

**THE CURRENT FUEL ETHANOL INDUSTRY
TRANSPORTATION, MARKETING, DISTRIBUTION,
AND TECHNICAL CONSIDERATIONS**

Downstream Alternatives Inc.

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EXECUTIVE SUMMARY

This study is an assessment of the current practices used to market, transport, and distribute ethanol and gasoline ethanol blends in the United States. Additionally major technical considerations are discussed. Information on developing and potential uses for ethanol as a transportation fuel such as E-85 and Oxydiesel are also discussed as are the petroleum industry's attitudes and views toward ethanol use and production.

This report represents completion of the second task of a multiple task project which will culminate in a detailed analysis of transportation, marketing, and distribution costs and issues that would be associated with expanding the ethanol industry.

Petroleum Industry Views on Ethanol

The development of the industry to date has been driven largely by agricultural interests. At one point, Ashland Petroleum (now part of Marathon/Ashland) and Texaco Inc. were joint partners in ethanol production facilities. Today, however, the only petroleum industry company with any significant involvement in ethanol production is Williams Energy which owns two ethanol plants. Since the petroleum industry is not directly involved in the ethanol industry, there is little incentive for refiners to promote its use. Obviously more rapid growth could occur if the petroleum industry was more involved in ethanol production because they control the distribution of transportation fuels in the United States.

In assuming ethanol's potential for expansion, whether for MTBE replacement or other fuel uses, it is important to understand how the refining industry views ethanol. The petroleum industry views ethanol in more of its traditional role as an octane enhancer. They would like to have the option of using ethanol but not be required to do so. One of the primary concerns about mandated use of ethanol, or any other product, is that it limits refinery flexibility thereby impacting the return on investment for various processing equipment. There are also other areas of consideration. Such considerations may be different for net buyers and net sellers of crude and/or refined products. Another concern about

mandated use of ethanol is the potential need to reject product streams to achieve the lower volatility required to accommodate the use of ethanol in volatility controlled RFG.

Other concerns include the supply and availability of ethanol, which by petroleum industry standards is rather limited. Further, both supply and pricing has, in the past, been impacted by high corn prices resulting from drought.

The petroleum industry is also concerned about the fungibility issue and the inability to treat ethanol and/or gasoline ethanol blends like any other petroleum product in the pipeline system or terminal. They are somewhat reluctant to make investments to accommodate ethanol use, not only at the refinery, but also for terminal equipment necessary to store and blend ethanol. The concern here is, that while such investments may not be significant on a per gallon basis, if the motor fuel excise tax credit for gasoline ethanol blends is not extended or prematurely repealed, such expenses could become stranded investments if no other profitable use was identified.

One element of this work was to examine under what circumstances or conditions (exclusive of mandates or regulatory compliance) refiners might consider participation in the ethanol industry as part of an overall energy strategy. The simple answer is somewhat obvious. Ethanol would need to provide profitability equal to or greater than that realized from other production/processing operations. However there are several nuances as to how such profitability would be interpreted. These include the following:

- Ethanol would need to be cost competitive with other gasoline components (without tax incentives) on a long term basis.
- Product supply would need to be much greater than it currently is.
- The profitability of using ethanol would need to reflect any special handling considerations at all levels of operation (i.e. refinery, pipeline, terminal and retail).

- The profitability of ethanol would need to reflect the cost of any refinery modifications necessary to accommodate its use and the economics of any product streams rejected or downgraded. It would also need to reflect the economics from the loss of any crude oil throughput.
- Participation by exchange partners would need to be favorably addressed.

Some refiners noted that the trend today is not to think of the industry as the petroleum industry but rather as the energy industry. They believe that if return on investment (ROI) for ethanol plants exceeds that of petroleum processing facilities, and if demand warranted, that some companies would consider investing in ethanol production facilities. Again, however, they indicated that ROI performance projections would not include tax incentives that are subject to possible premature cancellation. Some also believe that if ethanol were produced by the refining industry from a more abundant supply source than corn (e.g. biomass) that this could address concerns about supply limitations and price stability.

Industry contacts indicated that decisions such as plant investment would involve input and review by not only senior management but also by investment committees, project study groups, and various corporate personnel, all of whom have various opinions about ethanol. Such a cumulative effort is necessary to determine the suitability of such investments as well as planned integration into overall operations. This would include not only whether such investments would prove profitable but also whether or not they would impact the profitability of other investments or production processes.

Ethanol Production

There are currently over fifty operating ethanol plants in the United States. They are geographically dispersed in twenty states although the majority of production still occurs in the Midwest and north-central states of Indiana, Illinois, Iowa, Minnesota, and Nebraska. Total U.S. ethanol nameplate production capacity is 1.855 billion gallons per year (121 mbd). A total of 1.67 mmgy (109 mbd) or 90.2% is based in these five states.

There are five plants currently under construction totaling an additional 1.34 mmgy of production capacity (8.7 mbd). These plants are scheduled to come on line in 2000 and 2001.

Proposed ethanol plants under consideration equate to an additional 1 billion gallons of annual production (65.8 mbd). Of course there are a number of uncertainties in developing these plants and it is not currently possible to determine which of these plants will be built.

In 1999, total fuel ethanol production was 1.47 mm gallons (95.9 mbd) and in January and February 2000 the industry operated at record production levels of 107 mbd and 108 mbd respectively.

Ethanol Transportation/Distribution

While ethanol continues to be shipped to its destination market by barge/ship, rail, and truck, the volume shipped by each mode has changed dramatically. Industry estimates for the percentage of volume shipped by each mode are:

- 30-35% Barge (or barge/ship combination)
- 30-35% Rail
- 30-35% Truck

The current volumes shipped by the above modes reflect several developments that have occurred in recent years. These developments include greater use of ethanol by major petroleum refiners in reformulated gasoline programs in Chicago and Milwaukee and greater use of ethanol in oxygenated fuel programs, as well as larger market shares of gasoline ethanol blends in some traditional markets. This results in larger volume shipments over greater distances which favors transporting ethanol by barge and rail.

Among existing ethanol plants, five are located on navigable waters enabling them to ship via barge. Two additional plants have initiated programs to transport their product overland to navigable waters. Collectively these plants can ship 928 mmgy by barge, or 50% of industry capacity.

Most of the remaining plants ship by a combination of rail and transport truck although some of the smaller plants (i.e. under 20 mmgy) ship exclusively by transport truck.

These shipping capabilities enable the ethanol industry to access any market in the contiguous forty-eight states in a reasonably efficient manner. In the case of waterborne shipments to coastal

markets it is necessary to first barge the product to the Gulf Coast, usually New Orleans, LA, where it is staged for shipment to the east coast by ocean going barge or the west coast by ship via the Panama Canal. Transportation costs can be as low as a few cents per gallon in markets close to the plants or as much as 14-15 cents per gallon in the case of shipping from the Midwest to the west coast.

A recent development that will further affect the product transportation mode of ethanol is product exchanges. While product exchanges are routine in the petroleum industry, they have been rare among ethanol plants. This is because in the early developmental years ethanol was largely produced by a number of Midwestern based plants selling in Midwestern states. Consequently, there was little advantage to pursuing product exchanges.

Now, however, more distant markets are involved, as is the method of transportation. Companies with plants that have water access have been discussing product exchanges with landlocked plants. The goal here is that landlocked production could be exchanged for water accessible production. This would enable landlocked producers to access markets that are serviced more effectively by waterborne cargo. It would also give water accessible plants the ability to ship more product by barge while continuing to service Midwestern customers with the exchange product they receive from landlocked plants. These exchanges would contribute to greater transportation efficiencies and lower overall distribution costs.

Pipeline Shipments of Ethanol/Gasoline Ethanol Blends

Of course, the cheapest mode of transportation to many markets would be via pipeline. Unfortunately ethanol and gasoline ethanol blends are not currently shipped by pipeline due to a number of technical and operational difficulties. Prime among these is ethanol's sensitivity to water. The U.S. pipeline system is a "wet system" with moisture resulting from the transport of various products. Unless programs are undertaken to remove moisture from the system, ethanol could absorb this moisture and arrive at its destination off specification due to high water content levels. Additionally most pipeline segments would need to undergo some type of preparatory cleaning to remove built up lacquers, gums, and deposits in the system. If not, the solvency effect of ethanol could remove such deposits potentially contaminating the ethanol and trailing products in the system.

Pipeline operators consider the special treatment required to ship ethanol and gasoline ethanol blends too troublesome for the volumes currently involved. In addition, if ethanol and gasoline ethanol blends were new, additional products (as opposed to displacing an existing product) tankage at destination terminals may be insufficient. Finally, another consideration is the fact that most pipelines originate in the Gulf Coast running north, northeast, and northwest. With most ethanol plants located in the Midwest it would still be necessary to barge product south to access many pipeline markets.

The inability to ship gasoline ethanol blends by pipeline has resulted in the current industry practice of blending ethanol into gasoline at the finished products terminal just before it is to be delivered to the retail facility or end user. This of course necessitates that storage tanks and blending equipment be available at the terminal level.

Construction of dedicated pipelines for transportation of ethanol or gasoline ethanol blends is not currently viewed as feasible due to the low shipment volumes that would be involved.

Product Storage Considerations

It is at the finished product terminal where gasoline and ethanol are finally blended. The gasoline arrives at the terminal via pipeline, barge, or ship while the ethanol arrives by transport truck, rail, barge or ship. Each is stored in its respective tank until drawn from inventory. In the case of ethanol, product is normally drawn from inventory at the time it is blended with the gasoline.

In order for a terminal to initiate an ethanol blending program it must have a tank, or install a tank, of sufficient size to meet projected ethanol demand. The tank or tanks must also be large enough to receive the minimum shipment size while still maintaining adequate working inventory. Blending systems must be installed (or existing blending systems modified) to accommodate gasoline ethanol blending. Additionally, piping modifications and modifications to the loading rack may, in some cases, be necessary. It may also be necessary to install a rail spur if the intended method of ethanol receipt is by rail.

The estimated cost of installing a 25m barrel tank is \$450,000 while costs for blending systems and modifications to receive ethanol at the terminal could push the cost to a total of \$1.0 million. However if one assumes 24 inventory turns per year, this equates to a cost of only \$0.007 per gallon of ethanol (29.4 cents per barrel) after amortizing the initial capital investment.

If the ethanol blending program will utilize a specialized base fuel such as a sub-octane gasoline or reformulated blendstock for oxygenate blending (RBOB) additional costs may be associated with their storage if they represent additional grades (as opposed to replacing an existing grade).

Once blended at the terminal level gasoline ethanol blends are transported via truck to the retail outlet and distributed like any other gasoline. There are, however, some preparatory steps required when a retail unit is first converted to gasoline ethanol blends. These steps are necessary primarily to avoid water contamination.

While ethanol continues to be transported by its traditional modes, the blending process is much more sophisticated today and handling at the retail level is also much improved due to the development of various guides covering the exact steps necessary for a trouble-free conversion to gasoline ethanol blends.

Ethanol Use

Though the transportation and distribution of ethanol and gasoline ethanol blends may not have changed markedly from the past, the motivation for selling gasoline ethanol blends has.

In the early years of gasoline ethanol blending, ethanol was used primarily as a product extender and octane enhancer which provided margin improvement for the independent marketer. Today ethanol is used not only in conventional gasoline for its octane value but also as an oxygenate for compliance with federally mandated oxygenated and reformulated gasoline programs. It is also used as an octane enhancer in sub-octane blending programs.

The EPA Blue Ribbon Panel estimated that ethanol use in oxygenated fuel programs was 237.6mm gallons for calendar year 1997 while ethanol use in RFG was 378.7mm gallons. This is also very close to estimates by the Renewable Fuels Association which puts the combined use of ethanol for oxygenated fuel programs and reformulated gasoline at a total of 650mm gallons annually. Since ethanol production for 1999 was 1.47mm gallons, this would indicate that the remaining 800mmgy of ethanol production is being used in conventional and sub-octane gasoline.

While ethanol is widely used in the oxygenated fuels program, its use in reformulated gasoline has been rather minimal. This is due to the low vapor pressure restrictions for summer RFG and the fact that the RBOB must be shipped to the terminal and then blended. The necessary RBOB is available in only a few markets. The major markets for ethanol RBOB are Chicago and Milwaukee although

RBOB is also available, on a limited basis, in Kentucky, Pennsylvania, and New York. A small amount of ethanol CaRBOB (California Reformulated Blendstock for Oxygenate Blending) is also sold in California.

Sub-Octane Gasoline

Sub-octane gasoline is manufactured especially for ethanol blending at the terminal level. Ethanol is added to this fuel to bring it up to octane specification thereby allowing for the capture of ethanol's full octane value.

In addition to the states where RBOB is available there are nine states where sub-octane gasoline is available. In fact, sub-octane is shipped on the Williams Pipeline System and is available at five of Williams' terminals.

Ethanol Pricing and Values

While ethanol continues to be priced similarly to historic pricing mechanisms, its price and value is to some degree affected by how it is used. Ethanol is generally more valuable as an oxygenate for compliance with federally mandated clean fuel programs than as an octane enhancer. The price of ethanol is also dramatically affected by supply/demand balances with ethanol being discounted to its value when the ethanol market is long (supply exceeds demand).

Obviously the pricing and value of ethanol is significantly impacted by the federal motor fuel excise tax credit for gasoline ethanol blends and, when applicable, by similar state level tax credits.

The value calculations are different for a refiner as compared to an independent marketer. This is because the refiner must consider not only octane value but also volatility adjustments in the case of volatility controlled RFG. They must also consider any applicable processing penalty in the case of sub-octane gasoline.

MTBE Concerns and Its Impact on Ethanol Demand

Another important issue that could impact ethanol demand is current concerns about MTBE contaminating ground water. California has already taken action to ban the use of MTBE. The EPA Blue Ribbon Panel has recommended that its use be phased out or dramatically reduced. The EPA has

announced that it supports a phase out of the use of MTBE and that the agency will proceed to attempt to limit its use through the Toxic Substances Control Act (TSCA). If the use of MTBE is eliminated or significantly limited this would create greater demand for ethanol. However this will depend largely on whether the oxygen requirement for RFG is left intact or rescinded. If the RFG oxygen requirement is unchanged a complete phase out of MTBE would create a minimum additional demand of 1.66mm gallons of ethanol annually for use in RFG.

Infrastructure Barriers

The infrastructure barriers to expanded ethanol use continue to be the water sensitivity of gasoline ethanol blends and the consequent inability for these blends to be treated as fungible products in the petroleum distribution network. The inability to ship gasoline ethanol blends via pipeline results in the need to blend ethanol at the finished product terminal, with all its associated expenses for extra storage capacity, blending equipment, and product receipt modifications.

State Regulations

Although more of a nuisance than a barrier, the regulations governing the use of ethanol in gasoline vary from state to state. Regulations governing pump labeling, vapor pressure, distillation properties, and conversion procedures are not uniform from one state to the next. This patchwork quilt of regulations can be confusing for the multi-state marketer. Uniformity in state regulations pertaining to ethanol and gasoline ethanol blends would eliminate this problem.

Oxygenate Free Fuel Formulations May Reduce Ethanol Use

In the face of the pending phase out of MTBE use in California and similar action likely at the federal level, refiners have renewed their call to remove the oxygen requirement from the federal RFG program. The refining industry's position is that they can meet the emissions reduction requirements of the Clean Air Act without the use of oxygenates, at least for a large portion of their RFG production. They note, however, that oxygenate use may be necessary in a portion of production but such use should be optional, not mandated.

The removal of the RFG oxygen requirement could impact ethanol use in several ways depending on the baseline scenario assumed. If MTBE were banned and the oxygen requirement remained intact the minimum total ethanol demand to meet the 2.0 wt% oxygen level is 1.98 bgy. Obviously if the oxygen requirement is rescinded, a large portion of this market would not materialize.

In the RFG requirement is removed and MTBE is not banned, the negative effect on ethanol demand would likely be much worse. If oxygenate use in RFG is not required, demand for all oxygenates would be reduced. This could result in greater MTBE use in conventional gasoline. In this case, ethanol would not only lose its market potential for the RFG oxygen requirement but could be displaced by MTBE in some of its conventional gasoline markets. The extent of any such displacement cannot be predicted within the scope of this analysis.

The removal of the oxygen requirement from federal RFG would reduce ethanol demand regardless of the baseline comparison selected.

The Affect of Automotive Technology on Oxygen Requirements

Advancements in automotive emissions control technology continue at a rapid pace resulting in ever lower emissions on an individual vehicle basis. One of the key strategies employed to reduce exhaust emissions is more precision in air fuel management. More precise control of the vehicle's air fuel ratio lessens the impact that oxygenates have in reducing tailpipe emissions of CO and HC. In fact, in some instances variations in oxygen content may be a detriment to engineering the most precise air fuel management strategies.

As these advanced technology vehicles replace older vehicles, the benefits of using oxygenates in gasoline will be limited to an ever shrinking number of older vehicles. Of course oxygenates will still provide benefits for "high emitters" and off-road engines such as lawn mowers, power equipment, and contractor equipment. These latter sources will make up a larger portion of the emissions inventory as automobile emissions become less. However with lower emissions inventories the cost per ton of emissions reduced from the use of oxygenates would likely increase making the use of such fuel components more difficult to justify.

Developing and Potential Transportation Uses for Ethanol

While oxygenate-free gasoline formulations and automotive technology may reduce demand for ethanol (and other oxygenates), there are also potential transportation fuel uses that could increase ethanol demand. These potential uses are in various stages of commercialization or development.

The use of E-85 (~85 v% ethanol/15 v% gasoline) in flexible fuel vehicles (FFV) is currently the highest profile alternative fuel use for ethanol. Over a million FFVs capable of using E-85 have already entered the market. Estimates indicate FFV production for Model Year 2000 will reach 703,000 vehicles with similar or greater volumes being produced in future years. Future production depends on the ability of the auto manufacturer to continue to receive fuel economy credits for their Corporate Average Fuel Economy (CAFE) requirements.

While FFVs are rapidly entering the market, places to fuel them are practically nonexistent.

Only one state has more than 20 fueling facilities. No other state currently has in excess of six such facilities. This slow growth is in large part because E-85 does not usually replace an existing product but rather represents a new product at the retail level. This has usually necessitated the installation of an underground tank and new dispensing equipment which can cost in excess of \$100,000 per unit. In order to expand the use of E-85 it would likely take participation of a retailer with a national, or at least a regional, presence.

If the fueling infrastructure can be developed, the potential ethanol demand created could be significant. Based on vehicle production estimates, by the end of model year 2003, a projected 3.6 million FFVs will be on the road. If these vehicles operated 50% of the time on E-85 it would create a demand for slightly more than 1 billion gallons of ethanol per year. In order for such volume to be realized, it would also be necessary for E-85 to be priced competitively with gasoline on a miles traveled basis. This is not occurring at the present time.

Until only a few years ago, production of ETBE was thought to be another use for ethanol that would be developed to create new demand. Originally ETBE promoters noted its similarity to MTBE which would include the ability to ship gasolines containing ETBE in the pipeline where they would be treated as a fungible product. However with recent concerns about MTBE ground water contamina-

tion, ETBE's similarity to MTBE has now become a negative since it would present similar concerns. It is unlikely that ETBE production and use will see much support in the U.S. unless ground water issues concerning ethers used in gasoline are favorably resolved.

Another promising alternative fuel use for ethanol is as a diesel fuel component in Oxydiesel. The use of Oxydiesel is currently in the demonstration stage. Oxydiesel is a blend of diesel fuel containing 10-15 v% ethanol. Limited tests indicate that unmodified diesel engines can achieve dramatic emissions reductions when operating on Oxydiesel. Since Oxydiesel can be used in unmodified diesel engines, its handling and distribution would be similar to E-10 gasoline blends. No special equipment would be necessary at the retail location so market penetration could increase rapidly if demand materializes. If Oxydiesel achieved the same level of market penetration that E-10 gasoline blends have achieved, this would create a demand for 4.44 billion gallons of Oxydiesel annually. At a 10 v% ethanol blend level this would require 444 million gallons of ethanol per year.

The use of ethanol in aviation applications has also been explored. Some aircraft have been certified to operate on ethanol. Ethanol has been demonstrated to have excellent properties as an aviation gasoline (av-gas) for piston powered aircraft. Such use would require an extensive effort to obtain certification for numerous engine/airframe configurations from the Federal Aviation Administration (FAA). It would also require making the fuel available at fixed base operations (FBO) where aircraft are fueled. The av-gas market is estimated at 400 million gallons per year. If ethanol were blended at the 88 v% level as is the case in Aviation Grade Ethanol 85 (AGE-85), the resultant ethanol demand would be in the area of 352 million gallons per year.

Finally, ethanol could be used in fuel cells. The future is much less certain for this application because it is not clear when fuel cell vehicles will achieve commercial reality. There are also a number of fuels vying for a position in this market. Based on participation in the California Fuel Cell Partnership, hydrogen, methanol, and gasoline appear to have the interest of the auto manufacturers at the current time. Still, ethanol does have many favorable attributes as a fuel for fuel cell use. Due to the uncertain timetable for fuel cell commercialization and the apparent lack of automaker interest in ethanol for this application, it is not possible to estimate what, if any, potential ethanol demand could result.

Clearly there are numerous issues and considerations involved with the use of ethanol as a transportation motor fuel. This work has attempted to identify these issues and discuss existing and potential methods to address them. The petroleum industry's viewpoints on ethanol are also discussed. The many topics covered in this report will serve as the foundation for future work that will identify and implement an approach for analyzing the transportation, marketing, and distribution issues and costs associated with an ethanol industry expansion.

Section 1
Background & Introduction

1.0 Background & Introduction

The U.S. Department of Energy's (DOE) Office of Transportation Technologies (OTT) through its Office of Fuels Development (OFD) is responsible for major planning and analysis to ensure consistency of various program objectives with the Energy Policy Act (EPACT). Oak Ridge National Laboratory (ORNL) is supporting OFD in its analysis of current and future ethanol demand for the transportation fuels market. However this report deals only with current industry practices and issues.

Downstream, Alternatives Inc. (DAI) was retained to provide support services specifically related to ethanol transportation, distribution, and marketing issues. The work is divided into two phases. The first phase includes three major tasks. The first task was a literature search and document review to identify documents and reports that could be used for other Phase I tasks. The literature search and document review was completed in December 1999. Many of the documents identified serve as references in this Task 2 report. Task 3 will utilize this report and other information sources to identify an approach for analyzing transportation, marketing, and distribution costs and issues for an expanded ethanol industry. Finally Phase II will represent implementation of the recommendations in Phase II Task 3.

1.1 Purpose

Preparation of this report describing current ethanol transportation, distribution, and marketing issues and related costs represents completion of Task 2 to describe the present system and current practices utilized by the ethanol and petroleum industries in distribution, transportation, and marketing current ethanol production. The report does not address specifically how the system could or should be expanded to accommodate larger ethanol volumes.

The primary focus of this report is on the common ethanol blends in current use, i.e. E-10 (90% gasoline/10% denatured ethanol) and to a lesser degree E-5.7 and E-7.7. The transportation, distribution, and marketing issues and costs for all of these blends are basically the same.

In addition, other developing and potential transportation fuels uses of ethanol, such as E-85,

oxydiesel, and fuel cells are discussed but not to the same degree. Again, many of the transportation and distribution issues for these uses are the same as for E-10. However in some cases there may be additional infrastructure costs at the retail level.

1.2 Methodology

Since this report is on existing practices, no major assumptions are required. Rather this report is based on numerous information sources. Such sources include numerous documents identified in the aforementioned literature search/document review as well as DAI's familiarity with many of the topics due to its extensive involvement in the ethanol industry. Additionally numerous calls were made to contacts in the ethanol, petroleum, and transportation (i.e. barge/ship, rail) industries. Calls were also made to automotive industry personnel and various state regulators on specific topics.

Information from all of the above sources is combined into applicable topic areas to convey a detailed assessment of how ethanol is transported, distributed, and marketed at the current time.

1.3 Report Structure

This report is divided into major topic areas which, in addition to this section and the Executive Summary, include the following:

Sections

- Gasoline Ethanol Blends - Overview of Current Industry Practices
- Ethanol Transportation Modes and Cost Estimates
- Shipping Ethanol and Gasoline Ethanol Blends Via Pipeline
- Storage Facility Requirements for Gasoline Ethanol Blending Programs
- Gasoline Ethanol Blends-Handling and Marketing Considerations for Distributors and Retail
- Infrastructure Barriers for Ethanol Fuels
- Petroleum Industry Attitudes Towards the Use of Ethanol
- Ethanol Prices and Values and Regional Differences in Ethanol Pricing
- Ethanol in Winter RFG versus Summer RFG and the Potential for Use of Ethanol in Phase II RFG

- Concerns about MTBE and Its Impact on Ethanol Demand
- Alternative Fuel Formulations Without Oxygenates and Their Impact on Ethanol Demand
- State Regulations and Their Effect on Gasoline Ethanol Blend Programs
- Automotive Technology and Its Effect on Oxygen Requirements
- Developing and Potential Transportation Fuel Uses for Ethanol
- Ethanol-Technical Information
- Glossary

Sections are numbered numerically and subsections are numbered by decimal point, i.e. subsection 4 of section 1 would be 1.4. Numbers in superscript (raised letters) denote specific references listed at the end of each chapter. Documents serving as general references are also listed as such at the end of each chapter.

Note that Section 16 is a compendium of technical information about fuel grade ethanol. For the reader who is not familiar with the technical specifications and blending characteristics of ethanol as a gasoline component it might actually be advantageous to read the “Ethanol-Technical Information” section first.

Section 2

Gasoline Ethanol Blends

Overview of Current Industry Practices

2.0 Gasoline Ethanol Blends - Overview of Current Industry Practices

This section discusses current industry practices used to transport, distribute, and market ethanol for use in gasoline ethanol blends. The gasoline distribution infrastructure is also described to provide the reader with a proper frame of reference for these interrelated systems. Note that this report does not address ethanol production issues but rather the aspects of the industry that occur after the ethanol is produced. Some elements of production such as production capacity, specifications and regulatory compliance are discussed when they affect downstream marketing, blending, or other aspects of gasoline ethanol blending programs. While this section focuses on ethanol's use in gasoline ethanol blend programs, many of the same transportation and distribution issues would also be applicable to other ethanol fuel uses such as E-85 and oxydiesel. These products are discussed separately later in this report.

The intent here is to provide the reader with an understanding of the dynamics of current ethanol industry practices and lay a foundation to aid in understanding the other sections of this report.

2.1 Gasoline Distribution Infrastructure

The gasoline distribution infrastructure is divided into three major segments; Primary, Secondary, and Tertiary. Collectively these systems employ tankers, barges, rail cars, tank trucks, thousands of miles of pipeline, and hundreds of storage terminals, and of course the refineries. By petroleum industry definition the Primary Distribution System includes oil gathering at the well head, transport to gathering tanks, crude oil storage, and refinery processing. For purposes of our analysis, these segments of the Primary Distribution System are omitted since it is not germane to the transportation and distribution of gasoline and gasoline ethanol blends.

2.1.1 Primary Distribution Infrastructure

Gasoline's odyssey in the primary distribution system begins at the refinery, about midway in the system⁽¹⁾. There are 159 refineries in the U.S., 155 of which are currently operating,⁽²⁾ although not all refineries produce gasoline. Once gasoline components are refined they are blended at the refinery to

make the desired grades (octane levels) and to meet various seasonal requirements (volatility) as well as to meet applicable environmental requirements (e.g. reformulated gasoline, low vapor pressure gasoline) for their intended destinations.

Product is moved to refinery finished product tankage for distribution into the product transportation network. This includes transfer to tanks for shipment into pipelines and for many refiners to tankage for loading waterborne cargoes (i.e. tankers or barges). Some refiners also have loading racks at their facilities enabling them to load tank cars and tank trucks directly from the refinery for delivery to the secondary and tertiary systems.

The refined products pipeline system consists of approximately 72,000 miles of line⁽³⁾ and carries over half of the gasoline to market. Product moved by pipeline, ship or barge is transported to bulk storage finished product terminals.

A finished product terminal may consist of just a few small tanks storing perhaps 50,000 barrels or numerous tanks, both large and small, storing a combined total of millions of barrels of finished product. It may in some cases be owned by an individual petroleum company, jointly operated by two or more companies, or it may be independently owned by a company whose sole purpose is the storage and outloading of their customers' products. Some terminals may store and distribute only gasoline or diesel. Larger terminals typically handle a full range of light products.

Terminals can be supplied by one or more of the following: Pipeline, barge, ship, or rail. In addition, some terminals can receive product via transport truck. Terminals serving the retail markets have one or more transport truck loading racks. There are hundreds of gasoline distribution terminals across the United States.

2.1.2 Secondary Distribution System

From the finished product terminal, product is then distributed by transport tank truck to the retail outlets and, in some cases, to bulk plants. A small amount of product is also moved by rail.

It is at the end of the primary distribution system that ethanol enters the process with delivery to refined products terminals. The secondary distribution system consists of retail outlets and bulk plants.

Bulk plants are defined as wholesale storage facilities that have less than 50,000 barrels of storage capacity and receive product only by tank car or truck (not by barge, ships, or pipeline). It should be noted that the use of bulk plants has decreased dramatically in recent years.

Environmental regulations and inventory carrying costs have resulted in many jobbers ceasing bulk plant operations. The bulk plant population dropped from 18,000 in 1983 to 15,000 in 1988⁽⁴⁾ and stood at approximately 10,300 in 1991⁽⁵⁾. The more typical use of bulk plants, when still in use, is for kerosene and heating oil. For the most part, ethanol blended with gasoline at the refined products terminal is delivered directly to retail facilities. The estimate of the number of retail outlets in operation varies but one of the more reliable sources puts the count at 180,567 for 1999⁽²⁾. Retail outlets are, of course, the service stations and convenience stores with which the consumer is familiar. The typical retail outlet has two or more underground tanks, offering three gasoline products through one or more service islands and may also offer kerosene and diesel products.

2.1.3 Tertiary Storage Segment

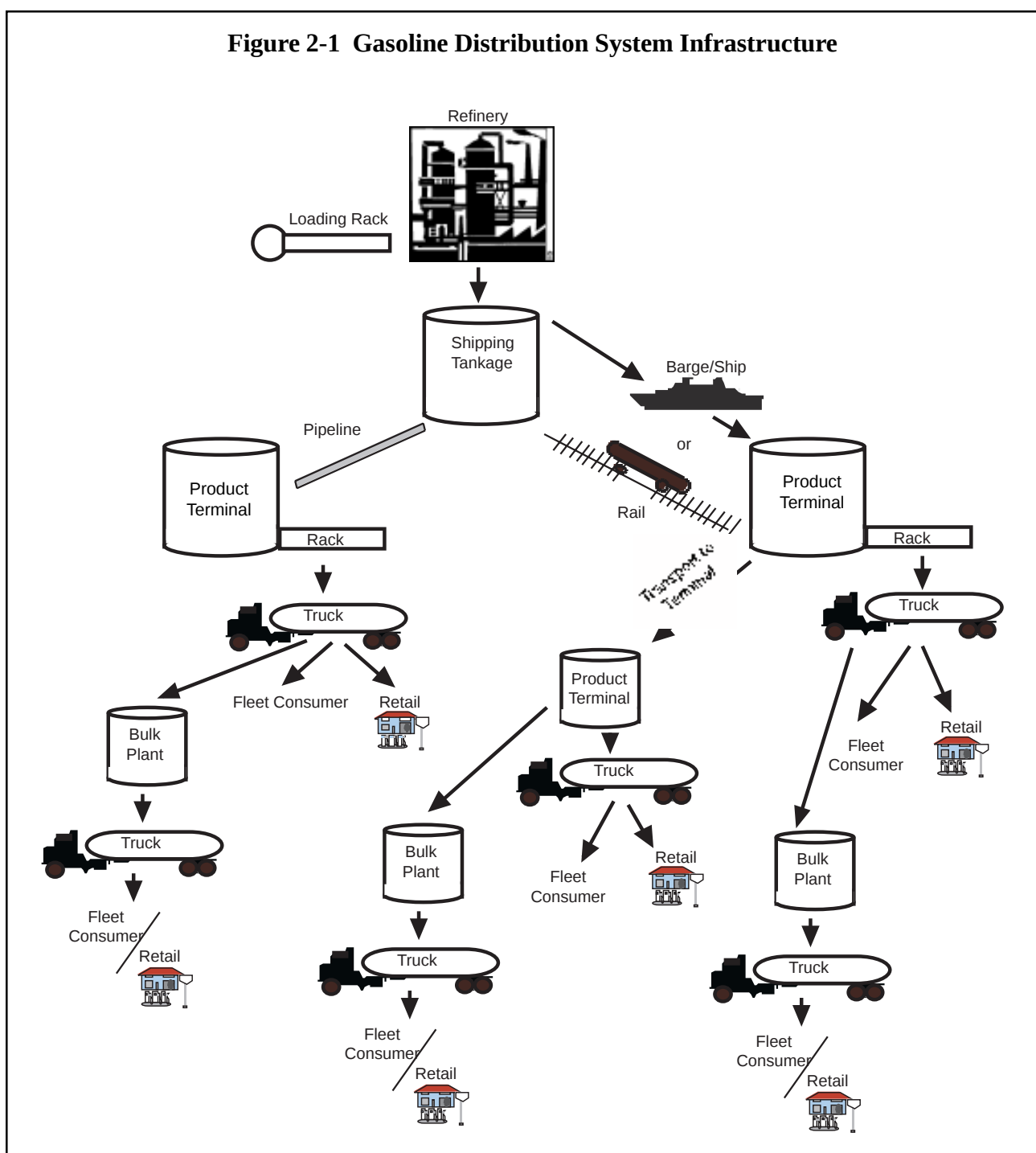
This industry segment consists of end users. For purposes of potential ethanol use the focus would be on fleet operations and other commercial endeavors that maintain their own gasoline inventory. This category also includes consumer autos although this would not be germane to ethanol issues since consumer vehicles are fueled at retail outlets.

Estimated gasoline storage capacity in each of the aforementioned segments of the system as of 1988 was estimated to be:

Primary	451 mm barrels
Secondary	92 mm barrels
Tertiary	109 mm barrels
Total	652 mm barrels

Source: Petroleum Storage & Transportation-Petroleum Inventories and Storage, National Petroleum Council, April 1989

Figure 2-1 Gasoline Distribution System Infrastructure



The various segments of the gasoline distribution infrastructure are graphically depicted in figure 2-1.

2.2 Ethanol Distribution Infrastructure

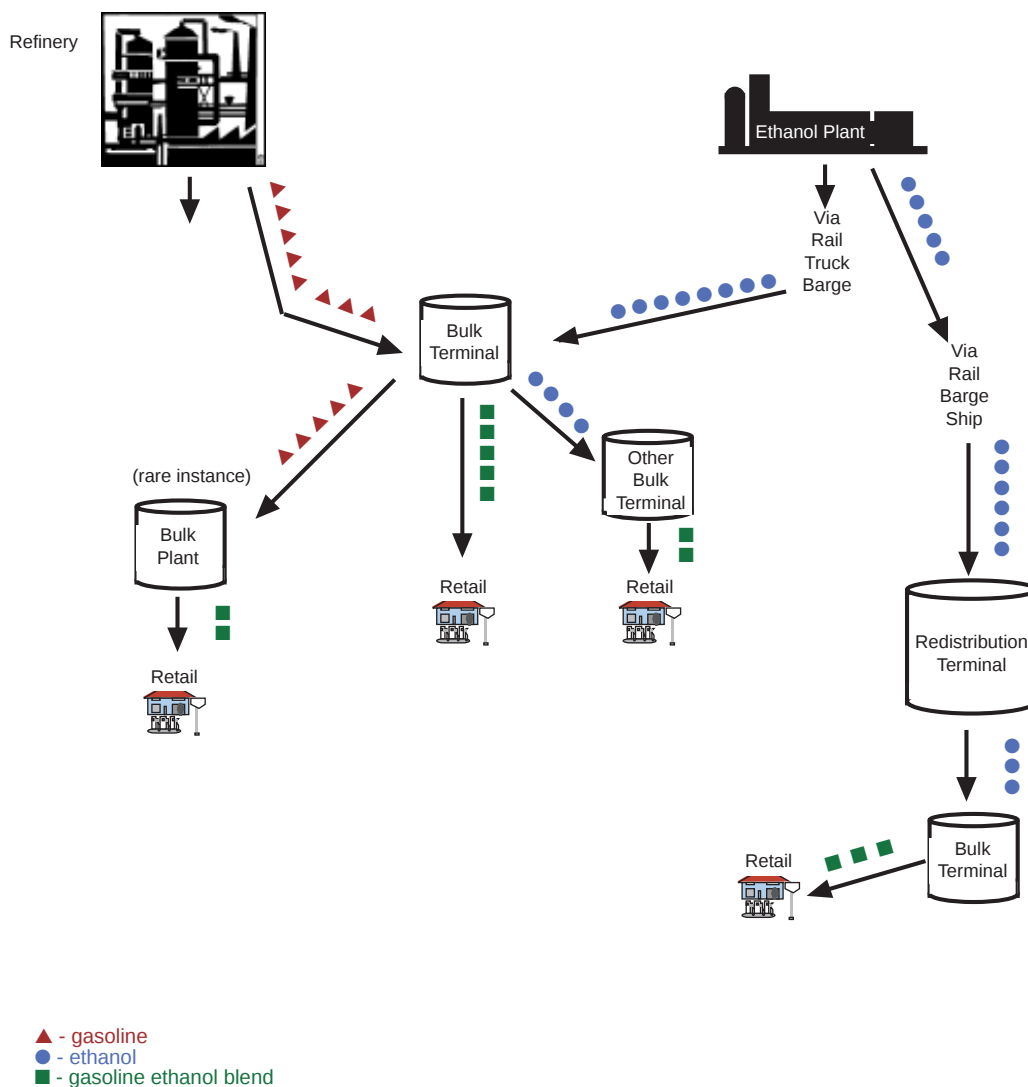
The specifics of how ethanol is integrated into the petroleum distribution system are covered below

2.2.1 Distribution of Ethanol

The ethanol distribution infrastructure consists primarily of movements from ethanol plants to bulk terminals. Distribution of ethanol starts at the ethanol production facility. Near anhydrous ethanol is denatured at the plant, typically by adding 5 gallons of unleaded gasoline or natural gasoline to 100 gallons of ethanol. The ethanol distributed for fuel use must meet ASTM D 4806 “Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel” (see Ethanol-Technical Information Section).

Product is shipped from the plant by one of three modes; transport truck, rail car, or river barge. From the plant, the ethanol is transported to one of two primary destinations, either a bulk terminal or a redistribution bulk terminal. In most cases ethanol is shipped by truck, rail car, or river barge to a bulk terminal where it is stored until it is blended with gasoline as the transport truck is loaded. In some cases ethanol will be lifted from these terminals in full transport truck loads for distribution to other terminals that may not be capable of storing larger quantities. In some cases, such as servicing terminals in more distant coastal locations such as the Northeast coastal area or California, ethanol is shipped by river barge (or could be shipped by rail) to New Orleans where it is staged in storage tanks until sufficient quantities exist for loading ocean going barges or ship compartments. It is then shipped to a redistribution terminal in the destination market. Once at the redistribution terminal, the ethanol is broken down into smaller quantities, usually transport truck loads, and delivered to other terminals in the area. Some of the ethanol may also be blended into gasoline and distributed as a blend directly from the redistribution terminal. The ethanol distribution system infrastructure is depicted in Figure 2-2.

Figure 2-2 Ethanol Distribution Infrastructure



It should be noted that storage tanks must meet certain requirements. In addition terminal operators typically use computerized in-line blending to control the blending process. These issues are covered in Section 5 of this report.

2.2.2 Distribution of Gasoline Ethanol Blends

Ethanol is typically stored separately at the terminal, being blended only as the transport truck is loaded. This is done for two reasons. First to avoid excessive moisture contamination of the gasoline ethanol blend and secondly, to minimize the tankage requirements for blended and non-blended product.

When a transport truck pulls to the loading rack, the driver activates the process with the use of magnetically striped cards that identify the transport carrier and truck as well as the end customer. Information for the desired grade and volume is input. If an ethanol blend is ordered the computer will activate the gasoline and ethanol flow into a blending unit where the two products are combined in the proper proportion and transferred on to the loading rack for delivery into the transport truck.

NOTE: Although computerized blending is the preferred method, there are some variations to this process as follows.⁽⁶⁾

Sequential Blending: This process is also computerized but instead of going through a blending unit the products are injected into the truck in the proper proportion, in sequence. This process depends on the agitation of the loading, transport, and dropping of the blended product to achieve a homogenous blend.

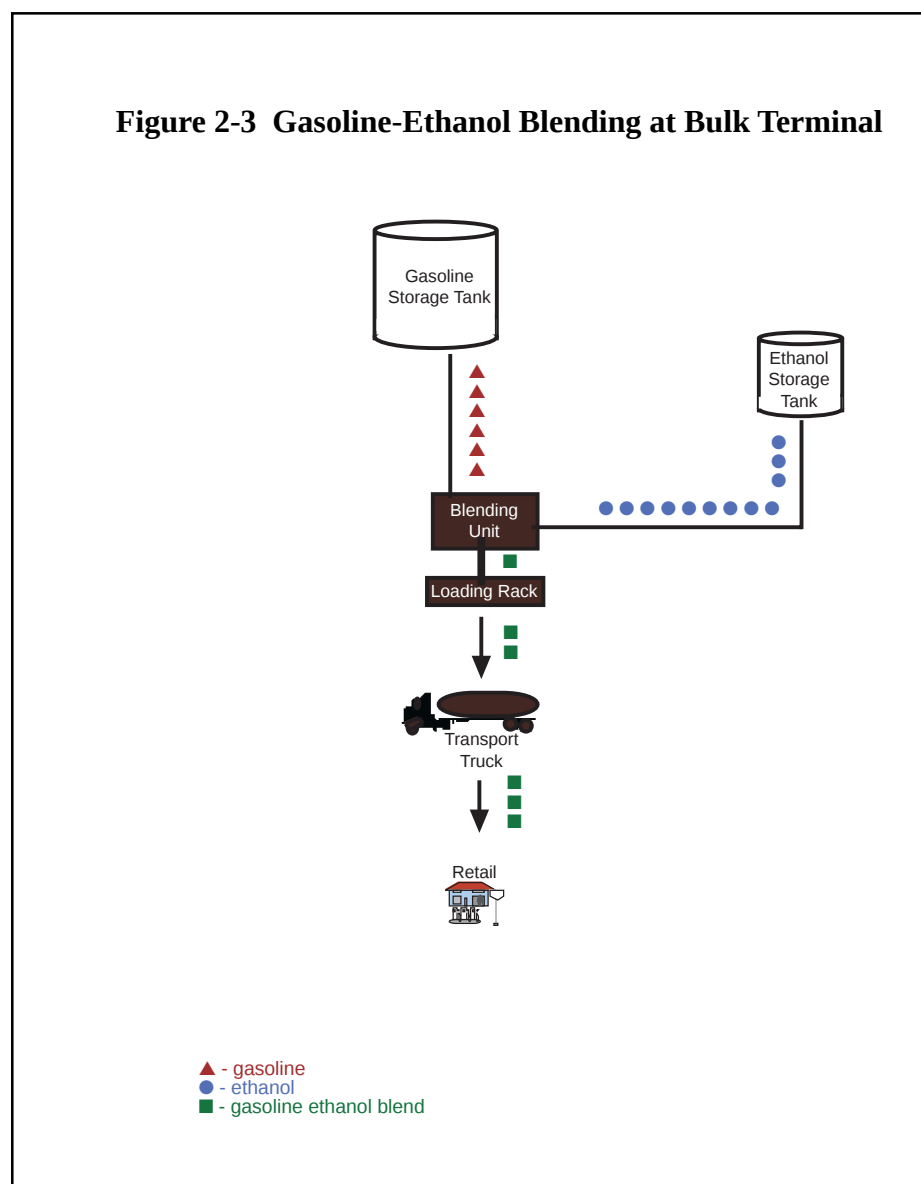
Top-off Blending: In this scenario, ethanol and gasoline are injected separately into the transport truck with the agitation from loading, transport, and unloading accomplishing the blending process. Volumes are controlled by preset meters activated by loading cards. This could be done within a single terminal (i.e. one loading rack) or by loading the ethanol at one terminal and the gasoline at another terminal (both terminals in the same proximity). This method was successfully used throughout the Midwest for a number of years and is still utilized at some terminals .

Tank Blending: Ethanol and gasoline could be blended in one or more terminal tanks. A few terminals in the Midwest, especially those with recirculation capability (in tank devices to recirculate/stir the product) have distributed ethanol blends in this manner. However this method is the least preferred due to the potential for the blend to encounter excessive moisture which could result in the ethanol phase separating from the blend. Additionally terminal tankage is not routinely equipped with recirculation/mixing devices.

Once the blending process is accomplished by one of the above methods, the gasoline ethanol blend is then handled and delivered to retail and commercial facilities like any other gasoline.

For locations first converting to gasoline ethanol blends, there are a number of preparatory steps at the retail level. These are covered in the “Gasoline Ethanol Blends-Handling and Marketing Consideration for Distributors and Retailers” section of this report.

Figure 2-3 depicts the typical gasoline ethanol blending set up at a bulk terminal.



2.3 Current Ethanol Production Information

The U.S. ethanol industry is currently comprised of over 50 ethanol plants operating in a total of 20 states. However, the majority of production is located in the states of Indiana, Illinois, Iowa, Minnesota, Nebraska, and Kansas. This heavy concentration of Midwestern states production is due to the fact that most domestic ethanol is produced from corn and the plants have been located close to feed-stock sources.

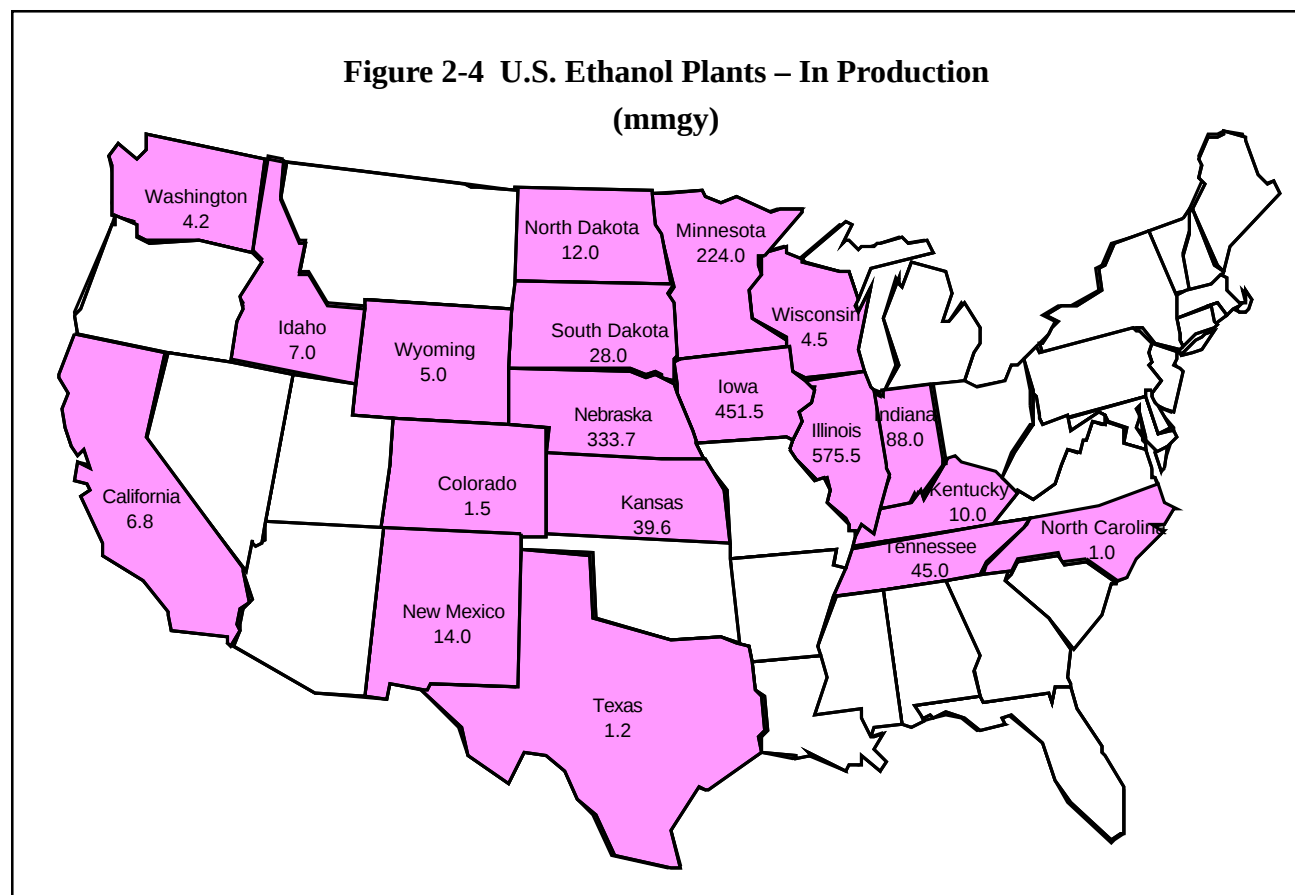
Table 2-1 lists the location and denatured fuel grade ethanol capacity of currently operating plants.

**The Current Fuel Ethanol Industry - Transportation, Marketing,
Distribution, And Technical Considerations**

**Table 2-1 U.S. Ethanol Production Capacity (Nameplate)
million gallons per year (mmgy)**

<u>COMPANY</u>	<u>LOCATION</u>		<u>FEEDSTOCK</u>	<u>mmgy</u>
A.E. Staley	Loudon	TN	Corn	45
AgPower Inc.	Commerce City	CA		2
AGP	Hastings	NE	Corn	45
Agri-Energy	Luverne	MN	Corn	18
Alchem	Grafton	ND	Wheat	12
Al-Corn	Claremont	MN	Corn	18
Archer Daniels Midland	Decatur	IL	Corn	750
(total capacity)	Peoria	IL	Corn	
	Cedar Rapids	IA	Corn	
Broin Enterprises	Clinton	IA	Corn	
Cargill (total capacity)	Scotland	SD	Corn	8
	Blair	NE	Corn	105
	Eddyville	IA	Corn	
Central Minnesota	Little Falls	MN	Corn	18
Chief Ethanol	Hastings	NE	Corn	62
Chippewa Valley Ethanol	Benson	MN	Corn	20
Corn Plus	Winnebago	MN	Corn	17.5
DENCO, LLC.	Morris	MN	Corn	15
Eco Products of Plover	Plover	WI	Whey/potato waste	4
ESE Alcohol	Leoti	KS	Seed corn	1.1
Ethanol2000	Bingham Lake	MN	Corn	15
Exol, Inc.	Albert Lea	MN	Corn	18
Farm Tech USA	Spring Green	WI	Corn	0.5
Georgia-Pacific	Bellingham	WA	Paper waste	3.5
Golden Cheese	Corona	CA	Whey	2.8
Grain Processing Corp.	Muscatine	IA	Corn	10
Heartland Corn Products	Winthrop	MN	Corn	17
Heartland Grain Fuel	Aberdeen	SD	Corn	8
	Huron	SD	Corn	12
High Plains Corporation	York	NE	Corn/milo	74
(total capacity)	Colwich	KS		
	Portales	NM		
Hubinger	Keokuk	IA	Corn	18
J.R. Simplot	Caldwell	ID	Potato waste	4
	Heyburn	ID	Potato waste	3
Jonton Alcohol	Edinburg	TX	Corn	1.2
Kraft, Inc.	Melrose	MN	Whey	3
Manildra Ethanol	Hamburg	IA	Corn/milo/wheat starch	7
MMI/ETOH (Merrick/Coors)	Golden	CO	Brewery waste	1.5
Midwest Grain (total capacity)	Pekin	IL	Corn/wheat starch	108
	Atchison	KS		
Minnesota Clean Fuels	Dundas	MN	Waste sucrose	1.5
Minnesota Corn Processors	Columbus	NE	Corn	122
* (total capacity)	Marshall	MN	Corn	
Minnesota Energy*	Buffalo Lake	MN	Corn	12
New Energy Corp.	South Bend	IN	Corn	88
Pabst Brewing	Olympia	WA	Brewery waste	0.7
Parallel Products	Louisville	KY	Beverage waste	10
	R. Cucamonga	CA	Beverage waste	2
Permeate Refining	Hopkinton	IA	Sugars & Starches	1.5
Pro-Corn*	Preston	MN	Corn	19
Reeve Agri-Energy	Garden City	KS	Corn/milo	10.5
Stroh's Brewery	Winston Salem	NC	Beverage waste	2
Sunrise Energy	Blairstown	NE	Corn	5
Vienna Correctional	Vienna	IL	corn	0.5
Williams Energy Services	Pekin	IL	Corn	100
Nebraska Energy (Williams Energy)	Aurora	NE	Corn	30
Wyoming Ethanol	Torrington	WY	Corn	5
Total Capacity-March 2000				1855.8
<i>Source: Ability of the U.S. Ethanol Industry to Replace MTBE, AUS Consultants, March 2000</i>				

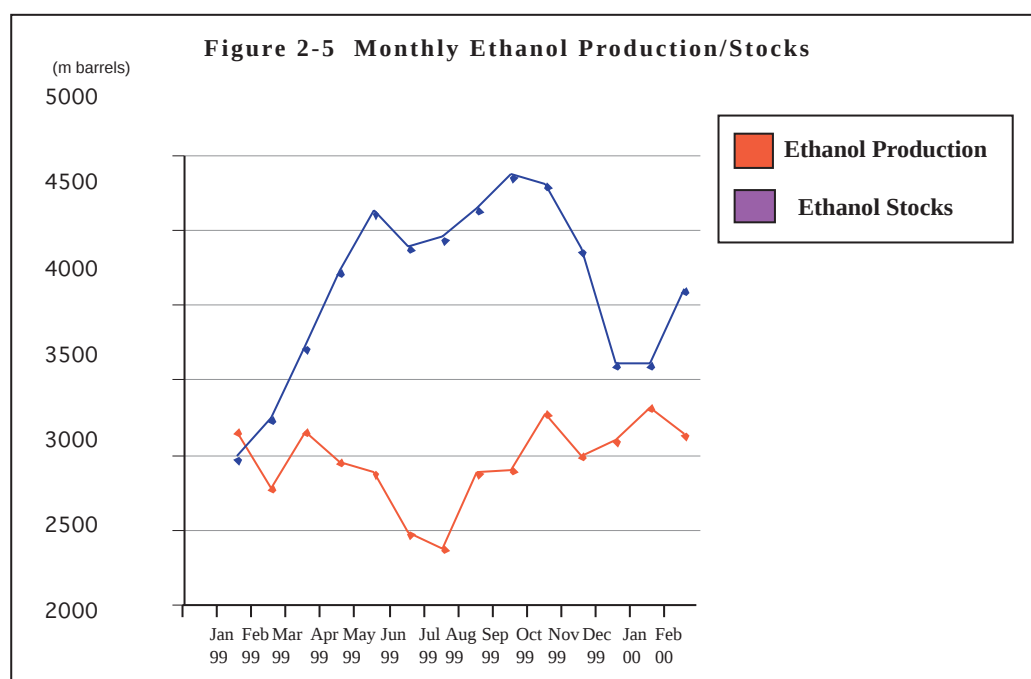
Current denatured fuel ethanol production capacity by state is depicted graphically in Figure 2-4.



Total nameplate fuel grade ethanol production capacity is 1.855 mm gallons (121 mbd). Production for 1999 was 1.47 mm gallons.⁽⁷⁾ In February 2000, the ethanol industry operated at a record rate of 108m bpd⁽⁷⁾ (4.5 million gallons per day). The ethanol industry usually runs higher production levels in the winter (due to wet mill swing capacity) and greater demand for oxygenated fuel programs. Wet mills manufacture both ethanol and high fructose corn syrup (HFCS) and have the ability to alter the ratio of the production volume of ethanol to HFCS. Presently, most wet millers lower production of ethanol in the lower demand summer months and increase the production of HFCS which usually provides greater profit and is in higher demand in summer months. The exact swing capacity of each wet mill is not known as such information is considered proprietary. Table 2-2 lists monthly ethanol production and ending stocks for the most current 14 months which are also presented graphically in Figure 2-5. The table and graph demonstrate the lower rate of ethanol production in the summer months. While some reductions in

Table 2-2 Ethanol Production and Ending Stocks

<u>Date</u>	<u>Ethanol Production</u> <u>m Barrels per month</u>	<u>Ethanol Stocks</u> <u>m Barrels</u>
Jan 99	3162	2973
Feb 99	2772	3240
Mar 99	3162	3722
Apr 99	2970	4222
May 99	2883	4624
Jun 99	2490	4382
Jul 99	2387	4440
Aug 99	2883	4640
Sep 99	2910	4868
Oct 99	3286	4798
Nov 99	3000	4362
Dec 99	3100	3592
Total MBPY (1999)	35005	
Jan 00	3317	3603
Feb 00	3132	4097



production are a result of wet mill swing capacity the ethanol industry maintains that a large portion of the reduction is a result of lower ethanol demand in the summer due to ethanol's inability to participate in the RFG program on a wide scale. Note that the current combination of high gasoline prices and low corn prices have also been an incentive to operate at maximum rates resulting in record production in January and February 2000. However even if the industry averaged 10,000 bpd less than these current record levels, on an annual basis this would equate to 1.5 billion gallons.

