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ANALYSIS OF AND ACTION ON CALIFORNIA'S REQUEST FOR A WAIVER OF THE OXYGEN CONTENT IN GASOLINE

1. INTRODUCTION

a. The Clean Air Act requirements

Section 211(k)(2)(B)of the Act, 42 U.S.C. § 7545(k)(2)(B), establishes an oxygen content requirement for federal reformulated gasoline (RFG), and allows EPA to waive compliance with the requirement under certain circumstances. Section 211(k)(2)(B) reads:

> The oxygen content of the gasoline shall equal or exceed 2.0 percent by weight (subject to a testing tolerance established by the Administrator) except as otherwise required by this Act. The Administrator may waive, in whole or in part, the application of this subparagraph for any ozone nonattainment area upon a determination by the Administrator that compliance with such requirement would prevent or interfere with attainment by the area of a national primary ambient air quality standard.

EPA has the discretion under this section to waive the oxygen content requirement, to the extent reasonably necessary, where EPA determines that compliance with the oxygen content requirement would interfere with attainment of the primary National Ambient Air Quality Standard (NAAQS) in an ozone nonattainment area. In evaluating California's request for waiver of the oxygen requirement, EPA has analyzed the likely composition of gasoline in the relevant nonattainment area(s) with and without a waiver of the oxygen content requirement and the resulting impact of oxygen content on emissions. This analysis is needed so EPA can assess the potential effect that a waiver would have on California's efforts to attain the ozone and particulate matter NAAQS.

b. California's waiver request

In a letter dated April 12, 1999 from California Governor Gray Davis to Administrator Browner, California officially requested a waiver from the federal oxygen requirement for reformulated gasoline, under Section 211(k)(2)(B).[1] The April 12, 1999 submittal stated that "the ARB will be revising its CaRFG program this year, and

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[1] (Filed in docket A-2000-10, document number II.D.-1; also available at http://www.arb.ca.gov/cbg/Oxy/wav/041299.pdf)

continuing the oxygen mandate will make it more difficult to maintain the emission reductions benefits needed for California's SIP." The submittal did not, however, contain the technical analysis to support the statement that the oxygen requirement might actually prevent or interfere with the attainment of the NAAQS in California. As such, the Agency believed that the request submitted by California on April 12, 1999 did not provide enough detail about the underlying analyses upon which the request was premised to allow EPA to make a careful and fully informed decision on the request.

Subsequent submittals from the California Air Resources Board (CARB) provided additional information necessary to evaluate Calfiornia's request for a waiver from the oxygen requirement. In order to evaluate whether compliance with the oxygen content requirement prevents or interferes with a NAAQS, the Agency then began an independent evaluation of the data, modeling, and other information submitted by California in support of its request for a waiver from the federal RFG oxygen requirement.

c. California's argument for a waiver

California's waiver request rests first on CARB's assertion that additional NOx reductions are needed in California. CARB claims that the South Coast Air Quality Management District (SCAQMD) and Sacramento Metropolitan Air Quality Management District (SMAQMD) need additional NOx reductions beyond the commitments made in their recently approved State Implementation Plans (SIPs) for these areas to attain the National Ambient Air Quality Standards (NAAQS) for ozone and particulate matter.

CARB then claims that without the oxygen requirement, California RFG Phase 3 (CaRFG) would achieve greater NOx reductions. CARB's assertion regarding the benefits achievable under CaRFG3 without the oxygen requirement is based primarily on the relationship between fuel oxygen and NOx formation. CARB claims that increases in gasoline oxygen content increase NOx emissions and therefore the requirement for oxygen in RFG prevents the State from achieving the maximum amount of NOx reduction from CaRFG3.[2] In light of the additional NOx reductions needed in the SCAMQD and Sacramento RFG regions, CARB argues that NOx emissions

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[2] Specifically, CARB varied the values of the aromatics, olefins, sulfur, T50, T90, and benzene fuel parameters of each of the two sets of complying fuels (i.e., 2 weight percent oxygen fuels and zero percent oxygen fuels) between the lower and upper bound limits that it defined for each parameter. CARB then generated over 10 million combinations of fuel properties within the bounds it defined, and using its Predictive Model for CaRFG3 (PM3) identified the subset of these hypothetical fuels which would comply with CARB's standards for its CaRFG3. CARB's simulation analysis showed that on average among the large number of complying formulations, the additional reduction in NOx associated with going from a 2 weight percent oxygen fuel to a zero oxygen fuel is about 1.5 percent. On the basis of this simulation analysis CARB claimed that the reduction of NOx is greater without oxygen independent of which fuel properties are varied.

resulting from compliance with the oxygen content requirement would interfere with the attainment of the ozone and PM NAAQS.

