FUEL ETHANOL

Industry Guidelines
Specifications, and Procedures

NOTICE: This RFA document is currently under review by the Technical Committee with an updated version expected in late 2002.

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Introduction

The Renewable Fuels Association (RFA) is the Washington D.C. based trade association for the U.S. fuel ethanol industry. Membership is comprised of numerous ethanol producers, both large and small, as well as suppliers to the industry and other interested parties. Founded in 1981, the RFA's primary objective is to promote public policy initiatives that increase the market for fuel grade ethanol produced from a variety of feedstocks including grains, agricultural wastes, and various biomass feedstock sources.

As the ethanol industry has grown, so has the Renewable Fuels Association's areas of responsibility to its membership. Today the RFA not only focuses on legislative/regulatory and public policy type issues but also maintains several committees and task groups to address industry needs. These committees include a technical committee to address various technical issues and assist with technical industry publications (such as this one), a marketing committee to identify, assess, and pursue opportunities for market growth, and a membership committee. In addition there is a fuel cell task force working to pursue opportunities to use ethanol in fuel cell applications. These committees and task forces are comprised of representatives of our member companies, staff, and when necessary technical consultants and other interested stakeholders.

The RFA promotes the use of fuel grade ethanol in all its various applications. This includes not only E-10 (90% gasoline/10% ethanol), reformulated gasoline (RFG), and oxygenated fuels but developing markets such as E-85 (15% gasoline/85% ethanol). The RFA is also working on various developing applications such as fuel cell applications and E diesel, a cleaner burning diesel fuel containing up to 15% ethanol.

This document focuses primarily on fuel grade ethanol and its traditional application as a fuel component and is a compilation of the key technical aspects of fuel grade ethanol use based on the collective experience and expertise of our member companies. The purpose of this document is to serve as a condensed technical reference for ethanol producers, ethanol blenders, and other interested parties who need such information.

A great deal of the information in this document has been condensed from our more comprehensive program guide "Gasoline Ethanol Blends-Program Operations Guide" RFA Recommended Practice #930601 which is also available from the RFA or its member companies.

If you have any questions about the contents of this document, feel free to contact us. Our contact information is as follows:

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Gasoline Ethanol Blends

Whether ethanol is used in oxygenated fuels, reformulated gasoline, or conventional gasoline, there are certain technical parameters and issues that must be considered. Those items are covered in the following pages. Ethanol has been added to gasoline since the late 1970s. Since that time U.S. fuel grade ethanol production capacity has grown to over 2.0 billion gallons per year. Until the late 1980s ethanol's primary role in the fuels market was that of an octane enhancer and it was viewed as an environmentally sound alternative to the use of lead in gasoline. With its 112.5 blending octane value (R+M)/2, ethanol continues to be one of the most economic octane enhancers available to the refiner or fuel blender.

In the late 1980s some states began to use ethanol and other oxygenates in mandatory oxygenated fuel programs to reduce automobile tailpipe emissions of carbon monoxide (CO). Fuel oxygenates, such as ethanol, add chemical oxygen to the fuel which promotes more complete combustion thereby lowering CO emissions. Hydrocarbon (HC) exhaust emissions are also often reduced but to a lessor degree.

The success of these early oxygenated fuel programs led to a similar national program in the 1990 Clean Air Act Amendments. These amendments required that, beginning in November 1992, all CO non-attainment areas implement mandatory oxygenated fuel programs during certain winter months. These areas must sell only oxygenated gasoline containing an average of 2.7 weight percent oxygen during the applicable control period. Today about 18 areas of the country still require winter time oxygenated fuel programs, affecting a large portion of all gasoline sold during the winter months (i.e. November-February)

Ethanol is widely used to comply with oxygenated fuel requirements. Because of its higher oxygen content, compliance can be achieved with less volume addition than with other oxygenates. A blend of approximately 7.7 volume percent ethanol will achieve compliance with the 2.7 weight percent oxygen requirement. However ethanol is more frequently blended at the 10 volume percent level to take maximum advantage of available tax credits. At the 10 volume percent level ethanol would add approximately 3.5 weight percent oxygen to the blend, the highest level allowed under EPA regulations. Because of its higher oxygen content, ethanol competes quite favorably with other fuel oxygenates for use in oxygenated fuel programs.

The 1990 Clean Air Act Amendments also required that certain ozone non-attainment areas sell Reformulated Gasoline (RFG) beginning January 1, 1995. Other ozone non-attainment areas were allowed to "opt-in" to this program by request of the applicable state's governor. Areas of several states did "opt-in" to this program. It is currently estimated that reformulated gasoline comprises 32% of all gasoline sold.

There were two phases to the RFG program, Phase I which applied in years 1995-1999 required a 15% reduction in both volatile organic compounds (VOCs) and toxic emissions (benzene, 1,3 butadiene, formaldehyde, acetaldehyde, and polycyclic organic matter), with no net increase in emissions of oxides of nitrogen (NO_x). Phase II of the RFG program began in calendar year 2000 and required a 25% reduction in VOCs, 20% reduction in toxics, and a 5.5% reduction in NO_X (compared to the 1990 baseline). As with the last two years of Phase I, compliance with Phase II of the program is determined through the use of the "Complex Model". This model, developed by EPA, is a set of mathematical equations that predict the change in emissions levels that occur from various alterations to gasoline. Phase II RFG is still required to contain a minimum of 2.0 weight percent oxygen (on average) and benzene is limited to 1.0 weight percent maximum (on average).

Ethanol can also be used to meet the oxygen requirement for reformulated gasoline and has been widely used in some RFG areas. To meet the 2.0 weight percent oxygen requirement would require approximately 5.7 volume percent ethanol.

Specifications - Fuel Ethanol

Regardless of the blend level, the quality of the ethanol added to gasoline is important. The industry standard for ethanol is **ASTM D 4806 Standard Specification for Denatured Fuel Ethanol for Blending with Gasoline for Use as Automotive Spark Ignition Engine Fuel.**

The primary quality specifications contained in ASTM D 4806 are as follows:

ASTM D 4806

Property	Specification		ASTM Test Method
• Ethanol volume %, min	92.1		D 5501
• Methanol, volume %. max	0.5		
• Solvent-washed gum, mg/100 ml max	5.0		D 381
• Water content, volume %, max	1.0		E 203
• Denaturant content, volume %, min	1.96		
volume %, max	4.76		
• Inorganic Chloride content, mass ppm (mg/L) max	40	(32)	D 512
• Copper content, mg/kg, max	0.1		D1688
• Acidity (as acetic acid CH_3COOH), mass percent (mg/L), max	0.007	(56)	D1613
• pHe	6.5-9.0		D 6423
• Appearance - visibly free of suspended or precipitated contaminants (clear & bright)			

For a more detailed discussion of the importance of these properties, refer to a copy of the specification. Copies of ASTM D 4806 and other ASTM specifications and standards may be obtained from:

ASTM
100 Bar Harbor Drive
W. Conshohocken, PA 19428-2959
Publication orders • phone (610) 832-9585 • fax (610) 832-9555

The Renewable Fuels Association recommends that all of its member companies adhere to ASTM specifications and guidelines. In addition the RFA recommends that all its member companies adhere to the additional standards cited below:

Corrosion Inhibitors: The RFA recommends that its member companies add corrosion inhibitors to all their fuel grade ethanol at a treat rate sufficient to provide corrosion protection comparable to that of other available motor fuels.

Corrosion Inhibitors Recommended for Fuel Grade Ethanol

Additive	Treat Rate *PTBE-pounds per thousand barrels of ethanol*
Octel DCI-11	20 PTBE
Petrolite Tolad 3222	20 PTBE
Petrolite Tolad 3224	13 PTBE
Nalco 5403	30 PTBE
ENDCOR FE-9730(1)	20 PTBE
MidContinental MCC5011E	20 PTBE
MidContinental MCC5011EW	27 PTBE

(1) formerly Betz ® ACN 13

Corrosion inhibitors that have been shown to be effective for ethanol and gasoline/ethanol blends include those listed in the table at left:

These recommended levels were established for a limited number of gasoline ethanol blends and may not be representative of gasoline ethanol blends in all market areas. The RFA recommends that appropriate tests be performed to confirm the effectiveness of selected additives based on gasoline ethanol blends representative of each producer's market area. The RFA Technical Committee reviews additive data only for its effectiveness. Producers/blenders will find it necessary to calculate costs based on additive cost and recommended treat rate. The RFA does not endorse any additive or recommend one over another. Other corrosion protection additives of comparable performance are also acceptable for use. The criteria used for inclusion of the additives in the table is to add ethanol to an E rated gasoline (NACE Standard Test Method TM-01-72). The additive must then raise the NACE rating of the blend to B+ or better for the recommended additive treat rate.