There are also a number of ethanol plants under construction. These are listed in Table 2-3.

Table 2-3 Plants Currently Under Construction				
COMPANY	LOCATION		FEEDSTOCK	mmgy
Golden Triangle	St. Joseph	MO	Corn	14.0
Adkins Energy	Lena	IL	Corn	30..0
BC International	Jennings	LA	Bigasse/rice hulls	20.0
Nebraska Nutrients	Sutherland	NE	Corn	15..0
NE Missouri Grain Processors	Macon	MO	Corn	15..0
Total Under Construction Capacity (by 2000)				134.0
<i>Source: Ability of the U.S. Ethanol Industry to Replace MTBE, AUS Consultants, March 2000</i>				

Finally there are numerous proposed plants in various stages of planning. Which of these plants that are under consideration will actually be built is difficult to predict given current market uncertainties such as the possible removal of the oxygen content requirement in reformulated gasoline.

Proposed plants are listed in Table 2-4.

Table 2-4 Proposed Ethanol Plants/Under Consideration, March 2000			
City	State	Capacity (mmgy)	Feedstock
Grain			
Undisclosed	CO	20.0	corn
Central Iowa	IA	15.0	corn
NW Iowa	IA	40.0	corn
L Cascade	IL	100.0	corn
Pratte	KS	15.0	corn/milo
Undisclosed	KS	40.0	corn
Undisclosed	KY	20.0	corn
Central State	MI	40.0	corn
St. Paul	MN	30.0	corn
SE Missouri	MO	30.0	corn
Great Falls	MT	75.0	wheat/barley
Neely	NE	15.0	corn
Central State	NJ	10.0	corn
Clatskanie	OR	80.0	corn/wheat
Milbank	SD	40.0	corn
Platte	SD	15.0	corn
Rosholt	SD	15.0	corn
Undisclosed	TX	30.0	corn
Moses Lake	WA	40.0	corn/barley
Lacrosse	WI	20.0	corn
Subtotal		690.0	
Biomass Conversion			
SE Region	AK	8.0	wood waste
NE Region	CA	15.0	forest residue
Gridley	CA	20.0	rice straw
Mission Viejo	CA	8.0	rice straw
Chester	CA	20.0	forest residue
Onslow County	NC	60.0	sweet potatoes
Greene County	NC	60.0	sweet potatoes
Martin County	NC	60.0	sweet potatoes
Middle Town	NY	10.0	MSW
Central region	OR	30.0	wood waste
Philadelphia	PA	15.0	MSW
Black Hills	WY	12.0	forest residue
Subtotal		318.0	
Total New Capacity Under Consideration (Denatured Ethanol Basis)		1,008.0 (65.8 mbd)	

2.4 Gasoline Ethanol Blend Composition

Ethanol is currently blended into conventional gasoline, reformulated gasoline, and sub-octane gasoline. While the most common ethanol blend level is 10 v% ethanol it is sometimes blended at 5.7 v% (equating to 2.0 wt% oxygen) and 7.7 v% (equating to 2.7 wt% oxygen) to achieve regulatory compliance levels.

2.4.1 Ethanol - Reformulated Gasoline

When ethanol is used as the oxygenate in reformulated gasoline it must be blended to a Reformulated Blendstock for Oxygenate Blending (RBOB) or in the case of California, CaRBOB. These base fuels are designed such that when ethanol is blended into them the finished gasoline ethanol blend meets applicable requirements for the federal or California RFG programs. The producer of the RBOB or CaRBOB specifies the maximum level of ethanol that can be added. Although the minimum oxygen requirement is typically 2.0 wt% (~ 5.7 v% ethanol), many refiners make a RBOB to accommodate up to 10 v% ethanol to take full advantage of ethanol's lower cost than gasoline due to tax credits and to minimize the cost of producing the finished blend. The use of ethanol in RFG is discussed more thoroughly in Section 10 of this report.

2.4.2 Ethanol - Oxygenated Fuels

When ethanol is used as the oxygenate for oxygenated fuel programs, it is typically added to a conventional gasoline since the oxygenated fuel programs are usually only of three or four months duration each year. To meet the 2.7 wt% oxygen requirement of the oxygenated fuel program requires 7.7 v% ethanol although most companies blend at the 10 v% level since net of tax credits, ethanol has traditionally been cheaper than gasoline. This higher blend level yields the greatest economic advantage.

2.4.3 Ethanol - Conventional Gasoline

Blending ethanol into conventional gasoline still represents the largest market for ethanol sales. When blended in conventional gasoline, ethanol is almost always blended at the 10 v% level. In

conventional gasoline markets where ethanol is blended it is usually added to 87 octane regular to make a midgrade product and to a mixture of 87 octane regular and 92 octane premium to make a premium product. In areas where state tax credits are available or during periods of time when ethanol is in excess supply, it may also be blended with regular and simply sold as regular to take advantage of prevailing economics.

2.4.4 Ethanol - Sub-octane Blends

In some market areas a sub-octane gasoline is available for ethanol blending. This sub-octane basestock is usually 84 or 84.5 octane $(R+M)/2$. When ethanol is added the octane of the finished gasoline ethanol blend is 87. This sub-octane grade can be blended with premium and ethanol to achieve midgrade and premium level products. An overview of the economic considerations for the various types of ethanol blends is provided in Section 9 of this report. In addition the sub-octane product can also be blended with varying amounts of premium to make a full slate of the all hydrocarbon gasoline offerings.

The availability of sub-octane gasoline has expanded over the past few years. In fact sub-octane blends and/or RBOB are used in at least parts of twelve states. A distinction should be made on use versus availability. In some areas the terminals may offer a sub-octane grade to which the purchaser may add ethanol. In other areas the product may be offered only as a finished blend (i.e. sub-octane already blended with ethanol and sold as a finished product).

Marketers of sub-octane and RBOB will not disclose sales figures because such information is considered proprietary. The following list is of states where sub octane and/or ethanol RBOB are available as either a base fuel or where a sub-octane fuel is used to produce and sell a finished blend.

- Minnesota: Widely available. Marketers include Koch, Marathon/Ashland, and Amoco
- Kentucky: Some availability of RBOB in RFG areas

- Indiana: RBOB in Gary area, sub-octane in Indianapolis and southern areas. Marketers include Marathon/Ashland, Clark, and LaGloria
- Michigan: Sub-octane. Marketed by Marathon/Ashland
- Ohio: Sub-octane. Nearly everyone but Shell (e.g. Clark, Sun, Marathon/Ashland, etc.) offers sub-octane in at least a portion of their market and sub-octane is widely available
- Pennsylvania: There is some limited availability of RBOB
- New York: RBOB. Marketers are Tosco and Getty
- Nebraska: Sub-octane is available at the Williams Terminal in Des Moines
- Louisiana: Sub-octane in Baton Rouge area from Placid Refining
- Alabama: Sub-octane in Birmingham area from Placid Refining
- North Dakota: Sub-octane is available at the Williams Terminal in Fargo
- California: Tosco has a limited sub-octane CaRBOB program in portions of California

The availability of sub-octane in the Midwest has become widespread enough that it is shipped on the Williams Pipeline System (to 5 terminals) which has a specification for that grade (see Appendix 2-A).

Section 2.0

Gasoline Ethanol Blends

Overview of Current Industry Practices

Specific References

1. Petroleum Inventories and Storage Capacity, National Petroleum Council, June 1984
2. Energy Information Administration
3. Petroleum Storage and Transportation, Volume V, Petroleum Liquids Transportation, National Petroleum Council, April 1989
4. Petroleum Storage and Transportation Volume IV - Petroleum Inventories and Storage, National Petroleum Council, April 1989
5. Assessment of Ethanol Infrastructure for Transportation Use, EA Energy Technologies Group, April 1991
6. The Use of Ethanol in California Clean Burning Gasoline, Ethanol Supply/Demand and Logistics, Downstream Alternatives, February 1999
7. Monthly Fuel Production and Stocks by PADD, Monthly Oxygenate Report, Energy Information Administration

General References

Conversations with ethanol and petroleum industry personnel.

Section 2.0

Gasoline Ethanol Blends

Overview of Current Industry Practices

Appendix 2-A

Williams			
<u>SPECIFICATIONS FOR V-GRADE SUB-OCTANE UNLEADED GASOLINE</u>			
(Conventional Gasoline-This product does not meet the requirements for reformulated gasoline and may not be used in any reformulated gasoline covered area)			
<u>Specification Points</u>	<u>ASTM Test Method</u>	<u>Shipments (From Refineries)</u>	<u>Deliveries (At Terminals)</u>
Color		Undyed	
Volatility <u>1/</u>			
Mercaptan Sulfur, weight %, max <u>2/</u>	D 3227	0.004	
Hydrogen Sulfide	D 3227	None	
Corrosion, Copper Strip at 122°F, max	D 130	1	
Gum Existent, mg/100Ml	C 381	4	5
Oxidation Stability, min	D 525	240	180
Phosphorous, grams/gal, max	D 3231	0.003	0.005
Lead, grams/gal, max	D 3237, D 5059	0.010	0.05
Research Octane (R), min	D 2699	<u>4/</u>	<u>3/</u>
Motor Octane (M), min	D 2700	<u>4/</u>	<u>3/</u>
Anti-Knock Index (R+M)/2, min		<u>4/</u>	<u>3/</u>
Sulfur, wt percent, max	D 2622 or equivalent	0.10	
Acidity	D 1093	Negative	
Odor <u>5/</u>		nonoffensive	
<u>1/</u> Refer to Seasonal Gasoline Volatility Schedule, pages 13, 14, 15, 16, and 17 of Section 2.			
<u>2/</u> The Mercaptan Sulfur determination may be waived if the result of the Doctor Test (ASTM D 4952) is negative.			
<u>3/</u> Results on deliveries may be lower by amounts given in the ASTM methods for 95% confidence of reproducibility obtained by a single result in a second laboratory, the first being the laboratory of origin.			

Williams

SPECIFICATIONS FOR V-GRADE SUB-OCTANE UNLEADED GASOLINE

4/ Shipments will be required to meet one of the two options for octane certification from September 1 to April 30.

Option 1: The base gasoline will be certified with 7.8% ethanol to meet a minimum 87.0 R+M/2

Option 2: Meet a minimum 85.0 R+M/2 on the base gasoline
Research octane, min 86.0
Motor octane, min 79.0

Octane requirement from May 1 to August 31

Research octane, min	85.0
Motor Octane, min	79.0
R+M/2	84.0

5/ Gasoline exhibiting the odor of dienes are considered offensive and are not acceptable.

Additives and Dyes: V-grade gasoline shipments shall be undyed and meet the requirements of Paragraphs I and II in Specification, "Additive Requirements for Gasoline and Petroleum Fuel Oil Distillate Products", of the carrier.

Oxygenates: The use of any oxygenate blending component is prohibited.

Method of Inspection: Sampling and sample handling are published in 40 CFR Part 80 Appendix D pages 11886-11896 Vol. 4 No. 54 Wednesday, March 22, 1989, or ASTM 4814.

Effective January 16, 1998

Section 3

Ethanol Transportation Modes and Cost Estimates

3.0 Ethanol Transportation Modes & Cost

This section examines the current transportation modes used to transport ethanol to various geographic areas and markets, provides estimates of cost by mode to various areas, and estimates the percent of shipments currently moved by each mode. The efficiency of each mode for present day and future shipments is also discussed. Finally there is a brief discussion about any differences between this report and works of similar focus that have been completed by others.

3.1 Ethanol Transportation Modes

Ethanol is currently shipped to its destination markets by either transport truck, rail, or river barge, and in some cases a combination of river barge/ocean barge. The mode of transportation selected depends on the geographic location (distance) and whether or not the market is accessible by waterborne cargo. Operational efficiencies and cost factors must also be considered as must the storage capacity of the destination terminal. Each transportation mode is discussed in greater detail below.

3.1.1 Pipeline

Ethanol is not currently shipped via pipeline. While such movements would, in many cases, be the most economical method of delivery, there are operational considerations and challenges that must be addressed. Trial shipments of ethanol have been successfully shipped via pipeline. However current ethanol shipment volumes are generally considered too low to justify the cost and operational challenges necessary to move ethanol by pipeline. This could change in a vastly expanded program. Shipping ethanol (and gasoline ethanol blends) via pipeline are discussed in greater detail in the next section of this report.

3.1.2 Ocean Barge/Ship

Moving large volumes of ethanol to coastal markets is sometimes accomplished via ocean barge or ship. Product is shipped to New Orleans by river barge where it is staged and then shipped to the east coast markets by ocean barge or west coast markets via ship (through the Panama Canal). This process would essentially be carried out as follows:

West Coast Destinations: Ethanol is shipped down the Mississippi via multiple 10,000 barrel river barges. The product is then staged at a terminal facility in New Orleans until sufficient quantities of ethanol are accumulated to warrant shipment. Such shipments could be as small as one compartment of an ocean going vessel or as large as an entire ship. This depends to some degree on the capacity of the destination terminal(s). Shipments could be as small as one million gallons or as large as 10-12 million gallons.

Once staged in New Orleans and loaded on to ships, the product goes south through the Panama Canal and then north to west coast ports. The entire process requires slightly more time than rail shipments. Shipping from Illinois to New Orleans via river barge requires approximately 14 days while shipping from New Orleans to west coast ports via the Panama Canal requires at least 20 days. Consequently the entire process takes a minimum of 34 days.

It should be noted that the movement of ethanol by ship between U.S. ports requires use of Jones Act vessels. The Jones Act (Merchant Marine Act of 1920) requires that product shipped between U.S. ports must be shipped in vessels that are U.S. owned, flagged, and manned and must have been built in the U.S. There are a limited number of “clean product” Jones Act Vessels” and under the 1990 Oil Pollution Act (OPA 90) a number of vessels were scheduled to be retired/scrapped in calendar year 2000⁽²⁾. However the amount of ethanol that is or would be moved by such vessels is relatively small in comparison to the total clean products moved by ship.

The cost of moving ethanol by marine cargo does not present major economic incentives over rail. While the cost of shipping ethanol from New Orleans to the west coast in a Jones Act vessel could be as low as 8 to 10 cents per gallon, this process also has the cost of river barge movement from the plant to New Orleans and a terminaling fee to stage product prior to loading the ship. Ethanol plant transportation personnel have indicated that total marine cargo movement costs are nearly the same as rail or may, in some cases, present a slight cost advantage. The main benefit of marine cargoes is for the destination terminal which in many cases prefers single shipments of large quantities as opposed to the more time consuming task of spotting, inspecting, and unloading numerous rail cars. Additionally, this reduces strain on the ethanol producers rail car fleets.

East Coast Destinations: East coast destinations would be handled in similar fashion except that upon leaving the New Orleans staging facility, product would be shipped in ocean barges rather than ship. For the densely populated Northeast, the cost of this process would be in the range of \$0.10 to \$0.12 per gallon⁽³⁾ depending on how far north the destination terminal is. In some cases this does represent a savings over rail shipment. Shipments of product by both ship and ocean going barge are typically subject to cargo quality inspections/tests by an independent company (at the destination terminal).

3.1.3 River Barge

River barges are used to transport ethanol to destination terminals accessible by river, primarily the Mississippi River and its tributaries. Shipments north of Illinois cannot be made in the coldest winter months since the Mississippi River is normally frozen.

River barges are ~10,000 barrel capacity. Usually several barges are moved together in one unit. The other barges in a given movement could contain ethanol or other products. The barges are shipped to destination terminals where they are unloaded into suitable storage tanks. Usually some ethanol is blended into gasoline at these terminals and delivered to retail. Typically a portion of the ethanol is also delivered to smaller outlying terminals by transport truck. Depending on the volume of the shipment, product quality may be verified through tests by independent cargo inspection companies or by terminal personnel.

3.1.4 Rail

Ethanol is also moved from the production facility to destination terminals via rail. At the current time, volume usually dictates less than unit train movements. Consequently, today's shipments may typically be as small as one rail car but are often multiple car movements of 3 to 25 cars. Rail cars in current use have a capacity of approximately 29,000 gallons. These shipments, of one or more rail cars, are delivered directly to a terminal capable of receiving rail cars. From there ethanol is blended with gasoline for delivery to retail/end users via transport truck. In some cases full transport trucks of ethanol may also be taken from the terminal to smaller terminals that do not have rail receipt capability.

Rail shipment is generally the most cost effective delivery method for medium range distance and longer distance destinations incapable of receiving product by marine cargo (i.e. 300 to 2,000 miles). Because of the number of units and smaller volume per unit (compared to barges) as well as the more labor intensive efforts for cargo unloading and inspection, rail shipments do require more effort at the terminal level.

It should be noted that in an expanded ethanol blending program rail cars would be shipped via unit train. For instance GATX has what they refer to as their “rolling pipeline”. GATX has indicated⁽³⁾ that their typical unit train shipment would consist of 78 cars of 34,000 gallon capacity each (2.65 mm gallons) pulled by dedicated power. These cars are capable of unloading at 3000 gallons per minute (GPM) enabling eighteen cars to be unloaded in four hours. Consequently, the entire unit train could be spotted and unloaded in one day. With dedicated power unit trains, the turnaround to deliver product from the Midwest to the west coast and return the empty cars would be two weeks or less. GATX has indicated they could expand their rolling pipeline program and that lead time for manufacture of additional rail cars would be approximately 6 months.

3.1.5 Transport Truck

About one-third of fuel grade ethanol is delivered to the destination terminal by transport truck. Typically a transport truck picks up ethanol directly from the plant. The delivery capacity will generally be 7800 to 8200 gallons and product is delivered directly to the destination terminal. For short term distances (i.e. under 300 miles) transport truck is usually the most efficient and cost effective delivery mode.

In distant markets, transport trucks may also pick up ethanol at larger terminals that have received ethanol by barge or rail, and deliver to area terminals that either cannot take product other than by truck or that have insufficient tankage for larger quantity delivery.

3.2 Logistic Considerations

The mode of transportation selected for a given ethanol facility will depend on a number of fac-

tors. These factors include shipping costs, the destination terminal, the size of shipment, customer preferences, and whether the plant's shipping capability includes rail and barge. Recently greater consideration is also being given to product exchanges.

3.2.1 Shipping Costs

Since ethanol has traditionally been priced on a destination market basis, the plant operator/ethanol marketer generally absorbs the cost of shipment. Like any business, ethanol producers try to utilize the lowest cost shipping method available within the confines of customer preferences and shipping capabilities. The current estimated split among delivery modes⁽⁴⁾ is:

30-35% via truck

30-35% via rail

30-35% via barge/ship

Current transportation choices reflect the large amount of ethanol blending that occurs in the Midwest, near production facilities. Expansion in more distant markets (e.g. coastal markets) would increase the amount of product delivered via rail and barge.

Appendix 3-1 provides information on ethanol shipping costs to various markets by the most likely mode of delivery. The Appendix provides costs to numerous destination markets which should provide a basis for accurate estimated delivery costs in nearly every state.

3.2.2 Destination Terminal

The destination terminal plays a role in the selected transportation delivery mode based on distance and its receipt capabilities. The greater the distance, the more economically advantageous it becomes to ship ethanol by rail or waterborne cargo. Barge and ship quantities are usually preferred by terminal operators with the capability to receive by this mode. This is because handling the same volume by rail requires much greater effort to spot, inspect, unload, and prepare the rail cars for return. Distant terminals that cannot receive waterborne shipments but have rail capability would consider rail

car delivery the next best alternative. Terminals in close proximity to ethanol production facilities generally receive shipments by transport truck.

Terminal receipt capabilities also includes storage capacity. The volume of the delivery must be small enough to fit into available storage capacity. An example here would be that if a terminal only had a 5,000 bbl storage tank they obviously could not receive a 10,000 bbl barge shipment and rail or truck delivery would therefore be necessary.

3.2.3 Shipment Size

The larger the shipment the greater the incentive to use barge or barge/ship combinations if the destination terminal has the necessary receipt capabilities.

3.2.4 Customer Preference

The terminal operator may have a preferred mode of delivery based on operational considerations such as manpower, storage capability, and volume demand.

3.2.5 Ethanol Plant Shipping Capabilities

Some smaller ethanol plants ship exclusively by truck. Larger land locked plants ship by rail and truck, while larger plants located on the water ship by barge, rail, and truck. The following table represents a breakdown of currently operating plants by size category.

Table 3-1 Plants by Production Size (mmgy)	
<u>Size</u>	<u>Number of plants</u>
up to 5.0	20
5.1 to 10.0	4
10.0 to 25.0	17
25.1 to 50.0	7
50.0 +	10

Very Small plants: Very small plants (i.e. up to 10 million gallons annual capacity), especially those under 5 million gallons capacity, ship predominantly, and in some cases exclusively, by truck. At a rate of 5 million gallons and 340 stream days, this equates to 14,705 gallons daily production. It would take 2 days of production to fill a rail car and about a month's production to fill a barge. Given operational and cash flow considerations, rail shipments and especially barge shipments, are not a viable mode of transport. Even at 10 million gallons annual capacity of production these considerations would apply. No plants under 10 million gallons annual capacity currently have barge shipment capability.

Small Plants: Small plants with 10-25 million gallons of annual production capacity find rail shipments more viable. At the low volume end of this category, a rail car represents ~ one day of production, while at the upper end, a plant could load in excess of two rail cars per day. Barge shipments are still not viable, even at 25 million gallons of annual production, because this would represent nearly six days of production. No plants in this size category are currently capable of shipping by barge.

Medium Size Plants: Medium size plants with 25-50 million gallons of annual production capacity ship mostly by truck and rail. Plants at the upper end of this size category could find barge shipments viable although only one such plant currently has barge shipping capabilities.

Large Plants: Large plants, with production over 50 million gallons per year, usually ship by all three modes. Of the large plants, four have barge shipment capabilities. In addition ADM has arrangements in place for shipping from their land locked plants (Decatur and Cedar Rapids) to the Mississippi River for loading onto barges.

A breakdown of plants with water shipping capabilities currently in place are as follows:

<u>Plants</u>	<u>Production Capacity (mmgy)</u>
ADM (Clinton IA & Peoria IL)	280
ADM (Decatur IL & Cedar Rapids IA)	470 (via land to river)
Williams (Pekin IL)	100
Midwest grains (Pekin IL)	78
Staley (Louden TN)	42
Total	928

Based on the above breakdown, the ethanol industry is currently capable of shipping up to half of its production capacity via barge. These plants can therefore access those markets on or near navigable waterways. A list of major U.S. navigable waterways is included as Appendix 3-B

3.2.6 Product Exchanges

Product exchanges are routinely used in the petroleum industry to minimize transportation costs and enable companies to market in areas where they might not otherwise be able to. During the ethanol industry's developmental years product exchanges for ethanol were not widely used in part because most plants were located in the same geographic areas. Today plants are more widely dispersed. Additionally the mode of transport capabilities could now become a marketing issue.

Major ethanol producers are now in negotiations to implement product exchange agreements.⁽³⁾ These agreements will not only minimize transportation costs but will enable land locked producers to participate in more distant markets at lower costs.

For instance land locked producers in Indiana and Minnesota could provide ethanol (to a barge capable exchange partner) in truck and rail markets. In turn they could receive an equivalent exchange volume of ethanol on the east or west coasts. The barge capable producer would then be able to direct its production to waterborne cargos while smaller landlocked plants could direct their production to truck and rail markets.

The advantages to the barge capable plant would be more ethanol directed to, for instance, developing coastal markets while still serving their traditional Midwest markets. The small and/or land

locked plant would then be able to market in more distant markets where shipping costs and/or shipping volume requirements might otherwise preclude their presence.

3.3 Variation to Other Studies

In the course of preparing this report, other studies of a similar nature were reviewed. This report's transportation and cost estimates differ from most of these studies. A discussion of two of the more detailed reports follows:

The Economics of Gasoline Ethanol Blends-API Research Study #045, November 1988

This study predates the 1990 Clean Air Act Amendments and also represents a time of much lower ethanol production. In fact, API has pulled this study from its list of available documents. At the time the study was prepared, regionalized seasonal mandates of oxygenated fuels in CO non-attainment areas were not yet implemented. Some of the study's numbers were based on the fact that CO programs are seasonal and therefore require tank cleaning and preparation each season. The study also estimated a cost of 21 to 24 cents per gallon in capital and operating costs because the assumption was made that for a national mandate, ethanol would be moved by pipeline. It estimated a cost of 15 cents per gallon of ethanol for transportation and blend costs which are higher than currently experienced in actual practice.

With the ethanol volumes currently available, or likely to be available in the future, it is not likely that ethanol or gasoline ethanol blends would be transported by pipeline except in markets where such products achieve very high volumes.

Conversely, this report is based on actual costs of moving ethanol by the current modes utilized for today's markets.

As such, the costs in this report are lower reflecting in-use practices, and of course, much greater volumes, than were in use in 1988.

Assessment of Ethanol Infrastructure For Transportation Use, EA Energy Technologies Group, April 1991

Part of the variations between EA Energy's assessment and that of DAI's is simply an issue of the time frames in which the reports were prepared. EA Energy's report dates to 1991 whereas this report was prepared in early 2000.

Again, some variations are attributed to the assumptions made. EA Energy assumed 48% of ethanol would be moved by pipeline. Assumptions for E-85 use were much greater than what has been experienced. The study also assumed commercialization of ETBE which has not happened. But the main variation is simply that EA Energy's report is based on the assumption that 8 bgy of ethanol would be used in transportation fuels in 2010. Their report assumes much larger volumes of ethanol sold in the coastal markets than is currently expected and this of course raises overall transportation costs. They also assumed 12% movement by barge where today such movements represent 30-35%.

In short, the fact that EA Energy had to make assumptions and projections into the future versus our report which focuses on current in-use practices and costs results in significant differences in transportation and logistic costs.

Section 3: Ethanol Transportation Modes and Cost Estimates

References

1. U.S. Petroleum Refining-Meeting Requirements for Cleaner Fuels and Refineries, Volume I Analysis and Results, National Petroleum Council, August 1993
2. RFG/MTBE Issues and Options in the Northeast, comments of Robert E. Reynolds, May 11, 1999
3. Dan Penovich (GATX) speaking at the Sacramento DOE Workshop, October 5, 1999
4. Private conversations with major ethanol producers
5. Confidential information provided by ethanol producers

General References

The Economics of Gasoline Ethanol Blends, Research Study #045, American Petroleum Institute, November 1988

Assessment of Ethanol Infrastructure for Transportation Use, EA Energy Technologies Group, April 1991

Section 3: Ethanol Transportation Modes and Cost Estimates

Appendix 3-A Ethanol Transportation Costs

Costs by Mode & Geographic Locale ⁽¹⁾			Origination Point-Illinois	
City	Ship/Ocean	Barge-Cost	Truck-Cost	Rail-Cost
	<u>Barge-Cost⁽²⁾</u> \$/gal	<u>Barge-Cost</u> \$/gal	<u>Truck-Cost</u> \$/gal	<u>Rail-Cost</u> \$/gal
Albuquerque NM	n/a	n/a	n/a	0.125
Atlanta GA	n/a	n/a	n/a	0.135
Baltimore MD	n/a	n/a	n/a	0.100
Birmingham AL	n/a	n/a	n/a	0.110
Boise ID	n/a	n/a	n/a	0.125
Butte MT	n/a	n/a	n/a	0.145
Cheyenne WY	n/a	n/a	n/a	0.120
Charleston SC	n/a	0.100e	n/a	0.135e
Charlotte NC	n/a	n/a	n/a	0.130e
Chicago IL	0.025	n/a	0.040	n/a
Cincinnati OH	n/a	n/a	n/a	0.060
Columbus OH	n/a	n/a	n/a	0.055
Dallas TX	n/a	n/a	n/a	0.085
Denver CO	n/a	n/a	n/a	0.065
Des Moines IA	n/a	n/a	0.065	0.035
Detroit MI	n/a	n/a	n/a	0.090
Fargo ND	n/a	n/a	n/a	0.095
Houston TX	0.400e	--	n/a	0.075
Indianapolis IN	n/a	n/a	0.050	n/a
Jackson MS	n/a	n/a	n/a	0.115
Jacksonville FL	n/a	n/a	n/a	0.140
Kansas City MO	n/a	n/a	n/a	0.060
Las Vegas NV	n/a	n/a	n/a	0.145
Little Rock AR	n/a	n/a	n/a	0.100
Los Angeles CA	n/a	0.140-0.150	n/a	0.150
Memphis TN	0.040	n/a	n/a	0.060
Miami FL	n/a	0.080e	n/a	0.145
Milwaukee WI	n/a	n/a	0.065	0.070
Minneapolis MN	0.040e	n/a	n/a	0.055
Mobile AL	n/a	0.080e	n/a	0.115
Nashville TN	n/a	n/a	n/a	0.080
New Orleans LA	0.040	n/a	n/a	n/a
New York Harbor NY	n/a	0.110e	n/a	0.120e
Omaha NE	n/a	n/a	n/a	0.070
Philadelphia	n/a	n/a	n/a	0.120e
Phoenix AZ	n/a	n/a	n/a	0.120
Pittsburgh PA	n/a	n/a	n/a	0.100e
Portland ME	n/a	0.130e	n/a	0.140e
Portland OR	n/a	0.150-0.160e	n/a	0.135
Reno NV	n/a	n/a	n/a	0.145
Salt Lake City UT	n/a	n/a	n/a	0.140
San Antonio TX	n/a	n/a	n/a	0.085
San Francisco CA	n/a	0.140-0.150e	n/a	0.135
Seattle WA	n/a	0.150-0.160e	n/a	0.135
Shreveport LA	0.040	n/a	n/a	n/a
Sioux Fall SD	n/a	n/a	n/a	0.090
St. Louis MO	0.020	n/a	0.035	0.035
Tulsa OK	n/a	n/a	n/a	0.090
Wichita KS	n/a	n/a	n/a	0.085

(1) Actual shipping costs as verified unless estimate indicated by an e following the cost listing
(2) Tranship through New Orleans

Domestic Traffic for Selected U.S. Inland Waterways in 1998 (Millions of Short Tons, Billions of Ton-miles ¹ and Change from 1997)			
Waterway	Length (miles)	Tons 1998	Ton-miles 1998
Atlantic Coast			
Atlantic Intracoastal Waterway	793	3.8	0.2
Intercoastal waterway from Jacksonville to Miami FL	349	0.7	**
Gulf Coast			
Alabama-Coosa Rivers, AL and GA	305	0.7	**
Bayou Teche, LA	107	1.9	**
Black Warrior and Tombigbee Rivers, AL	449	24.2	5.6
Chocolate Bayou, TX	13	4.0	**
Gulf Intracoastal Waterway	1,109	113.6	18.5
Morgan City-Port Allen Route, LA	64	24.0	1.5
Petit Anse, Tigre, Carlin Bayous, LA	16	2.3	**
Tennessee-Tombigbee Waterway, AL and MS	234	8.5	1.6
Mississippi River System			
Allegheny River, PA	72	3.9	**
Atchafalaya River, LA ²	121	12.5	0.8
Big Sandy River, KY and WV	27	19.8	0.1
Cumberland River, KY and TN	381	23.3	2.3
Green and Barren Rivers, KY	109	5.9	0.3
Illinois Waterway, IL	357	41.8	8.7
Kanawha River, WV	91	23.0	1.6
Kaskaskia River, IL	36	0.8	**
McClellan-Kerr Arkansas River Navigation System	462	12.0	2.6
Mississippi River, Minneapolis, MN to Mouth of Passes	1,814	324.0	177.1
Minneapolis, MN to Mouth of Missouri River	663	79.6	15.7
Mouth of Missouri River to Mouth of Ohio River	195	115.8	19.4
Mouth of Ohio River to but not including Baton Rouge, LA	720	195.9	118.8
Baton Rouge to but not including New Orleans, LA	130	219.8	7.2
New Orleans, LA to Mouth of Passes	106	129.5	6.0
Missouri River to Sioux City, IA	732	8.3	0.8
Monongahela River, PA and WV	129	36.8	1.2
Ohio River	981	241.9	56.8
Ouachita and Black Rivers, AR and LA	332	1.6	0.2
Red River, LA ²	212	3.8	0.3
Tennessee River	652	52.0	7.7
Pacific Coast			
Columbia River, Mouth to Snake River, OR and WA	324	17.2	2.4
Above Dalles Dam to McNary Lock and Dam	100	9.2	0.8
Tributaries above McNary Lock and Dam to Kennewick, WA	39	7.1	0.2
Snake River to Lewiston, ID	141	5.8	0.4
Willamette River above Portland and Yamhill River, OR	118	1.1	**
----- 1. ** denotes ton-miles of less than 100 million. 2. Revised distances from previous year based on reviews of project waterway navigable mileage during CY 1999. -----			
Source: U.S. Army Corps of Engineers, Navigation Data Center, May 2000			

Section 4

Shipping Ethanol and Gasoline Ethanol Blends via Pipeline

4.0 Shipping Ethanol and Gasoline Ethanol Blends via Pipeline

Ethanol and gasoline ethanol blends are not currently transported via pipeline because of a number of operational and technical considerations.

4.1 Technical Considerations

Ethanol and gasoline ethanol blends have been moved by pipeline on a test basis.^(1, 2, 3, 4) In addition to the ethanol tests, pipeline shipments of Oxinol® and gasoline Oxinol® blends were made by Arco Chemical/Arco Pipeline^(5, 6), including tests in 1982 followed by commercial shipment of Oxinol® blends totaling 35 million barrels in the 1982/1983 time frame. Oxynol® is a mixture of 50% methanol and 50% gasoline grade Tertiary Butyl Alcohol (TBA) and requires many of the same technical and logistical considerations as ethanol. The Arco program also helped identify technical obstacles to shipping alcohol and gasoline alcohol blends and ways to overcome them.

From the above tests and other available information, the technical considerations and concerns can be identified. These include the following:

4.1.1 Water Tolerance

Alcohols, including ethanol, have an affinity for water. They will pick up and suspend water that is present in the pipeline system and terminal tankage. The pipeline system is a “wet” system containing residual amounts of moisture from petroleum products. In the case of neat denatured ethanol shipments, the product could pick up excessive water.⁽¹⁾⁽²⁾

Ethanol with an excessive water content can phase separate from the gasoline to which it is blended. The maximum water level permitted by ASTM D 4806 is 1 v%. Similarly, in the case of gasoline ethanol blends the ethanol in the blend would pick up moisture. If the water level exceeds ~ 0.5% of the total blend volume it would induce phase separation.⁽⁷⁾ Once an ethanol blend phase separates it is extremely difficult and usually impossible to reblend. In many cases the ethanol/water bottoms must be disposed of in accordance with hazardous waste regulations.

Depending upon the pipeline configuration, pigs (see next section) can usually be run through the

pipeline to ensure minimal moisture levels⁽⁵⁾. In the test programs run thus far (both ethanol and ethanol blends), moisture levels were kept to acceptable levels. However it should be noted that these test programs utilized preparatory steps and monitoring levels in excess of what would be considered normal. In addition these tests were on specific pipeline segments that may or may not be representative of the majority of the U.S. finished products pipeline system.

4.1.2 Product Contamination/Discoloration

Ethanol has a stronger solvent effect than petroleum products shipped through the pipeline system. Consequently ethanol and gasoline containing ethanol will remove water, rust, gums, and other contaminants in the system. This can result in contamination and discoloration of the ethanol or gasoline ethanol blend. In some cases, a small portion of the trailing product (the product behind the ethanol or gasoline ethanol blend in the system) may also be contaminated. When this occurs it is necessary to downgrade out of spec products. Interface downgrade is that portion of product between two products in the pipeline that no longer meets the specification of either product. In some cases, this is handled by simply transferring to a lower specification product. For instance if the octane of a premium gasoline interface is lower than premium but higher than regular it could be downgraded to regular since it exceeds that specification. In the case of ethanol and gasoline ethanol blends, such options do not currently exist so it is important that product arrive on specification.

In test shipments, this has been addressed by cleaning the applicable pipeline segment with scrapper pigs followed by Super Pigs (scrapper pigs are brush type devices inserted into the pipeline to scrape and clean the system, super pigs are cup type devices which are more suitable for pushing sludge and water from the system) to minimize contaminants. However not all systems are set up for routine launch and receipt of pigs.

Once ethanol or gasoline ethanol blends are routinely shipped on the pipeline, it is likely that contaminants would be at very low levels precluding the need for frequent use of scrapers. Interface problems could also be minimized by using cup pigs between gasoline ethanol blends or ethanol and other products although this may not be needed if the system is frequently used for ethanol or gasoline ethanol blends.

4.1.3 Corrosion

One of the issues that remains somewhat of an open technical issues is pipeline corrosion. The new pHe specification contained in ASTM D 4806 should eliminate some concerns related to corrosion. The pHe number for alcohol solutions is a measure of acid strength and is not directly comparable to pH values for water solutions. However ethanol's different electrical conductivity may have an effect on corrosion rates and any such effect cannot be thoroughly assessed based on the limited test shipments that have been made thus far. It is likely that if routine shipments are initiated, the pipeline companies would install metal corrosion coupons at various locations to monitor corrosion protection.

Ethanol and gasoline ethanol blends have also been shown to strip the corrosion inhibitor coating on the interior pipeline surface. This could be addressed by either development of more robust corrosion protection additives/coatings or by heavier dosage of corrosion inhibitors in the product following ethanol or gasoline ethanol blend shipments.

4.1.4 Materials Compatibility

The test programs conducted thus far have not indicated any materials compatibility problems with nonmetallic parts in the pipeline system.⁽¹⁾⁽²⁾⁽³⁾⁽⁴⁾⁽⁵⁾⁽⁶⁾ Various elastomers (i.e. rubber and plastics) are used in the pipeline system. These are believed to be compatible with both gasoline ethanol blends and ethanol. However once frequent routine shipments begin, it is likely that a periodic and routine inspection program will be needed until such compatibility is confirmed for long term use.

4.2 Operational Considerations

There are operational considerations when shipping ethanol or ethanol blends. In many cases the reality of these operational considerations has resulted in pipeline companies deciding against attempting to address technical considerations. Operational considerations include the following:

4.2.1 Fungibility

Ethanol and gasoline ethanol blends are not shipped on a fungible basis. Common carrier pipe-

lines operate largely on the principal of fungibility. Refiners put product meeting the pipeline specifications in the pipeline. Downstream they lift like products meeting the same specification but not necessarily the product they input into the system. It may be from one of the other refiners. Companies receive a like barrel for the one shipped, not necessarily the same barrel.

Along the course of its pipeline shipment, product may be pulled off in breakout tankage (for instance to move another product ahead in the shipping schedule). So fungible products are routinely mingled with one another. Fungible grades can be placed in the pipeline in relatively small patches (e.g. 10m barrels) if desired although batches are often larger, in the 25m to 50m barrel range.

However ethanol and gasoline ethanol blends would have to be shipped as a segregated batch and “tight lined”. It must bypass breakout tankage or any form of being mingled with other gasoline products because the product resulting from such mixing would not meet the pipeline specification and would not likely meet other product specifications for state and federal regulations.

It is more difficult to schedule shipments on a segregated basis which usually leads to the pipeline requiring bigger batches for such shipments. This in turn results in the need for more or larger shipping and receiving tankage (which may not be available).

4.2.2 Insufficient Volumes

The volume of ethanol sold represents about 1.2% of all gasoline sold. Gasoline ethanol blends represent about 12% of gasoline sold. In the grand scheme of total pipeline shipments this is not very much volume and is deemed insufficient for most pipelines to undertake programs to address the technical issues of shipping these products. Even in markets where gasoline ethanol blends approach 40% market share, such efforts have not been undertaken.

Ultimately, common carrier pipelines designate fungible grades to meet their customer needs. This is done through polling shippers to assess their needs. If enough shippers (representing enough volume) were to desire shipping ethanol or gasoline ethanol blends, the pipeline company would likely give serious consideration to such shipments. This is especially true in markets that might have very large ethanol market shares since shipping 90% gasoline by pipeline for 10% ethanol addition represents a 10% volume/revenue loss for the pipeline operator compared to all hydrocarbon or MTBE

blended fuels. For instance, a representative of Kinder Morgan (one of California's major pipeline carriers) commenting at the October 5, 1999 DOE Ethanol Workshop in Sacramento California, indicated they were considering ethanol shipments on their system and were investigating what all would be involved in doing so. The primary motivation cited was the loss of shipment volume/revenues that would result from the ethanol being shipped by some other mode.

It is quite likely that pipeline operators would consider shipment of ethanol or gasoline ethanol blends. However they are unlikely to do so until such time that the shipments would represent a large portion of their gasoline shipments, perhaps in the case of gasoline ethanol blends, in excess of 50% of total gasoline shipped. Given enough volume the most likely scenario for shipments would be to ship on private pipelines or specific segments of common carrier pipelines.

4.2.3 Logistics

Another important consideration is the location of the plants and destination markets in relationship to pipeline movements. Most pipelines originate in the south shipping product North/Northeast/Northwest. Conversely, most ethanol production is in the Midwest. Currently, pipeline shipments to most markets would require barge movement to the Gulf Coast, or at least southern destinations, for insertion into the pipeline and shipment north to destination markets. In many cases, this process would exceed the cost of simply delivering the ethanol to the destination market.

Again, the possibility exists for some shipments on private pipelines or specific segments of common carrier pipelines. An example would be to input ethanol in Illinois for shipment to destinations in Wisconsin and Minnesota.

4.2.4 Dedicated Pipelines

The possibility of constructing dedicated ethanol pipelines has, on occasion, been raised. However it is unlikely that such an approach could ever be pursued on a market-wide or even regional scale.

Rough estimates for current costs of constructing pipelines are one million dollars per mile.⁽⁸⁾ This cost can vary dramatically based on right of way issues, number of required pumping stations, and other considerations. It would not be possible to justify these types of costs to carry one low volume

product such as ethanol. Indeed, in recent years it has been difficult to justify new pipeline projects for multiple products representing much greater volumes than would be expected for ethanol shipments.

Again there are possible exceptions such as a short pipeline connecting an ethanol plant with a refinery or major terminal. But any such project would need to involve pipeline runs of short distances and constant ethanol volumes at very high levels.

Section 4 - Shipping Ethanol and Gasoline Ethanol Blends via Pipeline

References

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Section 5

Storage Facility Requirements for Gasoline Ethanol Blending Programs

5.0 Facility Requirements for Gasoline Ethanol Blending Programs

This section discusses storage facility requirements of ethanol and gasoline ethanol blends focusing primarily on current practice. While many elements of distribution for these products are similar to gasoline, there are some differences, especially at the terminal level.

5.1 Current Practice

Ethanol is currently blended at the distribution terminal (finished products terminal). The gasoline, whether conventional, RBOB, or sub-octane is shipped to the terminal via traditional modes (i.e. pipeline, barge, or ship). The ethanol is shipped to the terminal via transport truck, rail car, barge, or ship. Each is stored in its respective tank with blending usually occurring in a blending unit at the transport loading rack. Once blended at the rack, the distribution of the gasoline ethanol blend is identical to gasoline in so far as storage requirements are concerned. It is shipped to retail and dispensed through the same tanks and dispensers as the gasoline product it replaces. Since under current practices, ethanol and gasoline ethanol blends do not enter the picture prior to the distribution terminal, there are no major costs prior to that point (RBOB and sub-octane base fuels may result in additional costs prior to the terminal-see discussion 5.3).

5.1.1 Terminal Tankage and Equipment

Assuming ethanol is blended to conventional gasoline at the terminal level, the primary needs would be for an ethanol storage tank, piping modifications, and blending units. It may also be necessary to make modifications to accommodate receipt of ethanol product (e.g. rail spur, transport truck unloading).

In many cases, an existing tank can be reassigned to ethanol storage although modification may be necessary. When selecting a tank there are also operational considerations.

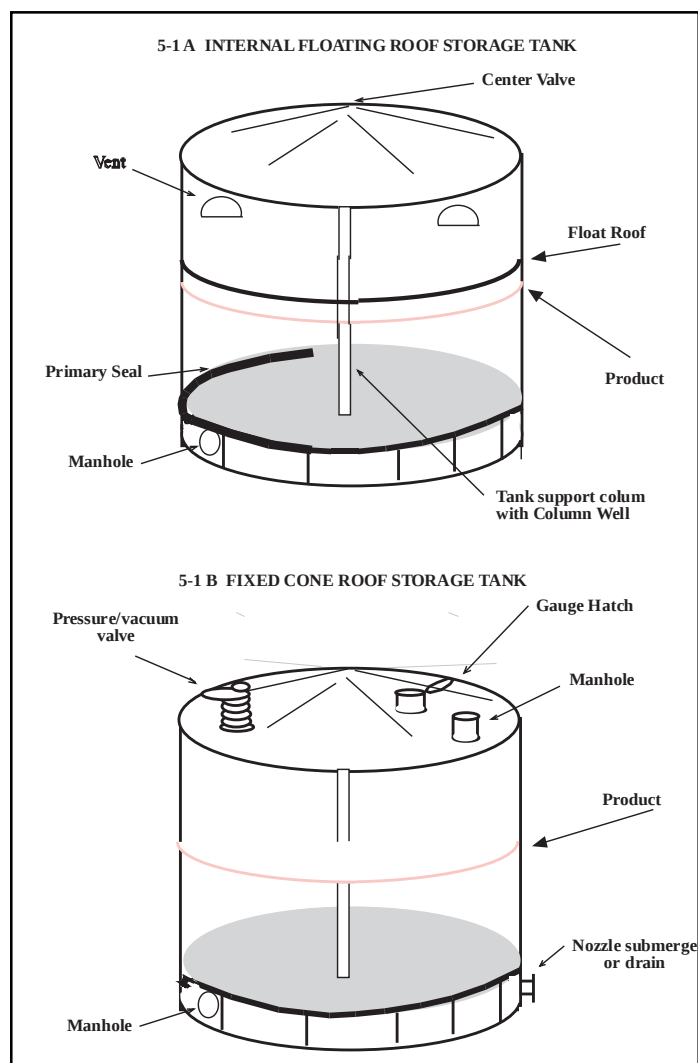
Tank Size: The tank must be of sufficient size to meet not only necessary demand but to receive the minimum tender size while still having adequate working inventory. For instance, if shipments are to

come in as a 10,000 barrel barge and demand is 1,000 barrels per day, the terminal operator will probably consider 5,000 barrels of inventory as a back up supply plus 10,000 barrels of space for product receipt which then requires a minimum of 15,000 barrels storage capacity.

Piping Configuration: The piping configuration must be suitable for, or be modified for, planned operations. So the tank must be piped to the blend unit and/or loading rack as well as for product receipt by one or more delivery modes. Such requirements are difficult to describe here because they will be terminal specific.

Tank Types: When a tank is selected or installed it must be suitable for ethanol storage. Tanks used for storing ethanol (or gasoline ethanol blends) should have a fixed roof with a floating internal cover^(1, 2). In the case of ethanol, a small cone roof tank without the floating internal cover could be used providing it meets applicable air quality requirements^(1, 2). To minimize moisture absorption and vapor loss, a 16-ounce pressure 1-ounce vacuum pressure vacuum vent should be installed in the tank. The pressure/vacuum vent provides for pressure equalization under certain conditions but also stays closed under certain pressures to prevent vapor loss. In addition it reduces the intake of ambient moisture when product is being removed from the

tank. It should be verified that the tank design accommodates this type of pressure vacuum vent. Figure 5-1 A and B depict the two types of tanks currently recommended for ethanol storage.



As with any storage tank, proper cleaning and preparation is also required and the American Petroleum Institute (API) offers guidance for tank cleaning and preparation.

Blending Unit/System: Ethanol could simply be splash blended into the truck. This would only require installation of the piping from the storage tank to the loading rack (if necessary) and a separate meter and loading arm. While this was the norm in the early years of ethanol blending, today the preferred method is computer controlled or fixed ratio in-line blending. Such systems supply accounting, inventory control, and ease compliance documentation with various regulations (e.g. antidumping, oxygenated fuel requirements, and reformulated gasoline regulations). Different types of blending systems can be utilized.⁽¹⁾ In some cases terminals may be able to modify existing blending systems, such as those used to blend regular and premium to make midgrade, to accommodate ethanol blending.

Skid Mounted Units: One commonly used injection system is the skid mounted unit. These units are brought in pre-assembled and simply piped to the applicable tanks and loading racks. These units are similar to the system used to blend detergents and additive packages at the terminal level. Within this category there are various types of blending units such as sequential, dual preset, wild stream, and selectable wild stream. ⁽⁵⁾

There are also more sophisticated (and more expensive) systems that resemble the blending system used in a refinery or lube oil plant. An example here would be Waugh Controls Petro Blend Units.⁽⁶⁾

Variable Capacity/Proportioning Systems: A terminal operator could design and install their own blending and delivery system using variable capacity pumps. These systems are typically mechanically designed and set to flow the correct proportions of each liquid to achieve the desired blend.

As with the previously described systems, the end result is the same, a correctly proportioned amount of each product to achieve the desired blend level.

Loading Rack Requirements: From the blending unit the blend is pumped to the meter and loading rack. If the gasoline ethanol blend is simply displacing an existing product it could be moved through an existing meter and loading rack arm. If it is a new additional product, installation of a new meter and loading arm may be necessary.

5.2 Estimated Costs at Terminal Level

Costs of modifications will vary widely from one terminal to another depending on the extent of modification needed, the volume of ethanol handled and the mode of receipt.

Tanks: New tankage, if required, would cost about \$450,000 for a 25m barrel tank⁽³⁾. This tank size should be adequate for most terminals to store sufficient ethanol supplies. Larger tanks, up to 100m barrels, could be estimated by using a scale up factor of 0.7⁽³⁾ (e.g. a 50m barrel tank would cost approximately \$765,000). It is unlikely that tanks in excess of 100m barrels capacity would be required in many instances.

Blending Systems: Estimates for blending systems and necessary piping modifications, meters, rack modification, etc. cover a fairly broad range from about \$150,000 to \$400,000^(3, 4).

Product Receipt: For terminals receiving product by transport truck, modifications to accommodate such receipt would be minimal, often under \$10,000. However terminals receiving product by rail or barge may have more complicated modifications such as adding delivery lines, or installing a rail spur. Such modifications have been estimated to be as high as \$300,000 per terminal⁽³⁾ in the case where a rail spur addition is necessary.

While these costs sound expensive, if one looks at it on a cost per gallon basis, these are relatively insignificant sums. For instance, combining the above investment sums for a 25m barrel tank, blending system/piping modifications, and a rail receipt facility results in high side cost estimates of approximately one million dollars. However if one assumes 24 inventory turns per year for ten years, this equates to 6 million barrels of throughput or a cost of \$0.166 per barrel of ethanol (\$0.004 per gallon). In turn, this equates to only \$0.0004 per gallon of gasoline ethanol blend containing 10% ethanol. After amortizing the initial investment, this would equate to \$0.294 per barrel (\$0.007 per gallon) for ethanol or \$0.0007 per gallon of gasoline ethanol blend (at 10 v% ethanol).

5.3 Sub-octane Base Fuel Blending and RBOB

When ethanol is simply blended to conventional gasoline, the only storage facility costs are for the aforementioned items to receive, store, and blend the ethanol. However in some cases ethanol may be blended to a special fuel designed to more fully capture its octane value, i.e. a sub-octane base fuel. In addition, when ethanol is used in reformulated gasoline programs, it must be blended to a base gasoline which, when blended with ethanol, will fully meet all the reformulated gasoline requirements. Such fuels are defined in regulatory language as reformulated blend stock for oxygenate blending (RBOB).

When sub-octane fuels or RBOB are employed as the basestock in an ethanol blending program, there are additional considerations. These fuels cannot be commingled with other gasoline because the resultant product would not meet product specifications and would also fail to meet reformulated gasoline requirements.

Consequently these sub-octane fuels and RBOB are not fungible grades within the system and they may need to be shipped on a segregated basis until the volume of such shipments is sufficient for the pipeline operator to designate a fungible product code for them.

If shipped as a segregated product, sub-octane gasoline and RBOB would face some of the aforementioned operational obstacles for shipping ethanol (the technical obstacles mentioned would not be applicable). This would include the need to avoid commingling of product in breakout tankage along the pipeline system and possibly a requirement to ship larger batches to justify its special treatment.

At the terminal level these products may or may not require additional tankage. If the sub-octane fuel or RBOB is replacing another grade of gasoline, no requirements beyond those for handling the ethanol are needed. If however the terminal operator intends to carry its traditional hydrocarbon fuels plus a sub-octane fuel or RBOB, then an additional tank and piping would need to be reassigned or built for that product. Tankage costs would be similar to those identified for ethanol although it would not be necessary to have both a fixed roof and a floating internal cover.

Once at the terminal level, ethanol is blended to sub-octane gasoline or RBOB the same as to any other gasoline.

Section 5.0 Storage Facility Requirements for Gasoline Ethanol Blending Programs

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Section 6
Gasoline Ethanol Blends
Handling and Marketing Considerations for
Distributors and Retailers

6.0 Gasoline Ethanol Blends-Handling and Marketing Considerations for Distributors and Retailers

Distributors and retailers also have handling and marketing considerations when they handle gasoline ethanol blends. To the extent they are also involved in terminal facilities, those issues covered in the preceding section would apply. However there are also issues to be addressed beyond the terminal (i.e. transport, retail facility, etc.). Those items are discussed in this section.

6.1 Legal/Regulatory Compliance

Legal and regulatory compliance aspects of the petroleum business have grown increasingly complex. In some cases, a portion of these complex laws and regulations may apply to gasoline/ethanol blends. Following are some of the more important items that need to be considered by distributors and/or retailers. Note that the Appendix in Section 13 of this report includes a more comprehensive list of state laws and regulations pertaining to gasoline ethanol blends.

6.1.1 Fuel Registration

If the distributor/retailer will be the "blender of record", it will be necessary to register with the United States Environmental Protection Agency (EPA) as a fuel manufacturer and to file quarterly reports with the EPA on the product blended. The addition of oxygenates to gasoline is regulated by EPA under a series of definitions and waivers. The addition of ethanol to gasoline is limited to a maximum of 10 volume %. The base fuel for a 10% blend must be free of other oxygenates, except, EPA will permit the (unintentional) presence of up to 2 volume % MTBE. If ethanol is being used at lower levels in combination with other oxygenates in conventional gasoline or winter RFG, the total oxygen level of the blend cannot exceed 2.7 weight %. Certain states may also require that each grade of gasoline be registered with the state. Since gasoline/ethanol blends are a separate or new grade, registration would be required.

6.1.2 Fuel Volatility

As with gasoline comprised solely of hydrocarbons, gasoline/ethanol blends are subject to EPA's Phase II Fuel Volatility requirements. Phase II sets limits on the vapor pressure of gasoline sold (at retail) during a control period from June 1st to September 15th of each year. The maximum vapor pressure permitted is either 9.0 psi or 7.8 psi depending upon the area. During this control period, conventional gasoline/ethanol blends containing 9 to 10 volume % ethanol are allowed to have a vapor pressure up to 1.0 psi higher than the specified limit. During the remainder of the year, there are no federal fuel volatility requirements on gasoline ethanol blends. Some states also have fuel volatility regulations which limit vapor pressure. A portion of these states also place restrictions on distillation characteristics such as T_{50} (the temperature required to evaporate 50% of a gasoline sample). It is necessary for the distributor/retailer to ascertain if the states in which they will be selling blended fuels have any such requirements.

