Final Report

Development of Technical Information for a Regional Fuels Strategy

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1.0 Introduction

There are a wide range of gasoline fuel volatilities in the LADCO region in the summer. The volatilities range from 6.7 RVP in the Chicago area (which includes parts of Indiana, Illinois, and Wisconsin), to almost 10 RVP in many rural counties in all five states (the limit is 9, but with a 1 psi ethanol waiver, the actual RVP can be as high as 10). The Detroit area currently requires gasoline RVP to be 7.8 or less in the summer, and this area has plans to reduce gasoline volatility to about 7.0 RVP. Other areas in the region may also study lower volatility gasoline.

There are a number of counties in the LADCO region that currently do not attain the 8-hour ozone standard, and there are varying dates for when these counties are required to attain standard. The LADCO states are studying many different emission control programs that could be implemented to reduce NOx, PM, and VOC emissions to assist in attaining both the ozone standards and the air quality standards for particulate matter (PM). Gasoline volatility control is just one of many programs being evaluated.

States do not have the authority on their own to reduce gasoline volatility and must obtain a waiver from the EPA to do so. There are specific criteria that have been developed by the EPA that states must meet in order to reduce gasoline volatility. Several states have followed these criteria and have been successful in reducing gasoline volatility lower than 7.8. Two of these areas are Atlanta, Georgia and Birmingham, Alabama.

Lowering gasoline volatility reduces evaporative volatile organic carbon (VOC) emissions from anything that either uses gasoline or is used to transport or store gasoline, including on-road vehicles, off-road equipment such as lawnmowers, portable fuel containers, gasoline dispensing facilities, and above ground gasoline storage tanks. Emission models used to estimate emissions for on-road vehicles and portable equipment include the capability to estimate emissions for different gasoline RVPs. Also, there are procedures established for estimating lower emissions for portable fuel containers and the gasoline distribution system. However, the use of ethanol blended with gasoline can also have an impact on the emissions benefits of volatility controls. Ethanol increases the volatility of gasoline when splash-blended. Because of this, some of the states in the region allow ethanol blends to have higher volatilities with ethanol than without. Even if gasoline volatility is reduced in some areas, these allowances for higher RVP may continue. Ethanol use is also increasing throughout the region. Thus, there are many factors to consider when developing emission benefits of lower volatility gasoline.

The purpose of this report is to develop technical information for a regional fuels strategy to reduce gasoline volatility. Information is needed on the current EPA policy, how other states reduced gasoline volatility, whether the LADCO modeling systems currently estimate baseline VOC emissions correctly, and whether modifications are needed in the various models to account for the effects of lower volatility gasoline, including ethanol effects. In addition, this study develops the tools necessary to properly estimate the benefits of lower volatility fuels, with any ethanol content. However, this study does not specifically estimate the benefits of lower volatility fuels in the LADCO region. This information will be developed by LADCO from the tools provided by this study.

This study is organized into the following sections:

- Background
- EPA Policy on Fuel Waivers
- Summary of Other States 7 RVP Waiver Request Submittals
- Evaluation of Baseline Fuel Properties Relative to RVP Benefits in LADCO Modeling System
- Permeation Impacts of Ethanol
- Model Changes and Method of Modeling Lower RVP
- Method of Modeling RVP Effects on Portable Containers
- Method of Modeling RVP Effects for GDFs and Storage Tanks
- Summary of Electronic Deliverables

2.0 Background

This section contains background information on the following subjects:

- 8-hour Ozone Nonattainment Counties in LADCO Region
- Factors Affecting Gasoline RVP
- Current Fuel Regulations in the LADCO Region
- RVP's Effects on Exhaust and Evaporative Emissions
- MOBILE6.2
- NONROAD and NMIM
- SEMCOG Fuel Study
- API Study of the Impact of the 8-Hour Ozone Standard on Gasoline Supply, Demand, and Production Costs

2.1 Ozone Nonattainment Counties in the LADCO Region

Ozone nonattainment counties in the LADCO region are either Moderate areas or Basic areas, and are shown in Figures 1 and 2 below. Figure 1 shows the nonattainment areas in Illinois and Wisconsin, and Figure 2 shows the nonattainment areas in Michigan, Ohio, and Indiana.

Figure 1

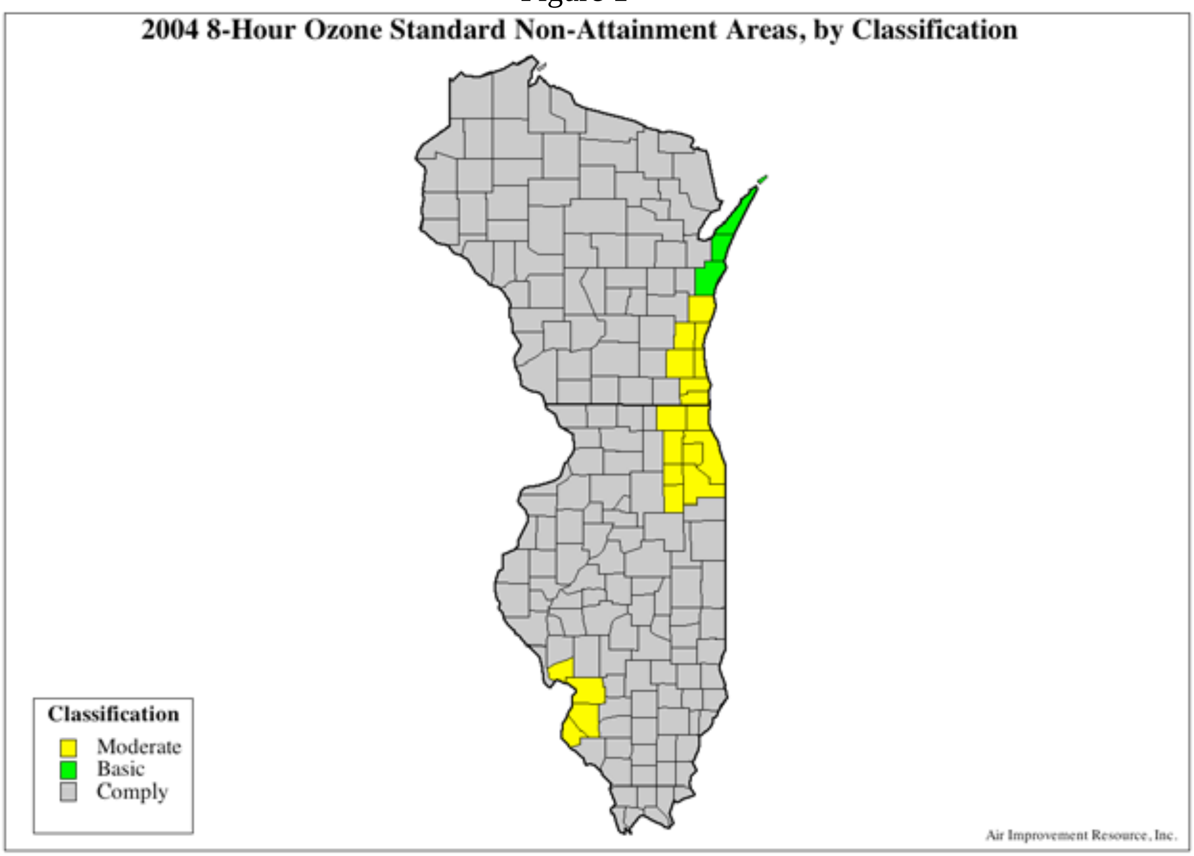
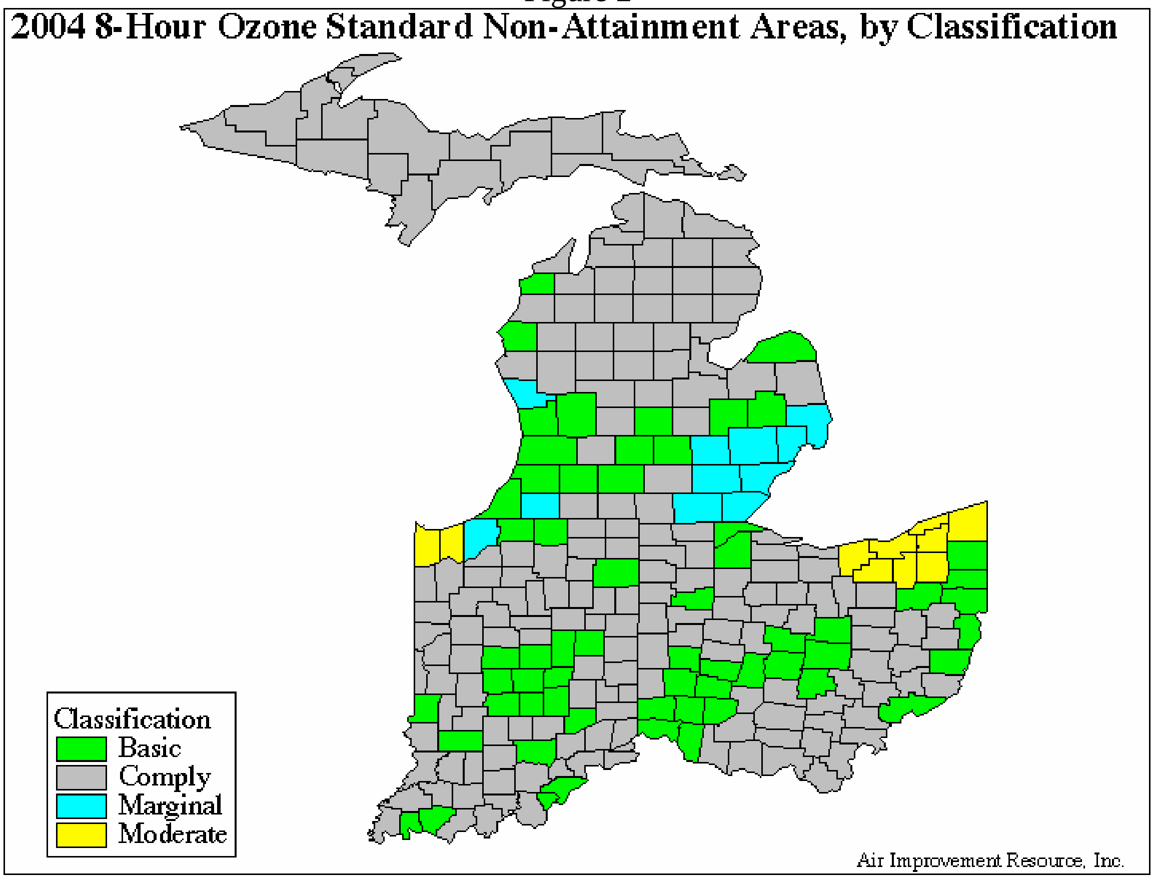


Figure 2



Illinois – Two sections of Illinois are currently moderate nonattainment areas – the Chicago region, and four counties in southwestern Illinois in the St Louis area.