NOTE: Some additives listed may also assist in altering pHe levels. Check with additive manufacturer for details.

Sulfur Content: Refiners are currently faced with the need to reduce the sulfur content of their gasoline to comply with federal and state regulations. California has approved sulfur limits and other specifications for denatured fuel ethanol that is blended into California Phase 3 RFG also referred to as California Reformulated Blendstock for Oxygenate Blending (CARBOB). The California denatured fuel ethanol standards specify that denatured fuel ethanol may not exceed a sulfur concentration of 10 parts per million (ppm). The California Air Resource Board (CARB) phase 3 RFG amendments including the specifications for denatured fuel ethanol will become effective on December 31, 2003.

The Federal Tier 2 sulfur regulations will become effective on January 1, 2004. These regulations require all gasoline and ethanol blended into gasoline be less than 30 ppm sulfur average. Although these regulations take effect at future dates, refiners can accumulate credits for reducing gasoline sulfur content early. In addition, some refiners have focused on sulfur reduction to achieve reductions for the Phase II RFG requirements.

It is important that ethanol producers recognize that sulfur reductions present a significant challenge to refiners. A sulfur limit is listed in the appendix to ASTM D 4806 Standard Specification for Denatured Fuel Ethanol for Blending with Gasoline for Use as Automotive Spark Ignition Engine Fuel prior to the effective dates of the respective regulations. The RFA supports such efforts provided they represent realistic and attainable levels and that they include adoption of test methods with acceptable repeatability and reproducibility. NOTE: On July 23, 2002, the RFA Board of Directors adopted a recommended sulfur specification of 10 ppm maximum for ethanol and encourages all RFA member companies to adhere to this recommendation.

The RFA recommends that the sulfur content of the denatured fuel ethanol supplied by its member companies not exceed 10 ppm as determined by ASTM Test Method D 5453. This ASTM standard has been certified as the sulfur method for denatured fuel ethanol in California.

As a result of the above recommendations, ethanol producers should review the specifications of their denaturants to assure they do not contribute to sulfur levels above the recommended limit.

Comparison of Typical Properties of Common Oxygenates

Property	*Denatured Ethanol*	*MTBE*	*ETBE*	*TAME*
Oxygen wt. %	33.0	18.15	15.06	15.06
Blending Octane (R+M)/2	112.5	111.0	111.0	105.5
Blending Research Octane	129.0	119.0	119.0	112.0
Blending Motor Octane	96.0	103.0	103.0	99.0
Blending Vapor Pressure, psi	18.0	8.0	4.0	2.5
Energy Content btu/gal	76.1M	93.5M	96.9M	100.6M
Boiling Point ˚F	152-174	131	161	187
Density (lb./gal @ 60˚F)	6.58	6.19	6.20	6.41
Legal Maximum vol % for gasoline blending	10.0%	15.0%	17.2%	17.2%

Note that property values may vary slightly depending on the composition and density of the base gasoline to which ethanol is added.

Specifications - Gasoline Ethanol Blends

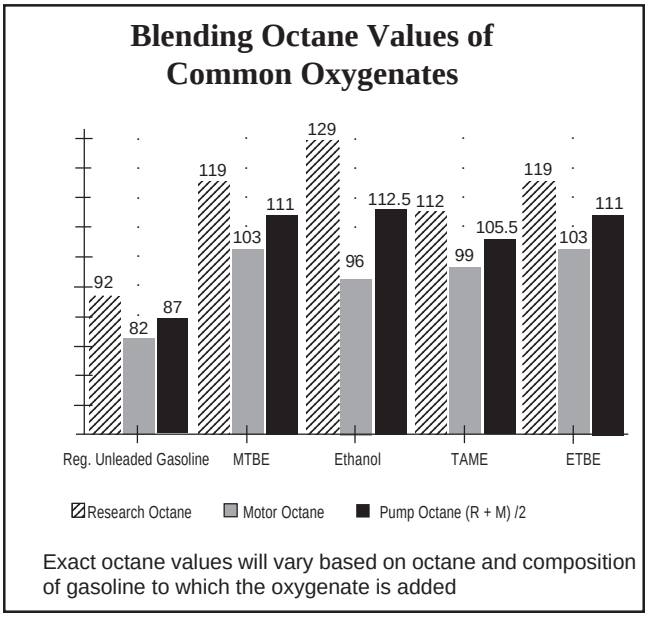
Ethanol will affect a number of properties of the gasoline to which it is added. These properties include octane, oxygen content, volatility, and water solubility.

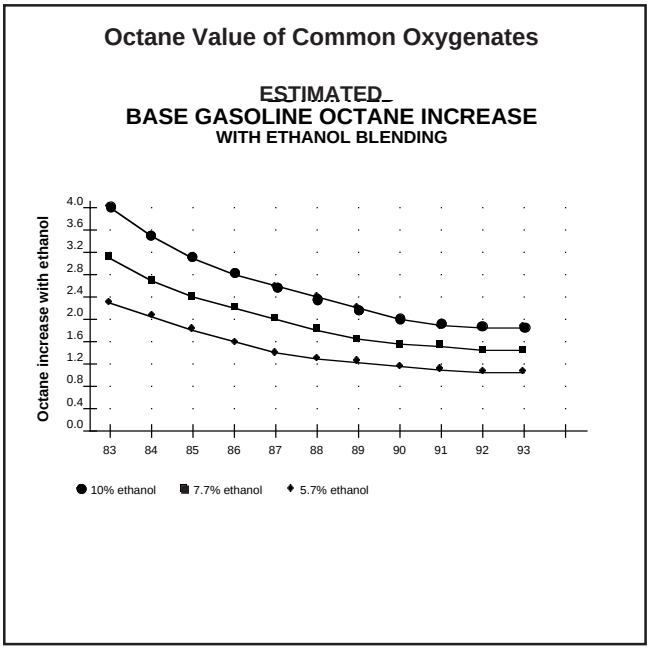
Gasoline and gasoline/ethanol blends are subject to a variety of federal and state laws and regulations. These include FTC octane posting requirements and EPA Phase II volatility regulations. In carbon monoxide non-attainment areas, these fuels are subject to minimum and/or average oxygen content requirements. Gasolines sold in certain ozone non-attainment areas are required to be reformulated, including among other things an average oxygen content of 2 wt. % and stricter controls on VOC, NOx, and toxic emissions.

In addition to the above regulations, some states place certain requirements on fuels including such items as restrictions on Reid Vapor Pressure, Distillation Characteristics, and in some cases a minimum octane requirement for fuels that are designated as Super or Premium grades. Many states also require that marketers register each grade marketed with the appropriate state agency.

It should also be noted that the State of California, through its Air Resources Board (CARB), has several fuel restrictions that are different, and often more stringent, than federal requirements.

Finally, most refiners and marketers require that, at a minimum, their fuels meet some or all of the parameters set forth in ASTM D 4814 "Standard Specification for Automotive Spark-Ignition Engine Fuel". Some refiners have standards that exceed those required by the ASTM specifications.





It would be impossible to try and include all of the state and federal requirements in a brief document such as this. Moreover, many of these laws can change in a short time frame. Those involved in gasoline/ethanol blend programs should check the most recent version of applicable laws and regulations to ensure that they are in compliance.

The purpose of the ASTM specification is to provide parameters so that gasoline and gasoline oxygenate blends will perform satisfactorily in as wide a range of consumer vehicles as possible.

It should be noted that ASTM standards and specifications are voluntary compliance standards. However some states have adopted all, or a portion of, ASTM D 4814 into law making adherence mandatory in those states.

Whether mandatory or voluntary the Renewable Fuels Association believes adherence to the guidelines contained in ASTM D 4814 are important in ensuring the delivery of a high quality spark ignition engine fuel.

