Ethanol and Gasoline Ethanol Blends Coming to Hawaii

An Informational Workshop

for

The Petroleum Industry

Presented by:

Robert E. Reynolds
President
Downstream Alternatives Inc.
2259 Harwood Street
South Bend, IN 46614
phone: (574) 250-2811
fax: (574) 231-8975
email: rreynolds-dai@earthlink.net

Introduction

Slide 1 (title/DAI)

Good morning (afternoon), as you are aware, the State of Hawaii has passed legislation requiring the future use of ethanol in gasoline. The State has now proposed regulations to implement those requirements.

The purpose of my presentation today is not to debate the merits of the program but to discuss what types of things need to take place in preparation of meeting these requirements, what such preparations have traditionally cost in other areas, provide some additional information resources, and finally to give you a chance to ask any questions you may have. I would prefer to hold questions until the end of the presentation since I may well be covering topics that would answer such questions. However, if you have a question you feel cannot wait, feel free to interrupt me.

Ethanol Demand & Supply - Anticipated Volumes

I want to start by looking at the gasoline and ethanol volume requirements since those affect a number of transportation, storage, and inventory issues.

Slide 2

Hawaii Gasoline Demand - 2003

Oahu	Hawaii	Kauai	Maui County	State Total
263,025,311	85,189,449	32,796,102	73,834,662	454,845,525

This slide covers gasoline demand for 2003. Gasoline sales have been increasing an average of 1.74% in Hawaii. If we use this figure, it would result in the following projected gasoline demand in 2006, the first year of the ethanol requirement.

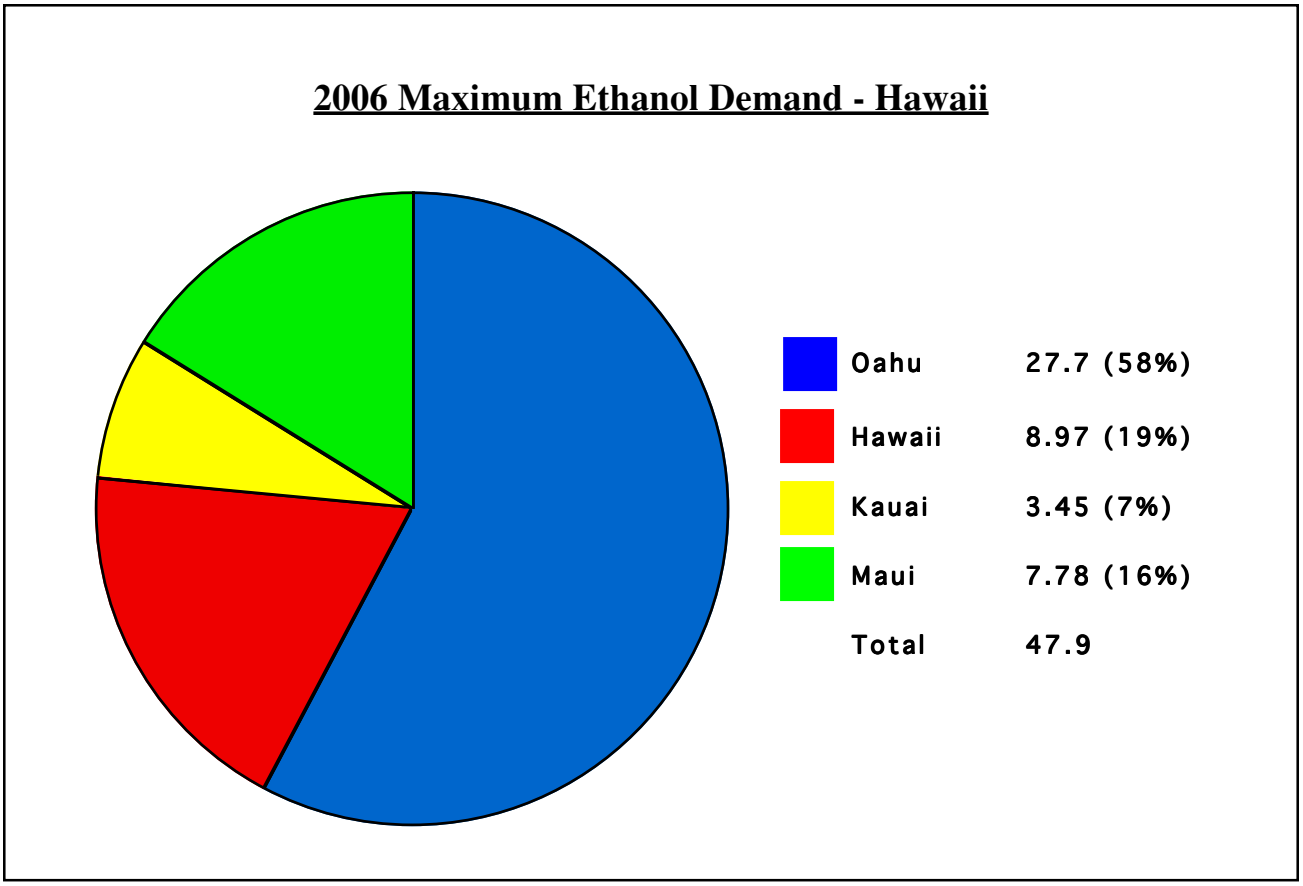
Slide 3

Projected Hawaii Gasoline Demand - 2006

Oahu	Hawaii	Kauai	Maui County	State Total
276,995,518	89,714,162	34,538,019	77,756,282	479,003,981

If we assume 85% to 100% of the gasoline is blended with ethanol this would equate to 40.7 million to 47.9 million gallons per year (mgy) of ethanol demand. For purposes of this discussion, I will use 47.9 million gallons since it represents the high side number. This slide graphically depicts the ethanol volume by area.

Slide 4



Hawaii has adequate feedstocks to produce ethanol volumes well in excess of demand. That does not mean that all feedstocks would be converted because there are obviously numerous considerations. Local plants being considered, if all are built/converted, could produce adequate supplies to cover in-state ethanol demand.

Slides 5

Ethanol Production Plants Being Considered

Island	MMGY
Maui	7 (+7 mmgy Phase II)
Kauai	6 (+6 mmgy Phase II)
Kauai	10
Oahu	15
Total	48 (+13 mmgy Phase II)

No one can say with certainty that each plant will be built and/or built and expanded. Nor can we be certain that all plants would be on line, at full production, by 2006. So the most likely scenario, when the ethanol requirement takes effect, is a combination of domestic production and ethanol imported from the mainland and/or Caribbean Basin producers. Ethanol imported from the mainland or Caribbean would come into Oahu and then be redistributed by barge to the other islands. Ethanol from local plants would first be used to meet demand on the island where they are located with the remainder being shipped to the other islands. Regardless of source, total demand will drive storage and transportation considerations. This first necessitates a look at the terminals here on the islands.

