Renewable Fuels Association

FUEL ETHANOL

Industry Guidelines, Specifications, and Procedures

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Introduction

As the national trade association for the U.S. ethanol industry, the Renewable Fuels Association (RFA) promotes policies, regulations and research and development initiatives that will lead to the increased production and use of fuel ethanol. RFA membership includes a broad cross section of businesses, individuals and organizations dedicated to the expansion of U.S. fuel ethanol industry.

Organized in 1981, RFA serves as the voice of the ethanol industry, providing advocacy, authoritative analysis, and important industry data to its members, Congress, federal and state government agencies, strategic partners, the media and other opinion-leader audiences.

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), an Education and Promotion Committee that seeks to educate consumers and organizations as well as to identify, assess, and pursue opportunities for market growth, a Membership Committee, a Feed CoProducts Committee and a Plant and Employee Safety 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, through its research and education arm, the "Renewable Fuels Foundation," provides the support structure for the E diesel Consortium. The E diesel Consortium is a standing committee of the Renewable Fuels Foundation and is comprised of various stakeholder companies and organizations. The E diesel Consortium is exploring various technical issues associated with the potential commercialization pathways for diesel ethanol blends.

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 (85% ethanol/15% gasoline). 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 transportation 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 a 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 4 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 lesser 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. The oxygenated fuels program has been tremendously successful and nearly all of the original non-attainment areas have now achieved compliance.

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 over 32% of all gasoline sold. The purpose of the RFG program is to reduce automobile emissions of volatile organic compounds (VOCs), and Oxides of Nitrogen (NOx), which are ozone precursors. The program is also designed to reduce toxic emissions (benzene, 1,3 butadiene, formaldehyde, acetaldehydes, and polycyclic organic matter), which pose high cancer risks.

Compliance with the RFG 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. RFG is 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 is the oxygenate most widely used in reformulated gasoline. This is in part due to the fact that use of the other oxygenate, MTBE, has been banned in 25 states.

While ethanol has been blended at the 5.7% and 7.7% level, it is more frequently blended at the 10 volume percent level to take maximum advantage of available tax credits. At the 10 volume percent

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† Compliance in the State of California is determined through the California Air Resources Board's (CARB) "Predictive Model," which differs somewhat from EPA's Complex Model.

†† The Domenici-Barton Energy Policy Act of 2005 signed into law in August 2005, removed the RFG oxygenate requirement in California immediately, with the rest of the nation to follow 270 days after enactment.

level ethanol would add approximately 3.5 weight percent oxygen to the blend, the highest level allowed under EPA regulations.

The requirement to use oxygen in RFG was replaced by a Renewable Fuels Standard (RFS) in the Energy Policy Act of 2005. The RFS requires an increasing amount of renewable transportation fuel use beginning with a 4.0 billion gallon per year usage requirement in 2006 and escalating to 7.5 billion gallons of annual usage requirement in 2012. While some of this requirement will be met with Biodiesel, it is anticipated that the greater majority of the requirement will be met with ethanol due to its much wider availability.

The Renewable Fuels Association views the RFS as a floor, not a ceiling. We will expand our ethanol production not only to meet the supply requirements of the RFS but to exceed them. With record high crude oil and gasoline prices, and an increasing need to replace the octane and volume lost by numerous state MTBE bans, the demand for ethanol has increased dramatically.

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 and practices cited below:

Filtering of Product: The product delivery system dispensing denatured ethanol from plant storage tanks should be equipped with a final filter sized no larger than a maximum of 10 microns nominal to control any suspended particulates or precipitates.

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
CorrPro 654	13 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.

California and Federal Ethanol Requirements: Refiners are currently faced with the need to reduce the sulfur content of their gasoline to comply with federal and state regulations. As such, it is important that the sulfur content of ethanol be kept to very low levels. The federal government has adopted a requirement that denatured ethanol used in conventional or reformulated gasoline contain no more than 30 ppm sulfur beginning January 1, 2004. The State of California has adopted requirements that are more stringent and require a lower sulfur level, and that place limits on other compounds. The California Denatured Ethanol Standards are recapped in the following table.

California Denatured Ethanol Standards
(In Addition to the Performance Requirements in ASTM D 4806)

Property	Specification Limit	Test Method
Sulfur, ppm max	10	ASTM D 5453-93
Benzene, vol% max	0.06*	D5580-95 test results of a sample of the denaturant multiplied by 0.0476
Olefins, vol% max	0.5*	D 6550-00 (modified) test results of a sample of the denaturant multiplied by 0.0476
Aromatics, vol% max	1.7*	D5580-95 test results of a sample of the denaturant multiplied by 0.0476

** (exceptions may apply-see applicable section of ASTM D4806)*

Additionally, the State of California places limits on the denaturants used to denature ethanol that is blended into their gasoline. These requirements are set forth in the following table.

California Denaturant Standards

Property	Specification Limit	Test Method
Benzene, vol% max	1.1	D5580-95
Olefins, vol% max	10	D6550-00 (modified)
Aromatics, vol% max	35	D5580-95

Note that there are exceptions to the above California limits based on the properties of the gasoline to which the ethanol is added. Those producers who distribute ethanol for use in California must meet the above specifications unless otherwise agreed to by a refiner who indicates it can accept nonconforming ethanol for use in its gasoline and still meet the exception rules. If a producer intends to market under such an exception, they should conduct a detailed review of the applicable California regulations.

Ethanol is routinely commingled when in storage making it difficult to segregate ethanol destined for California from other destinations. As such, in July 2002, the RFA Board of Directors adopted a recommendation that all ethanol distributed for fuel use in the United States, by its member companies, meet the more stringent California specifications as set forth in the above tables.

As a result of the above recommendations, ethanol producers should review the specifications of their denaturants with their denaturant suppliers to assure they do not contribute to levels above the recommended limit for sulfur and other specified ingredients.

