

Renewable Fuels: Information for Regulators

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Just a bit about me...



1994: Started at largest distillery in the world.

2000: Transferred to largest corn processing plant in the world.

2007: Worked for ethanol trade association.

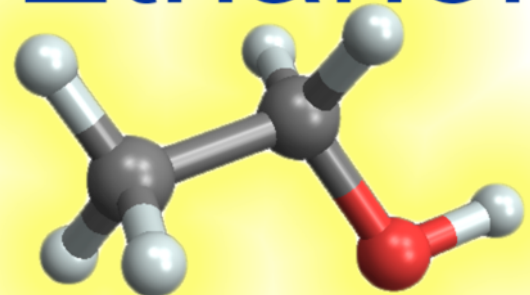
2015: Opened up a consulting gig to feed my family.

2018: Building markets globally...

What is Ethanol?

- Ethanol is a water-white, polar solvent that is used in many applications, mostly as a gasoline additive.
- Other applications:
 - Solvent: cleaners, sanitizers.
 - Pharmaceutical: many new active ingredients are not water soluble.
 - Food, beverage: Vinegar, Spirits, Vodka.
 - Industrial: Chemical intermediates.

Ethanol



Physical Properties of Ethanol

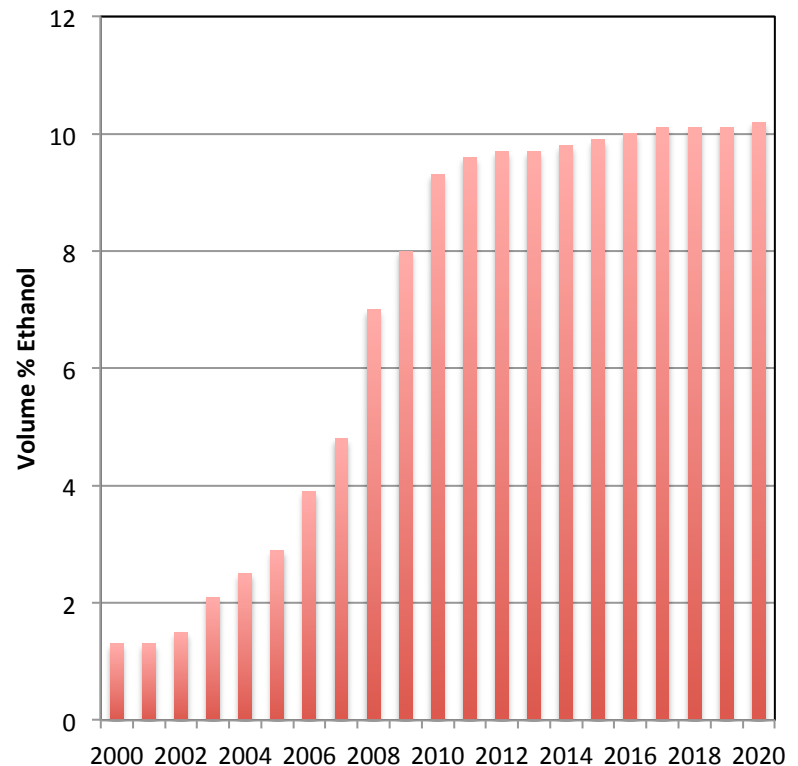
Property	Denatured Fuel Ethanol	Hydrocarbon Gasoline
Vapor Pressure	3 psi 21 kPa	7-15 psi 48- 103 kPa
Boiling Point	152- 174°F 67- 79°C	80- 437°F 27- 225°C
Octane (AKI)	99	87, 91
Flammability Limits in Air	1.4- 7.6%	3-19%
Flash Point	-5°F -20°C	-40°F -40°C
Auto Ignition Temperature	495°F 257°C	689°F 365°C
Shelf-life	Infinite when protected from fire, environment	3- 6 months when protected from fire, environment