Petroleum Industry Infrastructure

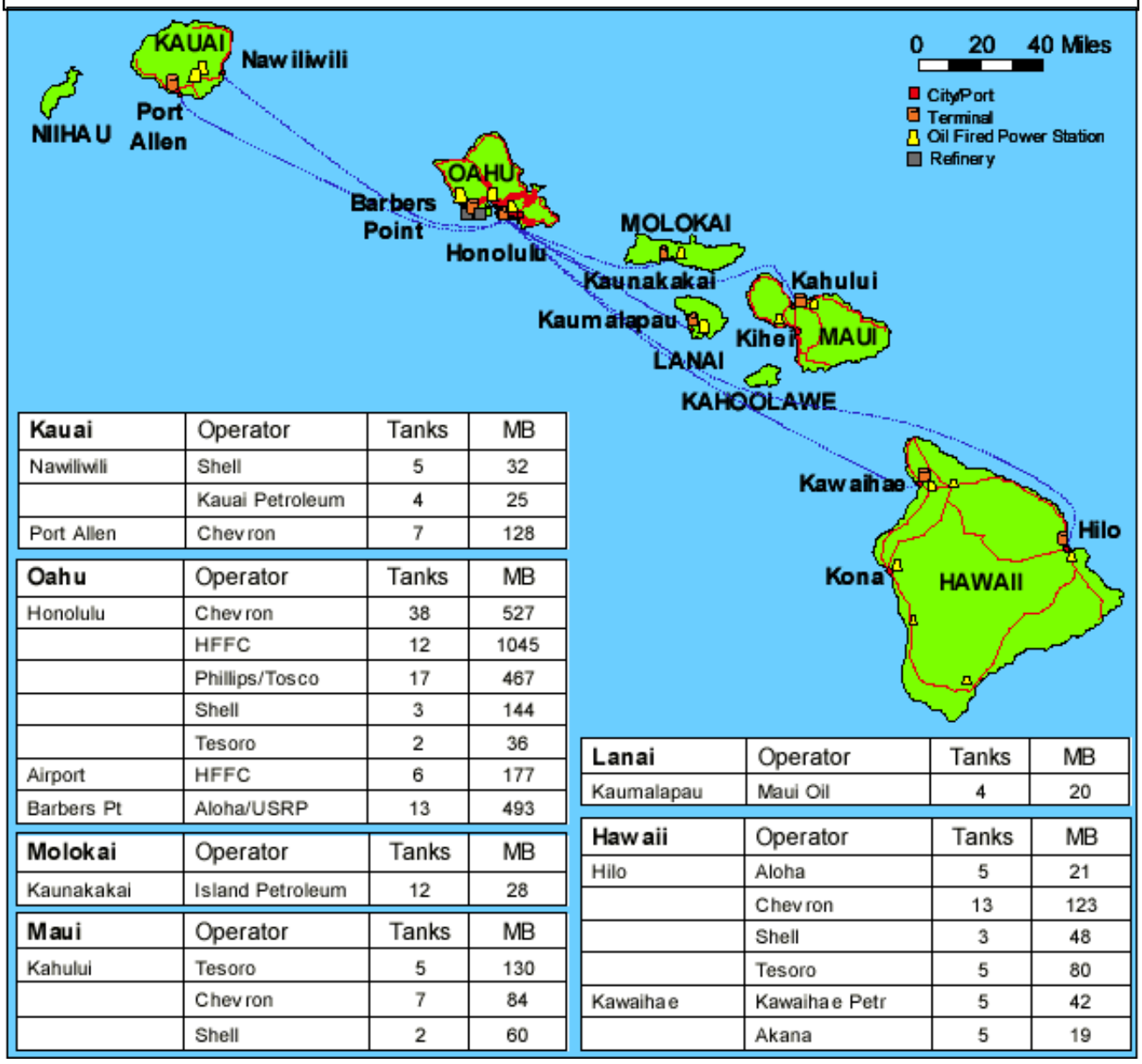
Petroleum Products Terminals - Hawaiian Islands

Island	Company	Location	Capacity (MB)	No. of Tanks	Truck Rack	Comments
Oahu	Aloha Petroleum	Kapolei/Barbers Point	500	13	x	
	Chevron Texaco	Honolulu	527	38	x	
	Shell/Equilon	Honolulu	274-302	15	x	
	Tesoro Hawaii	Honolulu	36	2	x	barge/pipeline receiving?
	Tesoro West	Sands Island	–			diesel only
	ConocoPhillips	Honolulu	457	17	x	
	Transmontangue	Mililani	–			????
	AGI	Sands Island	–			jet fuel
	HECO	Barbers Point	–			fuel oil only
Hawaii	Chevron Texaco	Hilo	115-123	13	x	
	Shell/Equilon	Hilo	48-60	3	x	
	Tesoro Hawaii	Hilo	80-86	5		distillates
	Tesoro West	Hilo	–			naphtha
	ConocoPhillips	Kawaihae	–	5		
	Akana Petroleum	Kawaihae	19			trucked from Hilo
	Kawaihae Petroleum		19	5		
	Aloha Petroleum		21	5		
Maui	Shell	Kahului	–			diesel/lease
	Chevron Texaco	Kahului	75			
	Tesoro Hawaii	Kahului	125			
	ConocoPhillips	Kahului	–			
Kauai	Shell	Lihue/Niailliwilli	32	5		
	Kaui Petroleum	LihueNiailliwilli	25	4		
	Chevron Texaco	Port Allen	128	7		
	Tesoro Hawaii	Lihue	–		x	
Lanai	Maui Oil	Kaumalapau	20		x	4 MB barges
Molokai	Inter Islands Pet.	Kaunakakai	28	12		

This slide represents the information we could pull together for all of the various terminal atlases. As you can see, a number of terminals have numerous tanks while some have only a few. So the considerations will be somewhat different among terminals.

Slide 7

Hawaii Petroleum Infrastructure



Kauai	Operator	Tanks	MB
Nawiliwili	Shell	5	32
	Kauai Petroleum	4	25
Port Allen	Chevron	7	128

Oahu	Operator	Tanks	MB
Honolulu	Chevron	38	527
	HFFC	12	1045
	Phillips/Tosco	17	467
	Shell	3	144
	Tesoro	2	36
Airport	HFFC	6	177
Barbers Pt	Aloha/USRP	13	493

Molokai	Operator	Tanks	MB
Kaunakakai	Island Petroleum	12	28

Maui	Operator	Tanks	MB
Kahului	Tesoro	5	130
	Chevron	7	84
	Shell	2	60

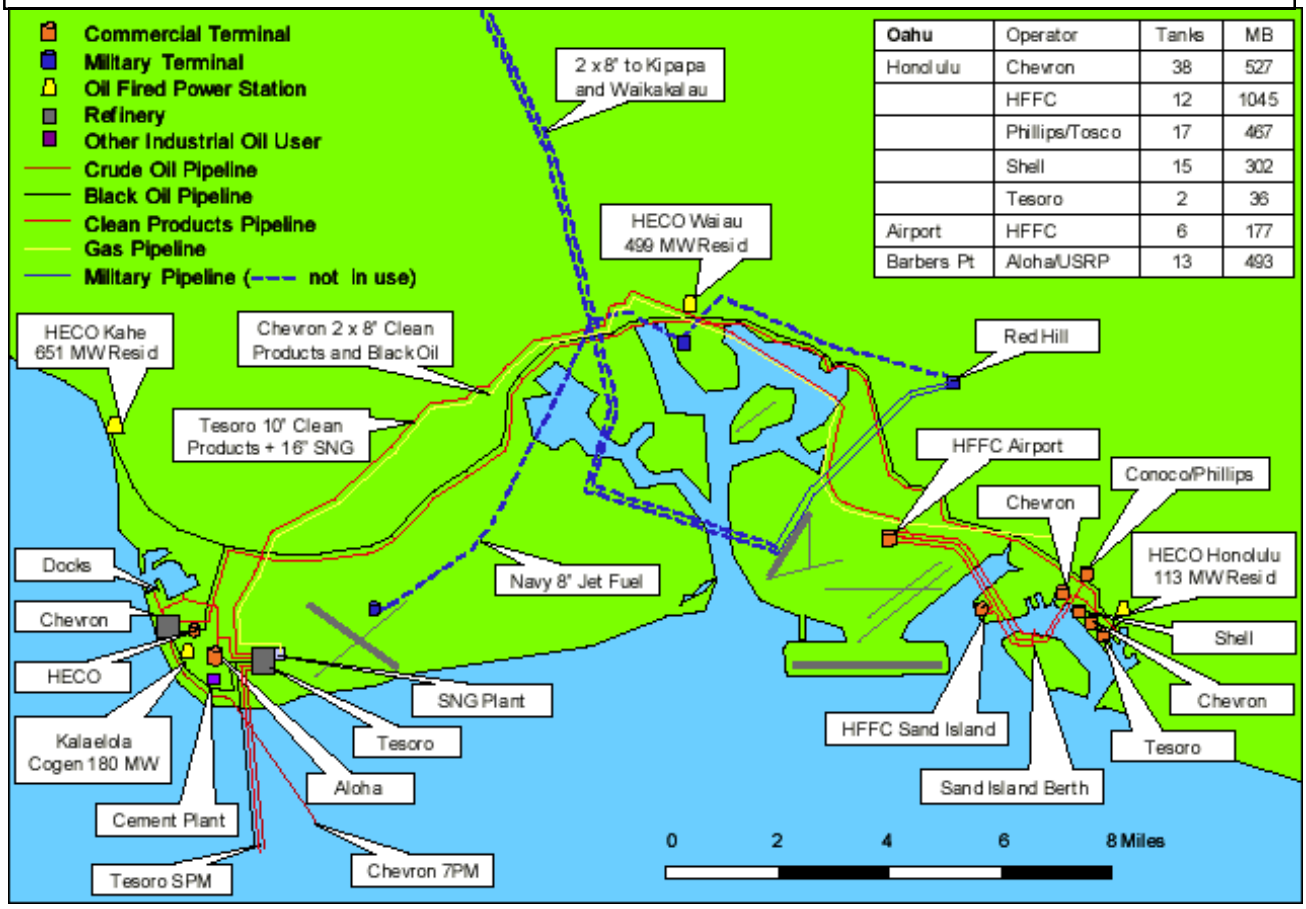
Lanai	Operator	Tanks	MB
Kaumalapau	Maui Oil	4	20