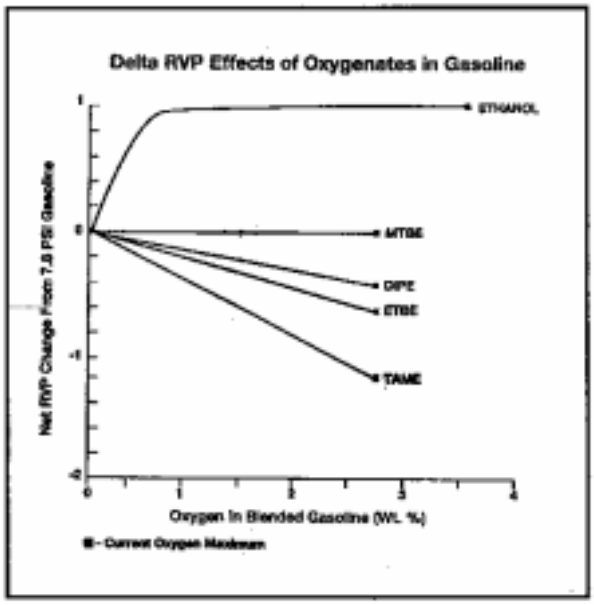
An overview of the primary fuel quality parameters is as follows:

Octane: Until recently, ethanol was almost always added to gasoline at the 10 volume percent level. However in the past few years environmentally driven fuel specifications and changes in motor fuel excise tax laws have encouraged ethanol blending at lower levels of 5.7 v% and 7.7 v%.

At the 10v% level ethanol will increase octane levels by approximately 2.0 to 3.0 octane numbers (R+M)/2. At the 7.7v% level the octane increase typically ranges from 1.5 to 2.5 octane numbers. At the 5.7v% level, the increase is typically 1.0 to 1.5 octane numbers. The aforementioned increases are provided as general guidelines. The actual octane increase will vary depending on the octane and, to a lesser degree, the composition of the base fuel. Research Octane Number is increased to a greater degree than Motor Octane Number.

Fuel Volatility: The addition of ethanol to gasoline will generally increase the volatility of the base fuel to which it is added. It will increase the vapor pressure and decrease the 50% distillation point (T_{50}). Because of its effect on T_{50}. it may also effect the Driveability Index (DI) and the Vapor Lock Protection Class as measured by Temperature for Vapor Liquid Ratio of 20 (TV/L20) as discussed on pages 9 and 10.

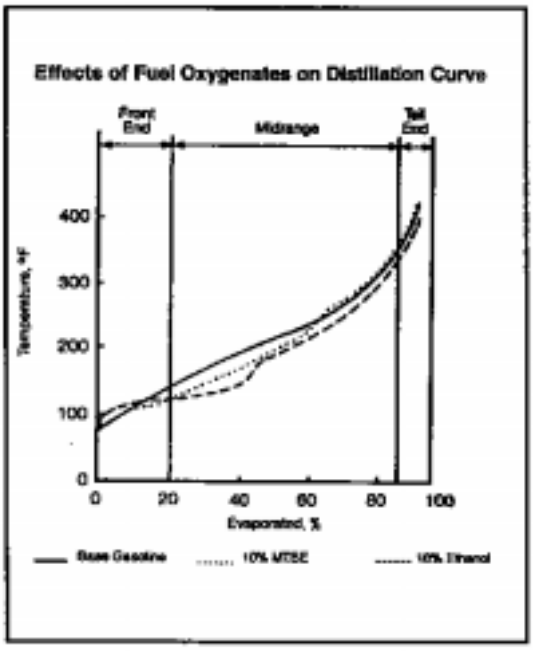
Vapor Pressure: ASTM D 4814 specifies a vapor pressure by state (or in some cases, portions of a state) for each month of the year. During the regulatory control period of June 1st to September 15th (at retail), the EPA's Phase II volatility restrictions apply. These restrictions require that fuels sold during the control period have a vapor pressure not greater than 9.0 psi or 7.8 psi depending upon the area. During this control period gasoline/ethanol blends containing 9-10v% ethanol are allowed to be up to 1.0 psi higher in vapor pressure. Exclusive of this control period, there are currently no federal restrictions on the vapor pressure of gasoline/ethanol blends except for reformulated gasoline. Reformulated gasoline containing ethanol must meet the applicable RFG requirements for the RFG program.



During the portion of the year when no federal volatility restrictions apply to gasoline, it is still recommended that the vapor pressure increase for gasoline/ethanol blends be no more than 1.0 psi higher than the all-hydrocarbon base fuel. Unless other more volatile blending components are being used the addition of ethanol should not create a vapor pressure increase above 1.0 psi and in fact the increase is often below 1.0 psi.

The vapor pressure of a fuel is a measure of its "front end" volatility. Fuels with excessively high vapor pressures may contribute to hot driveability/hot restart problems such as vapor lock. Fuels of too low a volatility may contribute to poor cold starts (long cranking time) and poor warm up performance.

Distillation Properties: ASTM D 4814 also provides guidance on distillation characteristics. Table 1 of 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. This 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.



Most states which require that hydrocarbon gasoline meet the ASTM T_{50} specification require only that the base fuel in a gasoline-ethanol blend meet the standard. However a few states do require that gasoline-ethanol blends meet the T_{50} specification.

Studies have shown that later model fuel injected cars are less sensitive to gasolines with T_{50}s as low as 150˚F. Some older vehicles may be more sensitive to low T_{50} gasolines although this would apply predominantly in warm weather. The lower T_{50} standard of 150˚F allowed by ASTM applies only to cold weather volatility classes of gasoline. While you

may not be, in every case, required by law to adhere to the aforementioned guidelines for T_{50} it should be noted that there is insufficient data to demonstrate satisfactory hot driveability/hot restart performance at T_{50} levels below those specified by ASTM D 4814.

Driveability Index: ASTM D 4814 also includes specifications for a Driveability Index (DI). The DI is based on the relationship between fuel distillation temperatures and vehicle cold start and warm up driveability performance. The DI is indicated by the following formula:

$$\mathbf{DI = 1.5\ T_{10} + 3.0\ T_{50} + 1.0\ T_{90}}$$

DI = driveability index
T10 = distillation temperature at 10% evaporated
T50 = distillation temperature at 50% evaporated
T90 = distillation temperature at 90% evaporated

The DI is specified as a maximum for each volatility class ranging from 1250 for volatility class AA and A down to 1200 for volatility class E. These numbers are based on the Fahrenheit Scale. Generally speaking, DIs above those specified tend to be more prone to contribute to poor cold start and/or poor warm up performance, especially in sensitive vehicles.

Vapor Lock Protection Class: The ASTM D 4814 Standard also specifies "Vapor Lock Protection Class Requirements" in Table 3 of the standard specification. The six vapor lock protection classes are based on the Vapor/Liquid Ratio (V/L) of the fuel.

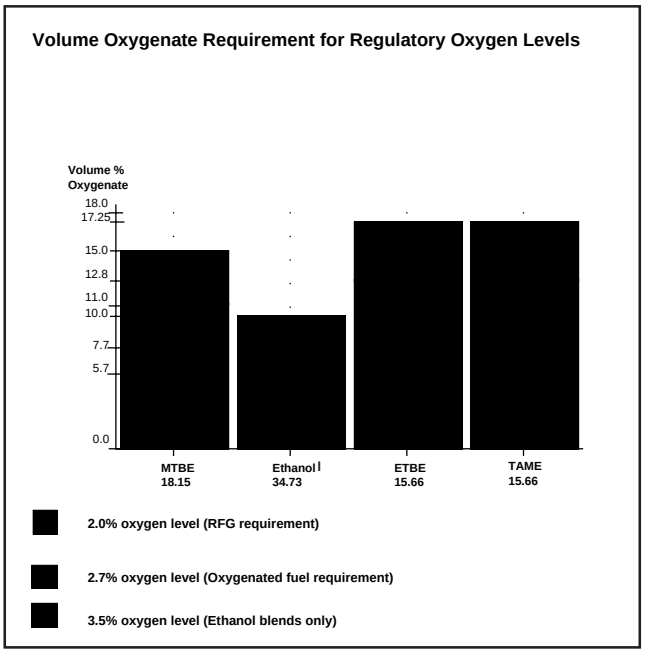
ASTM defines that the "Vapor-liquid ratio is the ratio of the volume of vapor formed at atmospheric pressure to the volume of fuel tested in Test Method D 2533." The tendency of a fuel to cause vapor lock, as evidenced by loss of power during full throttle acceleration, is indicated by the gasoline temperature at a V/L of approximately 20 (TV/L20). Therefore, some refiners and petroleum companies also utilize a specification for Vapor-Liquid Ratio. More volatile fuels require lower temperatures to achieve specified ratios. More detailed information on V/L is contained in ASTM D 4814. Currently there is some debate about the accuracy of TV/L20 in predicting hot driveability problems. Ongoing tests are being conducted to determine the accuracy of TV/L20 in predicting hot driveability problems in modern vehicles.