CARB acknowledges that reducing oxygen content would increase carbon monoxide (CO) emissions. CARB claims, however, that with a waiver there would be a reduction in oxygenated fuels (i.e., reduction of ethanol) which would lead to a decrease in the emissions associated with permeation of VOC through vehicle fuel system components such as hoses and seals that occurs with the use of ethanol as an oxygenate. Based on the use of reactivity factors, CARB argues that the VOC emission decrease from reduction in permeation losses offsets the increase in CO, resulting in an ozone neutral effect. (This is discussed in further detail in Section 4 below).

CARB also acknowledges that with a waiver, both oxygenated and non-oxygenated gasolines would be used, resulting in commingling of ethanol and non-ethanol gasolines in automobile gas tanks. Since ethanol acts to boost the Reid Vapor Pressure (RVP) of gasoline, such commingling would result in a VOC increase. CARB estimates that commingling would increase VOC emissions by an amount equivalent to an overall increase in RVP of 0.1 psi. CARB has set the flat limit of RVP in CaRFG3 0.1 psi lower than it otherwise would have been (i.e., 6.9 rather than 7.0) and asserts that the lower RVP offsets the VOC increase due to commingling.

d. Criteria for acting on California's request

As previously stated, the Clean Air Act requires that, in order to waive the federal RFG oxygen requirement, EPA must determine that the requirement will prevent or interfere with the State's ability to attain a NAAQS. The key question before the agency therefore involves the air quality impacts of a waiver for the relevant NAAQS.

To address the air quality impact, it is critical to consider both the potential changes in gasoline quality which could occur if a waiver were granted and the potential emissions impacts of these changes. All relevant categories of emissions should reasonably be considered. This information is needed to evaluate the impacts of a waiver on each applicable NAAQS.

EPA believes it should not make a determination of interference or prevention and should not grant a waiver unless the impacts of a waiver are clearly demonstrated for each applicable NAAQS. Absent such a clear demonstration, EPA is not able to determine whether a waiver would aid, hinder, or have no effect on attainment of a NAAQS. It is important that the impacts of a waiver be clearly demonstrated for each applicable NAAQS, because EPA believes it should not grant a waiver unless, at a minimum, it has been clearly demonstrated that granting a waiver would aid in attaining at least one NAAQS, and would not hinder attainment for any other NAAQS.

2. EPA'S ANALYSIS OF THE EMISSIONS IMPACTS OF A WAIVER

a. Background

EPA performed a complex analysis to evaluate the effect of a waiver on NOx, VOC, and CO inventories. In order to perform this analysis it was necessary to estimate both how emissions were likely to change as a result of fuel property changes, and how California Phase 3 RFG (CaRFG3) fuel properties were likely to differ with and without a waiver. EPA considered various pre-existing models and estimates relating fuel properties to emissions and, where warranted and feasible, produced new models to relate fuel properties and emissions for evaluation of the waiver. EPA also reviewed existing refinery modeling results which predicted the composition of CaRFG3 with and without a waiver. EPA ultimately concluded that additional refinery modeling was needed and, through its contractor MathPro, performed such modeling. EPA used these emission models in conjunction with refinery modeling results in order to estimate factors, generally as percent changes, which could then be applied to emissions inventory estimates to predict the tons/day emission changes in year 2005 resulting from a waiver. The analysis included both on-road and non-road emissions, and addressed emissions of NOx, CO, and VOC.

The following brief description of the process highlights some of EPA's major decisions and assumptions. EPA's analysis is described in detail in our Technical Support Document (TSD), Docket Number A-2000-10, Document II-B-2.

b. Refinery modeling

EPA's initial waiver analysis included use of certain fuel property estimates from a December 9, 1999 MathPro refinery modeling analysis for the California Energy Commission. EPA concluded that this modeling, for reasons discussed in the technical support document, did not provide a sufficient basis for evaluation of California's waiver request. Consequently, EPA commissioned MathPro to do additional modeling.