Hawaii	Operator	Tanks	MB
Hilo	Aloha	5	21
	Chevron	13	123
	Shell	3	48
	Tesoro	5	80
Kawaihae	Kawaihae Petr	5	42
	Akana	5	19

This slide, taken from a report for the state by Stillwater and Associates, shows an overview of the petroleum distribution system on Oahu and lists the various terminals and tankage.

Slide 8

Oahu Petroleum Infrastructure



Oahu	Operator	Tanks	MB
Honolulu	Chevron	38	527
	HFFC	12	1045
	Phillips/Tosco	17	467
	Shell	15	302
	Tesoro	2	36
Airport	HFFC	6	177
Barbers Pt	Aloha/USRP	13	493

This slide (also from Stillwater) is a blow up of the Oahu/Honolulu area petroleum infrastructure with the same type of information.

It is likely that the combination of ethanol producers/importers and refiners/blenders can be expected to maintain a working inventory equal to a 20 to 40 day supply of ethanol demand or about 4 million gallons (95 MB to 100 MB). This would ideally be maintained on a market proportional basis on each major island as follows:

Slide 9

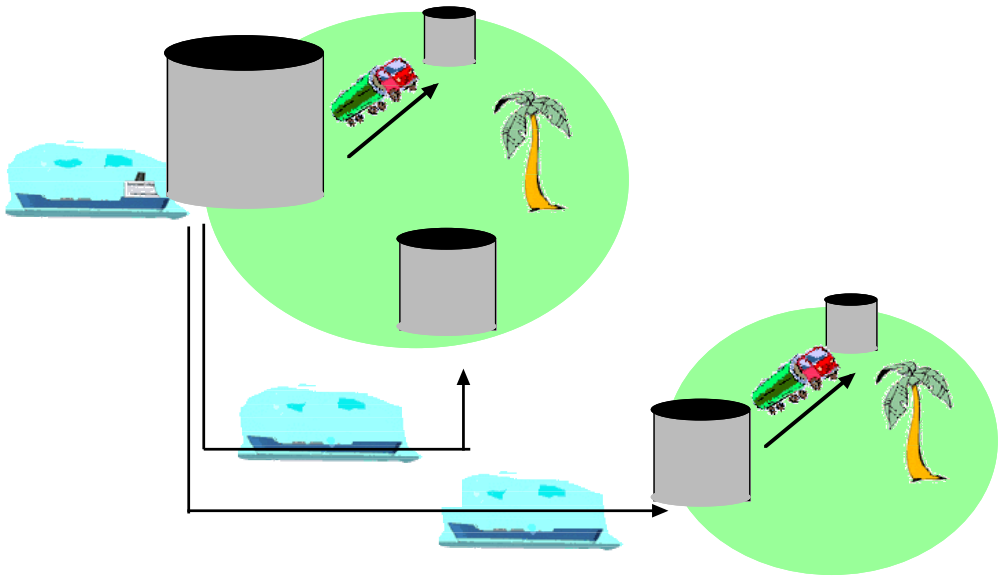
Projected Working Inventory by Island Market

Market	Million gallons	Barrels
Oahu	2.30	55,000
Hawaii	0.75	18,000
Kanai	0.29	7,000
Maui	0.65	26,000
Total	3.99	96,000

While in many cases, the ethanol may be trucked from local plants, blenders will usually want barge delivery capability for their ethanol to accommodate purchasing opportunities and to keep local plants competitive.

Slide 10

Ethanol Movements Between Islands



For the same reason gasoline ethanol blends are not shipped via pipeline, they will not routinely be shipped by barge. Ethanol will be delivered by barge or truck for blending at the terminal. On Oahu, it is likely that imports (or shipments from other islands) would come into the Aloha Terminal and be trucked or barged to other terminals. If all product were handled this way, this would require less than 90 MB of storage. This would allow enough storage for maintaining working inventory levels and additional space to receive shipments. Product produced locally would most likely be trucked to the terminals. Aloha has tanks available for such ethanol shipments on Oahu. Also, on Oahu, Shell has a tank available and ConocoPhillips also has a tank available but it needs retrofitting.

On Kauai, Shell has a tank that could accommodate ethanol while Chevron Texaco's availability is unknown.

On Maui, Shell has a tank available. Tesoro is limited on tankage although an ethanol supplier may install tankage next door and connect supply via pipeline. Again, the availability of tankage at Chevron Texaco is not known.

On Hawaii, Shell has a tank available on the Hilo side and Aloha may be able to make tanks available. Tesoro's and Chevron Texaco's status is unknown. On the Kona side, Conoco Phillips and Akana Petroleum have small terminals. These terminals may need to install tanks or work out exchanges.

At least one terminal on each of the main islands will want to receive ethanol via barge. There are currently 6 inter-island petroleum barges that handle clean products and they range in size from 4 MB to 70 MB.

Slide 11

Inter Island Clean Product Barges

Company	Name	Service	Bbl	Charter
Sause Brothers	Pepeekeo	24 compartments	53,000	Chevron to Port Allen, Kahului and Hilo
Smith Brothers (Hawaiian Inter Island Towing)	Hui Mana	10 compartments	40,000	Tesoro to Nawiliwili, Hilo, Kahului, Kawaihae
	Namoku	9 compartments	37,000	Aloha to Hilo Tesoro to Nawailiwili, Kahului
	No'eau	12 compartments	30,000	Aloha to Hilo Tesoro to Nawiliwili, Kahului
	Tara	6 compartments	4,000	Owned by Lanai Oil, operated by Hawaiian Inter Island

These barges are compartmentalized to accommodate delivery of multiple products to one or more of the islands. Terminal operators will, of course, want to size their tanks to maintain 30 days inventory while still being capable of receiving at least the smallest delivery size before working inventory drops below 10 to 15 days of supply. This will of course be dependant on each individual terminal's throughput volume but would likely not exceed 5 M - 10 M barrels for most terminals.

In an ideal world, each terminal would have adequate tankage to receive barges and maintain working inventories. They would also have their own sophisticated blending system. But petroleum logistics are never ideal and other options will be considered.

Cooperation within the industry on tankage could reduce costs for some terminal operators and perhaps generate revenues for others. For instance, it is really only necessary for one terminal on each of the main islands to have marine receipt capabilities for ethanol. If product were handled this way, other terminals could reduce tankage size and working inventory by trucking product from a central point.

Slide 12

Terminal Agreements

Pre-program		Post-program	
A	**B**	**A**	**B**
UL	UL	UL	D
P	P	P	D
D	D	E	?

Another example of industry cooperation would be when two adjacent or nearby terminals both handle gasoline and diesel fuel but neither has storage for ethanol. They could both install new tanks. But they could also agree to put all gasoline through terminal A and all diesel through terminal B freeing up tanks to store ethanol at terminal A and then arrange throughput agreements. This eliminates the need for a tank, blending equipment, and other modifications at one terminal (terminal B is this example).

So there are a number of ways to reduce cost. I do want to cover what needs to happen for program preparation at the terminal level and what the costs may be for those terminals making such preparations.

