CRC Report No. E-79

SUMMARY OF THE STUDY OF E85 FUEL IN THE USA 2006

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COORDINATING RESEARCH COUNCIL, INC.
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Summary of the Study of E85 Fuel in the USA 2006

Prepared for

The Coordinating Research Council, Inc.

Project No. E-79

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INTRODUCTION

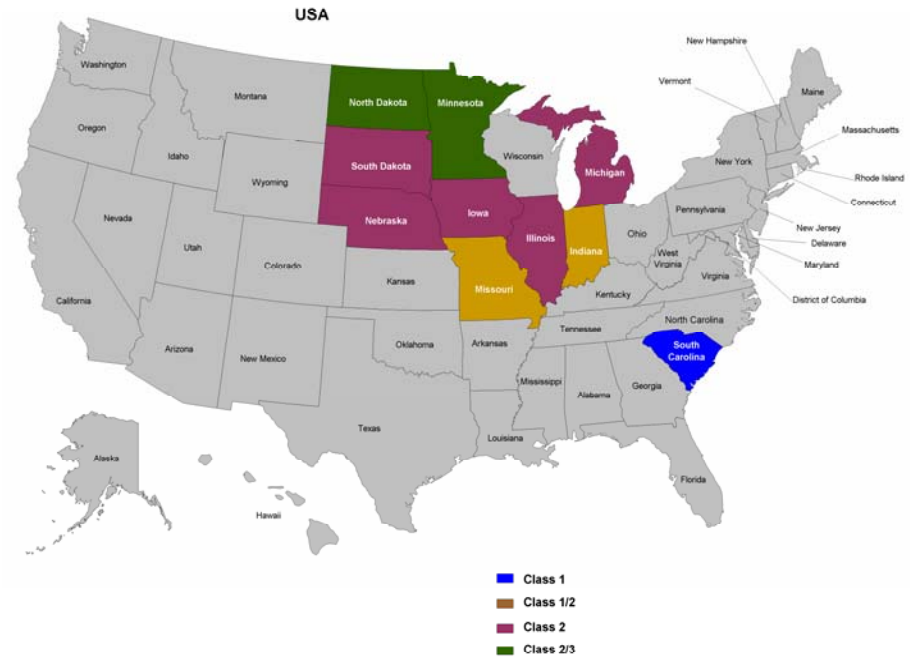
In the spring of 2006, SGS Germany GmbH conducted a survey of E85 fuels (nominally 70 to 85 percent denatured ethanol + 30 to 15 percent gasoline or other hydrocarbons) in the U.S. Samples were purchased at retail outlets and shipped to SGS laboratories in Germany for analysis.

This summary of the results was prepared for the Coordinating Research Council, Inc. (CRC) for use in planning vehicle test programs. A complete report, ("*Joint Venture Project, United States, E85 Survey, Spring & Summer 2006*"), containing individual sample data, as well as results on many other properties not contained in this summary, can be purchased from SGS. Contact SGS at www.us.sgs.com or at the address shown on the inside title page of this report.

SAMPLING AREAS

Forty-seven samples of E85 fuels were obtained from retail outlets in the following ten states:

Illinois	Missouri
Indiana	Nebraska
Iowa	North Dakota
Michigan	South Carolina
Minnesota	South Dakota



The complete report available from SGS includes individual sample identification and specific sampling location.

FUEL PROPERTIES

This summary report contains analytical data on the following properties that are controlled by ASTM D 5798, "Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines."

Vapor pressure	ASTM D 5191
Ethanol content	ASTM D 6729 mod
Higher alcohol content	ASTM D 5599
Methanol content	ASTM D 5599
Sulfur content	ASTM D 5453 or D 6334
Unwashed gum	ASTM D 381
Solvent-washed gum	ASTM D 381
Acidity as acetic acid	ASTM D 1613
pHe	ASTM D 6423
Water content	ASTM E 1064
Lead content	ASTM D 5059
Total chlorine as chlorides	ASTM D 4929/B
Inorganic chloride	Ion chromatography (SGS inhouse)
Sulfate	Ion chromatography (SGS inhouse)

The complete report available from SGS also contains data on many other fuel properties.

