. The syringe shall be 1 to 20-ml capacity with a $\pm 1\%$ or better precision. The capacity of the syringe should not exceed two times the volume of the test specimen being dispensed.
- (4.0) Ice Water Bath or Refrigerator (Air Bath): for chilling the samples and syringe to temperatures between 0 and 1°C (32 to 34°F).
- (5.0) Mercury Barometer (if required by the manufacturer's instructions): in the 0 to 120 kPa (0 to 17.4 psi) range.
- (6.0) McLeod Vacuum Gage (if required by the manufacturer's instructions): to cover at least the range from 0 to 0.67 kPa (0 to 5mm Hg).

(d) Sampling

- (1.0) Obtain a sample in accordance with Section 2261 of Title 13 of the California Code of Regulations.
- (2.0) The extreme sensitivity of vapor pressure measurements to losses through evaporation and the resulting changes in composition is such as to require the utmost precaution and most meticulous care in the handling of samples.
- (3.0) Protect samples from excessive high temperatures prior to testing. This can be accomplished by storage in an appropriate ice water bath or refrigerator.
- (4.0) Do not test samples stored in leaky containers. Discard and obtain another sample if leaks are detected.

(e) Preparation of Apparatus

- (1.0) Prepare the instrument for operation in accordance with the manufacturer's instructions.
- (2.0) Clean and prepare the test chamber as required to avoid contamination of the test specimen.
- (3.0) For instruments that require that the test chamber be evacuated prior to the introduction of the test specimen: Prior to specimen introduction, visually determine from the instrument display that the test chamber pressure is stable and does not exceed 0.1 kPa (0.01 psi). When the pressure is not stable or exceeds this value check that the chamber is clean of volatile materials remaining in the chamber from a previous specimen or check the calibration of the transducer.
- (4.0) If a syringe is used for introduction of the specimen, chill it to between 0 and 4.5°C (32 and 40°F) in an ice water bath or a refrigerator before drawing in the specimen. Avoid water contamination of the syringe reservoir by suitably sealing the outlet of the syringe during the cooling process.
- (5.0) For instruments using a pre-heated test chamber: Prior to introduction of the test specimen check that the temperature of the test chamber is within the required range from $37.8 \pm 0.1^\circ\text{C}$ ($100 \pm 0.2^\circ\text{F}$).

(f) Calibration

- (1.0) Pressure Transducer:
 - (1.1) Check the calibration of the pressure transducer on a monthly basis or when needed as indicated from the quality control checks (paragraph (g)). The calibration of the pressure transducer is checked using two reference points, zero pressure (<0.1 kPa) and the ambient barometric pressure.
 - (1.2) Connect a McLeod gage to the vacuum source in line with the test chamber. Apply a vacuum to the test chamber. When the McLeod gage registers a pressure less than 0.1 kPa (0.8 mm Hg, or 0.01 psi), adjust the pressure transducer control to zero or to the actual reading on the McLeod gage as dictated by the instrument design and manufacturer's instructions.
 - (1.3) Open the test chamber to the atmosphere and observe the pressure transducer reading. If the pressure reading is not equal to the

ambient barometric pressure, then adjust the pressure transducer span control until the appropriate reading is observed. Ensure that the instrument is set to display the total pressure and not a calculated or corrected value.

- (1.4) Repeat steps (f)(1.2) and (f)(1.3) until the zero and barometric pressures read correctly without further adjustments.
- (2.0) Thermometer - Check the calibration of the platinum resistance thermometer used to monitor the temperature of the test chamber at least every six months against a National Institute on Standards and Technology (NIST) traceable thermometer.

(g) Quality Control Checks

- (1.0) Check the performance of the instrument each day it is in use by running a quality control sample consisting of a pure solvent of known vapor pressure similar to the vapor pressure of the samples to be tested. Treat the pure solvent quality control check sample in the same manner as a sample (paragraph (h)). Record the total vapor pressure (do not calculate a Reid vapor pressure equivalent) in a log for the purpose of tracking the instrument's performance. If the total vapor pressure differs from the previous entry (for the same pure solvent) in the log by more than ± 1.0 kPa (0.15 psi), then check the instrument calibration (paragraph (f)). If the trend of the log shows variations of more than ± 1.0 kPa (0.15 psi) (for the same pure solvent), also check the instrument calibration.
- (2.0) Some of the possible reference pure materials and their corresponding absolute vapor pressures¹ include:

cyclohexane	22.5 kPa	(3.27 psi)
cyclopentane	68.3 kPa	(9.92 psi)
2,2-dimethylbutane	67.9 kPa	(9.86 psi)
2,3-dimethylbutane	51.1 kPa	(7.41 psi)
2-methylpentane	46.7 kPa	(6.77 psi)
toluene	7.1 kPa	(1.03 psi)

1. The total pressure values cited were obtained from Phillips Petroleum Co., Bartlesville, OK, or the Table of Physical Constants, National Gas Producer Association.