Terminal Preparations

Tankage: Each terminal handling ethanol will need to rededicate an existing tank to ethanol storage or install a new one. The ethanol tank will need to be large enough to accept the largest anticipated delivery size, plus working inventory. For most terminals, 5 MB - 10 MB barrels will be more than adequate.

Slide 13

Tankage Requirements at Terminals

- Correctly sized for working inventory/deliveries
- Fixed roof with internal floater (recommended)
- 16 ounce pressure/1 ounce vacuum vent (p/v vent) (confirm tank can tolerate pressure and vacuum)
- Retrofits-clean tank & inspect
- Inspect for SCC
- #40 mesh filter

Ideally tanks should be fixed roof with a floating internal cover. Tanks should be fitted with a 16 oz. pressure/1 ounce vacuum (pv) vent (verify tank withstands these ratings). If the tank is a retrofit, it should be thoroughly cleaned and inspected, including an inspection for stress corrosion cracking (SCC). Some companies are now lining bottoms to minimize stress corrosion cracking. The line to blending system should be equipped with a #40 mesh filter.

The cost of tankage will, of course, depend on whether an existing tank is retrofitted or a new tank is installed. The NPC estimates new tanks at $18.00 per steel barrel which is consistent with our experience. However, these costs are an average. Smaller tanks tend to run more. In addition, these prices do not include permitting and site work which could bring prices closer to $25.00 per steel barrel for a 5 MB/10 MB tank These are prices on the mainland. Some industry contacts have indicated costs could be as much as 30% higher here, i.e., $32.50 per steel barrel. This would put new tank costs at up to $162,500-for a 5 MB tank and $325,000 for a 10 MB tank.

The cost of retrofitting is obviously much less and depends on the configuration and condition of the existing tank. While cleaning and inspection are relatively minimal expenses, installing a floating internal cover can be more costly. Typically costs can be 20 to 40% of a new installation, or more,

if internal floaters or significant tank maintenance such as rebottoming is required. It should be kept in mind that these tank requirements are for the terminals receiving product by barge. Other terminals on an island that would receive product by truck could probably install day tanks of 1-2 MB.

Blending Options & Equipment: Terminal operators will also need to determine what blend strategy they will employ.

Slide 14

Blending Options

- **In tank blending (not recommended)**
- **Top-off/satellite blending (not ideal)**
- **Sequential blending**
- **In-line/wildstream blending**

There are a number of ways to blend gasoline and ethanol at the terminal, some better than others.

In-tank blending is not recommended. Due to ethanol's sensitivity to moisture, the product could phase separate in storage. Such blending has been successfully done but it has also presented problems in some cases.

Top-off and satellite blending were used on the mainland in the 1980s and early 1990s. This is simply where the gasoline and ethanol are metered into the transport compartment separately relying on the transport driver to achieve the desired blend. (Drivers are furnished calculation cards.) Usually the ethanol and gasoline are at the same rack. In the case of satellite blending, gasoline is picked up at one terminal while the ethanol is picked up at another.

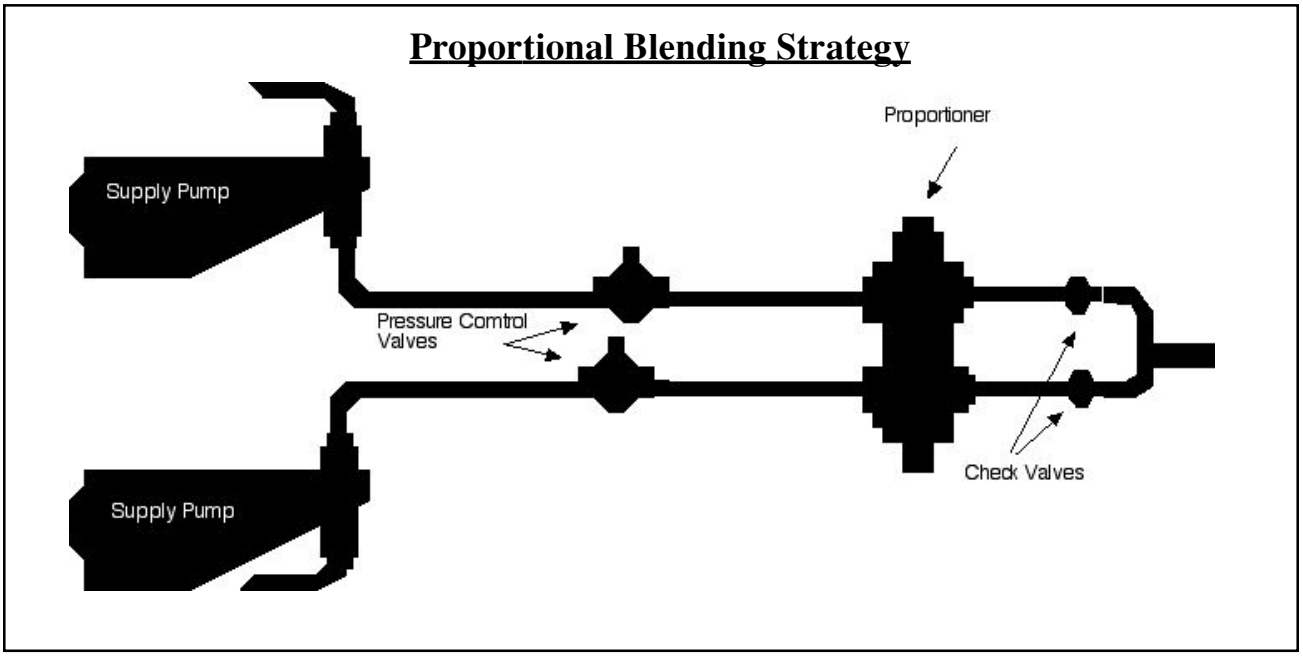
While top-off blending has been used to successfully blend billions of gallons of gasoline ethanol blends, it has its disadvantages. You are relying on the driver to achieve accurate blend levels, and on the loading process, and the motion of the truck in route, to agitate the products into a homogenous blend. Also two bills of lading, invoices, etc. are involved, increasing the level of paperwork.

In the case of satellite blending, some terminals may have policies prohibiting loading on retains, limiting this option. The only real advantage to top-off or satellite blending is the ability to eliminate or delay capital investments on blending equipment.

Today, most companies use automated systems to accomplish ethanol blending. These include proportional blending and sequential blending strategies as well as in-line or "wild stream" blending systems.

Automated systems encompass a range from fairly simplistic to extremely complicated and as you might imagine, represent a wide range of capital expenditures. Some systems are miniature versions of those used in refinery blending and can run up to $200,000. Many prefabricated systems employed at the terminal level can be purchased for much less, usually in the range of $50,000 to $60,000 per truck rack.

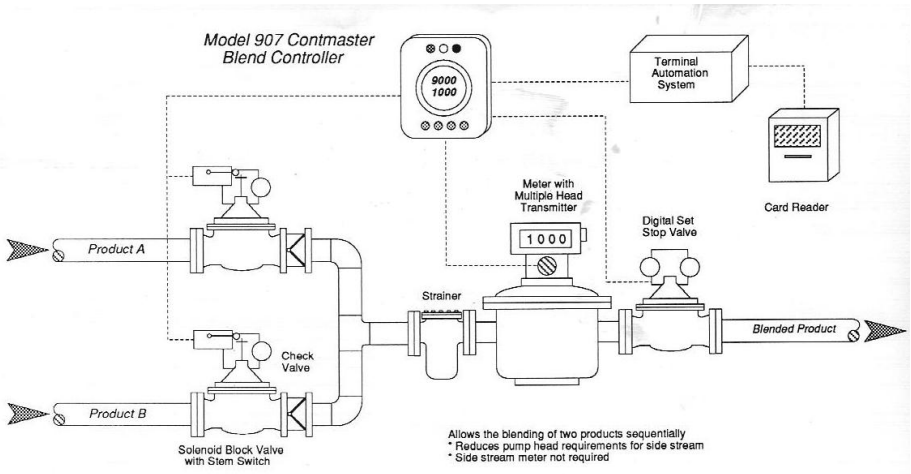
Slide 15



Proportional Blending: Some petroleum companies will design blending systems using proportioning pumps which are off the shelf type items. Many terminals use this approach for mid grade blending. A basic proportioning unit consists of two supply pumps and two proportioning pumps (as liquid motors), to proportion two different liquids. By adjusting the flow rate of the proportioning pumps, precise proportioning of the flow through both lines can be achieved. Each revolution of a proportioning pump displaces the same volume of fluid-regardless of speed variations-proportioning remains accurate even if the pump speed fluctuates. The advantages of this system are its simplicity, relatively low cost, and product is metered through a single meter resulting in one bill of lading and one invoice. The primary disadvantage is that if the system goes down, you cannot load any product.