- Clean Air Act of 1970
 - Creation of EPA
- Ban of tetra-ethyl lead 1974
 - Creates need for new octane source
- Clean Air Act of 1990
 - Create evaporative and exhaust emissions controls and RFG
- Winter Oxygenate Fuel Program (1992)
 - Program includes Colorado (elevation)
- Gasoline Detergents (1995)
 - Deposit control additive requirement
- Phase 1 Reformulated Gasoline (1995)
 - Required 17% reduction in VOCs.
- Mobile Source Air Toxics of 2002, 2011
 - Reduction in benzene, etc.
- Tier 2, 3 Sulfur Standards (2004, 2017)
 - Gasoline to 30ppm first, then 10ppm.
- Energy Policy Act of 2005
 - Initiated funds from Department of Agriculture and Energy for alternative fuel sources
- Energy Independence and Security Act of 2007 (Renewable Fuels Standard 1& 2)
 - Required blending volume of renewable fuels into fossil fuels.

Why Ethanol?

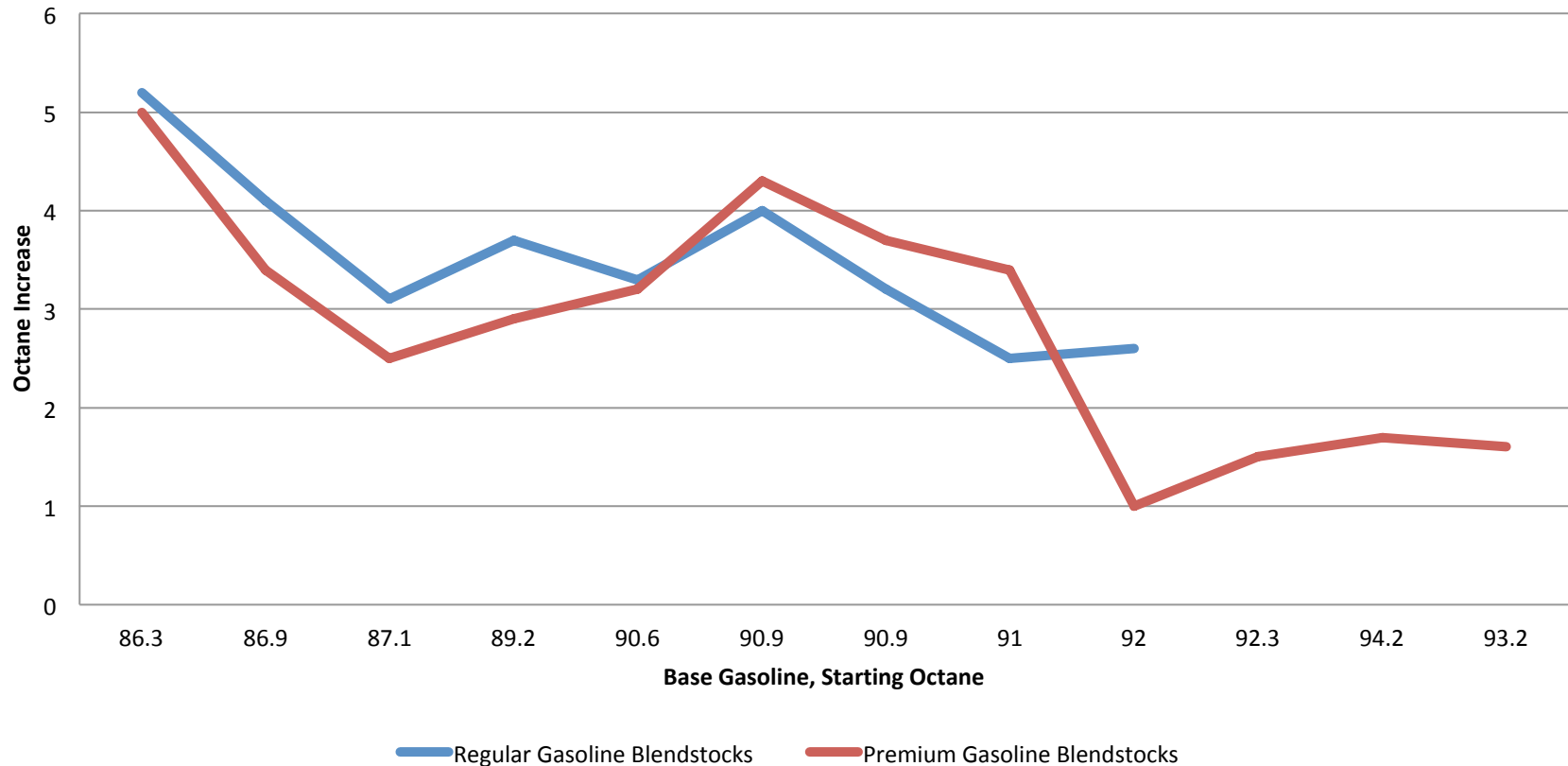
Nearly every policy since the creation of the EPA requires a clean oxygenate like ethanol.