6.1.3 Mandatory Oxygenated Fuel Programs

The 1990 Clean Air Act Amendments require that mandatory oxygenated fuel programs be implemented in areas failing to meet the National Ambient Air Quality Standard (NAAQS) for carbon monoxide (CO) (Areas with CO exceedences resulting from a dominant stationary source can be excluded from this requirement). Affected metropolitan areas are required to implement oxygenated fuel programs during certain winter months. The applicable months of the program vary from one area to another depending on when each area has historically experienced CO exceedences. In some cases logistic considerations among interrelated areas have also been considered. The EPA has developed time frames for these programs to be in effect. Each of the areas will generally fit into one of the following control periods:

September 1-February 29

October 1-January 31

October 1-February 29

November 1-February 29

NOTE: Some states may elect to require longer control periods if they so choose.

During the applicable control period, each area will be required to implement a program that requires all gasoline sold during the control period contain 2.7 wt. % oxygen. The exact method of compliance will vary among areas. For instance, some states utilize oxygenate credits trading programs which allow oxygen content of fuels in excess of 2.7 wt % to be credited to gasolines containing less than 2.7 wt.%. Other areas may simply require a 2.7 wt.% minimum in all fuels. During the control period there are also requirements that pumps be labeled to identify that the fuels comply with the program. The specifics of these programs are rather detailed. If a gasoline/ethanol blending program is being implemented to comply with these requirements, review of the applicable regulations is necessary.

6.1.4 Reformulated Gasoline

The Clean Air Act Amendments required the nine worst ozone non-attainment areas (classified as Extreme or Severe) to implement reformulated gasoline (RFG) programs. These areas originally included the Baltimore, Chicago, Hartford, Houston, Los Angeles, Milwaukee, New York City, Philadelphia, and San Diego metropolitan areas.

Other ozone non-attainment areas (classified as serious, moderate, or marginal) may "opt-in" to the RFG program upon request of that state's governor to the EPA. Several governors have made such requests resulting in several other areas being subject to the reformulated gasoline requirements.

If the distributor/retailer is subject to RFG requirements, they must ensure that their gasoline ethanol blends meet the applicable regulations.

6.1.5 Antidumping Requirements

In conjunction with the reformulated gasoline program, EPA also implemented an antidumping program. This was done to ensure that fuel components removed from gasoline to meet RFG requirements would not simply be blended into conventional gasoline thereby increasing emissions in other areas.

Conventional gasoline represents all gasoline sold in non-control areas or in other words, all gasoline that is not regulated under the reformulated gasoline program. The rule requires that each refiner cannot produce gasoline that, on average, would increase emissions of volatile organic compounds

(VOC), oxides of nitrogen (NO_x), carbon monoxide (CO), and toxic air pollutants (TAP) when compared to the gasoline they were producing in 1990. Toxic air pollutants are defined as benzene, 1,3 butadiene, polycyclic organic matter, acetaldehyde, and formaldehyde.

If the distributor/retailer is classified as a refiner, it may be necessary, or even desirable, to include the ethanol they blend in their compliance calculations.

6.1.6 Detergent/Deposit Control Requirements

As required by the 1990 Clean Air Act amendments, EPA has also adopted regulations that require all gasolines sold contain detergents that have been shown to keep carburetors, fuel injectors, and intake valves clean. Subsequent regulations also establish the guidelines for demonstrating detergent performance.

If the distributor/retailer is the blender they will need to ensure that a sufficient amount of an approved detergent/deposit control additive is added to be compliant with these regulations.

NOTE: While most of the burden for reformulated gasoline, antidumping, and detergent programs fall on the refiner, everyone in the distribution system is, in some cases, considered liable. Therefore it is necessary to consult the applicable regulations to ensure compliance.

6.1.7 Octane Posting

The FTC requires that an octane decal be posted on each dispenser to identify the octane of the grade being dispensed. If gasoline/ethanol blends will have an (R+M)/2 (pump octane) different than the grade previously dispensed, it will be necessary to change the octane decal. Some states may also have requirements regarding posting of octane.

6.1.8 Fuel Tax

Gasoline/ethanol blends qualify for special tax treatment under certain considerations. There are various levels of tax incentives available, all of which equate to 54 cents per gallon of ethanol. The federal motor fuel excise tax for gasoline/ethanol blends is reduced dependent upon the ethanol content of the blend as follows:

<u>Ethanol Content</u>	<u>Excise Tax Reduction</u>
10.0%	5.4 cents per blended gallon
7.7%	4.16 cents per blended gallon
5.7%	3.08 cents per blended gallon

In lieu of reductions in the federal motor fuel excise tax, a credit can also be taken under the "blenders tax credit" which allows for a credit of 54¢ per gallon of ethanol used. This credit can be less advantageous than the excise tax credit and requires a higher degree of consideration to determine its usefulness. However it can be utilized for other blend ratios and has been used by some companies. Accounting personnel would need to review these regulations for their applicability to their company's operations as well as compliance with necessary accounting procedures. A few states also still offer tax incentives to encourage the sale of gasoline/ethanol blends. Distributors/retailers need to assess not only the economic benefits of these credits but any paperwork or necessary actions to properly file for them.

6.1.9 Pump Labeling

Many states require that gasoline containing ethanol be identified by placing decals on the retail dispenser. Requirements vary from one state to the next. Retailers need to determine if any pump labeling regulations apply and take appropriate action. In addition, such state regulations may require invoice disclosure in which case the distributor would need to indicate on the bill of lading or invoice that the product contains ethanol and in some cases at what volume %.

6.1.10 Administrative Costs for Legal/Regulatory Compliance

While the aforementioned legal and regulatory compliance issues may seem extensive, in fact many of them apply to all gasoline and represent no additional costs. Many others such as fuel registration and pump decals are minimal one-time costs. While the remaining items may require some attendant administrative expense, primarily for accounting type functions, these costs would be very small ranging in the few thousandths of a cent per gallon range.

6.2 Additional Considerations at the Terminal Level

If the distributor/retailer is also the terminal operator, there are some additional; considerations for legal compliance, safety and maintenance type issues.

6.2.1 Compliance Issues

If any actions taken at the terminal require EPA or other permits or filings, these should be obtained and kept on file. Also if total tankage is changed or products are altered, it may be necessary to update the terminal's Spill Prevention Plan (SPP).

Specifications and operating requirements for the terminals evaporative emissions system should be checked to ensure that they are adequate to handle any new products and/or resulting increased volumes.

Finally, if the terminal utilizes a color coding system such as the API Color Code⁽¹⁾ or other product identification system, the appropriate changes should be made to reflect any product changes.

6.2.2 Personnel, Safety, and Operating Procedures

It is necessary to familiarize the terminal personnel with any new equipment and its operation. This information will be company, terminal, and equipment specific. Additionally, any new or modified company procedure such as accounting changes should be addressed.

Safety and firefighting information should be covered and Material Safety Data Sheets (MSDS) should be posted or issued to each employee.

Information on the proper procedures for receiving ethanol should be thoroughly covered, including instructions for properly unloading rail cars and tanker trucks of ethanol. Procedures for receiving marine shipments should be covered if applicable.

In order to ensure product quality, many companies require that product be checked for "proof" and visual clarity. Checking proof with a proof hydrometer⁽²⁾ provides a general indication of alcohol and moisture content and is a test that can be performed with relative ease at the terminal. Some companies may also require testing product with a hand held refractometer. Refractive Index⁽²⁾ also provides an

indication of ethanol purity. Company procedures regarding retention of samples should be established.

Some terminals have experienced frequent filter/strainer plugging when converting to ethanol for the first time. This is due to ethanol's solvency affect which may loosen lacquers and deposits built up over years of petroleum product use. This will depend largely on the condition and cleanliness of tanks and lines, but the appropriate personnel should be advised that such occurrences are possible. Once the system is relatively clean from the initial conversion, any additional incidence of filter plugging or slow down should not be experienced.

Ethanol may loosen system deposits, that have built up over the years. It may therefore be necessary to test and/or recalibrate affected meters after the first 10 to 15 days of use to ensure accuracy of product delivery. The expense associated with terminal operations are essentially one time costs (e.g. filter replacement) and do not add significantly to product cost.

6.3 Retail Operations

Gasoline ethanol blends are delivered to the retail unit, stored in underground tanks as other products, and dispensed through standard dispensing equipment. Once converted to gasoline ethanol blends, operations are comparable to those for any other transportation motor fuel. However there are certain steps the retailer must take during the initial conversion process.

6.3.1 Retail Unit Conversion

By far the most important precautions necessary to ensure product integrity are those applicable to the retail location. Since some companies may be converting a large number of stores within a short time frame, it is advisable to have the store/station manager maintain a check list for all preparations at his/her location. Maintenance personnel should also be aware of these steps to the extent that they are responsible for those items. The key to ensuring product integrity and a successful program basically involves ensuring that materials will be compatible, that the system is clean, and that moisture contamination is avoided.

The key steps for a retail unit conversion include several actions. First it is necessary to verify that tank (or liner) material is compatible with gasoline/ethanol blends. Next, any history of water problems

should be investigated. Any water problems must be eliminated before conversion. Fill caps should be checked for a tight seal and manhole covers should be checked for proper water run off. Some submersible pumps (especially older models) may require modification to be totally compatible with gasoline/ethanol blends. In order to avoid impeller "swell" it may be necessary to upgrade seals and impellers. One should check with the equipment manufacturer to determine if their submersible pumps are compatible with gasoline/ethanol blends.

Water bottoms should be removed from underground tanks. Tilted tanks should be checked at each end. If "tank bottom protectors" have been installed, they should be removed (if possible) during pump out of water bottoms to ensure that all water is removed. Tanks, especially older tanks, should be cleaned.

All pumps and dispensers should be equipped with a 10 micron final filter. Some companies may elect to use special "water slug" filters. These type of filters are sensitive to water and will stop product flow if water is pumped through them. Shortly before delivery of the first load, tank bottoms should again be checked for water and any water should be removed. Maintenance personnel should, at this point, be utilizing water detection paste that is suitable for use with gasoline ethanol blends. Some regular water pastes are alcohol based and do not work properly in ethanol blends.

Maintenance personnel should be advised that it may be necessary to remove water bottoms and or any sludge build up during the first few days after conversion. Likewise it may be necessary to change final filters once or twice until the built up residue is removed. These activities could result in more frequent calls during the initial conversion period so maintenance personnel should be advised to take whatever steps necessary to ensure adequate response times. Materials used in the dispenser, hoses, nozzle, etc., should not present any problems since these items were upgraded, years ago, to be compatible with gasoline/ethanol blends.

It is also necessary to ensure that maintenance personnel or contractors are following correct procedures and complying with applicable laws concerning water bottoms disposal. This material is considered a hazardous substance and must be handled and disposed of according to applicable laws.

Also, some maintenance personnel could be handling water bottoms consisting of ethanol and gasoline so appropriate MSDS's should be issued.

Finally, since gasoline/ethanol blends may remove lacquer and deposits that build up in pump meters, it is advisable to recalibrate pumps/dispensers about two weeks after the initial conversion especially on older dispensers .

Beyond the above actions, there are no ongoing special considerations except taking normal steps to ensure that water does not find its way into tanks. Based on conversations with maintenance companies, oil companies, and independent retailers the average cost range for converting one retail unit with three underground storage tanks is in the \$300-\$700 range depending on whether or not a tank cleaning is required and whether or not a contractor or in-house personnel are used for certain tasks. These cost estimates do not include any maintenance expense associated with any steps to upgrade equipment for ethanol compatibility if necessary (e.g. new fill caps, submersible pump impeller). Nor do they include situations where it is necessary to pump out water bottoms more than once.

Section 6: Gasoline Ethanol Blends-Handling and Marketing Considerations for Distributors and Retailers

References

1. Using the API Color-Symbol System to Mark Equipment and Vehicles for Product Identification at Service Stations and Distribution Terminals, RP1673, American Petroleum Institute, September 1995
2. Fuel Ethanol-Industry Guidelines, Specifications and Procedures, RFA Publication # 960501, Renewable Fuels Association, January 1998

General References

Gasoline Ethanol Blends-Program Operations Guide, RFA Recommended Practice #930601, Renewable Fuels Association (Revised January 1998)

Section 7

Infrastructure Barriers for Ethanol Fuels

7.0 Infrastructure Barriers for Ethanol Fuels

There are a number of infrastructure barriers that affect the marketability of ethanol and gasoline ethanol blends. Current practice is to address these issues on a market specific or in some cases marketer specific basis. However broader solutions encompassing large market areas would be required in an expanded ethanol market. This section discusses these infrastructure barriers.

7.1 Fungibility

Most of the infrastructure barriers are a result of ethanol and gasoline ethanol blends not being treated as fungible products in the petroleum distribution system. This results in additional transportation costs and additional storage costs for the ethanol. The primary reason that ethanol and gasoline ethanol blends are not fungible is their sensitivity to water. In addition, mixing ethanol blends with non-ethanol blends will increase the vapor pressure of the non-blended fuel. Also ethanol concentrations must be kept at specific levels to qualify for the federal motor excise tax exemptions.

7.2 Pipeline Shipments

Ethanol and gasoline ethanol blends are not currently shipped via pipeline. If ethanol and especially if gasoline ethanol blends could be shipped by pipeline it would eliminate many of the downstream terminal operation costs associated with terminal blending.

There are only two methods to address this. It would be necessary to either overcome the technical and operational barriers to shipping ethanol and/or gasoline ethanol blends in the current pipeline system or necessary to build pipelines to handle these products. The latter is currently perceived as prohibitively expensive (see Section 4).

The most plausible course of action is to identify and implement solutions to the problems of shipping ethanol and/or gasoline ethanol blends in the existing pipeline infrastructure or portion thereof.

7.2.1 Pipeline Shipments of Gasoline Ethanol Blends

The most beneficial situation for ethanol expansion would be to ship gasoline ethanol blends since

this would eliminate the need for a separate storage tank for the ethanol as well as the need for blending units at the terminal level. How obstacles to pipeline shipments are approached will depend to some degree whether a system is private (owned and operated by one company servicing primarily their own system) or a common carrier system (i.e. several shippers utilizing the same system).

In a private system the operator/shipper could convert enough of their system to justify shipping gasoline ethanol blends within their system and could control the flow and sequencing of product.^(2, 3, 4) This would also make control of moisture in the system more manageable. Such an approach is more likely to work when shorter lines with little or no breakout tankage are utilized between the refinery and the destination market, as an example a northeast refinery serving a large market such as New York.

In a common carrier system, it will be necessary to achieve volumes that are sufficient to warrant designation of a shipping grade. While such a grade would still need special handling in the system this would at least make it a fungible product from the standpoint of impact on the shipping schedule and lifting product at destination terminals.

It is difficult to estimate the costs of keeping a pipeline system moisture free since this has not been done on any regular ongoing basis.

It should also be noted that since most pipelines originate in the south and run north along the coasts and mid continent that it would still be necessary to ship ethanol south (via current modes of transportation) to the refinery's applicable pipeline shipping origination point. This ongoing cost of what amounts to double shipping must be weighed against investments necessary to blend ethanol at the terminal level.

Perhaps the biggest drawback to shipping gasoline ethanol blends by pipeline would be destinations storage.

A common carrier system is likely to find it necessary to continue to carry its full slate of hydrocarbon only gasolines.⁽¹⁾ Therefore gasoline ethanol blends would require additional tankage as a new product. This would mean the pipeline/terminal operator may need to have the real estate to install one or more new tanks and be able to get the necessary permits to do so. If efforts were focused on moving

only one grade, such as unleaded regular with ethanol, terminals might be able to utilize existing tankage or at least reduce the number of new tanks required.

7.2.2. Pipeline Shipment of Ethanol

If pipeline shipments of gasoline ethanol blends do not prove feasible, an alternative would be to ship denatured fuel grade ethanol in the pipeline. While there would still be technical obstacles to overcome, shipments would be much smaller, approximately one tenth of that needed to ship the equivalent blend volume. This would make tracking and control of the shipments more manageable. At least one pipeline operator has indicated they are exploring the potential of shipping neat ethanol on their system.⁽⁵⁾

The biggest drawback to this approach is again that most pipelines originate at southern points while most current ethanol plants are in the Midwest. This would necessitate shipping ethanol south by currently used modes (e.g. barge, rail) for insertion in the pipelines to move back north. While this wouldn't prove practical in all cases there are instances where it could. For instance, rather than barging product to New Orleans and then to the east coast, ethanol could be barged to the Gulf coast area and placed in the pipeline serving the east coast, eliminating the second leg of a barge shipment. Other examples where pipeline shipments of ethanol might prove feasible would be when an ethanol production facility is far enough south on the pipeline system to ship north to at least some of the markets serviced.

As with gasoline ethanol blends, shipping ethanol via pipeline would likely prove easier on specific segments of a private pipeline than a common carrier pipeline.

Costs associated with pipeline shipment of ethanol are difficult to project since no such long term program in the U.S. pipeline system has been undertaken.

Clearly, ethanol would be shipped as a segregated "tightlined" product and would probably require slightly more monitoring than other products. These costs would be minimal on a per gallon basis especially as pipeline operators gain experience with shipping the product. It is also likely that some minor costs would be associated with more extensive corrosion monitoring since some pipeline operators have expressed concerns about the unknowns related to corrosion.

The predominant cost associated with pipeline shipments of ethanol would be the receiving storage tanks and associated piping. If existing tankage could be used, it would need to be modified for ethanol storage as specified in Section 5 (fixed roof, floating internal cover, applicable pressure vacuum vents, etc.). If insufficient tankage is available, new tankage would need to be installed at an estimated cost of \$450,000 per 25m barrel tank. Additionally, piping to the blending unit would be necessary. Piping costs are terminal dependent since the location of the storage tanks proximity to the blending unit/loading rack would be a key factor in determining cost.

Finally as noted in Section 5, if the ethanol is blended at the terminal, blending equipment would be required.

7.3 Product Exchanges

One last area that could prove a barrier to expanded use of ethanol is product exchange agreements. Many petroleum products companies utilize product exchanges to service markets where they do not have equity terminals and/or to reduce shipping/distribution costs.

As an example, refiner A may lift product from refiner B in one market. Refiner B would then take a like amount of similar product from refiner A in a different market. Small differences in product volume and distribution costs are adjusted via an exchange differential paid from one exchange partner to the other. There may be several exchange agreements in place (i.e. multiple exchange partners lifting product from a given terminal).

Consequently, when deciding whether or not to handle gasoline ethanol blends, exchange agreements must also be considered.

When ethanol is stored and blended to conventional gasoline at a terminal, this is not a major consideration because the terminal operator always has the option of providing their exchange partner(s) their hydrocarbon products. However if the ethanol blends replace hydrocarbon only fuels, then it would be necessary to secure the approval of the exchange partner(s) or risk losing an exchange agreement.

Exchange agreements can often save one to two cents per gallon in distribution costs and refiners are therefore obviously reluctant to initiate programs that impact negatively on exchange agreements.

Examples of where this could happen would be when gasoline ethanol blends or RBOB/sub-octane are shipped via pipeline and replace an existing all hydrocarbon product (or ether blend) to enable use of existing tankage.

In summary, the primary infrastructure barriers to expanded use of ethanol are its current restricted ability to move in the existing pipeline system and the need to expand tankage at the terminal level so it can be offered as an additional product.

Section 7.0

Infrastructure Barriers for Ethanol Fuels

References

1. Personal conversations with pipeline operator representatives
2. Pipelining of Gasohol, M.B. Weiss, Amoco Pipeline Co., date, (describing 1980 test)
3. Handling of Oxygenated Fuels in Pipeline Operations, E. Temple, Arco Pipeline Co., presented to API Transportation Committee, March 1985
4. Pipeline Movements and Handling of Gasoline/Oxygenate Blends and Neat Oxygenates, W. Kilmartin, Arco Chemical Co., presented to API Committee 5-3, October 1985
5. Russ Kinzig, Kinder Morgan, speaking at the DOE Ethanol Workshop, Sacramento CA, October 5, 1999

Section 8

Petroleum Industry Attitudes Towards the Use of Ethanol

8.0 Petroleum Industry Attitudes Towards the Use of Ethanol

In preparing this section, we spoke with a number of petroleum industry and ethanol industry contacts to assess current petroleum industry attitudes towards the use of ethanol. In the case of the petroleum industry we spoke to both integrated majors and independents and attempted to speak to a mix of refinery, technical, logistics, marketing, and governmental affairs personnel. In the case of ethanol producers we spoke primarily with marketers asking the types of objections they normally confront when attempting to persuade a petroleum company to initiate a gasoline ethanol blend program.

In nearly every case, representatives will not discuss their own specific operations because they consider such information proprietary. Likewise many were reluctant to be quoted directly due to the politicized nature of the ethanol debate (i.e. use of ethanol in RFG, replacement of MTBE, etc.). Several parties noted that with all the uncertainties about the oxygen mandate for RFG, possible restrictions on the use of MTBE, and the ethanol industry's politically active nature, they were concerned about any comments being taken out of context. In short, they were very defensive about certain topic areas. Nonetheless, the collective information from the wide variety of sources does offer insight into how the petroleum industry views ethanol. There are some variations in attitude depending on the industry segment (e.g. fully integrated majors versus independent refiners). The majority of the information in this section relates to the major refiners since an expanded ethanol program would almost certainly require their participation. Where independent refiners or marketers vary markedly in their opinions, such differences are noted.

8.1 Refinery Flexibility

Refiners note that their plants are large multimillion dollar projects consisting of numerous process units designed to accomplish a variety of needs including processing a varying slate of crude oil, adjusting to market demands which necessitates product slate changes (e.g. seasonal distillate to gasoline ratio), and to comply with an ever growing list of regulatory compliance items for both cleaner fuels and reductions in stationary source emissions. Various process units were installed in anticipa-

tion of using them at a level to recoup their investment and improve product margins (i.e. improve crack spreads by lowering processing costs).

Refiners note that in order to maximize their return on these investments they need the flexibility to utilize these process units in the most advantageous way while still meeting market demand and achieving regulatory compliance. Consequently anything that hints of mandated use of a product outside their production stream is viewed negatively in that it is a restraint on system flexibility.

As a general statement, refiners want ethanol use to be an option, not a requirement. They wish to be able to use it should long term economics and business factors dictate.

8.1.1 Net Crude Buyers versus Sellers

Net buyers of crude may in some cases be more receptive to ethanol use than net sellers. The reasoning here is that a net seller of crude who uses ethanol would displace their own crude oil use thereby creating a longer position on crude. Conversely, a net buyer of crude is buying crude to refine and if the profit margin from ethanol use (on a projected long term basis) exceeds their refinery processing margins they could chose to purchase ethanol instead of crude oil without the ramifications of being in a long position on crude.

8.1.2 Net Refined Products Buyers versus Sellers

Similar to net buyers and sellers of crude oil, a refiners position on gasoline/refined products might also affect their decision to use ethanol. A net seller of refined products (produces more refined products than used for their own controlled volume) would theoretically be less likely to use ethanol since to do so would result in a longer position on refined products. A net buyer (one who sells more product through controlled volume than they refine) may be more inclined to embrace an ethanol blending program because they are purchasing a product to meet their volume requirements. If ethanol's long term profitability exceeded that of the gasoline they were purchasing, it would improve economics to purchase ethanol instead of gasoline.

8.1.3 Product Stream Rejection

Another consideration is that the use of ethanol may result in rejection of product streams. For instance, since ethanol increases fuel volatility it is necessary to reduce the volatility of the gasoline to which it is added. This is done by reducing the amount of butane, and sometimes pentane, in the gasoline. If ethanol blending is expanded and more of these products are rejected, the oversupply could result in lower prices or possibly even the need to use such products as refinery fuel.

8.1.4 Octane

Ethanol is often discussed more in its role as an oxygenate to comply with reformulated and oxygenated gasoline programs. However, the refiner views ethanol in its more traditional role as an octane enhancer. Ethanol has excellent octane blending properties with an (R+M)/2 blending value of ~ 112.5. Refiners note that ethanol provides an attractive option for increasing octane but must be weighed economically against the need to reduce vapor pressure. Additionally ethanol does have a greater octane sensitivity than some octane components, having a motor octane of approximately 96 and a research octane of 129. Auto manufacturers maintain⁽¹⁾ that the octane sensitivity of a finished gasoline should not exceed 10. Additionally ASTM D 4814 recommends a minimum motor octane of 82. Generally it is more difficult for refiners to increase motor octane than to increase research octane. In any event, refiners that are octane short would have an increased incentive to use ethanol.

8.2 Ethanol Supply and Price Stability

For most refiners the increased use of ethanol would require some capital investment to reduce base fuel volatility. Some are reluctant to make such investments to use a product that, by petroleum industry standards, is available only in limited quantity. Furthermore, expanding supply to levels that would create a greater comfort level depends largely on tax incentives and public policy which create a high degree of uncertainty. In addition, ethanol supply is not within the control of the refiner. There have been instances in the past where ethanol supplies have been constrained due to high corn prices resulting from drought and/or tight corn supply. There is also concern that ethanol may not be competi-

tively priced during periods of short supply. Price concerns could possibly be addressed through properly structured long term agreements (see Section 9.6).

Without tax incentives ethanol would not be able to compete against other gasoline components. The tax credits that keep ethanol competitive are set to expire in 2007 and are, of course, subject to attack and repeal at any time.

Due to these uncertainties, it is very difficult for refiners to commit capital to facilitate the type of long term ethanol blending program that allows ethanol to approach its true blending value and market potential.

8.3 Fungibility

As discussed in earlier sections of this report, fungibility is a major premise of the current petroleum distribution sector. Refiners cannot currently ship ethanol via pipeline. Blending is accomplished at the terminal level which means the final blending process occurs outside of the immediate quality control of the refiner.

Some refiners note that the terminal blending process currently used makes regulatory compliance calculations and tracking more difficult than when done at the refinery.

8.4 Terminal Equipment Requirement

Because of the various aforementioned uncertainties, refiners are hesitant, not only to make investments at the refinery level, but also at the terminal level. Most refiners indicate that an ethanol blending program would require investments in their terminal operations. Such investments include modifications to existing tankage or installation of additional tankage, associated piping modifications, and installation of blending equipment. When such investments are amortized over a ten year time frame and the total gallons throughput, they are not necessarily significant. However refiners fear that if tax credits for ethanol use are not extended, or perhaps even repealed, they would not have adequate time to recapture their capital investment. If other uses for tankage and equipment didn't materialize, this equipment would essentially represent a stranded investment.

8.5 Technical Issues

While the “Ethanol-Technical Information” section of this report discusses the technical issues related to ethanol in detail, they are also worth mentioning here since several industry contacts mentioned them.

8.5.1 Volatility

Ethanol increases the volatility of the gasoline to which it is added. While this is most often discussed in the context of ethanol increasing vapor pressure, ethanol also depresses T_{50} (50% distillation temperatures by ASTM D 86) and alters TV/L 20, both considerations for refineries wishing to continue to meet ASTM guidelines.

8.5.2 Water Tolerance

Because of ethanol’s affinity for water, gasoline ethanol blends must avoid water contamination once they are blended. This requires special preparation at retail when converting to gasoline ethanol blends and diligent monitoring for water once converted.

This prompts two concerns. The first is that some precautionary measures may need to be handled by store/station personnel which is often subject to high turnover. The second and greater concern is that due to the necessary conversion procedures for tankage at terminals and retail, gasoline ethanol blends cannot easily be switched in and out of to take advantage of market conditions, be they price, market considerations, or whatever. Ethanol programs are largely viewed as-you are either “in or out” for extended periods.

8.6 Petroleum Industry Participation

Petroleum industry personnel were also asked under what conditions or circumstances (exclusive of mandates or regulatory compliance) they believed refiners would consider expanded participation in the ethanol industry as part of an overall energy strategy.

The simple answer is obvious, profitability equal to or greater than those realized from current operations. However there are several nuances to how that is interpreted. Of specific note are the following issues.

- Ethanol would need to be cost competitive with other gasoline components (without tax incentives) on a long term basis.
- Product supply would need to be much greater than it currently is.
- The profitability of using ethanol would need to reflect any special handling considerations at all levels of operation (i.e. refinery, pipeline, terminal and retail).
- The profitability of ethanol would need to reflect any refinery modifications and product streams rejected or downgraded. It would also need to reflect the loss of any crude oil throughput.
- Participation by exchange partners would need to be favorably addressed.

It was also noted that an octane shortfall when combined with addressing the above issues would further stimulate ethanol demand.

Most refiner contacts though mentioning some or all of the above, indicated that such a decision would not be made by them. Rather it would be undertaken by senior management with input/review from investment committees, project study groups, and various corporate personnel all of whom have various opinions, both positive and negative about ethanol.

Some refiners noted that the trend today is not to think of the industry as the petroleum industry but rather as the energy industry. They believe that if return on investment (ROI) for ethanol plants exceeds that of petroleum processing facilities and if demand warranted, that some companies would consider ethanol production facilities. Again, however they indicated that ROI performance projections would not include tax incentives that are subject to possible premature cancellation. Some also believe that if ethanol were produced by the refining industry from a more abundant supply source than corn (e.g. biomass) that this could address concerns about supply and price stability.

Section 8.0: Petroleum Industry Attitudes Towards the Use of Ethanol

References

1. World-Wide Fuels Charter, AAMA, ACEA, EMA, JAMA, December 1998

General References

This section was based on a compilation of interviews with various petroleum and ethanol industry personnel.

RFA Recommended Practice #930601 Gasoline Ethanol Blends-Program Operations Guide, Renewable Fuels Association

Section 9
Ethanol Prices and Values
and
Regional Differences in Ethanol Pricing

9.0 Ethanol Prices and Values and Regional Differences in Ethanol Pricing

The market price of ethanol, as well as its value, depends on a number of variables many of which are not applicable to gasoline. These include its value from volume contribution, octane enhancement, tax credits, and when applicable its value as an oxygenate for regulatory compliance. On the debit side, ethanol's price and value are reduced due to its need for special handling (due to its affinity for water) and its affect on increasing fuel volatility. Ethanol's energy content is also lower than gasoline although this is not reflected in industry value calculations or price formulas. As with any transportation motor fuel or motor fuel component, ethanol prices are also affected by supply and demand. This section discusses ethanol pricing and ethanol's value, which are not always well synchronized.

9.1 Historical Pricing Patterns

It is important to recognize the historical ethanol pricing trends since, to some degree, they contribute to today's ethanol pricing mechanisms and a consequent discounting of ethanol's market value.

In the late 1970s and early 1980s, ethanol was originally promoted as a product extender. At that time gasoline prices were relatively high and there were a number of state tax credits (especially in agriculturally oriented Midwestern states) that enabled ethanol to compete with gasoline. Also, at the time there was only, what today we call, conventional gasoline.

Later ethanol was promoted not only as an economical way to extend gasoline supply but also to increase octane. In this manner ethanol was priced comparable to gasoline (net of available tax credits). This enabled marketers to add ethanol to unleaded regular and sell it as a midgrade or to blend a mixture of unleaded regular and premium selling it as a premium grade. However ethanol production increased dramatically as the mid 1980s approached. In order to encourage more widespread use of ethanol, producers priced much of their product below the price of gasoline (net of tax credits) to encourage blenders/marketers to use it in all three grades (i.e. regular, midgrade, premium) so as to develop sufficient demand for this increased ethanol availability. This set the stage for a certain amount of octane giveaway on the unleaded regular grade.

During this time frame the pricing mechanism was basically as follows:

$$GP + (10 \times FETC) + (10 \times SC) - MI = EP$$

where:

GP = gasoline price

FETC = Federal Excise Tax Credit

SC = state credit

MI = margin improvement

EP = ethanol price

Using today's federal credit, a one cent state tax incentive, and a wholesale gasoline price of 75¢ and a margin improvement of 1¢ per blended gallon (i.e. 10¢ per gallon of ethanol), an example of the formula would be as follows:

$$\$0.75 + (10 \times \$0.054) + (10 \times \$0.01) - \$0.10 = \$1.29$$

The example formula allows the blender to improve their product margin by 1 cent per gallon (10¢ for each gallon of ethanol used) on the unleaded grade. Unfortunately such pricing resulted in much larger margins for midgrade and premium blends (4-8 cents per gallon).

During periods of extreme oversupply, it has not been uncommon for ethanol producers to increase the margin incentives to 2¢ or more per blended gallon to induce more companies to initiate blending programs. This was usually done on a regional basis with higher margins being offered in states with tax credits. Such markets were also often in states near ethanol plants with lower attendant freight costs. As a result, some of today's strongest major ethanol markets are Midwestern states that offer, or formerly offered, state tax incentives. In more distant outlying markets without credits, marketers have traditionally priced ethanol closer to its value for upgrading unleaded regular to midgrade /premium grade due to the absence of credits and greater freight charges.

In those few instances when ethanol has been in tight supply, it is traditionally priced at parity to unleaded gasoline or slightly higher at which time it would be used to upgrade unleaded regular to midgrade and/or to create premium grades similar to the above mentioned outlying markets.

As ethanol began to see use for its oxygen content to comply with oxygenated and reformulated gasoline programs, the ethanol price was sometimes adjusted upward to reflect its oxygen value. This was done by pricing ethanol off of, but at a discount to, MTBE. Unfortunately since ethanol has not captured much of the RFG market, this approach has not stuck and ethanol continues to be priced on the preceding formulas although there is some variation depending on market, base fuel, and application. Nonetheless, ethanol pricing must still reflect the need for special handling and in the case of volatility controlled fuels, its negative impact on vapor pressure.

9.2 Conventional Gasoline and Octane Blending

While ethanol has been used in oxygenated and reformulated gasoline programs, its largest market continues to be independent marketers who blend it with conventional gasoline at the terminal level for octane value and margin improvement. The extent of margin incentive offered by the ethanol producer/marketer depends on the supply/demand balance for ethanol.

For this market segment the pricing mechanism continues to be the previously cited formula,

$$GP + (10 \times FETC) + (10 \times SC) - MI = \text{Ethanol Price}$$

In a balanced market, the margin incentive (MI) is typically 0.0 which results in ethanol being blended only in midgrade and premium. Similarly in a tight market the MI is a negative number which restricts ethanol's use to midgrade and premium at a somewhat lower margin improvement. In the case where the ethanol market is long (supply exceeds demand) producers typically offer a MI of 1¢ per blended gallon (i.e. 10¢ per ethanol gallon) or more which enables ethanol to be blended into all grades. The following examples demonstrate how this might work in each market scenario (assuming a 75¢ rack gasoline price and no state tax incentive).

9.2.1 Balanced Market

From the ethanol industry perspective, a balanced market is characterized by supply and demand being in near balance which enables the producer to price its ethanol at parity to unleaded gasoline (net of tax credits). This results in gasoline ethanol blends being sold as midgrade and premium products capturing a portion of ethanol's octane value.

With a pricing formula of $\$0.75 + \$0.54 + \$0.0 - \$0.0 = \$1.29$ (\$0.75 net of tax credits), the blender calculations would be as follows

Unleaded Regular - 87 octane		Price Contribution	Octane Contribution
87 unleaded regular	90% x .75	.675	78.3
112.5 Ethanol	10% x .75	.075	11.2
Total		.750	89.5
Compared to hydrocarbon fuel		.750	
Margin improvement		0.000 (if sold as unleaded regular)	

Unleaded Midgrade - 89+ octane		Price Contribution	Octane Contribution
87 unleaded regular	90% x .75	.675	78.3
112.5 Ethanol	10% x .75	.075	11.2
Total		.750	89.5
Compared to hydrocarbon fuel		.770	
Margin improvement		.020	

Unleaded Premium - 92 octane		Price Contribution	Octane Contribution
87 unleaded regular	40% x .75	.300	34.8
92 unleaded premium	50% x .82	.410	46.0
112.5 Ethanol	10% x .75	.075	11.2
Total		.785	92.0
Compared to hydrocarbon fuel		.820	
Margin improvement		.035	

9.2.2 Short Market

A short market is characterized by demand exceeding supply and the ability to price ethanol slightly above the price of unleaded regular gasoline (net of tax incentives).

An example of the pricing formula is $\$0.75 + \$0.54 + \$0.0 + \$0.10 = \$1.39$ (\$0.85 net of tax credits)

Unleaded Regular - 87 octane	Price Contribution	Octane Contribution
87 unleaded regular 90% x .75	.675	78.3
112.5 Ethanol 10% x .85	.085	11.2
Total	.760	89.5
Compared to hydrocarbon fuel	.750	
Margin improvement	(0.01) (if sold as unleaded regular)	

Unleaded Midgrade - 89+ octane	Price Contribution	Octane Contribution
87 unleaded regular 90% x .75	.675	78.3
112.5 Ethanol 10% x .85	.085	11.2
Total	.760	89.5
Compared to hydrocarbon fuel	.770	
Margin improvement	.010	

Unleaded Premium - 92 octane	Price Contribution	Octane Contribution
87 unleaded regular 40% x .75	.300	34.8
92 unleaded premium 50% x .82	.410	46.0
112.5 Ethanol 10% x .85	.085	11.2
Total	.795	92.0
Compared to hydrocarbon fuel	.820	
Margin improvement	.025	

9.2.3 Long Market

A long market is, of course, characterized by supply exceeding demand. This usually results in ethanol producers offering significantly larger margin improvements (lower ethanol prices) to induce more companies to blend and encourage blending in all grades

The pricing formula of $\$0.75 + \$0.54 + \$0.0 - \$0.10 = \$1.19$ (\$0.65 net of tax credits) is more representative of these market conditions.

Unleaded Regular - 87 octane		Price Contribution	Octane Contribution
87 unleaded regular	90% x .75	.675	78.3
112.5 Ethanol	10% x .65	.065	11.2
Total		.740	89.5
Compared to hydrocarbon fuel		.750	
Margin improvement		0.010 (sold as unleaded with octane giveaway)	

Unleaded Midgrade - 89+ octane		Price Contribution	Octane Contribution
87 unleaded regular	90% x .75	.675	78.3
112.5 Ethanol	10% x .65	.065	11.2
Total		.740	89.5
Compared to hydrocarbon fuel		.770	
Margin improvement		.030	

Unleaded Premium - 92 octane			
87 unleaded regular	40% x .75	.300	34.8
92 unleaded premium	50% x .82	.410	46.0
112.5 Ethanol	10% x .65	.065	11.2
Total		.775	92.0
Compared to hydrocarbon fuel		.820	
Margin improvement		.045	

By altering the amount of margin incentive, ethanol producers/marketers can adjust to market conditions by pricing ethanol in a fashion that works in 1, 2, or all three grades.

The pricing mechanism for determining the gasoline price in the formula is generally based on a published pricing service, usually Oil Price Information Service (OPIS). The low or average gasoline price for a destination market as posted by OPIS serves as the base gasoline price in the formula. This generally results in a slightly higher price for ethanol used in RFG since the posted price for RFG is higher than conventional gasoline. The appendices to this section include a listing of CO non-attainment areas (9-A) and a map of reformulated gasoline areas (9-B).

9.3 Oxygenated Fuel Programs

A number of CO non-attainment areas in the U.S. are still required to use oxygenated fuels (or if recently redesignated as in attainment then as part of their maintenance program to maintain attainment levels). These programs require that gasoline sold during the high CO season contain an average of 2.7 wt% oxygen (2.0 wt% in California). This level can be achieved by adding ~15 v% MTBE or 7.7 v% ethanol. The programs are usually three or four months long beginning in November or December and ending in February. Many of these areas are distant markets from the Midwest ethanol production facilities. Moreover, the blending is seasonal only, as opposed to the year round blending programs found in the Midwest. Consequently ethanol producers try to capture a slight price premium for these markets when market circumstances permit.

Here the pricing mechanism may be similar to the aforementioned formula for a balanced market or even a short market. In this case the price of MTBE (the competing oxygenate) serves as a price ceiling limiting the price of ethanol to that of MTBE less some special handling discount usually 10¢ to 15¢ less per gallon than the price of MTBE.

The above applies only in the areas where oxygenated fuels are based on blending of conventional gasoline. If the area is also subject to reformulated gasoline requirements, different economics would apply. The oxygenated fuel areas are typically based on short term contracts (due to the shortness of program duration). The RFG areas would usually be based on longer term contracts.

9.4 Reformulated Gasoline

Refiners have a number of value based calculations beyond those of the typical company engaged in a terminal level program. These are most apparent when using ethanol in reformulated gasoline. The current market practice for using ethanol in RFG is to make a reformulated blendstock for oxygenate blending (RBOB). This fuel is designed so that once shipped to the destination market and blended with ethanol, it will comply with all RFG regulations/requirements.

While ethanol is still often priced by the producer with one of the traditional formulas, the refiner has a more complex set of economics to consider. In simplest terms, ethanol would simply be compared against competing oxygenates in the refinery linear program. If it is significantly more economically advantageous than MTBE then a refiner might choose to utilize ethanol.

It should be kept in mind however that unlike other fuel components, a refiner cannot just simply use ethanol on specific batches when economics dictate. Due to ethanol's special handling characteristic, refiners would only use it when economics dictate over a long time frame (at least months). Because of this, refiners typically wish to purchase ethanol on a long term agreement with some type of pricing mechanism keyed off of gasoline prices. The degree of margin improvement they must realize is more complicated to calculate than for the simple terminal blending program and includes the following.

9.4.1 Octane Value

The value of octane varies among refiners depending on the processing equipment they have installed, the mix of their gasoline slate (i.e. regular to premium), and of course the market price for merchant octane components.

A good benchmark in the industry is that octane (at the production level) is worth about 1 cent per gallon per octane number. For most refiners this would place the octane value of 10 v% ethanol at 2¢ to 3¢ above a gallon of gasoline (i.e. ethanol at 20 - 30 cents per gallon higher than gasoline). In reality this is usually discounted to the low end because of ethanol's octane sensitivity and low motor octane number.

9.4.2 Volatility

The addition of ethanol to gasoline results in a finished blend with higher volatility than the base fuel. The vapor pressure is increased by up to 1.1 psi and the T₅₀ distillation point (ASTM D 86) is typically lowered by 20°-30°F. Vapor pressure and distillation properties are both important compliance parameters in EPA's complex model. In order to accommodate the use of ethanol and meet summer time volatility specifications for RFG, refiners must lower the volatility of their summer base gasoline when producing the RBOB. This is done by reducing/eliminating butane from the RBOB. In some cases where an extremely low volatility base fuel is required, it may also be necessary to remove pentanes. Again, the cost of such actions will vary from one refiner to the next. However the cost of this so called butane/pentane debit is generally considered to be ~ 1¢ per gallon for each 1 psi reduction but could be higher in the case of RBOB required to be below ~ 6.5 psi.

9.4.3 Sulfur Content

The sulfur level of ethanol is much lower than currently marketed gasoline (outside of California). However ethanol does contain a small amount of sulfur from the manufacturing process as well as from the hydrocarbons used to denature ethanol. Once EPA's Tier II rules requiring lower sulfur levels are fully implemented, the difference in sulfur content levels will be too small to affect product value (i.e. ~ 25 ppm). However in the interim, ethanol would have some value as a strategy to build up sulfur credits for later use in the credits trading and banking program. Octane values may also increase modestly as a result of reduced sulfur levels.

9.4.4 Summary of Economic Considerations for Ethanol Use in Reformulated Gasoline

Based on the above, and assuming a long term contact and suitable pricing mechanism, a refiner would look at the following when considering ethanol use in reformulated gasoline:

<u>Item</u>	<u>Approximate Value</u>	
Handling discount to traditional gasoline	(0.01)	
Octane value	0.02	
Butane/pentane debit	(0.012)	(summer control season only)
Sulfur credits (through 2003)	?	
Approximate comparative value to gasoline	(.002)	summer
	.0.01	winter

The above is a simplistic example. Actual numbers will vary from refinery to refinery.

9.5 Sub Octane Blending

The extent of sub-octane blending has waned over the years but has recently seen a resurgence with sub-octane base fuels for ethanol blending now available in several Midwestern markets (listed in Section 2). In this case a base gasoline with an octane of ~ 84.5 is produced and shipped to destination terminals and then blended with ethanol. The resulting blend meets the 87 octane requirement for unleaded regular. The sub-octane fuel may also be blended with premium to make a hydrocarbon midgrade or with a blend of premium and ethanol to make both midgrade and premium.

While such programs are very similar to those utilizing RBOB for RFG compliance, there are some major differences. These are related primarily to the fact that refiners are not required to use oxygenates in conventional gasoline and conventional gasolines containing 9-10 v% ethanol are allowed a 1.0 psi vapor pressure increase over their hydrocarbon counterparts. As a result refiners would still expect the handling discount and realize the octane value mentioned for RBOB/RFG. They would not experience a butane/pentane debit. There could however be the additional consideration of reduced refinery runs.

9.5.1 Refinery Runs and Crack Spreads

If the refinery is operating at less than 100% of volume, the introduction of 10 v% ethanol would result in displacing 1 gallon of gasoline for each gallon of ethanol used. Refiners would therefore need

to consider the loss of any refining margin or crack spread (i.e. the difference between crude price and sales price of refined products). For instance if a refiner's crack spread is \$5.00 per barrel and gasoline yields and processing technology results in gasoline margins of \$.08 per gallon, then the refiner would need to capture an additional \$.08 per gallon of ethanol used (\$.008 per blended gallon) processing debit.

9.5.2 Summary of Economic Considerations for Ethanol Use in Sub-octane Gasoline

For the refiner producing sub-octane gasoline for ethanol blending, the economic considerations would then include the following:

<u>Item</u>	<u>Approximate Value</u>
Handling discount	(\$0.010)
Octane	\$0.020
Butane/pentane debit	--
Processing penalty	\$(0.008)*
Approximate comparative value to gasoline	\$0.002 with processing penalty
	\$0.010 with no processing penalty

* This would only apply to refiners who reduce manufacturing runs to utilize ethanol.

It should be kept in mind that these are simplistic examples and refiners would, of course, need to consider their entire finished product slate and other factors. But this serves to provide a general idea of how the refiner would value ethanol.

9.6 Long Term Pricing

As noted elsewhere in this report, ethanol has special handling considerations which result in ethanol being blended at the terminal. If suboctane base fuel or RBOB are used to capture more of

ethanol's value, various terminal modifications may be necessary,. Pipeline handling and scheduling may be affected. This is why refiners/marketers expect to capture a margin that represents some type of handling discount. Moreover, before a refiner engages in such investments they need to be sure that ethanol will be available in the quantities needed and at predictable prices.

Most refiners considering a major blending program would require that a large portion of their ethanol needs be contracted for extended periods (several months to a year or more). Further, an established price mechanism to guarantee some type of consistent margin improvement would be necessary. Such prices are normally keyed off of the price listings of Oil Price Information Service (OPIS) at a given destination, which in the case of refiners may be the U.S. Gulf Coast or New York Harbor. As an example, the refiner and ethanol producer may agree to a price that equates to the lowest unleaded price posted by OPIS for the Gulf Coast plus 50¢ per gallon. This is simply another simplified variation of the pricing formulas mentioned earlier.

9.7 Geographic Price Variations

There are some regional variations in ethanol pricing due primarily to the availability of state tax credits, gasoline prices, transportation costs, and market stability. Oxygen requirements may also affect pricing. Finally developing markets may be priced differently.

These items usually result in only small price modifications (with the exception of state tax credits). The value of the ethanol to the blender or refiner is based on its price at its destination market. Consequently ethanol producers do not usually capture all of the freight associated with servicing outlying markets. Instead they work on a weighted net back price. That is, the revenue of all sales less all transportation and terminaling costs divided by gallons sold.

9.7.1 State Exemptions

Although most states have rescinded tax credits for ethanol blends a few still offer modest incentives. These include the following:

	<u>Cents per gallon</u>	<u>percent</u>	
Alaska	\$.06		
Connecticut	\$.01		
Hawaii		4%	
Idaho	\$.025		
Illinois		2%	(sunset 2003)
Iowa	\$.01		(sunset 2007)
South Dakota	\$.02		

Source: The Use of Ethanol in California Clean Burning Gasoline-Ethanol Supply/Demand and Logistics, Downstream Alternatives Inc., February 1999

In most cases these state level credits increase the value of ethanol in a given state by 10 cents per gallon for each 1 cent per blended gallon credit. While the value increases by that amount the actual price may lag the value depending on market conditions as well as the factors discussed in the next sections. In other words, though a plant located in Indiana would have the same basic shipping and handling expense shipping to both Ohio (no credit) and Illinois (~ 1¢ credit), the value of the ethanol in Illinois is approximately 10¢ per gallon higher. In theory this would result in ethanol prices being 10¢ higher. In reality a portion of the state credit is usually realized by the blender, especially in markets in close proximity to plants.

9.7.2 Gasoline Prices

Gasoline prices (wholesale, before taxes) can at times vary dramatically from one area of the nation to another. As an example, California gasoline prices are often much higher than the rest of the nation while Houston Texas is often much lower. All other things being equal, ethanol value and price (in a balanced market) would move in lock-step with gasoline, increasing and decreasing by similar amounts.

9.7.3 Transportation Costs

Depending on the many other factors discussed in this section, ethanol producers may be able to recoup a portion of the increased transportation costs associated with outlying markets. For instance since wholesale gasoline prices are usually about 6 to 8 cent per gallon higher in California than the Midwest, ethanol's value and consequently its price would be higher, allowing the producer to recapture about half of the additional freight costs associated with this market. In a balanced market, producers will usually try to lower the blending incentive (i.e. increase price) by 2¢ or so (per gallon of ethanol) also allowing them to recapture some of the increased transportation costs.

9.7.4 Market Stability

When market conditions permit, ethanol producers tend to charge a slight price premium for unstable markets. An example here would be markets where ethanol is used only for oxyfuel program compliance. At the other end of the spectrum is the established stable market where producers try to price product to always offer some level of margin incentive rather than lose an established market.

9.7.5 Oxygen Requirements

While MTBE has captured the greater share of the oxygen market for compliance driven programs, ethanol is widely used in the winter oxyfuel programs and has enjoyed widespread use in Phase I RFG in the Chicago and Milwaukee markets. However there have been only modest price increases as a result of these programs. Ethanol's large market share in Chicago RFG is attributed in large part to the existence of a state tax credit and close proximity to major ethanol producers.

9.7.6 Developing Markets

Convention sometimes goes out the window in the case of developing markets. In some cases ethanol producers have significantly discounted their ethanol price to establish a market presence in a target area. In the past, blend margins incentive of 2¢ or more per blended gallon have not been uncommon in some developing markets.

9.7.7 Market Balance

It is worth mentioning again that all of these variables yield, to some degree, to the law of supply and demand. To some extent, ethanol is still priced as a commodity. When ethanol supply significantly exceeds demand it is not uncommon for ethanol producers to increase the margin incentives (lower prices) by significant amounts. In periods when demand exceeds supply, ethanol producers increase price (reduce the margin incentive) to favor ethanol blending in the higher octane grades and/or oxygen mandate markets.

Section 9.0: Ethanol Prices and Values and Regional Differences in Ethanol Pricing

References

General References

This section is based on numerous conversations with various industry personnel.

9-A Oxygenated Fuel Program Areas

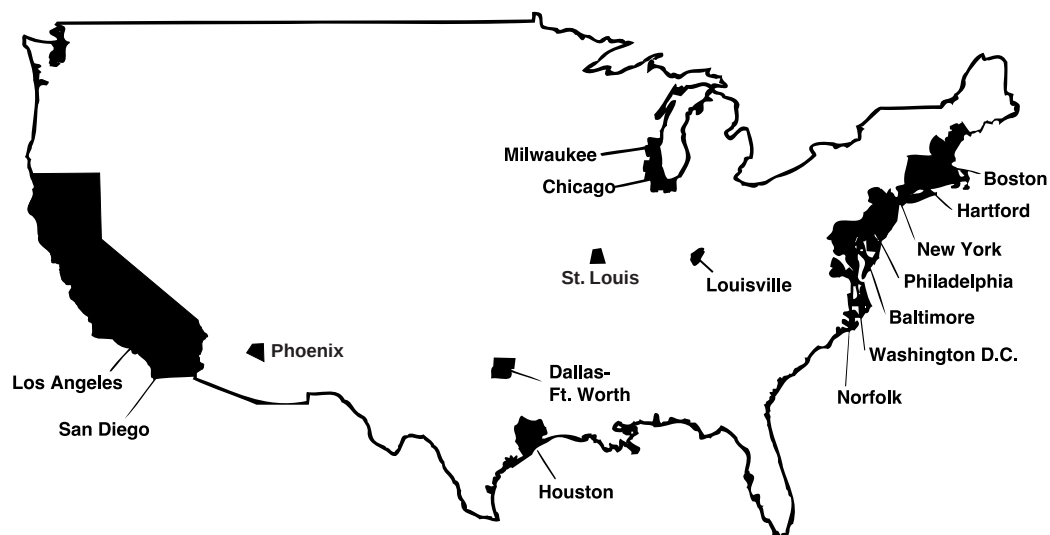
The metropolitan areas listed below required wintertime oxygenated fuel programs as of 1999. Over twenty areas that originally required oxygenated fuel programs have been redesignated as CO attainment areas and no longer require oxygenated fuel. Such areas include Baltimore, Boston, Hartford, Philadelphia, Washington D.C., Greensboro, Syracuse, Cleveland, Duluth, Memphis, and several cities in California.

<u>City</u>	<u>State(s)</u>	<u>City</u>	<u>State(s)</u>
El Paso	TX	Reno	NV
Colorado Springs	CO	Grant's Pass	OR
Denver/Boulder	CO	Klamath Co.	OR
Ft. Collins	CO	Medford	OR
Missoula	MT	Las Vegas	NV
Provo/Orem	UT	Phoenix	AZ
Anchorage	AK	Los Angeles	CA
Portland/Vancouver	OR/WA	Spokane	WA
Minneapolis/St. Paul (1)	MN		

(1) The State of Minnesota has implemented a statewide oxygenated fuels program

Source: Changes in Gasoline III-Year 2000 Supplemental Update, Downstream Alternatives Inc., 1999

9-B Reformulated Gasoline Area Map



Source: USEPA and Changes in Gasoline III-Year 2000 Supplement Update, Downstream ALternatives Inc., 1999

Section 10

Ethanol in Winter RFG versus Summer RFG

and the

Potential for Use of Ethanol in Phase II RFG

10.0 Ethanol in Winter RFG versus Summer RFG and Potential for Use of Ethanol in Phase II RFG

This section discusses the difference between using ethanol in winter RFG versus summer RFG as well as impediments to seasonal switching of oxygenates. In addition the potential for ethanol to be used in Phase II RFG is discussed.

10.1 Winter RFG versus Summer RFG

In these comparisons we are referring to the regulatory compliance differences between summer RFG (VOC control season) requirements between June 1 and September 15 at retail and winter RFG (non-VOC control season) required the remainder of the year.

During the summer months, when most ozone exceedences occur, refiners are required to achieve reduced emissions of VOCs which is accomplished in large part by lowering the volatility (vapor pressure) of gasoline. Summer grade RFG does not enjoy an ethanol vapor pressure allowance similar to conventional gasoline. Since ethanol increases the vapor pressure of RFG by ~ 1.0 psi (compared to a base fuel or an RFG/MTBE blend) the refiner must make a base fuel that is ~1.0 psi lower vapor pressure than they otherwise would. Cost estimates for reducing vapor pressure in low volatility gasolines have been estimated at 1.0 to 1.5 cents per blended gallon of ethanol. This equates to 10¢ to 15¢ per gallon of ethanol when blended at 10 v%.

Consequently the cost of using ethanol in summer RFG is prohibitively expensive for many refiners as compared to using MTBE which has less impact on vapor pressure.

The only major RFG markets where ethanol has been the primary oxygenate are Chicago Illinois and Milwaukee Wisconsin. In the case of Chicago, the economics of using ethanol are enhanced by the 2% state sales tax exemption which has equated to about 1.2 to 1.4 cents per blended gallon in recent years. This exemption was apparently enough that when combined with prevailing ethanol prices, refiners could justify the cost of producing a low volatility RBOB for ethanol blending.

In the case of Milwaukee, there is no tax credit involved. However in 1995 there was an extreme consumer backlash against MTBE due to health related concerns.^(1, 2) Due to widespread negative publicity most petroleum marketers converted to ethanol. This combined with the fact that the low

volatility summer grade RBOB was available in Chicago led to widespread market use of ethanol in Milwaukee. It was a simple matter to ship additional RBOB on to Milwaukee from Chicago. No other markets possess these same combination of attributes.

During the non-VOC control season, refiners do not need to produce extremely low volatility gasoline. The economics of using ethanol during this time frame are much better since there is no butane debit to produce a low vapor pressure RBOB. This led some to predict that ethanol would be widely used in the winter months of the program. However such use never materialized. Those areas that used MTBE in the summer months continued its use on a year round basis.

