NREL
NATIONAL RENEWABLE ENERGY LABORATORY

E85 Quality Specifications and Market Surveys

Clean Cities Webinar

Teresa L. Alleman

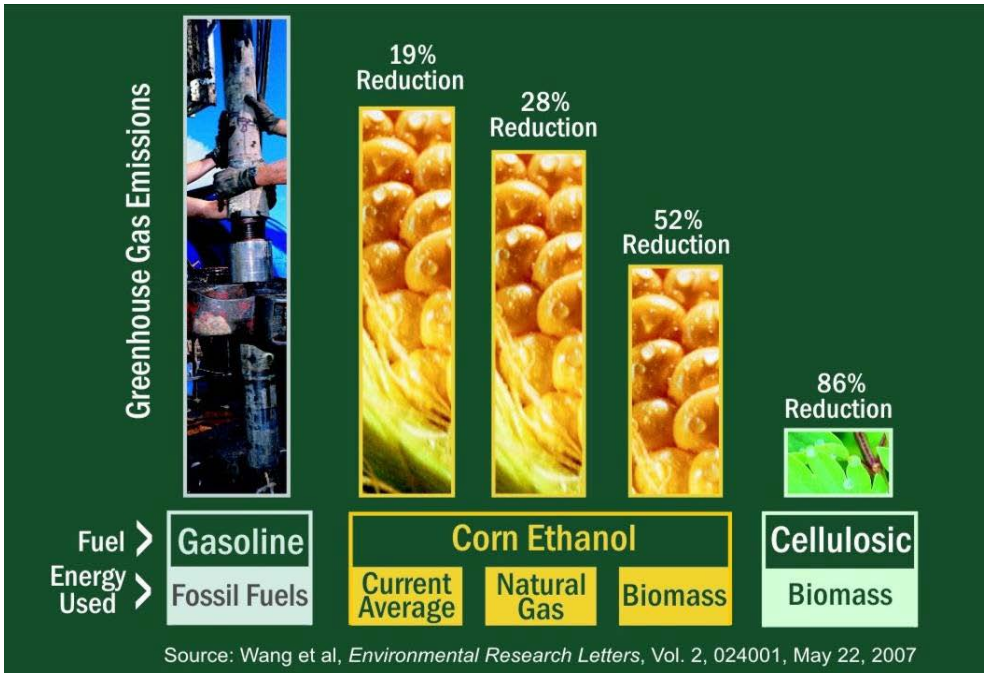
April 20, 2010

NREL/PR-540-48534

Ethanol Properties

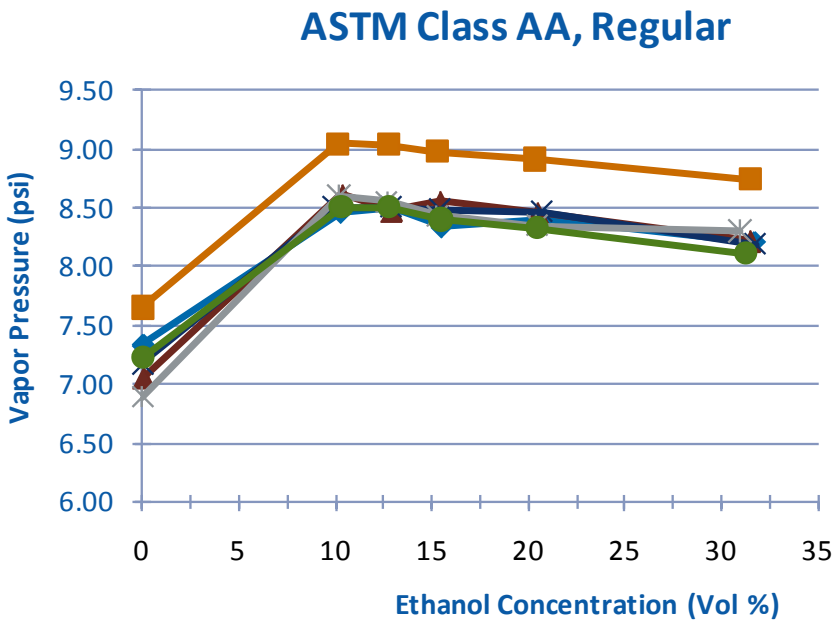
Good Gasoline Blending Properties:

- Blending Octane = 115
- Completely miscible with hydrocarbons
- GHG profile



Bad Gasoline Blending Properties:

- 30% lower volumetric energy content – an inconvenience
- Non-ideal vapor pressure bump
- Potential to partition into water