Ethanol as a Percent of U.S. Motor Gasoline Pool



Ethanol's Octane Boost

Octane Increase with 10% Ethanol Addition



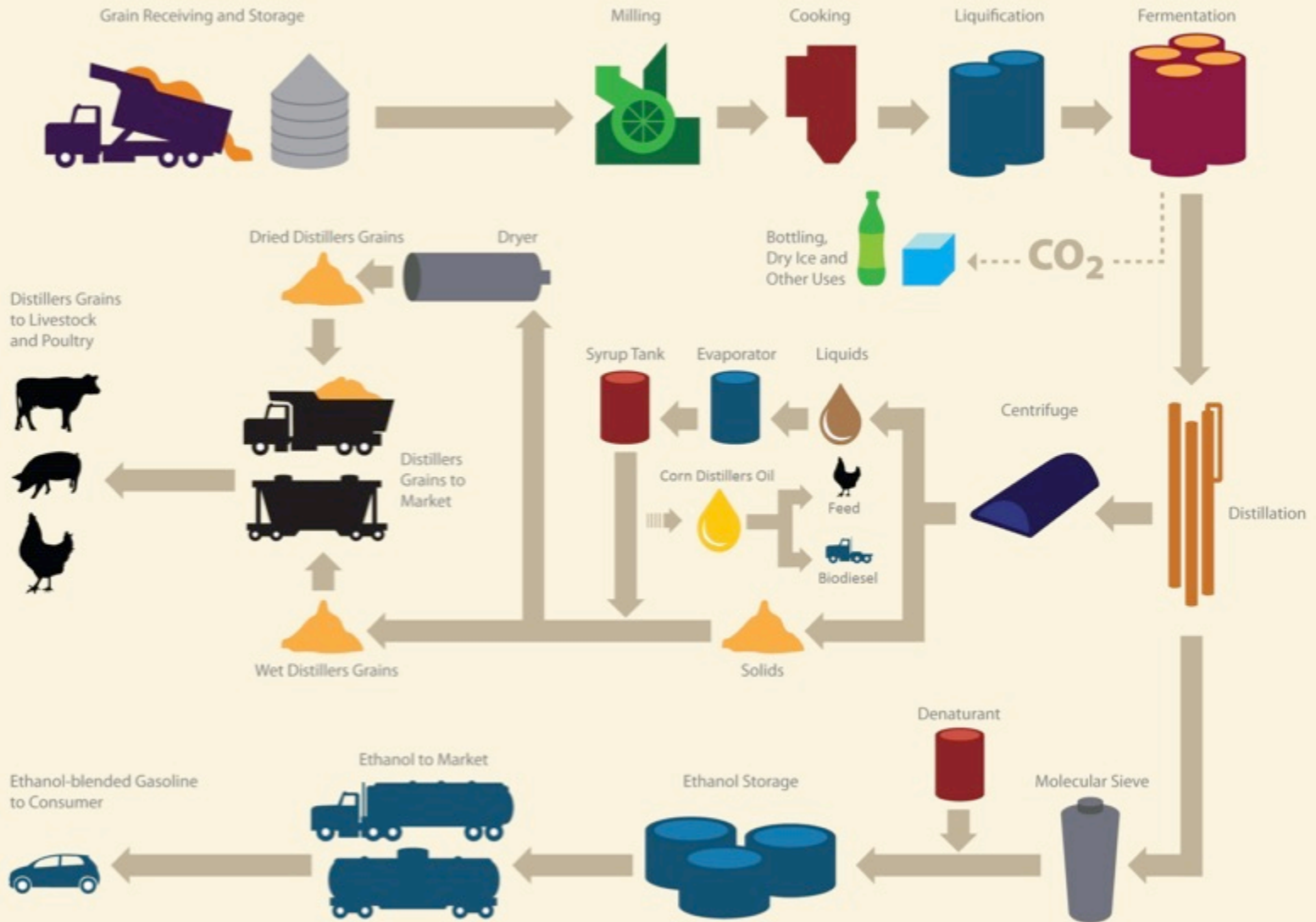
Adding an additional 5% ethanol (up to 15% volume) adds an average ~1.2 AKI.