10.2 Seasonal Oxygenate Switching

There are a number of operational obstacles to the seasonal switching of oxygenates, i.e. using MTBE during the VOC control period and ethanol the remainder of the year. First, each time a switch to ethanol is made it would be necessary to go through some or all of the conversion steps required when initiating an ethanol blending program. These items include tank preparation at the terminal as well as the retail unit procedures described in this report. It would also be necessary to have a suitable ethanol storage tank and blending equipment at each terminal offering an ethanol blend. Additionally, unless there was a market-wide shift by all marketers in a region, pipeline shipments would be fragmented by the additional non-fungible RBOB grades.

In addition there are various regulatory barriers. At the terminal level, refiners must ship VOC controlled RFG on May 1st of each year. This means they must be receiving shipments of VOC controlled RFG in early April and it is not permissible to commingle these products. At the end of the VOC season, refiners must ensure that adequate stocks of VOC controlled RFG are available for shipment until September 15th which means they would likely have adequate product for at least a few days beyond that date. These circumstances essentially result in the marketing season for VOC controlled gasoline being six months. Put another way, the market season for the non-VOC controlled gasoline, in which ethanol could be used, is only 6 months long. It is very difficult to both justify the expense of tanks and blending equipment and address operational difficulties for a product that could only be used six months out of the year.

The only seasonal programs that have been favorable to ethanol use have been the oxygenated fuel programs in CO non-attainment areas especially those that are in compliance for ozone. There are differences here that are in some cases more favorable to ethanol.

In the case of CO non-attainment areas that are in ozone compliance (i.e. oxygen requirement in winter months only) the difficulties about phasing in and out (seasonal switching) of ethanol are minimized. There is no need to gear up for a low volatility RFG at a specific date. This enables marketers to time their conversions to suit market circumstances. Furthermore ethanol blended at the 9-10 v% level during summer months is allowed the 1.0 psi waiver in these areas. This permits year round blending of ethanol at least in the higher octane grades where economics are most favorable. Thus, it is easier to justify tanks and blending equipment. Finally, the oxygenated fuel programs require higher oxygen levels than the RFG program (2.7 wt% vs. 2.0 wt%). Since MTBE's cost has traditionally been higher than ethanol's cost (net of tax credits) the economics favor ethanol.

In CO non-attainment areas that are not in ozone compliance and required to use RFG, it becomes more difficult for ethanol to enjoy any level of use because of the above mentioned seasonal switching obstacles. So while the higher oxygen requirement may tilt the economics in favor of ethanol over MTBE in the winter months in these areas, the operational obstacles and regulatory barriers usually still result in year round MTBE use.

10.3 Ethanol Use in Phase II RFG

The required VOC reductions for Phase II RFG are much greater than for Phase I, as demonstrated in Table 10-1.

Table 10-1: RFG Emissions Reduction Requirements

<u>Pollutant</u>	<u>Phase I</u>	<u>Phase II</u>
VOC	15%-17%	25%-29%
Toxics	15%-17%	20%-22%
NOx	---	5%-7%

The ranges provided in this table represent the fact that there are different requirements between Region 1 and Region 2 and also depends on whether compliance is calculated on an average or per gallon basis.

Refiners will make various adjustments in gasoline components to achieve these more stringent requirements. Key among these will be further reductions in fuel volatility. This will make it even more difficult to use ethanol in Phase II RFG than in Phase I RFG. In order to achieve further reductions in VOCs, refiners will reject more light ends, not only butane but pentane as well. For some refiners it may be near impossible to achieve a vapor pressure level ~ 1.0 psi below the required level to accommodate the addition of ethanol.

It is questionable whether or not ethanol will continue to be used in Phase II RFG in its traditional strongholds of Chicago and Milwaukee. As mentioned above the 2% Illinois sales tax exemption for ethanol has helped enable the use of ethanol in Phase I RFG in Chicago and Milwaukee. However with the need to further reduce vapor pressure, industry observers believe refiners may switch to MTBE use in April 2000 (the first time period when Phase II RFG summer grade will be required).

Perhaps with the currently prevailing high gasoline prices, ethanol producers may be able to price their ethanol at a sufficient discount to gasoline to retain some of their market share. This would amount to them lowering their prices an estimated 10¢ to 15¢ per gallon to offset the butane/pentane debit. However even in this case, some refiners may find it simply too difficult to manufacture a RBOB of suitably low volatility.

Consequently, whether or not ethanol will be used in Phase II RFG, in Chicago and Milwaukee is questionable. Its use in other RFG markets appears even more unlikely to occur.

Section 10: Ethanol in Winter RFG versus Summer RFG and the Potential for Use of Ethanol in Phase II RFG

References

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Section 11
Concerns About MTBE and
Its Impact on Ethanol Demand

11.0 Concerns About MTBE and Their Its on Ethanol Demand

Various concerns about the use of MTBE began to appear with its widespread introduction in the oxyfuel program (1992) and even more so with its dramatically expanded use as a result of the reformulated gasoline programs implemented in 1995.

One of the first areas where concerns were expressed was in Alaska, especially Fairbanks. In 1992 when the oxygenated fuel program was first implemented in Alaska concerns were expressed about automotive issues and health complaints. There were similar experiences in a few other oxygenated fuel program areas. As a result, Alaska temporarily halted their oxygenated fuels program, re-implementing it later (in Anchorage only) using ethanol⁽¹⁾.

Similarly, in 1995 when RFG was introduced in applicable areas there were numerous automotive complaints and health complaints in the Milwaukee area. These concerns were magnified and distorted by the media, and stroked by local politicians to the point of consumer backlash and an absence, of rational analysis⁽²⁾. In response to consumer concerns most marketers switched to an ethanol based RFG. While there were isolated complaints in other areas, they did not approach the level of concern in Milwaukee.

Finally in the last few years, MTBE has come under close scrutiny because of widespread ground/well water contamination problems across the nation. It is the latter that appears to be MTBE's "Achilles Heel" with California already requiring a phase out and ban on the use of MTBE. Iowa has also banned MTBE use and several states have entertained similar action.

This section provides a brief overview of these concerns and discusses their potential impact on ethanol use/demand.

11.1 MTBE and Automotive Concerns

Initially there were concerns pertaining to the use of MTBE and its impact on the automotive engine and fuel system. Consumer concerns ranged from poorer fuel economy to cases of blown engines. There were numerous investigations of these alleged problems and all were proven to be unfounded with the exception of poorer fuel economy.⁽²⁾ Fuel economy in most vehicles is reduced when an oxygenate is present in the fuel due to its lower energy density (lower btu value). The typical fuel economy loss (attributed to oxygenates) in a modern vehicle in a proper state of tune is 2%-3%.⁽³⁾

11.2 MTBE and Health Concerns

Due to the nature of the over-hyped media coverage in areas experiencing health complaints, it proved difficult to compile accurate statistical data. However as a result of these complaints, various studies were undertaken. While MTBE was not found to be necessarily more dangerous than some of the hydrocarbon components in gasoline, there was evidence that some sensitive subpopulations were experiencing problems that correlated with exposure to MTBE (vapor and exhaust). Additionally tumors have been observed in rats and mice at high exposure levels.⁽⁴⁾ Still a number of scientists agree that the health effects of MTBE and its combustion products require a great deal of further study.⁽⁵⁾

Health complaints have to some degree subsided. Additionally regulators and politicians seemed to have refocused their attention on the ground water implications of MTBE use.

11.3 MTBE and Ground Water Contamination

Leaks and spills of gasoline have been with us since its introduction into commerce. Over the years various actions have been taken to minimize the contamination of soil and water from gasoline leaks and spills, most notably EPA's Leaking Underground Storage Tank (LUST) requirements.⁽⁶⁾ In addition numerous spills of gasoline, kerosene, and diesel fuel, and the resulting contamination problems over a number of years, have led to development of various proven hydrocarbon clean up technologies such as air stripping and bioremediation.

However, when a gasoline containing MTBE is leaked or spilled, the MTBE in the fuel tends to separate and, under most conditions, moves further and faster than the hydrocarbons in the fuel.^(7,8) The contamination plume is typically longer, wider, and sometimes deeper than the benzene/hydrocarbon plume. This is widely documented at various contamination sites. Thus contamination of drinking water sources can occur more easily compared to hydrocarbon fuels. In fact in its short history of use, MTBE has become the second most frequently detected ground water contaminant.⁽⁸⁾ MTBE has very low order and taste thresholds. Consequently very small contamination levels, on the order of 10-20µg/L are noticeable. While such low levels may not be of great health concern, they render the water unacceptable due to odor and taste. EPA has issued a Drinking Water Advisory recommending that MTBE contamination levels be kept in the range of 20-40 µg/L or below.⁽¹⁰⁾

Further adding to concerns is the fact that not all conventional technologies used to clean up hydrocarbon from soil and water will work for MTBE contamination. Those that will work do so at much greater expense.⁽⁷⁾

Given time, new more efficient and economical clean up technologies for MTBE will likely be developed. Some are already in development. Whether or not such technologies will be developed before MTBE dies a political death is not clear.

The Clean Air Act Advisory Committee on Oxygenate Use in Gasoline (EPA Blue Ribbon Panel on Oxygenate Use) has recommended that the use of MTBE be dramatically reduced and several politicians have called for a ban on its use. It therefore appears likely that the use of MTBE will be reduced significantly if not totally eliminated.

11.4 Impact of Reduced MTBE Use on Ethanol Demand

On Monday, March 20, 2000, EPA announced their support for amendments to the Clean Air Act to significantly reduce or eliminate the use of MTBE. However they also noted they favored removal of the oxygen requirement in RFG.

If MTBE use is banned or significantly reduced and the oxygen requirement in the RFG program remains in place, this would dramatically increase ethanol demand.

MTBE contains 18% oxygen while denatured ethanol is ~ 35% oxygen. Consequently MTBE needs to be blended at the 11 v% level to achieve a 2.0 wt% oxygen level while ethanol requires only 5.7 v% to achieve the same level.⁽³⁾ Based on these calculations for each 1.93 gallons of MTBE removed from RFG, a minimum demand of 1 gallon of ethanol would be created.

In 1999 RFG demand was 34.7 billion gallons.⁽¹¹⁾ The portion of RFG blended with MTBE was estimated to be 84%. MTBE demand for RFG use was then 3.2 billion gallons. At an equal oxygen replacement value this equates to 1.66 billion gallons of ethanol demand. So if MTBE were completely banned and the oxygen requirement for RFG remains in tact, this would represent new demand for ethanol.

Section 11.0: Concerns About MTBE and Its Impact on Ethanol Demand

References

1. Downstream Alternatives Inc. was involved with the MTBE backlash in Alaska and was also the contractor retained to provide program implementation guidance and subsequent programs for re-implementation of the program with ethanol.
2. Downstream Alternatives Inc. president Robert Reynolds was involved in several meetings and hearings in the Milwaukee market during this time frame. Activities included testimony at legislative hearings, serving on EPA's panel of industry experts at a public hearing, and conducting seminars for auto service technicians.
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Section 12
Alternative Fuel Formulations Without Oxygenates
and
Their Impact on Ethanol Demand

12.0 Alternative Fuel Formulations Without Oxygenates and Their Impact on Ethanol Demand

Refiners are currently faced with an upcoming ban on the use of MTBE in California and such bans are being considered by other states. EPA has indicated that it will attempt to eliminate or reduce the use of MTBE under the Toxic Substances Control Act (TSCA). In the face of these developments, the refining industry has lobbied to have the oxygen requirement removed from the reformulated gasoline requirements. The refining industry has argued that they can produce a reformulated gasoline that is compliant with all standards (i.e. achieves all required emissions reductions) without the use of oxygenates. This section discusses the potential for oxygen-free reformulated gasoline and what impact such formulations would have on ethanol demand.

12.1 Alternative Fuel Formulations Without Oxygenates

The 1990 Clean Air Act Amendments and subsequent related EPA regulations require that reformulated gasoline meet certain targeted emissions reductions for Volatile Organic Compounds (VOCs), oxides of nitrogen (NO_x) and toxics. In addition the Clean Air Act Amendments required that reformulated gasoline have an oxygen content of 2.1 wt%⁽¹⁾ when refinery oxygen averaging is used. Specifications are also placed on Benzene content and certain toxics.

Refiners use EPA's "Complex Model" (or in California the "Predictive Model") to calculate compliance with these regulations. The Complex Model and Predictive Model use a set of mathematical equations that calculate the emissions impact of various changes in fuel parameters such as lowering olefin content, aromatics, benzene, and sulfur content as well as the effect of oxygen content, vapor pressure, and distillation properties. Refiners have argued that they can meet the established emissions reduction targets without the use of oxygen in at least a portion of their gasoline products. They have further argued that if the emissions targets are met without oxygen there would be no negative effect on air quality and therefore the oxygen requirement should be rescinded.

Refiners have stated that they could meet the emissions targets through other gasoline parameter changes such as greater sulfur reduction and increased alkylate production. They have indicated that while they can make some portion of compliant RFG without using oxygenates, that they would still need to use oxygenates in a portion of their gasoline production.

Similarly, in California refiners have argued that they can produce a portion of their gasoline to be compliant with California RFG requirements without the use of oxygenates. They would like the flexibility to use oxygenates since it would be necessary for a portion of their production.⁽²⁾ The State of California has requested that the oxygen requirement for its RFG be rescinded.⁽³⁾

The ethanol industry has been skeptical about how much ethanol would actually be used in California (where MTBE is scheduled to be banned) if the oxygen requirement is lifted. They are equally skeptical about the volume of ethanol that would be used in other RFG areas if the oxygen requirement were lifted in other areas. This is largely because, on a historical basis, the refining industry has always found ways to achieve various regulatory requirements through the development of process technology, catalysts, and other technological advancements, rather than the use of ethanol.

12.2 Ethanol Demand for California RFG

Projected ethanol demand to meet the oxygen requirement in the federally mandated California RFG areas after a full MTBE ban is 36 to 41 mbd (550 mm to 628 mm gallons annually).⁽⁶⁾ If the oxygen requirement is lifted, demand would obviously be much less.

12.3 Ethanol Demand for Federal RFG

Currently, ethanol demand in Federal RFG is very minimal. During 1997 only 25 mbd (378.6 mm gallons annually) of ethanol is estimated to have been used in RFG.⁽⁴⁾ It appears that if modification to the Phase II RFG rules are not made, ethanol may well not be used in any Phase II RFG since the economics and operational practicalities favor MTBE. Consequently the impact of rescinding the oxygen requirement from Phase II RFG would depend on whether or not MTBE use is prohibited or restricted.

Refiners and industry analysts have noted that one of the key components to the manufacture of oxygenate-free RFG is alkylate which is in short supply. The California Energy Commission completed an analysis of alkylate availability in 1998⁽⁵⁾. In this study, the refiners that were CaRBOB capable were identified. Since federal RFG would also require alkylate to produce oxygenate-free RFG those numbers prove of interest.

The following table lists the alkylate availability of CaRBOB capable refineries from the CEC report

Table 12-1 Alkylate Availability-RFG Capable Refineries			
(m barrels per day)			
	<u>Alkylate Capacity</u>	<u>Estimated Production</u>	<u>Alkylate Availability</u>
Pacific Northwest	12	10	4
US Gulf Coast	503	428	86
Caribbean	22	18	11
Europe	258	134	27
Latin America	84	63	25
Middle East	27	21	8
Far East	85	68	14
Total	891	742	175
<i>Source California Energy Commission</i>			

If the estimates for alkylate availability in Table 12-1 are correct, this equates to 2.683 billion gallons per year or approximately 7.73% of current RFG volume. It is this low volume of alkylate availability that have led to refiners claiming they would still need to use oxygenates in at least some of their RFG to make up the volume lost from removing ~ 11 v% MTBE.

12.3.1 Continued MTBE Use

If MTBE use continues to be permitted and Phase II RFG rules remain as originally written, ethanol use in Phase II RFG would be largely precluded as MTBE would continue to be used. The effect of doing away with the RFG oxygen requirement in this scenario would have no impact on ethanol demand in RFG markets since none would be blended in any case.

However if the oxygen requirement is lifted it is likely that less MTBE would be used in RFG II. Consequently some of the MTBE used in RFG would be redirected to conventional gasoline. This would either displace ethanol or, at a minimum, dramatically limit the growth of its use. It is not possible to predict to what extent MTBE would be used in conventional gasoline within the scope of this work.

12.3.2 Banned MTBE Use

If MTBE were banned from use, ethanol is the only other oxygenate that is widely available to meet the oxygen requirement. RFG volume for 1999 was estimated to be 34.71 billion gallons. For ethanol to be used as the only oxygenate to meet the 2.0 wt% oxygen requirement (i.e. 5.7 v% blend) would the require 1.98 billion gallons of ethanol annually.

If this is the comparative baseline, rescinding the oxygen requirement in the face of a MTBE ban would lower ethanol demand by that amount-1.98 billion gallons in the RFG market.

12.3.3 Reduced MTBE Use

If the baseline scenario were reduced MTBE use in RFG II (through some type of volume restrictions) the effect would be for ethanol to replace the reduced volume at a ratio of approximately 1 gallon of ethanol for each 1.93 gallons of MTBE removed. This would assume the restrictions also applied to conventional gasoline. If not, some level of MTBE would unquestionably be redirected to the conventional gasoline market displacing ethanol there.

There is little question that oxygenate-free alternative fuel formulations would have a significant negative impact on ethanol demand in most scenarios. The extent of that impact depends largely on the baseline scenario used for comparison.

Section 12

Alternative Fuel Formulations Without Oxygenates and Their Impact on Ethanol Demand

References

1. Public Law 101-549 (101st Congress) Clean Air Act Amendments, 1990 Title I Provisions for Attainment and Maintenance of National Ambient Air Quality Standards
2. Potential Economic Benefits of the Feinstein Bilbray Bill, Mathpro Inc., March 18, 1999 (Analysis performed for Chevron Products Company & Tosco Corporation)
3. Letter from California Governor Gray Davis to EPA Administrator Carol Browner, April 12, 1999
4. Achieving Clean Air and Clean Water-The Report of the Blue Ribbon Panel on Oxygenates in Gasoline, Appendix D, September 1999
5. Supply and Cost Alternatives to MTBE in Gasoline Technical Appendices-External CARB Gasoline Supply, October 1998, California Energy Commission
6. The Use of Ethanol in California Clean Burning Gasoline-Ethanol Supply/Demand and Logistics, Downstream Alternatives Inc., February, 1999

Section 13
State Regulations and Their Effect on
Gasoline Ethanol Blend Programs

13.0 State Regulations and Their Effect on Gasoline Ethanol Blend Programs

In addition to various federal regulations, the marketing and distribution of ethanol blends can also be affected by various state laws and regulations. This section discusses various gasoline specification parameters that are, or may in the future be, regulated by some states. In addition a compendium of which states have regulations on which gasoline ethanol blend properties is provided.

13.1 NO_x and VOC

Regulations of air pollutants and ozone precursors such as oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) are largely preempted by federal regulation. When EPA adopts environmentally related fuel standards such as those for sulfur, VOCs, and NO_x, states are generally prohibited from adopting standards that are not identical to the federal standards.⁽¹⁾ Any modification to the federal requirements by a state would need to be integrated into its State Implementation Plan and approved by EPA or alternatively they would be required to obtain a waiver from EPA under § 211(c)(4)(c) of the Clean Air Act. Consequently most fuel related regulations at the state level pertain to consumer protection issues. However these regulations can have an impact on ethanol demand.

The State of California at one time limited oxygen content to ~ 2.0 wt% in its reformulated gasoline in the belief that it would reduce NO_x emissions. However California has lifted this restriction.

In addition to California's unique situation of often setting their own emissions standards and fuel controls.⁽⁹⁾ States could take similar action through the State Implementation Plan (SIP) process.⁽¹⁰⁾

Though states are largely preempted from implementing certain environmentally motivated fuel regulations in general, they are permitted to utilize such controls as part of their SIP. States that encompass areas that are out of attainment for criteria pollutants must submit a SIP to the EPA to demonstrate the actions they are taking, and will take, to bring non-attainment areas into compliance. If a state included certain fuel specifications to control NO_x or VOC and EPA agreed the technical and scientific information supported such controls, it could approve such state action.

However to date there are no state regulations that preclude or control the level of ethanol added to fuel as part of VOC or NO_x control strategy.

The most common VOC or NO_x related controls a state would likely pursue that could impact ethanol use would be controls on the oxygen level or fuel volatility as defined by vapor pressure. These items are covered individually below.

13.2 Oxygen Limits

Federal regulations permit the oxygen content of an oxygenate blend to be 2.7 wt% for aliphatic ethers and alcohols (excluding methanol). Such fuels meet EPA's "Substantially Similar" definition. Fuels with higher oxygen levels require a waiver under section 211(f) of the Clean Air Act. The ethanol content of gasoline ethanol blends is permitted to be up to 10 v% under the so called "Gasohol Waiver".⁽²⁾ Most ethanol blends contain 10 v% ethanol for a variety of technical and economic reasons.

Oxygen limits below 10 v% ethanol equivalent (i.e. ~ 3.5 wt% O₂) create a host of issues that make it more difficult to market gasoline ethanol blends. Among these are the following:

- During the VOC control season, gasoline ethanol blends sold in conventional gasoline markets must contain 9-10 v% ethanol to qualify for the 1.0 psi vapor pressure waiver.⁽³⁾ So if an oxygen limit required lower blend levels the fuel would not be qualified to use the 1.0 psi waiver. As an example if a state were to place an oxygen limit of 2.0 wt% on their conventional gasoline, marketers would not be able to blend at a high enough level to utilize the EPA vapor pressure waiver for the summer control season. Blending ethanol would then require a specially produced low volatility base fuel. This fuel would have all the attendant special handling requirements of a non-fungible fuel (segregated shipping, separate terminal storage tanks, etc.) covered elsewhere in this report.
- Some states require a minimum ethanol content of 10 v% to take advantage of their tax credits.
- The water tolerance of gasoline ethanol blends is reduced at lower blend levels.⁽⁴⁾

- The blending vapor pressure increase for ethanol peaks around 3 v%.⁽⁴⁾ Consequently the butane penalty to alter vapor pressure for VOC controlled gasolines, such as RFG, is about the same at 3.0 v% as at 10.0 v%.

13.3 Vapor Pressure

Vapor Pressure (VP) is a measure of a fuels “front end” volatility. Refiners adjust VP so that it is higher (more volatile) in the winter. Thus fuel vaporizes more readily providing good cold start and warm up characteristics. In the summer refiners produce a lower VP gasoline to minimize hot start and hot driveability problems and to meet environmental regulations.

Ethanol increases the vapor pressure of a gasoline to which it is added by ~ 1.0 psi. States generally permit the increase in vapor pressure provided the base fuel to which it is blended meets applicable ASTM standards.

Requirements to meet standard vapor pressure requirements imposed on hydrocarbon fuels usually precludes the ability to blend ethanol since a special non-fungible base fuel would be required.

13.4 Distillation Properties

Controlling distillation properties is another way to control fuel volatility. Some states place restrictions on distillation properties by limiting the T₅₀ point (the point at which 50% of the gasoline has vaporized in the ASTM Distillation test-ASTM D 86)⁽⁵⁾. Ethanol typically depresses (lowers) the T₅₀ of the gasoline to which it is added by 20° to 30° F. The minimum T₅₀ for gasoline is 150°F (winter grade) to 170°F (summer grade) as specified in ASTM D 4814⁽⁶⁾. If the T₅₀ of a base gasoline is near the specification minimum, adding ethanol could result in a gasoline with a T₅₀ lower than the specified amount. To ensure compliance with the minimum T₅₀, ethanol blenders would need to engage in extensive testing and could find it necessary to have a special non-fungible fuel for ethanol blending. As such, control on distillation properties (especially T₅₀) could have a negative impact on ethanol blending. Most states do not regulate T₅₀ or do not rigorously test or enforce T₅₀ regulations. Those that do typically do not place the same level of restrictions on gasoline ethanol blends.

13.5 Vapor Lock/VL Ratios

The Vapor/Liquid Ratio of gasoline helps define its tendency to contribute to vapor lock in the automotive fuel system. ASTM D 4814 also includes a Vapor Lock Protection Class that specifies a maximum for T-V/L20 (the ratio of vapor to liquid at a specific temperature by ASTM Test Method D 2533⁽⁷⁾ or ASTM Test Method D 5188⁽⁸⁾ or its calculated equivalent).

The addition of ethanol typically lowers the temperature at which the maximum permitted ratio occurs. As an example a summer grade gasoline would be expected to have a maximum V/L of 20 at 140°F. The addition of ethanol would result in the ratio being achieved at a lower temperature (i.e. exceeding specification at the test temperature).

Similar to vapor pressure and T₅₀ controls, meeting the vapor lock index may prove problematic for ethanol blenders, first because of the testing to monitor it and secondly because of the potential necessity to secure a specially produced non-fungible base fuel.

Very few states have regulations controlling T-V/L20. A few include controls in their regulation but do not test and enforce them. Those few that do typically give some type of allowance to gasoline ethanol blends.

13.6 Driveability Index

ASTM recently added a driveability index (DI) standard to specification ASTM D 4814. DI is a calculated number based on a weighting of distillation points as follows:

$$DI = 1.5 T_{10} + 3.0 T_{50} + T_{90}$$

Where: T₁₀ = temperature at 10% distillation

T₅₀ = temperature at 50% distillation

T₉₀ = temperature at 90% distillation

Under the formula calculations, ethanol and other oxygenates mathematically improve DI due to its impact of lowering T₅₀. However the mathematical changes alter the predictive accuracy of the DI

formula. Various formulas have been proposed to adjust for this effect. Some of these formulas, if adopted, could create the need for a special non-fungible base fuel.

Although no states are currently enforcing a DI limit, some states do automatically adopt ASTM D 4814 and could choose to do so at any time.

13.7 Grade Registration

Some states require registration of each grade sold. In such cases, when a marketer first introduces a gasoline ethanol blend it would need to be registered. Such requirements present no major marketing obstacles compared to any other fuel.

13.8 Sub-Octane Shipments

No states currently place major restrictions on sub-octane base fuel shipments except that they be designated as a blendstock (not for retail sale) until properly blended.

13.9 Conversion Procedures

A few states require certain procedures be followed when converting to gasoline ethanol blends. This is not a major problem unless these are over-restrictive requirements that result in tanks being out of service for extended periods of time.

13.10 Pump Labeling

Several states require that dispensers offering gasoline ethanol blends be labeled to identify that the fuel contains ethanol. These labels are relatively inexpensive and do not, in themselves, present any problem. However, in the past, numerous marketers have indicated that since ethanol is the only fuel ingredient so identified some consumers perceive this as a negative warning about the fuels quality. There has been a great deal of evidence that these claims have merit in a number of markets.

13.11 Lack of Uniformity

One additional problem that warrants mentioning is simply the patchwork quilt of state regulations that pertain to ethanol blends. For the multi-state marketer this often means a different compliance scheme in each state.

13.12 Summary of State Regulations Pertaining to Ethanol Blends

Since regulations on gasoline ethanol blends can vary dramatically from one state to the next, we retained Herman & Associates to prepare a compendium and summary of each state's regulations. Herman & Associates is extensively involved in tracking state level fuel regulations and maintains a data base of regulations pertaining to oxygenates. This summary of state regulations is included in this section as Appendix 13A.

Section 13.0: State Regulations and Their Effect on Gasoline Ethanol Blend Programs

References

1. Clean Air Act § 211(c)(4)(14)
2. Gasohol Waiver-Federal Register/Vol. 44, No. 681, April 1979
3. EPA Phase II Volatility Controls
4. RFA Recommended Practice #930601 Gasoline Ethanol Blends-Program Operations Guide, Renewable Fuels Association
5. ASTM D 86 Test Method for Distillation of Petroleum Products
6. ASTM D 4814 Standard Specification for Automotive Spark-Ignition Engine Fuel
7. D 2533 Test Method for Vapor-Liquid Ratio of Spark-Ignition Engine Fuels
8. D 5188 Test Method for Vapor-Liquid Ratio Temperature Determination of Fuels (Evacuated Chamber Method)
9. Clean Air Act, §211(c)(4)(b) and §209(b)
10. 42 USC 7410 (a)(2)

Section 13.0: State Regulations and Their Effect on Gasoline Ethanol Blend Programs

Append 13A - State Laws and Regulations for Ethanol Blended Fuels

This Appendix was prepared for this study by Herman & Associates. Herman & Associates is extensively involved in monitoring laws and regulations affecting ethanol blended fuels and maintains a data base of such items. This data base was updated and especially formatted for use in this report. This appendix includes:

- A recap sheet entitled “State Laws/Regulations for Ethanol Blended Fuels” which provides a quick recap of which properties (if any) that each state regulates for ethanol blends.
- A recap of which states automatically adopt the most current version of ASTM D 4814 and a recap of which states require low vapor pressure gasoline.
- A detailed description of applicable laws/regulations by state.

It should be noted that in some cases a state’s interpretation of ASTM D 4814 may vary from industry practice. This is because ASTM D 4814 includes some items that are considered as part of the standard while other items may be considered informational. Variations sometimes result from the way a state interprets the informational items. In addition there is sometimes a certain amount of interpretation and enforcement discretion with the agency enforcing these regulations.

State Laws/Regulations for Ethanol-Blended Fuels							
State	RVP	T50	TV/L20	DI	Grade Restriction	Conversion Procedure	Pump Labeling
Alabama	A	A	X		X		X
Alaska							X
Arizona	A	A	A		X	X	X
Arkansas	A	A	A	X		X	X
California	X	X	X	X	X		X
Colorado	A	A	A	A			X
Connecticut	A	X	X	X			X
Delaware	X	X	X	X		X	X
District of Columbia							
Florida	A	A	A			X	X
Georgia	A	A	X		X	X	X
Hawaii	X	X	X				
Idaho		X	X	X			X
Illinois	A	A	A	A	X		X
Indiana	A	X					
Iowa	A	A	A	A	X		X
Kansas	A	A	A	A			X
Kentucky	A	A	A				B
Louisiana	X	X				X	X
Maine							X
Maryland	A	X	X	X			
Massachusetts							X
Michigan	A	A				X	X
Minnesota	A	A	A				B
Mississippi	A	A	X	X	X	X	X
Missouri	A	A	X			X	X
Montana	A	A	A	A			X
Nebraska		X	X				X
Nevada	A	X	X				
New Jersey							
New Hampshire	A	A	A	A			X
New Mexico	A	A	X	X			X
New York	A	A	X			X	X
North Carolina	A	A	X	X	X		X
North Dakota	A	A	A				X
Ohio							X
Oklahoma		X					X
Oregon	A	A	A				X
Pennsylvania							X
Rhode Island	X	X	X				X
South Carolina	A	X	X	X	X		X
South Dakota	A	A	A				X
Tennessee	A	A	X	X			X
Texas							X
Utah	X	X				X	X
Vermont							X
Virginia	A	A					X
Washington	A	A	A	A	X		X
West Virginia	A	A	A	A			X
Wisconsin	A	A	A				X
Wyoming	X	X	X				X
X Gasoline-ethanol blends required to meet same volatility limits as gasoline. A Provides ethanol waiver. Base fuel must meet ASTM, or ethanol-blends provided 1.0 psi higher vapor pressure than base fuel. B No pump labeling, but does require invoice disclosure.							

States Automatically Adopting ASTM D 4814

Arkansas
California
Colorado
Idaho
Illinois
Iowa
Kansas
Maryland
Mississippi
Montana
New Hampshire
New Mexico
North Carolina
South Carolina
Tennessee
Washington
West Virginia

Note: States whose regulations or legislation
adopt the most recent version of ASTM
D 4814

States That Require Low Vapor Pressure Gasoline in Certain Areas (Exclusive of Reformulated Gasoline Requirements)

Alabama
Arizona*
Georgia
Illinois
Indiana
Kansas
Maine*
Michigan*
Missouri
Nevada*
Pennsylvania*
Texas*

*No ethanol waiver from state low-RVP limit

State Regulations for Ethanol-Blended Fuels

ALABAMA

LABELING REQUIREMENTS: Alabama requires ethanol-blends to meet the following pump labeling and invoice disclosure requirements. Any dispensing device used to dispense gasoline which contains more than 1% by volume of any ethanol or methanol shall be labeled as follows:

"Contains Ethanol", or
"Contains Methanol and Cosolvent"

The letters appearing on the label must be a minimum of 1/2" in height with a minimum 1/16" stroke. Labels must appear on both sides of the dispensing device which face the vehicle and must be in black letters with a distinctly contrasting background.

INVOICE DISCLOSURE: Alabama requires ethanol blends to meet the following invoice disclosure requirements. "Any manufacturer, hauler, blender, agent, jobber, consignment agent, or distributor who distributes motor vehicle fuel products which contain at least one percent alcohol must state on any invoice, bill of lading, shipping paper, or other documentation used in normal customary business practices, or as required by federal law, the percentage of alcohol, and cosolvent, the type of alcohol, and the antiknock index number of the products distributed."

MOTOR FUEL SPECIFICATIONS: Alabama has adopted "Standards for Gasoline and Gasohol" which are "applicable to all gasoline and gasohol sold or offered for sale in Alabama".

Specifications for gasoline, unless noted, are "determined in accordance with the test methods presented in the latest edition of The American Society for Testing and Materials Standards . . . and those specifications published by the United States Department of Commerce as required by §8-17-81, Code of Alabama (1975)."

Gasoline containing 9-10% by volume ethanol is provided a vapor pressure waiver of 1.0 psi RVP, and an exemption from the minimum T 50 distillation requirements as long as the base gasoline meets the required standards.

Volatility requirements are as follows:

1. Vapor Pressure and Distillation Class Requirements:

Volatility Class	10% max	50%		90% max	Endpoint max	Vapor Pressure max	Distillation Residue max
		min	max				
A	70(158)	77(170)	121(250)	190(374)	225(437)	62(9.0)	2
C	60(140)	77(170)	116(240)	185(365)	225(437)	79(11.5)	2
D	55(131)	77(170)	113(235)	185(365)	225(437)	93(13.5)	2

Note: Vapor Pressure kPa (psi) and Distillation Temperatures °C (°F) at Volume Percent Evaporated

2. Vapor Lock Protection Class Requirements:

Vapor Lock Protection Class	Vapor/Liquid Ratio Test Temperature °C (°F)	Vapor/Liquid Ratio max
2	56 (133)	20
3	51 (124)	20
4	47 (116)	20

3. Schedule for Volatility Requirements:

January (D-4)	June (A-3)	September 16-30 (A-2/C-3)
February (D-4)	July (A-3)	October (C-3)
March (D-4/C-3)	August (A-2)	November (C-3/D-4)
April (C-3/A-3)	September 1-15 (A-2)	December (D-4)
May (A-3)		

Under Alabama's "Minimum Standards for Gasoline", the State has established standards for sulfur, corrosion, existent gum, lead, and phosphorous as follows:

Sulfur, Leaded	0.15 weight % maximum
Unleaded	0.10 weight % maximum
Copper Strip Corrosion	No. 1 maximum after three hours at 122°F
Existent Gum	5 mg/100 ml maximum
Lead, Leaded	4.2 g/gal maximum
Unleaded	0.05 g/gal maximum
Phosphorous	0.005 g/gal maximum

The finished gasoline must be visually free of undissolved water, sediment, and suspended matter, and shall be clear and bright at the ambient temperature or 70°F (21°C), whichever is higher.

LOW-RVP PROGRAM: On April 13, 1999, the Alabama Environmental Management Commission adopted a rule establishing low-RVP and sulfur content requirements for fuels sold in Jefferson and Shelby Counties beginning in 1999 and continuing each season through 2002.

Effective June 1, 1999, during the period from June 1 to September 15 of any calendar year, the Reid vapor pressure of the gasoline sold in Jefferson and Shelby Counties shall not exceed 7.0 psi.

An ethanol blend is considered in compliance if its measured Reid vapor pressure does not exceed 8.0 psi. This waiver is subject to the following conditions:

1. Gasoline must contain denatured, anhydrous ethanol. The concentration of ethanol, excluding the required denaturing agent, must be at least 9 percent and no more than 10 percent (by volume) of the gasoline.
2. Each invoice, loading ticket, bill of lading, delivery ticket and any other document that accompanies a shipment of gasoline containing ethanol shall contain a legible and conspicuous statement that the gasoline being shipped contains ethanol and the percentage concentration of ethanol.

For sulfur content, effective May 20, 1999 and subsequent years through March 31, 2003, the sulfur content of all gasoline supplied (during the control period of June 1 to September 15) by each producer or importer to comply with the Reid vapor pressure limits required in Jefferson and Shelby Counties shall not exceed an average of 150 ppm (by weight). For each calendar year, the sulfur content shall be averaged on a volume-weighted basis over the pool of gasoline supplied by the producer or importer to comply with the applicable Reid vapor pressure requirements.

GRADE RESTRICTIONS: Alabama requires that all petroleum products be registered with the Commissioner of Agriculture and Industries prior to sale. The permit application must include the brand name, the name(s) and address(es) of the manufacturer from which the product was obtained, the capacity of the containers in which it is to be sold, and a statement guaranteeing that the product meets all applicable standards. Alabama further requires that the product meet applicable state standards. All permits expire on September 30. Persons selling a product obtained from a person who has already obtained a permit are not required to obtain a permit.

In addition to the requirements for registration of petroleum products, Alabama requires that all gasoline containing more than 1% ethanol or methanol must have a separate product registration from a product under the same brand name that does not contain ethanol or methanol. For example, a company selling two products, "premium unleaded" and "premium unleaded - contains ethanol" would be required to have two registrations. The words "contains

ethanol" must also be included in that product identity for registration purposes. All gasoline registrations must include the octane rating for the particular product being sold.

ALASKA

LABELING REQUIREMENTS: The Alaska Department of Environmental Conservation requires that the owner or operator of a dispenser that dispenses oxygenated gasoline in a control area shall label each dispenser if the gasoline contains at least 2.0% oxygen by weight. The Department recommends that all areas of the state conform with the labeling requirements. If the gasoline contains oxygenates other than MTBE or ETBE, a second label is required. The first label must identify the type of oxygenate in the gasoline, state the gasoline's maximum oxygen content by volume and by weight, state that the gasoline contains an oxygen content of not less than 2.0% by weight, and include the statement "The gasoline dispensed from this pump is oxygenated and will reduce carbon monoxide pollution from motor vehicles." For example:

THE GASOLINE DISPENSED FROM THIS PUMP IS
OXYGENATED AND WILL REDUCE CARBON
MONOXIDE POLLUTION FROM MOTOR VEHICLES.
THE GASOLINE IS OXYGENATED WITH ETHANOL
AND CONTAINS NO MORE THAN 10 PERCENT
ETHANOL BY VOLUME. ITS OXYGEN CONTENT IS
NOT LESS THAN 2.0 PERCENT BY WEIGHT.

The label must be in legible block-style lettering of at least 20 point bold type. The lettering must be in a color that contrasts with the background, and the background color must contrast with the dispenser. Labels must be placed on the upper two-thirds of the dispenser in a position clear and conspicuous to the consumer. The following abbreviations may be used on the dispenser label to identify the oxygenate in the gasoline: "MTBE" for methyl tertiary butyl ether, "ETBE" for ethyl tertiary butyl ether, and "TAME" for tertiary amyl methyl ether.

Unless the oxygenate in the gasoline is MTBE or ETBE, the owner or operator must place on the dispenser a second label until oxygenated gasoline is no longer being dispensed. The second label must meet the same requirements for lettering, color, and location, and must be placed immediately adjacent to the first label. The second label must read:

"WARNING: THIS FUEL IS PROHIBITED FOR USE IN
AIRCRAFT."

INVOICE DISCLOSURE: Alaska requires disclosure of oxygenates on invoices and other wholesale documentation as part of the oxygenated fuels program. The transferor must provide to the transferee a product transfer document containing the following information in addition to, or as part of a bill of lading or invoice. The product transfer document must accompany every shipment of gasoline to a control area after it has been dispensed by a terminal. The product transfer document must legibly and conspicuously contain the bill of lading or invoice number; the date of transfer; the name, address, and CAR or Blender CAR permit number of the transferor; the name, address, and CAR or Blender CAR permit number of the transferee, if applicable; the volume of gasoline transferred; identification of the gasoline as nonoxygenated or oxygenated; the location of the gasoline at the time of transfer; the type of oxygenate; the percentage by volume, to the nearest percent, of oxygenate in the fuel; the percentage by weight, to the nearest tenth of a percent, of oxygen content in the fuel; and for gasoline in the distribution network between the refinery or import facility and the control area terminal, the oxygen content by weight of the gasoline.

MOTOR FUEL SPECIFICATIONS: Alaska has not adopted any motor fuel quality standards.

ARIZONA

LABELING REQUIREMENTS: Arizona has adopted the following pump labeling requirements.

"All service station dispensers shall be labeled when offering gasoline containing an oxygenate, or combination of oxygenates, that results in a gasoline blend containing 1.5 percent or more by weight of oxygen. If only one oxygenate is being blended into a gasoline, dispensers shall be labeled if the percent by volume is:

More than 0.3 percent by volume of methanol, or
More than 4.3 percent by volume of ethanol, or
More than 8.3 percent by volume of MTBE, or

Any other oxygenate or combination of oxygenates at a level that requires an EPA waiver."

Labels required above shall be posted on the upper 60 percent of each face of the dispenser. Lettering on labels shall be no less than 1/4". The label must state:

"Contains up to % ethanol";
"Contains up to % methanol and % cosolvent";
"Contains up to % ether (MTBE)"; or
"Contains up to % other (specify name of oxygenate)".

INVOICE DISCLOSURE: Under Revisions to Article 7, "Motor Fuels and Petroleum Products," Arizona has established product transfer documentation and record retention requirements for motor fuel other than Arizona CBG and AZRBOB. Under the regulation, if a person transfers custody or title to a motor fuel other than Arizona CBG or AZRBOB, other than when motor fuel is sold or dispensed at a service station or fleet vehicle fueling facility,

- the transferor shall provide to the transferee documents that include the following information:
- the name and address of the transferor;
- the name and address of the transferee;
- the grade of the motor fuel; the volume of each grade of motor fuel that is being transferred;
- The date of the transfer;
- Product transfer document number;
- For conventional gasoline, the minimum octane rating of each grade;
- For conventional gasoline, the type and maximum volume of oxygenate contained in each grade of the motor fuel;
- For conventional gasoline that is transported in the CBG covered area, the statement, "This gasoline is not intended for sale inside Maricopa County or area A;" and
- Whether a lead substitute is present and the type of lead substitute used.

A registered supplier, 3rd-party terminal, or pipeline may comply with this requirement by using standardized product codes on pipeline tickets. A service station owner or operator shall retain product transfer documents for each shipment delivered during the 12 months preceding that shipment. The documentation for the transfers or deliveries made during the preceding 30-day period, involving any person other than a service station or fleet owner, shall be maintained at the business address listed on the product transfer document. The documentation for the 3 most recent deliveries of each grade of motor fuel shall be maintained on the service station or fleet owner's premises and shall be available to the Department for review. Documentation for the remainder of all deliveries for the same 12 months shall be available within 2 working days from the time of the Department's request. A legible photocopy of a product transfer document may be submitted.

MOTOR FUEL SPECIFICATIONS:

Conventional Gasoline Areas (Non-CBG):

Arizona requires that gasoline and gasoline-oxygenate blends outside of Maricopa County meet all the requirements of ASTM D 4814 except the minimum vapor pressure allowed shall be 6.4 pounds per square inch, and from May 1 through September 30 maximum vapor pressures in pounds per square inch shall be 9.0, and other volatilities shall be consistent with the corresponding volatility classes established by ASTM D 4814. Arizona has adopted by reference ASTM D 4814-97b.

Maximum Vapor Pressure for non-CBG areas is:

Oct. 1 - March 31	9.0 pounds per square inch (psi)
April	10.0 psi
May	9.0 psi
June 1 - Sept. 30	7.0 psi

For gasoline-ethanol blends, "the vapor pressure may be up to one pound per square inch higher than the vapor pressures established by ASTM D 4814" during May 1 through September 15 if the base fuel meets the requirements of ASTM D 4814, the volatility requirements of R20-2-714(A)(2) and the final gasoline-ethanol blend contains at least nine percent ethanol by volume but does not exceed EPA waivers. A 1.0 psi RVP waiver is provided from September 16 through April 30, if the base fuel meets the requirements of ASTM D 4814 and the final gasoline-ethanol blend contains 1.5 percent or more by weight of ethanol and does not exceed EPA waiver limits.

Cleaner Burning Gasoline Areas (Maricopa County - Phoenix Area):

Arizona has adopted Cleaner Burning Gasoline (CBG) standards for the Phoenix area (Area A). Under these standards, the maximum RVP for Area A is 9.0 psi from September 30 through March 31 and 7.0 psi from May 31 through September 30. All other volatilities must be consistent with ASTM D 4814.

Gasoline-ethanol blends are required to meet the 7.0 psi from May 31 through September 30. Gasoline-ethanol blends are not provided a volatility exemption from September 30 through March 31.

GRADE RESTRICTIONS: Any person who blends gasoline with an oxygenate, or combination of oxygenates that results in a motor fuel blend containing 1.5 percent or more by weight of oxygen, shall file a report with the Department prior to the initial sale or use of the blend. In addition, any person who blends gasoline with methanol resulting in a motor fuel blend containing 0.15 percent or more by weight shall file a report with the Department prior to the initial sale or use of the blend. If only one oxygenate is being blended into a motor fuel, a report shall be submitted if the percent by volume is: more than 0.3 percent by volume of methanol, or more than 4.3 percent by volume of ethanol, or more than 8.3 percent by volume of MTBE, or any other oxygenate or combination of oxygenates at a level that requires an EPA waiver.

The report shall remain confidential and shall contain the following: the name of the person blending oxygenates with gasoline and the person's address and telephone number; the name, address, telephone number, and signature of the person preparing the report; the date the report was prepared; the type and maximum volume of each oxygenate as a percent of the total blend; and the amount of cosolvent contained in methanol-gasoline blends.

CONVERSION PROCEDURES: No neat oxygenate blending shall occur at a service station or fleet location. When a service station storage tank contains less than the required amount of oxygen, the service station owner or operator shall do the following to correct the oxygenate blend: introduce fuel that contains no more than 20% by volume of any oxygenate; or empty the storage tank and replace the gasoline with a legal oxygenate blend.

Prior to the introduction of any alcohol-oxygenated gasoline into a motor fuel storage tank, the following procedures shall be followed: the tank shall be tested for the presence of water and, if any water is detected, it shall be removed from the tank. Fuel filters designed for use with alcohol-oxygenated gasoline shall be installed in the fuel line of all

dispensers that will dispense alcohol blends. If standing water is detected in a storage tank containing alcohol-oxygenated gasoline, the entire contents shall be removed from the tank.

ARKANSAS

LABELING REQUIREMENTS: Arkansas requires that "all spark-ignition motor fuel" kept, offered, or exposed for sale, or sold, at retail containing at least 1% by volume of ethanol, methanol, or a combination shall be identified as "with" or "containing" (or similar wording) "ethanol", "methanol" or "ethanol/methanol", in letters at least 1/2" in height, and 1/16" in stroke (width of type). "Spark-ignition motor fuel" is defined as "gasoline and its blends with oxygenates such as alcohols and ethers." The label should appear on the upper 50% of the dispenser front panel in a position clear and conspicuous from the driver's position.

INVOICE DISCLOSURE: Arkansas requires that "the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, the presence and maximum amount of ethanol, methanol, or any combination of ethanol/methanol (in terms of percent by volume) contained in the fuel. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the motor fuel before blending." Where shipment is by truck or other vehicle, the invoice for each shipment must state that the product meets the current ASTM standards of the specifications listed.

MOTOR FUEL SPECIFICATIONS: Arkansas requires that all gasoline sold in the State must meet the most current standards and test methods of ASTM D 4814, "Standard Specification for Automotive Spark-Ignition Engine Fuel".

Under "Regulations for Selling of Alcohol Blended Fuels", Arkansas has adopted the National Conference on Weights and Measures volatility exemption for unleaded gasoline containing up to 10 percent ethanol, as contained in NIST Handbook 130. Arkansas regulations for ethanol blended fuels are as follows: "Spark-ignition motor fuel...shall meet the most recently adopted ASTM standard for spark-ignition motor fuel except that, volatility standards for unleaded gasoline blends containing up to 10% ethanol shall not be more restrictive than those adopted under the rules, regulations, and Clean Air Act waivers of the U.S. Environmental Protection Agency, and provided that the gasoline used in the blend meets the volatility specifications of ASTM for the area and season in which the blend is sold. Also, the unleaded gasoline blends containing up to 10% ethanol must not, by ASTM Method D 86, have a 50% evaporated temperature less than 158°F (70°C) and the Reid vapor pressure by ASTM Method D 4814 A2 will have a tolerance not exceeding one pound per square inch (psi)." The term "spark-ignition motor fuel" is defined as "gasoline and its blends with oxygenates such as alcohols and ethers."

GRADE RESTRICTIONS: Arkansas requires that distributors of spark-ignition motor fuels containing more than 1% by volume ethanol, methanol or a combination must register the product with the Arkansas Bureau of Standards on Form PC-17A "Application for Registration of Alcohol Blended Fuels," and provide a written list of the stations and/or companies who will sell such product. When stations are converted to sell spark-ignition motor fuel blended with more than one percent of ethanol, methanol or a combination, the Arkansas Bureau of Standards must be notified

CONVERSION PROCEDURES: Arkansas requires that for retail establishments offering spark-ignition motor fuel containing more than 1% by volume ethanol, methanol, or a combination for the first time, the tank must be filled with the blended product and must stand for a minimum of 24 hours to allow any sludge or varnish that remains in the system to be dissolved by the alcohol blended fuel and precipitate to the bottom of the tank. The precipitated mixture must be pumped from the tank before selling or proper procedures for inspecting, cleaning, and pumping out water bottoms of storage tanks must be followed before selling of alcohol blended fuel. When stations are converted to sell spark-ignition motor fuel blended with more than one percent of ethanol, methanol or a combination, the Arkansas Bureau of Standards must be notified. A suitable pump filter must be installed on the dispenser for alcohol blended fuels. The type of filter and installation must be approved prior to the use of that

dispenser by the Arkansas Bureau of Standards. There must be installed on the storage vent pipe a pressure vacuum vent (P.V.) that meets National Fire Prevention Association regulation, Code 30, Chapter 2, on tank storage on the aboveground storage tanks. This requirement is optional on the underground storage tanks.

CALIFORNIA

LABELING REQUIREMENTS: California does not require the labeling of ethanol-blended fuels on motor fuel dispensing pumps.

California requires all pumps dispensing gasoline containing methyl tertiary butyl ether (MTBE) to be labeled. Under the regulation, "all devices dispensing gasoline containing methyl tertiary butyl ether (MTBE) at filling stations, garages or other outlets where petroleum products are sold or offered for retail shall be marked with a conspicuous label at all times the product is offered for retail sale."

The label shall contain the following language:

"Contains MTBE. The State of California has determined that the use of this chemical presents a significant risk to the environment. "

The label shall be contrasting in color to the gasoline dispensing equipment and be in capital letters using not less than one-eighth inch high letters, except that "MTBE" shall have lettering using not less than five-eighth inch high letters with a stroke of not less than one-eighth in width and "Contains" shall have lettering using not less than one-quarter inch high letters.

The label shall be placed on the gasoline dispensing equipment's vertical surface, on each side with gallonage and price meters. The label shall be conspicuous and legible to a customer when viewed from the driver's position inside the car. The label shall be capable of withstanding extremes of weather conditions for at least one year and shall be resistant to gasoline, oil, grease, solvents, detergents, and water. Damaged labels that are not legible must be replaced. requiring the prominent labeling of retail pumps dispensing gasoline containing methyl tertiary butyl ether (MTBE).

INVOICE DISCLOSURE: The Department of Food and Agriculture has adopted regulations requiring any "manufacturer, blender, agent, jobber, consignment agent or distributor who distributes motor fuel products which contain at least 1 percent alcohol by volume," must identify on any "invoice, bill of lading, shipping paper, or other documentation used in normal and customary business practices," the percentage and type of alcohol and, except in documentation required under Federal law, the minimum anti-knock index number of the product.

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

No person shall deliver gasoline containing 0.6 percent by volume or more MTBE to a storage tank at a retail gasoline outlet unless at the time of the delivery either:

- (A) All pumps dispensing gasoline from the storage tank are labeled as containing MTBE, or
- (B) The party delivering the gasoline, or on whose behalf the delivery is being made, can demonstrate that it has received and is maintaining a nonsuperseded written notification from the operator of the retail

gasoline outlet that all of the outlet's gasoline dispensing equipment, or all of the outlet's dispensing equipment dispensing gasoline of the grade being delivered, is labeled as containing MTBE.

MOTOR FUEL SPECIFICATIONS: The Department of Food and Agriculture has adopted the most recent version of ASTM D 4814, however, all gasoline sold in California is currently subject to California Phase 2 reformulated gasoline regulations. Effective December 31, 2002, all gasoline sold in California will be required to comply with California Phase 3 reformulated gasoline standards.

California reformulated gasoline regulations require that no person shall sell, offer for sale, dispense, supply, offer for supply, or transport California gasoline which has an RVP exceeding 7.00 psi within each of the air basins during the designated regulatory control periods.

The California Air Resources Board has eliminated the RVP waiver for gasoline for gasoline containing 10% ethanol.

On December 9, 1999, the California Air Resources Board (ARB) adopted Phase 3 standards. The regulations are anticipated to become effective December 31, 2002.

COLORADO

LABELING REQUIREMENTS: Colorado requires that all dispensers of motor fuel blends containing Class A products and at least 2% by volume alcohol or Methyl Tert Butyl Ether (MTBE) must be labeled in a visible place with information indicating the presence of alcohol or MTBE in the blend. If the volume of methanol exceeds 2%, or if the volume of ethanol exceeds 10%, or if the volume of Methyl Tert Butyl Ether exceeds 11%, the label shall state the exact percentage by volume. Class A products include gasoline, benzine, benzene, naphtha, and benzol. The label must identify the maximum percentage by volume to the nearest whole percent of ethanol, of methanol or methanol with cosolvents, or of MTBE. The label must be placed on the front of the pump, in a position clear and conspicuous to the driver's position, in block letters at least 1/2" in height.

INVOICE DISCLOSURE: Colorado does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: Colorado requires that gasoline (all Class A products except for naphtha, benzol, benzine, and benzene) must comply with ASTM D 4814 and any supplements or revisions thereof. All tests made by the State Inspector of Oils shall be made in accordance with the most recent standard test methods of the American Society for Testing and Materials.

If Class A products are blended with ethanol, the ASTM Specifications apply only to the gasoline prior to blending.

CONNECTICUT

LABELING REQUIREMENTS: Connecticut has adopted the National Conference on Weights and Measures (NCWM) Uniform Regulation for the Method of Sale of Commodities and its revisions as regulations within the state.

Under Section 2.20.1 of the NCWM Uniform Regulation, Connecticut requires that all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or "containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information should be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2 inch in height, 1/16 inch stroke (width of type)."

INVOICE DISCLOSURE: Under Section 2.20.2 of NCWM's Method of Sale Regulation, Connecticut requires that the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. The documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the motor fuel before blending.

MOTOR FUEL SPECIFICATIONS: Connecticut has adopted by reference ASTM D 4814, "Standard Specification for Automotive Spark-Ignition Engine Fuel," as the motor fuel quality standard within the state with the following exceptions: A vapor pressure test tolerance not exceeding 0.5 psi is allowed for gasohol, leaded gasohol, and gasoline-oxygenate blends.

The minimum temperature for gasoline-oxygenate blends at 50% evaporated shall be 158°F (70°C) as determined by ASTM Test Method D 86.

DELAWARE

LABELING REQUIREMENTS: Delaware requires that a retail seller "shall clearly label all pumps dispensing gasohol." "Gasohol" is defined as a "blend of nine (9) parts unleaded gasoline and one (1) part ethanol and shall be mixed by a distributor at time of delivery to a purchaser."

INVOICE DISCLOSURE: Delaware does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: Delaware has adopted "the specifications of motor fuels as defined by the American Society for Testing and Materials." "Gasohol", as defined above, is subject to the same specifications as gasoline.

CONVERSION PROCEDURES: The state prohibits the sale of gasohol if the ethanol content of a sample of gasohol is significantly more or less than 10%. If this is determined to be the case, the state will issue a "Stop Sale" notice to the seller until the situation is corrected. The "stop sale" requirement applies only to 90% gasoline-10% ethanol blends; it does not apply to lower level blends.

The state does not permit the addition of straight ethanol to the storage tank to raise the ethanol content, and requires the product to be pumped out and rebled at the proper temperature for homogenizing before replacing into storage.