All ASTM standards are available from ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428, telephone 610-832-9585, internet www.astm.org.

DATA ANALYSIS

The analytical data were grouped according to the volatility class assignments defined in ASTM D 5798. The assignments are based on the sampling location and the month the samples were taken.

The following volatility class assignments were represented by the fuels in the survey:

Class 1
Class 2/1
Class 2
Class 3/2

ASTM D 5798 defines requirements for Volatility Class 1 (warm ambient temperature), Class 2 (intermediate ambient temperature), and Class 3 (cold ambient temperature). During transition months, when fuels are changing from one class to another, the fuels are permitted to meet the requirements of either of the two classes. For example, when the table of volatility class assignments in D 5798 shows "2/1" or "1/2" for a particular state and month, the fuels in that location can meet the requirements of either Class 1 or Class 2. Thus, the allowable limits for some properties may cover a wider range during a transition month than during a month with a single volatility class assignment.

To provide the information needed by CRC for developing its test programs, this summary contains the following statistical data for each of the fuel properties in each volatility class assignment:

10^{th} percentile
Average
Median
90^{th} percentile

In addition, the percentage of fuels in each volatility class that did not meet all of the requirements of ASTM D 5798 is reported, along with the reasons for failure to meet the requirements.

As specified by CRC, the 10^{th} and 90^{th} percentiles were determined as follows:

- Sample size <10: 10^{th} pctl = minimum value, 90^{th} pctl = maximum value
- Sample size =10: 10^{th} pctl = average of two lowest values, 90^{th} pctl = average of two highest values
- Sample size >10 and <20: 10^{th} pctl = second lowest value, 90^{th} pctl = second highest value
- Sample size =20: 10^{th} pctl = average of second and third lowest values, 90^{th} pctl = average of second and third highest values
- Sample size >20 and <30: 10^{th} pctl = third lowest value, 90^{th} pctl = third highest value

RESULTS

The data for vapor pressure are shown graphically in Figures 1a and 1b, ethanol content in Figure 2, and sulfur content in Figure 3. The ASTM D 5798 limits for those properties are stated in the figures.

ASTM D 5798 sets minimum limits for ethanol + higher alcohols, rather than for ethanol alone, and those limits are listed in Figure 2. The higher alcohol contents of the fuels in this survey did not exceed 0.1 percent.

Table 1 presents the results for the fuels required to meet Volatility Class 1. All of the fuels in Class 1 met the requirements of ASTM D 5798.

Table 1. Statistical Data for E85 Fuels in Volatility Class 1

			Volatility Class 1			
Property	Units	Test Method	10th pctl	average	median	90th pctl
Vapor pressure	kPa	ASTM D 5191	39.9	41.8	41.7	43.7
Vapor pressure	psi	ASTM D 5191	5.8	6.1	6.0	6.3
Ethanol	vol.%	ASTM D 6729 mod	81.1	81.5	81.6	81.8
Higher alcohols	vol.%	ASTM D 5599	0.08	0.09	0.08	0.10
Ethanol+higher alcohols	vol.%		81.2	81.6	81.7	81.9
Methanol	vol.%	ASTM D 5599	<0.01	<0.01	<0.01	<0.01
Sulfur	mg/kg	ASTM D 5453, D 6334	11	12	11	13
Unwashed gum	mg/100 mL	ASTM D 381	5.2	6.0	5.2	7.6
Solvent washed gum	mg/100 mL	ASTM D 381	<1.0	<1.0	1.0	1.2
Acidity as acetic acid	mg/L	ASTM D 1613	8	11	11	13
pHe		ASTM D 6423	7.2	7.3	7.4	7.6
Water	mg/kg	ASTM E 1064	5357	5817	5685	6409
Lead	mg/L	ASTM D 5059	<0.1	<0.1	<0.1	<0.1
Total chlorine	mg/kg	ASTM D 4929/B	0.5	0.7	0.6	1.0
Inorganic chloride	mg/kg	Ion Chromatography	<0.2	0.2	<0.2	0.6
Sulfate	mg/kg	Ion Chromatography	0.8	1.0	0.8	1.4
Number of Samples	3					
Percent of fuels not meeting ASTM D 5798: 0%						