The EPA MathPro modeling provided property estimates for oxygenated CaRFG3 if no waiver were granted, and property and market share estimates for non-oxygenated and oxygenated CaRFG3 if a waiver were granted. The refinery modeling investigated a number of cases in which refiners blended CaRFG3 with and without a waiver using the phase 3 predictive model, the flat limit reference specifications, and the exhaust plus evaporative VOC compliance option. In these cases the impact of various factors was considered. Specifically, this modeling evaluated the properties of CaRFG3 where oxygen was used at 2.0 percent or 2.7 percent by weight, the constraints of the Unocal patent were imposed (requiring refiners to avoid the parameter ranges established by the patent) or eliminated (assuming, for whatever reasons, refiners did not need to avoid the patent), and where MTBE use outside of California was assumed to be reduced (e.g., because of MTBE bans or refiner liability concerns) or assumed to continue at current levels.

The modeling predicted non-oxygenated CaRFG3 shares ranging from 35 percent to 74 percent if a waiver were granted, with six of the eight cases being greater than the 40 percent non-oxygenated share EPA had assumed based on earlier modeling. With an increase in oxygen content from 2.0 percent to 2.7 percent by weight, all else being constant, the analysis predicts a decrease in non-oxygenated market share. Also, it predicts that a reduction of MTBE use outside of California would result in an increase in the non-oxygenated market share of the CaRFG3 pool. The Unocal Patent may also affect the non-oxygenated/oxygenated market split. Specifically, avoidance of T50 less than 210º F could limit the use of alkylate for premium CaRFG3, possibly increasing the use of oxygen. Based on the refinery modeling, we concluded that under a number of sets of foreseeable “waiver” circumstances, there would be substantial quantities of both oxygenated and non-oxygenated CaRFG3 produced. EPA’s refinery modeling provides a number of alternative cases, incorporating the finalized version of the Phase 3 predictive model and CaRFG3 flat limit reference specifications. This allowed EPA to examine potential waiver emissions impacts under various alternative scenarios which incorporate a variety of potential conditions. EPA evaluated emission impacts for the eight basic cases from the modeling and for four cases where the “no waiver” oxygen level was 2.7 weight percent, and the “waiver” oxygen level for the oxygenated portion of the pool was 2.0 percent.

c. Emissions modeling

At the time that EPA began its analysis of the California waiver request, there were several available emission models which related fuel properties to emissions of on-road light duty vehicles. These were the complex model (the compliance model for federal RFG), the Phase 2 predictive model (the compliance model for phase 2 California RFG), and the PM3 (the compliance model for phase 3 California RFG which had not yet been officially adopted). Each of these models was based on statistical regression analysis of thousands of emission test results. The Phase 3 predictive model was developed using statistical procedures and software not available for use in developing the complex model or the Phase 2 predictive model. Although additional data were used to develop the Phase 3 model, much of the same data were used in the development of all three models.

EPA was concerned that considerable disparity existed among the models in the estimated direction and magnitude of the NOx response to changes in oxygen content, all else being constant. The Phase 2 and Phase 3 models both indicate a NOx increase with increasing oxygen, however the Phase 3 model shows a much steeper response. The Complex Model, by contrast, predicts that NOx will decrease slightly as oxygen increases. It should be noted that the magnitude of the NOx response to oxygen, even as predicted by the Phase 3 model, is not large when compared to NOx emission differences between vehicles, or test-to-test variability in emissions. The small size of the oxygen effect on NOx emissions indicated in all of these models makes it difficult to detect statistically and to quantify precisely. In an attempt to resolve the uncertainty about the NOx/oxygen relationship, EPA staff and a consultant audited the process that CARB staff used to develop the Phase 3 predictive model.[3] Additionally, EPA independently developed alternative models for NOx as a function of fuel properties for the Tech 4 vehicles.[4]