DISTRICT OF COLUMBIA

LABELING REQUIREMENTS: The District of Columbia does not require the labeling of oxygenated fuels on motor fuel dispensing pumps.

INVOICE DISCLOSURE: The District of Columbia does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: The District of Columbia has not adopted any motor fuel quality standards.

FLORIDA

LABELING REQUIREMENTS: Florida requires that all motor fuel kept, offered, or exposed for sale, or sold at retail, containing at least 1% by volume of ethanol, methanol, or a combination, shall be identified as:

"contains ethanol"
"contains methanol"
"contains ethanol/methanol".

The label must be displayed on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2" in height and 1/16" stroke (width of stroke).

INVOICE DISCLOSURE: Florida does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: Florida requires that all gasoline sold or offered for sale in Florida must meet the standards set forth in ASTM D 4814-94a, "Standard Specification for Automotive Spark-Ignition Engine Fuel".

Under Florida statutes, Florida exempts gasoline containing 10% ethanol and 90% unleaded gasoline from ASTM volatility and other requirements as long as the gasoline component complies with Florida specifications. "Alcohol-blended fuels which contain 90 percent unleaded gasoline and 10 percent ethyl alcohol of a minimum of 198 proof and a maximum 50 parts per million of acetic acid, commonly known as 'gasohol', may be sold at retail service stations for use in motor vehicles, as long as the gasoline component complies with current state specifications, until the American Society for Testing and Materials approves specifications for gasohol."

GRADE RESTRICTIONS: Florida requires that storage tanks containing gasoline or other petroleum products sold at retail must not contain water exceeding two inches in depth when measured from the bottom of the tank.

Before selling or offering for sale any petroleum fuels in the state, all manufacturers, wholesalers and jobbers must file with the department an affidavit that they desire to do business in the state, the address of the manufacturer, and a statement that the petroleum fuel is in conformity with the standards prescribed by department rule.

CONVERSION PROCEDURES: Florida requires that storage tanks containing gasoline or other petroleum products sold at retail must not contain water exceeding two inches in depth when measured from the bottom of the tank.

GEORGIA

LABELING REQUIREMENTS: The Department of Agriculture has published a "Guideline for Ethanol Gasoline Blends" which requires gasoline-ethanol blends containing 1% by volume or more ethanol to be labeled at the pump. The identity of ethanol and concentration must be displayed at the pump. Designated percentages can be in whole numbers. Product identification of gasoline-ethanol blends must be clarified with the Department of Agriculture at the time of registration. Approved blending percentages are 5.5%; 7.7%; and 10% ethanol with unleaded gasoline. Other blending percentages under 10% ethanol are permitted. The concentration of ethanol must be within 0.5% of the concentration labeled or registered.

A suitable label for a 90% unleaded gasoline mixed with 10% ethyl alcohol is as follows:

"UNLEADED WITH 10% ETHANOL"

Posted ethanol blending percentages can be no less than 1/2 the size of the name of gasoline with which it is blended. All pump identification must be located such that it is readily visible by the purchaser.

INVOICE DISCLOSURE: Under Georgia's "Guideline for Ethanol Gasoline Blends", the State requires that the identity of ethanol and concentration of ethanol must be included on shipping papers.

MOTOR FUEL SPECIFICATIONS: Georgia has adopted standards for gasoline and petroleum products based on ASTM standards and test methods.

Ethanol blends must meet all applicable requirements for automotive gasoline, except for vapor pressure and T 50 limits.

Under the "Guideline for Ethanol Gasoline Blends", Georgia requires that "the finished blend shall meet gasoline volatility requirements as applicable." As a matter of administrative interpretation, Georgia allows gasoline containing 9 to 10 volume percent ethanol a 1.0 psi RVP waiver and a minimum distillation allowance (T50) of 150°F.

Volatility requirements are as follows:

1. Distillation Temperatures °C (°F) at Percent Evaporated at 101.3 kPa Pressure (760 mm Hg):

Volatility Class	10% max	50%		90% max	Endpoint max
		min	max		
AA-2	70 (158)	77 (170)	121 (250)	190 (374)	225 (437)
AA-3	70 (158)	77 (170)	121 (250)	190 (374)	225 (437)
A-2	70 (158)	77 (170)	121 (250)	190 (374)	225 (437)
A-3	70 (158)	77 (170)	121 (250)	190 (374)	225 (437)
C-3	60 (140)	77 (170)	116 (240)	185 (365)	225 (437)
D-4	55 (131)	77 (170)	113 (235)	185 (365)	225 (437)

2. Distillation Residue is 2% volume maximum for all classes.

3. Vapor/Liquid Ratio at 101.3 kPa Pressure (760 mm Hg) and Vapor Pressure:

Volatility Class	V/L (20 max) Test Temp °C (°F)	Vapor Pressure kPa (psi)
AA-2	56 (133)	54 (7.8)
AA-3	51 (124)	54 (7.8)
A-2	56 (133)	62 (9.0)
A-3	51 (124)	62 (9.0)
C-3	51 (124)	79 (11.5)
D-4	47 (116)	93 (13.5)

4. Permissible Volatility Classes by month of sale:

AA-2	August, September 1-15. (Required for Atlanta ozone nonattainment area by EPA)
AA-3	June, July. (Required for Atlanta ozone nonattainment area by EPA)
A-2	August, September.
A-3	April, May, June, July.
C-3	March, April, May (end user shipments only), September 16-30, October, November.
D-4	January, February, March, November, December.

GRADE RESTRICTIONS: Georgia requires that all petroleum products offered for sale, including ethanol blended fuels, must be registered with the state prior to sale. All manufacturers, refiners, wholesalers and jobbers, before selling or offering for sale any gasoline or kerosene or like products, under whatever name designated, must file with the Commissioner of Agriculture a declaration or statement that they desire to sell such products in the state and must furnish the name, brand, or a trademark of the product which they desire to sell, together with the name and address of the manufacturer, and that all such products are in conformity with specifications. The registration must include the octane rating or antiknock index of motor fuels covered by FTC Octane Posting and Certification Rule.

The following standards are also required for ethanol blended fuels. The finished blend must not contain significant amounts of free or dissolved water and shall have a minimum water tolerance as found in the 1985 ASTM information document on gasohol. It shall be the manufacturer's responsibility to ensure that the base gasoline used for blending be essentially free of oxygenates.

All individuals and companies who blend or mix "gasoline" with "alcohols" are considered to be manufacturers.

Samples of the gasoline base stock and ethanol may be required for analysis when requested. The use of proper and adequate corrosion inhibitors is recommended. The blending or mixing of gasoline with ethanol at the retail level is prohibited.

Under Georgia's "Standards for Petroleum Products" the State requires that "manufacturers of gasoline-alcohol blended motor fuels (also other gasoline-oxygenate blends) shall declare with the State the type and quantity of nonhydrocarbon (oxygenate) used in the fuel."

CONVERSION PROCEDURES: The Department of Agriculture recommends that prior to marketing ethanol-gasoline blends, proper preparations should be made to all equipment used to store, pump, and dispense blended fuels to ensure that the product is clean and dry. The Department also recommends that on initial blending, the product remains in the system for a minimum of 48 hours and be sampled and tested prior to selling. The marketer shall notify the Department prior to initial blending.

LOW-RVP PROGRAM: The Georgia Department of Natural Resources requires all gasoline marketed in the Atlanta ozone nonattainment area to meet Reid vapor pressure and sulfur requirements.

During the period from June 1 to September 15 of any calendar year, no "person may produce, store, transport, supply, offer to supply, transfer or otherwise handle, sell, offer for sale, or dispense gasoline" that does not meet a 7.0 psi RVP.

An ethanol blend is considered in compliance if the Reid vapor pressure does not exceed 8.0 psi. The gasoline must contain denatured, anhydrous ethanol and the concentration of ethanol, excluding the required denaturing agent, must be at least 9 percent and no more than 10 percent (by volume). Each invoice, loading ticket, bill of lading, delivery ticket and any other document that accompanies a shipment of gasoline containing ethanol shall contain a legible and conspicuous statement that the gasoline being shipped contains ethanol and the percentage concentration of ethanol.

Effective April 1, 1999 and subsequent years through March 31, 2003, the sulfur content of all gasoline supplied by each producer or shall not exceed an average of 150 ppm (by weight) and effective April 1, 2003, the sulfur content of all gasoline supplied by each producer or importer shall not exceed an annual average of 30 ppm (by weight) and a per-gallon cap of 150 ppm (by weight)

HAWAII

LABELING REQUIREMENTS: Hawaii does not require the labeling of ethanol on motor fuel dispensing pumps.

INVOICE DISCLOSURE: Hawaii does not require the disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: Hawaii has adopted specifications for petroleum products which require that automotive gasoline conform to ASTM D 439-79, Class C volatility only, as published in the 1980 Annual Book of ASTM Standards, Part 23, 1980 edition.

Hawaii requires that "motor fuel gasohol" shall not contain less than 10 percent volume denatured ethanol in the base gasoline. "In the absence of a gasohol standard, the vapor lock tendencies for gasohol shall approximate that of a Class C volatility gasoline." "The effect of adding ten percent volume of ethanol to a base gasoline will increase the initial boiling point, the midpoint, and usually the endpoint, as well as increase the Reid vapor pressure, alter the vapor/liquid ratio, and enhance the octane index of the base gasoline."

GRADE RESTRICTIONS: Hawaii requires that any person marketing a petroleum product or after-market additive must register the product prior to sale with the Director of the Division of Measurement Standards on registration form MSP 2-306. If the product has been reformulated or changed, the registration must be renewed annually.

IDAHO

LABELING REQUIREMENTS: Idaho requires that all spark-ignition engine fuel kept, offered, or exposed for sale, or sold, at retail containing at least 1% by volume of any oxygenate or combination of oxygenates shall be identified as "with" or "containing" (or similar wording) the specific type of oxygenate(s) in the fuel. Spark-ignition motor fuel means gasoline and its blends with oxygenates, such as alcohols and ethers. For example, the label may read "contains ethanol" or "with MTBE/ETBE".

The label must be displayed on the upper 50% of both faces of the dispenser as near the unit price display as practical and in a position clear and conspicuous from the driver's position. The type must be at least 1/2 inch in height and 1/16 inch in stroke. The retail owner or operator must furnish the labels. Letters must be bold face, block and not less than 1/2" in height. The lettering must be black on a contrasting background in non-fade colors.

INVOICE DISCLOSURE: Idaho requires that retailers be provided, at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of any oxygenate or combination of oxygenates present in concentrations of at least 1% by volume of the fuel. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the engine fuel before blending.

MOTOR FUEL SPECIFICATIONS: Idaho requires that "motor gasoline" and other petroleum products meet the "latest specifications adopted by the American Society for Testing and Materials," or "other specifications adopted as standard by an Idaho governmental agency for its use, for those products."

ILLINOIS

LABELING REQUIREMENTS: Illinois requires any retail motor fuel dispensing device which is used to dispense a motor fuel containing at least 1% by volume ethanol, methanol or a combination thereof to display a label identifying the maximum percentage by volume, to the nearest whole percent, of ethanol, methanol, and co-solvent contained in the motor fuel. The label is required to be in contrasting colors with block letters at least 1/2" in height and 1/4" in width and not more than 1" in height and 1/2" in width, and must be visible to consumers.

INVOICE DISCLOSURE: Illinois requires that each seller of motor fuel containing ethanol or methanol provide the purchaser a bill of lading, manifest, or delivery ticket identifying the percentage by volume of ethanol, methanol, and cosolvent added to the fuel. This requirement does not apply to sales at retail. All motor fuel sold or offered for sale by the distributor shall contain the percentage and type of alcohol as stated on the bill of lading, manifest or delivery ticket.

MOTOR FUEL SPECIFICATIONS: Illinois requires that all motor fuel and petroleum sold or offered for sale in Illinois meet the most recently adopted ASTM standards for spark-ignition motor fuel.

Illinois provides ethanol-blends a vapor pressure waiver from ASTM standards. "All gasoline products shall meet the most recently adopted ASTM standards for spark-ignition motor fuel, and those standards adopted under provisions of the federal Clean Air Act by the U.S. Environmental Protection Agency shall be the standards of this State in those areas in which the federal Clean Air Act fuel standards apply."

LOW-RVP PROGRAM: Illinois requires that no person shall sell, offer for sale, dispense, supply, offer for supply, or transport for use in Madison, Monroe, and St. Clair Counties gasoline whose Reid vapor pressure exceeds 7.2 psi from June 1 to September 15.

During the regulatory control period, "the Reid vapor pressure of ethanol blend gasolines having at least nine percent (9%) but not more than ten percent (10%) ethyl alcohol by volume of the blended mixture shall not exceed the limitations of gasoline [set forth in this regulation]...by more than 1.0 psi (6.9 kPa). Notwithstanding this limitation, blenders of ethanol blend gasolines whose Reid vapor pressure is less than 1.0 psi above the base stock gasoline immediately after blending with ethanol are prohibited from adding butane or any product that will increase the Reid vapor pressure of the blended gasoline."

Each refiner or supplier that distributes gasoline or ethanol blends must during the regulatory control period state that the Reid vapor pressure of all gasoline or ethanol blends leaving the refinery or distribution facility for use in Illinois complies with the Reid vapor pressure limitations set forth above. "Any source receiving this gasoline shall be provided with a copy of an invoice, bill of lading, or other documentation used in normal business practice stating that the Reid vapor pressure of the gasoline complies with the State Reid vapor pressure standard."

INDIANA

LABELING REQUIREMENTS: Indiana does not require the labeling of oxygenates on motor fuel dispensing pumps. Indiana law prohibits the Department of Health from adopting "rules requiring the posting of notices concerning oxygenates on or near engine fuel dispensers located at retail service stations".

INVOICE DISCLOSURE: Indiana requires any "person who sells or delivers a petroleum product" containing ethanol, methanol or both to other than a retail consumer to identify on the "instrument evidencing the sale or delivery of the petroleum product": 1) the name of each alcohol (including cosolvent), and 2) the volume percentage (rounded to the nearest percent) of each alcohol contained in the fuel. A sales and delivery invoice is considered any invoice or document including a bill of lading, manifest or pipeline ticket, or exchange statement which reflects the amount of gallon transferred in a transaction.

MOTOR FUEL SPECIFICATIONS: Indiana has adopted the following specifications for gasoline and gasohol. The inspections and tests made by the Department of Health must be conducted in accordance with the methods outlined by ASTM.

For corrosion, a clean copper strip may not show more than extremely slight discoloration when submerged in gasoline for 3 hours at 122°F. Sulfur may not exceed 0.25%. Distillation requirements are as follows: at 167°F, not less than 10% shall be evaporated; at 284°F, not less than 50% shall be evaporated; at 392°F, not less than 90% shall be evaporated; and residue shall not exceed 2%. The Reid vapor pressure for gasoline at 100°F may not exceed 15.0 psi at the point of delivery during December through March, 14.0 psi during April, October, and November, and 12.0 psi during May through September.

Gasohol must meet the same specifications as gasoline, except for vapor pressure. The Department defines "gasohol" as a blend of 10% ethanol and 90% gasoline. Indiana provides gasohol a 0.5 psi higher RVP standard than that required for gasoline. For gasohol, the vapor pressure may not exceed 15.5 psi during December through March, 14.5 psi during April, October, and November, and 12.5 psi during May through September.

LOW-RVP PROGRAM: The Air Pollution Control Board requires that between May 1 and September 15 of each calendar year, all gasoline sold or distributed in the ozone nonattainment area of Clark and Floyd Counties must meet a new summertime gasoline Reid vapor pressure limit of 7.8 psi RVP or less.

During the applicable control period, Indiana requires that only a "compliant fuel" or an "alternate fuel" may be sold in Clark and Floyd Counties. "Compliant fuel" is defined as gasoline with an RVP of 7.8 psi, Federal RFG, or ethanol blended low-RVP gasoline. "Alternate fuel" is defined as methanol, alcohol, other alcohols containing 85% or more by volume of such alcohol with gasoline or other fuels, natural gas, liquified petroleum gas, hydrogen, electricity, and diesel fuel.

Gasoline containing ethanol may exceed the 7.8 psi RVP limit by up to 1.0 psi RVP, if the gasoline meets the following requirements:

- (1) the gasoline must contain denatured, anhydrous ethanol;
- (2) the concentration of anhydrous ethanol, excluding the required denaturing agent, must be at least 9 percent and no more than 10 percent by volume of the gasoline;
- (3) the ethanol content of the gasoline shall be determined by use of one of the testing methods specified in 40 CFR 80, Appendix F. The maximum ethanol content of gasoline shall not exceed any applicable waiver condition under section 211(f) (4) of the Clean Air Act, as amended; and
- (4) each invoice, loading ticket, bill of lading, delivery ticket, and other document that accompanies a shipment of gasoline containing ethanol shall contain a statement that the gasoline being shipped contains ethanol and shall list the type and volume percentage of the concentration of ethanol in that gasoline.

Any party selling, dispensing, or transferring gasoline intended for use in Clark and Floyd Counties during the applicable control period must have a transfer document indicating the date of all transfers; volume of gasoline transferred; volume percentage of ethanol if ethanol blended, with a date and location of blending; the location and time of transfer; and a statement certifying that the gasoline has an RVP of 7.8 psi or less per gallon, is ethanol blended, or is certified as RFG. This document must accompany every shipment of gasoline after it has been dispensed by the refinery.

IOWA

LABELING REQUIREMENTS: Iowa requires that all motor vehicle fuel kept, offered, or exposed for sale, or sold at retail containing over one percent ethanol, methanol, MTBE, or any combination of "oxygenate octane enhancers" must be identified on motor fuel dispensing pumps. Iowa also requires that all diesel fuel containing over 1% soybean oil by volume shall be identified as "with soydiesel" or similar wording.

For motor vehicle fuel containing over 1% "renewable fuel", the pump shall be identified with a decal located on the front and placed between 30" and 50" above the driveway level. "'Renewable fuel' means an energy source at least in part derived from an organic compound capable of powering machinery, including an engine or power plant. A renewable fuel includes but is not limited to ethanol-blended or soydiesel fuel." In accordance with regulations adopted by the Department, the appearance of the decal shall conform to the following standards adopted by the renewable fuels and coproducts advisory committee:

The only two sizes of decals approved are a design of 1.25" by 4" and a design of 2" by 6". All labels shall have the word "with" in letters with a minimum of .1875" high, and the name of the renewable fuel in letters a minimum of .5" high. The use of color, design and wording must be approved by the renewable fuels and coproducts advisory committee. The renewable fuel decals are provided by the Department of Agriculture and Land Stewardship and contain the following language:

"Cleaner Air For Iowa With Ethanol"

For motor vehicle fuel containing over 1% MTBE, the pump must be labeled as either "Contains MTBE"; or "MTBE blend" with the words "METHYL TERTIARY BUTYL ETHER" directly below. The lettering for "Contains MTBE" or "MTBE blend" must be black and no less than 1/2" in height, 1/8" in stroke. The lettering for "METHYL TERTIARY BUTYL ETHER" must be black in type size no less than 20 point. The label must be placed 30" to 40" above driveway level on the front of the pump. Additional wording or statements may be allowed upon submission to and approval by the Department.

INVOICE DISCLOSURE: Iowa requires that motor fuel sold to a retailer containing more than 1% by weight "oxygenate octane enhancers" must disclose the type and amount of oxygenate octane enhancers contained in the fuel at the time of delivery on the invoice, bill of lading, shipping papers, or other documentation.

MOTOR FUEL SPECIFICATIONS: Iowa requires that motor fuel meet the specifications set forth in the most recent version of ASTM.

For ethanol blended fuels, Iowa requires as a matter of enforcement policy that only the gasoline component of the blend must meet ASTM specifications.

Gasoline shall not contain a mixture of more than 25% ethanol, or more than 5% methanol. When methanol is blended, an equal amount of cosolvent must be used. Gasoline with a mixture of 10% or more ethanol, but no more than 13%, shall be known as "gasohol". Gasoline with a mixture of more than 13% ethanol, but no more than 25%, shall be known as "high blend ethanol".

GRADE RESTRICTIONS: Iowa requires that any wholesale dealer, retail dealer, pipeline, refinery, barge or bulk plant that sells or holds for sale natural gasoline raffinate below the minimum 87 octane that is intended or is to be blended with an oxygenate octane enhancer or higher gasoline components must register with the Department. All retail shipments of blended natural gasoline/raffinate must be accompanied by a certificate showing the true standards and tests of such blended motor fuel. The certificate must accompany the shipping document or bill of lading before such blended fuel can be received or unloaded.

KANSAS

LABELING REQUIREMENTS: Kansas has adopted the 1997 version of the National Institute of Standards and Technology Handbook 130. The Secretary of the Board of Agriculture is authorized to adopt a later version of Handbook 130 through rule or regulation.

Under NCWM's Uniform Regulations as contained in the 1997 version of Handbook 130, Kansas requires that "all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or "containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information shall be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2 inch in height, 1/16 inch stroke (width of type)".

INVOICE DISCLOSURE: Under NCWM's Uniform Regulation as contained in the 1997 version of Handbook 130, Kansas requires the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the motor fuel before blending.

MOTOR FUEL SPECIFICATIONS: Kansas has adopted the 1997 version of NIST Handbook 130, as motor fuel quality standards in the state. Under the NCWM Uniform Regulation for Engine Fuels, Petroleum Products, and Automotive Lubricants, gasoline and gasoline-oxygenate blends must meet the requirements of "the most recent version of ASTM D 4814, 'Standard Specification for Spark-Ignition Engine Fuel,' except that volatility standards for unleaded gasoline blended with ethanol shall not be more restrictive than those adopted under the rules, regulations, and Clean Air Act waivers of the U.S. Environmental Protection Agency (which includes rules promulgated by the State)."

Gasoline blended with ethanol shall be blended under any of the following three options: the base gasoline must meet the requirements of ASTM D 4814; the blend must meet the requirements of ASTM D 4814; or the base gasoline must meet all the requirements of ASTM D 4814 except distillation, and the blend must meet the specification's distillation requirements. Blends of gasoline and ethanol may not exceed the ASTM D 4814 vapor pressure standard by more than 1.0 psi. Ethanol intended for blending with gasoline "shall meet the most recent version of ASTM D 4806, 'Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel.'"

LOW-RVP PROGRAM: The Kansas Department of Health and Environment requires that all gasoline intended for use in the Kansas City area have a Reid vapor pressure not exceeding 7.2 psi between June 1 and September 15. The Kansas City control area consists of Johnson and Wyandotte Counties.

"For the period beginning June 1 through September 15 of each year, no person shall dispense, supply, exchange in trade, offer for sale or supply, sell, or store gasoline that is to be used as a fuel for motor vehicles and that has a Reid vapor pressure (RVP) greater than these levels:

- (1) 7.2 pounds per square inch (psi); or
- (2) 8.2 psi for gasoline containing at least 9.0 percent by volume but not more than 10.0 percent by volume ethanol."

KENTUCKY

LABELING REQUIREMENTS: Kentucky does not require the labeling of gasoline-oxygenate blends on motor fuel dispensing pumps.

INVOICE DISCLOSURE: Kentucky requires that for all gasoline, diesel fuel, and gasoline-oxygenate blends sold in the state, the following information must be identified on either the bill of lading or invoice: the name of the person transferring the motor fuel; the name of the person to whom the motor fuel is being transferred; the date of the transfer; the octane rating, if the motor fuel is gasoline or a gasoline oxygenate blend; and a declaration of any oxygenate or combination of oxygenates present in concentration of at least 1% by volume in the motor fuel.

MOTOR FUEL SPECIFICATIONS: Kentucky requires that all gasoline offered for sale at a retail facility shall conform with the January 1993 edition of ASTM D 4814, with the following exceptions:

The distillation range (ASTM D 86) of gasoline containing up to 10% ethanol shall be the same as specified for gasoline, except the minimum temperature at 50% evaporated shall be 150°F. (66°C.).

For gasoline containing up to 10% ethanol, the vapor pressure limit for each class shall be increased by 1.0 psi and the ASTM V/L (vapor to liquid ratio) specification is waived. For the period May 1 through September 15, the concentration of ethanol must be at least 9% and no more than 10% by volume of the gasoline to qualify for the increased vapor pressure allowance.

LOUISIANA

LABELING REQUIREMENTS: Louisiana requires that every container or pump from which "gasohol" or "methanol" is sold or dispensed as a motor fuel shall be conspicuously, clearly, and distinctly labeled on each side which faces the motor vehicle. The label must be readily visible in an upright position and shall not obscure any information which is required to be displayed by Federal or State law or regulation. The label must contain the following words:

"CONTAINS ETHANOL" or
"CONTAINS METHANOL".

For "gasohol," the label shall be in a type not less than 1/2" in height with a 1/16" stroke in contrasting colors. "Gasohol" is defined as "a fuel that contains not more than ninety percent gasoline and at least ten percent ethanol." "Ethanol" is defined as "an ethyl alcohol which has a purity of at least ninety-nine percent, determined without regard to any added denaturants, has been denatured in conformity with one of the approved methods set forth by the United States Bureau of Alcohol, Bureau, Tobacco, and Firearms, and has been derived from agricultural products."

For "methanol", the label must have solid black block letters on a yellow background in letters at least 1 1/2" high and 1/8" wide and be as close as possible to thirty six inches from the bottom of the pump. "Methanol" is defined as "a fuel that contains ninety percent gasoline and at least ten percent methanol."

INVOICE DISCLOSURE: Louisiana does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: Louisiana has adopted specifications which require all gasoline sold in the state to meet the following limits.

"Approved regular gasoline" must be a refined volatile hydrocarbon mixture having a tag closed cup flash point below 110°F, and shall be free from water and suspended matter. A clean copper strip shall not be darker than No. 1 on ASTM copper strip Corrosion Scale, when submerged in the gasoline for three hours at 122°F. Reid vapor pressure is not to exceed 13.5 psi. For distillation, when the thermometer reads 167°F, not less than 10% shall be evaporated; when the thermometer reads 284°F, not less than 50% evaporated; when the thermometer reads 392°F, not less than 90% evaporated; the end point shall not be higher than 437°F, and residue shall not exceed 2%. Recovery shall not be less than 95%. Percent evaporation shall be determined by adding distillation loss to the amount collected in the receiver at each specification temperature. Sulfur shall not exceed 0.25%. All testing and analysis of fuels are to be conducted in accordance with procedures established by ASTM.

The Louisiana Department of Transportation and Development adopted "Amended Specifications for Gasohol or 10% Ethanol Enriched Gasoline" which applies to a mixture of gasoline and ethanol in a 90-10 volume mixture for use in automotive internal combustion engines. "Gasohol" or "10% ethanol enriched gasoline" must conform with the following detailed requirements:

Fuel Property	Fuel Specification
Percent Ethanol	9.5% - 13.0%
Percent Gasoline	87% - 90.5%
Flash Point	110°F. maximum
Suspended Matter	None
Water	0.30% maximum
Sulfur	0.25% maximum
Reid Vapor Pressure	13.5 psi maximum
Methanol	1.0% maximum
Octane Number (R+M)/2	87 - Regular Unleaded 89 - Regular Leaded 91 - Premium

Distillation Property	Distillation Specification
Percent Distilled 0-167°F.	10% minimum
Percent Distilled 168-284°F.	50% minimum
Percent Distilled 285-392°F.	90% minimum
Residue	2.0% maximum
Recovery	95% minimum
End Point	437°F. maximum
Purity	99.0
Denaturants	5% maximum
Water	1.0% maximum

CONVERSION PROCEDURES: Louisiana requires that "gasohol" or "10% ethanol enriched gasoline" meet the following requirements. For blending at top-loading rack, the loading arm must be equipped with drop pipes and flow deflectors, and should be filled 90% with gasoline and then 10% with ethanol. For blending at bottom-load terminals, the transport compartment must be filled first with 10% of the compartment's volume with alcohol and bottom-load to the compartment's capacity with gasoline.

For storing the alcohol "in gasohol" or "10 percent ethanol enriched gasoline" in previously used gasoline tanks, all tanks must be "rested for 24 hours and the bottom thieved" before the product can be dispensed. For storage stability in new gasoline tanks, any new tank must be graded down three inches to the fill stack at the "A" end of the tank. The suction stub should not be any further than three inches from the bottom of the tank. Under no circumstances should a fill stack be placed in the center of a tank unless an opening is provided to thief the tank at the low ("A") end. A P.V. vent should be placed on the vent riser discharge. All fill stacks must have interior drop tubes. All gasohol storage tanks over 1,500 gallons must have drop tubes.

MAINE

LABELING REQUIREMENTS: Maine has adopted the National Conference on Weights and Measures (NCWM) Uniform Regulation for the Method of Sale of Commodities and its revisions as regulations within the state.

Under Section 2.20.1 of the NCWM Uniform Regulation, effective January 1, 1997, Maine requires that all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or "containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information should be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2 inch in height, 1/16 inch stroke (width of type)."

INVOICE DISCLOSURE: Under Section 2.20.2 of NCWM's Method of Sale Regulation, effective January 1, 1997, Maine requires that the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. The documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the motor fuel before blending.

MOTOR FUEL SPECIFICATIONS: Maine has not adopted any motor fuel quality specifications.

LOW-RVP PROGRAM: On February 17, 2000, the Department of Environmental Protection adopted a revision to its gasoline volatility rule pertaining to counties previously opting out of the Federal RFG program. Under the rule, all gasoline distributed or marketed by bulk gasoline terminals or delivered to gasoline service stations or bulk gasoline plants in York, Cumberland, Sagadahoc, Androscoggin, Kennebec, Knox and Lincoln counties shall not have a Reid Vapor Pressure greater than 7.8 psi during the period between May 1 and September 15 of each year.

Ethanol -gasoline blends are not provided a vapor pressure tolerance from the 7.8 psi RVP requirement.

MARYLAND

LABELING REQUIREMENTS: Maryland does not require the labeling of oxygenated fuels on dispensing pumps.

INVOICE DISCLOSURE: Maryland does not require the disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: Maryland requires that gasoline meet all the requirements and test methods of the latest version of ASTM Standard Specification for Automotive Spark-Ignition Engine Fuel, D 4814.

Maryland requires that the vapor pressure of gasoline may not exceed the following limits when tested in accordance with ASTM Test Method D 5190-92 or as otherwise required under the Motor Fuel Inspection Regulations.

January, February, March, and December	15 psi
April, October, and November	13.5 psi
May	9.0 psi
June, July, August, September 1-15 (in RFG VOC control region 1)	7.4 psi
June, July, August, September 1-5 (in RFG VOC control region 2)	8.3 psi
June, July, August, September 1-15 (in ozone attainment areas)	9.0 psi
September 16-30	11.5 psi

For ethanol blends, "an ethanol-enhanced oxygenated gasoline or ethanol blends is considered to be in compliance with Section D(1)(a)(b) and (e) of this regulation if its measured vapor pressure does not exceed the limit specified by more than 1.0 psi, the gasoline portion of the product was not produced and identified as VOC gasoline by the refiner and the product is sold for use or distribution outside a VOC Control Region."

For distillation, Maryland has amended its "Standard Specifications for Gasoline" to allow a 50 percent minimum distillation temperature of 150°F for all gasoline.

MASSACHUSETTS

LABELING REQUIREMENTS: The Massachusetts Division of Standards requires that all pumps and other dispensing devices including computing pumps dispensing motor fuel blended or mixed with more than 1% alcohol at retail must be labeled with the type and percentage of ethanol, methanol, and cosolvent contained in the fuel. The label must be affixed on the main display panel and be made of waterproof materials.

The label must be 5" wide by 5" long with a 1/8" black border with the following prototype language:

"ALCOHOL CONTENT
Max. % by Volume
Ethanol ____ %
Methanol ____ %
Alcohol Cosolvent ____ %".

Block letters and numerals must be used on the label. The words "ALCOHOL CONTENT" shall be in letters 1/2" high and 3/8" wide. All other letters and numerals shall be at least 1/4" high and 1/8" wide. Labels must be in black print on a yellow background. Both colors shall be non-fade.

INVOICE DISCLOSURE: Massachusetts does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: Massachusetts has not adopted any motor fuel quality laws.

MICHIGAN

LABELING REQUIREMENTS: The Michigan Department of Agriculture requires retail gasoline dealers to post a notice on the dispenser which contains all the following information listed in the following order: (1) The statement: "MEETS MICH. QUALITY & PURITY STANDARDS FOR", (2) the name of 1 of the 8 uniform grades or 1 of the 2 special grades of gasoline, (3) a statement that the gasoline contains ethanol, methanol, cosolvent, or any additives in the amount of 1% or more by volume, and (4) the statement: "CONSUMER COMPLAINT TOLL-FREE HOT LINE: CALL 1-800-MDA-FUEL".

If the gasoline contains 1% or more by volume alcohol, the label must state the type of alcohol and the percent by volume to the nearest whole percent of the alcohol and cosolvent contained in the gasoline. If the additive is methanol, the notice must state: "CONTAINS ALCOHOL: METHANOL ____ %". If the additive is ethanol or another alcohol such as tertiary butyl alcohol other than methanol and is used as a cosolvent, the notice must also include the statement: "CONTAINS ____ %". Gasoline containing an alcohol or ether which has a molecular weight greater than ethanol and which is not mixed with ethanol or methanol is not required to be posted.

Following are examples of acceptable notices:

"CONTAINS ETHANOL 10%",
"CONTAINS ALCOHOL: METHANOL 2%", or
"CONTAINS ALCOHOL: METHANOL 4% and CONTAINS TERTIARY BUTYL ALCOHOL 4%".

Letters for the statement "MEETS MICH. QUALITY & PURITY STANDARDS FOR" and "CALL 1-800-MDA-FUEL" shall be not less than 24-point type size. Letters for "CONSUMER COMPLAINT TOLL-FREE HOT LINE" shall be at least 10-point type. All other letters and numerals (including the alcohol notice) shall be printed in not less than 48-point type size and Helvetica medium typeface. Only upper case letters of identical color shall be used for all statements and notices.

The notice or notices shall be located on every side of the dispenser which has a price computation or quantity display panel and shall be placed not less than 34 inches and not more than 78 inches above the driveway elevation. The notice shall be conspicuous and legible to the customer when viewed from the driver's position of a motor vehicle positioned in front of the dispenser. The consumer complaint toll free hotline information is permitted to be placed separately from the grade name and additive information on single and multi product dispensers.

Where a single dispenser has multiple grades, one notice can be placed on each side of the dispenser with a price computation or quantity display panel containing the statements, "Meets Michigan Quality & Purity Standards For" and "Consumer Complaint Toll-Free Hot Line".

However, for each grade offered from a single dispenser, there must be a separate additive content label placed on the dispenser "immediately adjacent to either the associated brand name, the associated pump nozzle, or the unit price for that grade in a manner which clearly corresponds to the required notice to the associated brand name, nozzle, or unit price."

INVOICE DISCLOSURE: The Department of Agriculture requires that any distributor or refiner selling gasoline to a retail dealer must include on a bill, invoice, or other instrument indicating delivery, a guarantee that the gasoline meets the quality and purity standards for gasoline established by the Department of Agriculture and "indicate the concentration range of alcohol in the gasoline, except for alcohols or ethers that have a molecular weight greater than ethanol and are not mixed with methanol or ethanol, or both and shall indicate the possible presence, without regard to concentration range, of any alcohols or ethers that have a molecular weight greater than ethanol and are not mixed with methanol or ethanol, or both."

MOTOR FUEL SPECIFICATIONS: The Department of Agriculture has adopted the following specifications for gasoline in Regulation No. 564, "Automotive Gasoline Purity, Additives, and Grading."

For distillation, the Department requires that the 10% evaporated temperature not exceed 122°F in January, February, March, November, and December; 131°F in April, May, September, and October; and 140°F in June, July and August. The 50% evaporated temperature must not be less than 170°F, and must not exceed 230°F in January, February, March, November, and December; 235°F in April, May, September, and October; and 240°F in June, July, and August. Use of the next higher temperature for T-10 and T-50 is allowable during the transition months of March, May, September, and November. The maximum 90% evaporated point is 365°F, the maximum end point is 437°F, and the maximum residue is 2%. Copper strip corrosion shall not exceed no. 1 on the test scale. Existent gum shall not exceed 5.0 mg per 100.0 ml.

The maximum allowable Reid vapor pressure is 16.5 psi during January, February, March, November and December; 13.5 psi during April, May, September and October; and 11.5 psi during June, July and August.

The maximum temperature (°F) for phase separation of gasoline containing alcohol is one of the following temperatures:

Month:	Lower Peninsula:	Upper Peninsula:
January	0	-6
February	1	-4
March	10	5
April	27	21
May	34	30
June	45	43
July	50	48
August	48	48
September	41	39
October	32	30
November	21	16
December	7	0

Alcohol-gasoline blends are required to meet all specifications for gasoline, except for Reid vapor pressure and distillation. The standards established by the State shall not prohibit a gasoline blend that is permitted by a valid waiver granted by the U.S. EPA under the Clean Air Act, and the 1.0 psi ethanol waiver in Section 211(h)(4) of Title II of the Clean Air Act, provided the gasoline blend meets all of the conditions set forth in the waiver.

CONVERSION PROCEDURES: The Department of Agriculture requires that storage tanks at retail outlets must be periodically tested to ensure that the tank does not have water or water-alcohol at the bottom in an amount greater than 2 inches. If there is more than 2 inches of water or water-alcohol at the bottom of the storage tank, gasoline shall not be sold to a consumer from that tank until the water or water-alcohol level is reduced to a level of less than 2 inches. Adequate testing supplies, as determined by the Department of Agriculture, must be maintained at the retail outlet and must also be made available to the Department to determine the water-alcohol level in the storage tank.

LOW-RVP PROGRAM: From June 1 through September 15, gasoline sold in Wayne, Oakland, Macomb, Livingston, St. Clair, Monroe and Washtenaw Counties shall have a Reid vapor pressure of no more than 7.8 psi.

Suppliers have the option of providing reformulated gasoline in place of the 7.8 psi RVP gasoline required by the regulation.

Ethanol-blends are required to meet the same vapor pressure requirements as gasoline.

MINNESOTA

LABELING REQUIREMENTS: Minnesota does not require the labeling of oxygenates on motor fuel dispensing pumps.

INVOICE DISCLOSURE: Minnesota requires the disclosure of oxygenates on invoices and other wholesale documentation under the state-wide oxygen requirement. When gasoline contains an oxygenate, a person responsible for the product shall not blend the product with ethanol or with any other oxygenate after it is transferred or removed from a refinery or terminal. A refinery or terminal, must provide, at the time gasoline is sold or transferred from the refinery or terminal, a bill of lading or shipping manifest to the person who receives the gasoline.

For oxygenated gasoline, the bill of lading or shipping manifest must include the identity and the volume percentage or gallons of oxygenate included in the gasoline, and it must state: "This fuel contains an oxygenate. Do not blend this fuel with ethanol or with any other oxygenate." For non-oxygenated gasoline, the bill or manifest must state: "This fuel is not oxygenated. It must not be sold at retail in Minnesota."

MOTOR FUEL SPECIFICATIONS: Minnesota requires petroleum products to meet the following specifications.

Gasoline sold in the State, except for ethanol blended fuels, must comply with ASTM specification D 4814-96, must not be contaminated with water or other impurities, and must comply with the EPA volatility requirements set forth in Code of Federal Regulations, Title 40, Part 80. Gasoline must not be blended with casinghead gasoline, absorption gasoline, condensation gasoline, drip gasoline, or natural gasoline. Gasoline may be blended with a detergent additive, an anti-knock additive, or an EPA registered lead replacement.

Denatured ethanol to be blended with gasoline must be agriculturally derived and must comply with ASTM specification D 4806-95b. The ethanol may be denatured only as specified in Code of Federal Regulations, Title 27, parts 20 and 21.

Gasoline blended with an oxygenate other than denatured ethanol, must comply with ASTM specification D 4814-96.

Oxygenates, other than denatured ethanol, must not be blended into gasoline after the gasoline has been sold, transferred, or otherwise removed from a refinery or terminal.

MISSISSIPPI

LABELING REQUIREMENTS: Mississippi requires all gasoline, leaded or unleaded, kept, offered, or exposed for sale, or sold at retail containing 1% or more by volume of ethanol, methanol, or an ethanol/methanol mixture to be identified as "with" or "containing" (or similar wording) "ethanol", "methanol" or "ethanol/methanol" on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position in a

position clear and conspicuous from the driver's position. The type must be at least 1/2" in height, 1/16" stroke (width of type). All letters on the label must be in black with a contrasting background.

INVOICE DISCLOSURE: Mississippi requires all distributors, processors, refiners and other persons receiving, storing, selling, distributing or transporting gasoline that contains 1% by volume or more of methanol, ethanol, or other alcohol must identify the type or chemical name and percentage of such alcohol on any invoice, bill of lading, shipping paper or other type of documentation used in normal and customary business practice.

MOTOR FUEL SPECIFICATIONS: Mississippi requires that all gasoline and gasoline blends including gasohol and alcohol blended fuels must meet all specifications and standards set forth in ASTM D 4814, as set forth in the most current book of ASTM standards, except for volatility and octane classification.

For volatility, Mississippi requires that all gasoline offered for sale, exposed or sold at wholesale or retail in the State meet ASTM D 4814 volatility standards, except that U.S. EPA volatility standards "shall preempt such standards during the applicable period". Volatility standards for unleaded gasoline blends containing up to 10% ethanol shall not be more restrictive than those adopted under the rules, regulations, and Clean Air Act waivers of the U.S. EPA.

"Gasoline/Alcohol Blends" are required to meet all applicable requirements for gasoline, except for vapor pressure and distillation limits. Mississippi provides "blends containing up to 10 percent (10%) ethanol" a one pound per square inch vapor pressure tolerance from January through December, and a "fifty percent (50%) evaporated distillation temperature of not less than 158°F as determined by ASTM D 86."

GRADE RESTRICTIONS: Any dealer of gasoline or alcohol blended fuel is required to register his desire to sell gasoline or alcohol blended fuel with the Commissioner of Agriculture and Commerce and State Chemist prior to sale and annually thereafter on a certificate designated by the Commissioner. The dealer is required to provide information on the name, manner, and type of pump or pumps to be used at each location where such product is sold.

CONVERSION PROCEDURES: Mississippi requires that water level in retail storage tanks should not exceed three inches in depth. If the water level exceeds 3 inches, the Department will issue an order requiring the tank to be taken out of service and all water removed from the tank prior to delivery and/or subsequent sale of additional product from that storage tank.

MISSOURI

LABELING REQUIREMENTS: Missouri requires that all motor fuel kept, offered, or exposed for sale, or sold at retail containing at least 1% by volume of any alcohol shall be identified using the word "contains", or other wording approved by the director, with the maximum volume percentages to the nearest whole percent and the name of each alcohol additive on the upper 50% of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2" in height, 1/16" stroke. Examples are:

"CONTAINS 10% ETHANOL" or
"CONTAINS ALCOHOL
5% METHANOL
5% TERTIARY BUTANOL"

INVOICE DISCLOSURE: Missouri requires that the retailer must be provided at the time of delivery of the fuel on an invoice, bill of lading, shipping paper or other documentation, the presence and maximum amount of ethanol, methanol or any type of alcohol (in terms of percent by volume) contained in the fuel. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content

of the motor fuel before blending. In addition, gasoline-alcohol blends must be identified by "leaded" or "unleaded" and the octane (antiknock index) number.

MOTOR FUEL SPECIFICATIONS:

Missouri requires that all automotive gasoline containing oxygenated additives must meet the requirements set forth in the Annual Book of ASTM Standards, specification D 4814-88a with the following exceptions and additions.

Missouri provides gasoline blended with 10% denatured ethanol a vapor pressure tolerance of up to 1.0 psi RVP, and a tolerance at the 50% evaporated distillation temperature of not less than 158°F. For oxygenated fuels, Missouri requires that the total alcohol content shall not exceed 10 volume percent, that the oxygen content shall not exceed 3.7% by weight, and that when methanol is blended in quantities greater than 0.3 volume percent, the finished blend shall contain at least an equal amount of butanol or higher molecular weight alcohol.

CONVERSION PROCEDURES: Missouri requires that retail outlets offering "any gasoline-alcohol blended fuel" for the first time are required to observe special procedures for storage of motor fuels if the total alcohol content of motor fuels exceeds 0.3 volume percent:

- (1) all water and precipitated materials should be removed from the storage tank before the gasoline-alcohol blend is delivered into the tank, and
- (2) a suitable filter, 10 microns or less, must be installed in the meter inlet or discharge line and immediately adjacent to the meter.

Water in retail tanks shall not exceed 1" in depth, when measured from the bottom through the fill pipe, of any tank utilized in the storage of regulated products sold at retail. Water must be removed from the tank prior to the delivery and subsequent selling of additional product from the storage tank.

LOW-RVP PROGRAM:

Kansas City:

Under rules adopted by the Missouri Department of Natural Resources, Missouri requires that all gasoline sold, dispensed, supplied, offered for sale, offered for supply, transported, or exchanged in trade for use in the Kansas City Metropolitan Area from June 1 to September 15 of each year shall have a Reid vapor pressure of 7.2 psi or less. The regulations were effective June 1, 1997. The Kansas City Metropolitan Area consists of Clay, Platte and Jackson Counties. Federal specification reformulated gasoline (RFG) fully satisfies the requirements of the rule.

Gasoline blends containing at least 9% but not more than 10% ethyl alcohol by volume are provided a 1.0 psi RVP allowance.

Under the rule's recordkeeping requirements, each bill of lading, invoice, loading ticket, delivery ticket, and other document which accompanies a shipment of gasoline (including gasoline-ethanol blends) must contain a legible and conspicuous statement that the RVP of the gasoline does not exceed 7.2 psi for conventional gasoline, or 8.2 psi for 9%-10% ethyl alcohol blends.

In addition, each shipment of gasoline containing ethyl alcohol must contain a legible and conspicuous statement on a bill of lading, invoice, loading ticket, delivery ticket, and other documentation that the gasoline being shipped contains ethyl alcohol and that the percentage concentration of ethyl alcohol is between nine to ten percent (9%-10%). All persons subject to the regulations must maintain records of these documents for at least 2 years after the date of delivery. The director may require additional recordkeeping on a case-by-case basis.

All persons subject to this rule must maintain records of any RVP testing and test results during the compliance period. These records must be kept for at least 2 years after the date of a completed RVP test, and must be made available immediately upon request to Department of Natural Resources personnel.

MONTANA

LABELING REQUIREMENTS: Montana has adopted the Uniform Laws and Regulations of the National Institute of Standards and Technology Handbook 130, Part IV, G. Uniform Regulation of Engine Fuels, Petroleum Products, and Automotive Lubricants, 1996 Edition.

Under Section 2.20.1 of NCWM's Method of Sale Regulation, Montana requires that "all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or "containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information should be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2" in height, 1/16" stroke (width of type)."

INVOICE DISCLOSURE: Montana has adopted the Uniform Laws and Regulations of the National Institute of Standards and Technology Handbook 130, Part IV, G. Uniform Regulation of Engine Fuels, Petroleum Products, and Automotive Lubricants, 1996 Edition.

Under Section 2.20.2 of NCWM's Method of Sale Regulation, Montana requires that "the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the engine fuel before blending."

MOTOR FUEL SPECIFICATIONS: Montana has adopted the Uniform Laws and Regulations of the National Institute of Standards and Technology Handbook 130, Part IV, G. Uniform Regulation of Engine Fuels, Petroleum Products, and Automotive Lubricants, 1996 Edition.

Under the Uniform Regulation, Montana requires that gasoline and gasoline-oxygenate blends meet the requirements of the most recent version of ASTM D 4814, "Standard Specifications for Automotive Spark-Ignition Engine Fuel."

Gasoline-ethanol blends are provided an exception from ASTM volatility standards as follows. For gasoline-alcohol blends where ethanol is the predominant alcohol, volatility standards are as follows.

"Gasoline blended with ethanol shall be blended under any of the following three options: The base gasoline used in such blends shall meet the requirements of ASTM D 4814; or the blend shall meet the requirements of ASTM D 4818; or the base gasoline used in such blends shall meet all the requirements of ASTM except distillation, and the blend shall meet the distillation requirements of ASTM D 4814. Gasoline-ethanol blends shall not exceed the applicable ASTM D 4814 vapor pressure standard by more than 1.0 psi."

NEBRASKA

LABELING REQUIREMENTS: Nebraska has adopted the National Conference on Weights and Measures (NCWM) Uniform Method of Sale of Commodities Regulation as it existed on September 9, 1993.

Under NCWM's Uniform Regulation on "Gasoline-Oxygenate Blends" contained in Section 2.20 of the 1993 version of Handbook 130, Nebraska requires: "All spark-ignition engine fuel kept, offered, or exposed for sale, or sold, at retail containing at least one percent by volume of any oxygenate or combination of oxygenates shall be identified as "with" or "containing" (or similar wording) the specific type of oxygenate(s) in the engine fuel. For example, the label may read "contains ethanol" or "with MTBE/ETBE." This information should be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2" in height, 1/16" stroke (width of type)."

INVOICE DISCLOSURE: Nebraska has adopted the National Conference on Weights and Measures (NCWM) Uniform Method of Sale of Commodities Regulation as it existed on September 9, 1993. Under NCWM's Uniform Regulation on "Gasoline-Oxygenate Blends" contained in Section 2.20 of the 1993 version of Handbook 130, Nebraska requires that retailers be provided, at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of any oxygenate or combination of oxygenates present in concentrations of at least 1 percent by volume of the fuel. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the engine fuel before blending.

MOTOR FUEL SPECIFICATIONS: Nebraska has adopted by reference the American Society for Testing and Materials publication D 4814-89. All automotive spark-ignition engine fuel sold in the State must meet ASTM D 4814-89, "Standard Specification for Automotive Spark-Ignition Engine Fuel". Automotive spark-ignition engine fuels are defined as "gasoline and its blends with oxygenates such as alcohols and ethers."

NEVADA

LABELING REQUIREMENTS: The Department of Business and Industry does not require the labeling of oxygenated fuels on motor fuel dispensing pumps.

INVOICE DISCLOSURE: The Department of Business and Industry does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: The State Board of Agriculture has adopted by reference the specification for gasoline contained in volume 05.03, Petroleum Products and Lubricants, of the 1998 Annual Book of ASTM Standards, ASTM designation D 4814-97b. The ASTM designation was revised by the Nevada Board of Agriculture on October 29, 1998, and became effective December 14, 1998.

Gasoline sold in Clark County between October 1 and the following March 30 must not exceed a vapor pressure of 9.0 pounds per square inch and must meet distillation specifications set forth for volatility Class A, B, or C in ASTM designation D 4814-97b.

Except in Clark County from October 1 and March 30, gasoline containing 9 percent ethanol by volume or more is permitted an additional 1.0 psi vapor pressure. Under section 590.065 of the Nevada Administrative Code, Nevada requires that "gasoline sold in Clark County between October 1 and the following March 30 must not exceed a vapor

pressure of 9 pounds per square inch and must meet the specifications relating to distillation set forth for volatility class A, B, or C in ASTM designation D 4814-94d."

On April 22, 1999, the District Board of Health of Clark County approved a final rule establishing new Cleaner Burning Gasoline specifications for Clark County. The rule adds a new section to Clark County's Air Pollution Control Regulations "Section 54 - Cleaner Burning Gasoline (CBG): Wintertime Program". Under the cleaner burning gasoline rule, all fuel sold in Clark County, Nevada, from November 1, 1999 to March 31, 2000, and each such winter season thereafter is required to meet a maximum sulfur standard of 80 parts per million by weight and a maximum aromatic hydrocarbon standard of 30.0 percent by volume. Compliance with the standard can be met by either a flat limit or through averaging.

NEW HAMPSHIRE

LABELING REQUIREMENTS: New Hampshire has adopted the National Conference on Weights and Measures (NCWM) Uniform Method of Sale of Commodities Regulation and its revisions as regulations within the state.

Under Section 2.20.1 of the NCWM Uniform Regulation, New Hampshire requires that all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or "containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information shall be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2 inch in height, 1/16 inch stroke (width of type).

INVOICE DISCLOSURE: Under Section 2.20.2 of NCWM's Method of Sale Regulation, New Hampshire requires that the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the motor fuel before blending.

MOTOR FUEL SPECIFICATIONS: New Hampshire has adopted the NCWM Uniform Regulation for Engine Fuels, Petroleum Products, and Automotive Lubricants. Under the Uniform Regulation, gasoline and gasoline-oxygenate blends must meet the requirements of "the most recent version of ASTM D 4814, 'Standard Specification for Spark-Ignition Engine Fuel,' except that volatility standards for unleaded gasoline blended with ethanol shall not be more restrictive than those adopted under the rules, regulations, and Clean Air Act waivers of the U.S. Environmental Protection Agency (which includes rules promulgated by the State)."

"Gasoline blended with ethanol shall be blended under any of the following three options: the base gasoline must meet the requirements of ASTM D 4814; the blend must meet the requirements of ASTM D 4814; or the base gasoline must meet all the requirements of ASTM D 4814 except distillation, and the blend must meet the specification's distillation requirements. Blends of gasoline and ethanol may not exceed the ASTM D 4814 vapor pressure standard by more than 1.0 psi. Ethanol intended for blending with gasoline "shall meet the most recent version of ASTM D 4806, 'Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel.'"

NEW JERSEY

LABELING REQUIREMENTS: The Office of Weights and Measures of the New Jersey Department of Law and Public Safety does not require the labeling of oxygenates on motor fuel dispensing pumps.

INVOICE DISCLOSURE: New Jersey does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: New Jersey has not adopted any motor fuel quality standards.

NEW MEXICO

LABELING REQUIREMENTS: New Mexico requires that all gasoline-alcohol blends containing in excess of 1% alcohol, must be labeled with the type of alcohol used for blending. The letters must be at least 1/2" in height in appropriate stroke and in contrasting color to its associated background. The label must be placed on all faces of the retail dispenser, and "located as near the customer readout as possible".

INVOICE DISCLOSURE: New Mexico does not require the disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: New Mexico requires that petroleum products meet the most recent standards and test methods adopted and published by the American Society for Testing and Materials or the Society of Automotive Engineers, except as modified by regulation.

New Mexico has adopted the following modifications to ASTM's "Standard Specification for Automotive Spark-Ignition Engine Fuel." For gasoline-alcohol blends in excess of 1% alcohol, a vapor pressure increase not exceeding 1.0 psi is allowed and the minimum temperature at 50 percent evaporated shall be 158°F. (170°C). Applications for temporary exceptions to vapor pressure and vapor/liquid specifications may be made to the Director of the Department of Agriculture.

NEW YORK

LABELING REQUIREMENTS: The New York State Department of Agriculture and Markets requires any retailer or reseller transferring, selling, dispensing, or offering gasoline containing more than 1.0% of total volume or ethanol, or 0.3% total volume methanol, to label the retail dispensing device with the maximum percentage of alcohol in the blend. For ethanol, the label should state the maximum percentage of ethanol as follows:

"Contains ____ % ethanol"

For methanol, the label should state the maximum volume of methanol and the minimum volume of co-solvent as follows:

"Contains ____ % methanol"

"Contains ____ % co-solvent"

The lettering on the label should be at least 1/4" block letters on a contrasting background. The label should be "continuously displayed" on the upper 50 percent of the dispenser.

INVOICE DISCLOSURE: The Department of Agriculture and Markets requires that all refiners or distributors of "automotive gasoline" must provide certification to the person receiving the product identifying the ethanol or methanol content of the gasoline. If the product contains more than 1.0 percent of ethanol by volume, the maximum percentage of ethanol in the gasoline must be identified. If the product contains more than 0.3 percent methanol by volume, the maximum percentage of methanol and the minimum percentage of co-solvent in the gasoline must be identified. The certification required may be made either on delivery documents, a letter, or other written statement.

MOTOR FUEL SPECIFICATIONS: The New York State Department of Agriculture and Markets requires that all automotive gasoline meet the requirements in the Annual Book of ASTM Standards, specification number D 4814, as in effect on January 1, 1992, except as noted below.

Vapor pressure may not exceed 9.0 psi from May 1 to September 15; 13.5 psi from April 1 to 30 and September 16 to October 31; and 15.0 psi from November 1 to March 31. The Commissioner of Environmental Conservation may grant exceptions from the 9.0 psi vapor pressure standard under 6 NYCRR part 225-3.

The Department of Agriculture and Markets provides gasoline-ethanol blends a vapor pressure exemption from ASTM D 4814 vapor pressure limits during the winter months, as recognized in the EPA waiver for gasoline. The Department of Agriculture and Markets provides blends of 10% ethanol by volume a reduction of the ASTM T50 limit as follows: "The 50% distillation temperature shall not be less than 158 degrees Fahrenheit (70 degrees Celsius) for blends containing ten (10) percent ethanol by volume."