ASTM Specifications for Ethanol Fuels

- ASTM D4806: Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel
  - Anhydrous denatured ethanol
  - Ensures adequate purity for use in gasoline
- ASTM D4814: Standard Specification for Automotive Spark-Ignition Engine Fuel
  - Performance based specification for gasoline
  - US EPA currently allows up to 10 volume percent ethanol in gasoline
  - Potentially could accommodate higher levels of ethanol if approved
- ASTM D5798: Standard Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines
  - Performance based specification for flexfuel vehicles
  - Currently being modified to require minimum 68% ethanol for all grades
- *Under development: Standard Practice for Blending Mid-Level Ethanol Fuel Blends For Flexible Fuel Vehicles With Automotive Spark-Ignition Engines*
  - For blender pump fuels made using D4814 and D5798 compliant blendstocks

D5798

Specifications are used to ensure fuel is “fit for purpose”

- Protects consumers
- Provides regulatory agencies a “gold standard” to enforce fuel quality

Gasoline and gasoline/ethanol blends are subdivided into classes based on geography and time of year

E85 has 3 distinct classes

- Class 1: Warm ambient temperature
- Class 2: Moderate ambient temperature
- Class 3: Cold ambient temperatures
- Shoulder seasons: In-between two other classes where either grade is acceptable (e.g. 3/2)

Main difference between classes is vapor pressure and ethanol content

Not every state will require every class (most often Class 3 is omitted for warmer states or Class 2 for colder states)

D5798 con't

Why are the changes in vapor pressure and ethanol content necessary?

More gasoline in the blend provides better cold start performance (higher vapor pressure)

Lower vapor pressures help prevent handling problems in warmer months

Major parameter is vapor pressure, ethanol content will vary depending on vapor pressure requirements (ethanol has very low vapor pressure compared to gasoline)

ASTM Specifications are "living" documents and can change from year to year, fuel providers must stay informed on most recent changes and how it impacts local regulations

Previous CRC E85 Quality Surveys

CRC E-79 (2006)

10 states sampled (IL, IN, IA, MI, MN, MO, NE, ND, SD, SC)

47 samples collected in Class 1, 1/2, 2, 2/3 volatility classes

Most samples failed to meet vapor pressure (too low)

CRC E-79-2 (2007)

15 states (CO, IL, IN, IA, MI, MN, MO, NE, NC, ND, OH, SC, SD, TX, WI)

55 samples collected (3 in Class 2, and 52 in Class 3)

In Class 2, samples did not meet vapor pressure (too high, 67%) and ethanol content (too low, 67%

In Class 3, samples did not meet vapor pressure (too low, 58%) and ethanol content (too low, 15%)

CRC E-85: E85 Survey

Project goal is to collect nationwide survey of E85 quality

- Samples taken across US from public pumps
- Cover all 3 volatility classes
- Provide data to industry on E85 quality
  - Interest from CRC for designing future projects