EPA's audit of CARB's model included a review of the decisions for inclusion and exclusion of data from the data set, the statistical approach, treatment of "high emitters" and selection of a final model. EPA also reviewed the sufficiency of data and the approach taken in CARB's representation of Tech 5 emissions in the predictive model. EPA's review raised a number of concerns about CARB's model development process. These concerns included CARBs decision not to consider high emitter terms for potential inclusion in the model, its decision to discard the primary results of the Phase 3 model-building process and return to the terms from the earlier Phase 2 effort, and modeling of emissions from Tech 5 vehicles. These concerns contributed to EPA's decision to pursue its development of alternative Tech 4 models for both NOx and exhaust VOCs (modeling non-methane hydrocarbons), for evaluation of the waiver request. EPA additionally concluded that there was considerable uncertainty about the accuracy of CARB's Tech 5 models, given the small amount of Tech 5 data and CARB's modeling approach which relied heavily on Tech 4 data to develop the Tech 5 models. Consequently, based on engineering judgment, EPA concluded that the best approach for waiver evaluation was to assume that Tech 5 NOx, VOC and CO exhaust emissions would not be affected by fuel property differences. EPA elected to use the Tech 3 portion of the phase 3 predictive model, and the allocations of exhaust VOCs and NOx emissions that would occur with a waiver (based on the use of CARB's emission inventory model EMFAC7g) among the three technology groups assumed in the predictive model.

While the Phase 3 predictive model contains an equation to calculate a CO credit as a function of oxygen content it does not explicitly calculate CO mass emissions as a function of fuel properties. EPA used CARB's assumptions regarding oxygen effect on CO (contained in Appendix G -"Estimation of a CO Credit" of its staff report for the CaRFG3 rule) in calculating CO changes. However, EPA did not assume that the CO would change due to changes in sulfur or T50. EPA split the CO change among the Tech 3, Tech 4 and Tech 5 categories as CARB did, assuming that there

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[3] EPA utilized the consulting expertise of Southwest Research Institute (SwRI) which had previously been involved in emissions modeling efforts such as development of EPA's complex model.

[4] For modeling purposes, CARB separated vehicles into technology classes 3, 4, and 5. Tech 3 vehicles represent the oldest technology vehicles, Tech 4 represents "middle-aged" vehicles which make up the majority of the fleet and its emissions, and Tech 5 represents the newest technology vehicles. For a more complete description, see the TSD.

would be no change in CO as a result of oxygen reduction in Tech 5 vehicles (which CARB assumed as well).

When EPA developed its alternative Tech 4 models, a number of possible candidate models resulted. Certain of these models did not show substantially different predictive utility based on statistical criteria. Therefore, EPA had to use engineering judgment of the likely effect on emissions as well as statistical measures to select the models it would use for evaluating California's waiver petition. Ultimately, EPA selected six different NOx models and decided to average results in order to determine applicable percent change factors for the waiver analysis. Similarly, EPA selected three models from among the candidate NMHC exhaust models. Two of these NMHC models contained terms which indicated that "high emitters" and "normal emitters" would respond differently to certain fuel property changes. EPA requested information, based on EMFAC7G, from CARB in order to properly weight normal and high emitter contributions.

EPA also included non-exhaust VOC emission effects in its analysis. Such effects could arise from differences in RVP in as-blended gasoline under a waiver compared to no waiver, and from in-vehicle commingling of ethanol-oxygenated and non-oxygenated gasoline. Additionally, permeation VOC emissions through non-metallic fuel system components are expected to be higher with ethanol-oxygenated gasolines than with non-oxygenated gasolines.

To quantify RVP-related changes in evaporative emissions, EPA used an equation, based on EMFAC7G, published in a report prepared by Sierra Research for the American Methanol Institute.[5] This equation expresses evaporative emissions, in tons per day, as a function of RVP. Rather than use the tons per day estimates directly, EPA calculated percent change factors, and applied them to evaporative VOC emission inventory estimates. CARB estimated, in its February 7, 2000 submittal, that the difference in VOC emissions due to permeation losses when comparing non-oxygenated gasoline to gasoline/ethanol blends with 2.0 weight percent oxygen is about 13 tons/day for all federal RFG areas, assuming 100 percent penetration of non-oxygenated fuels. EPA quantified permeation effects by adjusting proportionally for various non-oxygenated penetrations and oxygen contents different than 2.0 weight percent, assuming that 60 percent of these permeation losses would represent SCAQMD.

The MathPro modeling indicated that the as-blended RVP of the CaRFG3 pool with a waiver would be lower than the RVP without a waiver for all scenarios. This results in a net reduction in VOC emissions for all scenarios with a waiver when exhaust, as-blended evaporative and permeation emission changes are considered. If

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5 Report No. SR00-0101 "Potential Evaporative Emission Impacts Associated with the Introduction of Ethanol-Gasoline Blends in California" January 11, 2000.