CONVERSION PROCEDURES: The New York State Department of Agriculture and Markets requires that all retailers storing, selling, or offering for sale any gasoline-alcohol blend for the first time must remove all "water and precipitated materials from the storage tank before the gasoline-alcohol blend is delivered into the storage tank." New York defines "gasoline-alcohol blend" as "any gasoline containing a substantial amount of one or more aliphatic alcohols".

NORTH CAROLINA

LABELING REQUIREMENTS: The North Carolina Department of Agriculture requires gasoline-oxygenate blends containing at least 1% by volume of ethanol, methanol, or a combination, to be labeled with the registered brand name plus an additional label which states that the blend:

"contains alcohol",
"contains ethanol",
"contains methanol", or
"contains ethanol/methanol".

The label must be composed of letters at least 1" in height, minimum 1/8" stroke, which contrast distinctly with the label background and must be located on the dispenser front panel in a position clear and conspicuous from the driver's position. Fuels not covered by an EPA waiver must have an additional label identifying the percent by volume of ethanol and/or methanol in the blend. Fuels which meet the EPA's "Substantially Similar" rule and do not contain ethanol or methanol are not required to have an additional label.

INVOICE DISCLOSURE: The Department of Agriculture does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: North Carolina has adopted by reference the most recent version of ASTM D 4814, "Standard Specification for Automotive Spark-Ignition Engine Fuel," as the standard specification for gasoline.

North Carolina requires "alcohol blends" to meet the most recent version of ASTM D-4814, "Standard Specification for Automotive Spark-Ignition Engine Fuel", with the following exceptions. North Carolina provides "alcohol blends" a vapor pressure tolerance not to exceed 1.0 psi and the minimum temperature at 50% evaporated shall be 158°F. (70°C.), as determined by ASTM Test Method D-86. The vapor pressure tolerance and distillation tolerance for the minimum temperature at 50 percent evaporated applies to any alcohol blend which has an EPA waiver.

"Alcohol blends" are required to meet the following standards. The minimum lead content for gasoline-oxygenate blends registered or labeled as "leaded" or "regular" shall contain "not less than 0.05 grams lead per U.S. gallon (0.013 grams lead per liter) or an approved lead substitute which provides a lead equivalency of at least 0.10 gram lead per U.S. gallon (0.026 gram per liter)." Octane rating shall not be less than the octane index certified on the brand name registration. All blends, both leaded and unleaded, shall be blended according to the EPA "substantially similar" rule or an EPA waiver and water tolerance shall be such that no phase separation occurs when subjected to a temperature equal to the temperatures specified in Table 4, ASTM D-4814. "Denatured fuel ethanol" is required to meet ASTM D-4806, "Standard Specification for Denatured Fuel Ethanol for Blending with Gasoline for Use as Automotive Spark-Ignition Engine Fuel."

GRADE RESTRICTIONS: North Carolina requires that all motor fuels sold or delivered to a purchaser in North Carolina (as well as fuels containing alcohol or other oxygenates) must be "branded", and every brand name "registered" with the Director of the Standards Division prior to sale. For automotive gasolines and gasoline-oxygenate blends, North Carolina requires a minimum octane index of 87, except for those designated as "Premium" or a word or term of equivalent meaning, a minimum octane index of 91 is required. The Director has the authority to require additional written certification for any EPA waived fuel. For persons wishing to register a non-waived fuel, the Director may require test data and performance evaluations as well as detailed chemical and physical characteristics.

NORTH DAKOTA

LABELING REQUIREMENTS: North Dakota requires that "all gasoline or gasohol" sold or offered for sale containing 1% or more by volume ethanol, methanol, or cosolvent alcohol, or any combination thereof, must be labeled with the conventional name or name(s) of the alcohol contained in the gasoline or gasohol. For gasoline containing methanol, the label must conspicuously display the maximum percentage of methanol and cosolvent alcohol if the product contains 3 percent or more by volume methanol.

The label must be on any price advertising and the dispenser's front panel in a position that is clear and conspicuous from the driver's position. The letters must be the same size as those used for the label of the basic grade of gasoline and must be next to the gasoline grade label.

INVOICE DISCLOSURE: North Dakota requires that suppliers of alcohol blended gasoline containing 1% or more by volume of any alcohol or combination of alcohols to retail service stations or to other resuppliers must provide the retailer or other reseller an invoice or delivery ticket indicating within one percentage point the specific content by volume of any alcohol or combination of alcohols. This information must be readily available to the consumer of an alcohol blended gasoline.

MOTOR FUEL SPECIFICATIONS: North Dakota has adopted specifications for gasoline based on standards of the American Society for Testing and Materials (ASTM).

North Dakota requires a maximum vapor pressure of 15.0 psi for gasoline sold during the months of November through March; 13.5 psi during the months of March, April, October and November; 11.5 psi from September 16 through the month of October; and 9.0 psi from April through September 15. For the month of May, the specification only applies to gasoline and gasoline-oxygenate blend tankage at refineries, importers, pipelines, and terminals.

North Dakota provides ethanol blended gasoline a year-round 1.0 psi vapor pressure allowance. "North Dakota and U.S. Environmental Protection Agency regulations allow a 1.0 pounds per square inch higher vapor pressure for gasoline-ethanol blends containing 9 to 10 volume percent ethanol..."

North Dakota has adopted the following: "Gasohol Specifications," "Leaded Gasohol Specifications," "Alcohol Specifications," and limits governing "Permissible Levels of Alcohol."

Gasohol Specifications: Gasohol is defined as "a motor fuel composed of ninety volume percent of unleaded gasoline meeting all of the requirements of the North Dakota gasoline specifications except for those regarding octane and ten volume percent of denatured ethanol." The final product must meet the octane requirements of the North Dakota gasoline specifications.

Leaded Gasohol Specifications: Leaded gasohol is defined as "a motor fuel composed of ninety volume percent of leaded gasoline meeting all of the requirements of the North Dakota gasoline specifications except for those regarding octane and ten volume percent of denatured ethanol." The final product must meet the octane requirements of the North Dakota gasoline specifications.

Alternative Specifications: A permitted alternative to the Gasohol or Leaded Gasohol Specifications is gasohol or leaded gasohol prepared by the addition of a nominal ten volume percent of denatured ethanol meeting the alcohol specification to an unleaded or leaded gasoline, respectively, that may not meet the requirements of the North Dakota gasoline specifications, provided that the finished product meets the North Dakota gasoline specifications.

Alcohol Specifications: The alcohol specification requires that denatured ethanol at the time of blending either gasohol or leaded gasohol must contain no more than 1.25 weight percent of water, and must be denatured in accordance with BATF regulations.

Permissible Levels of Alcohol: The maximum level of ethanol, methanol or other alcohol in gasoline or gasohol must conform to levels established by EPA and the Department of Interior. Any blender or wholesaler distributing gasoline containing methanol which has been granted a waiver by EPA must inform the Department of Health and Consolidated Laboratories and the retailer of the waiver in writing, prior to distribution.

OHIO

LABELING REQUIREMENTS: Ohio requires that any retailer selling or offering for sale gasoline containing more than 0.3% by volume ethanol, methanol, or cosolvent, or any combination thereof, must label the motor fuel dispensing pump with the type and maximum percent of alcohol and co-solvent in the gasoline. The label must identify that the gasoline contains ethanol, methanol, or cosolvent, and the maximum percentage to the nearest tenth of a percent, of any ethanol, methanol or cosolvent contained in the gasoline. "Maximum percentage" is defined as "the highest amount by volume of ethanol, methanol, or co-solvent permitted to be blended or mixed with gasoline in conformity with the specifications established by the United States Environmental Protection Agency pursuant to section 211 of the Clean Air Act, 42 U.S.C. Section 7545.

The word "Contains" shall be in block letters not less than 1/2" in height. All other required disclosures must be in block letters or numerals not less than 1/4" in height. The label or printed sign must be affixed to the retail

dispensing pump, and must be visible and legible to the purchaser and displayed in a clear, conspicuous, and prominent manner.

INVOICE DISCLOSURE: Ohio requires that any party transferring gasoline at wholesale which may affect a consumer transaction must provide before, or at the time of transfer, a written notice identifying that the gasoline contains more than 0.3 percent by volume of ethanol, methanol or cosolvent, any or any combination thereof. The type and maximum percentage by volume to the nearest then of a percent of ethanol, methanol, or co-solvent must be identified in capital letters. The notice must be contained in, or affixed to, a manifest, invoice, or other instrument or document of sale of title.

MOTOR FUEL SPECIFICATIONS: Ohio has not adopted any motor fuel quality standards.

OKLAHOMA

LABELING REQUIREMENTS: Oklahoma requires that every pump or delivery device selling motor fuel containing "ethyl alcohol" must be labeled as follows:

"WITH 10% ALCOHOL",
"WITH ALCOHOL",
"GASOHOL",
"REGOHOL",
"WITH ETHANOL (ALCOHOL)", or
"WITH ETHYL ALCOHOL",
"OXYGENATED WITH ALCOHOL OR ETHERS".

The label must be displayed on the face of the pump or delivery device, in the same size letter as the type or grade of motor fuel.

INVOICE DISCLOSURE: Oklahoma requires that "any manufacturer, hauler, blender, agent, jobber, consignment agent, or distributor who handles motor fuel products, which include any additive or octane booster whose volume is 0.1% or more, must state existence of such additives on any invoice, bill of lading, shipping paper, or other documents used in normal and customary business practices."

MOTOR FUEL SPECIFICATIONS: The Oklahoma Corporation Commission has adopted "Specifications, Standards, and Labeling for Motor Fuels" which require gasoline, "gasohol," and "regohol" to meet the following specifications. "Gasohol" is defined as "an unleaded motor fuel containing 9 parts gasoline to 1 part denatured ethyl alcohol (ethanol) by volume." "Regohol" is defined as "a leaded motor fuel containing 9 parts gasoline to 1 part denatured ethyl alcohol (ethanol) by volume and shall be practicable and suitable for use as a fuel in a spark ignition, internal combustion engine."

For distillation, when 10% is evaporated, the thermometer reading shall be greater than 90°F and shall not exceed 158°F; when 50% is evaporated, the thermometer reading shall be greater than 170°F and shall not exceed 250°F; when 90% is evaporated, the thermometer reading shall be greater than 265°F and shall not exceed 374°F; when the endpoint is reached, the thermometer reading shall be greater than 360°F and shall not exceed 437°F. Residue shall not exceed 2%, and recovery must be 92.5% or greater in the months of November through February. In all other months the recovery must be 94% or greater.

Gasoline, "gasohol", and "regohol" shall be essentially free of undissolved water, sediment, and suspended matter and "shall be clear and bright at the ambient temperature or 70°F., whichever is higher." Sulfur content shall not exceed 0.10% for unleaded fuel or 0.15% for leaded fuel by weight. Gum content shall not exceed 5 milligrams per 100 milliliters. For corrosion, a clean copper strip shall not show more discoloration than Classification No. 1.

The Oklahoma Corporation Commission has set limitations on ethanol content which require that all motor fuel containing ethyl alcohol sold in the state shall have a maximum ethanol content of 10 volume percent, plus or minus 1%.

OREGON

LABELING REQUIREMENTS: Oregon requires gasoline-oxygenate blends to meet the labeling requirements of the National Conference on Weights and Measures Uniform Regulation for Engine Fuels, Petroleum Products, and Automotive Lubricants. Gasoline blended with ethanol, methanol, co-solvent, alcohol or other oxygenates in quantities greater than 1.5 mass percent shall be identified as "with," "containing" or other similar language indicating the oxygenate contributing the largest mass percentage to the blend in the gasoline. When mixtures of only ethers are present, the retail dealer or nonretail dealer shall post the predominant oxygenate followed by the phrase "or other ethers." Gasoline-methanol blends containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol.

The label must be posted on the upper 50 percent of the dispensing device front panel in the position clear and conspicuous from the driver's position in type at least one-half inch in height and one-sixteenth inch in width.

In any county, city or other area designated as a carbon monoxide nonattainment area pursuant to the provision of the Clean Air Act, and in which the sale of oxygenated gasoline is required, any retail dealer of gasoline who sells or dispenses a petroleum product that contains at least one percent, by volume, ethanol, methanol or other oxygenate, shall be required to post only the Clean Air label during the oxygenated fuels control period.

INVOICE DISCLOSURE: Oregon requires that before or at the time of delivery of gasoline from a wholesale dealer to a retail dealer or nonretail dealer, the wholesale dealer must give the retail dealer or nonretail dealer on an invoice, bill of lading, shipping notice or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentration sufficient to yield an oxygen content of at least 1.5 mass percent in the gasoline. When mixtures of only ethers are present, the wholesale dealer shall identify the predominant oxygenate in the gasoline followed by the phrase "or other ethers." Any gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol.

MOTOR FUEL SPECIFICATIONS: Oregon requires gasoline and gasoline-oxygenate blends to meet the requirements of ASTM D 4814, "Standard Specifications for Automotive Spark-Ignition Engine Fuel." Ethanol intended for blending with gasoline is required to meet ASTM D 4806, "Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel."

Gasoline-ethanol blends are provided an exception from ASTM volatility standards as follows. For gasoline-alcohol blends where ethanol is the predominant alcohol, volatility standards are as follows. "Gasoline blended with ethanol shall be blended under any of the following three options:

Volatility standards shall not be more restrictive than those set forth in 40 CFR 80.27, the State Implementation Plan for Oregon (40 CFR 1970 et. Seq.) or any federal waiver by the U.S. Environmental Protection Agency under the Clean Air Act; and volatility standards shall be met under one of the following three options:

- The base gasoline used in such blends shall meet the requirements of ASTM D 4814; or
 - The blend shall meet the requirements of ASTM D 4818; or
 - The base gasoline used in such blends shall meet all the requirements of ASTM except distillation, and the blend shall meet the distillation requirements of ASTM D 4814.
- Gasoline-ethanol blends shall not exceed the applicable ASTM D 4814 vapor pressure standard by more than 1.0 psi.

PENNSYLVANIA

LABELING REQUIREMENTS: The Pennsylvania Department of Agriculture has adopted the "Uniform Regulation for the Method of Sale of Commodities" and its supplements contained in NIST Handbook 130.

Under Section 2.20.1 of the NCWM Uniform Regulation, Pennsylvania requires that all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or "containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information should be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2 inch in height, 1/16 inch stroke (width of type)."

INVOICE DISCLOSURE: The Pennsylvania Department of Agriculture has adopted the "Uniform Regulation for the Method of Sale of Commodities" and its supplements as contained in NIST Handbook 130.

Under Section 2.20.2 of NCWM's Method of Sale Regulation, Pennsylvania requires that the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. The documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the motor fuel before blending.

MOTOR FUEL SPECIFICATIONS: Pennsylvania has not adopted any motor fuel quality standards.

LOW-RVP PROGRAM:

Pittsburgh-Beaver Valley Area:

Under rules adopted by the Pennsylvania Department of Environmental Protection, Pennsylvania requires that all gasoline sold or transferred into or within the Pittsburgh-Beaver Valley area from May 1 through September 15 for refiners, distributors, resellers, carriers, and wholesalers, and June 1 through September 15 for all wholesale- purchaser consumers and retailers of gasoline, must meet an RVP of 7.8 psi or less. The Pittsburgh-Beaver Valley area is comprised of the seven counties of Allegheny, Armstrong, Beaver, Butler, Fayette, Washington and Westmoreland.

The rule requires that during the period May 1 through September 30, 1998, and continuing every year thereafter, "a refiner, importer, distributor, reseller, terminal owner and operator or carrier may not sell, exchange, or supply gasoline that is not a compliant fuel...A retailer or wholesale-purchaser consumer may not sell, exchange, or supply gasoline that is not a compliant fuel during the period June 1 through September 15, 1998, and continuing every year thereafter." "Compliant fuel" is defined as gasoline with a Reid vapor pressure of 7.8 psi or less per gallon, as determined by the appropriate sampling and testing methodologies set forth in 40 CFR Part 80 Appendix E.

Allegheny County:

On August 12, 1999 the Allegheny County Commissioners adopted a final rule revising the Allegheny County cleaner gas regulations to conform with the regulations adopted for the entire Pittsburgh-Beaver

Valley area. The final rule requires gasoline with a 7.8 psi RVP from June 1 through September 15 each year.

RHODE ISLAND

LABELING REQUIREMENTS: The Rhode Island Department of Labor has adopted the National Conference on Weights and Measures (NCWM) Uniform Method of Sale of Commodities Regulation and its revisions as regulations within the state.

Under Section 2.20.1 of the NCWM Uniform Regulation, Rhode Island requires that all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or "containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate.

Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information should be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2" in height, 1/16" stroke (width of type).

INVOICE DISCLOSURE: Under Section 2.20.2 of NCWM's Method of Sale Regulation, Rhode Island requires that the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate.

Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the engine fuel before blending.

MOTOR FUEL SPECIFICATIONS: The Rhode Island Division of Taxation has adopted standards for gasoline which requires that "no person shall sell, offer for sale, deliver or have in his possession for the purpose of sale, any article or product represented as gasoline for use in internal combustion engines used in motor vehicles that does not equal the 'American society for testing and materials standard specification for automotive gasoline D 439-82a."

SOUTH CAROLINA

LABELING REQUIREMENTS: South Carolina has adopted the Uniform Regulation for the Method of Sale of Commodities adopted by the National Conference on Weights and Measures and published in the National Institute of Standards and Technology Handbook 130, "Uniform Laws and Regulations", and its supplements and revisions.

Under the Method of Sale Regulation, South Carolina requires that "all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or

"containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate.

Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information shall be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2 inch in height, 1/16 inch stroke (width of type).

INVOICE DISCLOSURE: Under the Method of Sale Regulation, South Carolina requires the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate.

Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the motor fuel before blending.

MOTOR FUEL SPECIFICATIONS: South Carolina has adopted by reference the most recent ASTM standards for gasoline and other petroleum products in the state.

Ethanol, methanol and any other alcohol sold or offered for sale as a motor fuel or to be blended with gasoline for the purpose of producing motor fuel are subject to inspection, sampling and testing by the Department of Agriculture. Gasohol is defined as "a blend of gasoline and at least ten percent ethyl alcohol." "Alcohol blended with gasohol shall be anhydrous." The Department may limit the total oxygenates in motor fuel consistent with industry practices and acceptable consumer motoring performance.

GRADE RESTRICTIONS: The Department of Agriculture requires that all "gasoline, gasohol, and alcohol-gasoline mixtures for gasoline-type engines" that are sold, offered or exposed for sale or distribution in the state must be registered by each identifying brand name or grade designation and the corresponding minimum guaranteed Octane Index with the Department of Agriculture on prescribed registration forms.

The Octane Index, the average of the Research Octane Number and the Motor Octane Number, (R+M)/2, shall be the designated number for registration, delivery invoices, bills of lading, delivery tickets, posting on dispensing pumps and for advertising purposes, when so stated. The minimum Octane Index guarantee for premium grade gasoline, gasohol and alcohol-gasoline mixtures is 91. The minimum Octane Index guarantee for regular grade gasoline, gasohol and alcohol-gasoline mixtures is 87. Gasoline, gasohol and alcohol-gasoline blends having Octane Indices below 87 must be registered and labeled as sub-standard or sub-regular.

SOUTH DAKOTA

LABELING REQUIREMENTS: The South Dakota Department of Commerce and Regulation requires that any gasoline kept, offered or exposed for sale, or sold, at retail containing 2% or more by volume of any oxygenate or combination of oxygenates must be identified as "with" or "contains" the specific type of oxygenate or combination of oxygenates in the gasoline. For example, the label may read, "contains ethanol" or "with MTBE/ETBE". The label must be posted on the upper 50 percent of the dispenser front panel in a position clear and conspicuous from the driver's position in type at least 1/2" in height and 1/16" in stroke.

INVOICE DISCLOSURE: The Department of Commerce and Regulation requires that any distributor or supplier of oxygenated fuels must provide the retailer or distributor with an invoice, bill of lading, shipping paper or other documentation declaring the presence of any oxygenate or combination of oxygenates in a concentration of 2% or more by volume. This documentation is only for dispenser labeling purposes. Any potential blender must determine the total oxygen content of the gasoline before blending.

MOTOR FUEL SPECIFICATIONS: The Department of Commerce and Regulation is authorized to adopt such rules and regulations as necessary to carry out the provisions of Sec. 37-2-5 to 37-2-24, relating to standards for petroleum products. "The rules shall be in general conformity with ASTM standards".

The Department has adopted regulations requiring that "the methods to be used for inspection and testing of petroleum products and the standards for the specification and tolerance requirements for petroleum products are those in the 1988 Annual Book of the American Society for Testing and Materials, Volumes 05.01, 05.02, and 05.03."

As a matter of enforcement policy, the Department of Commerce and Regulation requires that for ethanol-blended fuels, only the gasoline portion of the blend is required to meet state volatility standards.

TENNESSEE

LABELING REQUIREMENTS: The Department of Agriculture does not require retail labeling of oxygenated fuels on motor fuel dispensers.

INVOICE DISCLOSURE: Under the Department of Agriculture's "Kerosene and Motor Fuels Quality Inspection Regulations", Tennessee requires that "when gasoline, diesel fuel, kerosene, aviation turbine fuels or fuel oils are sold or offered for sale an invoice, bill of lading, shipping paper or other documentation, must accompany each delivery other than a retail sale. This document must identify the name of the product, the particular grade of the product as designated by ASTM and when applicable, the minimum octane index and alcohol content, the name and address of the seller and buyer, and the date and time of the sale. A bill of lading must be retained at the retail establishment for a period not less than thirty (30) days."

MOTOR FUEL SPECIFICATIONS: The Department of Agriculture has adopted standard specifications for "gasoline" and "gasoline-oxygenate blends" which requires the product to meet the most recent version of ASTM D 4814, "Standard Specification for Automotive Spark-Ignition Engine Fuel", with the exception that volatility standards are those required by U.S. EPA as outlined in the Gasoline Volatility Regulations, 54 Fed. Reg. 11,868 (1989) and subsequent amendments.

In addition, for gasoline-oxygenate blends, the Department provides the following modifications and/or exceptions to ASTM D 4814. Distillation range (ASTM D 86) of unleaded gasoline containing 10 percent ethanol shall be the same as specified for gasoline except the minimum temperature at 50 percent evaporated shall be 158°F. A vapor pressure tolerance not exceeding 1.0 psi shall be allowed for unleaded gasoline containing 10 percent by volume ethanol.

Gasoline-oxygenate blends may not exceed a total oxygen content of 3.7 percent by weight. The total ethanol content may not exceed 10 percent, plus or minus 1 percent, by volume. The total methanol content may not exceed 5 percent, plus or minus 0.5 percent, by volume. An equal amount of cosolvents, butanol or higher molecular weight alcohol, must be added to methanol blends containing 0.3 percent or more methanol by volume unless the finished methanol blend meets all requirements of an applicable waiver granted by the U.S. EPA pursuant to methanol blended fuels.

CONVERSION PROCEDURES: Tennessee requires that water shall not exceed two inches in depth, when measured from the fill pipe, of any tank utilized in the storage of regulated products sold at retail.

TEXAS

LABELING REQUIREMENTS: Texas requires that no "motor fuel dealer" sell or offer for sale from a motor fuel pump motor fuel supplied by a storage tank into which motor fuel containing 1% or more by volume ethanol or 1% or more by volume methanol has been delivered within the 60 day period preceding the day of sale, unless each face of the pump on which the price is displayed is labeled "Contains Ethanol" or "Contains Methanol" as applicable. The sign must appear in contrasting colors with block letters at least 1/2" in height and 1/4" in width and shall be displayed in a clear, conspicuous, and prominent manner, visible to customers using either side of the pump. Motor fuel containing 10% or more by volume ethanol or 5% or more by volume methanol which has been delivered to the storage tank within the 60 day period preceding the sale must be labeled to identify the volume percent of ethanol or methanol to the nearest percent.

INVOICE DISCLOSURE: Texas requires that any distributor, supplier, wholesaler or jobber of motor fuel may not make a delivery of motor fuel exceeding 1% by volume ethanol or methanol unless they provide the outlet receiving the delivery at the time of delivery sufficient quantities of the required labeling signs as well as a statement on a manifest, bill of sale or lading, or any other document evidencing delivery of the motor fuel showing the percentage of ethanol or methanol in the mixture and types and percentages of cosolvents, if any. The document shall also identify delivery of the labels. Upon request of any "motor fuel user", the dealer is required to "reveal" the percentage of ethanol, methanol or cosolvents.

Motor fuel dealers are required to maintain a copy of such delivery documents for four years, and during the first 60 days following delivery of the mixture, are required to maintain a copy of such documents at the station or retail outlet where the motor fuel was delivered. Each distributor, supplier, wholesaler or jobber is required to keep for four years at their principal place of business a copy of each delivery document.

MOTOR FUEL SPECIFICATIONS: Texas has not adopted any motor fuel quality specifications.

Texas law prohibits the sale of motor fuel with automotive fuel rating lower than rating posted on pump label. A motor fuel dealer in this state may not sell or offer for sale motor fuel from a motor fuel pump if the motor fuel contains an automotive fuel rating that is lower than the automotive fuel rating for that motor fuel posted on the motor fuel pump.

LOW-RVP PROGRAM:

El Paso:

The Texas Natural Resource Conservation Commission requires that "no person shall place, store, or hold in any stationary tank, reservoir, or other container, any gasoline which may ultimately be used in a motor vehicle in the El Paso area with a Reid vapor pressure (RVP) greater than 7.0 pounds per square inch absolute (psia) or that does not meet the U.S. Environmental Protection Agency (EPA) specifications for reformulated gasoline." In addition, "no person shall transfer or allow the transfer of gasoline, which may ultimately be used in a motor vehicle in the El Paso Area with a RVP greater than 7.0 psia or that does not meet EPA specifications for reformulated gasoline to or from any storage vessel or tank-truck tank at any gasoline terminal, bulk plant, or motor vehicle fuel dispensing facility." The requirement applies from June 1 through September 16 of each year for motor vehicle fuel dispensing facilities and May 1 through September 16 for all other affected facilities.

Ethanol-blends are required to meet the same vapor pressure as gasoline.

Eastern Texas:

The Texas Natural Resource Conservation Commission (TNRCC) adopted a state rule establishing cleaner gasoline and vapor recovery equipment requirements in 95 counties in the eastern half of Texas. The rule was effective July 21, 1999. The Rule requires, that for Reid vapor pressure, beginning May 1, 2000 through October 1 of each year "no person shall transfer, allow the transfer, place, store, or hold in any stationary tank, reservoir, or other container any gasoline with a Reid vapor pressure greater than 7.8 pounds per square inch". The RVP control period runs from June 1 through October 1 of each year for gasoline dispensing facilities; and May 1 through October 1 of each year for all other affected facilities.

The TNRCC is amending the rule to delete the gasoline sulfur requirement, and impose new restrictions on increased use of MTBE.

The rule applies in the following 95 counties of the eastern half of Texas: Anderson, Angelina, Aransas, Atascosa, Austin, Bastrop, Bee, Bell, Bexar, Bosque, Bowie, Brazos, Burleson, Caldwell, Calhoun, Camp, Cass, Cherokee, Colorado, Comal, Cooke, Coryell, De Witt, Delta, Ellis, Falls, Fannin, Fayette, Franklin, Freestone, Goliad, Gonzales, Grayson, Gregg, Grimes, Guadalupe, Harrison, Hays, Henderson, Hill, Hood, Hopkins, Houston, Hunt, Jackson, Jasper, Johnson, Karnes, Kaufman, Lamar, Lavaca, Lee, Leon, Limestone, Live Oak, Madison, Marion, Matagorda, McLennan, Milam, Morris, Nacogdoches, Navarro, Newton, Nueces, Panola, Parker, Polk, Rains, Red River, Refugio, Robertson, Rockwall, Rusk, Sabine, San Jacinto, San Patricio, San Augustine, Shelby, Smith, Somervell, Titus, Travis, Trinity, Tyler, Upshur, Van Zandt, Victoria, Walker, Washington, Wharton, Williamson, Wilson, Wise, and Wood.

Ethanol-blends are required to meet the same vapor pressure as gasoline.

UTAH

LABELING REQUIREMENTS: The Utah Department of Agriculture requires that all motor fuel, kept, offered or exposed for sale or sold containing at least 1% by volume methanol, ethanol, or ethers must be labeled on the pump "in a prominent, conspicuous manner" as follows:

"___ % METHANOL",
"___ % ETHANOL", or
"___ % ETHERS".

Letters on the label must be at least 1 1/2" high and in contrasting colors. Labels must be located on the face of each dispenser near the area designating the grade of the product.

INVOICE DISCLOSURE: The Department of Agriculture requires that all bulk sales of motor fuels must be accompanied by a delivery ticket indicating: 1) name and address of vendor and purchaser, 2) date delivered, 3) quantity delivered and the quantity on which the price is based, and 4) identification of the product sold, including grade and percent of methanol, ethanol, or ethers in the blend. This information is required to be available at each retail outlet and furnished to the inspector upon request.

MOTOR FUEL SPECIFICATIONS: The Department of Agriculture requires that sampling, testing, analyzing and designating motor fuels shall conform with those specified and published by the American Society for Testing and Materials. "The Department shall use the latest published standards of the American Society for Testing and Materials." Utah requires that gasoline meet the RVP limits of ASTM D 4814.

The Department has adopted a regulation establishing requirements for the blending and sale of motor fuel in the state. Motor fuels are required to meet the following standards (test methods):

Octane (R+M)/2,	ASTM D 4814
Vapor Pressure*	ASTM D 323 on Reid vapor pressure and ASTM's Information Document on Oxygenated Fuels, Section 4.2.1
Distillation	ASTM D 86 and ASTM Revised D 4814 relative to methanol/ethanol gasoline blend (along with ASTM's Information Document on Oxygenated Fuels)
Water Tolerance	ASTM D 4814
Phase Separation	Must be homogenous, no phase separation
Corrosivity	ASTM D 4814
Benzene	ASTM D 3606
Flash Point	ASTM D 93 or D 56
Gravity	ASTM D 1298
Sulfur	(X-ray method) ASTM D 2622, 1266, 1552, 2622 or 4294
Aromatics	ASTM D 1319
Leads	ASTM D 3237
Cloud Point	ASTM D 2500
Conductivity	ASTM D 2624
Cetane	ASTM D 976 or 4737
Cosolvents	Methanol or ethanol fuels shall include such cosolvents required to increase the water tolerance to the limits specified in D 4814.

CONVERSION PROCEDURES: The Department of Agriculture requires that all storage tanks must be kept free from water content. All storage tanks and equipment must be purged and cleansed before using methanol, ethanol or ether blended motor fuels. A separate fixed tank or a method approved by the Department of Agriculture must be used for blending the "methanol or ethanol-based fuel" into the gasoline. In addition, the Department requires that blending of motor fuels may only be done at "refineries" or "qualified blending stations" that have the "proper equipment to accurately measure the products to be blended, to provide adequate safety standards. The finished blend must meet the requirements of octane, vapor pressure, distillation, and other standards as outlined by ASTM."

The Department requires that equipment be operated only in the manner that is "obviously indicated by its construction or that is indicated by instructions on the equipment." All equipment in service must be continuously maintained in proper operating condition throughout the period of service. The fill connection for any storage tank or vessel supplying retail motor fuel must be permanently, plainly, and visibly marked. When the fill connection device is marked by means of a color code, the color key must be conspicuously displayed at the place of business.

VERMONT

LABELING REQUIREMENTS: Vermont has adopted the National Conference on Weights and Measures (NCWM) Uniform Method of Sale of Commodities Regulation and its revisions as regulations within the State.

Under Section 2.20.1 of the NCWM Uniform Regulation, effective January 1, 1997, Vermont requires that all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or "containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information should be posted on the upper fifty percent of the dispenser front panel in a

position clear and conspicuous from the driver's position, in a type at least 1/2" in height, 1/16" stroke (width of type).

INVOICE DISCLOSURE: Under Section 2.20.2 of the NCWM Method of Sale Regulation, effective January 1, 1997, Vermont requires that the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol.

MOTOR FUEL SPECIFICATIONS: Vermont has not adopted any motor fuel specifications.

Under Vermont's "Motor Fuel Octane Content and Quality" law, the state does require that "it shall be unlawful for a person to misrepresent the octane content or the quality of motor fuel sold or offered for sale in this state." The Commissioner of Agriculture may randomly test motor fuel dispensers and motor fuel for the accuracy of any advertised, labeled, or other declarations regarding the octane content and the quality of the fuel dispensed.

VIRGINIA

LABELING REQUIREMENTS: The Virginia Department of Agriculture and Consumer Services requires that every dispensing device used in the retail sale of gasoline must be plainly and conspicuously labeled with the brand name or trade name of the gasoline. If the product contains 1.0% or more ethanol or methanol, a label identifying the kind of alcohol and the percentage of each at the time of blending must be posted in letters not less than 1" in height.

INVOICE DISCLOSURE: The Department of Agriculture and Consumer Services requires that "every person delivering gasoline at wholesale to a reseller which contains one percent or more of ethanol or methanol shall provide a written manifest or invoice which conspicuously identifies the gasoline containing one percent or more of ethanol or methanol, and the percentage of ethanol or methanol contained therein."

MOTOR FUEL SPECIFICATIONS: The Department of Agriculture and Consumer Services requires that gasoline meet the following requirements when tested in compliance with the latest version of American Society for Testing and Materials (ASTM) test methods or other specified test methods. Distillation limits are as follows: a minimum 10% evaporated at 122 degrees F. for November through February; a minimum 10% evaporated at 131 degrees F. for March, April, May, September, and October; a minimum 10% evaporated at 158 degrees F. for June, July, and August; a minimum 50% evaporated at 230 degrees F. for November through February; a minimum 50% evaporated at 235 degrees F. for March, April, May, September, and October; a minimum 50% evaporated at 250 degrees F. for June, July, and August; a minimum 90% evaporated at 365 degrees F. for September through May; a minimum 90% evaporated at 374 degrees F. for June, July, and August. Endpoint must be a maximum of 437 degrees F. and residue cannot exceed 2%.

Except for nonattainment areas, the maximum Reid vapor pressure standard shall be 9.0 psi for June 1 through September 15; 13.5 psi for September 16 through 30; 13.5 psi for March, April, May, and October; and 15.0 psi for November through February.

In the Northern Virginia, Richmond, and Hampton Roads nonattainment areas, the maximum Reid vapor pressure standard shall be 7.8 psi for June 1 to September 15. The Northern Virginia nonattainment area consists of the Counties of Arlington, Fairfax, Loudoun, Prince William, Stafford, and includes the cities of Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park. The Richmond nonattainment area consists of the Counties of Charles

City, Chesterfield, Hanover, Henrico, and includes the cities of Colonial Heights, Hopewell, and Richmond. The Hampton Roads nonattainment area consists of the Counties of James City, York, and includes the cities of Chesapeake, Hampton, Newport News, Norfolk, Poquoson, Portsmouth, Suffolk, Virginia Beach, and Williamsburg. For May 1 through May 31 each year, gasoline refiners, importers, pipeline operators, and terminal operators shall supply fuel with a maximum Reid vapor pressure standard of 9.0 psi.

Virginia provides gasoline containing 9 to 10% ethanol by volume a 1.0 psi vapor pressure waiver. Reid vapor pressure "shall be increased 1.0 psi for gasoline-ethanol blends containing at least 9, but not more than 10 percent ethanol by volume."

GRADE RESTRICTIONS: The Department of Agriculture and Consumer Services requires that before any gasoline or diesel fuel is sold or offered for sale in the state, those products must be registered with the Virginia Department of Agriculture and Consumer Services. The following information must be included on forms provided by the Commissioner of Agriculture: 1) the name and address of the registrant, 2) the brand name or trade name under which the gasoline or diesel fuel will be offered for sale, 3) the octane number of each gasoline as determined by the latest version of ASTM Research Method D 2699 and ASTM Motor Method D 2700, and expressed as an average of the two methods $(R+M)/2$, 4) the percentage and kinds of alcohol included in the gasoline, and 5) a statement that the gasoline or diesel fuel complies with all applicable laws and regulations.

WASHINGTON

LABELING REQUIREMENTS: The Washington Department of Agriculture requires that all retail motor fuel devices dispensing alcohol blended gasoline must be labeled on the face of the device with the percentage of alcohol contained in the fuel as follows:

"CONTAINS ___ % ethyl ALCOHOL" (or)
"CONTAINS ___ % methyl ALCOHOL".

The statement must be "conspicuously posted in gothic letters at least one inch in height in contrasting letters, in a location as to be easily seen by consumers." The percentage of alcohol disclosed is required to be "the ratio between the amount of ethyl alcohol, or methyl alcohol including co-solvents or proprietary inhibitors, or any other alcohol, to the total product volume."

Washington provides retailers dispensing oxygenated fuels in the Spokane carbon monoxide nonattainment areas an exemption from state labeling requirements during the oxygenated fuels control period as follows: "In any county, city, or other political subdivision designated as a carbon monoxide nonattainment area pursuant to the provisions of subchapter I of the Clean Air Act Amendments of 1990, P.L. 101-549, and in which the sale of oxygenated petroleum products is required by section 211(m) of the Clean Air Act Amendments of 1990, 42 U.S.C. 7545(m), any dealer or service station...who sells or dispenses a petroleum product that contains at least 1% by volume ethanol, methanol, or other oxygenate, shall post only such label or notice as may be required pursuant to 42 U.S.C. 7545(m)(4) or any amendments thereto."

INVOICE DISCLOSURE: Washington does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: Washington has adopted the standards set forth in the Annual Book of ASTM Standards and its supplements and revisions as well as applicable Federal Environmental Protection Agency standards.

The Motor Fuel Quality Act states that "if a conflict exists between Federal Environmental Protection Agency standards, ASTM standards, or state standards, for purposes of uniformity, Federal Environmental Protection

Agency standards shall take precedence over ASTM standards. Any state standards adopted must be consistent with Federal Environmental Protection Agency standards and ASTM standards, not in conflict with Federal Environmental Protection Agency standards."

GRADE RESTRICTIONS: The Washington Department of Agriculture requires that all motor fuel must be registered by the name, brand, or trademark under which it will be sold at the terminal. Registration must include 1) the name and address of the person registering the motor fuel; 2) the antiknock index or cetane number of the fuel; and 3) a certification, declaration, or affidavit that each individual grade or type of motor fuel shall conform to standards adopted by the state.

WEST VIRGINIA

LABELING REQUIREMENTS: West Virginia has adopted the National Conference on Weights and Measures (NCWM) Uniform Regulation for Motor Fuel as published in the National Institute of Standards and Technology (NIST) Handbook 130, and its revisions, as regulations within the State.

Under Section 2.20.1 of the NCWM Uniform Regulation, West Virginia requires that all automotive gasoline kept, offered, or exposed for sale, or sold, at retail containing at least 1.5 mass percent oxygen shall be identified as "with" or "containing" (or similar wording) the predominant oxygenate in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the retailer may post the predominant oxygenate followed by the phrase "or other ethers," or alternatively post the phrase "contains MTBE or other ethers." In addition, gasoline-methanol blend fuels containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This information should be posted on the upper fifty percent of the dispenser front panel in a position clear and conspicuous from the driver's position, in a type at least 1/2" in height, 1/16" stroke (width of type).

INVOICE DISCLOSURE: Under Section 2.20.2 of the NCWM Uniform Regulation, West Virginia requires that the retailer must be provided at the time of delivery of the fuel, on an invoice, bill of lading, shipping paper, or other documentation, a declaration of the predominant oxygenate or combination of oxygenates present in concentrations sufficient to yield an oxygen content of at least 1.5 mass percent in the fuel. The oxygenate contributing the largest mass percent oxygen to the blend shall be considered the "predominant" oxygenate. Where mixtures of only ethers are present, the fuel supplier may identify either the predominant oxygenate in the fuel, or alternatively state the phrase "contains MTBE or other ethers." In addition, gasoline containing more than 0.15 mass percent oxygen from methanol shall be identified as "with" or "containing" methanol. This documentation is only for dispenser labeling purposes; it is the responsibility of any potential blender to determine the total oxygen content of the engine fuel before blending.

MOTOR FUEL SPECIFICATIONS: West Virginia has adopted the NCWM Uniform Regulation for Motor Fuel as published in NIST Handbook 130, and any revisions thereof, as motor fuel quality standards in the state. Under the "Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulation," gasoline and gasoline-oxygenate blends must meet "the most recent version of ASTM D 4814, 'Standard Specification for Spark-Ignition Engine Fuel,' except that volatility standards for unleaded gasoline blended with ethanol shall not be more restrictive than those adopted under the rules, regulations, and Clean Air Act waivers of the U.S. Environmental Protection Agency (which includes rules promulgated by the State)."

Gasoline blended with ethanol shall be blended under any of the following three options: the base gasoline must meet the requirements of ASTM D 4814; the blend must meet the requirements of ASTM D 4814; or the base gasoline must meet all the requirements of ASTM D 4814 except distillation, and the blend must meet the specification's distillation requirements. Blends of gasoline and ethanol may not exceed the ASTM D 4814 vapor pressure standard by more than 1.0 psi. Ethanol intended for blending with gasoline "shall meet the most recent

version of ASTM D 4806, 'Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel.'

WISCONSIN

LABELING REQUIREMENTS: The Wisconsin Department of Industry, Labor, and Human Relations requires that any device that dispenses a gasoline-ethanol fuel blend of more than 2% by volume of ethanol shall be labeled with the maximum volume percent of ethanol at all times the product is offered for retail sale. A device that dispenses reformulated gasoline that contains an oxygenate other than ethanol must be labeled with the identity of the oxygenate at all times the product is offered for retail sale. If the reformulated gasoline contains multiple oxygenates, the label must identify the predominate oxygenate based upon volume percent. Reformulated gasoline is defined as "gasoline formulated to reduce emissions of volatile organic compounds and toxic air pollutants as provided in 42 USC 7545(k)(5). The addition of an oxygenate to a fuel alone does not create a reformulated gasoline; other criteria specified in the law must also be met."

Labels shall identify the oxygenate as either "Ethanol", "Methyl Tertiary Butyl Ether (MTBE)", "Ethyl Tertiary Butyl Ether (ETBE)", "Tertiary Amyl Methyl Ether (TAME)", "Tertiary Butyl Alcohol (TBA)", or as another oxygenate name approved by the Bureau of Petroleum. A label shall state that the product being dispensed "Contains" followed by the approved name for the oxygenate.

Labels shall be placed on the face of the dispenser next to the name and grade of the product being dispensed and shall be conspicuous and legible to a customer when viewed from the driver's seat of a motor vehicle that is located within 6 feet of the dispensing device. Labels shall be contrasting in color to the dispenser, in lettering not less than 1/2" high with a stroke of not less than 1/8" in width.

INVOICE DISCLOSURE: The Department of Industry, Labor, and Human Relations requires that any person who distributes gasoline products which contain one percent or more by volume of ethyl alcohol or methyl alcohol, or both, shall state on any invoice, bill of lading, shipping paper or other documentation accompanying the shipment used in normal and customary business practices, the type and percentage of alcohol rounded to a whole number or half number equal to or less than the determined percentage.

MOTOR FUEL SPECIFICATIONS: The Department of Industry, Labor, and Human Relations has adopted the following specifications for gasoline and other petroleum products. Gasoline, automotive gasoline, and gasoline/alcohol-ether blends sold or offered for sale in the State must be visually free of undissolved water, sediment, and suspended matter and must be clear and bright at the ambient temperature or 70°F, whichever is higher.

The Department has adopted the following schedule for seasonal volatility classes for distillation temperature, vapor/liquid ratio, and Reid vapor pressure: January, volatility class E; February, E; March, E/D; April, D; May, D/C; June, C; July, C; August, C; September, C; October C/D; November, D/E; and December, E.

"Automotive gasoline" is required to meet the following requirements:

Test	Volatility Class C	Volatility Class D	Volatility Class E
Distillation Temperature:			
10% Evaporation (max.)	140°F (60°C)	131°F (55°C)	122°F (50°C)
50% Evaporation (min.)	170°F (77°C)	170°F (77°C)	170°F (77°C)
50% Evaporation (max.)	240°F (116°C)	235°F (113°C)	230°F (110°C)
90% Evaporation (max.)	365°F (185°C)	365°F (185°C)	365°F (185°C)
Endpoint (max.)	437°F (225°C)	437°F (235°C)	437°F (225°C)
Residue (max.)	2%	2%	2%
Vapor Liquid Ratio:			
Test Temperature	124°F (51°C)	166°F (47°C)	105°F (41°C)
Vapor/liquid (max.)	20	20	20
Reid Vapor Pressure (max.)	11.5 psi	13.5 psi	15.0 psi
Lead Content (max.)			
Unleaded	.05 g/gal	.05 g/gal	.05 g/gal
Conventional	EPA limit	EPA limit	EPA limit
Corrosion (copper strip)(max.)	No. 1	No. 1	No. 1
Existent Gum (max.)	5	5	5
Sulfur (max.)			
Leaded	.20 weight %	.20 weight %	.20 weight %
Unleaded	.10 weight %	.10 weight %	.10 weight %

Under the Department's specifications for gasoline/oxygenate blends, "anhydrous denatured alcohol may be added to gasoline if the original gasoline product meets the requirements of automotive gasoline."

WYOMING

LABELING REQUIREMENTS: Wyoming's "Petroleum and Antifreeze Laws" require that all products must be sold "under their true name and grades," and that "such names and grades must be impressed or otherwise plainly marked upon the container, can, barrel, vessel, or dispensing device in or through which the product is stored, sold, offered, or exposed for sale." Pumps dispensing gasohol must be labeled as such. Gasohol is defined as "a motor fuel comprised of ninety percent (90%) gasoline by volume and ten percent (10%) denatured ethanol by volume."

Under Wyoming Tax Laws 39-17-103, "every person who sells or offers to sell to the retail trade gasoline blended with alcohol or ethers for use in motor vehicles shall conspicuously display a sign on each pump dispensing the fuel stating the blend of gasoline and alcohol or ethers."

INVOICE DISCLOSURE: Wyoming does not require disclosure of oxygenates on invoices or other wholesale documentation.

MOTOR FUEL SPECIFICATIONS: Wyoming requires that "all fuels or petroleum products sold or offered for sale in the state of Wyoming must conform with ASTM Standards and Specifications for that petroleum product and listed under ASTM's fixed designation without regard to year of issuance or revision." All revisions to ASTM standards and specifications shall be adopted following their publication in ASTM's Annual Book of Standards and upon approval of the State Board of Agriculture."

The Department of Agriculture has adopted "Standards for Automotive Spark-Ignition Engine Fuel", ASTM fixed designation D 4814, with the following exceptions. Requirements imposed by EPA shall take precedence over ASTM standards, where applicable. Wyoming defines "automotive spark-ignition engine fuel" as all grades and qualities of gasoline, either leaded or unleaded, and gasoline-oxygenate blends, either leaded or unleaded.

Section 14

Automotive Technology and Its Affect on Oxygen Requirements

14.0 Automotive Technology and Its Affect on Oxygen Requirements

The concept of using fuel oxygenates to reduce mobile source emissions was first introduced in the Colorado Front Range in 1988 followed by other western areas in the late 80s/early 90s. These areas were generally higher altitude areas with less ambient oxygen available. Prior to vehicles with altitude compensation devices, vehicles in these markets emitted excessive CO levels due to richer air/fuel ratios experienced from the lower ambient oxygen levels.

By adding an oxygenate to the fuel, the chemically bound oxygen enleans the air/fuel ratio in certain technology vehicles. This results in reduced tailpipe emissions of CO and to a lesser degree HC⁽¹⁾. The effect is more dramatic in older technology vehicles than later model computerized vehicles. The latter continuously adjusts the air/fuel ratio of the vehicle during closed loop operations.

These early oxygenated fuel programs were quite successful at reducing CO emissions. As a result, Congress included a requirement in the 1990 Clean Air Act Amendments requiring that CO non-attainment areas sell oxygenated gasoline during certain winter months.⁽²⁾ These requirements began in 1992.

The 1990 Clean Air Act Amendments also included a requirement for the nations worst ozone non-attainment areas to implement reformulated gasoline programs beginning in 1995. The focus of the reformulated gasoline program is on reducing ozone and toxics. Congress also included a requirement for RFG to contain 2.0 wt% oxygen. This requirement was the subject of extensive debate and significant lobbying by various entities on both sides of the issue. Since the focus of RFG did not include reducing ambient CO levels, opponents argued that there was no need for an oxygen requirement. Further the petroleum industry argued that they could meet the emissions reduction targets for a portion of their RFG production without the use of oxygenates. Proponents of the oxygen standard argued that oxygenates would play an important role in maintaining octane quality and reducing toxics as more harmful aromatics were removed from gasoline. Further, proponents argued that RFG containing oxygenates, when properly formulated, could indeed reduce vehicle emissions of ozone precursors. Eventually supporters of the oxygen standard prevailed and the oxygen standard for RFG was included in the Clean Air Act Amendments.

EPA established a regulatory negotiation (reg/neg) of stakeholders to help formulate final rules and regulations for the program. In addition EPA, through various meetings, workshops, and data review prepared a Complex Model to estimate emissions reductions from various changes to gasoline parameters including oxygen content.

The EPA developed its Complex Model based on 1990 technology vehicles. Since the model was developed, more technically sophisticated vehicles have been introduced. Opponents to the oxygen requirement now argue, among other things, that current and future vehicle technology has, or soon will, eliminate the need for fuel oxygenates as a vehicle emissions control strategy.

This section discusses some of the progressions of vehicle emissions technology, whether or not it may preclude the need to use fuel oxygenates, and if so what implications this could have for ethanol demand.

14.1 Automotive Technology

Since the early 1970s there has been a progression of ever more stringent emissions standards imposed on the automobile. These standards have continually lowered the amounts of HC, CO, and NO_x permitted in automobile exhaust emissions.

The EPA's "Federal And California Exhaust And Evaporative Emissions Standards For Light-duty Vehicles And Light Duty Trucks" (EPA 420-13-00-001, February 2000) is included as Appendix 14-A. The EPA document provides a listing of regional emissions standards for vehicles designated Tier 0, Tier 1, Transitional Low Emissions Vehicles (TLEV), Low Emissions Vehicles (LEV), Ultra Low Emissions Vehicle (ULEV), and Zero Emissions Vehicles (ZEV). It also includes a chart indicating the percentage of required vehicles by model year as well as the Federal definition for subject vehicles. This information is included to provide the reader with some context of how rapidly these vehicles are entering the marketplace.

In addition to the standards covered in Appendix 14-A, EPA's recently released "Tier 2" Final Rule will further tighten emissions standards for future passenger automobiles and will require sport utility vehicles meet the same more stringent standards.

Among the technologies employed by the automakers to meet these more stringent emissions requirements is extremely precise control of the air/fuel ratio. The current generation of vehicles being produced largely offsets the CO/HC exhaust emissions reduction achieved by oxygenates through more precise air/fuel management. As these vehicles replace older vehicles over the next five to ten years, the benefit of oxygenates as CO/HC control strategy will be reduced.

14.2 Effect on Oxygen Requirement

As automotive technology reduces the benefits of oxygenates for reducing CO and HC, there will still be some benefit. Emissions reductions would still be realized for older vehicles, high emitters (autos that operate in less than a proper state of tune), and non-automotive gasoline engines (off-road) such as lawn mowers, power equipment and contractor equipment. These emissions sources would then make up a larger amount of the total emissions inventory as automotive emissions become less. The cost per ton of HC/CO emissions reduced will almost certainly increase. (It should be noted that oxygenates will continue to contribute to reductions of the toxics, benzene, and 1,3 butadiene). Higher costs per ton of reduced emissions could in turn lead to pressure to remove the oxygen requirement from reformulated gasolines. It is already anticipated that all CO non-attainment areas will achieve attainment status by 2005 with perhaps the exception of Los Angeles. This would eliminate the need for oxygenated fuel programs leaving only the RFG program (and octane needs) to stimulate oxygenate demand.

14.3 Effect on Oxygenate Demand

Current combined ethanol demand for RFG and oxygenated fuel programs is estimated at 650mm gallons per year (42.4 mbd).⁽³⁾ The EPA Blue Ribbon Panel estimated that in 1997, 237.6mm gallons of ethanol was used in oxygenated fuel programs while 378.7mm gallons of ethanol was used in RFG.⁽⁴⁾ As CO non-attainment areas come into compliance, ethanol demand from these programs will be eliminated resulting in a loss of 237.6mm gallons or more per year. If the fuel oxygen requirement is lifted for RFG this would result in a minimum loss of an estimated 378.7mm

gallons per year of ethanol demand. However, in a scenario where MTBE is banned and ethanol is the only viable gasoline oxygenate, loss of the oxygen requirement would be of much larger impact. At the respective current minimum oxygen requirement of 2.0 wt% for the reformulated gasoline program, the minimum ethanol demand in an MTBE ban scenario is 1.98 billion gallons annually. So removal of the oxygen requirement compared to keeping the oxygen requirement with an MTBE ban results in a minimum annual loss of 1.98 billion gallons (129 mbd) of lost ethanol market opportunity (plus normal sales volume growth in the applicable markets).

14.4 Automotive Industry Position on Gasoline Oxygen Content

It is worth mentioning that gasoline oxygen content also plays a role in engineering considerations. While the auto manufacturers have been strong supporters of cleaner burning gasolines, their support for higher oxygen content fuels has waned. Due to the need to engineer very precise air/fuel management strategies, the automakers would like to reduce the range of fuel variables such as oxygen content and T_{50} .⁽⁵⁾ Current fuel oxygen content in the U.S. ranges from 0.0 to ~3.5 wt%. Likewise T_{50} ranges from 140°-250°F. If the range in such variables were reduced it would make engineering to meet tighter emissions standards less troublesome.

Based on the above it is likely that while the auto manufacturers would not openly oppose 3.5 wt% oxygen blends (i.e. 10 v% ethanol blends) neither will it be likely that they would provide any measurable support for their expansion.