Transportation Equipment and Prior Commodities Recommendations

Transportation Equipment: Some transportation equipment used to deliver ethanol may have seen prior use delivering other commodities such as caustic soda, distillate, or other products that could contaminate the load. The association has been advised that some of our member companies have, upon inspection, had to reject barges (that had supposedly been properly cleaned) due to the presence of caustic soda. One member company has had to reject nearly 30% of all barges inspected.

Barges: Regardless of the prior commodity believed to be hauled, all barges should be inspected before loading. If caustic soda or other unacceptable commodities are present, the barge should be rejected.

All Equipment: Prior commodities that are acceptable in barges, rail cars, and trucks include ethanol, fuel grade denatured ethanol, unleaded gasoline, unleaded RBOB, unleaded CaRBOB, and natural gasoline. Equipment used to haul other commodities should not be used unless the equipment has been properly cleaned. The extent of cleaning necessary depends on the prior commodity. In general, prior commodities such as vegetable oil, linseed oil, lube oils, or distillates as well as all grades of glycol require a **Group I Wash**. Toluene, acetone, heavier alcohols, hexane, kerosene, and diesel fuel require a **Group III Strip**. Caustic soda and caustic potash, as well as sulfuric acid and calcium chloride, require a **Group IV Rinse**. Again **all barges**, regardless of prior commodities, should be inspected. An excellent reference on tank cleaning is Dr. Verwey's Tank Cleaning Guide. Available from:

Dr. A. Verwey
Chemical Laboratorial & Superintendence Company
P.O. Box 6003, 3002 AA Rotterdam
Coolhaven 32, 3024 AC Rotterdam
Phone: 010-476-1055
Fax: 010-476-1642 (Laboratory)
Fax: 010-477-0336 (Survey Department)

The following provides a general discussion of the cleaning procedures for transport trucks, rail cars, and barges.

Cleaning Instructions for Fuel Grade Ethanol Truck Shipments

This procedure is to be used as a guideline for the washing/cleaning of truck trailers. Typical trailers hauling ethanol-related products are constructed of stainless steel or aluminum. Trailers vary in the number of compartments, and some trailers have baffles in the compartments. The prior contents of an empty trailer need to be discussed with the cleaning contractor before any work is initiated to cover any special cleaning requirements, special hazards of the prior cargo, and any other general concerns. All safety procedures must be adhered to where applicable.

1. Complete a pre-wash inspection consisting of:
   a. Check trailer for contaminants
   b. Check for any rust or damage to trailer
   c. Check previous Bill of Lading for prior content documenting.
2. Open top manway for a visual inspection of the compartment. Wing nuts should be opened slowly to allow pressure to exhaust before completely removing any wing nut.
   a. If a visible heel of product exists, contact supervisor for correct disposition.
3. Insert spinner head or rotating nozzle-cleaning head into a compartment of the trailer. Multiple compartment trailers will need to repeat this procedure for each compartment being washed.
4. Clean the dome lid, vent caps, latches, and the rest of the crow's nest area with hot (>180˚F) water.
5. Remove all the hoses from the hose tubes and carefully remove the caps and plugs from the hoses. Allow any remaining product to drain into the wastewater collection.
6. Hook the hoses together and hook them to the discharge of the trailer placing the open end into the wastewater collection.
7. Open the product valve, and if so equipped, the safety valve. Make sure there is not any solid product blocking the discharge.
8. Start the wash cycle
   a. Wash cycle must consist of a minimum of >180˚F water, heel rinse not recycled ~ 100 psi pressure wash.
   b. A detergent is not recommended. If detergent is used, steps must be taken to verify the detergent has been completely rinsed.
   c. Repeat rinse cycle if odor remains in compartment.
9. Clean the underside of the dome lid, and replace gasket as necessary.
10. After the wash cycle, the compartments, hoses, and pump must be dried by using forced air apparatus. Air must be oil-free.
11. Close up the trailer, place hoses in compartments and replace discharge caps.
12. All entry points to the trailer should be sealed with tamper -evident, identifiable seals, and all seals accounted for on the wash ticket.
13. The wash ticket should include: the wash facility name and contact information, trailer information, date/time of wash, duration of the wash cycle from start to finish, prior contents of trailer washed out, seals installed on cleaned trailer, and signature of person completing the wash.

Cleaning Instructions for Fuel Grade Ethanol Railcar Shipment

This procedure is to be used as a guideline for the washing/cleaning of railcars. Typical railcars hauling ethanol-related products are constructed of carbon steel. The prior contents of an empty railcar need to be discussed with the cleaning contractor before any work is initiated to cover any special cleaning requirements, special hazards of the prior cargo, and any other general concerns. All safety procedures must be adhered to where applicable. Air used for blowing compartment dry must be oil-free. Compartment product heel must not be rinsed into the wash water return cycle.

Inspection

1. Open manway for a visual inspection of the interior.
2. Inspect interior for cleanliness and any cleanliness deficiency. If performing an inspection only, place seals on all vessel openings.

Strip

3. Remove the residual product out of the railcar with strong suction, which can include pumps, mechanical vacuums, etc. Be sure to open the eduction valves to release any product in the piping, Properly dispose of any residual material.
4. Hook up air hose to railcar piping and blow dry. Blow interior dry with air horns/movers, etc. If performing a product strip only, inspect railcar for cleanliness and any cleanliness deficiency, then place seals on all vessel openings.

Rinse

5. Drop the butterworth or rotating nozzle-cleaning head in through the manway to fully rinse the interior. Water used in cleaning must be heated to >140˚F, and pressured to approximately 100 psi, and not recycled.
6. Hook up air hose to railcar piping and blow dry. Blow interior dry with air horns/movers, etc. If performing a product rinse only, inspect railcar for cleanliness and any cleanliness deficiency, then place seals on all vessel openings.