EPA were to grant a waiver, however, in-vehicle commingling of ethanol blended oxygenated gasoline and non-oxygenated CaRFG3 would cause additional RVP increases to occur. California has estimated the likely magnitude of this increase to be about 0.1 psi (basically the lower of several RVP increases produced by CARB's analysis). EPA reviewed CARB's evaluation of the commingling effect. EPA also evaluated the possible commingling effect under various potential conditions. This analysis used a pre-existing EPA commingling model to help assess the average in-vehicle RVP increases that could occur if ethanol-oxygenated gasoline were commingled with non-oxygenated gasoline during vehicle refueling. Since EPA's model assumes that ethanol would be blended at 10 volume percent, EPA multiplied the model's RVP increase estimates by 0.8 (as CARB did) to evaluate potential RVP increases when ethanol is blended at 5.7 volume percent (2.0 weight percent oxygen). EPA also considered the analysis contained in the Sierra Research report cited earlier. EPA found that an RVP increase close to 0.2 psi is as likely to occur under a fairly broad set of conditions as a 0.1 psi increase. Since EPA recognized that there is considerable uncertainty about the magnitude of the commingling RVP increase, EPA evaluated net VOC (exhaust + as-blended evaporative + commingling evaporative + permeation) changes at various levels of RVP boost from 0 psi to 0.3 psi. For this analysis, EPA assumed that commingling RVP increases apply to non-road as well as on-road vehicles. EPA concluded that, depending on the scenario and the magnitude of the RVP increase, the net VOC benefit with the waiver would change and significantly could be reversed by the commingling component of VOC emissions. These results are discussed below.

EPA expected that non-road exhaust emission changes would be a function of oxygen content. We used information in an EPA document, Report No. NR-003, in conjunction with statewide California non-road inventory data to determine percent change factors for the waiver analysis. [6] Non-road RVP-related evaporative emissions were modeled using the on-road percent change factors. EPA recognized that the extremely limited amount of data available to estimate non-road effects added considerable uncertainty to the analysis. Furthermore, EPA had to make a number of assumptions to derive baseline non-road gasoline emission inventory estimates for the SCAQMD, and to separate the VOC estimate into exhaust and evaporative components.[7]

3. EMISSIONS CHANGES EXPECTED TO RESULT FROM A WAIVER

EPA's evaluation of the emissions impacts of a waiver, as discussed below, shows a likely decrease of NOx under all scenarios examined, an increase in CO under

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[6] Exhaust Emission Effects of Fuel Sulfur and Oxygen on Gasoline Nonroad Engines", Report No. NR-003, November 24, 1997, Christian E. Lindhjem, U.S. EPA

[7] Inventory assumptions are described in a memo in the Document II-B-1 in Docket A-2000-10.

these scenarios, and significant uncertainty about the change in VOC emissions. The VOC emissions impact ranges from a decrease in VOC to an increase, largely depending on the level of commingling emissions and whether they are or are not accounted for.

NOx Emissions Effects. The changes that refiners would make to the composition of California gasoline in response to a waiver, when evaluated with EPA's NOx emissions model, would likely reduce NOx emissions under every scenario that we evaluated (see Table 1). This finding, which is unique to California's regulatory structure and specific to California refineries' technical configurations, is directionally in agreement with CARB predictions, though the two analyses have important differences.

CO Emissions Effects. With a waiver, CO emissions would increase in all scenarios, as indicated in Table 1. This is because oxygenated gasoline generally produces lower CO emissions and a mixed pool of gasoline with significant quantities of non-oxygenated gasoline would result in poorer CO emissions performance. The refinery modeling, under various scenarios, estimates the proportion of the gasoline that would be oxygenated with a waiver and thus drives the inventory effects. CARB's model was used to determine the CO effects brought about by changes in oxygen content.

VOC Emissions Effects. Our analysis shows that the impact of a waiver on VOC emissions would be mixed. Exhaust VOC emissions would be higher with a waiver, as indicated when EPA's VOC emissions model is used to predict exhaust VOC emissions from the fuels that our refinery analysis indicates are likely to be produced with and without a waiver. But the refinery modeling also indicates that the RVP of both oxygenated and non-oxygenated fuels produced under a waiver would be lower than without a waiver, with a consequent reduction in "as-blended" evaporative emissions. Additionally, the smaller proportion of gasoline containing ethanol in the waiver case would also tend to reduce permeation emissions. (Permeation is the escape of gasoline components through the material used in soft fuel system components. Such losses are increased by the presence of ethanol in gasoline.) In the absence of any commingling considerations (discussed below), the net result of these opposite exhaust and non-exhaust effects would be a reduction in VOC emissions with a waiver, though the magnitude of the reduction varies across scenarios. As with NOx, the conclusion that the RVP of fuels produced with a waiver would be lower than without a waiver is based on the specific circumstances of California regulations and the fuel formulation decisions likely to be made by refineries supplying the California market.