Section 14.0: Automotive Technology and Its Affect on Oxygen Requirements

References

1. Auto/Oil Air Quality Improvement Research Program Final Report, January 1997
2. Clean Air Act § 211(c)(4)(14)
3. Estimates by the Renewable Fuels Association
4. Achieving Clean Air and Clean Water-The Report of the Blue Ribbon Panel on Oxygenates in Gasoline, Appendix D, September 1999
5. Private conversations with major automobile manufacturer engineers



Federal and California Exhaust and Evaporative Emission Standards for Light-Duty Vehicles and Light-Duty Trucks

Federal and California Exhaust and Evaporative Emission Standards for Light-Duty Vehicles and Light-Duty Trucks

Certification and Compliance Division
Office of Air Transportation and Air Quality
U.S. Environmental Protection Agency

NOTICE

*This technical report does not necessarily represent final EPA decisions or positions.
It is intended to present technical analysis of issues using data which are currently available.*

*The purpose in the release of such reports is to facilitate the exchange of
technical information and to inform the public of technical developments which
may form the basis for a final EPA decision, position, or regulatory action.*



Federal Certification Exhaust Emission Standards
for Light-Duty Vehicles (Passenger Cars) and Light Light-Duty Trucks:
Federal Test Procedure (FTP), Cold CO, and Highway & Idle Tests
(grams/mile)

US Environmental Protection Agency
Office of Transportation and Air Quality
EPA420-B-00-001
February 2000

	Vehicle Type	Emission Category	Vehicle Useful Life													
			5 Years / 50,000 Miles							10 Years / 100,000 Miles						
			THC ^[2,5,39]	NMHC ^[3]	NMOG	CO ^[35,39]	NO _x ^[4]	PM ^[29]	HCHO	THC ^[2,5]	NMHC ^[3]	NMOG	CO ^[38]	NO _x ^[9]	PM ^[29]	HCHO
Federal	LDV ^[37,40,43]	Tier 0	0.41 ^[28]	0.34 ^[6]	-	3.4	1.0 ^[4]	0.20	-	-	0.31 ^[6]	-	4.2	0.6 ^[9]	0.10 ^[4]	-
		Tier 1	0.41 ^[28]	0.25	-	3.4	0.4 ^[7]	0.08	-	-	0.31 ^[6]	-	4.2	0.6 ^[9]	0.10 ^[4]	-
	LDT1 ^[37,40,43]	Tier 0 ^[26]	-	-	-	-	-	-	-	0.80 ^[26,28]	0.67 ^[6]	-	10	1.2 ^[4]	0.26 ^[4]	-
		Tier 1	-	0.25	-	3.4	0.4 ^[7]	0.08	-	0.80 ^[26,28]	0.31 ^[6]	-	4.2	0.6 ^[9]	0.10 ^[4]	-
	LDT2 ^[37,40,43]	Tier 0 ^[26]	-	-	-	-	-	-	-	0.80 ^[26,28]	0.67 ^[6]	-	10	1.7 ^[4]	0.13 ^[4]	-
		Tier 1	-	0.32	-	4.4	0.7 ^[8]	0.08	-	0.80 ^[26,28]	0.40 ^[6]	-	5.5	0.97 ^[9]	0.10 ^[4]	-
Federal National Low Emission Vehicle (NLEV) Program	LDV ^[36,40,41]	TLEV	0.41 ^[28]	-	0.125 ^[1,31]	3.4	0.4 ^[34]	0.08	0.015	-	-	0.156 ^[1,31]	4.2	0.6 ^[34]	0.08 ^[32]	0.018
		LEV ^[42]	0.41 ^[28]	-	0.075 ^[1,31]	3.4	0.2 ^[34]	0.08	0.015	-	-	0.090 ^[1,31]	4.2	0.3 ^[34]	0.08 ^[32]	0.018
		ULEV ^[42]	0.41 ^[28]	-	0.040 ^[1,31]	1.7	0.2 ^[34]	0.08	0.008	-	-	0.055 ^[1,31]	2.1	0.3 ^[34]	0.04 ^[32]	0.011
		ZEV	0.00	0.00	0.000	0.0	0.0 ^[34]	0.00	0.000	0.00	0.000	0.000	0.0	0.0 ^[34]	0.00	0.000
	LDT1 ^[36,40,41]	TLEV	-	-	0.125 ^[1,31]	3.4	0.4 ^[34]	0.08	0.015	0.80 ^[26,28]	-	0.156 ^[1,31]	4.2	0.6 ^[34]	0.08 ^[32]	0.018
		LEV ^[42]	-	-	0.075 ^[1,31]	3.4	0.2 ^[34]	0.08	0.015	0.80 ^[26,28]	-	0.090 ^[1,31]	4.2	0.3 ^[34]	0.08 ^[32]	0.018
		ULEV ^[42]	-	-	0.040 ^[1,31]	1.7	0.2 ^[34]	0.08	0.008	0.80 ^[26,28]	-	0.055 ^[1,31]	2.1	0.3 ^[34]	0.04 ^[32]	0.011
		ZEV	0.00	0.00	0.000	0.0	0.0 ^[34]	0.00	0.000	0.00	0.000	0.000	0.0	0.0 ^[34]	0.00	0.000
	LDT2 ^[36,40,41]	TLEV	-	-	0.160 ^[1,31]	4.4	0.7 ^[34]	0.08	0.018	0.80 ^[26,28]	-	0.200 ^[1,31]	5.5	0.9 ^[34]	0.10 ^[32]	0.023
		LEV ^[42]	-	-	0.100 ^[1,31]	4.4	0.4 ^[34]	0.08	0.018	0.80 ^[26,28]	-	0.130 ^[1,31]	5.5	0.5 ^[34]	0.10 ^[32]	0.023
		ULEV ^[42]	-	-	0.050 ^[1,31]	2.2	0.4 ^[34]	0.08	0.009	0.80 ^[26,28]	-	0.070 ^[1,31]	2.8	0.5 ^[34]	0.05 ^[32]	0.013
		ZEV	0.00	0.00	0.000	0.0	0.0 ^[34]	0.00	0.000	0.00	0.000	0.000	0.0	0.0 ^[34]	0.00	0.000
Federal Clean Fueled Vehicle (CFV) Program	LDV ^[37,40,41]	LEV	0.41 ^[28]	-	0.075 ^[30]	3.4	0.2 ^[34]	-	0.015	-	-	0.090 ^[30]	4.2	0.3 ^[34]	0.08 ^[10]	0.018
		ILEV ^[33]	0.41 ^[28]	-	0.075	3.4	0.2 ^[34]	-	0.015	-	-	0.090	4.2	0.3 ^[34]	0.08 ^[10]	0.018
		ULEV	0.41 ^[28]	-	0.040 ^[30]	1.7	0.2 ^[34]	-	0.008	-	-	0.055 ^[30]	2.1	0.3 ^[34]	0.04 ^[10]	0.011
		ZEV	0.00	0.00	0.000	0.0	0.0 ^[34]	0.00	0.000	0.00	0.000	0.000	0.0	0.0 ^[34]	0.00	0.000
	LDT1 ^[37,40,41]	LEV	-	-	0.075 ^[30]	3.4	0.2 ^[34]	-	0.015	0.80 ^[26,28]	-	0.090 ^[30]	4.2	0.3 ^[34]	0.08 ^[10]	0.018
		ILEV ^[33]	-	-	0.075	3.4	0.2 ^[34]	-	0.015	0.80 ^[26,28]	-	0.090	4.2	0.3 ^[34]	0.08 ^[10]	0.018
		ULEV	-	-	0.040 ^[30]	1.7	0.2 ^[34]	-	0.008	0.80 ^[26,28]	-	0.055 ^[30]	2.1	0.3 ^[34]	0.04 ^[10]	0.011
		ZEV	0.00	0.00	0.000	0.0	0.0 ^[34]	0.00	0.000	0.00	0.000	0.000	0.0	0.0 ^[34]	0.00	0.000
	LDT2 ^[37,40,41]	LEV	-	-	0.100 ^[30]	4.4	0.4 ^[34]	-	0.018	0.80 ^[26,28]	-	0.130 ^[30]	5.5	0.5 ^[34]	0.08 ^[10]	0.023
		ILEV ^[33]	-	-	0.100	4.4	0.4 ^[34]	-	0.018	0.80 ^[26,28]	-	0.130	5.5	0.5 ^[34]	0.08 ^[10]	0.023
		ULEV	-	-	0.050 ^[30]	2.2	0.4 ^[34]	-	0.009	0.80 ^[26,28]	-	0.070 ^[30]	2.8	0.5 ^[34]	0.04 ^[10]	0.013
		ZEV	0.00	0.00	0.000	0.0	0.0 ^[34]	0.00	0.000	0.00	0.000	0.000	0.0	0.0 ^[34]	0.00	0.000



**Federal Certification Exhaust Emission Standards
for Heavy Light-Duty Trucks:
Federal Test Procedure (FTP), Cold CO, and Highway & Idle Tests
(grams/mile)**

	Vehicle Type	Emission Category	Vehicle Useful Life												
			5 Years / 50,000 Miles						11 Years / 120,000 Miles						
			NMHC ^[3]	NMOG	CO ^[35,39]	NO _x ^[8]	PM	HCHO	THC ^[2,5,39]	NMHC ^[3]	NMOG	CO ^[38]	NO _x	PM	HCHO
Federal [37,40,43]	LDT3	Tier 0							0.80 ^[6]	0.67	-	10	1.7 ^[4]	0.26	-
		Tier 1	0.32	-	4.4	0.7	-	-	0.80	0.46	-	6.4	0.98	0.10	-
	LDT4	Tier 0							0.80 ^[6]	0.67	-	10	1.7 ^[4]	0.13	-
		Tier 1	0.39	-	5.0	1.1	-	-	0.80	0.56	-	7.3	1.53	0.12	-
Federal Clean Fueled Vehicle (CFV) Program [37,40]	LDT3 0-3750 ALVW	LEV	-	^[30] 0.125	3.4	0.4	-	0.015	-	-	^[30] 0.180	5.0	0.6 ^[10]	0.08	0.022
		ILEV ^[33]	-	0.125	3.4	0.2	-	0.015	-	-	0.180	5.0	0.3 ^[10]	0.08	0.022
		ULEV	-	^[30] 0.075	1.7	0.2	-	0.008	-	-	^[30] 0.107	2.5	0.3 ^[10]	0.04	0.012
	LDT3 3751-5750 ALVW	LEV		^[30] 0.160	4.4	0.7	-	0.018	-	-	^[30] 0.230	6.4	1.0 ^[10]	0.10	0.027
		ILEV ^[33]	-	0.160	4.4	0.4	-	0.018	-	-	0.230	6.4	0.5 ^[10]	0.10	0.027
		ULEV	-	^[30] 0.100	2.2	0.4	-	0.009	-	-	^[30] 0.143	3.2	0.5 ^[10]	0.05	0.013
	LDT4 5751-8500 ALVW	LEV	-	^[30] 0.195	5.0	1.1	-	0.022	-	-	^[30] 0.280	7.3	1.5 ^[10]	0.12	0.032
		ILEV ^[33]	-	0.195	5.0	0.6	-	0.022	-	-	0.280	7.3	0.8 ^[10]	0.12	0.032
		ULEV	-	^[30] 0.117	2.5	0.6	-	0.011	-	-	^[30] 0.167	3.7	0.8 ^[10]	0.06	0.016

**Federal and California Certification Exhaust Emission Standards
for Light-Duty Vehicles (Passenger Cars), Light-Duty Trucks, and Medium-Duty Vehicles:
Supplemental Federal Test Procedure (SFTP)
(grams/mile)**

	Vehicle Type	Emission Category	4,000 Miles				5 Years / 50,000 Miles				10 Years / 100,000 Miles			
			US06 TEST		A / C TEST		COMPOSITE	A / C TEST	US06	COMPOSITE	COMPOSITE	A / C TEST	US06	COMPOSITE
			NMHC+NOx	CO	NMHC+NOx	CO								
Federal	LDV	Tier 1 ^[27]					^[21] 0.65	3.0	9.0	3.4	^[22] 0.91	3.7	11.1	4.2
	LDT1	Tier 1 ^[27]					^[21] 0.65	3.0	9.0	3.4	^[22] 0.91	3.7	11.1	4.2
	LDT2	Tier 1 ^[12]					1.02	3.9	11.6	4.4	1.37	4.9	14.6	5.5
	LDT3	Tier 1 ^[12]					1.02	3.9	11.6	4.4	^[26] 1.44	^[26] 5.6	^[26] 16.9	^[26] 6.4
	LDT4	Tier 1 ^[12]					1.49	4.4	13.2	5.0	^[26] 2.09	^[26] 6.4	^[26] 19.3	^[26] 7.3
Federal NLEV & California Programs	LDV/PC	Tier 1 / TLEV ^[27]					^[21] 0.65	^[8] 3.0	9.0	3.4	^[22] 0.91	^[8] 3.7	11.1	4.2
		LEV / ULEV ^[27]	0.14	8.0	0.20	2.7								
	LDT1	Tier 1 / TLEV ^[27]					^[21] 0.65	^[8] 3.0	9.0	3.4	^[22] 0.91	^[8] 3.7	11.1	4.2
		LEV / ULEV ^[27]	0.14	8.0	0.20	2.7								
		LDT2	Tier 1 / TLEV ^[12]					1.02	3.9	11.6	4.4	1.37	4.9	14.6
	LEV / ULEV ^[27]		0.25	10.5	0.27	3.5								
California	MDV1	N / A												
	MDV2	LEV / ULEV / SULEV	0.40	10.5	0.31	3.5								
	MDV3	LEV / ULEV / SULEV	0.60	11.8	0.44	4.0								
	MDV4	N / A												
	MDV5	N / A												



Federal Evaporative & Onboard Refueling (ORVR) Implementation Schedule for Light-Duty Vehicles (Passenger Cars) and Light-Duty Trucks

	Emission Standards	Vehicle Class	Emission Standards												
				1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Federal	Pre-Enhanced	LDV, LDT	Cert & In-use	100%	80% Max	60% Max	10% Max						Tier 2 Requirements Begin See www.epa.gov/oms/tr2home.htm		
	Enhanced	LDV, LDT	Cert & In-use ^[44]		20% Min	40% Min	90% Min	100%	100%	100%	100%	100%			
	ORVR	LDV	Cert & In-use ^[44]				40% Min	80% Min	100%	100%	100%	100%			
		LDT 1 & 2	Cert & In-use							40% Min	80% Min	100%			
		LDT 3 & 4	Cert & In-use										40% Min	80% Min	100%



**Federal Exhaust Emission Standards Implementation Schedule
for Light-Duty Vehicles (Passenger Cars) and Light-Duty Trucks**

	Vehicle Type	Test Procedure	Emission Category	Emission Standards	Model Year													2004	2005	2006
					1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003				
Federal (Non-NLEV)	LDV, LDT1 & LDT2	FTP	Tier 0	Cert & In-use	100%	100%	60% Max	20% Max	0%								Tier 2 Requirements Begin			
			Tier 1 ^[24]	Certification ^[44]			40% Min	80% Min	100%	100%	100%	100%	100%	100%	100%					
				Interim In-Use			40% Min	80% Min	60% Max	20% Max	0%									
				Final In-use ^[44]					40% Min	80% Min	100%	100%	100%	100%	100%					
		SFTP ^[44]	Tier 1	Cert & In-use								40% Min	80% Min	100%	100%					
	LDT3 & LDT4	FTP	Tier 0	Cert & In-use	100%	100%	100%	100%	50% Max	0%										
			Tier 1	Certification ^[44]					50% Min	100%	100%	100%	100%	100%	100%					
				Interim In-Use					50% Min	100%	50% Max									
				Final In-use ^[44]							50% Min	100%	100%	100%	100%	100%				
		SFTP ^[44]	Tier 1	Cert & In-use										40% Min	80% Min					
Federal (NLEV)	LDV & LDT1	FTP	Tier 1	Certification								NE Trading	Region	All States	Trading	Region				
			TLEV	(Fleet Average								0.148	0.095	0.075	0.075	0.075				
			LEV	Derived from								NMOG	NMOG	NMOG	NMOG	NMOG				
			ULEV	50K Standards)								Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.				
			ZEV									[45,46]	[45]	[46]						
		SFTP ^[25,44]	Tier 1	Cert & In-use										25% Min	50% Min	85% Min				
			TLEV																	
			LEV ^[23]	Certification										25% Min	50% Min	85% Min				
			ULEV ^[23]																	
	LDT2	FTP	Tier 1	Certification								NE Trading	Region	All States	Trading	Region				
			TLEV	(Fleet Average								0.190	0.124	0.100	0.100	0.100				
			LEV	Derived from								NMOG	NMOG	NMOG	NMOG	NMOG				
			ULEV	50K Standards)								Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.				
			ZEV									[45,46]	[45]	[46]						
		SFTP ^[25,44]	Tier 1	Cert & In-use										25% Min	50% Min	85% Min				
			TLEV																	
LEV ^[23]			Certification										25% Min	50% Min	85% Min					
		ULEV ^[23]																		



**California Certification Exhaust Emission Standards
for Light-Duty Vehicles (Passenger Cars) and Light Light-Duty Trucks:
Federal Test Procedure (FTP)
(grams/mile)**

	Vehicle Type	Emission Category	Vehicle Useful Life													
			5 Years / 50,000 Miles							10 Years / 100,000 Miles						
			THC ^[2,5]	NMHC ^[3]	NMOG ^[1]	CO	NOx	PM	HCHO	THC ^[2,5]	NMHC ^[3]	NMOG ^[1]	CO	NOx	PM	HCHO
California	PC	Tier 0	-	0.39	-	7.0	0.4 ^[10]	0.08 ^[11]	0.015							
		Tier 1	-	0.25	-	3.4	0.4 ^[10]	0.08 ^[11]	0.015	-	0.31	-	4.2	0.6	-	-
		TLEV	-	-	0.125	3.4	0.4	-	0.015	-	-	0.156	4.2	0.6 ^[10]	0.08	0.018
		LEV	-	-	0.075	3.4	0.2	-	0.015	-	-	0.090	4.2	0.3 ^[10]	0.08	0.018
		ULEV	-	-	0.040	1.7	0.2	-	0.008	-	-	0.055	2.1	0.3 ^[10]	0.04	0.011
		ZEV	0.00	0.00	0.000	0.0	0.0	0.00	0.000	0.00	0.000	0.000	0.0	0.0	0.00	0.000
	LDT1	Tier 0	-	0.39	-	9.0	0.4 ^[10]	0.08 ^[11]	0.015							
		Tier 1	-	0.25	-	3.4	0.4 ^[10]	0.08 ^[11]	0.015	-	0.31	-	4.2	0.6	-	-
		TLEV	-	-	0.125	3.4	0.4	-	0.015	-	-	0.156	4.2	0.6 ^[10]	0.08	0.018
		LEV	-	-	0.075	3.4	0.2	-	0.015	-	-	0.090	4.2	0.3 ^[10]	0.08	0.018
		ULEV	-	-	0.040	1.7	0.2	-	0.008	-	-	0.055	2.1	0.3 ^[10]	0.04	0.011
		ZEV	0.00	0.00	0.000	0.0	0.0	0.00	0.000	0.00	0.000	0.000	0.0	0.0	0.00	0.000
	LDT2	Tier 0	-	0.50	-	9.0	1.0 ^[10]	0.08 ^[11]	0.018							
		Tier 1	-	0.32	-	4.4	0.7 ^[10]	0.08 ^[11]	0.018	-	0.40	-	5.5	0.97	-	-
		TLEV	-	-	0.160	4.4	0.7	-	0.018	-	-	0.200	5.5	0.9 ^[10]	0.10	0.023
		LEV	-	-	0.100	4.4	0.4	-	0.018	-	-	0.130	5.5	0.5 ^[10]	0.10	0.023
		ULEV	-	-	0.050	2.2	0.4	-	0.009	-	-	0.070	2.8	0.5 ^[10]	0.05	0.013
		ZEV	0.00	0.00	0.000	0.0	0.0	0.00	0.000	0.00	0.000	0.000	0.0	0.0	0.00	0.000



**California Certification Exhaust Emission Standards
for Medium-Duty Vehicles:
Federal Test Procedure (FTP)
(grams/mile)**

	Vehicle Type	Emission Category	Vehicle Useful Life											
			5 Years / 50,000 Miles											
			NMHC ^[3]	NMOG ^[1]	CO	NO _x	PM	HCHO	NMHC ^[3]	NMOG ^[1]	CO	NO _x	PM	HCHO
California	MDV1	Tier 0	0.39	-	9.0	0.4 ^[10]	0.08	^[11] 0.015						
		Tier 1	0.25	-	3.4	0.4	-	^[11] 0.015	0.36	-	5.0	0.55	^[10] 0.08	-
		LEV	-	0.125	3.4	0.4	-	0.015	-	0.180	5.0	0.6	^[10] 0.08	0.022
		ULEV	-	0.075	1.7	0.2	-	0.008	-	0.107	2.5	0.3	^[10] 0.04	0.012
	MDV2	Tier 0	0.50	-	9.0	1.0 ^[10]	0.08	^[11] 0.018						
		Tier 1	0.32	-	4.4	0.7	-	^[11] 0.018	0.46	-	6.4	0.98	^[10] 0.10	-
		LEV		0.160	4.4	^[13] 0.4	-	0.018	-	0.230	6.4	^[14] 0.6	^[10] 0.10	0.027
		ULEV	-	0.100	4.4	0.4	-	0.009	-	0.143	6.4	0.6	^[10] 0.05	0.013
		SULEV	-	0.050	2.2	0.2	-	0.004	-	0.072	3.2	0.3	^[10] 0.05	0.006
	MDV3	Tier 0	0.60	-	9.0	1.5 ^[10]	0.08	^[11] 0.022						
		Tier 1	0.39	-	5.0	1.1	-	^[11] 0.022	0.56	-	7.3	1.53	^[10] 0.12	-
		LEV	-	0.195	5.0	^[15] 0.6	-	0.022	-	0.280	7.3	^[16] 0.9	^[10] 0.12	0.032
		ULEV	-	0.117	5.0	0.6	-	0.011	-	0.167	7.3	0.9	^[10] 0.06	0.016
		SULEV	-	0.059	2.5	0.3	-	0.006	-	0.084	3.7	0.45	^[10] 0.06	0.008
	MDV4	Tier 1	0.46	-	5.5	1.3	-	^[11] 0.028	0.66	-	8.1	1.81	^[10] 0.12	-
		LEV	-	0.230	5.5	^[17] 0.7	-	0.028	-	0.330	8.1	^[18] 1.0	^[10] 0.12	0.040
		ULEV	-	0.138	5.5	0.7	-	0.014	-	0.197	8.1	1.0	^[10] 0.06	0.021
		SULEV	-	0.069	2.8	0.35	-	0.007	-	0.100	4.1	0.5	^[10] 0.06	0.010
	MDV5	Tier 1	0.60	-	7.0	2.0	-	^[11] 0.036	0.86	-	10.3	2.77	^[10] 0.12	-
		LEV	-	0.300	7.0	^[19] 1.0	-	0.036	-	0.430	10.3	^[20] 1.5	^[10] 0.12	0.052
		ULEV	-	0.180	7.0	1.0	-	0.018	-	0.257	10.3	1.5	^[10] 0.06	0.026
		SULEV	-	0.090	3.5	0.5	-	0.009	-	0.130	5.2	0.7	^[10] 0.06	0.013



**California Exhaust Emission Standards Implementation Schedule for
Light-Duty Vehicles (Passenger Cars), Light-Duty Trucks, and Medium-Duty Vehicles**

	Vehicle Type	Test Procedure	Emission Category	Model Year															
				1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	
California	PC & LDT1	FTP	Tier 0	100%	60% Max	20% Max	0%											LEV 2 Requirements Begin See www.arb.ca.gov/cgi/search.exe	
			Tier 1		40% Min	80% Min													
			TLEV			0.250	0.231	0.225	0.202	0.157	0.113	0.073	0.070	0.068	0.062				
			LEV			NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG			
			ULEV			Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.				
			ZEV												10% Min				
		SFTP	Tier 1											25% Min	50% Min	85% Min			
			TLEV																
			LEV ^[23]											25% Min	50% Min	85% Min			
			ULEV ^[23]																
		LDT2	FTP	Tier 0	100%	60% Max	20% Max	0%											
				Tier 1		40% Min	80% Min												
				TLEV			0.320	0.295	0.287	0.260	0.205	0.150	0.099	0.098	0.095	0.093			
	LEV					NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG	NMOG			
	ULEV					Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.	Fleet Avg.			
	SFTP ^[25]		Tier 1											25% Min	50% Min	85% Min			
			TLEV																
			LEV ^[23]											25% Min	50% Min	85% Min			
			ULEV ^[23]																
	MDV1 - MDV5	FTP	Tier 0	100%	100%	100%	50% Max	0%											
			Tier 1				50% Min	100%	100%	73% Max	48% Max	23% Max	0%						
			LEV ^[23]							25% Min	50% Min	75% Min	80% Max	70% Max	60% Max				
			C ULEV ^[23]							2% Min	2% Min	2% Min	20% Min	30% Min	40% Min				
			C SULEV ^[23]																
	MDV2 & MDV3	SFTP	C LEV ^[23]																
			C ULEV ^[23]																
			SULEV ^[23]														25% Min		

Exhaust and Evaporative Emission Standards

Footnotes to the tables of emission standards

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1. NMHC FOR DIESEL CYCLE VEHICLES
2. THCE FOR METHANOL VEHICLES
3. THCE FOR TIER 0 METHANOL VEHICLES, NMHCE FOR OTHER ALCOHOL VEHICLES
4. APPLIES TO DIESEL VEHICLES ONLY
5. DOES NOT APPLY TO CNG VEHICLES
6. CNG VEHICLES ONLY
7. 1.0 FOR DIESEL-FUELED VEHICLES THROUGH 2003 MODEL YEAR
8. DOES NOT APPLY TO DIESEL-FUELED VEHICLES
9. 1.25 FOR DIESEL-FUELED VEHICLES THROUGH 2003 MODEL YEAR
10. DIESEL-FUELED VEHICLES ONLY
11. METHANOL AND ETHANOL VEHICLES ONLY
12. GASOLINE VEHICLES ONLY
13. 0.7 THROUGH MODEL YEAR 1997
14. 1.0 THROUGH MODEL YEAR 1997
15. 1.1 THROUGH MODEL YEAR 1997
16. 1.5 THROUGH MODEL YEAR 1997
17. 1.3 THROUGH MODEL YEAR 1997
18. 1.8 THROUGH MODEL YEAR 1997
19. 2.0 THROUGH MODEL YEAR 1997
20. 2.8 THROUGH MODEL YEAR 1997
21. 1.48 FOR DIESEL-FUELED VEHICLES
22. 2.07 FOR DIESEL-FUELED VEHICLES
23. OTHER EQUIVALENT SCHEDULES ALLOWED.
24. PC /LDV MAY BE COMBINED WITH LDT1 & LDT2 FOR TIER 1 PHASE-IN
25. PC /LDV & LDT1 COMBINED WITH LDT2 FOR SFTP PHASE-IN
26. STANDARDS APPLY AT A USEFUL LIFE OF 11 YEARS / 120,000 MILES
27. GASOLINE AND DIESEL VEHICLES ONLY
28. TOTAL HC COMPLIANCE STATEMENT ALLOWED (IN LIEU OF TEST DATA)
29. PARTICULATES COMPLIANCE STATEMENT ALLOWED FOR NON-DIESEL CYCLE VEHICLES (IN LIEU OF SUPPLYING ACTUAL TEST DATA)
30. SPECIAL NMOG STANDARDS APPLY TO DUAL & FLEXIBLE FUEL VEHICLES, SEE 40 CFR 88.104-94(h) & (i)
31. DUAL & FLEXIBLE FUEL VEHICLES MAY MEET NEXT HIGHER (LESS STRINGENT) NMOG STANDARD WHEN OPERATING ON GASOLINE.
32. 0.10 GM / MILE PARTICULATE STANDARD APPLIES TO NON-DIESEL VEHICLES
33. SPECIAL EVAPORATIVE REQUIREMENTS APPLY (5.0 GRAMS MAX WITH THE EVAPORATIVE SYSTEM DISCONNECTED)
34. HIGHWAY NO_x EMISSIONS SHALL NOT EXCEED 1.33 TIMES THE APPLICABLE FTP (CITY) NO_x STANDARDS
35. COLD CO EMISSIONS FOR GASOLINE FUELED VEHICLES SHALL NOT EXCEED 10.0 GR / MI (LDV, LDT1, LDT2) OR 12.5 GM / MI (LDT3 & LDT4) AT 50K MILES

Exhaust and Evaporative Emission Standards

Footnotes to the tables of emission standards - Continued

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36. CALIFORNIA OBD-II SYSTEM REQUIRED, REF 40 CFR 86.1717-99
37. FEDERAL OBD SYSTEM REQUIRED BEGINNING WITH 1994 MODEL YEAR VEHICLES, REF 40 CFR 86.1806-01
38. IDLE CO EMISSIONS FROM GASOLINE, METHANOL, CNG & LPG TRUCKS SHALL NOT EXCEED 0.50 PERCENT EXHAUST GAS AT 120K MILES / 11 YEARS COMPLIANCE STATEMENT ALLOWED (IN LIEU OF ACTUAL TEST DATA)
39. CERTIFICATION SHORT TEST (CST) EMISSIONS FROM GASOLINE VEHICLES SHALL NOT EXCEED 100 PPM HC OR 0.50 PERCENT EXHAUST GAS CO AT IDLE AND 2500 RPM AT 4K MILES; COMPLIANCE STATEMENT ALLOWED (IN LIEU OF DATA)
40. TIER 1, NLEV & CFV VEHICLES MUST MEET TIER 1 EMISSION STANDARDS AT HIGH ALTITUDE; TIER 0 VEHICLES MUST MEET SPECIAL HIGH ALTITUDE STANDARDS; COMPLIANCE STATEMENT ALLOWED (IN LIEU OF ACTUAL TEST DATA)
41. NLEV AND CFV (LDV, LDT1, LDT2) VEHICLES MUST MEET SPECIAL 50 DEG F EMISSION STANDARDS AT 4K MILES (NOT APPLICABLE TO DIESEL, CNG, OR HYBRID ELECTRIC VEHICLES); REF. 40 CFR 86.1708 & 1709-99 (b)(1)(iv)
42. SPECIAL INTERIM IN-USE EMISSION STANDARDS APPLY TO 1999 LEV AND 1999 TO 2002 ULEV VEHICLES; REF. 40 CFR 86.1808 & 1809-99(C) AS CORRECTED IN EPA GUIDANCE LETTER VPCD-98-03, APRIL 8, 1998.
43. TIER 0 AND TIER 1 EMISSION STANDARDS DO NOT APPLY TO ETHANOL VEHICLES
44. SMALL VOLUME MANUFACTURER EXEMPT UNTIL LAST YEAR OF PHASE-IN.
45. NOT APPLICABLE TO LOW VOLUME MANUFACTURERS (MANUFACTURERS WITH ANNUAL NATIONWIDE SALES OF CARS & LLDTs OF 40,000 UNITS OR LESS)
46. EARLY CREDITS AVAILABLE, REF. 40 CFR 86.1710-99(C)(7) & (8) AS CORRECTED IN EPA GUIDANCE LETTER VPCD-98-03, APRIL 8, 1998.
47. COMPLIANCE REQUIRED FOR NLEV AND CFV FLEXIBLE FUELED VEHICLES UNDER DEFEAT DEVICE REGULATIONS, REF. 40 CFR 86.1809-01.
48. WAIVERS ALLOWED IF CERTIFIED TO ORVR STANDARDS, REF. 40 CFR 86.1810-01(L)
49. MUST MEET ANSI/AGA NGV1 RECEPTACLE REQUIREMENTS, REF. 40CFR 86.1810 (K)
50. WAIVERS ALLOWED; REF 40 CFR 86.1810-01(M)
51. 2.6 GRAMS PER TEST AT HIGH ALTITUDE PRIOR TO 1996 MODEL YEAR

Exhaust and Evaporative Emission Standards

Abbreviations used in the tables of emission standards

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ALVW	Adjusted Loaded Vehicle Weight
CFV	Clean Fueled Vehicle
CNG	Compressed Natural Gas
CO	Carbon Monoxide
E10	A mixture of 10% ethanol and 90 % gasoline
E85	A mixture of 85% ethanol and 15 % gasoline
FTP	Federal Test Procedure
GVWR	Gross Vehicle Weight Rating
HCHO	Formaldehyde
HDV	Heavy-duty Vehicle [California definition] [federal definition]
HLDT	Heavy Light-duty Truck
ILEV	Inherently Low Emission Vehicle
LDT	Light-duty Truck [California definition] [federal definition]
LDT1	Light-duty Truck 1
LDT2	Light-duty Truck 2
LDT3	Light-duty Truck 3
LDT4	Light-duty Truck 4
LDV	Light-duty Vehicle
LLDT	Light Light-duty Truck
LEV	Low Emission Vehicle
LPG	Liquified Petroleum Gas (Propane)
LVW	Loaded Vehicle Weight
MDV	Medium-duty Vehicle
M10	A mixture of 10% methanol and 90 % gasoline
M85	A mixture of 85% methanol and 15 % gasoline
NLEV	National Low Emission Vehicle
NMHC	Non-methane Hydrocarbon
NMOG	Non-methane Organic Gases
NOx	Nitrogen Oxides
ORVR	Onboard Refueling Vapor Recovery
PC	Passenger Car
PM	Particulate Matter
SFTP	Supplemental Federal Test Procedure
SULEV	Super-Ultra-Low-Emission Vehicle
THC	Total Hydrocarbon
THCE	Total Hydrocarbon Equivalent
TLEV	Transitional Low-Emission Vehicle
TW	Test Weight
ULEV	Ultra-Low-Emission Vehicle
ZEV	Zero-Emission Vehicle

Exhaust and Evaporative Emission Standards

Federal Definitions

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Adjusted Loaded Vehicle Weight (ALVW)

The numerical average of vehicle curb weight and GVWR. (40 CFR 86.1803-01)

[Note: The federal "adjusted loaded vehicle weight" definition is identical to the California definition for "test weight."]

Approach Angle

The smallest angle in a plan side view of an automobile, formed by the level surface on which the automobile is standing and a line tangent to the front tire static loaded radius arc and touching the underside of the automobile forward of the front tire. (40 CFR 86.1803-01)

Axle Clearance

The vertical distance from the level surface on which an automobile is standing to the lowest point on the axle differential of the automobile. (40 CFR 86.1803-01)

Basic Vehicle Frontal Area

The area enclosed by the geometric projection of the basic vehicle along the longitudinal axis, which includes tires but excludes mirrors and air deflectors, onto a plane perpendicular to the longitudinal axis of the vehicle. (40 CFR 86.1803-01)

Breakover Angle

The supplement of the largest angle, in the plan side view of an automobile, that can be formed by two lines tangent to the front and rear static loaded radii arcs and intersecting at a point on the underside of the automobile. (40 CFR 86.1803-01)

Clean Fueled Vehicle (CFV) Program

The Federal program established to promote the sales of low emission vehicles in the State of California (California Pilot Program) and to promote the sales of LEV, ILEV and ULEV vehicles in twenty-two metropolitan areas in the United States (the Clean Fuel Fleet Program). (40 CFR Part 88) Eighteen areas have opted out of the Clean Fuel Fleet Program. The four areas which have adopted federal Clean Fuel Fleet programs are Atlanta, GA; Chicago-Gary-Lake County, IL/IN; Denver-Boulder, CO; and the Milwaukee-Racine, WI metropolitan areas.

Departure Angle

The smallest angle, in a plan side view of an automobile, formed by the level surface on which the automobile is standing and a line tangent to the rear tire static loaded radius arc and touching the underside of the automobile rearward of the rear tire. (40 CFR 86.1803-01)

Federal Test Procedure (FTP)

The test procedure as described in 40 CFR 86.130-00 paragraphs (a) through (d) and (f) which is designed to measure urban driving tail pipe exhaust emissions and evaporative emissions over the Urban Dynamometer Driving Schedule as described in 40 CFR Part 86 Appendix I. (40 CFR 86.1803-01)

Gross Vehicle Weight Rating (GVWR)

The value specified by the manufacturer as the maximum design loaded weight of a single vehicle. (40 CFR 86.1803-01)

Heavy Light-Duty Truck (HLDT)

Heavy light-duty truck means any light-duty truck rated greater than 6,000 lbs GVWR. (40 CFR 86.1803-01)

Heavy-Duty Vehicle (HDV)

Any motor vehicle rated at more than 8,500 pounds GVWR or that has a vehicle curb weight of more than 6000 pounds or that has a basic vehicle frontal area in excess of 45 square feet. (40 CFR 86.1803-01)

Incomplete Truck

Any truck which does not have the primary load carrying device or container attached. (40 CFR 86.1803-01)

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Low-Emission Vehicle (LEV)

Any vehicle certified to low-emission standards.

Light Light-Duty Truck (LLDT)

Light light-duty truck means any light-duty truck rated up through 6,000 lbs GVWR. (40 CFR 86.1803-01)

[Note: The definition for this category of trucks is essentially identical to the California definition for "light-duty truck.")

Light-Duty Truck (LDT)

Any motor vehicle rated at 8,500 pounds GVWR or less which has a vehicle curb weight of 6,000 pounds or less and which has a basic vehicle frontal area of 45 square feet or less, which is:

- (1) Designed primarily for purposes of transportation of property or is a derivation of such a vehicle, or
- (2) Designed primarily for transportation of persons and has a capacity of more than 12 persons, or
- (3) Available with special features enabling off-street or off-highway operation and use. (40 CFR 86.1803-01)

Light-Duty Truck 1 (LDT1)

Any light light-duty truck up through 3,750 lbs loaded vehicle weight. (40 CFR 86.1803-01)

Light-Duty Truck 2 (LDT2)

Any light light-duty truck greater than 3,750 lbs loaded vehicle weight. (40 CFR 86.1803-01)

Light-Duty Truck 3 (LDT3)

Any heavy light-duty truck up through 5,750 lbs adjusted loaded vehicle weight. (40 CFR 86.1803-01)

Light-Duty Truck 4 (LDT4)

Any heavy light-duty truck greater than 5,750 lbs adjusted loaded vehicle weight. (40 CFR 86.1803-01)

Light-Duty Vehicle (LDV)

A passenger car or passenger car derivative capable of seating 12 passengers or less. (40 CFR 86.1803-01)

[Note: The federal "light-duty vehicle" definition is essentially identical to the California definition for "passenger car."]

Loaded Vehicle Weight (LVW)

The vehicle curb weight plus 300 pounds. (40 CFR 86.1803-01)

National Low Emission Vehicle (NLEV) Program

The National Low Emission Vehicle Program (NLEV) program is a voluntary program to introduce cleaner cars and light trucks in all parts of the country. Under the agreement between the States and automobile manufacturers, manufacturers began selling cleaner model year 1999 and 2000 cars and trucks in Connecticut, Delaware, Maryland, New Hampshire, New Jersey, Pennsylvania, Rhode Island, Virginia, and the District of Columbia. (Massachusetts, New York, Vermont and Maine adopted California emission standards beginning in the 1999, 1999, 2000 and 2001 model years, respectively.) Twenty-four of the largest automobile manufacturers have voluntarily entered into the NLEV program. In model year 2001 to 2003 automobile manufacturers will voluntarily sell these cleaner cars and trucks in the 45 states nationwide which are participating in the NLEV program. Although the automobile manufacturers volunteered for the program, the lower emission levels and other requirements of the NLEV program are enforceable like any other federal new vehicle program. The NLEV program will continue to exist until the cleaner Federal Tier 2 emission standards become effective in the 2004 model year. (40 CFR Part 86 Subpart R)

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Non-Methane Organic Gases (NMOG)

The total mass of oxygenated and non-oxygenated hydrocarbon emissions.

SC03 Cycle

The test cycle, described in 40 CFR 86.160-00 and listed in Appendix I, paragraph (a), of 40 CFR part 86, which is designed to represent driving immediately following startup, in 95 degrees F ambient conditions with the vehicle air conditioning on. (40 CFR 86.1803-01)

Special Features Enabling Off-Street Or Off-Highway Operation And Use

A vehicle:

- (1) That has 4-wheel drive; and
- (2) That has at least four of the following characteristics calculated when the automobile is at curb weight, on a level surface, with the front wheels parallel to the vehicle's longitudinal centerline, and the tires inflated to the manufacturer's recommended pressure;
 - (i) Approach angle of not less than 28 degrees;
 - (ii) Breakover angle of not less than 14 degrees;
 - (iii) Departure angle of not less than 20 degrees;
 - (iv) Running clearance of not less than 8 inches;
 - (v) Front and rear axle clearances of not less than 7 inches each. (40 CFR 86.1803-01)

Supplemental Federal Test Procedure

The additional test procedures designed to measure emissions during aggressive and microtransient driving, as described in 40 CFR 86.159-00 over the US06 cycle, and also the test procedure designed to measure urban driving emissions while the vehicle's air conditioning system is operating, as described in 40 CFR 86.160-00 over the SC03 cycle. (40 CFR 86.1803-01)

Transitional Low-Emission Vehicle (TLEV)

Any vehicle certified to transitional low-emission standards.

Ultra-Low-Emission Vehicle (ULEV)

Any vehicle certified to ultra-low emission standards.

US06

The test cycle, described in 40 CFR 86.159-00 and listed in appendix 1, paragraph (g) of 40 CFR part 86, which is designed to evaluate emissions during aggressive and microtransient driving. (40 CFR 86.1803-01)

Vehicle Curb Weight (VCW)

The actual or the manufacturer's estimated weight of the vehicle in operational status with all standard equipment, and weight of fuel at nominal tank capacity, and the weight of optional equipment computed in accordance with 40 CFR 86.082-24; incomplete light-duty trucks shall have the curb weight specified by the manufacturer. (40 CFR 86.1803-01)

Zero-emission vehicle (ZEV)

Any vehicle certified to zero-emission standards.

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Heavy-Duty Vehicle (HDV)

Any motor vehicle having a manufacturer's gross vehicle weight rating greater than 6000 pounds, except passenger cars.

Incomplete Vehicle

Any vehicle which does not have the primary load carrying device or container attached. In situations where individual marketing relationships makes the status of the vehicle questionable, the Executive Officer shall determine whether a specific model complies with the definition of incomplete vehicle.

Light-Duty Truck (LDT)

Any motor vehicle, rated at 6000 pounds gross vehicle weight or less, which is designed primarily for purposes of transportation of property or is a derivative of such a vehicle, or is available with special features enabling off-street or off-highway operation and use.

[Note: The California "light-duty truck" definition is essentially identical to the federal definition for "light light-duty truck."]

Light-Duty Truck 1 (LDT1)

Any light-duty truck up through 3,750 lbs loaded vehicle weight.

[Note: California does not use the terms "light-duty truck 1" and "light-duty truck 2" in an official sense. However, they subdivide their light-duty trucks of less than 6000 pounds GVWR based on LVW in exactly the same way the federal regulations do, so these terms are applied to California emission standards to facilitate comparison.]

Light-Duty Truck 2 (LDT2)

Any light-duty truck greater than 3,750 lbs loaded vehicle weight.

[Note: California does not use the terms "light-duty truck 1" and "light-duty truck 2" in an official sense. However, they subdivide their light-duty trucks of less than 6000 pounds GVWR based on LVW in exactly the same way the federal regulations do, so these terms are applied to California emission standards to facilitate comparison.]

Low-Emission Vehicle (LEV)

Any vehicle certified to low-emission standards.

Medium-Duty Vehicle (MDV)

Any pre-1995 model year heavy-duty vehicle having a manufacturer's gross vehicle weight rating of 8,500 pounds or less, any 1992 and subsequent model year heavy-duty low-emission, ultra-low-emission, super-ultra-low-emission or zero-emission vehicle having a manufacturer's gross vehicle weight rating of 14,000 pounds or less, or any 1995 and subsequent model year heavy duty vehicle having a manufacturer's gross vehicle weight rating of 14,000 pounds or less. Medium-duty vehicles are subdivided into five classes (MDV1-MDV5) based on vehicle test weight.

Non-Methane Organic Gases (NMOG)

The total mass of oxygenated and non-oxygenated hydrocarbon emissions.

Passenger Car (PC)

Any motor vehicle designed primarily for transportation of persons and having a design capacity of 12 persons or less.

[Note: The California "passenger car" definition is essentially identical to the federal definition for "light-duty vehicle."]

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Super-Ultra-Low-Emission Vehicle (SULEV)

Any medium-duty vehicle certified to super-ultra-low-emission standards.

Test Weight (TW)

The average of the vehicle's curb weight and gross vehicle weight.

[Note: The California "test weight" definition is identical to the federal definition of "adjusted loaded vehicle weight."]

Transitional Low-Emission Vehicle (TLEV)

Any vehicle certified to transitional low-emission standards.

Ultra-Low-Emission Vehicle (ULEV)

Any vehicle certified to ultra-low emission standards.

Zero-emission vehicle (ZEV)

Any vehicle certified to zero-emission standards.

Section 15

Developing and Potential Transportation Fuel Uses for Ethanol

15.0 Developing and Potential Transportation Fuel Uses for Ethanol

In addition to the traditional use of ethanol as a low level blend component in conventional and reformulated gasoline, other potential transportation fuel uses of ethanol have varying degrees of potential. E-85 is in the early stages of commercialization. Oxydiesel is in the experimental/demonstration phase. The use of ETBE is currently clouded due to concerns about ethers and ground water quality. Other uses such as aviation applications and fuel cells are much less clear. This section discusses these other transportation fuel uses for ethanol, their current status, and considerations for development of their respective markets.

15.1 E-85

The term E-85 is commonly used to denote fuels containing 75 v% to 85 v% of denatured ethanol. The remainder of the blend is comprised of either conventional or reformulated gasoline.

The guiding industry specification for this fuel is ASTM D 5798 Standard Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines. In addition the former American Automobile Manufacturers Association (AAMA) developed a specification, most of which was incorporated into the ASTM specification.

Table # 15-1 lists some of the more important property requirements from the ASTM specification.⁽¹⁾

**Table 15-1 ASTM D 5798 Standard Specification for Fuel
Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines**

<u>Property</u>	<u>Value for Class</u>			<u>Test Method</u>
ASTM volatility class	1	2	3	n/a
Ethanol, plus higher alcohols (min., vol. %)	79	74	70	ASTM D 5501
Hydrocarbons (including denaturant)/(vol. %)	17-21	17-26	17-30	ASTM D 4815
Vapor pressure at 37.8°C				
kPa	38-59	48-65	66-83	ASTM D 4953, D 5190, D 5191
psi	5.5-8.5	7.0-9.5	9.5-12.0	
Lead (maximum, mg/L)	2.6	2.6	3.9	ASTM D 5059
Phosphorus (maximum, mg/L)	0.3	0.3	0.4	ASTM D 3231
Sulfur (maximum, mg/kg)	210	260	300	ASTM D 3120, D 1266, D 2622
Methanol (maximum, volume %)		0.5		n/a
Higher aliphatic alcohols, C3-C8 (max., volume %)		2		n/a
Water (maximum, mass %)		1.0		ASTM E 203
Acidity as ascetic acid (maximum, mg/kg)		50		ASTM D 1613
Inorganic chloride (maximum, mg/kg)		1		ASTM D 512, D 7988
Total chloride as chlorides (maximum, mg/kg)		2		ASTM D 4929
Gum, unwashed (maximum, mg/100 mL)		20		ASTM D 381
Gum, solvent-washed (maximum, mg/100 mL)		5.0		ASTM D 381
Copper (maximum, mg/L)		0.07		ASTM D 1688
Appearance	Product shall be visibly free of suspended or precipitated contaminants (shall be clear and bright).			Appearance determined at ambient temperature or 21°C (70°F), whichever is higher.

n/a = not applicable

The hydrocarbon content of E-85 is altered seasonally. Neat ethanol does not vaporize as easily as gasoline. The specification therefore requires more gasoline during the colder months to increase fuel volatility to minimize cold start and warm up performance problems.

E-85 is viewed by many to be an ideal alternative to gasoline. Since it is a liquid fuel it can be handled much like gasoline both in the distribution system and the automobile fuel system. E-85 also has a higher octane than gasoline. It does however contain less energy per gallon necessitating more frequent fueling events or alternatively, a larger fuel tank.

Important properties of E-85 in comparison to gasoline are listed in Table 15-2 Comparison of Fuel Properties.

Table 15-2 E-85 Comparison of Fuel Properties		
Property	Gasoline (87 Octane)	E85
Chemical composition	C ₄ to C ₁₂ chains	*
Main constituents (% by weight)	85-88C, 12-15H	57C, 13H, 30O
Octane (R+M)/2	86-92	96
Btu/Gallon	114,200	~81,700
Gasoline gallon equivalent	1	1.4
Relative tank size to yield driving range equivalent to gasoline	1	tank is 1.4 times larger
Reid vapor pressure (psi)	8-15	6-12
Specific gravity (60/60°F)	0.72-0.78	0.78
Vehicle power	standard	3-5% power increase
Stoichiometric air/fuel ratio (by weight)	14.7	10.0
* depends on percentage and type of the hydrocarbon fraction		

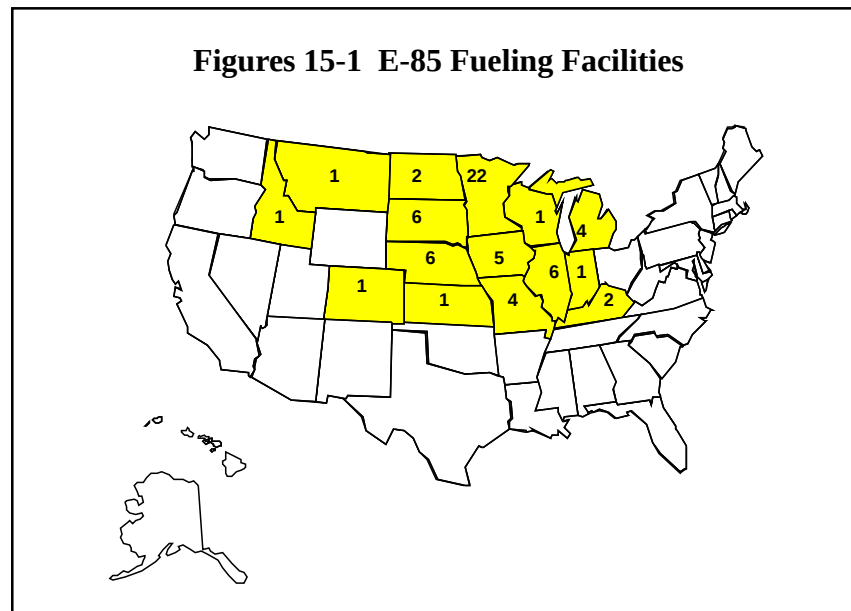
In the past few years some automakers have started offering Flexible-Fuel Vehicles (FFV). These autos are capable of operating on 100% gasoline or up to 85% denatured ethanol or any mixture of the two. Such vehicles meet the definition of an alternative fuel vehicle to comply with the 1992 Energy Policy Act (EPACT92). The automakers receive credits for their Corporate Average Fuel Economy (CAFE) for each FFV produced. This provides their incentive to produce such vehicles which require relatively inexpensive modifications to achieve their fuel flexibility. These credits were established in the Alternative Motor Fuels Act of 1988. The credit for alcohol FFVs is 1.2 miles per gallon through

model year 2004 and 0.9 miles per gallon for model years 2005 through 2008 (if the Act is extended to 2008).⁽²⁷⁾ Current offerings of Flexible Fueled Vehicles along with the year 2000 production estimates⁽³⁾ include the following.

Ford	Taurus	168,000
	Ranger Pickup (& Mazda B3000 twin)	200,000
Daimler Chrysler	minivans	160,000
GM	Chevy S10/GMC Sonoma Pickup (and Isuzu twin)	175,000
Total		703,000

Estimates put the current number of E-85 capable flexible fueled vehicles sold prior to 2000 at 1,000,000 units.⁽⁴⁾ Sales projections for these vehicles are 703,000+ units per year so the E-85 vehicle population is increasing very dramatically.

The real problem will not be vehicle availability, but rather fuel availability. E-85 fueling facilities are few and virtually nonexistent outside of the Midwest. Ethanol is available in at least a few terminals in every state which makes the blending of E-85 possible. However at the retail/consumer level, E-85 would require a dedicated dispensing unit. While E-85 could replace an existing low volume product such as mid-grade, most retailers have been reluctant to take this approach given the uncertainty of sales volumes and product margins. As a result the approach has been to install a new dispensing unit at existing locations. This also usually means installation of an underground storage tank. This approach is expensive and time consuming, dramatically limiting the growth of dispensing facilities to date. Sun Oil Company has estimated the cost of installing an E-85 fueling facility at an existing location at \$102,000. Figure 15-1 depicts the number of E-85 fueling facilities in each state.⁽⁵⁾



Flexible-Fuel Vehicles (FFVs) have been the subject of some controversy. Critics of the program have expressed concerns about the fact that while the auto manufacturers receive CAFE credits for providing these vehicles, there is no requirement for them to operate on E-85.⁽²³⁾ Since E-85 availability is very limited, most FFVs do not currently operate on E-85. Critics argue that the automakers receive CAFE credits, enabling them to produce more poor fuel economy vehicles, such as Sport Utility Vehicles (SUVs), without really creating any alternative fuel use.

Conversely the automakers argue that the alternative fuels infrastructure cannot be developed until a sufficient number of vehicles exist to create the demand to justify fueling facilities. Their position is that by producing flexible fuel vehicles they solve the “chicken and egg” problem by putting cars into the market that will operate on gasoline but can also operate on E-85 as the fueling infrastructure develops.

Theoretically the market potential for E-85 is very high. However it is dependent first on availability and second on competitive pricing. To demonstrate the market potential, projections have been made for various market penetration scenarios in Table 15-3

Table 15-3 Projected Potential E-85 Utilization at Various Usage Rates			
	Projected # of FFVs millions	25% E-85 use mmgy	50% E-85 use mmgy
2000	1.5	225	450
2001	2.2	330	660
2002	2.9	345	870
2003	3.6	540	1080
NOTE: The above projections are for demand at various utilization rates, not projected use. Calculations are based on a vehicle traveling 12,000 miles per year and averaging 20 mpg when E-85 is used.			

Based on the preceding information, it is possible to make some rough estimates as to the cost of infrastructure development. Table 15-3 indicates at a 50% utilization rate, 1.08 billion gallons of annual E-85 demand would be generated. If one assumes that the average facility would sell 400,000 gallons of E-85 per year, this would equate to a need for 2700 fueling facilities. Using Sun Oil Company's aforementioned estimate of \$102,000 per facility, this equates to a necessary investment of \$275 million. Of course in order to achieve this type of volume, the fueling facilities would need to be strategically located with high potential demand.

Another major issue is that of product pricing. The price of E-85 (Midwest average) was \$1.54 per gallon on 4/13/00.⁽²⁵⁾ Assuming it takes 1.3 gallons of E-85 to drive the same miles as when operating on gasoline⁽²³⁾, this equates to an equivalent gasoline price of \$2.00 per gallon. However the average retail price of gasoline in the Midwest market (PADD II), during the same time frame was \$1.357 per gallon.⁽²⁶⁾ Obviously consumers are not likely to embrace paying more for a fuel that provides lower fuel economy.

This may prove a particularly troublesome problem because the stakeholders who are trying to encourage development of the E-85 market have no influence over pricing at the retail level. Further, various laws would preclude them from such activity in any event. It would seem unlikely that consumers would seek out E-85 fuel for their vehicle until such time as it is competitively priced with gasoline on a miles traveled basis. At \$1.35 per gallon for gasoline this would equate to \$1.04 per gallon for E-85.

Public policy related issues affecting FFV demand include the Clean Air Act and the Energy Policy Act. The Clean Air Act requires that public or private fleet operators with 10 or more centrally fueled vehicles purchase increasing volumes of clean fuel vehicles. However such vehicles can include gasoline powered vehicles meeting clean fuel vehicle standards. Most of the E-85 vehicles to date have not been emissions certified to those low emissions levels and therefore do not qualify as meeting the requirements of the Clean Fueled Vehicle program. Moreover, of the twenty-two metropolitan areas in the Clean Fuel Fleet Program, eighteen have opted out. This leaves only four areas (exclusive of California) participating. The areas participating in the program are the Atlanta GA, Chicago-Gary-Lake County IN/IL, Denver-Boulder CO, and Milwaukee-Racine WI metropolitan areas.

The Energy Policy Act (EPACT) requires “persons” who own, operate, or control at least fifty centrally fueled vehicles operated primarily in Consolidated Metropolitan Statistical Areas (CMSA) with a 1980 population of 250,000 or more to meet increasing purchase requirements of Alternative Fueled Vehicles.

A listing of the subject areas along with specified purchase requirements information is included as Appendix 15-A. Note that the requirements are for alternative fuel vehicles which may include flexible fueled ethanol vehicles. However fleet operators are not required to select an alcohol fuel vehicle but simply an alternative fuel vehicle. Qualified vehicles specified in EPACT include those that can operate on ethanol (E-85), methanol (M-85), other alcohols meeting certain requirements, compressed natural gas (CNG), liquid natural gas (LNG), liquid petroleum gas (LPG), and hydrogen.

While E-85 holds the greatest near term potential among ethanol’s transportation fuel options (exclusive of the traditional low level blends), there are clearly a number of uncertainties. These include whether or not the required number of fueling facilities will be built, whether or not the retailers offer E-85 at a competitive price (on a miles traveled basis), and whether or not the automobile manufacturers continue to manufacture the vehicles. The latter, absent strong consumer demand, depends on the availability of CAFE credits.

15.2 ETBE

Ethyl Tertiary Butyl Ether (ETBE) was once thought to be the most likely avenue to overcome some of ethanol's negative handling characteristics (water sensitivity and vapor pressure increase). ETBE is produced similarly to MTBE, i.e. by reacting ethanol with isobutylene (MTBE is produced by reacting methanol with isobutylene). The following table compares key gasoline related properties of ETBE to MTBE and ethanol.⁽⁶⁾

Table 15-4 Gasoline Related Properties of Oxygenates			
	MTBE	ETBE	ETOH
Octane (R+M)/2	110	112	115
Vapor Pressure (Blending RVP)	8	4	18
Boiling Point (Degree F)	131	161	173
Oxygen Content (Vol%/2.0 wt% O ₂)	11	12.7	5.5
Max Oxygen Wt%	2.7	2.7	3.7
Water Solubility	low	low	high

ETBE's octane value is near that of ethanol and higher than MTBE. It has the lowest vapor pressure of the three oxygenates and is not sensitive to water. This would enable gasoline containing ETBE to be shipped via pipeline similar to fuels containing MTBE. Since ETBE has lower vapor pressure and a higher boiling point (i.e. less volatile) than MTBE, it is the most attractive oxygenate from a technical standpoint due to its ability to contribute to lower fuel volatility.