Report unbiased assessment of E85 quality

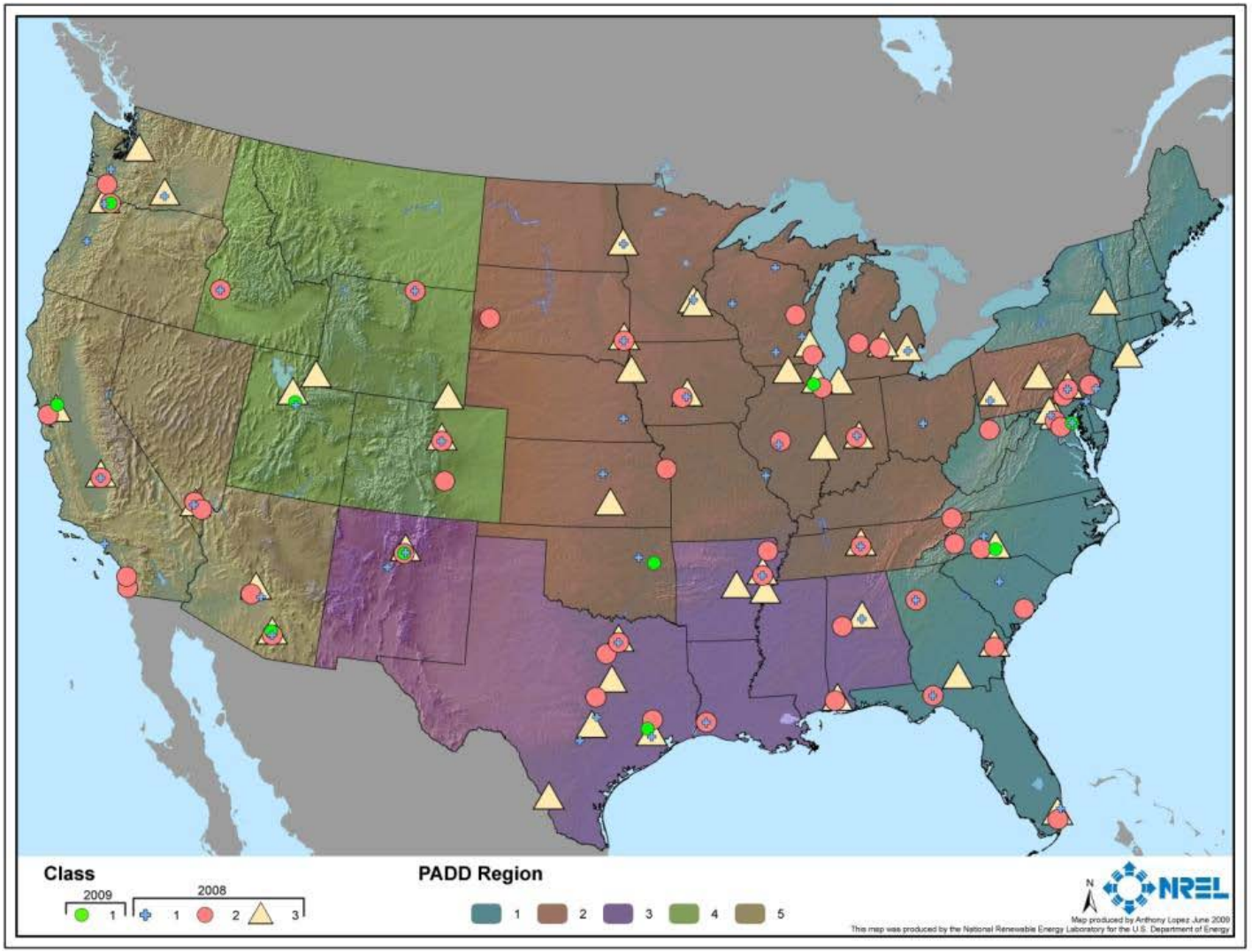
Property Tests

Property	Method	Notes
Ethanol/methanol	D5501	All samples
Dissolved water	D6304	All samples
Vapor pressure	D5191	All samples
Sulfur	D5453	All samples
Washed and unwashed gum	D381	All samples
pHe	D6423	All samples
Inorganic chloride and sulfate	D7319	All samples
Appearance	D5798	All samples
Distillation	D86	Select samples
Density/API gravity	D4052	Select samples
NACE corrosion	TM0172-2001	Select samples
RON/MON	D2699/D2700	Select samples
Peroxides	D3703	Select samples
Oxidation stability	D525	Select samples
Silver corrosion	D4814 Annex	Select samples

Property	Class 1	Class 2	Class 3
Ethanol, vol%	79-83	74-83	70-83
Vapor Pressure, psi	5.5-8.5	7.0-9.5	9.5-12.0

Survey Locations

3 rounds of sampling from all 5 PADDS – broad coverage of market



Results Summary Table

D5798 Class	# of samples	Vapor Pressure			Ethanol Content		
		Below minimum, %	Above Maximum, %	On-Specification, %	Below minimum, %	Above Maximum, %	On-Specification, %
1 (2008)	47	53.2	0	46.8	4.3	89.4	6.3
1 (2009)	10	90.0	0	10.0	10.0	10.0	80.0
1 (All Data)	57	60.0	0	40.0	5.3	66.7	28.0
2	26	61.5	7.7	30.8	3.8	38.5	57.7
3	40	87.5	0.4	12.1	12.0	5.0	83.0
All	123	73.1	0.7	26.2	7.5	35.7	56.8