Commingling effects on VOC emissions occur when ethanol-oxygenated gasolines and gasolines without ethanol are mixed in vehicle fuel tanks. This is due to the volatility boost caused when ethanol is added to all-hydrocarbon gasoline. This boost in volatility occurs even when a small amount of ethanol is added to gasoline. Therefore, in order to produce an ethanol-containing RFG meeting evaporative emissions requirements, the hydrocarbon blendstock to which the ethanol is added must have very low volatility to accommodate increased volatility produced by the ethanol. If the non-oxygenated RFGs are "commingled" in vehicle fuel tanks with ethanol RFG, the ethanol will similarly increase the volatility of these non-oxygenated RFGs resulting in an overall volatility of the "commingled" blends greater than that of either the ethanol RFG or the non-oxygenated RFG prior to commingling. In other words, when a vehicle with a partially full tank is refueled with a different type of gasoline (i.e., ethanol-oxygenated in the tank and non-oxygenated added or vice versa), the presence of ethanol will cause the resulting mixture to have an overall RVP greater than the original RVP of either of the gasolines prior to refueling.

Without a waiver it is reasonable to believe that there would be no appreciable commingling effects, since all of the gasoline in the RFG areas would contain ethanol.[8] With a waiver, commingling would certainly occur and would exert an upward pressure on VOC emissions. While the directional impact on emissions from commingling is clear, its magnitude is very difficult to forecast as it depends upon estimates of the oxygenated/non-oxygenated market share, the oxygen content used in ethanol-oxygenated RFG, and vehicle owners' refueling behavior (including brand loyalty and full versus partial fill-ups), among other variables.

CARB estimated that commingling would have the effect of raising the RVP of gasoline by about 0.1 psi. CARB's analysis assumed ethanol use in 100 percent of premium gasoline and 46 percent of regular gasoline, no grade switching (thus restricting the occurrence of commingling only vehicles using regular (i.e., non-premium) gasoline), a gasoline pool comprising 75 percent regular gasoline and 25 percent premium, and 63 percent of regular grade customers switching brands, potentially resulting in commingling. Using a "simplified" analysis CARB calculated the RVP boost for each possible outcome under two scenarios (three refills with initial tank volume at the quarter tank level and 4 refills at the half tank level) and averaged the results for each scenario. CARB estimated the RVP increase of the gasoline pool by multiplying the average result by the commingling probability (63 percent) and the regular grade market share (75 percent). Average increases (above 7 psi) were 0.12 psi for the quarter tank scenario and 0.16 psi for the half tank scenario. These calculations were based on ethanol content of 10 volume percent (about 3.5 weight percent oxygen) in ethanol oxygenated gasoline. CARB determined, based on the University of California, Davis commingling model, that the boost with 5.7 volume percent ethanol content RFG (about 2.0 weight percent oxygen) would be about 80

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8 There is actually always some commingling where one of two adjacent areas has ethanol in its gasoline owing to travel across area boundaries and the resulting fuel mixing. Some of this will occur in California with or without a waiver. We considered the difference in the magnitude of this cross-border commingling between waiver and non-waiver situations to be small enough to ignore for the purposes of this analysis.

percent of the boost with 10 volume percent. [9] Consequently, CARB applied an 80 percent adjustment factor to its 10 volume percent RVP boost estimates to estimate the boost if 5.7 volume percent ethanol content oxygenated RFG were used. Resultant estimates were 0.10 psi for the quarter tank scenario and 0.13 psi for the half tank scenario.

We believe that a 0.2 psi estimate of the commingling effect (as seen in Table 1 and further explained in the Technical Support Document) is at least as likely to be the case as CARB's 0.1 psi estimate. CARB estimated the commingling effect by calculating a small number of refueling iterations under a set of assumptions that would tend to produce an RVP boost estimate at the lower end of the range of likely RVP increases (i.e., 100 percent ethanol use in premium gasoline, no grade switching, and ethanol content at 5.7 volume percent). Furthermore, EPA's analysis indicates that even with these assumptions concerning ethanol use, content and grade switching, the commingling effect is still likely to be about 0.17 psi which is closer to 0.2 psi than 0.1 psi.