Slide 16

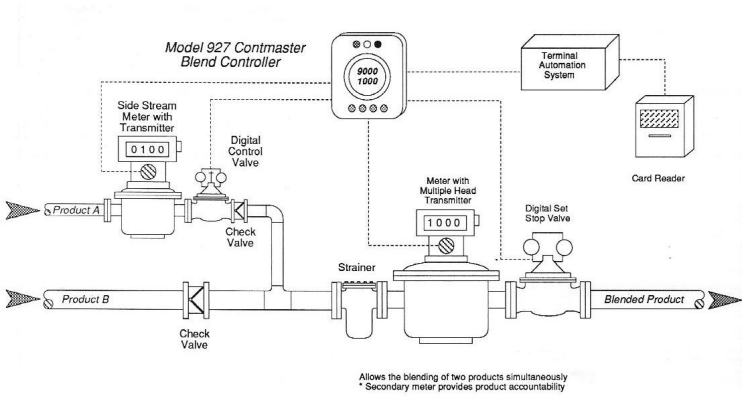
Sequential Blender



Sequential Blenders: Sequential blenders allow loading from a single meter and loading arm injecting the gasoline, followed by the ethanol into the truck compartment. These systems represent lower expense than more sophisticated systems. It is best if these systems are tied into electronic card activation so the driver does not enter blend rates which could be incorrect.

Slide 17

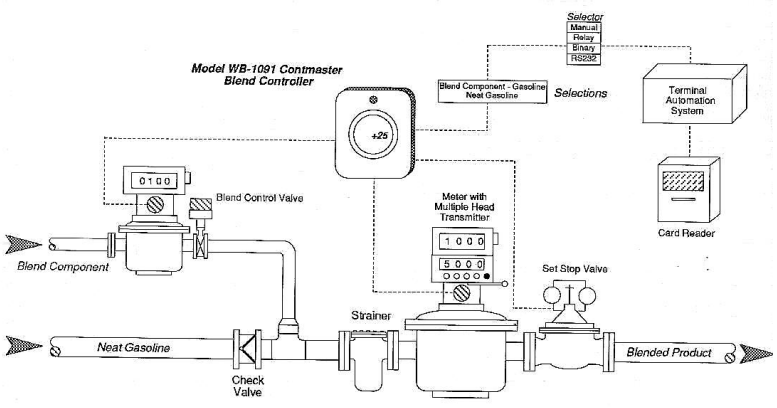
Dual Preset Blender



Dual Preset Blenders: Dual Preset Blenders are simply a variation of sequential blending with digital control valves.

Slide 18

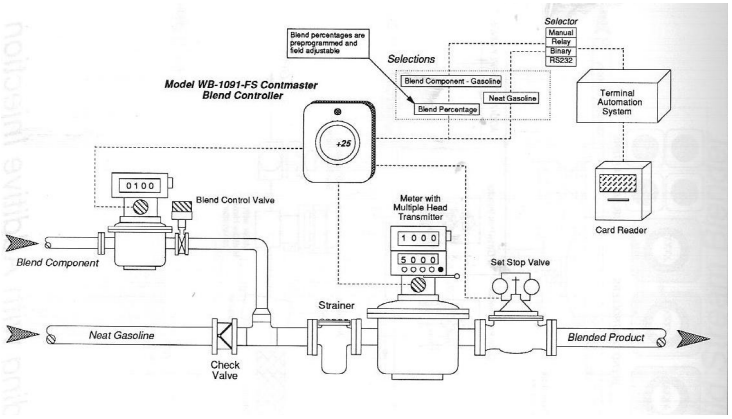
Single Stream Wild Stream Blender



There are also prefabricated skid mounted wild stream blenders. These can be fixed or single stream as in this example:

Slide 19

Selectable Wild Stream Blender



or selectable wild stream blenders as in this example. These units provide a stand alone design that is very cost effective. If installed as loading rack blenders, however, available space may be a consideration.

There are many configurations and equipment groupings to select from. For equipment and more complicated applications you may wish to consult with a company qualified in design and installation of this type of equipment. One example would be PFT/Alexander Services Inc. which has also done some presentations on ethanol handling here on the islands. Obviously, with the many topics I am covering, I am providing a simplified overview here and terminal operators will need details specific to their operations.

Ethanol Receipt Capability: For terminals receiving product by barge, existing product receipt equipment can be used although the ethanol should always be sequenced between off-loading of gasoline cargoes or compartments.

For those terminals receiving product by truck, it may be necessary to install a spot to unload the truck and the necessary manifolds and piping to do so. Such modifications are terminal specific so it is difficult to project cost but they are usually minor (less than $15,000).

Additionally, you need to consider that ethanol will likely cost 40¢ per gallon more than gasoline (before tax credits), so inventory control to minimize shrink will be very important. When outfitting an ethanol receipt station this should be kept in mind. Properly programed temperature compensating meters need to be installed where large quantities are involved. Air elimination is also important. In the case of small quantity truck receipt, air relief heads may be adequate while for larger barge quantities such as vessels, you will likely want an air eliminator prior to the custody transfer meter. Barge vessel receipt terminals may also want to install slip stream liquid density meters, which help monitor the quality of the ethanol being received. And, of course, off-loading stations should be equipped with grounding equipment.

Piping Modifications: Depending on the configuration of the terminal, some piping modifications to accomplish the aforementioned preparations may be necessary. Again, this is terminal specific so cost estimates are difficult but they are usually less than $10,000, especially for smaller terminals.

Other Issues: There are other issues that need to be assessed to determine if any equipment or operational procedures need to be modified. Vapor systems should be adequate since terminals are substituting ethanol volume (at lower vapor pressure) for gasoline volume.

Firefighting equipment and procedures should be reviewed and modified if necessary. The flame from a denatured ethanol fire is very faint and difficult to see in daylight. Local fire departments should be advised that the terminal is now handling ethanol so firefighting personnel are properly informed. A summary of firefighting recommendations based on the foam manufacturer's literature and the results of fire fighting tests conducted at Iowa State University indicates the in the case of

gasoline alcohol blend fires, for spill fires - preferred foams are polymer "alcohol type", fluoroprotein, and AFFF in that order for permanence of blanket and security of the area. "Alcohol type" and AFFF will produce more 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.

For 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.

In the case of ethanol fires, for spill fires - thin (less than one inch) spills can be controlled and extinguished by dilution with water. They can be more quickly controlled with alcohol type" foams or dry chemical BC application. Other foams are rapidly broken down by the alcohol and the net fire control effect is primarily by dilution, not smothering.

Tank fires - "Alcohol-type" foams are the only effective agents.

Initial Conversion - Product Shipments & Terminals

Once any necessary terminal level modifications are complete, the terminal and the retail and fleet facilities serviced by the terminal are ready for conversion. This is more of a procedural issue since costs are minor, but the steps are very important.

Ethanol Shipments: First and foremost, it is necessary to avoid any contamination of the ethanol shipment.

The RFA has issued recommendations for prior commodities hauled and proper cleaning procedures for transport trucks, rail cars, and barges. This recommendation is as follows:

Slide 20

Acceptable Prior Commodities

- Ethanol
- Fuel grade denatured ethanol
- Unleaded gasoline
- Unleaded RBOB
- Unleaded CaRBOB
- Natural gasoline
- E85

Prior commodities that are acceptable in barges, rail cars, and trucks include ethanol, fuel grade denatured ethanol, unleaded gasoline, unleaded RBOB, unleaded CaRBOB, natural gasoline, and E85. 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**.