In the 1990s the primary impediment to ETBE utilization was its inability to be produced at a price competitive with MTBE. During that time frame, methanol, the primary feedstock for MTBE, experienced very low prices resulting in MTBE production costs well below those possible for ETBE. Consequently ETBE blending in the U.S. has been limited to experimental and demonstration projects.

ETBE's similarity to MTBE was once thought to be a positive. However with recent concerns about MTBE water contamination problems, that positive has turned into a negative and interest in ETBE has waned. While ETBE's ability to impact water quality is not of as great a concern as with MTBE, it is still

much greater than with ethanol. MTBE's Henry's Law Coefficient is ~0.018 while ETBE's is ~0.11.⁽⁷⁾ It's higher coefficient limits ETBE's ability to wash out in rain, and makes it vaporize much faster from surface water and easier to strip from water (i.e. remediation). Though less resistant to biodegradation than MTBE, ETBE is still considered fairly recalcitrant⁽⁸⁾ and presents water contamination risks similar to MTBE. It also has low odor and taste thresholds.

Under the aura of current concerns about MTBE, it is not likely that there is any great potential for ETBE at this time.

15.3 Diesel Applications

There has, in the past, been some effort to utilize ethanol in diesel engines. Here we are referring to near neat ethanol (i.e. E-95 to E-98). Detroit Diesel has in fact received emissions certification of the DDC 6V-92 TA engine.⁽⁹⁾ For a period of time a portion of the methanol transit buses used in California operated on ethanol. As far back as 1992, Regina Transit (Saskatchewan, Canada) operated ethanol buses in field trials.⁽¹⁰⁾

However there are some technical and operational realities that impede the use of ethanol in compression ignition (CI) engines.

Ethanol's cetane rating is low which necessitates the use of cetane improver additives. Alcohols also generally require the use of lubricating additives. In addition, ethanol's energy content (lower heating value) of ~76,100 btu/gallon compares unfavorably with diesel's 126,000-131,000 btu/gallon.⁽¹¹⁾ Hardware changes such as different injectors and addition of glow plugs are also necessary on the engine.

Perhaps more importantly, using near neat ethanol in diesel engines would require dedicated dispensing equipment at the retail/fleet level. Similar to E-85 this would necessitate installation of tanks and dispensing equipment for what would initially be insufficient volume to justify such efforts. In the past few years the focus has shifted to Oxydiesel (see below) which would not carry the same technical and infrastructure obstacles.

15.4 Oxydiesel

Oxydiesel is a blend of traditional diesel fuel blended with up to 15% denatured fuel grade ethanol and special additives. It can be used in existing diesel engines without modification and delivered through the existing retail/fleet outlet system.

In late 1998 Archer Daniels Midland began a fleet demonstration/test of Oxydiesel with 15% ethanol.⁽¹²⁾ ADM committed three brand new Mack trucks to the test, two to operate on oxydiesel and one for a control unit. The oxydiesel blend in this test program also contained a proprietary additive supplied by Pure Energy Corporation. The engines were tested without undergoing any modification. The performance characteristics of oxydiesel are very similar to No. 2 diesel.⁽¹³⁾

Table 15-5 Performance Characteristics of OxyDiesel Based on ASTM Protocols			
Property	Test Method	No. 2 Diesel	OxyDiesel
Water & sediment % max	ASTM D 1796	0.05	n/d
Distillation temperature for T-90 (C)	ASTM D86	332	311
Kinematic viscosity, 40C (cSt)	ASTM D 445	1.9-4.1	2.25
Ash (%) max	ASTM D 482	0.01	0.001
Sulfur (%) max	ASTM D 2622	0.05	0.01
Copper corrosion @ 3 hr max	ASTM D 130	3b	1a
Cetane number, min	ASTM D 613	40	45
Cetane index, min	ASTM D 4737	45	42
Rams. carbon, 10% res.	ASTM D D4530	0.35	0.22
API gravity, max	ASTM D 287	39	38
Lubricity (g) min	ASTM D 6078*	3100	5200
Accel. stability, pass/fail test	Octel F-21	pass	pass
Cloud point (C)	ASTM D 2500*	-15	-5
LTFT at -11 C, pass/fail test	ASTM D 4539*	pass	pass
LTFT at -19 C, pass/fail test	ASTM D 4539*	fail	pass

Preliminary emissions testing on oxydiesel has been very favorable. Tests commissioned by Pure Energy Corporation at a major testing facility demonstrated significant reductions in key exhaust emission pollutants.⁽¹⁴⁾

Table 15-6 Oxydiesel Emissions Test Results-Pure Energy (% change compared to a diesel reference fuel)				
	CO	NO_x	PM	HC
Oxydiesel (10 v% ethanol)	(20)	(4)	(27)	+ 71
Oxydiesel (15% ethanol)	(27)	(5)	(41)	+ 110

In the tests reported in the above table, the 15% oxydiesel blend resulted in a 6% increase in fuel consumption while the 10% oxydiesel blend resulted in a 4% increase.

More recently, AAE Technologies has studied promoting oxydiesel with 10 v% ethanol content and their proprietary additive AAE₀₇. A recent presentation by AAE⁽¹⁵⁾ included two sets of emissions testing data. The first test by Institute de Pesquisas Technologicas, Sao Paulo, reported that compared to a diesel reference fuel, oxydiesel reduced CO by 14,6%, PM by 12.6%, and smoke by 22.3%. Power was increased by 5.7%. There was a 0.75% increase in NO_x.

In another test by Emissions Testing Services-Costa Mesa, California, oxydiesel was compared to CARB diesel. The results from this test are listed in Table 15-7

Table 15-7 Oxydiesel Emissions Test Results - Emissions Testing Service:				
	CO₂ avg %	NO_x gm/bhpH	PM gm/bhpH	HP average
CARB diesel	3.25	7.46	0.32	86.50
Oxydiesel	3.16	7.30	0.25	88.50

Clearly initial emissions testing is very favorable. The Chicago Transit Authority (CTA) is testing transit buses on oxydiesel as part of Phase II of the oxydiesel test program started by Archer Daniels Midland.⁽¹⁵⁾

Many ethanol industry participants feel that oxydiesel may be second only to E-10 in its ability to expand the ethanol market. Like E-10 blends, oxydiesel could be blended at the terminal and dispensed through existing equipment. It could be used in existing diesel engines without modification.

Based on EIA reports, production of low sulfur #2 diesel is approximately 37 billion gallons per year. If oxydiesel were to achieve the same market penetration that E-10 has achieved in gasoline, this would equate to 4.44 billion gallons of oxydiesel annually. If blended at the 10% level, this volume would require 444 million gallons of ethanol per year.

15.5 Aviation

Ethanol has also been examined for potential use in aviation applications. While a small amount of work has been done on turbine powered aircraft (jet engines), the primary focus has been on piston powered aircraft (spark ignition/internal combustion).

Part of the driving force for considering ethanol as an aviation fuel is the fact that 100LL aviation gasoline (av-gas) is the last commercial fuel allowed to contain lead. Eventually it is likely that lead will be banned in av-gas as well. This would leave owners of high compression aviation engines without a high enough octane fuel for their current engine configuration. While engines could be modified to operate on lower octane gasoline (e.g. reduce compression ratio), the result would be lowered power. In addition the use of leaded av-gas tends to increase maintenance frequency due to resulting lead deposits.

Research in this area dates to at least the 1980s with The Federal Aviation Administration (FAA) presenting a SAE paper on the topic in 1989.⁽¹⁷⁾ The paper reported on various testing and technical issues.

A great deal of pioneering work has been done by Max Shauck and the Aviation Sciences Program at Baylor University. In fact Shauck made a trans-Atlantic flight on ethanol, receiving the 1990 Harmon Trophy for his feat.^(18, 19) Shauck has also been involved in obtaining certification to operate various planes on ethanol.⁽¹⁹⁾

The South Dakota Corn Utilization Council (SDCUC) has also been involved in promoting ethanol as an aviation fuel and has sponsored the Vanguard Flying Team with four of their planes converted to run on ethanol. The Vanguard Flying Team performed at numerous air shows including the Oshkosh Air Show.⁽²⁰⁾

More recently an aviation-grade E-85 (AGE85) has been developed.⁽²¹⁾ AGE85 is ~88% ethanol, 11% pentane isomerate, and 1% biodiesel. The fuel has been developed and demonstrated by Great Planes Fuel Development, Brookings SD; South Dakota State University, Brookings SD; Lake Area Technical Institute, Watertown SD; Texas Skyways, Boerne TX; and University of North Dakota Energy & Environmental Research Center, Grand Forks ND and is funded by the South Dakota Corn Utilization Council and the U.S. Department of Agriculture National Alternative Fuels Laboratory Program.

In May 1999, AGE85 was certified by the FAA for use in the Cessna 180 and 182 engine-airframe combinations. Procedures are ongoing for certification of additional engine-airframe configurations. Whether as a near neat fuel or AGE85, ethanol demonstrates excellent properties as an aviation fuel.

Commercialization of an ethanol based aviation fuel does present some unique challenges. Such fuels must be certified for use by the FAA on an individual engine-airframe configuration basis, a time consuming and expensive process. It must also be made widely available at Fixed Base Operations (FBO) fueling facilities.

On the positive side, the current av-gas market is estimated at about 400 million gallons per year.⁽²¹⁾ At an 88% ethanol volume content, this represents a potential market of 352 million gallons per year for ethanol before adjustments for ethanol's lower energy content. It is also a higher priced specialty fuels market. Av-gas prices range from \$1.60 to \$2.80 per gallon so this could represent a higher valued market for fuel grade ethanol compared to automotive uses.

15.6 Fuel Cells

Fuel cells operate by combining hydrogen and oxygen in a chemical reaction that creates electricity to power vehicles or stationary sources. Fuel cell emissions, when operating on hydrogen consist primarily of water and steam.

Storage of hydrogen on board vehicles, though actively researched, has not seen any major breakthroughs. The more likely fuel source will be hydrogen reformed from a liquid fuel on board the vehicle.

To date the focus on fuels for reforming has been primarily on methanol and gasoline. However fuel cells could hold great promise for ethanol if it could somehow penetrate this market. This appears

unlikely at this point, however, as the driving force for development is the California Fuel Cell Partnership⁽²²⁾ which does not currently include an ethanol vehicle. The Chicago Transit Authority has discussed a fuel cell bus demonstration project but has not yet identified funding to initiate that effort.

Some fuel reformers such as the one developed by EPYX Corporation are multifuel capable and could therefore operate on gasoline, methanol, ethanol, etc.

The primary benefits that ethanol offers as a fuel cell fuel include the following:⁽²³⁾

- High energy density liquid stores well on vehicles
- Reductions in greenhouse gas emissions
- Delivered through existing fuel infrastructure
- Can be blended with gasoline for seamless motor fuel transition
- Less toxic than methanol and gasoline and does not pose as severe a threat to the environment in the event of a spill
- Easier to reform than gasoline, hydrocarbons and most alternative fuel options
- Utilizes agricultural, waste, and biomass feedstocks creating new markets for agricultural products while contributing to rural economic development
- Reduced reliance on imported fossil fuel energy

It is impossible to project when or how quickly fuel cell powered vehicles will enter the market at the current time. Likewise projections for market penetration of stationary source fuel cell powered units would be merely a guess. As such, it is not possible to make projections on resultant fuel demand.

15.7 Alternative Blend Levels

Some ethanol supporters have, in the past, advocated increasing the blend level used in gasoline ethanol blends for use in regular street vehicles. They have noted that raising the blend level from E-10 to E-17 or E-22 would dramatically increase demand and address certain technical problems. Advocates note that 22 v% ethanol blends have been used successfully in Brazil for a number of years. Part

of the advocacy of these higher blend levels comes from the mistaken belief that ethanol blend levels in the 20 v% range would address ethanol's blending vapor pressure increase. The peak vapor pressure increase from ethanol addition to gasoline is normally reached between 3 and 4 v% ethanol and results in a ~ 1.0-1.1 psi vapor pressure increase. Once above the 5 v% ethanol level the vapor pressure begins to drop modestly. However at the 20 v% ethanol level the vapor pressure increase has only dropped to about 0.7 psi, not enough to make a dramatic difference.

There are also a number of technical drawbacks to these blend levels. Key among these is opposition from the auto manufacturers. Automakers do not support gasoline ethanol blends exceeding 10 v% ethanol for use in their regular gasoline engine products. Some of the reasons cited include the following:

- As mentioned in Section 14, tighter emissions standards require more precise controls of air/fuel ratio management. Increasing the range of oxygen from 0.0-3.5 wt% to 0.0-7.7 wt% O₂ (for 22 v% ethanol) would create problems in this area. Further, the high oxygen levels would not be within the authority range of the engine management system programming.
- Not all elastomers used in the fuel system of vehicles manufactured for sale in the U.S. have been tested for durability at these blend levels. Materials compatibility issues represent an open technical issue.
- Fuel economy would be reduced significantly. The average fuel economy penalty for 3.5 wt% O₂ is 2-3%, usually not noticed by the average motorist. However at the 7.7 wt% O₂ level, the fuel economy penalty is in the 6-7 % range. The customer switching between an all hydrocarbon fuel and a 22 v% ethanol blend would notice more dramatic fuel economy penalties.
- Since E-17 or E-22 could not be used in the existing automotive fleet, it would need to be handled as a specialty fuel for cars designed for its use. The infrastructure requirement would be identical to that needed for E-85. Use of this infrastructure for E-85 would generate far more ethanol demand than an E-17 or E-22 blend.

Higher ethanol blend levels (for use in the current fleet) would require a waiver under §211f of the Clean Air Act. Such an effort would be opposed by the automakers based on the aforementioned technical obstacles. In the face of opposition from the automakers (for valid technical reasons) it is unlikely that EPA would grant a waiver for an oxygen level above those of currently waived fuels.

Section 15.0: Developing and Potential Transportation Fuel Uses for Ethanol

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ENERGY POLICY ACT

METROPOLITAN AREAS WITH A 1980 POPULATION OF 250, 000 OR MORE

Albany-Schenectady-Troy NY	Honolulu HI	Raleigh-Chapel Hill-Durham NC
Albuquerque NM	Houston-Galveston-Brazoria TX	Reading PA
Allentown-Bethlehem-Easton PA-NJ	Huntington-Ashland WV-KY-OH	Richmond-Petersburg VA
Appleton-Oshkosh-Neenah WI	Indianapolis IN	Rochester NY
Atlanta GA	Jackson MS	Rockford IL
Atlantic City NJ	Jacksonville FL	Sacramento-Yolo CA
Augusta-Aiken GA-SC	Johnson City-Kingsport-Bristol TN-VA	Saginaw-Bay City-Midland MI
Austin-San Marcos TX	Kansas City KS-MO	St. Louis MO-IL
Bakersfield CA	Knoxville TN	Salina CA
Baton Rouge LA	Lakeland-Winter Haven FL	Salt Lake City-Ogden UT
Beaumont-Port Arthur TX	Lancaster PA	San Antonio TX
Binghamton NY	Lansing-East Lansing MI	San Diego CA
Birmingham AL	Las Vegas NV	San Francisco-Oakland-San Jose CA
Boise City ID	Lexington KY	Santa Barbara-Santa Maria-Lompac CA
Boston-Lawrence-Worcester MA-NH-ME-CT	Little Rock N. Little Rock AR	Scranton-Wilkes Barre-Hazleton PA
Buffalo-Niagara Falls NY	Los Angeles-Riverside-Orange County CA	Seattle-Tacoma-Bremerton WA
Canton-Massillon OH	Louisville KY-IN	Shreveport-Bossier City LA
Charleston SC	Macon GA	Spokane WA
Charleston WV	Madison WI	Springfield MA
Charlotte-Gastonia-Rock Hill NC-SC	McAllen-Edinburg-Mission TX	Stockton-Lodi CA
Chattanooga TN-GA	Melbourne-Titusville-Palm Bay FL	Syracuse NY
Chicago-Gary-Kenosha IL-IN-WI	Memphis TN-AR-MS	Tampa-St. Petersburg-Clearwater FL
Cincinnati-Hamilton OH-KY-IN	Miami-Fort Lauderdale FL	Toledo OH
Cleveland-Akron OH	Milwaukee-Racine WI	Tucson AZ
Colorado Springs CO	Minneapolis-St. Paul MN-WI	Tulsa OK
Columbia SC	Mobile AL	Utica-Rome NY
Columbus OH	Modesto CA	Washington-Baltimore DC-MD-VA
Columbus SC-GA-AL	Montgomery AL	W. Palm Beach-Boca Raton FL
Corpus Christi TX	Nashville TN	Wichita KS
Dallas-Fort Worth TX	New London-Norwich CT-RI	York PA
Davenport-Rock Island-Moline IA-IL	New Orleans LA	Youngstown-Warren OH
Dayton-Springfield OH	New York-N. New Jersey-Long Island NY-NJ-CT-PA	
Daytona Beach FL	Norfolk-Virginia beach-Newport News VA-NC	
Denver-Boulder-Greeley CO	Oklahoma City OK	
Des Moines IA	Omaha NE-IA	
Detroit-Ann Arbor-Flint MI	Orlando FL	
El Paso TX	Penscola FL	
Erie PA	Peoria-Pekin IL	
Eugene-Springfield OR	Philadelphia-Wilmington-Atlantic City PA-NJ-DE-MD	
Evansville-Henderson IN-KY	Phoenix-Mesa AZ	
Fort Wayne IN	Pittsburgh PA	
Fresno CA	Portland-Vancouver OR-WA	
Grand Rapid-Mushegon-Holland MI	Providence-Warwick-Fall River RI-MA	
Greensboro-Winston-Salem-High Point NC		
Greenville-Spartanburg SC		
Harrisburg-Lebanon-Carlisle PA		
Hartford CT		

EPACT Purchase Requirements for Affected Fleets				
Year	Federal (a) (% or No. of AFVs)	State (b) (% of AFVs)	Alternative Fuel Provider (b) (% of AFVs)	Municipal/ Private 9c) (% of AFVs)
1993	5,000			
1994	7,500			
1995	10,000			
1996	25%			
1997	33%	10%	30%	
1998	50%	15%	50%	
1999	75%	25%	70%	20%
2000	75%	50%	90%	20%
2001	75%	75%	90%	20%
2002	75%	75%	90%	20%
2003	75%	75%	90%	40%
2004	75%	75%	90%	60%
2005	75%	75%	90%	70%
2006	75%	75%	90%	70%
(a) Fiscal year for federal fleet acquisition; model year for all others (b) As required by CFR Part 490 (c) May be required by regulations if DOE finds these acquisitions are necessary				

Section 16
Ethanol-Technical Information

16.0 Technical Information on Ethanol

The marketing, transportation, and blending methods used to incorporate ethanol into the transportation fuels pool are dramatically affected by its technical characteristics. For instance, octane value and blending vapor pressure affects ethanol's value as well as blending procedures. Ethanol's affinity for water affects how it is transported. This section provides technical information along with a brief discussion of why certain characteristics are important and/or how they effect the transportation and use of ethanol.

16.1 Denatured Fuel Ethanol Specifications.

Before fuel grade ethanol leaves the distribution plant for a gasoline blending destination, it must be denatured in accordance with the regulations of the Bureau of Alcohol Tobacco and Firearms (BATF).⁽¹⁾ The BATF has approved various materials for denaturing ethanol. However the material used must also be in compliance with ASTM specifications and suitable for use in gasoline. As a result, the most typical denaturants used are unleaded gasoline or natural gasoline. The minimum denaturant level requires that 2 gallons of denaturant be added to each 100 gallons of gasoline. Since the denaturants are less expensive than ethanol, they are typically added at the maximum permitted level of 5 gallons of denaturant added to 100 gallons of ethanol.

The industry recognized specification for fuel grade ethanol is ASTM D 4806 Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel. ASTM D 4806 provides guidelines for various fuel ethanol properties including those listed in Table 16-1.

**Table 16-1 ASTM D 4806 Standard Specification for Denatured Fuel Ethanol for Blending
with Gasolines for Use as Automotive Spark-Ignition Engine Fuel**

Important Properties

Ethanol, volume %, min.	92.1
Methanol, volume %, max.	0.5
Solvent-washed gum, mg/mL, max.	5.0
Water content, volume % max. %	1.
Denaturant content, volume %, min.	1.96
volume %, max.	4.76
Inorganic Chloride content, mass ppm (mg/L), max.	40 (32)
Copper content, max, mg/kg.....	0.1
Acidity (as acetic acid CH ₃ COOH)	0.007 (56)
max, mass % (mg/L)	
pHe	6.5 to 9.0
Appearance	Visibly free of suspended or pre- cipitated contaminants (clear and bright)

In addition to the ASTM specification, the Renewable Fuels Association has developed a product quality guide entitled “Fuel Ethanol-Industry Guidelines, Specifications, and Procedures” (RFA Recommended Practice #960501) which discusses quality issues for both ethanol and gasoline ethanol blends.

Many ethanol producers also have their own “Typical Property” or specification sheets for their ethanol. In addition, some purchasing companies may specify certain properties be met. An example here would be the recent trend to specify maximum sulfur content.

It should also be noted that there are industry standards for calculating the volume of product delivered/purchased. Ethanol is normally sold on a “temperature adjusted basis”, i.e. corrected to 60°F.

Gallons corrected to 60°F are referred to as net gallons while the volume of product on a non-temperature corrected basis is referred to as gross gallons. There are specific charts for calculating the gross to net gallon calculation.^(2, 3)

16.2 Denatured Fuel Ethanol-Gasoline Related Properties

When ethanol is blended to gasoline, a number of properties are affected. These include oxygen content, octane, vapor pressure, distillation properties, and energy content. Table 16-2 compares typical properties of denatured ethanol to MTBE and gasoline.^(2, 3)

Table 16-2 Typical Properties of Ethanol and MTBE Compared to Gasoline

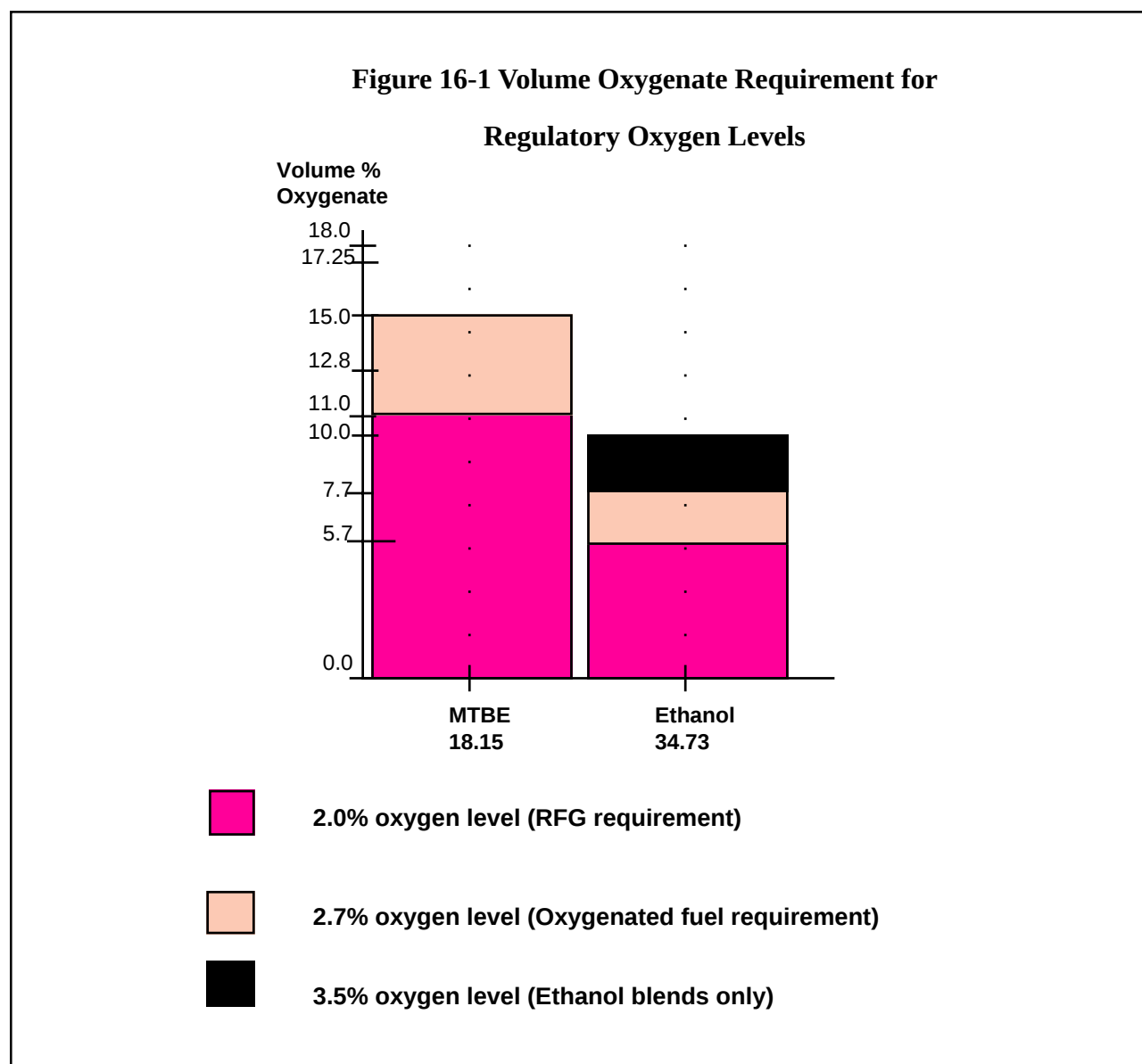
<i>Property</i>	<i>Denatured Ethanol</i>	<i>MTBE</i>	<i>Gasoline</i>
Oxygen wt. %	33.0	18.15	0.00
Stoichiometric Air/Fuel Ratio	9.2	11.7	14.7
Blending Octane (R+M)/2	112.5	111.0	87.0-94.0
Blending Research Octane	129.0	119.0	92.0-102.0
Blending Motor Octane	96.0	103.0	82.0-85.0
Vapor Pressure	2.3	7.8	7.0-15.0
Blending Vapor Pressure, psi	18.0	8.0	7.0-15.0
Boiling Point °F	152-174	131	80-437
Energy Content btu/gal	76.1M	93.5M	112.0-116.0M
Density (lb./gal @ 60°F)	6.58	6.19	6.7-7.4
Specific Gravity	0.794	0.744	0.690-0.790
Legal Maximum vol %	10.0%	15.0%	n/a
Water Solubility @ 70°F			
Fuel in Water (v%)	100	4.3	negligible
Water in Fuel	100	1.4	negligible

Note that certain blending property values of ethanol and MTBE may vary slightly depending on the composition and density of the base gasoline to which they are added.

The importance of the properties in Table 16-2 are discussed in more detail below.

16.2.1 Oxygen Content

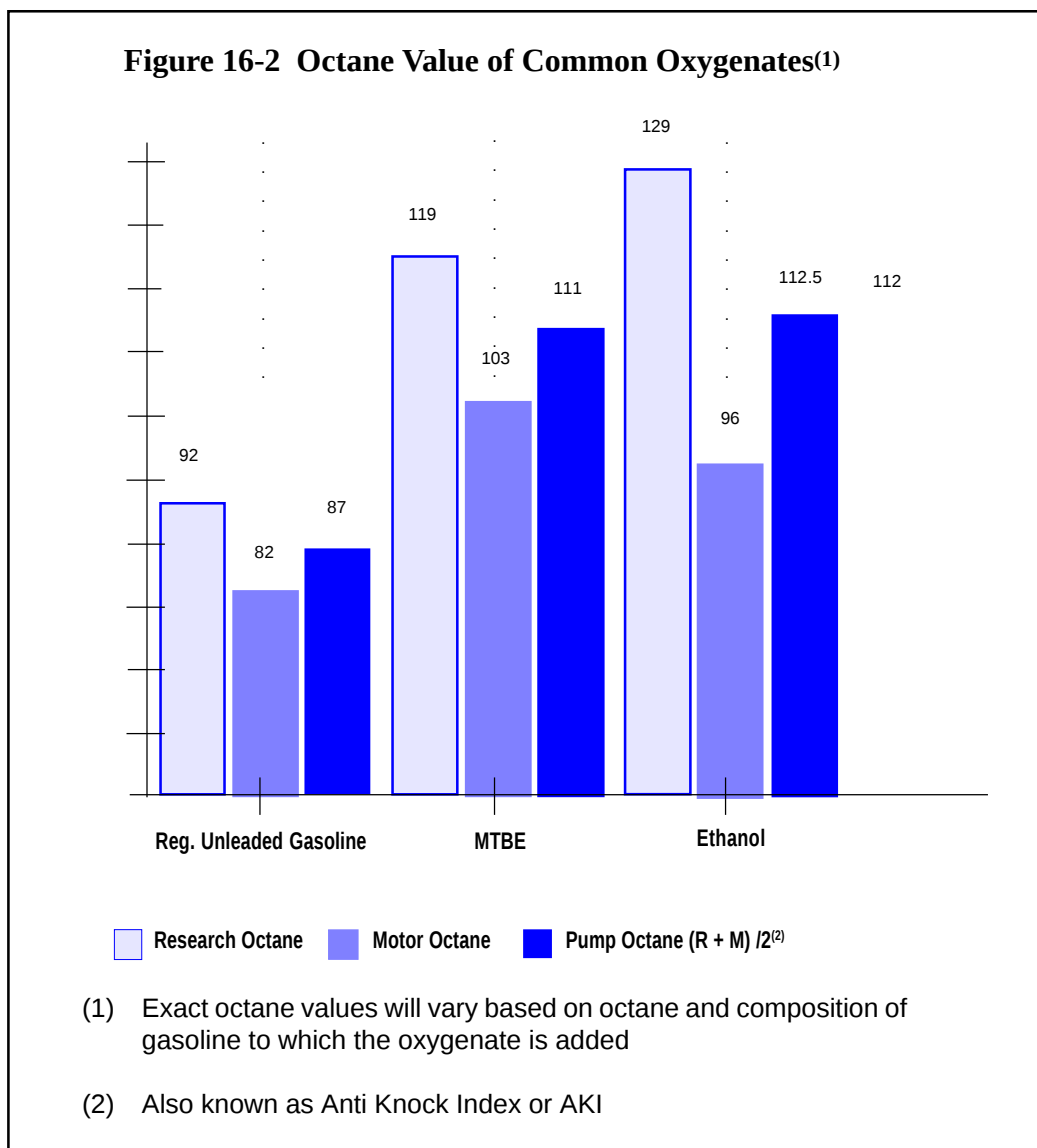
Oxygen content is primarily an issue for compliance with the oxygen content requirements of oxygenated fuel programs and reformulated gasoline programs. The oxygen content of ethanol at ~ 35.0 wt% is much greater than that of MTBE at 18.15%. Consequently much less ethanol has to be added to achieve the same oxygen levels of an MTBE blend. This is depicted in Figure 16-1.



16.2.2 Octane

Exclusive of oxygen for compliance with clean air programs, ethanol's primary role in the gasoline pool is as an octane enhancer. Ethanol's blending octane value of 112.5 (R+M)/2 compares quite favorably to MTBE and gasoline. See Figure 16-2.

Gasolines are most commonly rated based on their Antiknock Index (AKI), a measure of octane quality. The AKI is a measure of a fuel's ability to resist engine knock (ping). The AKI of a motor fuel is the average of the Research Octane Number (RON) and Motor Octane Number (MON) or (R+M)/2. Optimum performance and fuel economy is achieved when the AKI of a fuel is adequate for the engine in which it is combusted. There is no advantage in using gasoline of a higher AKI than the engine requires to operate knock-free.



The RON and MON of fuels are measured by recognized laboratory engine test methods. Results of these tests may generally be translated into approximate field performance.

In general, the RON affects low to medium speed knock and engine run-on or dieseling. If the Research Octane Number is too low, the driver could experience low speed knock and engine run-on after the engine is shut off.

The MON affects high speed and part-throttle knock. If the Motor Octane Number is too low, the driver could experience engine knock during periods of power acceleration such as passing vehicles or climbing hills.

The antiknock performance of a fuel, in some vehicles, may be best represented by the RON, while in others it may relate best to the MON. Extensive studies indicate that, on balance, gasoline antiknock performance is best related to the average of the Research and Motor Octane Numbers, or $(R+M)/2$. This formula is continuously reviewed for its accuracy in predicting gasoline performance in new automobiles.

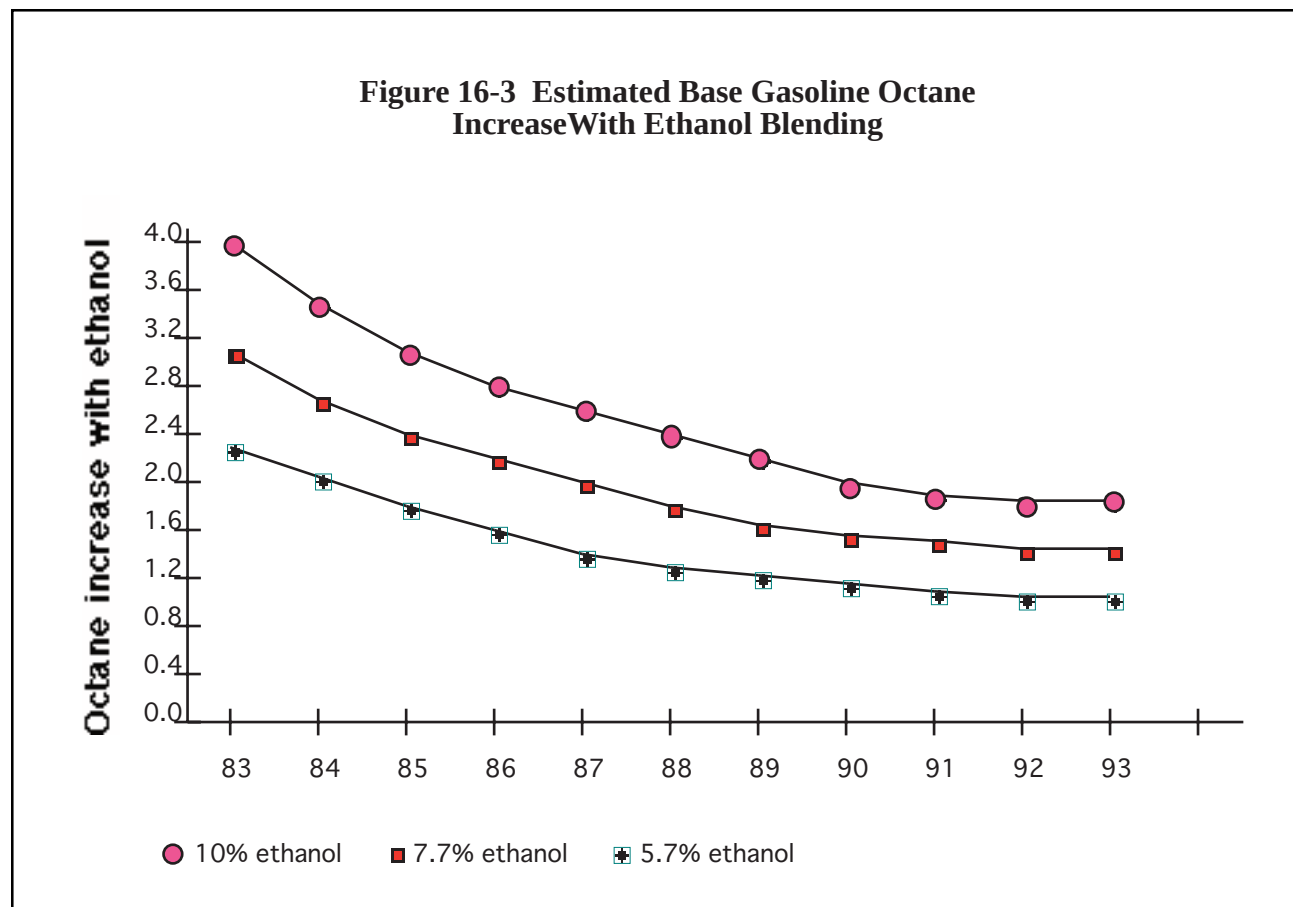
The RON of a fuel is typically 8 to 10 numbers higher than the MON. For instance, an 87 octane gasoline typically has a MON of 82 and a RON of 92. The difference between the MON and RON is referred to as octane sensitivity.

Ethanol will typically raise the octane of the gasoline to which it is added by 2 to 3 numbers $(R+M)/2$. The increase in research octane is greater than the increase in motor octane and octane sensitivity is usually increased. Table 16-3 provides an example of the typical octane increase from ethanol.

Table 16-3 Typical Octane Increase from Ethanol		
	<u>Base Gasoline</u>	<u>90% Base Gasoline 10% Ethanol</u>
$(R+M)/2$	87.00	89.35
Motor Octane	82.00	83.00
Research Octane	92.00	95.70
Sensitivity	10.00	12.70

Refiners consider not only the AKI increase but their balance on MON and RON.

Octane increase is also a factor of the amount of ethanol added. Figure 16-3 provides the octane response curve for the three common ethanol blend levels.

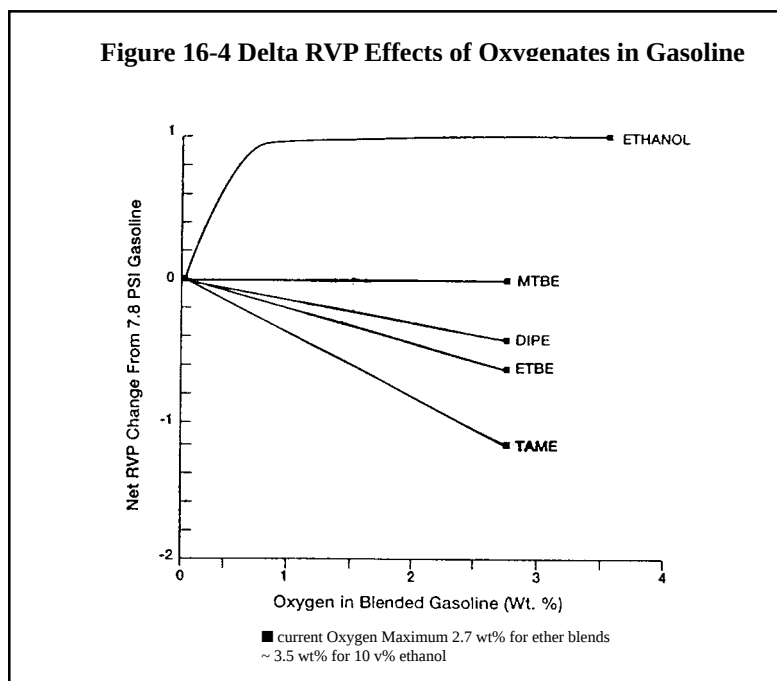


16.2.3 Volatility

Neat ethanol has a low vapor pressure. However its blending vapor pressure is relatively high due to azeotropes that are formed with gasoline components. The addition of as little as 3 v% ethanol will increase vapor pressure by up to 1.0 psi.

Figure 16-4 depicts the typical increase in vapor pressure for ethanol and MTBE when added to a 7.8 psi gasoline.

With today's emphasis on lower vapor pressure gasoline, ethanol's high blending vapor pressure



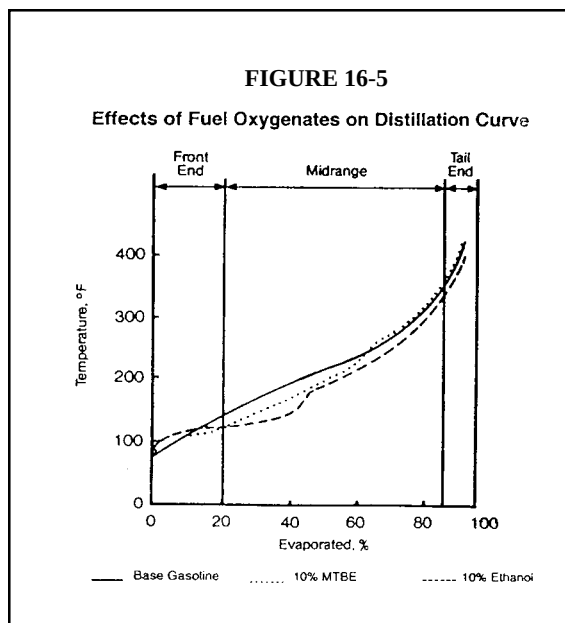
is a major issue for refiners considering an ethanol blend program if their market areas are subject to the low vapor pressure requirements of reformulated gasoline.

In addition to increasing fuel volatility through the rise in vapor pressure, ethanol with its low boiling range of 152°-174°F (depending of denaturant), also lowers the T_{50} of the gasoline to which it is added.

ASTM D 4814 also provides guidance on distillation characteristics. Table 1 of ASTM D 4814 provides a maximum temperature at which 10v%, 90v%, and 100v% (T_{10} , T_{90} , and end point) of a gasoline sample should evaporate. The specification also provides a temperature range at which 50% (T_{50}) of the sample should evaporate. The T_{50} range provides a minimum of 150°F - 170°F and a maximum of 230°-250°F depending on the volatility class. Ethanol will depress the T_{50} point of the gasoline to which it is added. As an example adding 10v% ethanol to a gasoline with a T_{50} of 210°F can result in a blend with a T_{50} of 180°-185°F.

Figure 16-5 depicts the typical effect ethanol has on the gasoline distillation curve compared to MTBE.

While most states exempt ethanol blends from meeting the ASTM T_{50} requirements, the effect of



ethanol on distillation properties also comes into play in EPA's reformulated gasoline complex model. This is another consideration for refiners to look at in relationship to the other gasoline components they are working with.

16.2.4 Energy Content

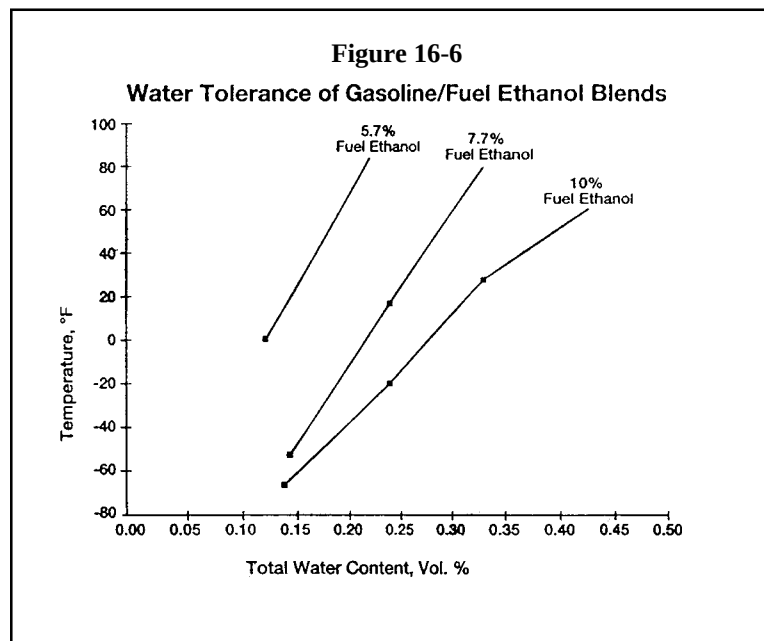
The energy content of denatured ethanol is ~ 76100 btu per gallon compared to gasoline's typical energy content of ~ 114,000 btu per gallon. So when ethanol is added to a base gasoline the resulting energy content will be lower. Table 16-4 compares the energy values of the three common ethanol blend levels to that of MTBE (when added to a gasoline of 114,000 btu per gallon).

Table 16-4 Energy Content of Oxygenate Blends (when blended with 114,000 btu/gallon base fuel)				
Oxygenate	Energy content (btu/gal)	2.0 wt% O ₂	2.7 wt% O ₂	3.5 wt% O ₂
Ethanol	76,100	111,836 (5.7 v%)	111,082 (7.7 v%)	110,210 (10.0 v%)
MTBE	93,500	111,745 (11.0 v%)	110,925 (15.0 v%)	n/a

Of course the energy content of gasoline also varies to some degree depending upon hydrocarbon composition. The lower energy content is not a major issue for refiners but is a consideration for public policy decisions.

16.2.5 Water Solubility

Ethanol is very sensitive to water with water solubility of 100% at 70°F. A 10 v% ethanol blend has a water tolerance of ~ 0.45% at 60°F and less at lower blend levels. The tolerance of the three common



ethanol blend levels is depicted in Figure 16-6. Once a gasoline ethanol blend reaches its water tolerance level (saturation), the water and alcohol will “phase separate”. This results in a lower phase of alcohol and water and an upper phase of predominantly hydrocarbon fuel. As noted in Figure 16-6. The amount of water that the three common ethanol blend levels can tolerate before phase separating (at 60°F) is 0.20 v% at 5.7 v% ethanol, 0.33 v% at 7.7 v%, and 0.45 v% at 10 v% ethanol.

Ethanol’s sensitivity to water requires special handling for ethanol and gasoline ethanol blends throughout the petroleum distribution system. As a result, ethanol and gasoline ethanol blends are not shipped via pipeline but rather blended at the terminal. This is the primary reason that gasoline ethanol blends are not considered fungible products.

16.3 Fuel Additives

There has been some limited use of additives to address undesirable ethanol properties and/or enhance its marketability. Thus far, additive use has been limited primarily to detergents and corrosion inhibitors. Industry efforts to identify additives to favorably alter water solubility and blending vapor pressure have thus far not been successful.

Primary areas of past and current activity are as follows:

16.3.1. Detergents

In the mid 1980s detergents were added to ethanol at the request of the auto manufacturers. Treat rates were set at a level high enough to treat the entire gallon of gasoline to which the ethanol was added. These detergent additive formulations were primarily to address an epidemic of fuel injector fouling that was occurring at the time. Later, major petroleum manufacturers began to request detergent free ethanol, preferring to treat the entire gallon of blended fuel with their own additive packages. These additives were primarily polyether amines which would address not only port fuel injector deposits but also intake valve and combustion chamber deposits.

The 1990 Clean Air Act Amendments required that, beginning in 1995 all gasoline, including ethanol blends, contain detergents that keep carburetors, fuel injectors, and intake valves clean. These

regulations include specific compliance procedures as well as guidelines for certifying the effectiveness of fuel/additive combinations. As a result, the fuel refiner or blender now handles the detergent/deposit control additive process.

16.3.2. Corrosion Inhibitors

Ethanol can contain low levels of acidic compounds. In addition, gasoline ethanol blends can have higher moisture content than hydrocarbon fuels. Consequently responsible ethanol producers have routinely added corrosion inhibitors to provide an added level of protection.

Recently ASTM added a pHe specification to ASTM D 4806 to limit the corrosion properties of ethanol that might contain low levels of more powerful acidic compounds. Some corrosion inhibitor packages can also be used to make modest adjustments in pHe levels.

16.3.3. Water Solubility

Relatively small amounts of water are capable of “phase separating” ethanol from the gasoline to which it is blended. An additive that would inhibit phase separation would be extremely advantageous. If such an additive were developed, it is possible that gasoline ethanol blends could be shipped more easily in the pipeline system. To date, no one has identified any type of additive to address this area.

16.3.4. Vapor Pressure

When combined with gasoline, ethanol forms a non-ideal mixture, meaning that the properties and behavior of the mixture differ significantly from what would be predicted from simple calculations based on the properties of each fuel components proportion in the blend.

Ethanol forms an azeotrope with pentanes and hexanes in the gasoline. It is this azeotrope that increases the vapor pressure of the blend, lowers the T₅₀ point, and the TV/L20. In other words all volatility related parameters of the fuel are increased (more volatile). This has always been a drawback of ethanol blends especially in recent years where low vapor pressure gasolines are necessary to comply with environmental programs.

Various companies have explored the possibility of using additives to control the vapor pressure increase with no success.

Any currently known approach to vapor pressure control of gasoline ethanol blends incorporates blend components or cosolvents, not additives.

Additives are typically added in small quantities (e.g. ppm range) and do not add volume to the fuel. Cosolvents and blend components, on the other hand, are usually added in volumes near equal to those of the ethanol content of the fuel.

Examples of blend components would be using a low vapor pressure raffinate or naphtha to lower the octane and vapor pressure of the base fuel to accommodate ethanol's addition. Examples of cosolvents would include heavier alcohols (e.g. isobutyl, isopropyl) or ethers (e.g. MTBE, TAME)

Hydrocarbon blend components are usually directed to other uses. Heavier alcohols generally add significant expense and are in short supply. Ethers, though a good option from a blend standpoint, are under close scrutiny due to water contamination concerns.

It is also worth noting that with a cosolvent approach, it would essentially be necessary to better than double the current market just to maintain existing ethanol volume. This is because the oxygen content of the fuel is restricted to 2.7 wt% O₂ when oxygenates are mixed and the fact that the cosolvent comprises half of the alcohol portion of the blend.

To date no one has shown scientific documentation of a credible and affordable solution to the vapor pressure increase problem.

Section 16: Technical Information on Ethanol

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Section 17.0

GLOSSARY

17.0 GLOSSARY

In the course of preparing this report, a number of acronyms and common industry terms have been used. For the convenience of the reader some of the more commonly used terms are listed here along with a brief description when deemed necessary.

Acronyms

AKI:	(Anti Knock Index) The average of the research and motor octanes of a gasoline, i.e. (R+M)/2. The AKI is the octane number posted on the retail gasoline dispenser.
API:	(American Petroleum Institute) The major national trade association for the petroleum industry representing companies with interests in exploration, production, transportation, refining, and marketing petroleum products.
bd:	(Barrels per day)
CAFE:	(Corporate Average Fuel Economy) The average fuel economy of an auto manufacturer's vehicles sold in the U.S. for compliance with federal fuel economy standards.
CARBOB:	(California Reformulated Blendstock for Oxygenate Blending). A base fuel made such that when the designated oxygenate is added in the specified volume it will meet the requirements of California's reformulated gasoline program.
CBG:	(Cleaner Burning Gasoline) The term California has chosen to identify their reformulated gasoline.
CO:	Carbon Monoxide.
DOE:	(U.S. Department of Energy)
E-10:	Commonly used term to describe gasoline containing 10 v% ethanol.
E-5.7:	Commonly used term to describe gasoline containing 5.7 v% ethanol.
E-7.7:	Commonly used term to describe gasoline containing 7.7 v% ethanol.
E-85:	Commonly used term to describe ethanol gasoline blends containing 75 v%-85 v% denatured ethanol. This fuel is used in vehicles specifically designed to allow the use of such fuels.
EPACT:	(1992 Energy Policy Act)
ETBE:	(Ethyl tertiary butyl ether)

FBO:	(Fixed Base Operation) The airport based fueling and servicing facilities for aircraft.
FFV:	(Flexible Fueled Vehicle) A vehicle designed to operate on either of two fuels. In this report, a vehicle that can operate on fuel blends of up to 85 v% denatured ethanol, 100 % gasoline, or any combination of the two.
HC:	(hydrocarbon)
LEV:	(Low Emissions Vehicle)
MTBE:	(Methyl tertiary butyl ether)
MSDS:	(Materials Safety Data Sheet)
NAAQS:	(National Ambient Air Quality Standard)
NO _x :	(Oxides of Nitrogen)
OFD:	(Office of Fuels Development)
OPA:	(1990 Oil Pollution Act)
OPIS:	(Oil Price Information Service) An independent service that tracks petroleum product prices and is used by some to establish key points for pricing formulas.
ORNL:	(Oak Ridge National Laboratory)
PADD:	(Petroleum Administration for Defense Districts) Originally established for national defense purposes breaking the nation into 5 geographic areas designated PADD 1 through 5. These geographically divided areas are also routinely used for the purpose of study and analysis of the industry.
ppm:	(Parts per million)
ppb:	(Parts per billion)
psi:	(Pounds per square inch)
RBOB:	(Reformulated Blendstock for Oxygenate Blending) A base gasoline designed to meet all requirements of the federal reformulated gasoline program when the designated oxygenate is added at specified levels.
RFG:	(Reformulated gasoline)

RVP:	(Reid vapor pressure) One early test method of measuring the vapor pressure of gasoline. The Reid test method is seldom used now but due to its frequent use in earlier years many in the industry still refer to a fuels vapor pressure as RVP.
SIP:	(State Implementation Plan)
SPP:	(Spill Prevention Plan)
TBA:	(Tertiary Butyl Alcohol) Also sometimes called GTBA-gasoline grade tertiary butyl alcohol.
TLEV:	Transitional Low Emissions Vehicle
T V/L20:	Temperature for a vapor to liquid ratio of 20 as determined by ASTM D 2533 or ASTM D 5188 A measure of a fuel's front end volatility. Also used to assign vapor lock protection classes for gasoline in ASTM specifications.
ULEV:	Ultra Low Emissions Vehicle
VOC:	(Volatile Organic Compounds)
VP:	(Vapor Pressure) A measure of a fuels volatility typically taken at 100 degrees by specified ASTM test methods. Fuels with higher VP vaporize more readily and therefore contribute more to evaporative emissions inventory. Lower VP fuels vaporize less readily. The VP of gasoline is adjusted seasonally to provide good vehicle operation as well as to control evaporative emissions in the summer months.
ZEV:	Zero Emissions Vehicle
µg/L:	(Micrograms per liter)

Commonly Used Industry Terms/Abbreviations

Alkylate:	Produced in refineries by a process called alkylation. Created by a reaction of propylene or butylene with iso-butane to form an iso-paraffin. The characteristics of alkylates include low vapor pressure and reasonably high octane making it a desirable component for reformulated gasoline.
Av-gas:	(Aviation Gasoline) For use in piston engine aircraft.
Common carrier:	An independent party delivering products for another party, examples include trucking companies who haul gasoline for second parties, and pipelines who deliver products for others. Common carriers do not own the product they are hauling or shipping.

Crack spread:	Gross refinery margin, the difference between the revenues from all refinery products sold and the net cost of the crude oil and feedstocks. Does not include capital costs or operational costs such as labor, maintenance, etc.
Exchange agreement:	A procedure used between two or more oil companies to minimize transportation costs and service areas where companies may not have equity operations. As an example, refiner A gives refiner B product in one geographical area and refiner B returns a like amount of product to refiner A in a different geographic location.
Exchange differential:	A charge to balance differences that occur from product exchanges. Differentials may be required because of differences in product value in geographic areas, different quality products such as exchanging midgrade for premium and product imbalance that results from companies not lifting identical volumes of product.
High emitters:	Vehicles that exceed their emissions standards by high amounts due to improper state of tune or failed pollution control equipment.
Light ends:	Typically used in the refining industry to refer to butanes but technically includes any products lighter than butane as well (e.g. butylene, propylene).
Light products:	Industry term typically used to refer to refined fuels, i.e. gasoline and distillates.
Nameplate capacity:	The design capacity of a plant.
On Spec/off-spec:	Industry lingo for product meeting designated specifications- “on spec” or failing to do so- “off spec”.
Phase separation:	When gasoline ethanol blends encounter too much moisture (greater than 0.45 v% at 60.F) the water and alcohol will drop to the bottom of the blend, referred to as phase separation.
Pigs:	Devices inserted into a petroleum products pipeline to clean the system. Includes Scraper Pigs designed for cleaning and Cup Pigs designed to push sludge and water from the system.
Pipeline interface:	The point in pipeline shipments where two products of different specifications meet. The materials at the interface may mingle resulting in a small amount of product that does not closely resemble the characteristics of either product. Pipeline operators sequence product in a manner to minimize any interface material that would be required to be downgraded or disposed of.
Redistribution terminal:	A terminal which serves as a facility to receive product for redistribution to other terminals.

Stream days:	The number of days a refinery is typically operated to achieve its annual volume. This is less than calendar days due to maintenance turn arounds (e.g. replacing catalysts, cleaning & servicing process units). An operating year is typically based on 330 stream days.
Sub-octane:	Industry term used for sub octane gasoline, a fuel designed for ethanol addition at the terminal. Usually 84 or 84.5 octane (R+M)/2.
Tight lined:	Term indicating a non-fungible product is to be shipped through the pipeline system without commingling with other products (e.g. bypassing breakout tanks or commingled storage).
Water bottoms:	Water that exists in the bottom of a petroleum products storage tank.
Wet Mill:	A wet mill ethanol plant steeps (soaks in warm water) the corn. This enables separation of the germ, oil, starch, etc. Wet mill ethanol plants produce not only ethanol from the starch but also protein feed, gluten meal, CO ₂ , and corn oil. Most wet mills can also direct a portion of their grind to production of high fructose corn syrup (HFCS) when demand and economics dictate. Dry mills, on the other hand, grind the corn kernel and ferment it. Resulting products in a dry mill are ethanol, distillers grains, and CO ₂ . Wet mills require more initial capital investment but have lower ethanol production costs.