In finalizing version 3 of the California RFG regulations, CARB adopted a 0.1 psi reduction in allowable RVP to compensate for the expected increase in VOC associated with commingling if a waiver were granted. If we credit CARB's 0.1 psi reduction in allowable RVP against the additional 0.2 psi equivalent increase in VOC emissions from commingling, the net increase in VOC emissions expected from a commingling effect would be 0.1 psi. If this figure is used in estimating the effect of a waiver on the VOC inventory, all but two of our modeled scenarios show overall VOC reductions with a waiver, but considerably smaller reductions than are predicted using CARB's approach (assumption of a commingling effect of 0.1 psi, with the entire effect offset by the 0.1 psi RVP reduction). See the Table 1 column labeled "VOC 0.1 psi boost"[10]

The columns for VOC emissions reflect the estimated impact of a waiver on actual VOC emissions (in tons/day), considering exhaust and evaporative emissions, including commingling and permeation, from on-road and non-road vehicles. The columns differ based on the estimates of average increase in RVP associated with commingling. For example, "VOC 0.1 psi boost" would reflect the impact of a waiver on the VOC inventory if commingling increases the average RVP by 0.2 psi, but this increase is treated as partially offset by CARB's adoption of a 0.1 psi reduction in

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9 A commingling model developed by Dr. D.M. Rocke, University of California at Davis.

10 For purposes of this decision EPA does not need to decide whether it is appropriate to offset the expected increase in emissions from commingling with the 0.1 psi RVP reduction adopted by CARB, as even if the 0.1 psi offset is applied , as discussed below, VOC reductions are too uncertain to resolve what the effect of a waiver on ozone would be.

RVP.[11] The column “VOC no boost” would reflect the impact on the VOC inventory if commingling increases RVP by 0.1 psi, and this increase is treated as fully offset by CARB’S adoption of a 0.1 psi reduction.

The impact of a waiver on the VOC inventory differs considerably depending on the estimates of commingling (comparing the VOC columns of Table 1). This highlights the importance of commingling emissions in assessing the overall VOC impact of a waiver. Using the 0.2 psi commingling effect (based on the discussion above), and crediting CARB’s 0.1 psi RVP adjustment, results in substantially less overall VOC reduction than otherwise, and we still have reasonably likely scenarios where there is a net VOC increase. Not only is commingling a quantitatively important factor in VOC emissions, it is also a component that is very sensitive to variables such as brand loyalty whose values have been only crudely estimated. As a result of this sensitivity, a plausible case can be made for commingling effects ranging all the way from 0.1 psi to 0.3 psi (see the Technical Support Document).

Our analysis indicates a waiver would likely result in a decrease in emissions of NOx, an increase in exhaust VOC, a decrease in evaporative VOC (as-blended), and an increase in CO. However, we are less confident about on-road permeation effects and off-road emissions of CO, NOx and VOC. The consistent decreases in NOx emissions shown by our analysis also indicate that there would likely also be an overall decrease in nitrogen-containing PM emissions. There is much uncertainty about the estimation of permeation and other emissions on off-road vehicles/engines as discussed in detail in the Technical Support Document. Finally, there is significant uncertainty regarding commingling effects. In summary, the impact of a waiver on VOC emissions is considerably more complex to model than the impact of a waiver on either NOx or CO emissions, and there is significant uncertainty as to the overall VOC effect of a waiver–in both the amount and the direction of the effect.

[11] This column would also reflect the impact of a waiver on the VOC inventory if commingling increases the average RVP of the gasoline by 0.1 psi and the impact is not offset.