Indiana – The northwestern part of Indiana is included in the Chicago metropolitan area is classified as a moderate nonattainment area. The remainder of the counties except LaPorte county are basic nonattainment areas, and this includes Indianapolis, Evansville, counties bordering Louisville, KY, and Fort Wayne. LaPorte county is a marginal area.

Ohio – The Cleveland area is a moderate nonattainment area, Cincinnati, Dayton and Columbus all form a contiguous basic area, and the Youngstown area is a basic area.

Michigan – Southeast Michigan, Muskegon, and Cass counties are marginal areas, and the remainder of the counties are basic areas.

Wisconsin – The Milwaukee/Racine area is part of the moderate nonattainment area abutting Chicago, while the northern counties are basic.

The counties shown in the previous two figures are the counties in the 5-state LADCO region where a regional fuels strategy could come into play. Currently, Southeast Michigan is moving forward to implement lower volatility gasoline. Indiana and Ohio are also pursuing low volatility gasoline rules. Other states could move forward with their own evaluations as more information becomes available.

2.2 Factors Affecting Gasoline RVP

There are five factors affecting local RVP in a county:

- Whether the area is an "RFG" area
- The RVP of the gasoline without any ethanol
- Ethanol market share
- Ethanol concentration for gasoline containing ethanol
- Whether the state has an RVP waiver for ethanol

Counties that have RFG must meet the RFG requirements, which specify an overall VOC, NOx, and toxics reduction for the gasoline. In northern areas, the gasoline volatility is typically less than 7.0 RVP. Up until the time that the Energy Policy Act of 2005 was passed (in August of 2005), every gallon of RFG was required to contain a minimum of 2.0 wt % oxygen, which, in most areas of the U.S, is now ethanol. In the Chicago area, for example, 100% of the gasoline sold contains ethanol, at about 2.7 wt %. No RVP waiver is allowed for RFG. However, under the Energy Policy Act, there is no minimum oxygen content for RFG, therefore, gasoline marketers could start marketing no-ethanol gasoline in Chicago area, as long as it meets the other RFG performance requirements. It is too early to determine what will happen in Chicago (currently the only RFG area in the LADCO region), so for this analysis, we assume the RVP in Chicago area is under 7, and 100% of the gasoline contains ethanol.

In every county except the RFG counties of the Chicago area, gasoline RVP depends on the last four factors. All of the counties without any RVP controls are still required to have 9 RVP or less under the ASTM standards. A county with no ethanol would have an RVP close to 9 RVP. A county where 100% of the gasoline contains ethanol, and with a 1 psi waiver for ethanol, however, would have an RVP closer to 10 RVP. If there were no RVP waiver for ethanol, the RVP would be back to 9. For counties with ethanol market share between 0-100%, the dispensed RVP will be between 9-10 RVP. Areas where the summer fuel RVP is limited to lower levels but also have ethanol waivers, like 7.8 in Detroit, for example, will have fuel volatilities ranging from 7.8-8.8.

Ethanol concentration also has an effect on RVP. Nearly all the non-RFG gasoline sold with ethanol is sometimes referred to as "gasohol", and contains nearly 3.4 wt% oxygen, or 10% ethanol by volume. However, if vehicle owners are not brand loyal, they will sometimes fill up with a gasohol, and other times fill up with gasoline containing no ethanol, thus, the fuel in vehicle tanks can be anywhere between 0-3.4 wt% oxygen. This fuel switching results in "commingling" of ethanol and non-ethanol blends in vehicle fuel tanks, which can result in higher a RVP than either of the fuels that were commingled.

Fortunately, as discussed later, the MOBILE model for on-road vehicles accounts for such "fuel-switching" and "commingling" effects in its calculations. The NONROAD model for off-road equipment does not, however, there is probably much less fuel switching (and therefore lower commingling) for off-road equipment than for on-road vehicles. [1]

There is a separate effect of ethanol on evaporative emissions from on-road vehicles, off-road equipment, and portable fuel containers that is not related to its RVP effects. Ethanol increases permeation VOCs through plastic fuel system components. This permeation increase for ethanol is not included in any of the existing MOBILE6 or NONROAD emissions models. The SEMCOG study (discussed in a later section) included ethanol permeation effects. Because ethanol use seems to be increasing throughout the region, LADCO requested that the modeling system be updated to include permeation effects of ethanol blends.

2.2 Current Fuel Regulations in LADCO Region

This section discusses the current fuel regulations in the LADCO region. Section 5 discusses the five fuel characteristics in the region in more detail.

Illinois – Six counties in the Chicago area – Cook, DuPage, Kane, Lake, McHenry, and Will, plus Aux Sable and Goose Lake Townships in Grundy County and Oswego Township in Kendall County − have Federal Reformulated Gasoline (RFG). The RVP of this gasoline is generally under 7.0 RVP. Several counties in southwestern Illinois – Madison, Monroe, and St. Clair − limit gasoline RVP to 7.2. In the remainder of the counties, summertime RVP is limited by ASTM standards to 9 RVP. Ethanol blends outside of the RFG areas are allowed a 1 psi RVP waiver.

Indiana – Two counties in northwestern Indiana – La Porte and Lake counties – are included in the Chicago-area RFG requirements. Two counties in southern Indiana – Clark and Floyd, have 7.8 RVP fuel. The rest of the counties in the state have an ASTM RVP limit of 9, and for all of these counties there is no RVP waiver for ethanol. The two counties with low RVP fuel (Clark and Floyd) are allowed a RVP waiver for ethanol.

Michigan – Eight counties in southeast Michigan – Livingston, Macomb, Wayne, Lenawee, Monroe, Oakland, St Clair, and Washtenaw – limit summertime RVP to 7.8. The remainder of the state has a 9 RVP limit in the summer. The Southeast Michigan Council of Governments (SEMCOG) is studying the possibility of reducing summertime RVP in southeastern Michigan to 7.0. All counties in Michigan have a 1 psi waiver for ethanol blends.

Ohio – All counties in Ohio currently have a 9 RVP summertime RVP limit. There is a 1 psi waiver throughout the state for ethanol blends.

[1] The home-owner who runs out of gas in his lawnmower and portable fuel container will probably always return to the closest fuel station, and is therefore "brand and station loyal."

Wisconsin – Seven counties in eastern Wisconsin – Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan, Washington, and Waukesha – have RFG and are part of the Chicago area RFG program. The remainder of Wisconsin has a 9 RVP limit in the summer. Outside of the RFG area, there is a 1 psi wavier for ethanol blends.

2.3 RVP's Effect on Exhaust and Evaporative Emissions

Lowering the RVP of gasoline has an effect on both exhaust and evaporative emissions from sources that use gasoline (on-road vehicles an off-road equipment). It also has an effect on the evaporative emissions of sources used to store and transport gasoline (fuel tanks of on-road vehicles and off-road equipment, portable fuel containers, and the gasoline distribution network).

Exhaust emissions from on-road vehicles and off-road equipment consist of VOC, CO, NOx, and PM. Lowering fuel volatility primarily affects VOC exhaust, and to a lesser degree CO and NOx. [1] Lowering volatility has no effect on PM directly emitted by on-road vehicles, but if exhaust VOC and evaporative VOC is lowered, secondary PM that forms in the atmosphere from VOCs may also be lower. At this time, there is not sufficient data to characterize the effects of lower volatility fuels on exhaust emissions from off-road equipment, so currently, the only effect of lower volatility for off-road equipment is on evaporative emissions.

Evaporative emissions from both on-road vehicles and off-road equipment consist of five types: diurnal emissions, hot soak emissions, running loss emissions, and permeation, or resting emissions, and refueling emissions. Diurnal emissions result from expansion of fuel vapor in the fuel tank during daily heating and cooling; hot soak emissions are the extra evaporative emissions at the end of a vehicle trip; running loss emissions are evaporative emissions that occur during engine operation; permeation emissions are emissions that are the result of migration of fuel through plastic fuel system components; and refueling emissions are the emissions that occur when a vehicle or piece of equipment is refueled, either from a station pump or (in the case of off-road equipment), from a portable fuel container. Lowering RVP will reduce diurnal, hot soak, running loss and refueling emissions, however, there is no effect on permeation emissions from an RVP change. There are also evaporative emissions due to vehicle which have fuel leaks, but generally, lowering RVP does not have a significant effect on leaking vehicle emissions, because all fuel that leaks is assumed to evaporate anyway.

Emissions from portable fuel containers consist of diurnal emissions, permeation emissions, and spillage. Lowering fuel volatility lowers the diurnal emissions, but again, does not change permeation emissions or spillage. Emissions from the above ground storage tanks are mostly diurnal emissions. Lowering fuel volatility therefore lowers these diurnal emissions.

Nearly all systems that come in contact with gasoline have some form of evaporative emissions controls to control these evaporative emissions, however, not

100% of the emissions are completely controlled, therefore a reduction in fuel volatility will reduce the evaporative emissions that are not controlled.

2.4 MOBILE6

MOBILE6.2 estimates emissions from all on-road vehicles. It also includes user inputs for the five characteristics mentioned in section 2.2 that affect local RVP, thus, the user has control over estimating the changes in emissions at different RVP levels. The one factor it does not include is the VOC permeation effects of ethanol. This was added to the model; the methods used to add this factor are discussed in Section 6.0.

2.5 NMIM and NONROAD

NMIM is the model that LADCO utilizes to run NONROAD. NONROAD estimates emissions for offroad equipment. EPA recently released an updated version of NONROAD and NMIM. [2] The primary change in this update is that EPA added significantly updated evaporative emissions for small and large spark ignited engines. EPA added hot soak, running loss, and permeation emissions for equipment with these engines. The diurnal, hot soak and running loss emissions are affected by changes in gasoline RVP.

Two items that EPA did not add to NONROAD are the permeation effects of ethanol, and the effects of RVP on hot soak and running loss emissions (RVP effects are included for diurnal emissions). The ethanol permeation item was added in this project, the discussion of this issue is addressed in Section 6.0 With regard to hot soak and running loss emissions, AIR was unable to find any data with which to adjust hot soak and running loss emissions in the NONROAD model. Therefore, this effect was not included, at least for hot soak and running loss emissions.