Barge Shipments: Note that the U.S. Coast Guard requires designating the product grade class of barge shipments. Specifically, Code of Federal Regulations (CFR) Title 46-Shipping, Chapter 1 - Coast Guard Department of Homeland Security, Part 30 General Provisions, 46 CFR 30.10-22 Flammable Liquid Status. Provisions. 46CFR30.10-22 Flammable liquid.

> "The term flammable liquid means any liquid which gives off flammable vapors (as determined by flashpoint from an open-cup tester, as used for test of burning oils) at or below a temperature of 80˚F. Flammable liquids are referred to by grades as follows:

Grade A. Any flammable liquid having a Reid vapor pressure of 14 pounds or more.

Grade B. Any flammable liquid having a Reid vapor pressure under 14 pounds and over 8 1/2 pounds.

Grade C. Any flammable liquid having a Reid vapor pressure of 8 1/2 pounds or less and a flashpoint of 80˚F. or below."

(http://a257.g.akamaitech.net/7/257/2422/01dec20031500/edocket.access.gpo.gov/cfr_2003/octqtr/46cfr30.10-22.htm)

Using the aforementioned criteria, denatured fuel ethanol is grade C because its vapor pressure is nominally 3.0 psi and its flash point is ~55˚F.

Although procedures for handling ethanol are similar to gasoline, all safety and firefighting procedures should be reviewed with both load out personnel at the origin terminal and personnel at the destination terminal. Material Safety Data Sheets (MSDS) should also be provided.

If a company utilizes sample retention and/or testing of product delivered, these procedures should be updated and covered with terminal personnel.

Truck Shipments: While a truck dedicated to ethanol transport is desirable, it is often impractical. Ethanol is generally hauled in transport trucks that are in service delivering other transportation fuels.

If trucks are not dedicated to ethanol service, the next best option would be trucks dedicated to gasoline deliveries. This would eliminate the need to worry about contamination by diesel oils or kerosene. Otherwise, it may be necessary to inspect the truck, which is often not practical.

Since transport loads of ethanol will typically be destined for a petroleum distribution terminal where they are unloaded and stored until the ethanol is blended, the carrier should also be aware of any applicable policies at the destination terminal.

All safety precautions applicable to loading gasoline or other Class I Flammable Liquids into a transport truck would also be applicable to fuel grade ethanol. The truck should be grounded when loading/unloading.

The RFA recommends that trucks be placarded as UN 1987 and use the description "Alcohol n.o.s. (ethanol, gasoline), 3, UN 1987". The technical names "ethanol" and "gasoline" are included to identify the denaturant in the fuel even though a technical name is not required for "Alcohol n.o.s.". The description should lead first responders to guide 127 in the Emergency Response Guidebook. Background on this recommendation, as opposed to using UN 1993, is included in RFA Publication # 960501.

Equipment Shakedown/Testing: Once product is delivered to the terminal, it is advisable to test blending equipment. It is also wise to recalibrate meters after 2-3 weeks of continuous operation to verify that they are still accurate.

A reminder here that all personal who will, or may, come in contact with denatured ethanol should receive or have access to, an MSDS. The following slide provides a quick checklist for orientation of terminal personnel.

Slide 21

Terminal Personnel - Orientation Check List

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

Initial Conversion - Retail & Fleet Facilities

Our data indicates there are approximately 360 retail gasoline outlets on the islands and these will need to undergo some preparation as well. The guidelines for implementing and maintaining a successful gasoline/ethanol blend sales program at the retail level can be divided into three phases, the Investigative/ Preparatory Phase, the Conversion Phase, and the On-going Phase. Each of these phases require certain steps as set forth below.

Slide 22

Retail Facility Operator Checklist

Investigative/Preparatory

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

Investigative/Preparatory Phase: Prior to converting a retail unit to gasoline/ethanol blends it is necessary to assess that units suitability for handling such products. The major concerns in this area are determining the compatibility of tanks (or tank liners) and determining tank history for any water problems.

Tank Compatibility - Steel tanks and nearly all fiberglass tanks are compatible with gasoline/ethanol blends. In some instances, tanks may have been relined with polyester or epoxy linings to prevent leakage. Although many of these lining materials are compatible with gasoline/ethanol blends not all are. Epoxy and polyester linings which are not suitable for gasoline/ethanol blends can deteriorate resulting in degradation of the gasoline being dispensed into the automobile. If a tank was lined due to leakage, the leak could reoccur if the lining is chemically incompatible with the blend. Fiberglass tanks also must be checked for suitability for use with gasoline/ethanol blends. If it is unknown whether a tank is steel, fiberglass, or "lined", this should be determined prior to conversion. It is important that the tank integrity and type be known prior to conversion to gasoline/ethanol blends. If there is any doubt regarding the suitability of a tank, contact the tank manufacturer or lining contractor prior to conversion.

Materials Compatibility - Above ground equipment such as nozzles, hoses, and meter seals have long been compatible with gasoline ethanol blend and should not present any need for modification. Very old submersible pumps may require modification to operate with gasoline/ethanol blends. Although this is rather rare, a determination should be made as to the compatibility of these pumps with gasoline/ethanol blends. Some units could require replacement of impellers and/or seals to avoid impeller "swell". If any doubt exists as to the compatibility of these units, the manufacturer should be consulted.

Control of Water Levels - Underground storage tanks frequently have small amounts of water at the bottom of the tanks, referred to as water bottoms. Excessive water levels can cause the ethanol in a gasoline/ethanol blend to "phase separate" resulting in a phase of water and ethanol on the bottom of the tank. Therefore, it is imperative that water be eliminated from the system. The maintenance history of all tanks to be used for storage of gasoline/ethanol blends should be reviewed. Any tank with a history of excessive water problems should be reviewed closely. The source of water entering the tank must be identified and eliminated before the tank is to be converted to gasoline/ethanol blends. If historic data is not available, it is recommended that historic data be developed and reviewed prior to conversion. There are normally no expenses in this phase unless maintenance that would otherwise be needed is required.

Once the investigative/preparatory phase is complete, the unit can be converted to gasoline/ethanol blends

Slide 23

Retail Facility Operator Checklist

Conversion Plan (before first delivery)

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

Conversion Phase: Prior to the first delivery of a gasoline/ethanol blend, several steps should be taken. These steps include the following.

Check to see if tanks have excessive tilt. This can usually be done by sticking opposite ends of the tank. If one end of the tank is lower, it will result in a higher stick reading than the other end. When one end of the tank is lower, water can collect at the low end and go undetected. In such cases, the low end of the tank should be tested for water prior to the first delivery as well as on an on-going basis. Also if tanks are equipped with tank bottom protectors, it is recommended that these be removed to test for and remove water. This will ensure that all water is removed.

Fill line caps should be checked for proper fit and seal. Any improper fit or seal should be repaired. Man hole covers should be checked for proper water run off and modified if necessary.

Each retail pump or dispenser should be fitted with a 10 micron filter. Some companies may desire to utilize a special filter such as a "water sorb" filter. It is desirable that the filter be installed at a location prior to the dispenser meter to eliminate any suspended sediment from entering the metering device. However this is not always possible.

Important Safety Note: When a unit is equipped with submersible pumps, product flow can be activated at a dispenser even though the dispenser is not turned on. In other words, if you are changing a filter on pump A and someone turns on pump B, if pump B is connected to the same submersible pump it will activate product flow. If you have the filter off of pump A when this happens, you could be sprayed with gasoline. For this reason, pumps should be deactivated <u>at the breaker panel</u> when filters are being installed or changed.

Utilizing water paste you should test for the presence of water bottoms, If any water bottoms are present, they should be pumped off and disposed of in accordance with any federal, state, or local laws and regulations.

Older tanks may have a build up of "silt" or sediment on the tank bottom or lacquer and gum build up on the tank wall. In such cases it is recommended that the tank or at least the tank bottoms be cleaned. This can be achieved by utilizing special equipment such as a Gorman-Rupp "Tank Kleenor".