Table 1: Waiver Impacts at Various Commingling-Related RVP Boosts

				Waiver Case Oxygen Market Shares and Oxy Levels			Emission Inventory Changes (tons/day) (On-road, off-road and all exhaust and evaporative VOC such as permeation and commingling)				
No Waiver Oxy Level	Waiver Oxy Level	Nationwide MTBE Use	Unocal Patent	% Oxyfuel	% Non-Oxyfuel	Year-round Oxygen Avg	NOx	VOC no boost[12]	VOC 0.1 psi boost[13]	VOC 0.2 psi boost[14]	CO
2.0	2.0	Reduced	Patent not avoided	35	65	1.0	-6.60	-4.02	2.54	9.23	173.13
2.7	2.7	Reduced	Patent not avoided	40	60	1.5	-7.53	-15.24	-9.15	-2.94	225.19
2.7	2.0	Reduced	Patent not avoided	35	65	1.0	-9.61	-16.23	-10.14	-3.93	274.24
2.0	2.0	Continues	Patent not avoided	50	50	1.3	-5.08	-4.10	2.46	9.15	133.18
2.7	2.7	Continues	Patent not avoided	60	40	1.9	-4.68	-9.72	-3.51	2.81	150.12
2.7	2.0	Continues	Patent not avoided	50	50	1.3	-8.21	-16.35	-10.26	-4.05	230.93
2.0	2.0	Reduced	Patent avoided	26	74	0.9	-7.20	-9.05	-2.69	3.79	197.11
2.7	2.7	Reduced	Patent avoided	46	54	1.6	-7.08	-12.12	-5.96	0.33	202.67
2.7	2.0	Reduced	Patent avoided	26	74	0.9	-10.89	-15.55	-9.44	-3.20	300.23
2.0	2.0	Continues	Patent avoided	50	50	1.3	-4.84	-8.17	-1.80	4.69	133.18
2.7	2.7	Continues	Patent avoided	65	35	2.0	-4.78	-9.35	-3.13	3.20	131.36
2.7	2.0	Continues	Patent avoided	50	50	1.3	-8.73	-14.73	-8.61	-2.36	230.93

12 This scenario is equivalent to a 0.1 psi RVP boost from commingling completely offset by California's 0.1 psi adjustment to its standards.

13 Equivalent to a 0.2 psi RVP boost from commingling offset by California's 0.1 psi adjustment to its standards resulting in a net commingling effect of 0.1 psi.

14 Equivalent to a 0.3 psi RVP boost from commingling offset by California's 0.1 psi adjustment to its standards resulting in a net commingling effect of 0.2 psi.

4. EFFECTS ON OZONE OF EMISSION CHANGES FROM A WAIVER

Given an expected reduction in NOx, an increase in CO, and significant uncertainty about the overall change in VOCs, the evidence is not clear what impact the emissions changes from a waiver would have on ozone.

All three of the pollutants discussed above influence ozone formation. The atmospheric chemistry is complex, but directionally we would expect NOx reductions to reduce ozone formation, CO increases to contribute to ozone formation, and VOC emissions to either increase or reduce ozone, depending on whether VOC emissions increase or decrease. In order to determine the direction of the overall impact on ozone from the changes in these three pollutants, we must consider the expected change in each of them and the overall balance that results from the directionally different impacts on ozone.

EPA does not believe that the evidence provided by California and developed through its own analyses clearly demonstrates what effect a waiver would have an on ozone. This is because: 1) there are three pollutants whose emission rates would be altered by a waiver, and all three affect ozone formation, 2) these pollutants are not equivalent, on a ton-for-ton basis, in their effects on ozone formation, and 3) while NOx will go down with a waiver, CO is expected to go up and VOC may go up or down resulting in an uncertain impact on ozone. (The uncertainties regarding the combined effect on ozone are more thoroughly discussed in the TSD.)

5. CONCLUSION

EPA has carefully evaluated all of the information in front of it, including information submitted by CARB, other interested parties, and developed by EPA. After considering what effect a waiver might have on the properties of California reformulated gasoline, and the effect this change in fuel properties would have on emissions from highway and off-road vehicles and equipment, EPA concludes that there has been no clear demonstration as to what effect a waiver would have on ozone. There is significant uncertainty associated with determining the expected emissions impact of a waiver, largely based on uncertainty regarding the expected impact on VOCs produced when gasoline containing ethanol is mixed with other gasolines in the marketplace. As a result, there is significant uncertainty in balancing the emissions impacts of the three different pollutants involved, each of which affect ozone, and determining their overall effect on ozone. This uncertainty has not been resolved, even using the approach suggested by CARB. Since there has been no clear demonstration of what effect a waiver would have on ozone, it is appropriate to deny California's request for a waiver.[15]

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[15] Since we are denying California's request based upon uncertainty associated with the effect of a waiver on ozone, we need not decide whether the expected reduction in NOx from a waiver and the associated reduction in PM would support a determination of interference with the PM NAAQS.