NONROAD does include the effects of ethanol on exhaust emissions. NONROAD contains an input for the gasoline oxygen weight percent. However, this oxygen content is not the oxygen content of the fuel containing ethanol, it is the weighted average oxygen content of fuel containing ethanol and fuel not containing ethanol. For example, in a county where 100% of the gasoline contains ethanol at 3.4 wt%, the NONROAD input would be 3.4%. But in a county where 50% of the gasoline contains ethanol at 3.4 wt %, the NONROAD input would be 1.7%. Thus, the NMIM input files for oxygen content are different than the MOBILE inputs for the same county.

2.6 SEMCOG Fuels Study

The SEMCOG fuels study evaluated the emission changes of a number of different fuels in the southeast Michigan area. [3] The fuels evaluated included California reformulated gasoline, lower sulfur gasoline, lower RVP gasoline, federal RFG, and 0% and 100% market share of ethanol. The study was the first of its kind in the LADCO region to include ethanol permeation effects for both on-road and off-road vehicles. Results of the study showed the reducing fuel RVP from 7.8 to 7.0 in the SEMCOG region would reduce VOC emissions from on-road and off-road sources by 7.4 tons per day and NOx by 0.3 tons per day. This VOC benefit was 70% of the benefit of Federal RFG, with substantially lower costs. [4]

2.7 API Study of the Impacts of the 8-Hour Ozone standard on Gasoline Supply, Demand, and Production Costs

In April of 2005, the American Petroleum Institute released a study entitled the "Potential Effects of the 8-Hour Ozone Standard on Gasoline Supply, Demand, and Production Costs", conducted by MathPro. [4] This study was designed to "identify and evaluate potential effects of the 8-hour ozone standard on operations, product supply, and costs in *normal steady-state* operation of the U.S. refining and logistics system." The analysis was comprised in three tasks:

- Task 1: Assess the capabilities of the gasoline distribution system to handle increased volumes of special gasolines that may be required
- Task 2: Project future gasoline demand and supply patterns, and
- Task 3: Estimate the average incremental refining cost and investment requirements for producing additional volumes of special gasolines

In general, MathPro found that the gasoline distribution system is capable of handling increased volumes of special gasolines and delivering these volumes to the nonattainment areas that may require them during period of normal, steady-state operations. However, MathPro also found that many existing pipeline and terminal facilities do not have the capacity to handle additional gasoline segregations, and that where this situation exists, the distribution system would be able to meet new requirements for special gasolines in given nonattainment areas, but only with some spill-over or quality give-way – that is, supply of a special gasoline requirement in a nonattainment area adjacent to or near-by areas that do not require that gasoline.

AIR examined the MathPro study for areas in the LADCO region where there would be spillover if lower volatility controls were implemented in the nonattainment areas. Our analysis of the MathPro report showed that only one county in Indiana – DeKalb County – would be a spillover county. Thus, there appears to be very little potential for spillover for special fuels in the LADCO region. In other words, if all the nonattainment counties in the LADCO region implemented more stringent fuel, only these counties plus DeKalb county would get this fuel.

The study also examined the volumes of conventional gasoline, 7.8 RVP gasoline, 7.0 RVP gasoline, and RFG if all nonattainment areas required the next level of gasoline control. For example, nonattainment areas with conventional gasoline were assumed to need 7.8 RVP gasoline, areas with 7.8 RVP gasoline were assumed to need 7.0 gasoline, and areas with 7.0 gasoline were assumed to require RFG. Areas with RFG were assumed to keep RFG (no further control in these areas). Not surprisingly, conventional gasoline decreased, with increases in low RVP gasoline and RFG. About 90% of the volume increase was in low RVP gasoline (7.8 or 7.0).

Finally, the study examined incremental costs of these special gasolines. For the LADCO region, the study estimated that 7.8 RVP gasoline would cost about 1.2 ¢/gallon more than conventional gasoline, 7.0 RVP gasoline would cost 0.6 ¢/gallon – 3.0 ¢/gallon more that 7.8 RVP gasoline, and RFG would cost 1.7¢/gallon − 6.2 ¢/gallon more than 7.0 RVP gasoline. The study's authors indicate that the cost ranges "reflect the economic effects of the source refining region, the choices of gasoline that is upgraded to the special gasoline of interest, and the volume share of 7.8 RVP, 7 RVP gasoline, or RFG in the refinery's gasoline pool."

3.0 EPA Policy on Fuel Waivers

Section 211(c)(4)(A) of the Clean Air Act (CAA) as amended in 1990 (the Act) generally preempts states from adopting controls respecting fuel characteristics or components that EPA had controlled under section 211(c)(1). However, under section 211(c)(4), EPA may approve an otherwise preempted state fuel control measure into a state implementation plan (SIP) if EPA finds the control is necessary to achieve a National Ambient Air Quality Standard (NAAQS) because no other reasonable or practicable measures exist that would bring about timely attainment.

In August, 1997, EPA published guidance on the use of opt-in to RFG and low RVP requirements in ozone SIPs. [5] There are different guidelines for opting-into Federal RFG and low volatility fuel, which are discussed below.

3.1 Opting Into Federal RFG

The Federal RFG program is authorized under section 211(k) of the CAA. EPA regulations specify content and performance requirements for cleaner reformulated gasoline, which reduces motor vehicle emissions of VOCs, NOx, CO, and toxics. Ozone nonattainment areas where the CAA does not mandate RFG may opt-into the federal RFG program under section 211(k). To opt-into RFG, the state Governor applies to the EPA, and EPA sets an effective date for the program to apply in that area, which is no later than one year from the date of application. EPA must grant the RFG opt-in to a state where the Governor requests to opt-in.

The EPA guidance indicates that "EPA supports the state opt-in to RFG as an environmentally beneficial, cost-effective, and administratively simple ozone control measure." EPA goes on to enumerate the qualities of RFG that existed in the 1997 timeframe.

There are two changes that have occurred since the 1997 guidance was issued that have had a significant effect on the relative benefits of RFG and RVP controls. The first is that EPA reduced gasoline sulfur as a part of the Tier 2/Low Sulfur gasoline rules. These rules lowered sulfur to about 30 ppm for all gasoline in the U.S. Because conventional gasoline became "cleaner", the benefits of RFG versus conventional gasoline are lower. The second is that many states have banned MTBE, the oxygenate that was prevalent in RFG in the 1997-2000 timeframe. MTBE has been largely replaced with ethanol, but ethanol is not equivalent from an emissions perspective to MTBE. In particular, ethanol can increase NOx exhaust emissions from 1988 and later vehicles, and also has been found to increase permeation VOC emissions from on-road vehicles, off-road equipment, and portable fuel containers. The use of ethanol as an oxygenate in RFG has further reduced the benefits of RFG versus conventional gasoline, or reduced RVP gasoline.

3.2 Opting Into Lower RVP Gasoline

If a state decides to pursue a state low RVP requirement rather than opt-in to federal RFG, the state must submit a SIP revision adopting the state fuel control and apply for a waiver from federal preemption. The state must include in its petition specific information showing the measure is necessary to meet the ozone NAAQS, based on the statutory requirements for showing necessity. According to the Guidance, the wavier must:

1. Identify the quantity of reductions needed to reach attainment (note that the necessity showing must be framed in terms of reductions needed for attainment of the NAAQS, and not reasonable further progress and 15% plan requirements);

2. Identify possible other control measures and the quantity of reductions each would achieve;

3. Explain in detail, with adequate factual support, which of those identified control measures are considered unreasonable or impracticable; and

4. Show that even with the implementation of all reasonable and practicable measures, the state would need additional emission reductions for timely attainment, and the state fuel measure would supply some or all of such additional reductions.

3.3 Identifying Quantity of Reductions Needed to Reach Attainment

LADCO has performed extensive ozone air quality modeling of the 5 states in LADCO region to determine if the areas that currently do not attain the 8-hour ozone standard will attain by the required dates. This modeling has generally shown that with all existing mobile source, stationary source and area source measures, that many areas may not attain by 2009. [6] More recent modeling provides information on the level of additional emission reduction needed for attainment of the ozone NAAQS (i.e., Round 3 modeling). This modeling indicates that a 25-35% reduction in local VOC emissions, combined with a 25-35% reduction in regional NOx emissions, may be sufficient to provide for attainment in the residual ozone nonattainment areas of Chicago, Milwaukee, and Cleveland.

3.4 Identify Possible Other Control Measures

LADCO has undertaken an extensive effort to identify other possible control measures. LADCO contracted with MACTEC to identify additional stationary and area source measures that could perhaps be implemented. LADCO also contracted with ENVIRON to identify additional mobile source measures that could be implemented. These two reports should be available shortly. The reports will identify possible measures, estimate the emission reductions, and discuss some of the feasibility and practicability issues of implementing these measures in the LADCO region.

3.5 Showing that Fuel Controls are Still Needed to Reach Attainment

Each state contemplating fuel controls will need to evaluate the feasibility and practicability of implementing the primary alternative measures in the MACTEC and ENVIRON reports. Comparisons will need to be made of the relative effectiveness of different measures as compared the RVP control. EPA presents the following discussion on how to determine whether other measures are unreasonable or impracticable.

“In determining whether other ozone control measures are unreasonable or impracticable, reasonableness and practicability should be determined in comparison to the low RVP measure that the state is petitioning to adopt. This is not an abstract consideration of whether the other measures are reasonable or practicable, but rather a consideration of whether it would be reasonable or practicable to require such other measures in light of the potential availability of the preempted state fuel control. Some measures may be reasonable and practicable for certain areas of the country, but given the advantages of a low RVP requirement under the specific circumstances of the particular area, the other measures may be comparatively unreasonable or impracticable. Finding another measure unreasonable or impracticable under this criteria would not necessarily imply that the measure would be unreasonable or impracticable for other areas, or even the same are under different circumstances.”

“While the basis for finding the unreasonableness or impracticability is in part comparative, the state still must provide solid reasons why the other measures are unreasonable or impracticable and demonstrate these reasons with adequate factual support. Reasons why a measure may be unreasonable or impracticable for a particular area include….the following: length of time to implement the measure; length of time to achieve ozone reduction benefits; degree of disruption entailed by the implementation; other implementation concerns such as supply issues; costs to industry, consumers and/or the state; cost-effectiveness; or reliance on commercially unavailable technology.”