Prior to the first load of gasoline/ethanol blends you should obtain an ethanol compatible water paste such as "Kolor Kut" or Sargel. Once you have been issued the appropriate water paste you should discard any old paste as it may not work properly with gasoline/ethanol blends.

Retailers should obtain the necessary dispenser labels and prepare placement instructions prior to the first delivery so they can be placed on the pumps/dispensers immediately after the first delivery.

Accounting procedures at the time of conversion vary significantly from one company to the next. Retailers should ensure that they have obtained and understand the proper accounting guidelines to be used at the time of conversion.

There are basically three ways to convert to gasoline/ethanol blends: A) To remove all product from the tank and replace with gasoline/ethanol blend., B) To order enough extra ethanol in the initial delivery to accomplish upgrading of existing inventory, C) To lower inventory to extremely low levels

and merely begin delivery of gasoline/ethanol blends (this procedure could result in product being below targeted blend levels for the first few deliveries). Typical costs to convert a retail unit run from a few hundred dollars to as much as $800 if tanks require cleaning.

Each of the procedures has advantages and disadvantages which in many cases are company specific. Additionally, each of the procedures may have certain variations from one company to the next. However, once the initial delivery is made, the procedures become similar if not identical.

Slide 24

Retail Facility Operator Checklist

First Delivery

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

Before the scheduled delivery, retest tanks for water bottoms. Water bottoms should be removed prior to the initial delivery. Manhole covers should be color coded for new product (API color code).

When the initial load arrives, follow normal delivery procedures. Take stick readings and pump readings so that you have an accurate inventory record at the time of delivery.

When you have more than one tank for a specific product and you are attempting to upgrade (up blend) product in storage, be sure the driver is putting the correct compartment into the correct tank. It is recommended that pumps be shut down during the initial delivery.

After the initial delivery is dropped, it is recommended that a few gallons of product be run through each dispenser to ensure that it is clear and bright. Ethanol blends have a solvency effect and may loosen sediment and sludge in tanks and fill lines. Once dispensed product is clear and bright, the tank can be placed back in service. Be sure to install any required pump labels, before tank is placed back in service. Also if the octane level is different than the previous product, the octane decal should be changed to reflect the correct octane.

NOTE: You should check with company management for the exact accounting and operational procedure to be used when using product to purge lines. As an example, some companies will return purged product to the appropriate tanks and list it as a pump test. Others may have lines purged by maintenance personnel who take the product to a terminal for disposal.

Conversion loads should fill tanks to 80% of capacity. If this is not accomplished with the initial load, a second load should be brought in immediately after the initial delivery. This allows the solvent effect of the ethanol to loosen any sediment or varnish type deposits from the sides and upper portions of the tank. It is recommended that the tanks be kept as full as possible for the first seven to ten days to accelerate this process. This will result in dealing with any build up in tank bottoms during a time frame when everyone is acutely aware of the program conversion.

During the first forty-eight hours after delivery, tanks should be tested for water bottoms and/or phase separation once every eight hours. This should be done with a tank gauge stick and the appropriate water detection paste. If your unit is equipped with an automatic inventory measurement system and water detector alarms, you should still utilize a tank gauge stick and water finder paste as an added precaution.

After this initial forty-eight hour period, you should utilize the tank gauge stick and water finder paste on a daily basis to detect any water bottoms. At any sign of water build up, you should notify the designated personnel or maintenance contractor and have the water removed at once. **The most important step in ensuring that your ethanol blending program is a success is to eliminate any moisture from the system before it can become a problem.**

Unless there is a problem with the tanks or lines, you should not experience any water build up after the conversion phase. Gasoline/ethanol blends will pick up and remove trace levels of water from the system thus eliminating water build up in properly maintained tanks. None the less, you should continue to monitor for water on a daily basis.

Some companies may utilize tank bottom samplers during the conversion process. These samplers help identify any build up of sludge in tank bottoms. The typical tank bottom sampler is affixed to the tank gauge stick. If your company intends to utilize such a device, they should provide instructions for its use.

Since ethanol loosens varnish like deposits in the tank, you may need to change pump filters once or twice shortly after your initial conversion load(s). Employees should watch for any signs of filter plugging (slow running pumps) and change out as necessary. It is recommended that pumps/dispensers be recalibrated approximately two weeks after initial conversion. Occasionally, some meters will over-dispense a small amount when first converted to ethanol blends. This should be corrected to avoid any unnecessary inventory shortage.

Slide 25

Retail/Fleet Operator Checklist

Ongoing Maintenance

❒ Check for water. No level is acceptable.

Ongoing Maintenance - Once through the initial conversion period, you should notice no difference in your day to day operations except for the need to check for water on a daily basis.

Phase Separation - If proper steps are taken to eliminate water from the storage system, you should not experience any phase separation. If excess water is introduced into the storage tank (e.g. leaving a fill cap off), phase separation could occur. This can happen because excess water can combine with the ethanol in the blend, causing it to drop out of suspension or "phase separate". When this occurs, the product separates into two phases. The upper phase is gasoline and a small amount of ethanol while the lower phase is predominantly ethanol (approximately 70%) and water (approximately 20%) plus around 10% hydrocarbons. Since tank submersibles or pumps pick up product from the bottom of the tank, it is this mixture that would de dispensed into the vehicle. Obviously, vehicles cannot operate on such a blend, so if you experience a phase separation, all dispensers supplied from that tank must be deactivated immediately. The appropriate company representatives should be notified. Since a portion of the phase separation contains some level of hydrocarbons, federal regulations require that they be treated as a hazardous substance. Their handling and disposal is therefore subject to very specific requirements.

It is also advisable to have an orientation session for transport drivers to provide a brief overview of conversion processes.

Slide 26

Outbound Blended Product Delivery - Transport Driver Orientation

- ❒ Cover information on new terminal blending equipment, or
- ❒ Cover splash blending procedure (if applicable)
- ❒ Cover color codes (API or company specific color codes)
- ❒ 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.
- ❒ Assuming no water bottoms are present, the load can be dropped per normal procedure.

This slide provides an example of typical topics you would want to cover.

Quality Assurance/Control.

Since ethanol's properties are different than gasoline, there are certain quality control/quality assurance issues about which you should be aware.

Ethanol should meet the properties specified in ASTM D 4806.

Slide 27

ASTM D 4806 Standard Specification for Denatured Fuel Ethanol for Blending with Gasoline for Use as Automotive Spark Ignition Engine Fuel

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)		

Your supplier should provide a certificate of analysis indicating that the ethanol they are supplying meets the guidelines set forth in ASTM D 4806 and any other contractual specifications you have set.

Slide 28

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

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 table in this slide provides the temperature correction factors to convert a fuel grade ethanol volume to 60˚F.

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.

Slide 29

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.

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 in this slide 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 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 these are provided in this slide:

Slide 30

Gravity Conversion Formulas

For converting API gravity to specific gravity at 60˚ F

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

For converting specific gravity to API gravity at 60˚ F

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

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.

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.

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 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.