Note: mg/kg = ppm (mass)

Table 2 presents the results for the fuels required to meet Volatility Classes 1 or 2. Forty percent of the fuels did not meet one or more of the requirements of ASTM D 5798 due to low vapor pressure, low ethanol content, or high unwashed gum.

Table 2. Statistical Data for E85 Fuels in Volatility Class 2/1

			Volatility Class 2/1			
Property	Units	Test Method	10th pctl	average	median	90th pctl
Vapor pressure	kPa	ASTM D 5191	37.1	43.9	43.1	53.5
Vapor pressure	psi	ASTM D 5191	5.4	6.4	6.3	7.8
Ethanol	vol.%	ASTM D 6729 mod	70.4	76.9	77.5	81.2
Higher alcohols	vol.%	ASTM D 5599	0.06	0.06	0.06	0.06
Ethanol+higher alcohols	vol.%		70.5	77.0	77.6	81.3
Methanol	vol.%	ASTM D 5599	<0.01	0.01	0.01	0.02
Sulfur	mg/kg	ASTM D 5453, D 6334	12	16	15	19
Unwashed gum	mg/100 mL	ASTM D 381	4.2	15.6	9.2	46.4
Solvent washed gum	mg/100 mL	ASTM D 381	<1.0	<1.0	1.0	1.4
Acidity as acetic acid	mg/L	ASTM D 1613	5	9	9	12
pHe		ASTM D 6423	6.9	7.4	7.5	7.7
Water	mg/kg	ASTM E 1064	4016	5642	5661	6753
Lead	mg/L	ASTM D 5059	<0.1	<0.1	<0.1	<0.1
Total chlorine	mg/kg	ASTM D 4929/B	0.4	0.5	0.4	0.8
Inorganic chloride	mg/kg	Ion Chromatography	<0.2	<0.2	<0.2	0.3
Sulfate	mg/kg	Ion Chromatography	0.8	1.1	1.1	1.2
Number of Samples	5					
Percent of fuels not meeting ASTM D 5798: 40%						
Reasons for not meeting ASTM D 5798: Low vapor pressure, low ethanol, high unwashed gum						

Note: mg/kg = ppm (mass)

Table 3 presents the results for the fuels required to meet Volatility Class 2. None of the fuels met all of the requirements of ASTM D 5798 due to low vapor pressure or low ethanol content.

Table 3. Statistical Data for E85 Fuels in Volatility Class 2

			Volatility Class 2			
Property	Units	Test Method	10th pctl	average	median	90th pctl
Vapor pressure	kPa	ASTM D 5191	39.2	43.1	42.9	46.8
Vapor pressure	psi	ASTM D 5191	5.7	6.3	6.2	6.8
Ethanol	vol.%	ASTM D 6729 mod	75.5	77.6	77.1	81.9
Higher alcohols	vol.%	ASTM D 5599	0.04	0.06	0.06	0.08
Ethanol+higher alcohols	vol.%		75.6	77.7	77.2	81.9
Methanol	vol.%	ASTM D 5599	<0.01	<0.01	<0.01	0.02
Sulfur	mg/kg	ASTM D 5453, D 6334	12	16	15	23
Unwashed gum	mg/100 mL	ASTM D 381	3.2	7.3	7.8	9.8
Solvent washed gum	mg/100 mL	ASTM D 381	<1.0	<1.0	<1.0	1.0
Acidity as acetic acid	mg/L	ASTM D 1613	8	12	9	20
pHe		ASTM D 6423	7.5	7.6	7.6	7.8
Water	mg/kg	ASTM E 1064	5220	5978	5670	8189
Lead	mg/L	ASTM D 5059	<0.1	<0.1	<0.1	<0.1
Total chlorine	mg/kg	ASTM D 4929/B	0.4	0.7	0.6	1.1
Inorganic chloride	mg/kg	Ion Chromatography	<0.2	0.2	<0.2	0.7
Sulfate	mg/kg	Ion Chromatography	0.4	0.8	0.8	1.4
Number of Samples	17					
Percent of fuels not meeting ASTM D 5798: 100%						
Reasons for not meeting ASTM D 5798: Low vapor pressure, low ethanol						