3.6 Showing that Even With All Implemented Measures, RVP Control Would Provide Reductions that Would Assist the State in Coming Into Attainment

After estimating the emission reductions from all reasonable and practicable controls measures, the state must show it needs additional reductions to attain the air quality standard. This is a straightforward calculation of the estimated reductions needed for attainment, the estimated reductions including all known measures, and the estimate of the ability of RVP control to provide some or all of the difference in these two estimates. For example, if reductions of 40 tpd of VOC are needed to project attainment, and implementation of all known reasonable and practicable measures only reduces VOC by 20 tpd, and RVP control would provide an additional 15 tpd, then RVP control would be providing 75% of the remaining reductions needed for attainment.

As noted above, only two areas are projected to still be nonattainment for ozone in 2009: Lake Michigan region (Chicago and Milwaukee) and Cleveland. Chicago and Milwaukee already have RFG, so the need for a low RVP fuel is mostly relevant for

Cleveland. [2] LADCO's recent modeling indicates that a 25% reduction in local VOC emissions, cmbined with a 25% reduction in regional NOx emissions, may be sufficient to provide for attainment in Cleveland. The full set of candidate area source control measures examined by MACTEC is expected to provide no more than a 15% reduction in total VOC emissions. Analyses by LADCO indicate that 7.0 RVP fuel in Cleveland will provide an additional 4% reduction in total VOC emissions there. The Chicago/Milwaukee areas, of course, already have RFG and not need a low RVP fuel.

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[2] Other areas in the upper Midwest area also considering (and may need) a low RVP fuel, including Indianapolis, Cincinnati, Dayton, and Columbus. Although the modeling indicates that these areas are expected to come into attainment by 2009, it should be noted that the future year modeled design values are only slightly below the standard and that there is uncertainty in the modeling analysis. In developing ozone attainment demonstrations, EPA encourages states to take a "weight of evidence" approach, especially when the modeling results are close to the standard. Adopting a low RVP fuel may be considered necessary to ensure timely attainment in these other areas.

4.0 Summary of Other States & RVP Waiver Request Submittals

At least two other states have requested and received a waiver to lower gasoline RVP to 7.0 RVP in certain areas of these states. The purpose of this section is to review the waiver information for Birmingham, Alabama, and Atlanta, Georgia.

4.1 Birmingham, Alabama

On November 7, 2001, EPA approved Alabama's control of sulfur and gasoline volatility for Shelby and Jefferson counties. [7] The Low Sulfur/Low RVP regulation included a maximum sulfur content limit of 150 ppm for June 1 through September 15 for each year for both 2002 and 2003. After 2003, the sulfur control requirement was phased-out, because EPA's Tier 2/Low sulfur regulation took effect. The low RVP part of the regulation reduced gasoline RVP for the June 1-September 15 period for each year to 7.0. Ethanol blends were allowed 8.0 RVP. The low volatility requirement is still in effect.

Prior to approving Alabama's waiver, EPA evaluated Alabama's 211(c) waiver submission against the four criteria contained its 1997 guidance. [8] The following sections summarize Alabama's submission.

4.1.1 Need For Additional Reductions to Attain

Alabama performed air quality modeling that determined that additional reductions in VOC and NOx were needed in the region to attain the 1-hour ozone standard in effect at the time. In the modeling analysis for this attainment demonstration, an air quality simulation was performed to determine the change in predicted ozone concentrations resulting from implementation of the fuel program in Jefferson and Shelby counties. The modeling revealed that 71.5 tons per day (tpd) of NOx emission reductions and 7.0 tpd of VOC emission reductions were needed to achieve attainment of the 1-hour ozone NAAQS in the Birmingham area by 2003.

4.1.2 Reasonable and Practicable Alternatives Considered

The state submission indicated that Alabama considered a wide range of control options to meet the NOx and VOC reductions. Through the SIP process Alabama adopted utility NOx controls on power plants, and NOx controls on cement kilns. The NOx reductions are shown in the table below.

Table 1. Alabama NOx Reductions (tons per day, or tpd)	
Emission reductions needed for attainment	71.5 tpd
Utility NOx controls on Gorgas and Miller power plants	-68.2
NOx controls on cement kilns	-1.98
Additional NOx reduction needed to attain	1.32 tpd

For VOC control, Alabama considered lower RVP, and implementing an Inspection and Maintenance program (I/M). Stage II refueling controls were also considered, but EPA controlled refueling emissions from vehicles with its Onboard Vapor Recover rule, and mobile source modeling showed that even if Stage II controls were implemented, a low RVP program would still be needed. I/M was not seen as a practicable strategy because (1) the implementation of I/M would require modification to Alabama law, (2) full implementation of I/M could not be achieve by 2003 (the attainment year), and (3) the program would require significant funding and human resources to implement.

4.1.3 Contribution of Low Sulfur/Low RVP to Reductions

The state estimated that the low sulfur/low RVP regulation would provide 3.3 tpd of NOx reductions and all 7.0 tpd of the VOC reductions. The NOx reductions were due to lower sulfur fuel, and the VOC reductions were due to a combination of low sulfur (effect on exhaust emissions) and low RVP. EPA therefore concluded that Alabama's low sulfur low RVP fuel program would provide the needed NOx and VOC reductions for the Birmingham ozone nonattainment area, and approved the SIP with low RVP fuel.

4.2 Atlanta, Georgia

On February 22, 2002, EPA approved Georgia's SIP plan revision, establishing low-sulfur and low-RVP requirements for gasoline distributed in the 13-county Atlanta nonattainment area, and 32 surrounding attainment counties. [9,10] The controls were implemented in two phases. The first phase, effective through 2002, required that gasoline sold during June 1st to September 15 in the 13-county nonattainament area contain a maximum RVP of 7 and maximum sulfur content of 150 ppm. The second phase applied to the 13 original counties and the additional 32 attainment counties, and lowered the sulfur level to a maximum of 30 ppm and implemented both the sulfur and low RVP requirement on a year-round basis. When the state's 30 ppm requirement was aligned with EPA's low sulfur requirement, the state's sulfur requirement was terminated. The low RVP requirement, however, has no termination date.

4.2.1 Need for Additional Reductions to Attain

There is a significant amount of vehicle travel from counties surrounding Atlanta and even beyond, into the Atlanta area. The Georgia submission indicates that implementing the low sulfur/low RVP program across all of the various counties that have significant vehicle travel into the Atlanta area would help reduce ozone in three ways:

- By reducing VOC and NOx in the Atlanta nonattainment area
- By reducing VOC and NOx being transported into the Atlanta nonattainment area from attainment areas surrounding Atlanta, and
- By reducing the ozone being transported into the nonattainment area from the attainment areas

Air quality modeling indicated that the Atlanta area needed an additional 35.8 tpd of NOx and 20.8 tpd of VOC reductions.

4.2.2 Reasonable and Practicable Alternatives Considered

A number of measures were adopted by Georgia prior to 2003, including

- Industrial, commercial and residential open burning bans
- Slash burning ban
- Additional EGU controls
- New Combustion Turbine rule

In addition, Georgia considered adoption of a long list of potential control measures. These included controls on:

- Furniture and fixtures manufacturing
- Good and kindred products facilities
- Commercial printing facilities
- Chemical products facilities
- Rubber and plastics facilities
- Petroleum refining facilities
- Asphalt and coating facilities
- Air transportation facilities
- Transportation equipment facilities
- Stone, glass, and clay facilities
- Hydraulic cement facilities
- Sewage plants
- Auto refinishing operations
- Surface cleaning and preparation operations
- Solvent degreasing operations
- New residential gas heaters
- Elimination of I/M waivers and exemption (Atlanta has an I/M program)
- Transportation demand management and vehicle usage disincentives
- Railroad switcher engines
- Recreational vehicle types and pleasure craft
- Lawn and garden equipment

After analysis of these potential control measures, Georgia concluded that it was not reasonable or practicable to adopt these strategies, and EPA concurred. Specifically, Georgia concluded that the time to implement controls was unpredictable because legislative action authorizing such regulation by Georgia would be required, or the number of facilities and potential discharge points affected by these controls measures would require a tremendous increase in resources to implement and ensure compliance.

4.2.3 Contribution of Low Sulfur/Low RVP to Reductions

Georgia estimated that the combined benefit of the low sulfur/low RVP program would result in an estimated 24.2 tpd reduction in NOx emissions and 42.9 tpd of VOC. These reductions were enough to project attainment of the 1-hour ozone standard by 2003, so EPA approved Georgia's SIP with low RVP fuel. However, the Atlanta are has not yet attained the 1-hour or 8-hour ozone standards.

5.0 Evaluation of Baseline Fuel Properties Relative to RVP Benefits in LADCO Modeling System

In order to properly estimate the emission reductions associated with lower RVP gasoline in many of the counties in the LADCO region, it is important for the baseline RVPs to be correct in the on-road and off-road modeling, therefore, AIR conducted a review of fuels inputs for both the MOBILE6.2 and NONROAD/NMIM model for every county in the LADCO region. Where there were concerns with the fuel inputs, these concerns were addressed, and the input files were modified. The following summarizes some of the findings, and the items that were modified.

5.1 MOBILE6.2 and NONROAD Inputs Affecting RVP

The MOBILE6.2 inputs affecting the RVP used by the program are as follows:

- RVP of gasoline without ethanol
- Ethanol market fraction
- Ethanol concentration
- Presence (or absence) of a ethanol waiver

The NONROAD inputs affecting RVP used by the program are:

- RVP only

For MOBILE6, the program takes the input RVP, the ethanol market fraction, the ethanol concentration, and the flag for whether there is an RVP waiver, and estimates an in-use vehicle fuel tank RVP level that takes into account fuel “weathering” (the process of the fuel experiencing a gradual decline in fuel RVP as the tank is used), “commingling”, and a number of other factors.

For areas that select RFG in the MOBILE program, the program assumes that all the gasoline in an RFG area has oxygenate, and the program also assigns a default RVP. For the Chicago area, the program assumes that the RVP is 6.7 RVP. And, in the Chicago area, all of the oxygen is currently ethanol. There is no RVP waiver for RFG.

For NONROAD, the model only uses the input RVP level. If ethanol is used and the area is not an RFG area, and there is a RVP waiver for ethanol, then the input RVP must be adjusted outside of the model for the ethanol use. This means that if ethanol is used in a certain county with an RVP waiver, then the input RVPs for the MOBILE6.2 model and for NONROAD should be different, with the MOBILE6.2 model RVPs being lower than for NONROAD. For areas with RFG, or areas without an ethanol waiver (or no ethanol at all), the input RVP’s between the two models should be the same. [3]

5.2 Evaluation of Input Files

[3] These conditions also assume that the off-road gasoline has basically the same properties as gasoline used in on-road applications. None of the LADCO states had information to the contrary.