Steam/Wash

7. If steam is necessary, place a steam hose with a distribution nozzle in each compartment for a minimum of 30 minutes. This process needs to make the shell interior of the railcar compartment sweat out the prior contents.
8. Apply detergent/cleaner/degreaser, whichever is necessary, to vessel.
9. Use the butterworth or rotating nozzle cleaning head again through the manway to fully rinse the interior. Be sure to hook up the water source to eduction tube to rinse piping.
10. Hook up air hose to railcar piping and blow dry. Blow interior dry with air horns/movers, etc. If performing a product steam/wash only, inspect trailer for cleanliness and any cleanliness deficiency, then place seals on all vessel openings.

Cleaning Instructions for Fuel Grade Ethanol Barge Shipment

This procedure is to be used as a guideline for the washing/cleaning of barges. Typical barges hauling ethanol are constructed of carbon steel. The prior contents of an empty barge need to be discussed with the cleaning contractor before any work is initiated to cover any special cleaning requirements, special hazards of the prior cargo, and any other general concerns. All safety procedures must be adhered to where applicable. Air used for blowing compartment dry must be oil-free.

Inspection

1. Open all manways and ullage/gauge holes for a visual inspection of the interior.
2. Inspect cargo piping, compartments, etc. for cleanliness and any cleanliness deficiency. If performing an inspection only, place seals in the following locations: one on each compartment manway, each stripping line cap, each ullage/gauge port, all cargo valves and blinds on both ends of header.

Strip

3. Remove the residual product out of the barge compartment with strong suction, which can include pumps, mechanical vacuums, etc. Be sure to open the compartment cargo valves to release any product in the cargo piping into the sumps. Properly dispose of any residual material.
4. Hook up air hose to barge piping and blow dry. Blow interior dry with air horns/movers, etc. If performing a product strip only, inspect cargo piping, compartments, etc. for cleanliness and any cleanliness deficiency. Place seals in the following locations: one on each component manway, each stripping line cap, each ullage/gauge port, all cargo valves, and blinds on both ends of header.

Rinse

5. Drop the butterworth or rotating nozzle-cleaning head in through the ullage/gauge port or manway to fully rinse the compartments. Be sure to hook up the water source to cargo piping, pinching back the compartment valve in order to flood the piping. Rinse to compartment sumps. Water used in cleaning must be heated to >140˚F, and pressurized to approximately 100 psi, and not recycled.
6. Manually strip compartment floors and sumps with squeegees, stripping pumps, hoses, etc.
7. Hook up air hose to cargo piping and blow dry. Blow compartments, etc. If performing a product rinse only, inspect cargo piping, compartments, etc. for cleanliness and any cleanliness deficiency. Place seals in the following locations: one on each compartment manway, each stripping line cap, each ullage/gauge port, all cargo valves, and blinds on both ends of header.

Steam/Wash

8. If steam is necessary, place a steam hose with a distribution nozzle in each compartment for a minimum of 30 minutes. The process needs to make the steel interior of the barge compartment sweat out the prior contents.
9. Apply detergent/cleaner/degreaser, whichever is necessary, to each compartment.
10. Use the butterworth or rotating nozzle cleaning head again through the ullage/gauge port and/or manway to fully rinse the compartments. Be sure to hook up the water source cargo piping, pinching back the compartment valve in order to flood the piping. Be sure to fully rinse the compartments, with a minium of 4500 gallons, to compartment sumps.
11. Manually strip compartment floors and sumps with squeegees, stripping pumps, hoses, etc.
12. Hook up air hose to cargo piping and blow dry. Blow compartments dry with air horns/movers, etc.

* If performing a product rinse only, inspect cargo piping, compartments, etc. for cleanliness and any cleanliness deficiency. Place seals in the following locations: one on each compartment manway, each stripping line cap, each ullage/gauge port, all cargo valves, and blinds on both ends of header.

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. The gasoline related properties of fuel grade ethanol are compared to other available fuel oxygenates in the following table.

Comparison of Typical Properties of Common Oxygenates

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

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	17.0	8.0	4.0	2.5
Energy Content mbtu/gal	78.0-78.3(1)	93.5	96.9	100.6
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%

(1) Energy content is given as a range due to potential energy content variations among approved denaturants

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 the few remaining 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 stricter controls on VOC, NOx, and toxic emissions profiles.

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 spark ignition 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.

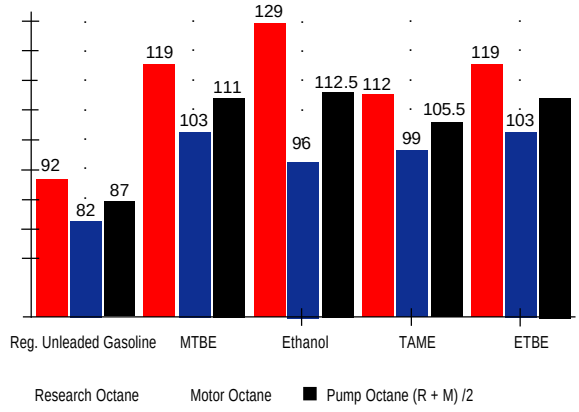
The purpose of the ASTM specification is to provide parameters so that gasoline and gasoline oxygenate blends will perform satisfactorily in as wide a range of consumer vehicles as possible.

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 follows:

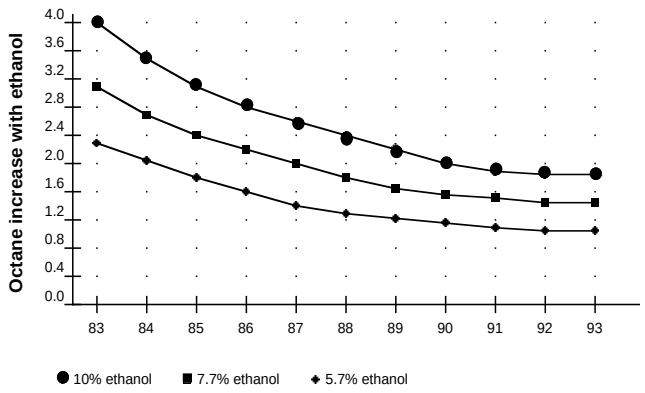
Octane: Initially, ethanol was almost always added to gasoline at the 10 volume percent level. However, over the past ten years environmentally driven fuel specifications, and changes in motor fuel excise tax laws, have, in some cases, encouraged ethanol blending at lower levels of 5.7 v% and 7.7 v%. The blending octane value of ethanol is compared to other oxygenates in the table below left.