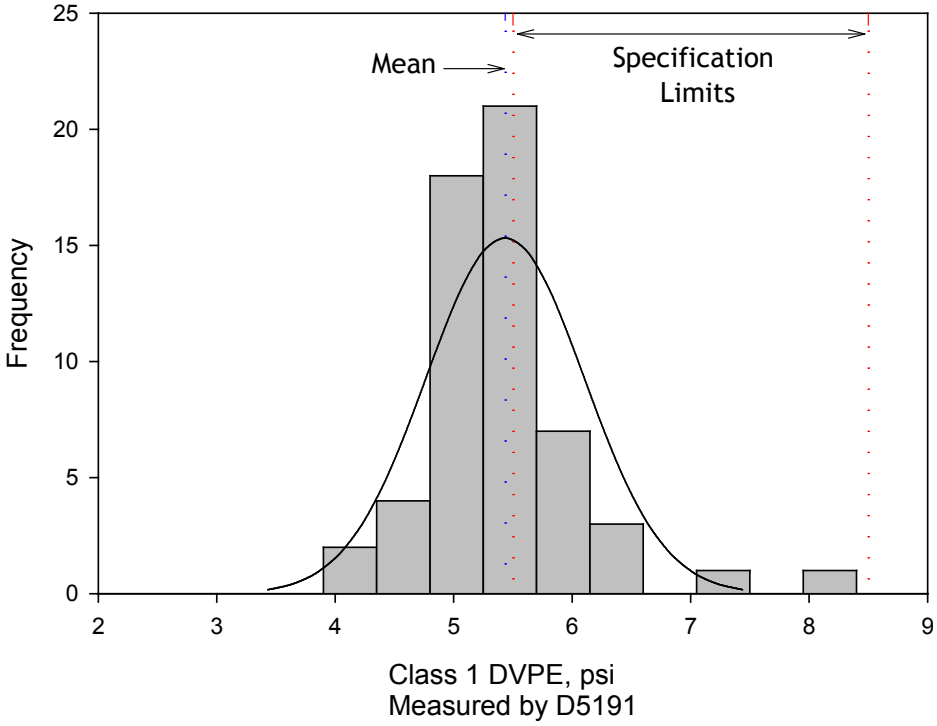
Results: Vapor Pressure

60% of Class 1 Summer time samples off spec on vapor pressure

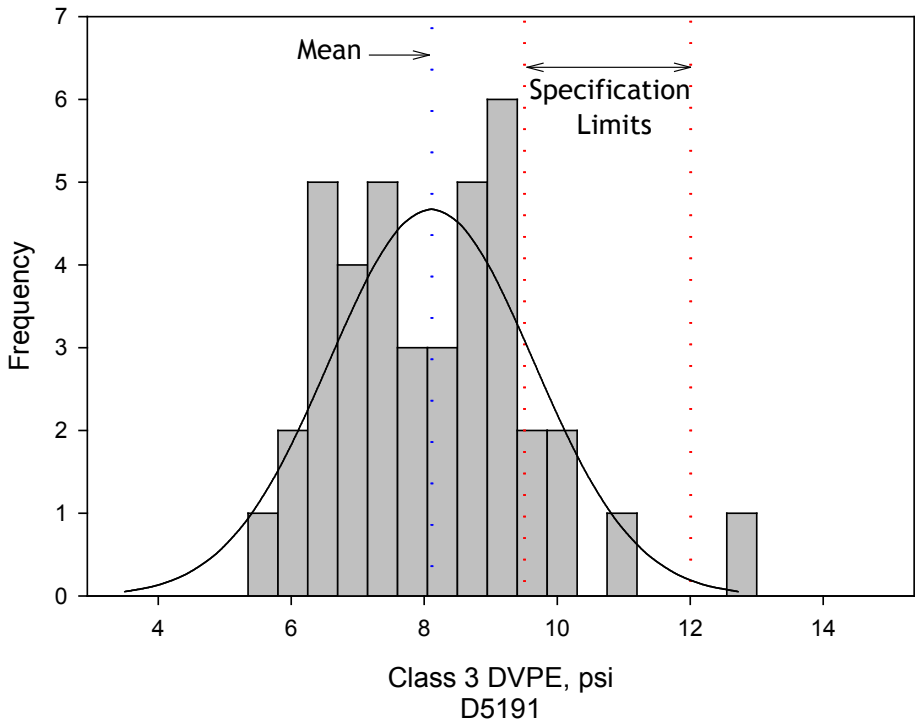
87% of Class 3 Winter time samples off spec on vapor pressure