To check the factors affecting baseline RVP, AIR compared the NONROAD/NMIM and MOBILE6.2 RVPs for every county in the region. AIR also evaluated the summer RVPs assumed for both models, the ethanol market fractions, the presence and absence of waivers, and ethanol concentrations. Maps of fuel properties were prepared and forwarded to the states in two memos. [11,12] State representatives carefully reviewed these inputs, and provided feedback on a number of issues. The following points summarize our primary findings.

- In some counties, the fraction of ethanol (and other oxygenates), even for the future years, was assumed to be quite low. The states reviewed the ethanol inputs, talked to local oil companies, and revised the ethanol fractions significantly. Table 2 summarizes the changes in ethanol market fraction and concentration in the various states.

Table 2. Revised Ethanol Market Fractions and Concentrations

State	Area	Ethanol Market Fraction (%)		Ethanol Concentration (wt %)	
		Before	After	Before	After
Illinois	RFG	100%	100%	3.6%	3.6%
	Metro East	30%	90%	3.6%	3.6%
	Remainder	30%	90%	3.6%	3.6%
Indiana	RFG	30%	100%	3.6%	2.7%
	Clark and Floyd counties	30%	30%	3.6%	3.6%
	Remainder	30%	75%	3.5%	3.5%
Michigan	SEMCOG	30%	40%	3.6%	3.2%
	Remainder	6%	40%	3.4%	3.2%
Ohio	Cleveland	100%	42%	2.1%	3.6%
	Remainder	39%	42%	3.4%	3.6%
Wisconsin	RFG	100%	100%	3.6%	3.6%
	Remainder	8%	8%	3.4%	3.4%

- In examining the ethanol RVP waivers, it was found that in the LADCO region, all counties have ethanol RVP waivers with exception of (1) the RFG area, with counties in Illinois, Wisconsin, and Indiana, and (2) all other counties in Indiana except for Floyd and Clark counties in southern Indiana.

- Examination of the counties with ethanol and with an RVP waiver showed that many counties had the same input RVP for both MOBILE6 and NONROAD. To fix this, the RVP levels from MOBILE6.2 modeling, ethanol concentration, ethanol market fractions, and wavier status information were reviewed for each county, and the NMIM/NONROAD RVP levels were modified accordingly. An example of how this was done is presented below.

Example: Assume for County A that the ethanol market fraction is 75%, the wt percent of gasoline using ethanol is 3.4%, the non-oxygenated blend RVP is 9.0, and there is an RVP wavier. The MOBILE6.2 input RVP would be 9.0, with the other characteristics also being input into the model. For NONROAD, the RVP used would be 75% * 10 + 25% * 9 = 9.75, and the input oxygen concentration would be 75% * 3.4% + 25% * 0 = 2.6%.

The NMIM model actually contains fuel inputs that are used for both MOBILE6.2 and NONROAD, however, LADCO only runs NMIM for NONROAD; MOBILE6.2 is run separately. Therefore, the NMIM fuel inputs were modified assuming the MOBILE model is not being used by NMIM. Also, the MOBILE6.2 inputs were modified separately.

5.3 Counties Affected by Low RVP Fuel

As indicated in Section 2, only one county in Indiana would be a spillover county, so the counties with lower RVP are all the basic, marginal and moderate nonattainment counties that do not have RFG, and also the one spillover county in Indiana (DeKalb).

5.4 Modification of Input Files to Model 7 RVP in Nonattainment Counties

After modifications to the baseline case above, the MOBILE6.2 and NONROAD/NMIM input files were modified for all counties that would get 7 RVP if just the nonattainment counties implemented 7 RVP. For the MOBILE6 input files, the input RVP was lowered to 6.8 RVP for these counties, to account for a 0.2 psi margin that would be likely under this scenario.[4] The RFG counties were not modified, nor were any counties modified other than the one "spillover" county in Indiana. No changes were made to the MOBILE6.2 input file for ethanol concentration, market fraction, or ethanol RVP wavier status.

For NONROAD/NMIM, the RVPs of all affected counties were also lowered from the baseline. The RVP inputs for NONROAD/NMIM for 7 RVP, however, were modified so that they reflected the proper ethanol market fraction and concentration, and wavier status.

[4] The test for vapor pressure has some variability, so gasoline marketers reduce the volatility of gasoline to a little below the standard to ensure that they are in compliance.

6.0 Permeation Impacts Due to Ethanol

Recent research indicates that ethanol increases permeation VOC emissions from on-road vehicles, off-road equipment and portable fuel containers. The current MOBILE6.2 and NONROAD models do not yet include the effects of ethanol on permeation VOC. While the benefits of 7 RVP control are not affected by permeation due to ethanol, LADCO desired to include the effects of ethanol permeation in both the base case (current RVP) and control case (low RVP in nonattainment counties), so that the simulation studies would be more accurate. This section therefore discusses how both the MOBILE6.2 and NONROAD2005 models were modified to include the ethanol permeation effects.

6.1 On-road vehicles

The permeation effects of ethanol in this report utilize the methods developed in the study by AIR for the American Petroleum Institute (API). [13] The study for API was based on testing conducted by the Coordinating Research Council (CRC) [14]. Generally, the ethanol permeation impacts are a function of the ethanol permeation increase for each type of source, the temperature correction factors for this permeation increase, and the ethanol market fraction. The AIR study developed inputs for California, Atlanta, Houston, and the New York/New Jersey/Connecticut areas, but very similar techniques have been applied in the LADCO region. This is discussed in the following sections.

6.2 On-Road Gasoline Vehicles and MOBILE6.2

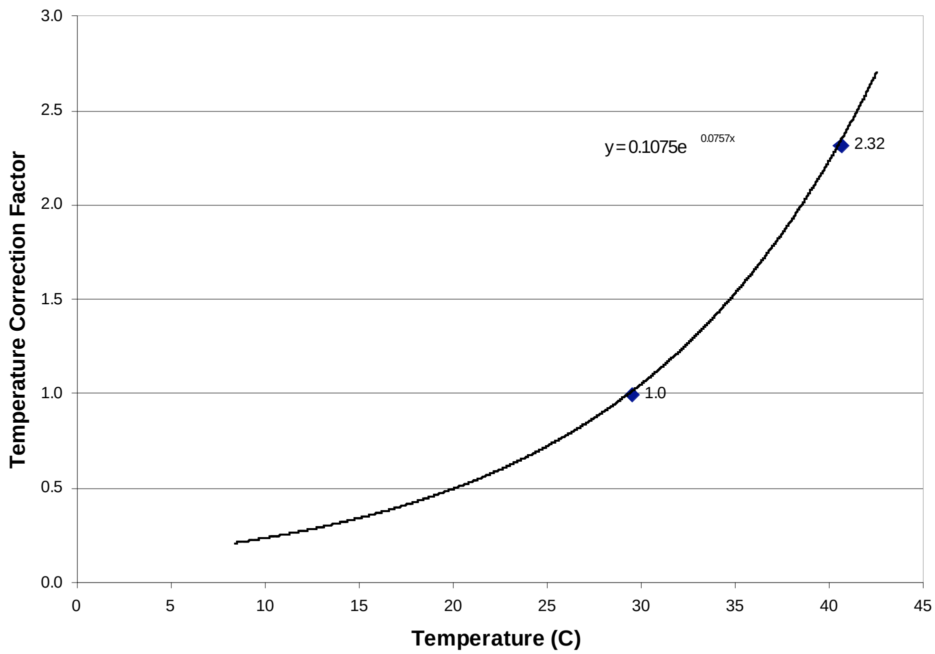
The ethanol permeation increases that were estimated in the report for API evaluated the difference in VOC evaporative emissions between a group of cars and light trucks that were tested on an ethanol blend (with 2.0 wt % oxygen), an MTBE fuel meeting California’s Phase 2 reformulated gasoline (RFG2) specifications, and a non-oxygenated gasoline meeting California’s specifications. The permeation VOC emissions of the MTBE blend were not statistically different from the non-oxygenate gasoline, so the results for these two gasolines were combined and compared to the emissions from the ethanol blend.

The testing procedure for the above permeation testing utilized a temperature profile from 65-105F. This is the testing temperature profile of the California diurnal procedure, but this profile is not typical of average minimum or maximum temperatures in either California or the Midwest, and so temperature correction factors were developed to correct from an average temperature of the testing profile (i.e., 85F) to other temperatures.

The increases in permeation emissions over a 24-hour period for various model year groups are shown in Table 3. These increases are applied to all gasoline vehicles (cars, light duty trucks, SUVs, and heavy-duty gasoline trucks) except motorcycles. Temperature correction factors for the permeation increases are shown in Figure 3.

Table 3. Permeation VOC Increases Due to Ethanol	
Model Year/Technology Group	Ethanol Permeation VOC Increase (g/day)
Pre-1991	2.03
1991-1995	0.86
Enhanced evaporative vehicles	0.80
Near zero evaporative vehicles (Tier II evap)	0.43

Figure 3. Temperature Correction Factors



The emission factors shown in Table 2, and the temperature correction factors shown in Figure 1 were input into the MOBILE6.2 model. Permeation emissions in the model are estimated with the following expression:

$$P_{etoh} = P * TCF * ETOH\ Market\ Fraction * ETOH\ Concentration/2.0$$

Where:

P_{etoh} = permeation VOC emissions added to each vehicle in g/day
P = the values in Table 3 in g/day
TCF = temperature correction factor
ETOH Market Fraction = ethanol market fraction that is input into the program
ETOH Concentration = ethanol concentration in wt%, but limited to 2.0 for all values over 2.0 wt %

Ethanol permeation increases are corrected for temperature, market fraction, and ethanol concentration. The temperature correction factors are shown in Figure 3. The permeation increase is also proportional to market share – if the market share is 100%, then all vehicles would have ethanol and all would experience an ethanol permeation increase. If the market share were 50%, then we are assuming that only ½ of the vehicle experience an increase. [5]

For concentration, the test data on which these permeation emissions are based utilized a test fuel with a 2.0 wt% ethanol concentration (typical of California fuel). We are assuming therefore that the ethanol increase is constant from 2.0 wt% to 3.4 wt %, and are assuming that less than 2.0 wt %, that the ethanol increase is proportional to ethanol concentration. The CRC is gathering additional data on ethanol permeation at concentrations above and below 2.0 wt%, but that data is not yet available.

6.3 Off-road equipment and vehicles and NONROAD2005

EPA recently released an updated version of the NONROAD model, NONROAD2005. This version completely updated the evaporative emission rates from all gasoline equipment, vehicles, and recreational vehicles. [15] AIR analyzed much of the emission rates in the model, and programmed the model for the EPA.