Note: mg/kg = ppm (mass)

Table 4 presents the results for the fuels required to meet Volatility Classes 2 or 3. Eighteen percent of the fuels did not meet the requirements of ASTM D 5798 due to low vapor pressure.

Table 4. Statistical Data for E85 Fuels in Volatility Class 3/2

			Volatility Class 3/2			
Property	Units	Test Method	10th pctl	average	median	90th pctl
Vapor pressure	kPa	ASTM D 5191	46.9	53.8	48.7	71.7
Vapor pressure	psi	ASTM D 5191	6.8	7.8	7.1	10.4
Ethanol	vol.%	ASTM D 6729 mod	70.8	74.1	74.6	78.6
Higher alcohols	vol.%	ASTM D 5599	0.05	0.06	0.06	0.07
Ethanol+higher alcohols	vol.%		70.9	74.2	74.7	78.6
Methanol	vol.%	ASTM D 5599	<0.01	<0.01	<0.01	<0.01
Sulfur	mg/kg	ASTM D 5453, D 6334	10	14	15	17
Unwashed gum	mg/100 mL	ASTM D 381	2.2	5.1	4.7	8.2
Solvent washed gum	mg/100 mL	ASTM D 381	<1.0	<1.0	<1.0	1.0
Acidity as acetic acid	mg/L	ASTM D 1613	5	7	7	9
pHe		ASTM D 6423	7.2	7.5	7.6	7.8
Water	mg/kg	ASTM E 1064	3633	4825	4998	5542
Lead	mg/L	ASTM D 5059	<0.1	<0.1	<0.1	<0.1
Total chlorine	mg/kg	ASTM D 4929/B	0.3	0.8	0.8	1.4
Inorganic chloride	mg/kg	Ion Chromatography	<0.2	<0.2	<0.2	<0.2
Sulfate	mg/kg	Ion Chromatography	0.3	1.4	1.5	2.0
Number of Samples	22					
Percent of fuels not meeting ASTM D 5798: 18 %						
Reasons for not meeting ASTM D 5798: Low vapor pressure						

Note: mg/kg = ppm (mass)