Oxygen Content: In addition to its use as an octane enhancer, ethanol is often used to comply with minimum and/or average oxygen content requirements. These oxygen requirements are applicable in CO non-attainment areas (oxyfuel programs) and certain ozone non-attainment areas (reformulated gasoline programs) as defined in the 1990 Clean Air Act Amendments and subsequent EPA rulemakings and guidance documents.

Until the early 1990s, ethanol was usually blended into gasoline at a concentration of 10v% of the final blend. With the advent of oxygenated fuel and reformulated gasoline (RFG) programs, some companies blend at lower levels to achieve targeted oxygen levels. Denatured ethanol contains approximately 33.0 wt% oxygen. Due to differences in gasoline density compared to ethanol density, the most popular blend ratios yield the following approximate oxygen contents

Volume % Denatured Ethanol in Fuel	Oxygen Content
10.0% by volume	3.5% by weight
7.7 % by volume	2.7% by weight
5.7% by volume	2.0% by weight

The final oxygen content of a gasoline/ethanol blend is affected by the purity of the ethanol, its denaturant level and moisture content, as well as the specific gravity of the gasoline to which it is being added. The EPA has issued guidance documents on compliance with oxygenated fuel and reformulated gasoline programs. Because of the above mentioned variables you should refer to the latest applicable EPA guidance documents if you are utilizing ethanol (or any oxygenate) to comply with the oxygen standards of a mandatory oxygenated fuels or reformulated gasoline program.

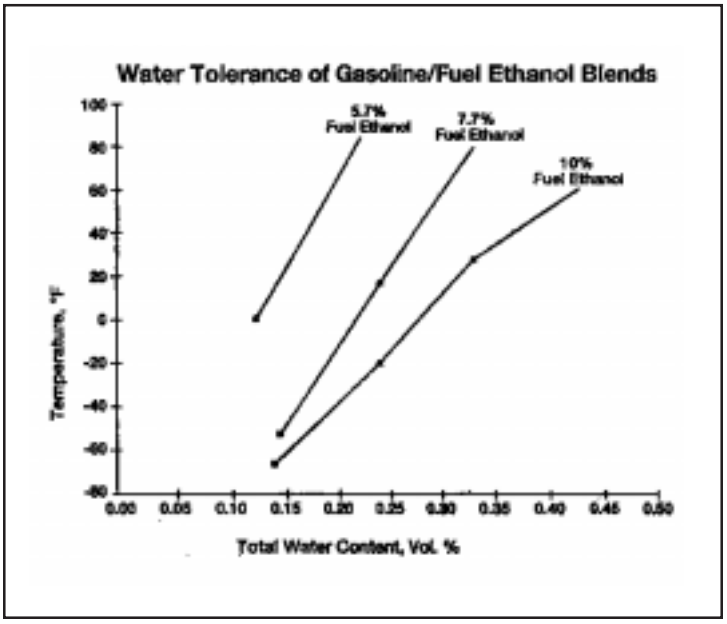


It should also be noted that when blending gasoline/ethanol blends under the "gasohol waiver" that an oxygenate free base gasoline must be used. EPA has, however, ruled that gasolines containing up to 2 v% MTBE, due to inadvertent commingling or contamination, may be used as the base fuel for gasoline/ethanol blends containing up to 10% ethanol.

NOTE: Some states such as California may have oxygen standards, specific to their state, which deviate from the Clean Air Act Amendments and EPA guidelines.

Water Tolerance: Ethanol has an affinity for water. For instance, it is not necessary to add any gas line antifreeze to a gasoline/ethanol blend since the ethanol will absorb trace amounts of water and pull it through the fuel system. Likewise, trace amounts of water in underground storage tanks are eliminated via the same mechanism.

However, ethanol's affinity for water also necessitates that steps be taken to eliminate excessive moisture from the fuel storage and delivery system. If a gasoline/ethanol blend encounters excessive moisture contamination, the water can pull the ethanol out of the blend resulting in tank bottoms comprised of water, ethanol, and some hydrocarbon content. The amount of water tolerated by a gasoline/ethanol blend is dependent upon the product temperature. The lower the temperature, the lower the water tolerance. For instance, at 60˚F, a 10% ethanol blend will tolerate approximately 0.5% water. However at 10˚F that tolerance is reduced to approximately 0.3%.



Gasoline Additives: Gasoline ethanol blends, like other gasolines are subject to EPA's gasoline detergency requirements. The RFA recommends that gasoline ethanol blends contain the appropriate detergent/ deposit control additive at levels to provide detergency performance comparable to other gasolines. In the past, the RFA Technical Committee routinely reviewed available additives to determine their effectiveness and provided recommendations. Today, the EPA regulations require that the additives must be registered with EPA and documentation of their effectiveness must be available for EPA review. Because of this, the RFA no longer makes recommendations on such additives. The blender should however be sure he/she is utilizing a properly registered detergent/deposit control additive and is in compliance with EPA regulations.

The RFA recommends that it's ethanol producing member companies treat their ethanol with a corrosion inhibitor to ensure that any final blend is properly treated for corrosion protection. You should check with your ethanol supplier if you have any questions regarding the type or level of corrosion inhibitor they use.

Additives other than the above should not normally be necessary.

Conversion Procedures - Retail Units

As mentioned, ethanol is infinitely soluble in water and the sensitivity of gasoline/ethanol blends to water requires certain precautionary steps to prevent phase separation. These steps include drying out wholesale storage tanks and proper preparation of retail storage tanks and dispensers. In addition, transport drivers should exercise proper precautions when making deliveries,.

The Renewable Fuels Association and its member companies offer a detailed guide on all aspects of properly implementing and maintaining a gasoline/ethanol blend program. The guide, RFA Recommended Practice #930601, is entitled "Gasoline Ethanol Blends-Program Operations Guide". While the guide provides more expanded guidance, we have excerpted the check lists that conclude each chapter for Retail Unit procedures, Terminal Operations, and Transportation Issues and included them on the following pages.

Gasoline Ethanol Blend Program
Station/Store Operator Checklist

Investigatory/Preparatory

- ❒ 1. Verify tank material compatibility. Also submersible pumps.
- ❒ 2. Investigate tank water problems and correct. Review history of water problems and initiate any necessary corrective action.
- ❒ 3. Tight seals on fill caps and proper water run off from man hole covers.
- ❒ 4. Remove water bottoms (if present). Check for tilted tanks.
- ❒ 5. Clean tank bottom, if necessary.

Conversion Plan

(before first delivery)

- ❒ 1. Equip pump or dispenser with 10 micron filter. (or "water slug" filter)
  (Remember - SAFETY FIRST - SHUT OFF BREAKER)
- ❒ 2. Recheck for water bottoms and remove any present.
- ❒ 3. Issue alcohol compatible paste. Discard any old incompatible pastes.
- ❒ 4. Procure proper pump labels.
- ❒ 5. Confirm any applicable accounting procedures.

First Delivery

- ❒ 1. Check for water. Water bottoms must be removed before first delivery of ethanol blends..
- ❒ 2. Follow normal delivery procedures and ensure that accurate tank gauge and dispenser readings are taken.
- ❒ 3. Verify (with transport driver) correct compartment for correct tank.
- ❒ 4. Pumps should be shut down during initial delivery. (check company policy)
- ❒ 5. Purge lines from tanks to dispensers. (check company policy)
- ❒ 6. Install required decals and if necessary change octane decals.
- ❒ 7. Fill tanks to at least 80% of capacity. Keep as full as possible for 7 to 10 days.
- ❒ 8. Test for water bottoms at the beginning of each shift for the first 48 hours after initial delivery.
- ❒ 9. Check for water bottoms daily.
- ❒ 10. Notify designated personnel if water is detected and have it removed at once.
- ❒ 11. Replace filters if pump/dispenser is running slow.
- ❒ 12. Check pump calibration two weeks after initial load(s).

Ongoing Maintenance

- ❒ 1. Check for water. No level is acceptable.

Please note that the American Petroleum Institute (API) also offers guidance through the following publications:

"Storing and Handling Ethanol and Gasoline/Ethanol Blends at Distribution Terminals and Service Stations" API Recommended Practice 1626

"Cleaning Petroleum Storage Tanks" API Recommended Practice 2015

NOTE: Be sure that you are using a water finder paste suitable for use with ethanol blends. Two suppliers of such pastes are:

The Sartomer Company
468 Thomas Jones Way
Exton, PA 19341
(610) 363-4100

KolorKut Products Co.
P.O. Box 5415
Houston, TX 77262
(713) 926-4780

Conversion Procedures for Terminal/Ethanol Storage

There are a few steps that should be taken at the terminal level to ensure the trouble-free implementation and ongoing operation of your ethanol program.