The new NONROAD2005 model divides evaporative emissions into the following types of evaporative emissions:

- Diurnal evaporation emissions
- Tank permeation emissions
- Hose permeation emissions
- Running losses, and
- Hot soak emissions

In NONROAD2005, diurnal emissions are from the fuel tank as temperature increases during the day. They are a function of the RVP of the fuel, tank size, the size of the vapor space of the fuel, and minimum and maximum temperatures of the day. Tank and hose permeation are the two major sources of permeation emissions on any piece of equipment or vehicle. Tank and hose permeation emissions are a function of average temperature and fuel tank and hose surface area. Running losses are the non-exhaust emissions (either permeation or fuel vapor) that are released during engine operation, and hot soak emissions are the emissions immediately following engine shut-off. Most of the running losses and hot soak emissions are assumed to be non-permeation related emissions.

Ethanol has two effects on the evaporative emissions from equipment. If the RVP increases, then diurnal emissions increase (RVP is an input to the diurnal emissions).

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[5] The actual fraction experiencing an increase would be higher than 50%, because many vehicles that normally refuel with non-ethanol blends will occasionally refuel with an ethanol blend. However, we are ignoring this as a second-order effect.

Ethanol also increases permeation emissions from non-metal fuel tanks and non-metal fuel lines.

In the study for API, we estimated ethanol increases for all off-road equipment types in g/day. Since EPA has modified the NONROAD model to include both hose and tank permeation emissions, for the NONROAD model it makes sense to develop a percent increase in permeation emissions due to ethanol, and make this percent increase a function of ethanol market share and ethanol concentration.

6.3.1 Increase in Permeation Emissions Due to Ethanol

Table 8 from the API report which shows diurnal tests on lawnmowers on both MTBE and ethanol fuel is shown in Table 4 below.

Table 4. 2nd ARB Fuel Program on Lawnmowers

Mower	MTBE (g/day)	Ethanol (g/day)	Increase (g/day)
B&S 1	2.849	2.969	0.120
B&S 2	2.578	3.374	0.796
Tecumseh 1	3.255	3.414	0.159
Tecumseh 2	3.537	3.149	-0.388
Honda 1	2.538	2.963	0.425
Honda 2	2.506	3.777	1.271
Average	2.877	3.274	0.397

The results show that, on average, emissions on the MTBE fuel are 2.88 g/day, and that on the ethanol fuel are 3.27 g/day. There was little change in RVP of the two fuels, so the majority of this difference would be due to ethanol. The percent increase in emissions is 14%.

ARB also tested a number of different fuel tanks from different types of equipment , which are summarized in Table 9 of the API study. On average, emissions from these tanks increased by 17% with ethanol fuel.

The tests on the lawnmowers in Table 4 included both fuel hoses and tanks. The second round of tests included just fuel tanks, and not fuel hoses. It would be preferable to have non-ethanol and ethanol blend permeation testing on both tanks and hoses separately, so they could be applied to the NONROAD tank and hose permeation emissions. However, this is not available, so we propose to increase both the tank and hose permeation emissions by 15% for ethanol blends.

The general expression used to account for ethanol blends in the NONROAD model is shown below:

For NONROAD input oxygen contents of 2.0% and higher:

$$P_{\text{tank, hose; ETOH}} = P_{\text{tank, hose}} * (1 + 0.15)$$

For NONROAD input oxygen contents of less than 2.0%

$$P_{tank,\ hose;\ ETOH} = P_{tank,\ hose} * (1 + 0.15 * wt\%/2.0)$$

Where:

$P_{tank,\ hose;\ ETOH}$ = permeation of tank and hose with ethanol
$P_{tank,\ hose}$ = permeation of tank and hose without ethanol
0.15 = ethanol permeation correction factor
wt % ethanol = input wt % ethanol into the NONROAD model, limited to no more than 2.0 %

The NONROAD wt% oxygen input is used to account for both the market share and the concentration of ethanol in gasoline containing ethanol.

Example #1: ethanol market fraction of 100%, concentration of 2.7%

Multiplier is 1+ 0.15 * 2/2 = 1.15 or a 15 % increase

Example #2: ethanol market fraction of 60%, concentration of 1.5%

In this case, the input concentration into the NONROAD model is 0.6* 1.5% = 0.9%

Multiplier is 1 + 0.15 * 0.9/2 = 1.067, or a 6.7% increase

The NONROAD2005 model provided to LADCO has been modified to include these ethanol permeation effects for off-road equipment and off-road vehicles. Only equipment with non-metal fuel tanks and non-metal fuel lines have been adjusted, equipment with metal tanks and metal fuel lines are assumed to have the permeation emissions as gasoline (zero).

7.0 Method of Modeling Ethanol and RVP Effects on Portable Containers

7.1 Ethanol Effects

The method of estimating evaporative emissions from portable containers was discussed in a White Paper by MACTEC. [16] The summary of the 2002 inventory for the MPRO for all areas (attainment and nonattainment) is shown in Table 5.

Table 5. Summary of 2002 PFC Inventory (tons per year)

SCC	Category Description	Total Emissions
25-01-011-010	Res. Transport Spillage	2,025
25-01-011-011	Res. Permeation	4,079
25-01-011-012	Res. Diurnal Evaporation	33,580
25-01-011-015	Res. Equipment Refueling Spillage	3,867
25-01-011-016	Res. Equipment Refueling Displacement	1,289
	Subtotal Residential	44,941
25-01-012-010	Comm. Transport Spillage	1,581
25-01-012-011	Comm. Permeation	255
25-01-012-012	Comm. Diurnal Evaporation	3,961
25-01-012-015	Comm. Equipment Refueling Spillage	252
25-01-012-016	Comm. Equipment Refueling Displacement	80
	Subtotal Commercial	6,129
	Total, Res. And Comm.	50,970

Nearly 74% of the emissions from portable containers are attributed to the diurnal evaporative emissions, and about 9% is due to permeation.

To estimate the increase in emissions on ethanol, AIR evaluated ARB data on plastic fuel tanks in the API report. These data are shown in Attachment 1. The results on a variety of different sizes of fuel tanks showed that with ethanol, permeation emissions increased by 39% with ethanol. All of the containers were tested with 2.0 wt % ethanol fuel.

The increase in permeation emissions due to ethanol fuels for PFCs is estimated with the following expression:

$$P_{total} = P_{non\text{-}ethanol} * [1 + (\text{Minimum (ETOH wt \%, 2)/2} * \text{ETOH market fraction} * 0.39]$$

Where:

P_{total} = total permeation emissions
$P_{non\text{-}ethanol}$ = current permeation emissions without ethanol correction
Minimum (ETOH wt%, 2) = the minimum of either the existing ETOH wt % or 2%
ETOH market fraction = ethanol market fraction (same as MOBILE input)
0.39 = 39 % increase in emissions

The Minimum (ETOH wt %, 2) term is designed to cap the ethanol increase at 39% for ethanol wt% of 2.0 and above, since the test data is based on 2.0 wt % ethanol. With ethanol concentrations less than 2.0 wt % ETOH, the percent increase in emissions is scaled down. It is also scaled down by the ETOH market fraction.

Example #1: Suppose a county has a 50% market share of ethanol at an ethanol weight fraction of 1.8%. The ethanol permeation multiplier for portable containers would then be:

1 + (1.8/2) * 0.5 * 0.39 = 1.176, or the increase in permeation emissions is 17.6%

Example #2: Suppose a county has a 80% market share of ethanol at an ethanol weight fraction of 3.4% The ethanol permeation multiplier for portable containers would then be:

1+ (2/2) * 0.8 * 0.39 = 1.31, or the increase in permeation emissions is 31%

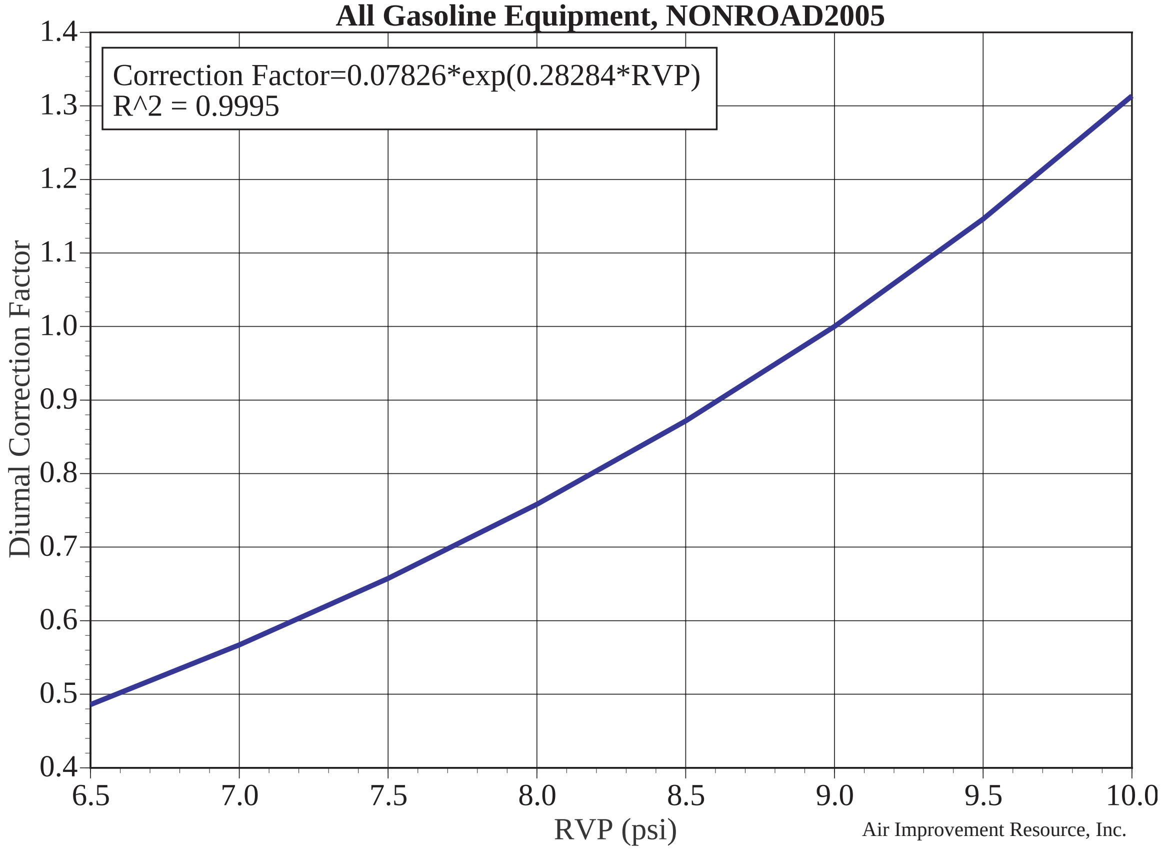
In Example 2, even though the ethanol weight percent is 3.4 wt %, the increase in permeation emissions is limited to the test data, which was tested with 2.0 wt % ethanol.