Ethanol Production Process

- Ethanol can be made from many renewable feedstocks: corn, sorghum, wheat, sugar cane, cellulose, etc.
- Ethanol is primary product. Many valuable co-products: feed, carbon dioxide, corn oil, zein proteins.



DRY MILL ETHANOL PROCESS



Most Common Ethanol Blends

Ethanol Content

10% Ethanol/ 90% Gasoline

- E10: Most common fuel blend.
- Utilized in all spark ignition engines.

15% Ethanol/ 85% Gasoline

- New fuel blend in U.S.
- Utilized in 2001 and newer model year vehicles.

18-27% Ethanol/ 82-73% Gasoline

- Petrol in Brazil
- Ethanol content varies with sugar cane/ Government requirement.
- Used in all spark-ignition engines.

51+% Ethanol/ Balance is Gasoline

- Ethanol Flex Fuel in U.S., Alcool in Brazil (hydrous), Sweden.
- Utilized in flexible (variable) fuel engines only.

ASTM Specification

- D4814, Automotive Spark-Ignition Engine Fuel
(0- 49% ethanol)
- D7794, Blending Practice Ethanol Fuel Blends
(16- 50% ethanol)
- D5798, Ethanol Flex Fuels
(51- 83% ethanol)
- D4806, Denatured Fuel Ethanol (>92.1% ethanol)



American Drivers Have Logged More Than 10 Billion Miles on E15

Millions of transactions
with no reported issues



Why would they risk liability?

Retailer	Gasoline Guarantee
Sheetz	Yes
Casey's	Yes
Thornton's	Yes
RaceTrac	Yes
QT	Yes
Kwik Trip	Yes