Primary reason cited by Marathon for cessation of E85 sales in Fall 2009

Summer 2008



Winter 2008-09

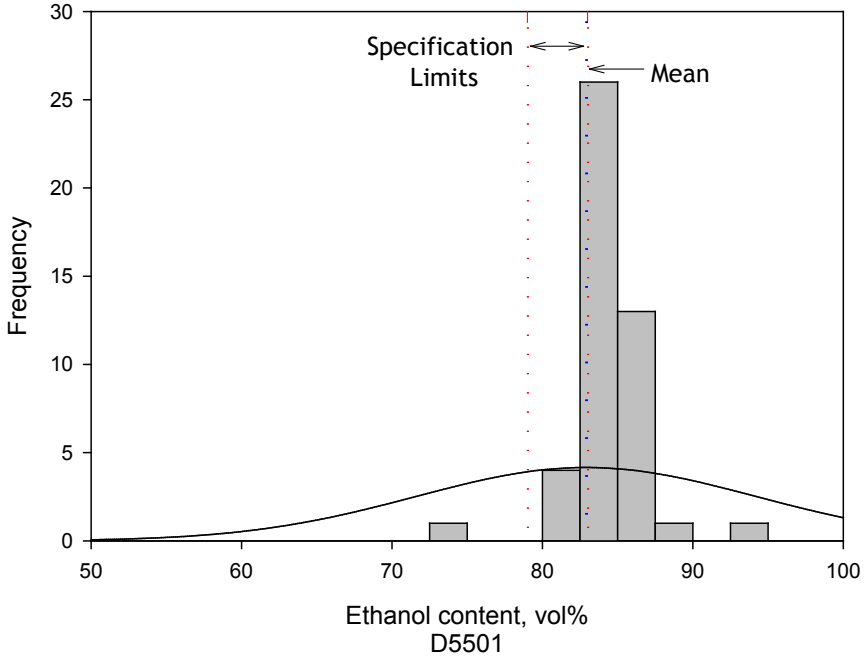


Results: Ethanol Content

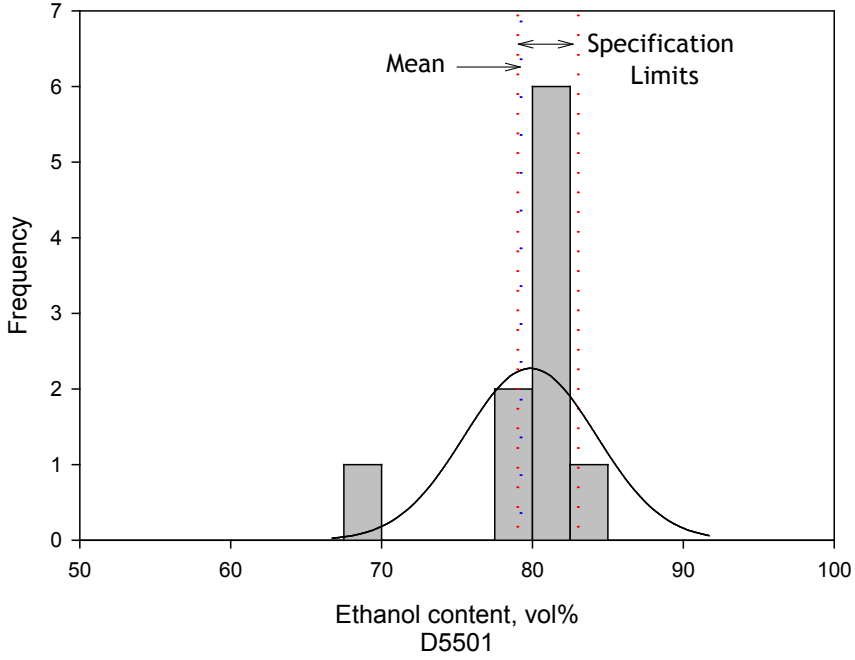
81% of 2008 Class 1 samples off-spec on ethanol (high gasoline $)

10% of 2009 Class 1 samples off-spec on ethanol (gas. < ethanol $)