Figure 1a. Vapor Pressure (kPa) of E85 Fuels

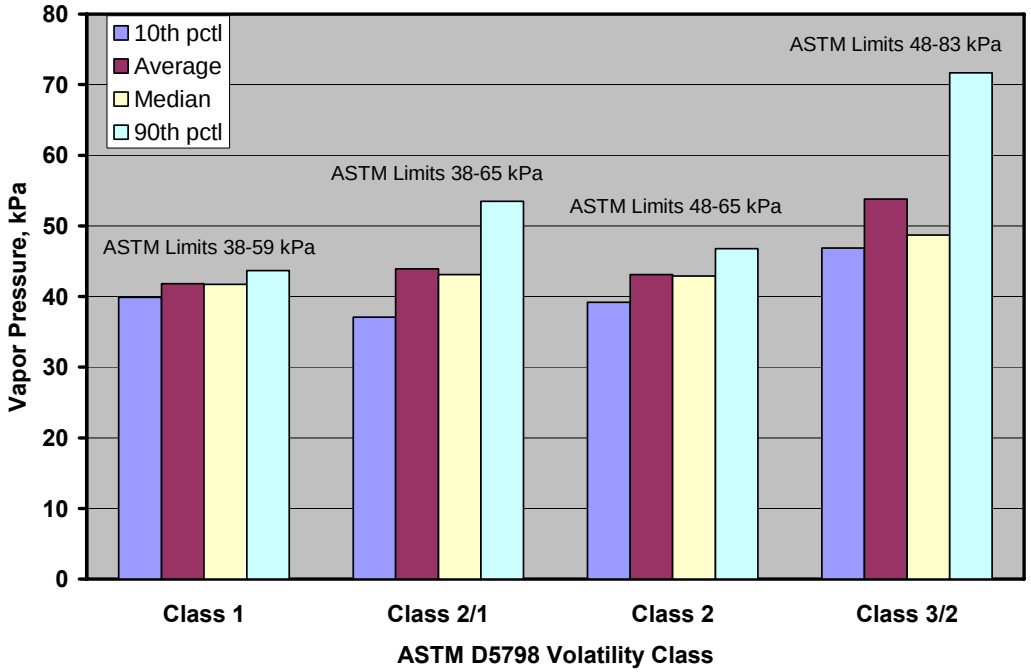


Figure 1b. Vapor Pressure (psi) of E85 Fuels

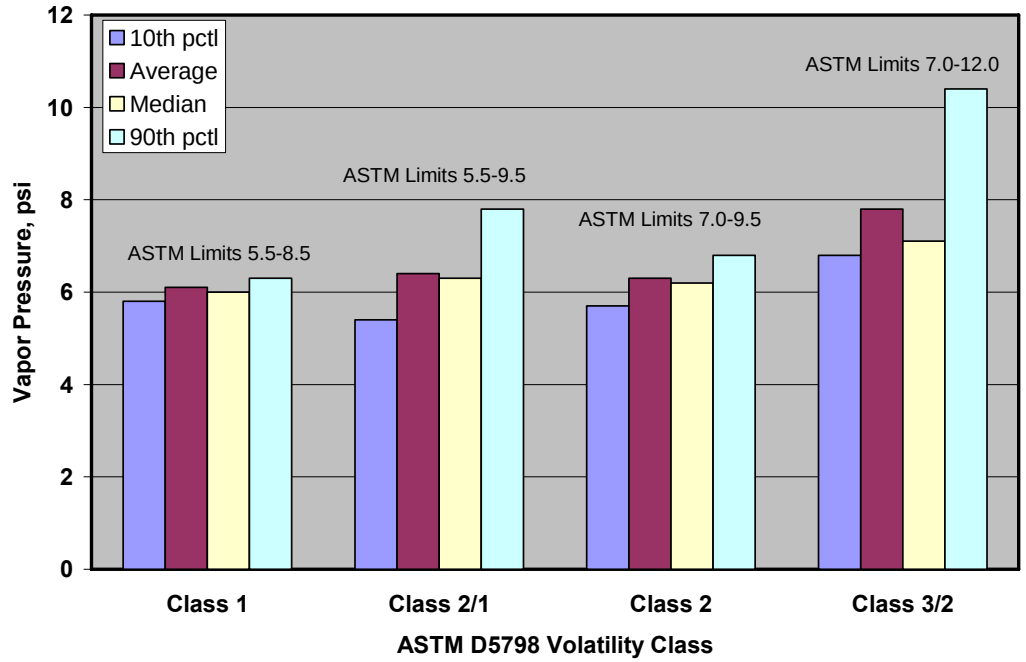


Figure 2. Ethanol Content of E85 Fuels