E15 Market Development

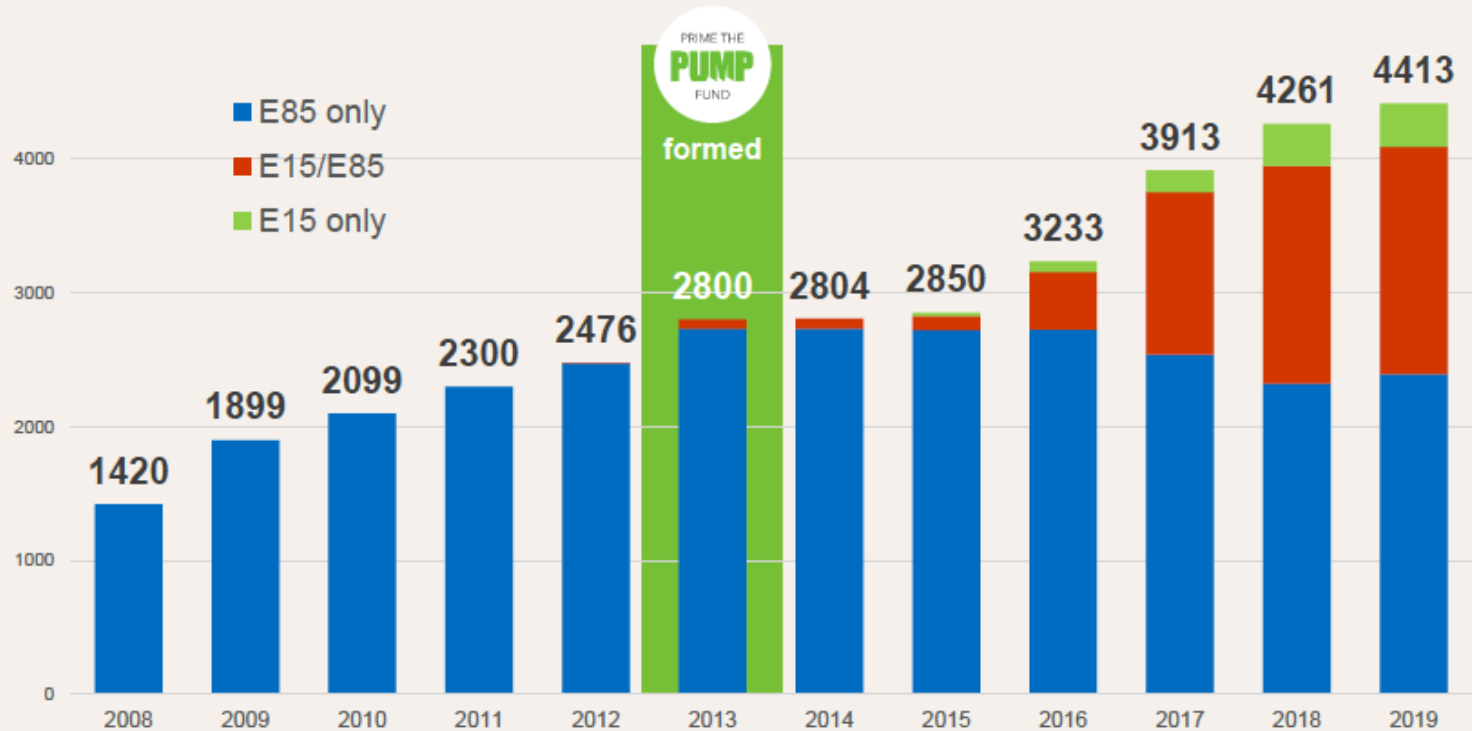
The average convenience store sells 1 million gallons of gasoline per year on average, while the bulk of the retailers involved in the industry-sponsored Prime the Pump programs sells 2.8 million gallons per year on average- nearly 3 times as much volume as the traditional retailer.