Tankage obviously needs to be sized to volume requirements and the size and frequency of anticipated deliveries. A fixed roof tank with a floating internal cover is recommended. In order to minimize vapor loss a 16 ounce pressure/one ounce vacuum (pressure/vacuum) vent should be installed. Be sure and confirm that the storage tank is designed to tolerate this much pressure before the pressure/vacuum vent is installed. Your petroleum equipment supplier can help with the proper selection of the vent based upon the size of the fitting and whether the storage tank is above or below ground.

The solvency effect of ethanol will loosen rust, varnish, and gum in tanks that have stored other products. The tank should be cleaned of all loose materials and be clean and dry before introduction of ethanol. A #40 mesh screen filter should be installed in the transfer line between the tank and the loading rack or blending unit. For terminal and transportation personnel orientation, please see the check lists.

Terminal Personnel - Orientation Check List

- ❒ 1. Equipment orientation
- ❒ 2. Cover new or modified procedures (accounting etc.)
- ❒ 3. Cover safety and firefighting information
- ❒ 4. Issue/post Material Safety Data Sheet (MSDS) (available from your ethanol supplier)
- ❒ 5. Cover product receipt procedure
- ❒ 6. Cover any procedure regarding product inspection and/or sample retention
- ❒ 7. Advise maintenance personnel of conversion and potential for filter/screen plugging
- ❒ 8. Test affected meters and recalibrate if needed (10 to 14 days after initial conversion)

Transportation Personnel - Orientation Check List

Inbound Ethanol Delivery

- ❒ 1. Cover product delivery procedures
- ❒ 2. Cover applicable firefighting & safety procedures
- ❒ 3. Issue Material Safety Data Sheet (MSDS) (available from your ethanol supplier)
- ❒ 4. Placard requirements

Outbound Blended Product Delivery

- ❒ 1. Cover information on new terminal blending equipment
- ❒ 2. Cover splash blending procedure (if applicable)
- ❒ 3. Cover color codes
- ❒ 4. Discuss need to test for water bottoms and what procedures to follow when water bottoms are present. Any level of water above 1/4" should be removed.
- ❒ 5. Assuming no water bottoms are present, the load can be dropped per normal procedure

Conversion Procedures

❒ 1. Review conversion procedures

❒ 2. Review any special requirements & resulting increase in transportation demands

❒ 3. Stress importance of no water bottoms

❒ 4. Cover importance of accurate blend ratios

Materials Compatibility Information

Most materials used in retail gasoline dispensing systems are totally compatible with gasoline/ethanol blends. Equipment used to dispense denatured ethanol (e.g. terminal meters) should be designed to withstand the solvent action of ethanol. The following discusses each major equipment category.

Tanks

The mild steel used in finished product terminal tanks is compatible with both ethanol and gasoline/ethanol blends. Underground tanks at the retail facility may be made of mild steel or fiberglass reinforced plastic. Both steel tanks and fiberglass tanks (manufactured after 1981) designed for gasoline storage are compatible with gasoline/ethanol blends containing up to ten volume percent ethanol. The RFA has letters on file to this effect from both Fluid Containment (formerly Owens Corning Fiberglass) and Xerxes Corporation, the two major fiberglass tank manufacturers. Higher blend concentrations (above 10 v% ethanol) may require a tank constructed of a special chemical resin.

The interior of some older steel tanks may have been lined to prevent small leaks and extend their useful life. Most of those lining materials are compatible with gasoline/ethanol blends but some are not. In particular general epoxy or polyester resin based materials used in the late 1970s and earlier 1980s are not compatible with gasoline/ethanol blends. If a tank has been relined the manufacturer of the lining material should be consulted.

Tanks for storing denatured fuel grade ethanol should have a fixed roof with an internal floater. They should also be equipped with a 16 ounce pressure/ one ounce vacuum (P/V) vent. Confirm that the storage tank can tolerate this pressure before the vent is installed.

Pumps

For denatured ethanol, the preferred materials for seals are carbon and ceramic. Teflon impregnated packing materials are recommended for packing construction. Your petroleum equipment supplier should be able to determine if your existing terminal pumps are compatible with ethanol.

Gasoline pumps (both above ground and submersible) should handle gasoline/ethanol blends with no problems.

Pipe Sealants

For pipe carrying neat ethanol, teflon tape is the best sealant. For retail facilities dispensing gasoline/ethanol blends, alcohol based pipe sealant should be avoided. Suitable sealants include

- Scotch Brand Pipe Sealant with Teflon, No. 4178
- Loctite Pipe Sealant with Teflon, No 592
- Permatex Seals Pipes, No. 804

Meters

Meters for neat ethanol should have internal o-rings and seals designed to withstand ethanol's solvent action. Consult your meter manufacturer for recommendations.

Gasoline meters have been used for gasoline/ethanol blends with no accelerated wear or leakage problems. When first converting to an ethanol program it is advisable to recalibrate meters after 10-14 days to ensure that the change of product has not caused any meters to over-dispense.

Filters

Filters and screens used at both the terminal and retail facility are compatible with gasoline/ethanol blends. A 10 micron filter is recommended for the retail dispenser. A #40 mesh screen in the transfer line is recommended for terminal operations. When stations are first converted to gasoline/ethanol blends the solvent action of the ethanol may loosen built up lacquer on the tank walls and sediment in the bottom of the tank. This may result in the need for a filter change shortly after conversion. Once the system is clean, filter life will be similar to that when using any gasoline.

Hoses

Manufacturers of hoses for retail gasoline dispensers have indicated their hoses are suitable for gasoline/ethanol blends containing up to 10v% ethanol. These blends have been dispensed through numerous brands of hoses over the past twenty years.

For applications where neat ethanol is dispensed, your petroleum equipment supplier should be consulted.

Nozzles

Gasoline/ethanol blends have been dispensed through all major brands of nozzles for a number of years without problem. As with hose manufacturers, the nozzle manufacturers have indicated their products are suitable for use with gasoline/ethanol blends containing up to 10v% ethanol.

Other Materials

There are a number of materials that may be suitable for use with ethanol and gasoline/ethanol blends. However such suitability may depend on the use application and it is therefore difficult to generalize. The following table lists various recommended and non-recommended materials.

Compatibility of Commonly Used Materials With Ethanol and Ethanol Blends

Recommended	Not Recommended
Metals	
Aluminum	Zinc-galvanized (ethanol only)
Carbon steel	
Stainless Steel	
Bronze	
Elastomers	
Buna-N (hoses & gaskets) (note 1)	Buna-N (seals only) (Note 1)
Fluorel (note 1)	Neoprene (seals only)
Fluorosilicone (note 2)	Urethane rubber
Neoprene (hoses & gaskets)	
Polysulfide rubber	
Natural rubber (ethanol only)	
Viton (note 1)	
Polymers	
Acetal	Polyurethane (note 2)
Nylon	Alcohol-based pipe dope (recently applied)
(note 2)	
Polypropylene	
Teflon (note 1)	
Fiberglass reinforced plastic (note 2)	

NOTES
1. Registered trademark
2. The manufacturer of the specific material should be consulted.

Source: API Recommended Pratice 1626

Handling and Receipt of Ethanol Deliveries

Inbound Ethanol Deliveries

Procedures for delivery of inbound ethanol encompasses barge, rail, and transport truck. The following provides a brief overview of considerations for each mode of delivery.

Barge

Procedures for receiving barge shipments vary from terminal to terminal and depend on whether or not an independent inspection company is involved.

Each company should conduct a review with the appropriate terminal manager to establish procedures which are incident-specific to the terminal involved. Such a review should address safety, product integrity, assurance of full measure and minimizing any demurrage on equipment as well as proper scheduling and inventory levels.

Rail

Many terminals receive product by rail, typically in up to 29,000-30,000 gallon capacity railcars. Whether the equipment belongs to the customer or the supplier, there are certain procedures that should be followed.

Inspection**:** If there is any indication of damage, leakage, tampering, or theft, the delivering railroad and supplier should be notified to ascertain appropriate action. Suppliers should use numerically identified seals, and write the numbers on the bill of lading. You should verify that these numbers correspond on arrival. After the tank car has been spotted, the grounding equipment should be affixed to the tank-car frame. You may then open the dome cover. Next check the main outlet valve, which should be completely closed. (Valve handles are located either on top near the dome, or at the bottom of the car near the outlet.) Most equipment will be equipped with an outlet cover which contains a small safety plug. Once the main valve is closed, you can remove the safety plug. Any evidence of ethanol in the main outlet cover indicates the valve is open or has been open.