- (3.0) Purity of Reagents - Use chemicals of at least 99% purity for quality control checks. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.² Lower purities can be used, provided it is first ascertained that the reagent is of sufficient purity to permit its use without lessening the accuracy of the determination.
- (4.0) The chemicals in this section are suggested for use in quality control procedures; not for instrument calibration.
- (5.0) **WARNING**--Cyclohexane, cyclopentane, 2,2-dimethylbutane, 3,2-dimethylbutane, 2-methylpentane, and toluene are extremely flammable. They are an aspiration hazard and are harmful if inhaled. They are also a skin irritant on repeated contact.

(h) Procedure

- (1.0) Sample Temperature - Cool the sample container and contents in an ice water bath or refrigerator to the 0 to 1°C (32 to 34°F) range prior to opening the sample container. Allow sufficient time to reach this temperature.
- (2.0) Verification of Sample Container Filling - After the sample reaches thermal equilibrium at 0 to 1°C, take the container from the ice water bath or refrigerator, wipe dry with an absorbent material, unseal and examine the ullage. With a suitable gage, determine that the liquid content in the container is between 70 to 80% of the volume of the container capacity.
- (2.1) Discard the sample if the liquid content of the container is less than 70% of the volume of the container capacity.
- (2.2) If the liquid content of the container is more than 80% of the volume of the container capacity, pour out enough sample to bring the liquid contents within the 70 to 80% volume range.

2. "Reagent Chemicals, American Chemical Society Specifications," Am. Chemical Soc., Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co, Inc., New York, NY and the "United State Pharmacopeia."

- (3.0) Air Saturation of Sample in Sample Container
- (3.1) After determining that the liquid content in the sample container is between 70 to 80% full, reseal the container and shake vigorously. Return the container to the ice water bath or refrigerator for a minimum of 2 minutes.
- (4.0) Remove the sample from the ice water bath or refrigerator, dry the exterior of the container with absorbent material, uncap, insert a transfer tube or syringe (paragraph (e)(4.0)). Draw a bubble-free aliquot of sample into a gas tight syringe or transfer tube and deliver this test specimen to the test chamber as rapidly as possible. The total time between opening the chilled sample container and inserting/securing the syringe into the sealed test chamber shall not exceed 1 minute.
- (5.0) The vapor pressure determination shall be performed on the first test specimen withdrawn from a sample container. Successive vapor pressure determinations can be made on the remaining test material in the same container if the container had been tightly sealed immediately after the previous vapor pressure determination.
- (6.0) Follow the manufacturer's instructions for the introduction of the test specimen into the test chamber, and for the operation of the instrument to obtain a total vapor pressure result for the test specimen.
- (7.0) Set the instrument to read the result in terms of total vapor pressure. If the instrument is capable of calculating a Reid vapor pressure equivalent value, ensure that only the parameters described in paragraph (i)(2.0) are used.
- (8.0) Verification of Single Phase - After drawing a test specimen and introducing it into the instrument for analysis, check the remaining sample for phase separation. If the sample is contained in a glass container, this observation can be made prior to sample transfer. If the sample is contained in a non-transparent container, mix the sample thoroughly and immediately pour a portion of the remaining sample into a glass container and observe for evidence of phase separation. If the sample is not clear and bright or if a second phase is observed, discretion shall be used to determine if the sample is truly representative.
- (9.0) Record the total vapor pressure reading from the instrument to the nearest 0.1 kPa (0.01 psi). For instruments that do not automatically

record or display a stable pressure value, manually record the pressure indicator reading every minute to the nearest 0.1 kPa; and, when three successive readings agree to within 0.1 kPa, record the result to the nearest 0.1 kPa (0.01 psi).

(i) Calculation

- (1.0) Calibration Equation - Calculate the Reid vapor pressure equivalent (RVPE) using the following calibration equation. Ensure that the instrument reading used in this equation corresponds to the total pressure and has not been corrected by an automatically programmed correction factor.

$$\text{Equation 1:} \quad \text{RVPE} = aX - b$$

where:

- "RVPE" is the vapor pressure value (in psi) that would be expected from test method ASTM D323-58;
- "a" is the correlative relationship of test data from the specific automated vapor pressure test instrument and test data from ASTM D323-58;
- "X" is the total vapor pressure value (in psi) as determined by the specific automated vapor pressure test instrument;
- "b" is the offset of the test data between the specific automated vapor pressure test instrument and the test data from ASTM D323-58.