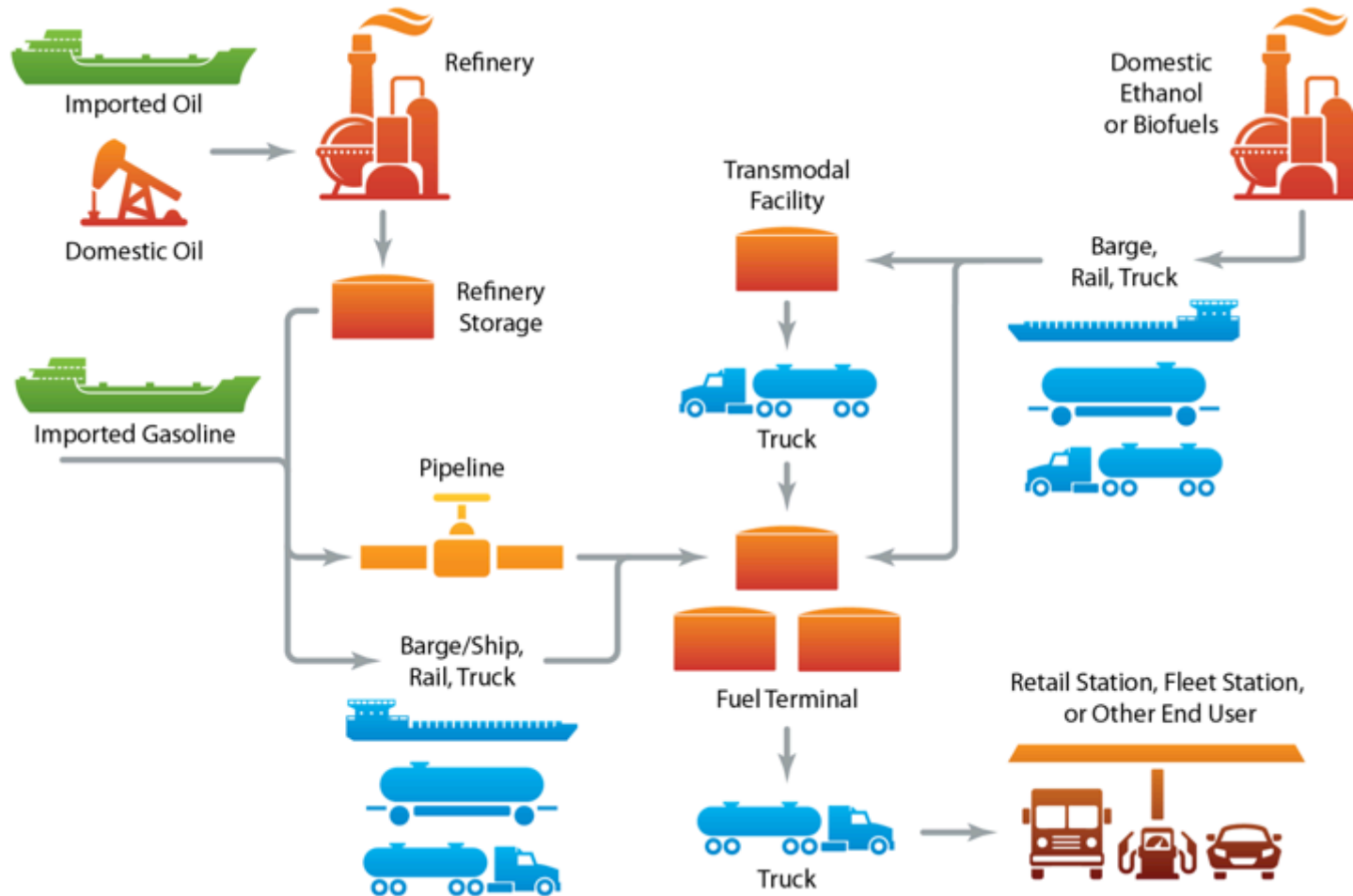
“But specific to any misfuelling issues- no, we have not experienced any misfuelling claims. Additionally, now that we have a set standard on being able to sell E15 year-round, it will further reduce the likelihood of future issues. ... There is a good reason we’re adding it to our offering, and we aren’t in the business of trying to sell products that customers don’t buy.”

- Nathaniel Doddridge, Director of Fuels for Casey’s General Stores.