Blending Octane Values of Common Oxygenates

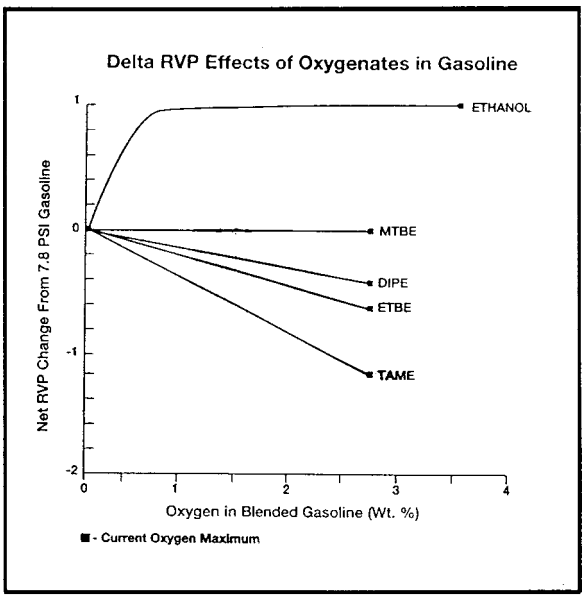


Exact octane values will vary based on the octane and composition of the gasoline to which the oxygenate is added

BASE GASOLINE OCTANE INCREASE
WITH ETHANOL BLENDING
ESTIMATED



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. The typical blending octane values of ethanol are displayed in the Octane Increase response graphic, bottom right on preceding page.

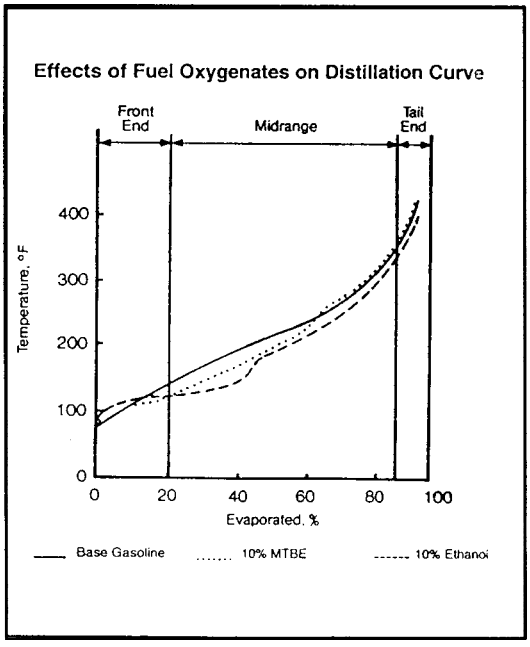


Fuel Volatility: The addition of ethanol to gasoline will generally increase the volatility of the base fuel to which it is added. It will increase the vapor pressure and decrease the 50% distillation point (T_{50}). Because of its effect on T_{50} it may also affect the Driveability Index (DI) and the Vapor Lock Protection Class as measured by Temperature for Vapor Liquid Ratio of 20 (TV/L20) as discussed on page 15.

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 no 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 in conventional gasoline, 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 pressure 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 that require hydrocarbon gasoline to 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 some states may not, in every case, require adherence 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:

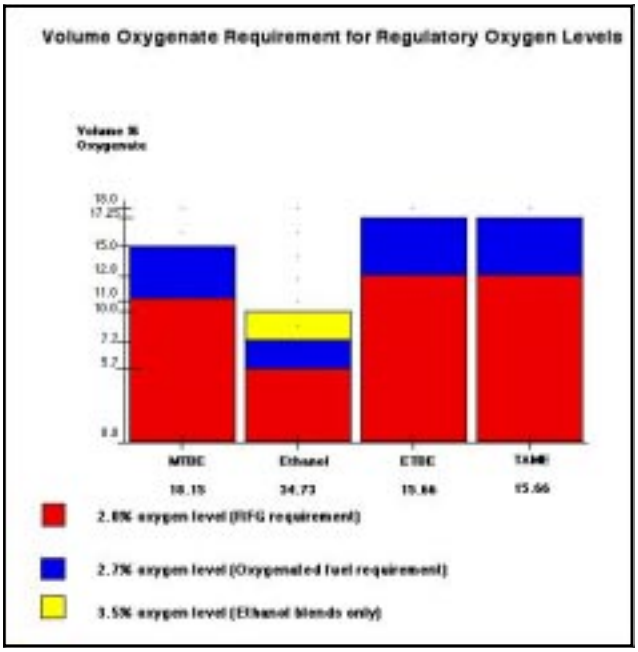
$$\mathbf{DI = 1.5\ T_{10} + 3.0\ T_{50} + 1.0\ T_{90}}$$

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 has often been used to comply with minimum and/or average oxygen content requirements. These oxygen requirements are applicable in the remaining CO non-attainment areas (oxyfuel programs) and certain ozone non-attainment areas (reformulated gasoline programs) also use oxygenates.