Summer 2008



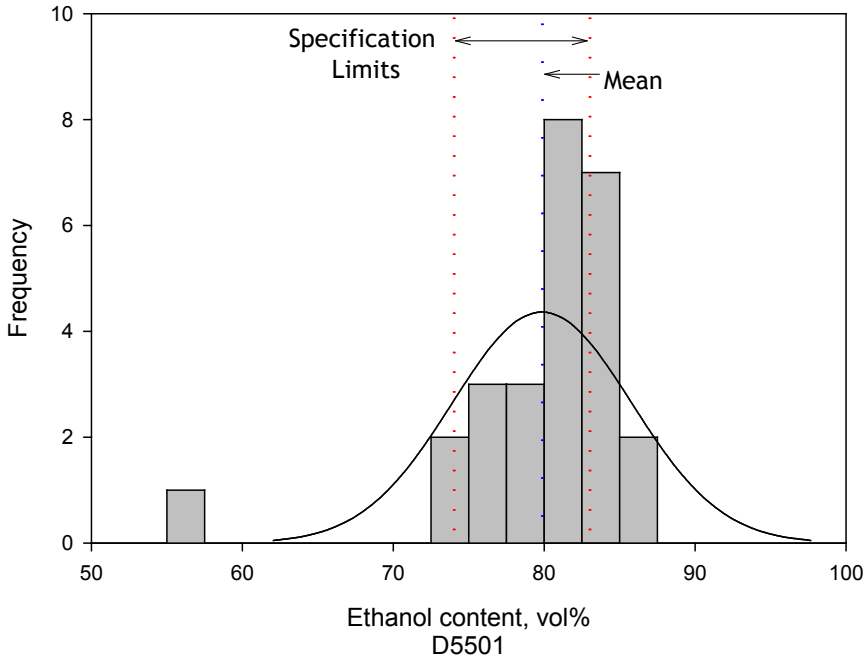
Summer 2009



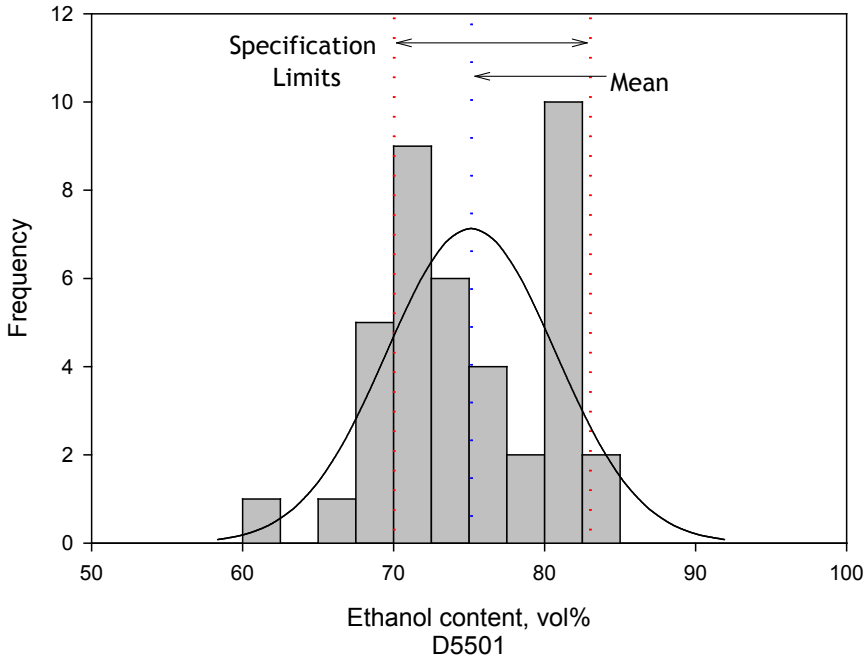
Class 2 and Class 3 Ethanol Content

Less significant problems with meeting ethanol limits when wider band of ethanol is allowed