The data used for determining the calibration equation for each instrument shall be obtained during an Air Resources Board vapor pressure test program. The data shall consist of test results obtained from the analysis of identical samples by the automated instrument and by ASTM D323-58. Vapor pressure test programs may be conducted on a periodic basis as needed. The Air Resources Board conducted such a program and determined that the following automated vapor pressure test instruments meet the requirements of paragraph (c). The data from the test program were used to arrive at the calibration equations for these instruments. The calibration equations are as follows:

1. Grabner Instruments,
Model: CCA-VP (laboratory Grabner) $\text{RVPE} = (.965)X - .304$
2. Grabner Instruments,
Model: CCA-VPS (portable Grabner) $\text{RVPE} = (.972)X - .715$
3. Stanhope-Seta Limited,

Model: Setavap

$$RVPE = (.961)X - .577$$

(2.0) The calculation described in paragraph (i)(1.0), above, can be accomplished automatically by the instrument, if so equipped, and in such cases the user shall not apply any further corrections.

(j) Report

(1.0) Report the Reid vapor pressure equivalent to the nearest 0.1 kPa (0.01 psi).

(k) Precision and Bias

(1.0) Precision - The precision of this test method as determined by the statistical examination of interlaboratory test results is as follows:

(1.1) Repeatability - The difference between successive test results obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the correct operation of the test method exceed the following value only in one case in twenty. The repeatability values for the specific automated vapor pressure test instruments listed in paragraph (i)(1.0) were equal to or less than 0.2 psi. For the purposes of determining compliance with Sections 2251 and 2251.5, the repeatability value for this method shall be 0.20 psi.

(1.2) Reproducibility - The difference between two single and independent test results obtained by different operators working in different laboratories using the same make and model test instrument on identical test material would, in the long run, exceed the following value only in one case in twenty. The reproducibility values for the specific automated vapor pressure test instruments listed in paragraph (i)(1.0) were equal to or less than 0.3 psi. For the purposes of determining compliance with Sections 2251 and 2251.5, the reproducibility value for this method shall be 0.30 psi.

(2.0) Bias - A relative bias was observed between the total pressure obtained using this test method and the Reid vapor pressure obtained using ASTM Test Method D323-58. This bias is corrected by the use of the calibration equation in paragraph (i)(1.0) which calculates a Reid vapor pressure equivalent value from the observed total pressure.

APPENDIX C

Proposed Amendments to the Test Methods Specified in
the Stationary Source Division
Proposed RVP Regulation, Section 2251.5

(Note: These are only the proposed amendments to the test methods.)

(c) **Sampling and Test Methods.**

(1) Compliance with the standards set forth in section (a)(1) and (2) shall be determined by use of an applicable sampling methodology set forth in 13 CCR section 2261, and by use of either [i] the American Society for Testing and Materials Method ASTM D 323-58 (which is incorporated by reference herein), deleting paragraph 4(b) concerning sampling, or by any ~~automated vapor pressure test instrument used in accordance with the procedures specified in ASTM Emergency Standards 14 or 15, and which the Executive Officer determines has satisfactory performance repeatability and reproducibility.~~ [ii] the test method set forth in Section 2262.

(2) For purposes of section (a)(3), the ethanol content of gasoline shall be determined by use of American Society of Testing and Materials Test Method D 4815-88, which is incorporated by reference herein. The volume of ethanol shall include the volume of any denaturant approved for that purpose by the United States Bureau of Alcohol, Tobacco and Firearms, provided those denaturants do not exceed 5 percent of the volume of alcohol (including denaturants).

APPENDIX D

Proposed Amendments to the Test Methods Specified in
the Stationary Source Division
Proposed RVP Regulation, Section 2251

(Note: These are only the proposed amendments to the test methods.)

Section 2251. Reid Vapor Pressure for Gasoline

No person shall sell or supply as a fuel for motor vehicles as defined by the Vehicle Code of the State of California a gasoline having a Reid vapor pressure greater than nine pounds per square inch as sampled pursuant to Section 2261 and tested by either [i] ASTM Method D 323-58 (which is incorporated by reference herein), deleting paragraph 4(b) concerning sampling, beginning in 1971 or [ii] the test method set forth in Section 2262 in the following air basins established by the State Air Resources Board.