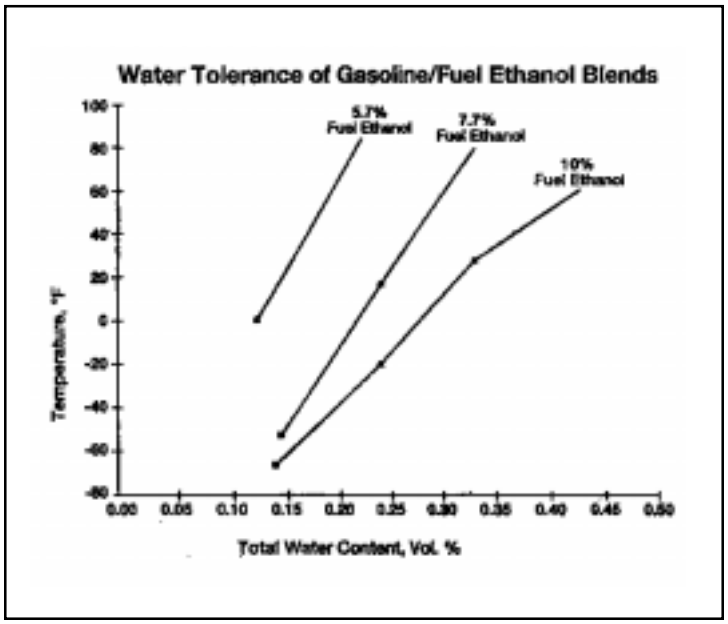
Until the early 1990s, ethanol was usually blended into gasoline at a concentration of 10v% of the final blend. With the advent of oxygenated fuel and reformulated gasoline (RFG) programs, some companies may blend at lower levels to achieve targeted oxygen levels. Denatured ethanol contains approximately 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 and 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 calculating oxygen content.

It should also be noted that when blending gasoline/ethanol blends under the "gasohol waiver" 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 10v% ethanol.

NOTE: Some states such as California may have rules and regulations, specific to their state, which deviate from 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 10v% 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, EPA regulations require that the additives 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 they are utilizing a properly registered detergent/deposit control additive that is in compliance with EPA regulations.

The RFA recommends that its ethanol producing member companies treat their ethanol with a corrosion inhibitor to ensure that any final blend is properly treated for corrosion protection. Blenders should check with their ethanol supplier if they have any questions regarding the type or level of corrosion inhibitor used. 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 are preparing a more 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" and will be available in 2006. It will provide more expanded guidance. We have excerpted the check lists that will 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. Also repaint manhole covers to proper color code (e.g., API color code).
- ❒ 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 conversion

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
- ❒ 5. Discuss approved prior commodities hauled

Outbound Blended Product Delivery

- ❒ 1. Cover information on new terminal blending equipment
- ❒ 2. Cover splash blending procedure (if applicable)
- ❒ 3. Cover color codes (API or company specific 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 pipes 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-five 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 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.

*** The information on materials listed in this table may not be applicable to Ed85. For specific recommendations on materials compatibility with Ed85, see the Ed85 section beginning on page 30. Also aluminum is not recommended for continual contact applications but is suitable for intermittent contact such as transport equipment.**

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 the considerations for each mode of delivery. In all cases, delivery equipment that has not been cleaned prior to use should conform to the recommendations for prior commodities hauled. (See page 8)

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 that are 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. It should be verified 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 empty 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 to avoid contamination. 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.

Placarding of Transportation Equipment

During the 2002-2004 time frame, there was a great deal of confusion about the proper placard number to use for denatured fuel grade ethanol. The lack of clarity results from the U.S. Department of Transportation (DOT) attempting to harmonize their regulations with United Nations (UN) recommendations for transport of hazardous materials.

On June 21, 2001, the U.S. DOT published HM-215D, the latest in a series of regulation changes designed to keep the United States regulations similar to the UN recommendations for transport of hazardous materials. HM-215D was issued as a final rule with an effective date of October 1, 2001. Compliance with the amendments adopted in this final rule was required beginning on October 1, 2002.

There were many additions, deletions, and revisions to the Hazardous Materials Table. One such change was that the entries for "Denatured Alcohol" were removed from the table.

Prior to the above regulations, placarding requirements were governed by the Code of Federal Regulations (CFR), Transportation Sections, specifically section 172 and 173. These regulations resulted in shippers using placard NA 1987 (Denatured Alcohol, Flammable Liquid). When the new regulations were passed, they reflected the deletion of the Denatured Alcohol/Flammable Liquid description for UN 1987.

This issue had caused some ethanol shippers to use the "Flammable Liquid" description, rather than the "Alcohol n.o.s. (ethanol, gasoline), 3, UN1987" description. This concerned the ethanol industry because the proper shipping name "Flammable Liquid n.o.s." has the ID number "UN1993" assigned to it, which refers to guide 128 in the Emergency Response Guidebook. Guide 128 recommends that fire fighters use "regular foam" to fight a large fire for products under this designation. Alcohol (ethanol) is soluble in water and breaks down regular foam almost immediately. Accordingly, it is difficult to extinguish a fire involving fuel ethanol by using regular foam. Secondly, water is not effective to fight a fire fueled by ethanol, until the alcohol contains approximately 80% water.

On the other hand, ID number 1987 refers first responders to guide 127 in the Emergency Response Handbook which recommends the use of an "alcohol resistant" foam, which can be used to fight an ethanol fueled fire. Therefore, in the case of ethanol the Haz Mat description should lead a first responder to guide 127, rather than guide 128 of the Emergency Response Guidebook.

In accordance with CFR § 172.602 the correct emergency response information must be provided.

As such, the RFA engaged in various communications with DOT that ultimately resulted in a petition to the DOT to reinstate the designation Denatured Alcohol, NA 1987." The response to this petition can be found in the Federal Register/Vol. 70 No. 112. The applicable entry from the Federal Register note is as follows:
"We are reinstating the entry 'Denatured Alcohol, NA 1987' in response to a petition by the Renewable Fuels Association (P-1430). We are also adding a new Special provison 172 for the entries 'Denatured Alcohol, NA 1987' and 'Alcohol, n.o.s., UN 1987' to allow solutions of alcohol and petroleum products to be described as either 'Denatured Alcohol' or 'alcohols, n.o.s.' provided the solution contains no more

than 5% petroleum products."

Ethanol Temperature Correction Factors

Fuel grade ethanol is typically sold on a net gallon basis, i.e., temperature corrected to 60˚F. This is also standard procedure for most petroleum products. However, fuel grade ethanol has a different coefficient of expansion than petroleum products and requires different conversion tables than gasoline.

The coefficient of expansion for fuel grade ethanol is 0.00063/F˚. This corresponds approximately to API temperature correction table 6B (General Products) for API Gravity 51.5˚. The following table provides the temperature correction factors to convert a fuel grade ethanol volume to 60˚F.