AIR has provided a set of adjustment factors by county to increase the permeation emissions from portable fuel containers for ethanol effects. These adjustment factors are found in the spreadsheet “Control Factors.xls.” These adjustment factors should be used to adjust the permeation emission SCC codes in Table 5 (25-01-011-011 and 25-01-012-011). Emissions of all counties are adjusted if the ethanol fractions are greater than zero (i.e., not just nonattainment counties)

7.2 RVP Effects

A change in gasoline RVP would be expected to change the diurnal evaporation emissions from PFCs. We are assuming that the diurnal emissions are based on current RVP levels, adjusted for ethanol effects, and have not reviewed all of the methods used to estimate these. To estimate the RVP effects, this analysis ran the NONROAD2005 model in the summer months for the state of Michigan (any of the states could have been used with approximately the same result) at variety of input fuel RVPs to evaluate diurnal evaporative emissions from off-road equipment and vehicles. The change in emissions versus RVP for portable containers should be approximately the same as the change in diurnal evaporative emissions from equipment. The result is shown in Figure 4.

Figure 4
Diurnal Correction Factor versus RVP
All Gasoline Equipment, NONROAD2005



The correction factors shown in Figure 4 are normalized to 9 RVP, and can be used to estimate a correction factor between any two RVPs.

Example: Estimate the net correction factor for diurnal emissions between 9.8 RVP and 7 RVP. The net correction factor is $CF_{9.8}/CF_{7.0}$.

$CF_{9.8}$ = 1.25
$CF_{7.0}$ = 0.56
$CF_{9.8}/CF_{7.0}$ = 0.448

Thus, diurnal emissions from portable fuel containers at 7.0 RVP are 55.2% less than at 9.8 RVP. The adjustments only apply in the summer, however, that is when volatility controls would be in effect.

The curve in Figure 4 was used to estimate diurnal control factors for 7 RVP for portable fuel containers for each nonattainment (or spillover) county in the region. These control factors take into account the baseline RVP in each county. The control factors are found in the “Control Factors.xls” spreadsheet, and should be applied only in nonattainment counties to the two SCC codes for diurnal emissions for portable fuel containers (25-01-011-012 and 25-01-012-012).

8.0 Method of Modeling RVP Effects on Other Area Sources

The other major source that would have lower emissions under a regional 7 RVP rule would be emissions from gasoline dispensing facilities, or GDFs (gas stations), and from storage tanks, which are either “fixed roof” tanks or “floating roof” tanks. Emissions from GDFs were discussed in a White Paper by MATCO. [17] This paper determined emission reductions that could be obtained with additional Stage I and Stage II controls in the LADCO region. The emission reductions for GDFs are discussed in Section 8.1 and 8.2, and for tanks are discussed in section 8.3.

8.1 Baseline Emissions for GDFs

Emissions associated with gasoline dispensing facilities are Stage I emissions, Stage II emissions, and tank breathing losses. These are described briefly below.

Stage I Emissions – these are emissions from the underground storage tanks when they are refilled with gasoline. The incoming gasoline displaces the gasoline vapor in the tank. EPA requires these emissions to be controlled by recycling the vapor back into the tank truck, but the control effectiveness is not 100%.

Stage II Emissions – these are the emissions at the pump when vehicles are refilled. The emissions come from the vehicle’s fuel tank. All modern vehicles are equipped with onboard vapor recovery systems or ORVR (phase-in of these requirements started in 1998), but older vehicles do not have these systems. The Stage II emissions should continue to decline, but there will always be some Stage II emissions from vehicles without ORVR or from vehicles with malfunctioning ORVR systems.

Breathing Losses – When vehicles are refueled, makeup air enters the UST from pipes above the ground, and this air mixes with the gasoline vapor in the UST, causing a small amount of UST breathing losses each time a vehicle is refueled.

The White Paper evaluated various ways to reduce all three sources of emissions from gasoline dispensing facilities. Some of these measures may be adopted by the states, however, the use of 7 RVP in nonattainment areas would significantly reduce these emissions, whether these controls are adopted or not.

Stage I emissions, Stage II emissions, and breathing losses from underground storage tanks (USTs) from the White Paper are shown in Table 6.

Table 6. 2002 VOC Emissions from Gasoline Dispensing Facilities in the LADCO Region (tons per year)				
LADCOArea	Stage I	Stage II	UST Breathing Losses	Total
Nonattainment areas	16,051	23,213	3,904	43,168
Adjacent to nonattainment areas	14,455	10,161	3,644	28,260
Not Adjacent to nonattainment areas	11,784	11,441	2,646	25,871
Total	42,290	44,815	10,194	97,299

SCCs for gasoline dispensing facilities in the LADCO region include:

2501060050 Stage I Total
2501060051 Stage I Submerged Fill
2501060052 Stage I Splash Fill
2501060053 Stage I Balanced Submerged Fill
2501060100 Stage II Total
2501060101 Stage II Uncontrolled
2501060102 Stage II Controlled
2501060103 Stage II Spillage
2501060201 Underground Storage Tank Breathing and Emptying

We are assuming that lower RVP would reduce Stage I Total emissions (regardless of the method by which the UST is filled) Stage II emissions, and UST breathing losses. However, Stage II emissions are estimated with MOBILE6.2, and the effects of RVP control are also readily estimated with MOBILE6.2. Storage tank breathing and emptying loss adjustments are discussed in sections 8.3 and 8.4.

8.2 Effects of Lower RVP Fuel for GDFs

Equations used to estimate loading losses from a gasoline tank truck in AP-42 can be used to develop a relationship between emissions and gasoline RVP. [18] Loading losses for an uncontrolled underground tank are given by the following equation:

$$L_l = 12.46 * [SPM/T]$$

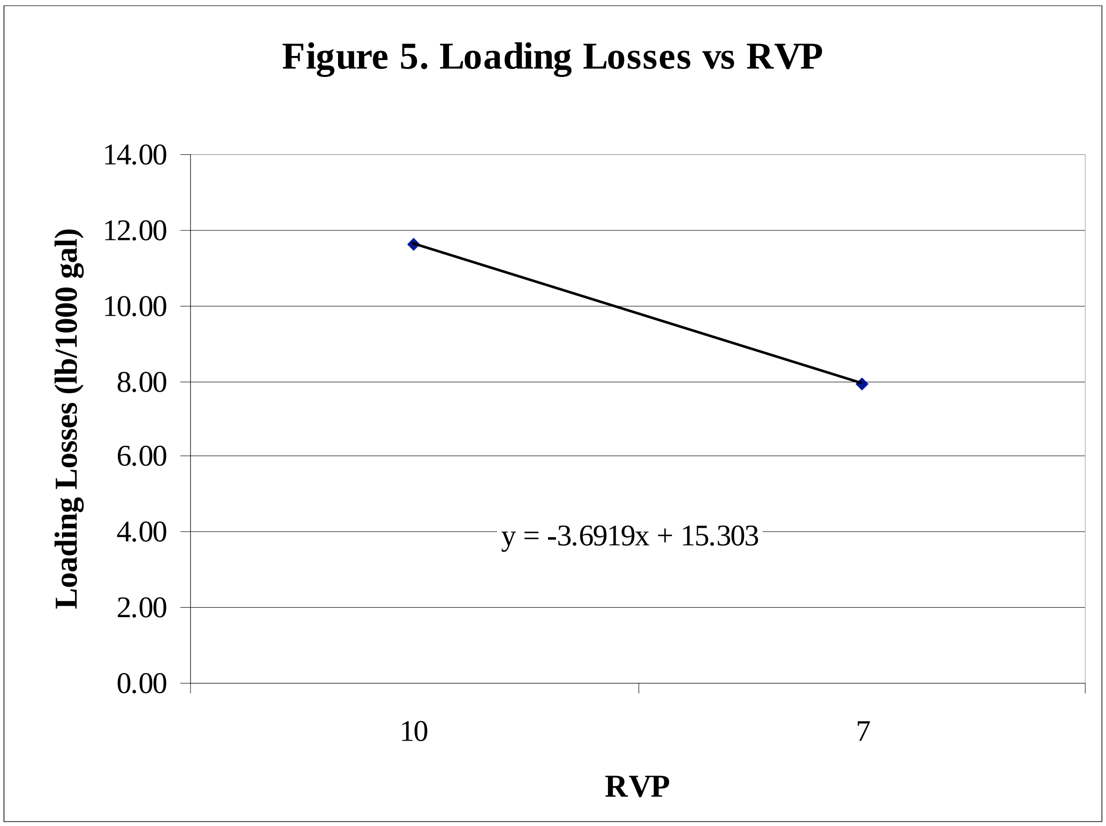
Where:

L_l = loading losses, in lb/1000 gallons
S = saturation factor = 1.0
P= true vapor pressure (psi)
M = molecular weight of gasoline vapors
T = temperature (R)

The equation above shows that loading losses are directly proportional to the vapor pressure. The table below provides the true vapor pressure and molecular weight of vapors for two different gasoline RVPs. These values are for a temperature of 80F, or 540R.

Table 7. Vapor Pressure and Molecular Weight for Two Gasolines		
RVP	True Vapor Pressure (psi)	Molecular Weight (lb/lb-mole)
7	5.2	68
10	7.4	66

The loading losses are estimated using these data, and are plotted in Figure 5.



The equation in Figure 5 was used, along with the base RVPs in all of the nonattainment counties, to estimate a set of control factors to reduce the Stage I emissions from the baseline RVP for each county to 7 RVP. These control factors are in the "Control Factor.xls" file provided to LADCO. Numerically, the control factors for GDFs are very similar to the control factors for diurnal emissions for portable fuel containers.

8.3 Above Ground Storage Tanks

There are two types of above ground storage tanks for petroleum and petroleum products – fixed roof tanks, and floating roof tanks. Methods for estimating emissions from both types of tanks are discussed in AP-42. [19] Effects of accounting for the effects of lower RVP are discussed in the next two sections.