Class 2

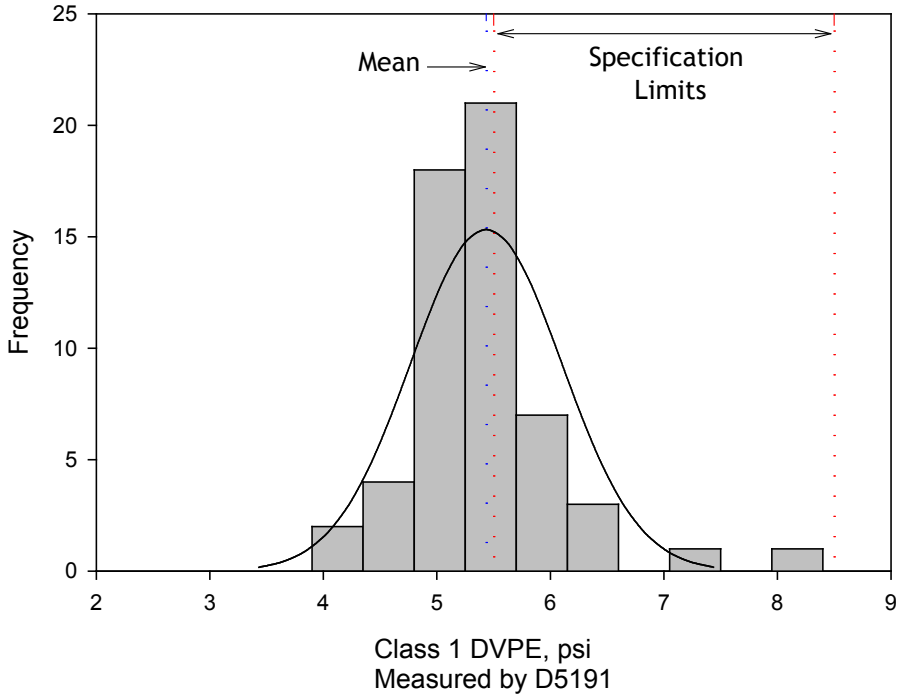


Class 3



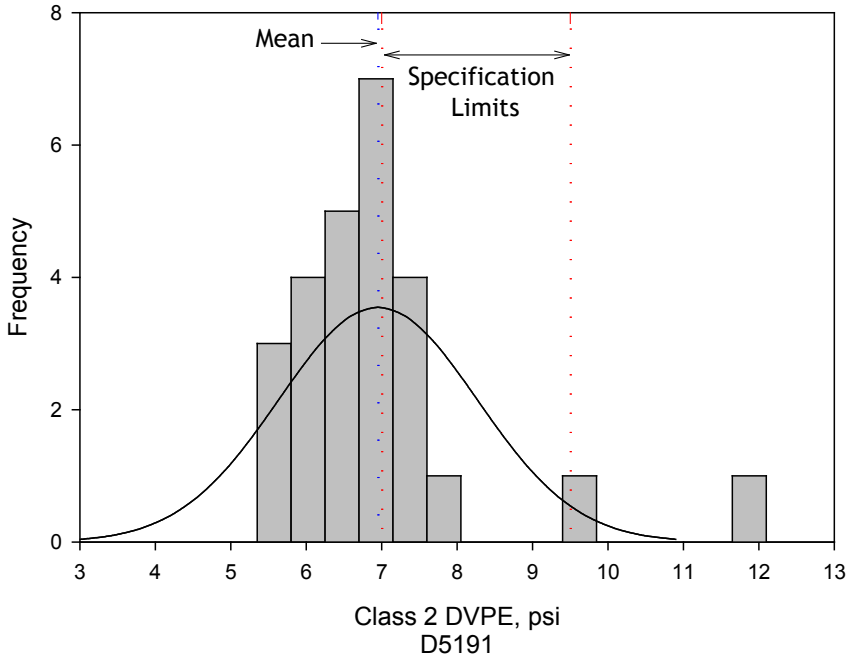
Results: Class 1 Vapor Pressure

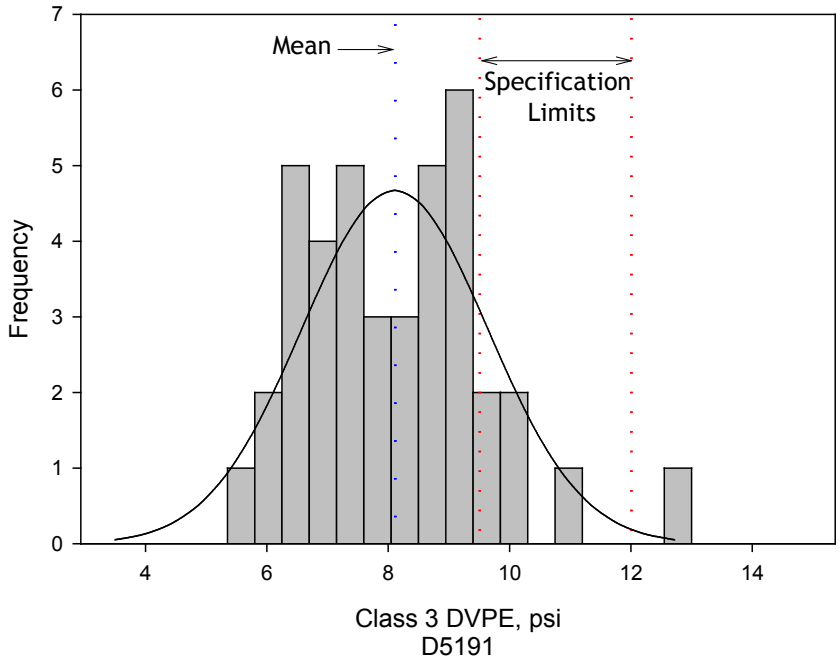
Data was pooled for vapor pressure (statistically "allowed") and showed the mean was well below the limit



Class 2 and Class 3 Vapor Pressure

Both classes show problems with meeting vapor pressure minimums





Other Properties

No significant failures for other properties (less than 5%)

Samples selected for additional tested showed quality was adequately met

Stability and corrosivity

E-85 Project Summary

Samples were consistently off-specification for low volatility and excessive ethanol content

Failures on other specification properties were very low

Random re-sampling of Class 1 showed improvement in ethanol content, likely due to reduced cost of gasoline compared to first sampling period

Final report is published at:

http://www.crcao.org/publications/emissions/index.html

Another sample will be conducted this year (starting in summer 2010) to reassess E85 quality

What is the future for ethanol in the US?