Fuel Ethanol
Table for Correction of Volume to 60ºF

Temp˚ F	Factor	Temp˚ F	Factor	Temp˚ F	Factor
-10	1.0441	27	1.0208	65	0.9968
-9	1.0435	28	1.0202	66	0.9962
-8	1.0428	29	1.0195	67	0.9956
-7	1.0422	30	1.0189	68	0.9950
-6	1.0416	31	1.0183	69	0.9943
-5	1.0409	32	1.0176	70	0.9937
-4	1.0403	33	1.0170	71	0.9931
-3	1.0397	34	1.0164	72	0.9924
-2	1.0391	35	1.0157	73	0.9918
-1	1.0384	36	1.0151	74	0.9912
0	1.0378	37	1.0145	75	0.9905
1	1.0372	38	1.0139	76	0.9899
2	1.0365	39	1.0132	77	0.9893
3	1.0359	40	1.0126	78	0.9887
4	1.0353	41	1.0120	79	0.9880
5	1.0346	42	1.0113	80	0.9874
6	1.0340	43	1.0107	81	0.9868
7	1.0334	44	1.0101	82	0.9861
8	1.0328	45	1.0094	83	0.9855
9	1.0321	46	1.0088	84	0.9849
10	1.0315	47	1.0082	85	0.9843
11	1.0309	48	1.0076	86	0.9836
12	1.0302	49	1.0069	87	0.9830
13	1.0296	50	1.0063	88	0.9824
14	1.0290	51	1.0057	89	0.9817
15	1.0283	52	1.0050	90	0.9811
16	1.0277	53	1.0044	91	0.9805
17	1.0271	54	1.0038	92	0.9798
18	1.0265	55	1.0031	93	0.9792
19	1.0258	56	1.0025	94	0.9786
20	1.0252	57	1.0019	95	0.9779
21	1.0246	58	1.0013	96	0.9773
22	1.0239	59	1.0006	97	0.9767
23	1.0233	60	1.0000	98	0.9761
24	1.0227	61	0.9994	99	0.9754
25	1.0221	62	0.9987	100	0.9748
26	1.0214	63	0.9981	101	0.9742

Gross gallons can be adjusted to net gallons at 60˚F with the preceding table. For instance, if 8,000 gross gallons with a temperature of 76˚F were converted to net gallons, this would equate to 7,919.2 net gallons as follows:

8,000 x 0.9899 = 7919.2

Tables may vary slightly among ethanol producers. This is because of potential small differences in gravity as well as the possible rounding of the coefficient of expansion (e.g., 0.0006 instead of 0.00063). The applicable ethanol supplier should be consulted to obtain copies of their temperature correction table and to determine if they differ from the previous table.

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. Petroleum or laboratory equipment suppliers should be able to supply 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

It should be noted that the addition of denaturant will result in a higher proof reading than would have been obtained if the proof reading had been taken on the ethanol before denaturing. As an example, 199 proof ethanol, once denatured, would typically yield a proof reading of 201.1 at 60˚F.

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˚)

Temp	200 Proof Ethanol*			199 Proof Ethanol*		
˚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

Temp	198 Proof Ethanol*			197 Proof Ethanol*		
˚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.

Note that the apparent proof is the hydrometer reading

The hydrometer renders accurate proof readings at 60˚F. If product temperature is not 60˚F, a correction table is used. The table at left covers ethanol which is 197 to 200 proof before denaturing. Fuel grade ethanol should not typically be below 197 proof prior to denaturing. Proof tables may vary slightly among ethanol producers if denaturants with a different API gravity are used.

API Gravity/Specific Gravity: The RFA Technical Committee has been advised that some terminals will also test for API Gravity. Among companies utilizing this test, of which we are aware, the specified API Gravity Range is API 46˚ to 49˚. This corresponds to a Specific Gravity range of 0.7972 to 0.7839 (the Specific Gravity scale is inverse to the API Gravity scale). This should not be a problem for properly denatured, uncontaminated ethanol that was at least 197 proof before denaturing. Note that terminals using API Gravity as a quality control procedure consider API Gravity outside the above specified range as necessitating further examination. API Gravity outside the range is generally not used as a sole reason to reject a load.

Finally some terminals are utilizing instruments that are not temperature compensated to account for the reproducibility of the test method. Consequently terminals will usually allow +/- 0.6 API units for test variability. For those who may not be familiar with the API Gravity/Specific Gravity conversion formulas they are provided below:

For converting API gravity to Specific gravity at 60˚F

$$\frac{141.5}{(131.5 + API^{\circ})} = \textbf{Specific Gravity}$$

For converting specific gravity to API gravity at 60˚

$$\frac{141.5}{\text{specific gravity}} \div 131.5 = \textbf{API Gravity}$$

Note that at the current time, RFA does not offer a recommended practice guideline for API Gravity or Specific Gravity. These issues, if applicable, are currently addressed between customer and supplier.

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 procedures 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 with 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 six.

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, as acetic acid, to 0.007 mass percent (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 six.

Sulfur Content: As noted on page seven, requirements to lower the sulfur content of gasoline have led to the sulfur content of ethanol being an important issue. ASTM has a sulfur specification for denatured ethanol in ASTM D 4806 and California has its own applicable regulation regarding the sulfur content of denatured ethanol.

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. This is the test method specified in California regulations. The most recent copy of ASTM D 4806 should be consulted for applicable sulfur limitations and appropriate test procedures.