Higher Blend Infrastructure



Ethanol Supply Chain and Distribution: Overlap with Refined Products Logistics



E15 Following E10 Types of Blending Methods: All Accurate

- Splash Blending
 - There are two separate load events. Gasoline is metered, with a set volume in to a vessel. Using different loading equipment, ethanol is metered into the same vessel. The two separate load events combine for the desired blend ratio and load volume.
- Sequential Blending
 - Each component utilizes a programmed meter and control valve, combining downstream of the meter into a common load line. Product flow is sequential, not simultaneous.
- Side Stream Blending
 - The smaller, metered proportion of the blend ratio (ethanol) flows into the larger proportion flow (gasoline), the blended product is metered.
- Ratio Blending
 - Two or more products are metered through separate meters, leading to a common blend point before the vessel. Product flow is simultaneous.

E15 Sampling Techniques Matter!

- There are many sampling techniques, depending on the product/ vessel.
- There have been many issues sampling E15 when blended at the dispenser.
- Ethanol content sampling is very different than octane sampling.
- Follow Procedure #3 for E15, MLEB, etc. (Page 27)



Ethanol Testing Issues

- There are many changes being made to the ASTM specifications for all fuels. New versions issues of these specs several times per year!
- Important to follow the specs for the appropriate test methods.
- Example: D5798 specifies the use of D5501 (GC method) for determination when there's high ethanol content. Recent incident with state lab using a method, D5845, that only detects ethanol content to 11% wt. on an E85 sample which was way off, shutting down dispensers, etc.

TABLE 1 Requirements for Ethanol Fuel Blends^A

Properties	Class 1 ^B	Class 2	Class 3	Class 4	Test Methods
Vapor pressure, kPa (psi)	38–62 (5.5–9.0)	48–65 (7.0–9.5)	59–83 (8.5–12.0)	66–103 (9.5–15.0)	D4953 or D5191
		All Classes ^C			
Ethanol Content, volume %		51–83			D5501
Water, % by volume (% by mass), max		0.8 (1.0)			D7923, E203, or E1064
Methanol Content, max, volume %		0.5			D5501
Sulfur Content, max, mg/kg		80			D5453 or D7039
Acidity, (as acetic acid CH ₃ COOH), mass % (mg/L) [mg/kg], max		0.005 (40) [50]			D7795
Solvent-washed gum content, max, mg/100 mL		5			D381
Unwashed gum content, max, mg/100 mL		20			D381
pHe		6.5 to 9.0			D6423
Inorganic chloride content, max, mg/kg		1			D7319 or D7328
Copper content, max, mg/L		0.07			D1688

^A For information on alternative fuels, see 4.1.2.1.

^B See 5.3.1 for volatility class criteria.

^C Ethanol content and selection of hydrocarbon blendstock are adjusted by the blender to meet vapor pressure requirements. See X1.3.2 for additional information and guidance for blending.

Ethanol's Value to Gasoline



- Valuable octane increase.
- Valuable sulfur dilution.
- Valuable benzene dilution.
- Valuable volume extension.
- Valuable greenhouse gas reductions.



Thank you!

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Ethanol at Retail

- Nearly all gasoline contains 10% ethanol.
- New fuel: 15% ethanol.
- Growing interest in mid-level ethanol blends due to ethanol's significant increase in octane.



Retail Fuel Equipment Compatibility

- This topic has been extensively studied in the United States over the last 15 or more years.
- Most Underground Storage Tanks (UST) compatible up to 10% ethanol from 1981- 1990. Compatible with up to 100% ethanol since 1990.
- Dispenser manufacturers have warranted with up to 15% ethanol for many years.
 - Wayne Fueling Systems has standardized all new dispensers are compatible up to 25% ethanol.
- Due to fire code, safety requirements, most equipment is certified by Underwriters Laboratory, ETL, etc. In the United States, ethanol was included in these standards decades ago.

Fire Code, Equipment Listing



- Fire code requirements often refer to model regulations, i.e. NFPA 30 and 30A.
 - Prescribe safety testing, certification, expectations.
- Ethanol, at all levels, is included in equipment listings, certifications.
- There are four certification levels now at UL: 10, 25, 40 and 85% ethanol.