Will E85 continue to grow? Will more consumers select E85 for their FFVs or purchase FFVs with the intent of using E85?

How else could ethanol penetrate the US gasoline market?

Higher levels of ethanol in conventional gasoline are gaining popular support (i.e. blender pumps)

http://www.opisnet.com/e85/headlines.html

http://www.growthenergy.org/2009/e15/index.asp

http://www.byoethanol.com/

Blender Pumps

A blender pump dispenses fuel for FFVs that is between conventional gasoline and E85

Typically, E20, E30, E50, and E85

Currently, geographically limited to Midwest

IA, KS, MI, MN, MO, ND, NE, OH, SD, WI, CO

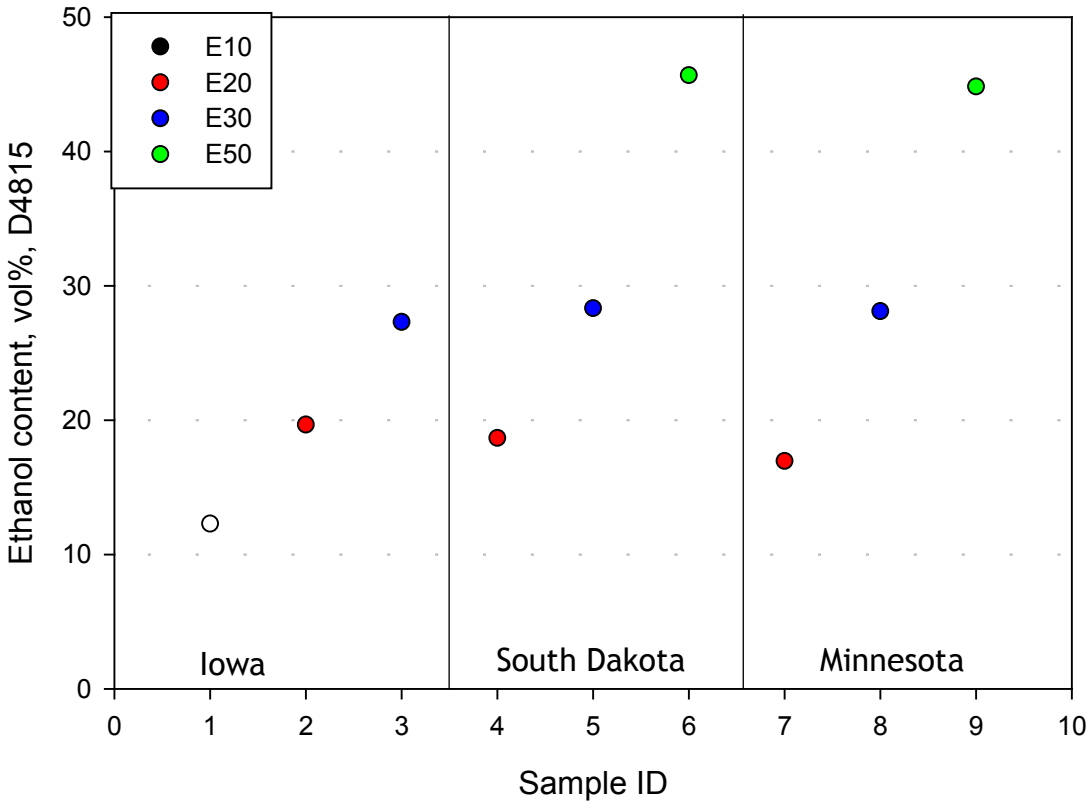
50% of blender pumps in MN and SD

Source: MN Departure of Commerce

Ethanol Content

Samples show expected ethanol values, indicating good mixing practices

All other oxygenates were below detection limits



Blender Pump Closing Remarks

Quick “snapshot” was taken of samples from blender pumps to assess quality of lower level ethanol FFV fuels

Pump labeling clearly shows “For Flex Fuel Vehicles”

Data shows samples are meeting the D4806 gasoline specification but not the D5798 E85 specification

In 2010, NREL and CRC will collaborate to conduct broader blender pump quality survey

Questions?