Unloading**:** Remove the main outlet cover and connect a tank-car-coupling assembly (45˚ elbow recommended) to the downleg. Use of a coupler such as an OPW 156-M allows reducers to be utilized with the elbow. After proper connections are made, open the main outlet valve and engage your unloading pump. Once the tank car is unloaded, close the main outlet valve, close and secure the dome cover and the large outlet cover. Advise railroad when car is ready for routing. Suppliers should provide a "Return Bill of Lading" to ensure prompt forwarding of the car. Caution - ethanol is a flammable liquid. Handle with the same safety precautions as gasoline. Avoid sparks and flames. It is advisable to wear safety goggles when unloading ethanol. If ethanol contacts the body or face, flush with water. See Material Safety Data Sheet - MSDS.

Transport Trucks

The most common method of ethanol delivery for a number of terminals is by transport truck (typically 7800-8200 gallons). While equipment suitable for transportation of gasoline is acceptable for handling ethanol, a few extra precautionary steps should be taken. Truck compartment(s) should be clean and dry before loading. Avoid contamination from water, leaded fuels such as racing gasoline/AV gas, or diesel, etc. Always ground the truck during loading and unloading operations. Hoses must be purged. It is best to have pumped ethanol or unleaded gasoline prior to pumping ethanol. Before the first delivery to the ethanol storage system, make certain that the lines and pump are clean. Ethanol is a flammable liquid. Handle with the same safety precautions as gasoline. Avoid sparks and flames. It is advisable to wear safety goggles when handling ethanol. If ethanol contacts the body or face, flush with water. Use good ventilation. Avoid breathing vapors, because they can cause headaches, dizziness, and nausea. If you are delivering to a terminal not within your own control, you should contact the terminal manager to verify their unloading hours and procedures. Transport loads of fuel grade ethanol should be placarded as flammable - placard number 1987. Additional information pertaining to the transportation of ethanol can be found in the Code of Federal Regulations-Transportation Section 49CFR § 172/173.

The majority of ethanol is sold on a net gallon basis, i.e. temperature corrected to 60˚F. This is also standard practice for most petroleum products. Ethanol producers utilize conversion charts to accomplish conversion from gross gallons to net gallons. These charts may very slightly from one company to another. Examples of two widely used conversion charts are provided here.

Table for Correction of Volume to 600F

TEMPERATURE — ˚F

-8˚	**-7˚**	**-6˚**	**-5˚**	**-4˚**	**-3˚**	**-2˚**	**-1˚**	**0˚**	**1˚**	**2˚**	**3˚1**	**4˚**	**5˚**
1.0428	1.0422	1.0416	1.0409	1.0403	1.0397	1.0391	1.0384	1.0378	1.0372	1.0365	1.0359	1.0353	1.0346
6˚	**7˚**	**8˚**	**9˚**	**10˚**	**11˚**	**12˚**	**13˚**	**14˚**	**15˚**	**16˚**	**17˚**	**18˚**	**19˚**
1.0340	1.0334	1.0328	1.0321	1.0315	1.0309	1.0302	1.0296	1.0290	1.0283	1.0277	1.0271	1.0265	1.0258
20˚	**21˚**	**22˚**	**23˚**	**24˚**	**25˚**	**26˚**	**27˚**	**28˚**	**29˚**	**30˚**	**31˚**	**32˚**	**33˚**
1.0252	1.0246	1.0239	1.0233	1.0227	1.0221	1.0214	1.0208	1.0202	1.0195	1.0189	1.0183	1.0176	1.0170
34˚	**35˚**	**36˚**	**37**	**38˚**	**39˚**	**40˚**	**41˚**	**42˚**	**43˚**	**44˚**	**45˚**	**46˚**	**47˚**
1.0164	1.0158	1.0151	1.0145	1.0139	1.0132	1.0126	1.0120	1.0113	1.0107	1.0101	1.0094	1.0088	1.0082
48˚	**49˚**	**50˚**	**51˚**	**52˚**	**53˚**	**54˚**	**55˚**	**56˚**	**57˚**	**58˚**	**59˚**	**60˚**	**61˚**
1.0076	1.0069	1.0063	1.0057	1.0050	1.0044	1.0038	1.0031	1.0025	1.0019	1.0013	1.0006	1.0000	0.9994

62˚	**63˚**	**64˚**	**65˚**	**66˚**	**67˚**	**68˚**	**69˚**	**70˚**	**71˚**	**72˚**	**73˚**	**74˚**	**75˚**
0.9987	0.9981	0.9975	0.9969	0.9962	0.9956	0.9950	0.9943	0.9937	0.9931	0.9924	0.9918	0.9912	0.9905

76˚	**77˚**	**78˚**	**79˚**	**80˚**	**81˚**	**82˚**	**83˚**	**84˚**	**85˚**	**86˚**	**87˚**	**88˚**	**89˚**
0.9899	0.9893	0.9887	0.9880	0.9874	0.9868	0.9861	0.9855	0.9849	0.9843	0.9836	0.9830	0.9824	0.9817

90˚	**91˚**	**92˚**	**93˚**	**94˚**	**95˚**	**96˚**	**97˚**	**98˚**	**99˚**	**100˚**
0.9811	0.9805	0.9798	0.9792	0.9786	0.9779	0.9773	0.9767	0.9761	0.9754	0.9748

The gross gallons received can be adjusted to net 60˚F gallons by using the above table.
Example: 19,593 gallons at 46˚F is to be corrected to volume at 60˚F
19,593 x 1.008 = 19,750 gallons at 60˚F

Temperature Correction Table
Denatured Ethanol

TEMP	CORRECTION FACTOR	TEMP	CORRECTION FACTOR	TEMP	CORRECTION FACTOR
˚F	Liquid Temp	˚F	Liquid Temp	˚F	Liquid Temp
-30	1.0540	16	1.0264	62	0.9988
-29	1.0534	17	1.0258	63	0.9982
-28	1.0528	18	1.0252	64	0.9976
-27	1.0522	19	1.0246	65	0.9970
-26	1.0516	20	1.0240	66	0.9964
-25	1.0510	21	1.0234	67	0.9958
-24	1.0504	22	1.0228	68	0.9952
-23	1.0498	23	1.0222	69	0.9946
-22	1.0492	24	1.0216	70	0.9940
-21	1.0486	25	1.0210	71	0.9934
-20	1.0480	26	1.0204	72	0.9928
-19	1.0474	27	1.0198	73	0.9922
-18	1.0468	28	1.0192	74	0.9916
-17	1.0462	29	1.0186	75	0.9910
-16	1.0456	30	1.0180	76	0.9904
-15	1.0450	31	1.0174	77	0.9898
-14	1.0444	32	1.0168	78	0.9892
-13	1.0438	33	1.0162	79	0.9886
-12	1.0432	34	1.0156	80	0.9880
-11	1.0426	35	1.0150	81	0.9874
-10	1.0420	36	1.0144	82	0.9868
-9	1.0414	37	1.0138	83	0.9862
-8	1.0408	38	1.0132	84	0.9856
-7	1.0402	39	1.0126	85	0.9850
-6	1.0396	40	1.0120	86	0.9844
-5	1.0390	41	1.0114	87	0.9838
-4	1.0384	42	1.0108	88	0.9832
-3	1.0378	43	1.0102	89	0.9826
-2	1.0372	44	1.0096	90	0.9820
-1	1.0366	45	1.0090	91	0.9814
0	1.0360	46	1.0084	92	0.9808
1	1.0354	47	1.0078	93	0.9802
2	1.0348	48	1.0072	94	0.9796
3	1.0342	49	1.0066	95	0.9790
4	1.0336	50	1.0060	96	0.9784
5	1.0330	51	1.0054	97	0.9778
6	1.0324	52	1.0048	98	0.9772
7	1.0318	53	1.0042	99	0.9766
8	1.0312	54	1.0036	100	0.9760
9	1.0306	55	1.0030	101	0.9754
10	1.0300	56	1.0024	102	0.9748
11	1.0294	57	1.0018	103	0.9742
12	1.0288	58	1.0012	104	0.9736
13	1.0282	59	1.0006	105	0.9730
14	1.0276	60	1.0000	106	0.9724
15	1.0270	61	0.9994	107	0.9718

Quality Assurance and Test Methods

There are several test methods that can be employed to ensure the quality and purity of your ethanol supply and gasoline/ethanol blends. Some are relatively simple field tests while others are more sophisticated requiring laboratory equipment and specialized training. The following provides an overview of the more common test methods.