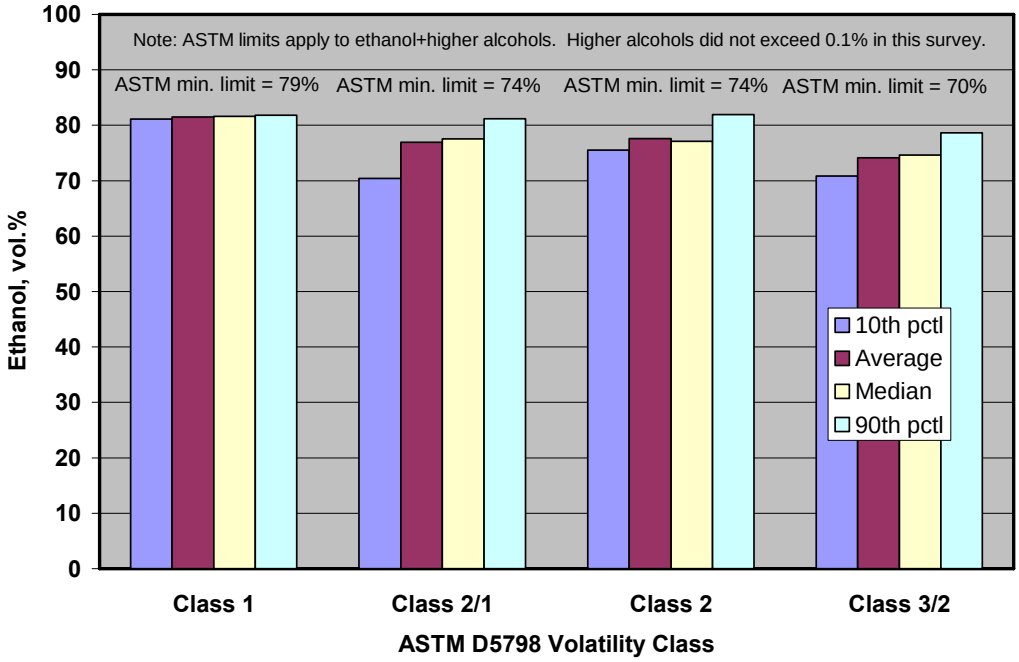
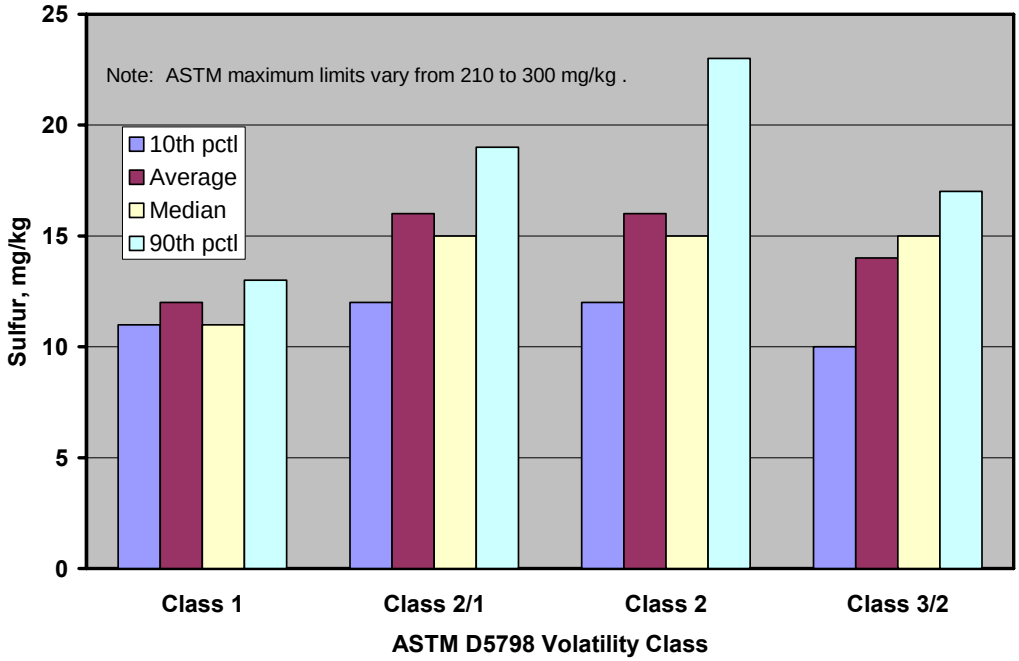


Figure 3. Sulfur Content of E85 Fuels



ACKNOWLEDGEMENT

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