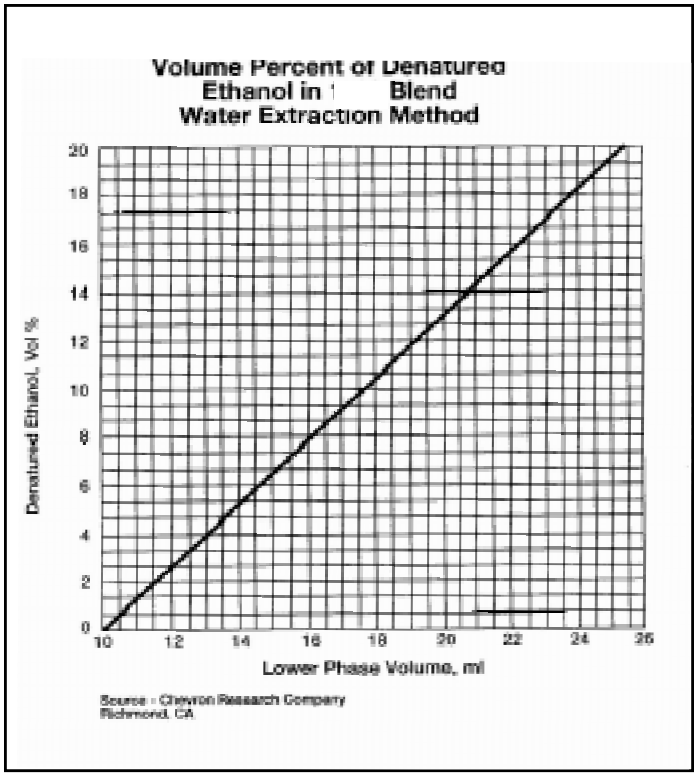
Gasoline Ethanol Blends

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.

Blenders 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 that 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, as well as other areas, and efforts are underway to increase their number.

Specifications and Properties of Ed85: 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".

Much like gasoline, the volatility of Ed85 is adjusted seasonally to improve cold start and warm up performance. This is done by increasing the amount of gasoline in blends sold during colder months. There are three volatility classes numbered 1, 2, and 3. A class is specified by state (or portions thereof) for each month of the calendar year. This information can be found in the tables in ASTM D 5798. Key properties controlled by the ASTM specifications are covered in the following table.

ASTM D5798-99 Standard Specification for Fuel Ethanol for Automotive Spark-Ignition Engines

Property	Value for Class			Test Method
ASTM volatility class	1	2	3	N/A
Ethanol, plus higher alcohols (minimum volume %)	79	74	70	ASTM D5501
Hydrocarbons (including denaturant) (volume %)	17-21	17-26	17-30	ASTM D4815
Vapor pressure at 37.8ºC kPa psi	 38-59 5.5-8.5	 48-65 7.0-9.5	 66-83 9.5-12.0	 ASTM D4953, D5190, D5191
Lead (maximum, mg/L)	2.6	2.6	3.9	ASTM D5059
Sulfur (maximum, mg/kg)	210	260	300	ASTM D3120, D1266, D2622
Methanol (maximum, volume %)	0.5	N/A		
Higher aliphatic alcohols, C3-C8 (maximum volume %)		2		N/A
Water (maximum, mass %)		1.0		ASTM E203
Acidity as acetic acid (maximum, mg/kg)		50		ASTM D1613
Inorganic chloride (maximum, mg/kg)		1		ASTM D512, D7988
Total chlorine as chlorides (maximum, mg/kg)		2		ASTM D4929
Gum, unwashed (maximum, mg/100mL)		20		ASTM D381
Gum, solvent washed (maximum, mg/100mL)		5.0		ASTM D381
Copper (maximum, mg/100mL)				ASTM D1688
Appearance				Product shall be visibily free of suspended or precipitated containmants (clear and bright). This shall be determined at ambient temperature or 21º C (70º F), whichever is higher.

The octane of Ed85 is much higher than that of gasoline, ranging from 96 to 97, depending on gasoline content. The motor octane number is typically 87.5-88.5 and the research octane number is typically 104.5 to 108. This results in the (R+M)/2 octane number of 96-97.

The energy content of Ed85 is lower than gasoline and ranges from 83,400 btu/gallon to 87,000 btu/gallon (depending on the gasoline content) compared to gasoline's typical energy content of 114,000 btu/gallon. Thus a gallon of Ed85 contains approximately 73% to 76% as much energy as a gallon of gasoline.

The Renewable Fuels Association has also made certain recommendations about appropriate detergent treatment of Ed85. 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 polyisobutylene 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.

Materials Compatibility - Ed85

Some materials become degraded by continual contact with fuel ethanol blends having high alcohol concentrations. Zinc, brass, lead, and aluminum are sensitive metals. Terne (lead-tin-alloy)-plated steel, which is commonly used for gasoline fuel tanks, and lead-based solder are also incompatible with E85. Avoid using these metals because of the possibility of fuel contamination and potential difficulties with vehicle driveability. Unplated steel, stainless steel, black iron, and bronze have shown acceptable resistance to ethanol corrosion.

Nonmetallic materials that degrade when in continual contact with fuel ethanol include natural rubber, polyurethane, cork gasket material, leather, polyvinyl chloride (PVC), polyamides, methyl-methacrylate plastics, and certain thermo and thermoset plastics. Nonmetallic materials that have been successfully used for transferring and storing fuel ethanol include nonmetallic thermoset reinforced fiberglass, thermoplastic piping, and thermoset reinforced fiberglass tanks as listed by Underwriters Laboratories, Inc. Buna-N, Neoprene rubber, polypropylene, nitrile, Viton, and Teflon materials may also be used with E85.

A list of Ed85 alcohol-compatible equipment can be found at http://www.e85fuel.com/information/manufacturers.htm. In addition, the National Renewable Energy 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 (DOE). The handbook contains additional information on materials compatibility. It is also a condensed, concise information source for Ed85 properties and specifications, fuel storage and dispensing, safety procedures, and additional industry contacts. This document can be obtained from the Renewable Fuels Association website (www.ethanolrfa.org). The DOE also has an "E-85 Tool Kit" available that covers a range of E-85 information. It is available on line at www.eere.gov/afdc/e85toolkit/index.html. Additional information on Ed85, Flexible Fueled Vehicles, and Ed85 fueling facilities can be found at the following websites:

National Ethanol Vehicle Coalition
www.e85fuel.com

Governor's Ethanol Coalition
www.ethanol-gec.org

Renewable Fuels Association
www.ethanolrfa.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 fuels. A number of fleet demonstrations have been completed with favorable results and some controlled testing has also been completed. E diesel blends have 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 blends with various fuel system parts and also to determine the long range effects 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.