8.3.1 Fixed Roof Tanks

Emissions from fixed roof tanks are estimated with the following two equations:

$$L_T = L_s + L_w$$

Where

L_T = total losses
L_s = storage losses
L_w = working losses

In AP42, EPA does not describe how the working losses are estimated, but they do describe how storage losses are estimated. Storage losses are directly proportional to the vapor density, which is proportional to the true vapor pressure, or P_{va}. The equation for P_{va} is

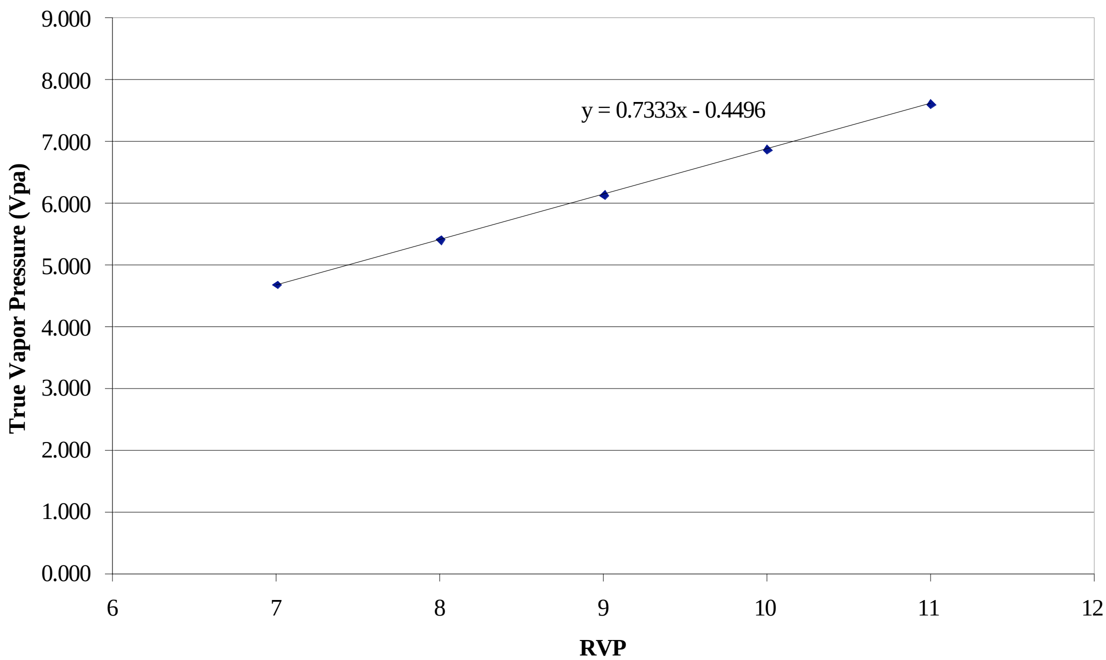
$$P_{va} = \exp\left[A - B/T_{LA}\right]$$

Where

A and B vary with RVP, and
T_{LA} = daily average liquid surface temperature, ºR

The constants A and B are provided in the AP42 documentation for refined petroleum products. AIR developed the relationship between RVP and true vapor pressure in Figure 6 from the above expression and the A and B constants. Since emissions from storage tanks are proportional to true vapor pressure, a set of control factors was developed from the relationship in Figure 6, and the starting and ending RVP levels in each of the counties. These control factors are provided in the spreadsheet "Control Factors.xls." Generally, these control factors have somewhat less effect on emissions on a percentage basis from gasoline storage tanks than the control factors developed for portable fuel containers and gasoline dispensing facilities. This could be because of the difference in basic emission control levels between the different sources. The control factors should only be applied to SCC codes for tanks storing gasoline (LADCO is currently investigating which SCC codes these are from the list provided to AIR).

Figure 6. True Vapor Presssure vs RVP



8.3.2 Floating Roof Tanks

Emissions from floating roof tanks are the sum of rim seal losses, withdrawl losses, deck fitting losses, and deck seam losses. Rim seal losses, deck fitting losses, and deck seam losses are all proportional to vapor pressure, but withdrawl losses are not. For the LADCO area, we are not sure what proportion of the emissions from floating roof tanks are withdrawl losses versus the other three types of losses. However, we are assuming that the other three types of losses are the majority of emissions, and so we estimate the reductions from floating roof tanks are the same as for fixed roof tanks.

8.4 Geographical Areas

This study is estimating the effects of lower RVP only in nonattainment areas, therefore, only storage tanks located in nonattainment areas should have lower emissions with 7 RVP fuel.

9.0 Summary of Electronic Deliverables

This section summarizes the deliverables under this contract. Many of these are required to model nonattainment area emissions at varying fuel RVPs.

1. Revised baseline MOBILE6 input files (provided in December, 2005)

The MOBILE6 input files were revised where necessary for ethanol market fractions, concentrations, RVP levels, and wavier status.

2. Revised NMIM input files (provided in December, 2005)

The NMIM input files for NONROAD were modified where necessary for input RVPs and ethanol concentrations.

3. Updated NONOAD model (provided in January, 2006)

The NONROAD model was modified to include the effects of ethanol on permeation emissions from hoses and fuel tanks. There are no changes in either input or output requirements.

4. Updated MOBILE6.2 model (provided in January, 2006)

The MOBILE6.2 model was modified to include the effects of ethanol on permeation emissions from on-road vehicles. There are no changes in either input or output requirements.

5. Revised MOBILE6 input files for 7 RVP (provided in January, 2006)

The MOBILE6.2 baseline files were revised to account for the effects of 7 RVP control in May through September for just the 8-hour nonattainment counties. The assumed RVP level for 7 RVP is 6.8.

6. Revised NMIM input files for 7 RVP (provided in January, 2006)

The NMIM baseline files were revised to account for the effects of 7 RVP control in May through September for just the 8-hour nonattainment counties. The assumed RVP level for 7 RVP is 6.8.

7. Control factor spreadsheet (provided in January, 2006)

The control factor spreadsheet contains four items:

a. ethanol adjustment factors for portable fuel containers for **all** counties
b. RVP control factors for diurnal emissions from portable fuel containers
c. RVP control factors for Gasoline Dispensing Facilities (Stage I only)

d. RVP control factors for gasoline storage tanks

The control factors in b-d should only be applied to SCC codes in the nonattainment counties.

8. In addition to this report, two memos were supplied that described our evaluation of the MOBILE6.2 and NMIM input files related to ethanol and RVP (see references 11 and 12).

References

1. “MOBILE6 Sensitivity Analysis”, EPA420-R-02-035, December, 2005.

2. “Frequently Asked Questions About NONROAD2005”, EPA420-F-05-058, December 2005.

3. “Emission Reductions from Changes to Gasoline and Diesel Specifications and Diesel Engine Retrofits in the Southeast Michigan Area”, by AIR for SEMCOG, The Alliance, and API, February 23, 2005.

4. “Potential Effects of the 8-Hour Ozone Standard on Gasoline Supply, Demand, and Production Costs”, MathPro Inc. and Stillwater Associates for the American Petroleum Institute, April 15, 2005.

5. “Guidance on Use of Opt-In to RFG and Low RVP Requirements in Ozone SIPs”, U. S. EPA, Office of Mobile Sources, August 1997.

6. “Round 2 Strategy Modeling” LADCO, July 12, 2005.

7. FR Volume 66, No 216, November 7, 2001, “Approval and Promulgation of Air Quality Implementation Plans (SIP); Alabama; Control of Gasoline Sulfur and Volatility”

8. “Technical Support Document, Birmingham Fuel Strategy and Waiver Request”, U.S. EPA.

9. FR for Georgia (will obtain for final report)

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10. Technical Support Document, “Atlanta Fuel Strategy and Waiver Request”, U.S. EPA.

11. Memo from Tom Darlington to Michael Koerber, “LADCO MOBILE6 Fuels Inputs”, August 19, 2005.

12. Memo from Tom Darlington to Michael Koerber, “Differences in RVP and Ethanol Inputs Between MOBILE6 and NONROAD”, November 2, 2005.

13. “Effects of Gasoline Ethanol Blends on Permeation Emissions Contribution to VOC Inventory From On-Road and Off-Road Sources”, AIR, Inc. for API, October 26, 2004.

14. “Fuel Permeation From Automotive Systems,” Final Report, Harold Haskew and Associates, and ATL, CRC Project E-65, September 2004.

15. “Nonroad Evaporative Emission Rates”, EPA420-R-05-020, December 2005.

16. "Interim White Paper-Midwest RPO Candidate Control Measures, Source Category: Portable Fuel Containers", MACTEC for LADCO, February 9, 2005.

17. "Interim White Paper-Midwest RPO Candidate Control Measures, Source Category: Gasoline Distribution Facilities", MACTEC, for LADCO April 8, 2005.

18. Chapter 5, Transportation and Marketing of Petroleum Liquids, AP-42, 5th Edition, Volume 1.

19. Chapter 7, Liquid Storage Tanks, AP-42, 5th Edition, Volume 1.

Attachment 1

Permeation Data on Portable Containers

ARB Permeation Testing of Portable Fuel Containers						
Fuel	Number	Mfg	Vol	ID	Loss (g/gal/day)	g/day
Ethanol	1	Wedco	6.6	EC.6W1	1.44	9.50
	2	Wedco	6.6	ERC6W1	1.77	11.68
	3	Wedco	5	ERCW3	2.17	10.85
	4	B&S	2.5	ECSF1	1.27	3.18
	5	Blitz	2.06	ECB1	2.29	4.72
	6	Blitz	2.06	ECB2	2.52	5.19
	7	Vemco	1.25	ECV1	3.44	4.30
	8	Wedco	1	ECV2	3.34	3.34
CERT	1	Wedco	6.6	C6W1	1.09	7.19
	2	Wedco	5	CW1	1.39	6.95
	3	Wedco	5	CW2	1.46	7.30
	4	Wedco	5	CW3	1.41	7.05
	5	Wedco	5	CW4	1.47	7.35
	6	B&S	2.5	CSF1	1.46	3.65
	7	B&S	2.5	CSF2	1.09	2.73
	8	Blitz	2.06	CB1	1.88	3.87
	9	Blitz	2.06	CB2	1.95	4.02
	10	Blitz	2.06	CB3	1.91	3.93
	11	Blitz	2.06	CB4	1.78	3.67
	12	Vemco	1.25	CV1	1.51	1.89
	13	Vemco	1.25	CV2	1.52	1.90
Average, Ethanol			3.38		2.28	6.59
Standard Deviation					0.8	3.49
Average, CERT			3.26		1.53	4.73
Standard Deviation					0.28	2.12
Ethanol Percent Amount Higher					49%	39%
Ethanol Amount Higher (g/day)						1.86

Source: Reference 13.