Ethanol

Visual Clarity: Ethanol when viewed in a clear glass container should be clear (clear to very pale straw color) and visibly free of any suspended particles. This is a very simple though somewhat subjective test.

Apparent proof: Alcohol proof can be determined with the use of a proof hydrometer. Your petroleum or laboratory equipment supplier should be able to procure a proof hydrometer. A 185-206 proof scale should be specified. Two suppliers who carry such products are:

H.B. Instrument Co.
102 W. 7th Avenue
Colleyville-Trappe, PA 19426
(610) 489-5500

Proof hydrometer catalogue # 6495A

Brooklyn Thermometer Co.
90 Verdi Street
Farmingdale, NY 11735
(516) 694-7610

Proof hydrometer catalogue # 94146

ETHANOL DENATURED WITH 5 PARTS NATURAL GASOLINE PER 100 PARTS ETHANOL

Apparent Proof, Specific Gravity and API Gravity at Various Temperatures

Denaturant Added - Natural Gasoline (API @ 60˚F = 80˚)

	200 Proof Ethanol*			199 Proof Ethanol*		
Temp ˚F	Apparent Proof	Specific Gravity	API Gravity	Apparent Proof	Specific Gravity	API Gravity
30	196.0	.8038	44.5	195.1	.8060	44.1
40	198.3	.7987	45.7	197.0	.8010	45.2
50	200.1	.7939	46.7	199.3	.7950	46.5
60	202.1	.7879	48.1	201.1	.7900	47.6
70	203.7	.7848	48.8	202.9	.7867	48.4
80	205.3	.7806	49.8	204.5	.7828	49.3

	198 Proof Ethanol*			197 Proof Ethanol*		
Temp ˚F	Apparent Proof	Specific Gravity	API Gravity	Apparent Proof	Specific Gravity	API Gravity
30	194.0	.8082	43.6	192.6	.8125	42.7
40	196.0	.8031	44.7	195.0	.8056	44.1
50	198.3	.7970	46.0	197.4	.7983	45.8
60	200.3	.7930	46.9	199.1	.7950	46.5
70	202.1	.7890	47.8	201.1	.7910	47.4
80	203.7	.7851	48.7	203.0	.7871	48.3

*Proof of the ethanol before denaturant natural gasoline was added.

The hydrometers render accurate proof readings at 60˚F. If sample product temperature is not 60˚F, the chart on the left, can be used to correct for temperature differences.

Refractive Index: The hand held T/C refractometer is a quick procedure for determining, with reasonable accuracy, the purity of the ethanol being received by the terminal. It checks the refractive index of the product, which should be within certain limits to be suitable for use in gasoline.

The refractive index of the ethanol can be altered any number of ways: i.e., water, denaturants, contaminants, etc. The following procedure will give, within reasonable confidence, an accurate assessment of the ethanol's suitability for use in gasolines.

PROCEDURES:

Step #1

(1) Obtain sample from transport barge, etc., prior to its being received into storage. A pint should be sufficient. Save the samples or retain for at least 30 days.

(2) Check refractive index in accordance to instructions provided with refractometer. Record this reading on log.

(3) Using the graduate provided, blend 70 ml ethanol with 30 ml H_2O. Please be quite accurate blending these mixtures. There should be no separation of mixtures but some haziness of the mixture will be noticed.

(4) Check refractive index. This value should be the same as ethanol index measured previously: +0.50ND. Record this value in the log.

Step #2

(1) Place 70 ml ethanol in the graduated cylinder.

(2) Add 20 ml H_2O. Final mixture should be clear and no visible haze present.

(3) With syringe, add water until haze forms (92-95 ml). Refractive index of this mixture should be 1.0-1.5 ND values higher than first measurement (ethanol only).

Using the 250 ml graduated cylinder:

(1) Measure 100 ml ethanol into the cylinder.

(2) Add water up to 250 ml mark.

(3) Insert stopper and shake

Note: Shaking this mixture will often result in pressure building up and possibly expelling the stopper. Be careful to relieve the pressure slowly.

(4) Allow to stand for five minutes.

(5) Read the amount of denaturant found in the top level separated from the lower phase.

Denaturant should be approximately 2-4 1/2 ml. If a significantly higher amount or no denaturant is found, you may wish to contact your ethanol supplier to discuss your test results.

DETERMINING ACCEPTABILITY OF ETHANOL

Passing Criteria:

(1) Initial reading 18.5-20.5
(2) 70/30 reading 18.5-20.5
(3) Haze value 93-95 ml.
(4) Haze ND value 1.0-1.5 ND above reading #1
(5) Denaturant layer 2-4 1/2 ml approximate after 15 minutes

NOTE
Occasionally check refractometer with distilled water. It should read 0 on the scale.

Purity: ASTM Test Method D 5501 Standard Test Method for Determination of Ethanol Content of Denatured Fuel Ethanol By Gas Chromatography can be used to determine ethanol purity. Copies of the ASTM test procedure can be obtained from ASTM at the address listed on page five.

Most independent laboratories are capable of performing this test. You may also wish to consult ASTM D 4806 for a list of other relevant laboratory test procedures for fuel grade ethanol.

pHe Level: Work by the auto manufacturers and others has indicated that low pHe ethanol (in both E-85 and E-10 blends) can contribute to accelerated corrosion of certain fuel system parts. While the ASTM Standards limit total acidity to 56 mg/L, this standard is not always sufficient to limit more aggressive sulfuric based acids. Ethanol meeting the ASTM acidity standard may still be of low pHe.

ASTM has developed a test method to monitor "pHe". This test method measures acid strength and reports a pHe value. (NOTE: A pHe value is not directly comparable to pH values for water solutions.)

The ASTM pHe test method is designated and titled as: ASTM Designation: D 6423 Standard Method for Determination of pHe of Ethanol, Denatured Fuel Ethanol, and Fuel Ethanol (Ed75-Ed-85).

As with the other ASTM standards mentioned in this document, ASTM D 6423 can be obtained from ASTM at the contact information on page 5.

Sulfur Content: As noted on page 6, requirements to lower the sulfur content of gasoline have led to the sulfur content of ethanol being an important issue. ASTM is adding a sulfur specification for denatured ethanol to ASTM D 4806.

At the current time, industry consensus indicates the most appropriate ASTM test method for determining the sulfur content of ethanol to be ASTM D 5453 Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Motor Fuels and Oils by Ultraviolet Fluorescence. The most recent copy of ASTM D 4806 should be consulted for applicable sulfur limitations and appropriate test procedures.

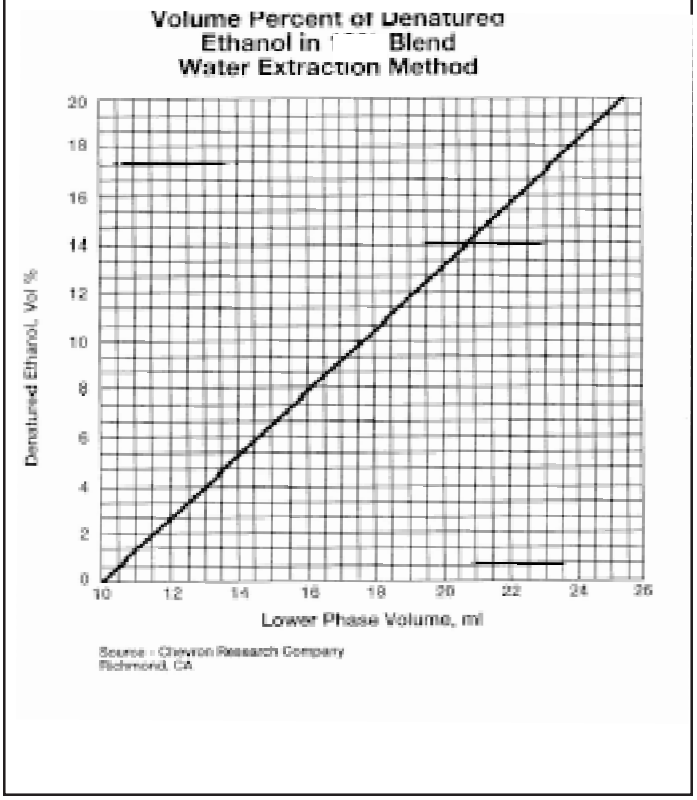
Gasoline Ethanol Blends

Ethanol Content: The approximate ethanol content of a gasoline ethanol blend can be tested by the "Water Extraction Test". This procedure is as follows.