Most E diesel blends have properties similar to standard diesel fuel, or can be modified to be similar through the use of additives. One important difference is the lower flash point of E diesel blends. While diesel fuel is designated as a Class II flammable liquid, E diesel blends are designated as Class I. There is the potential for an ignitable fuel vapor/air mixture to exist above E diesel blends in storage tanks and vehicle tanks. This necessitates several safety precautions as well as retraining of service personnel.

The typical properties of E diesel blends are listed in the following table.

Suggested Specification on Typical Properties
(E diesel Consortium 12/01/02)

Property	Test Method	No. 2 diesel	E diesel
Flash Point min. (C/F)	ASTM D93	52˚/125.6˚	10˚/50˚
Water & Sediment, % max.	ASTM D1796	0.05	?
Distillation % vol rec. T-90 (C) max	ASTM D 86	332	311
Kinetic Viscosity, 40 C (cSt)	ASTM D445	1.9-4.1	1.9-4.1
Ash (%) max	ASTM D482	0.01	0.01
Sulfur (%) max (on-road)	ASTM D2622	0.05	0.05
Sulfur (%) max (off-road)	ASTM D2622	0.50	0.50
Copper Corrosion @ 3 hr max	ASTM D130	No.3	No.3
Cetane Number, min	ASTM D613	40	40
Cetane Index, min	ASTM D4737	45	42
Cloud Point (C/F)	ASTM D2500		4.4˚/40˚
Ramsbottom Carbon, 10% res.	ASTM D4530	0.35	0.22
API Gravity, max	ASTM D287	39	38
Lubricity (g) min (SBOCLE,g)	ASTM D6078	3100	3100
Accel. Stability, pass/fail test	Octel F-21	Pass	Pass
LTFT at -11 C, pass/fail test	ASTM D4539	Pass	Pass
#2 diesel fuel vol (min/max)		100%	79-89
Ethanol vol (min/max)		0%	7-15
Proprietary additive vol % (min/max)		n/a	0.2-5%
Pour Point min. (C/F)			-17.7˚/0˚

a. Due to the low flash point of E diesel it should be treated as a Flammability Class 1 liquid (i.e. similar to gasoline).

b. Since ethanol has a lower btu content than #2 diesel, the btu content of E diesel will be lower than #2 diesel. This will vary dependent upon the volume % ethanol present in the blend. The actual affect this may have on fuel economy is dependent upon the engine type and duty cycle.

At present, there is no ASTM specification for E diesel blends. However, ASTM has recently formed a task group that is attempting to develop a specification. E diesel blends are not EPA approved for on-road use at the current time except for designated fleet demonstration programs. While the RFA is supportive of developing a commercialization pathway, it considers E diesel blends to be experimental fuels at the present time. Additional information on E diesel can be found on the National Renewable Energy Laboratory's website at www.nrel.gov. The E diesel Consortium also has a website, www.e-diesel.org.

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 proton 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 employed. Such fuel cells include phosphoric acid, molten carbonate, and solid oxide fuel cells, all of which operate at higher temperatures than PEM fuel cells.

The RFA believes ethanol will play an important role as a fuel cell fuel supplying the hydrogen for fuel cell operation. Multi-fuel reformers have already been developed which can process gasoline, ethanol, and other liquid fuels to provide hydrogen. Ethanol is, of course, produced at numerous locations and is inventoried at distribution terminals across the United States. On a global scale, ethanol is produced and/or used in several countries including Canada, Brazil, China, Thailand, and Japan.

As the hydrogen infrastructure is developed, various fuels may be used to produce hydrogen in different regions of the country. Ethanol is a clean, renewable, hydrogen source that provides enormous benefits in reducing the greenhouse gases (GHG) that contribute to climate change. 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 that continues to follow fuel cell developments and to position ethanol for a role in fuel cell applications.

Tax Incentives

Recognizing the many public policy benefits of ethanol the federal government, as well as some state governments, offers certain tax incentives for the production and/or use of ethanol for transportation fuel use. The structure of some of these incentives has been modified through recent legislation.

The Volumetric Ethanol Excise Tax Credit (VEETC) signed into law October 2004, allows blenders to claim the $0.51 per gallon tax benefit on each gallon of ethanol used. The VEETC replaces the former motor fuels tax exemption for ethanol. There are various requirements under the regulations for VEETC. The IRS has issued guidance in the form of *Fuel Tax Guidance, IRS Notice 2005-04.* See the IRS website at: www.irs.gov/puh/irs-drop/n-05-04.pdf. The RFA has also issued guidance and additional information is available on RFA's website.

Small Ethanol Producer Tax Credit: The 2005 Energy Policy Act expanded the definition of a small ethanol producer to include plants of up to 60,000,000 gallon annual production capacity. Plants defined as "small ethanol producers" are eligible for a production incentive of 10 cents per gallon on the first 15 million gallons of ethanol produced each year.

Other Documents Available From the Renewable Fuels Association
(www.ethanolrfa.org)

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 website or from RFA member companies.

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, National Renewable Energy Laboratory, (April 2002)

Guidelines for Establishing Ethanol Plant Quality Assurance and Quality Control Programs
RFA Publication # 040301, (August 2004)

Coming in 2006

We anticipate releasing new documents in 2006 as well as a complete revision of one of our "out of print" documents. These papers and their estimated availability dates are listed below.

Ethanol Transportation and Distribution Guide (estimated availability May 2006)

Gasoline Ethanol Blends-Program Operations Guide, RFA Recommended Practice #930601 (June 1993) *This document is being completely updated and changed to electronic format. (Estimated availability July 2006)*

Changes in Gasoline IV (estimated availability September 2006)

Numerous other papers, information sources and links to other websites are also available at the RFA website.