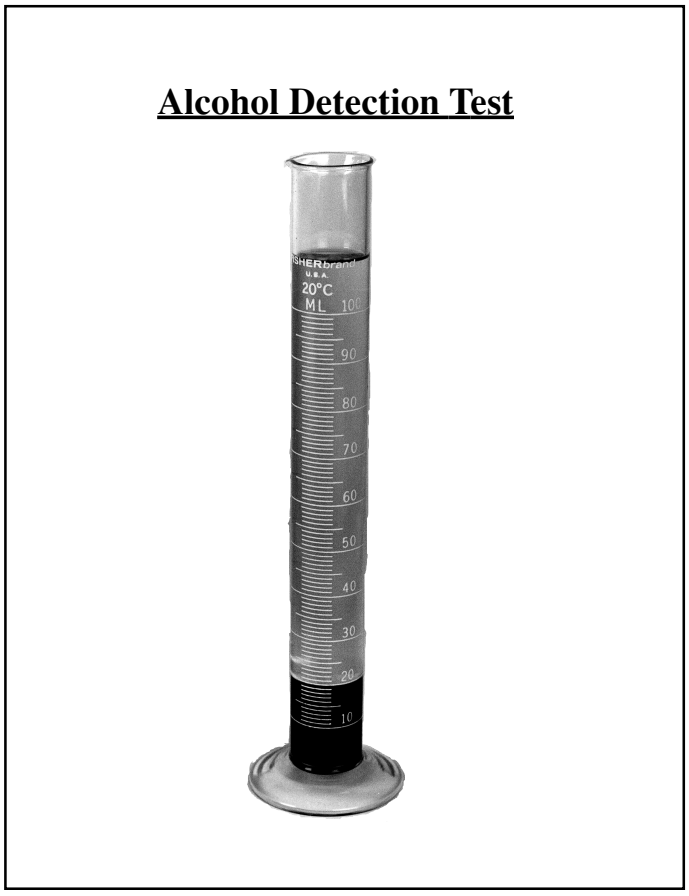
ASTM has developed a test method to monitor "pHe". This test method measures acid strength and reports a pHe value. (NOTE: A pHe value is not directly comparable to pH values for water solutions.) The ASTM pHe test method is designated and titled as: ASTM Designation: D 6423 Standard Method for Determination of pHe of Ethanol, Denatured Fuel Ethanol, and Fuel Ethanol (Ed75-Ed-85).

Sulfur Content: 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. While ethanol generally contains no more than 2-4 ppm sulfur, the denaturant used could add sulfur to the finished product.

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.

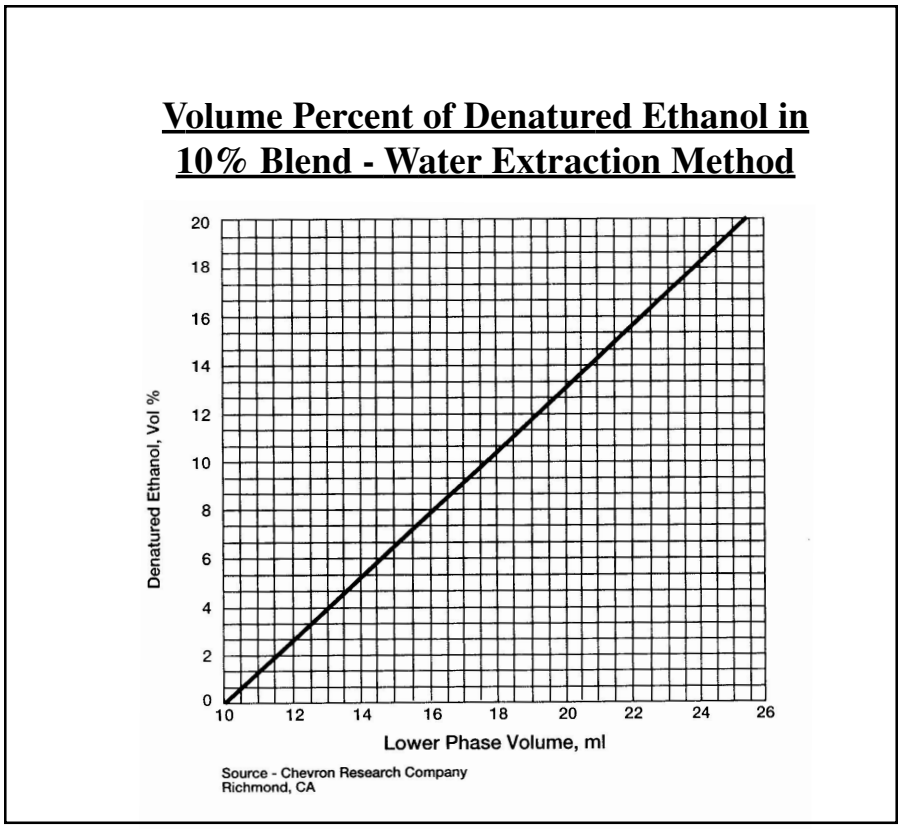
Ethanol Content of Blends: The approximate ethanol content of a gasoline ethanol blend can be tested by the "Water Extraction Test". This procedure is as follows.

Slide 31



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 graph to read the alcohol content.

Slide 32



For example, a reading of 17.2 ml. lower phase volume by this test is 10v% alcohol in the blend.

Obviously, you will need more detailed information on these numerous topics than I can provide in a brief workshop, so I also want to provide you some additional information sources.

Additional Information Sources

Slide 33

Documents Available From the American Petroleum Institute

Storing & Handling Ethanol & Gasoline-Ethanol Blends at Distribution Terminals & Service Stations - API Recommended Practice 1626, April 1985

Cleaning Petroleum Storage Tanks - API Publication 2015, September 1985

Product Identification Guidelines, API Recommended Practice 1637

Alcohols, Ethers, and Gasoline-Alcohol and -Ethanol Blends, A Report on Fire-Safety Considerations at Petroleum Marketing Facilities - API Publication 1642, February 1996

The API has several publications and recommended practices of interest.

Slide 34

Contact Information

American Petroleum Institute (API)
1220 L Street NW
Washington DC 20005-4070
202-682-8000
(202)-682-8375 (Publications and Distribution)
www.api.org

Contact information for API is as follows.

Slide 35

Documents Available From the Renewable Fuels Association

#960501 FUEL ETHANOL Industry Specifications, Guidelines, and Procedures

#040301 Ethanol Plant Quality Assurance/Quality Control Recommendations

Ethanol Transportation and Distribution Guide (estimated availability Fall 2004)

Gasoline Ethanol Blends-Program Operations Guide , RFA Recommended Practice #930601 (June 1993) *This document is out of print (Estimated availability 2005)*

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

Changes in Gasoline III - Year 2000 Supplemental Update

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.

Slide 36

RFA
Renewable Fuels Association

Renewable Fuels Association
One Massachusetts Avenue NW
Suite 820
Washington DC 20001
202-289-3835
email: info@ethanolRFA.org

www.ethanolrfa.org

Contact information for RFA is as follows.

The ASTM specifications and guidelines I mentioned are available from ASTM

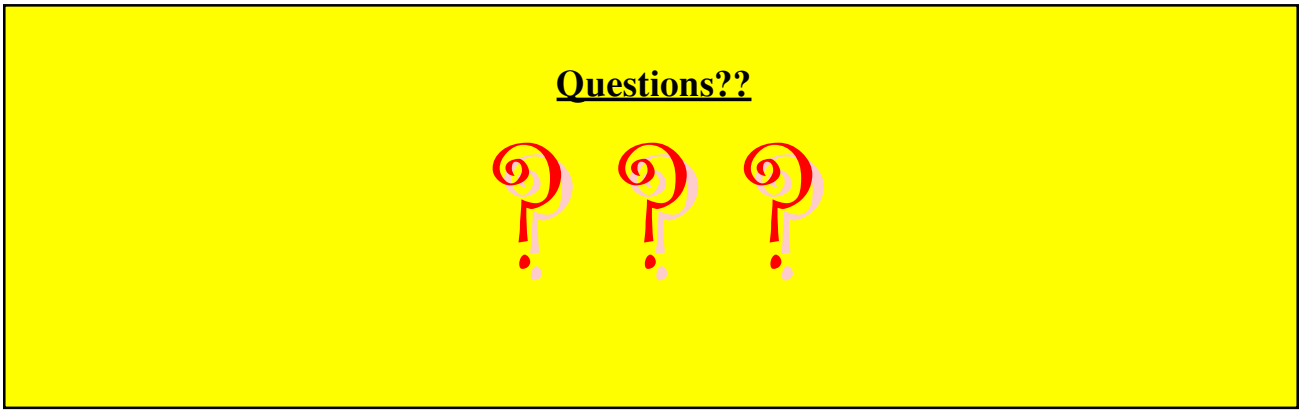
Slide 37

Contact information for ASTM is listed on this slide.

Obviously Implementing and maintaining a successful gasoline ethanol blending program requires a little effort. However, if proper steps are taken, such programs can be implemented without any problems. Hundreds of terminals and thousands of stations in the U.S. handle gasoline ethanol blends. With that I would like to open it up to questions.

Questions and Answer Session

Slide 31



Closure