Determination of Alcohol Content in Blends-Water Extraction Method

Place 100ml. of the gasoline/ethanol blend in 100 ml. glass stoppered graduated cylinder. Pipette 10 ml. of water into the cylinder and shake thoroughly for about one minute. Set aside for 2 minutes. Read the volume of the alcohol-water layer on the bottom and compare to the graph at right to read the alcohol content.

For example, a reading of 17.2 ml. lower phase volume by this test is 10v% alcohol in the blend. (See chart at right).



ASTM D 4815: There is also a more accurate laboratory test for determining the ethanol content of gasoline/ethanol blends, ASTM D 4815 Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C1 to C4 Alcohols by Gas Chromatography.

You may also wish to consult ASTM D 4814 Standard Specification for Automotive Spark-Ignition Engine Fuel for other test procedures relative to gasoline and gasoline/ethanol blends.

Summary of Safety and Fire Fighting Procedures

Although ethanol does not present any danger beyond those of other flammable products, it is important that pertinent safety and fire fighting details be covered with appropriate personnel.

Safety Information

Material Safety Data Sheets (MSDS) should be provided to all personnel who come in, or may come in, contact with ethanol. A current MSDS is available from your ethanol supplier. More detailed information on safety, flammability, and health considerations is available from the RFA offices or RFA member companies.

Fire Fighting Procedure Overview

Ethanol: Spills (less than one inch deep) can be controlled and extinguished by dilution with water but are more quickly extinguished by "alcohol type" foams or dry chemical applications. Tank fires can only be controlled and extinguished by the use of "alcohol type" foams.

Spill Fires: Preferred foams are polymeric "alcohol type", fluoroprotein, and AFFF, in that order, for performance of blanket and security of the area. "Alcohol type" and AFFF will produce most rapid fire knockdown, while the "alcohol type" and fluoroprotein will give the best protection against reflash. Small spill fires can be extinguished with BC extinguishers.

Tank Fires: For over the top application use "alcohol type" foam or Light Water AFFF. For subsurface application, the "alcohol type" foam is the preferred agent.

Burn back resistance in these applications is sometimes lowered and therefore, additional foam application after fire extinguishment is recommended.

More comprehensive information on Safety and Fire Fighting is provided in RFA Recommended Practice #930601 "Gasoline Ethanol Blends-Program Operations Guide" available from the Renewable Fuels Association and its member companies.

Ed85

Several manufacturers currently offer vehicles which are capable of operating on various blends of fuel ranging from 100% gasoline to 15% gasoline/85% denatured ethanol-commonly called Ed85 or simply E-85. These vehicles are called Flexible Fuel Vehicles (FFV) or Variable Fuel Vehicles (VFV). Ford, General Motors, and Daimler Chrysler Corporation all offer certain models of Flexible Fueled Vehicles (FFVs) that operate on Ed85.

Based on the current offerings, the number of Ed85 capable FFVs/VFVs, on the road is increasing by several hundred thousand units per year.

Retail facilities offering Ed85 have been established at a number of locations in the Midwest and efforts are underway to increase their number.

The properties of ethanol being provided for reblending as Ed85 should meet RFA recommendations and specification ASTM D 4806.

The ethanol content of Ed85 is actually altered by season to improve cold start and warm up performance. Denatured ethanol content can range from 75v% to 85v%.

The specification for Ed85 is covered in ASTM D 5798 "Specification for Fuel Ethanol (Ed85 - Ed75) for Automotive Spark Ignition Engines".

The former American Automobiles Manufacturers Association (AAMA) also issued guidelines for dispensing equipment entitled "Fuel Ethanol-Compatibility Standards and Dispensing Equipment List for Ed85 Fueled Vehicles". The AAMA has dissolved but copies of this document are available from the RFA.

In addition, the Center for Transportation Research at Argonne National Laboratory has developed a document entitled "Guide Book for Handling, Storing, and Dispensing Fuel Ethanol". This document was prepared under contract to the U.S. Department of Energy. For additional information contact Argonne National Laboratory • 9700 Cass Ave. • Bldg. 362-C264 • Argonne, IL 60439.

If the hydrocarbon portion of an Ed85 blend is made up of finished gasoline, the gasoline portion must contain detergent additives to comply with EPA's detergent regulations. Some detergents, such as poly isobutylene amine (PIBA), have performed poorly in FFV operation. At some blend levels, these additives may precipitate out of the blend resulting in excessive fuel system deposition. Consequently the RFA has issued a recommendation to minimize the occurrence of any such problems. Regarding the use of detergent additives in Ed85 the RFA recommends:

In order of preference, the hydrocarbon portion of an E85 blend is ranked as follows:

1. The hydrocarbon portion is natural gasoline. No detergent additive is added.
2. The hydrocarbon is finished gasoline. Only the gasoline portion receives the normal level of detergent additive. If it is available, use a polyether amine detergent.
3. The same as No. 2 except that if polyether amine is not available, use a PIBA detergent.

In no instance should the detergent be added in an amount that would treat the entire blend. It should be added at a level that will treat only the gasoline portion of the blend. For a more detailed version of this recommendation, contact the RFA office.

For additional information on Ed85, Flexible Fueled Vehicles, and Ed85 fueling facilities, you may also wish to visit the following websites:

National Ethanol Vehicle Coalition
www.e85fuel.com

Alternative Fuels Data Center
www.afdc.nrel.gov

Governors Ethanol Coalition
www.ethanol-gec.org

E diesel

Research exploring the possible commercialization of diesel ethanol blends is currently underway. These blends, containing up to 15v% ethanol blended with standard diesel and a proprietary additive are called E diesel. A number of fleet demonstrations have been completed with favorable results and some testing has also been completed. E diesel has the ability to reduce certain exhaust emissions, especially particulates, in certain diesel applications and duty cycles.

However, additional testing is needed to assess compatibility of E diesel with various fuel system parts and also to determine the long range affects on engine durability. Additional emissions tests are also needed to more accurately quantify the emissions profiles of various E diesel blend levels.

The RFA is working closely with industry stakeholders to address research and development needs and hopefully to develop a commercialization pathway.

Ethanol in Fuel Cells

Fuel cells for transportation applications are still in the developmental phase. Fuel cells operate on hydrogen which in seeking to combine itself with water through a protein exchange membrane (PEM), generates electricity. Fuel cells are more energy efficient than the internal combustion engine.

Fuel cells could operate on hydrogen from a number of sources including ethanol, methanol, gasoline, and perhaps, at some point, even water. Fuel cells can also be used for stationary applications such as power generation, although different types of fuel cells than those used for transportation applications are usually used.

In any event, the use of ethanol in fuel cells could become important in the future. It could even open up the stationary power generation market (electricity) to what, today, are considered transportation fuels. The RFA has a Fuel Cell Task Force which continues to follow fuel cell developments and work towards a role for ethanol in fuel cell applications.

Tax Credits/Exemptions

Gasoline/ethanol blends (and gasoline/ETBE blends) qualify for a partial exemption of the federal motor fuel excise tax at the following rates:

Ethanol Content	ETBE Content	Excise Tax Credit
5.7v%	12.7v%	3.078 cents per gallon
7.7v%	17.2v%	4.158 cents per gallon
10.0v%	---	5.400 cents per gallon

For information on the excise tax exemption contact your company's accountant. He or she can also provide information on the "blenders tax credit" which may be available for blends containing percentages of ethanol or ETBE other than those listed above.

Gasoline/ethanol blends also qualify for special tax treatment in some states. A list of these states is available from the RFA or your ethanol supplier.

Other Documents Available From the Renewable Fuels Association

The RFA has developed and/or obtained a number of documents useful to those with interests in ethanol and gasoline/ethanol blends. These are available through the RFA member website or from RFA member companies.

Gasoline Ethanol Blends-Program Operations Guide
RFA Recommended Practice #930601 (June 1993) (under revision-not currently available)

Changes in Gasoline III - The Auto Technician's Gasoline Quality Guide

Changes in Gasoline III - Year 2000 Supplemental Update

A Comparison of California Reformulated Gasoline to Federal Reformulated Gasoline
DAI Information Paper # 970401 (April 1997)

Driveability and Performance of Reformulated and Oxygenated Gasolines
DAI Information Paper # 970302 (March 1997)

Lubricity of Reformulated & Oxygenated Gasolines
DAI Information Paper # 970301 (March 1997)

The Compatibility of Reformulated and Oxygenated Gasoline with Fuel System Materials
DAI Information Paper # 970201 (February 1997)

Changes in Gasoline & The Classic Auto
DAI Informational Document # 960501, May 1996

Guidebook for Handling, Storing, & Dispensing Fuel Ethanol
U.S. Dept. of Energy

RFA website: www.ethanolrfa.org