

CRC Report No. E-79-2

**SUMMARY OF THE STUDY OF E85 FUEL
IN THE USA
WINTER 2006-2007**

May 2007



COORDINATING RESEARCH COUNCIL, INC.
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Summary of the Study of E85 Fuel in the USA
Winter 2006-2007

Prepared for

The Coordinating Research Council, Inc.

Project No. E-79-2

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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. A summary of that survey was prepared for the Coordinating Research Council (CRC). (“*Summary of the Study of E85 Fuel in the USA 2006*,” CRC Report No. E-79, August 2006.) That survey included summer volatility and intermediate volatility fuels, but no winter fuels.

Therefore, SGS conducted a second survey of E85 fuels in the U.S. in January and February 2007 to determine the properties of winter fuels. As in the earlier survey, 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 for use in planning vehicle test programs. A complete report, (“*Fuel Study of E85 in the USA, Winter 2006/2007*”), 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.

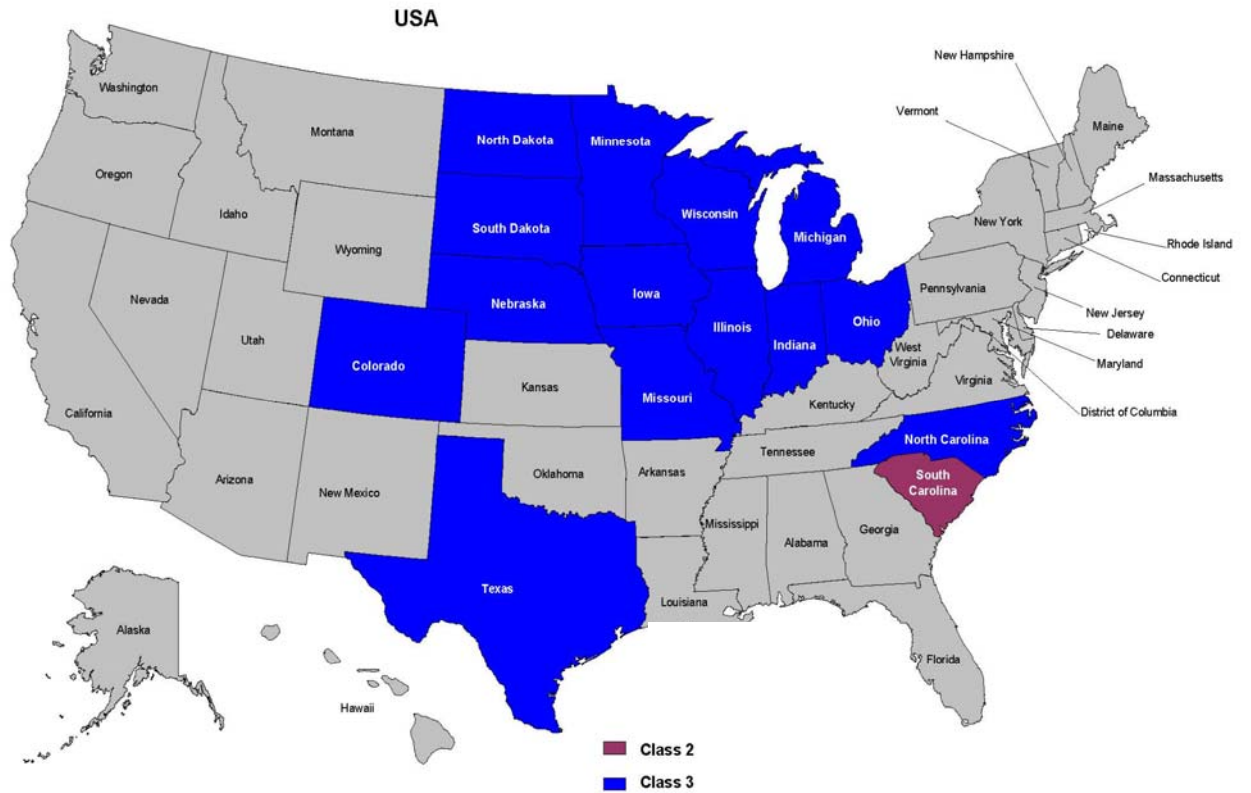
SAMPLING AREAS

Fifty-five samples of E85 fuel were obtained from retail outlets in the following 15 states:

Colorado	Minnesota	Ohio
Illinois	Missouri	South Carolina
Indiana	Nebraska	South Dakota
Iowa	North Carolina	Texas
Michigan	North Dakota	Wisconsin

The complete report available from SGS includes individual sample identification and specific sampling location. All but two of the fuels were sampled in January 2007. Two were sampled in February.

Sampling Map





FUEL PROPERTIES

This summary report contains analytical data on the following properties that, with the exception of sulfate content, 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
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
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.

Although there is no ASTM limit on the sulfate content of E85, there is a maximum sulfate limit of 4 mg/kg in fuel ethanol defined in ASTM D 4806, "Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel."

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.

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 “2/3” or “3/2” for a particular state and month, the fuels in that location can meet the requirements of either Class 2 or Class 3. 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.

The volatility class assignments for the fuels in this survey were either Class 2 (three fuels) or Class 3 (52 fuels).

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

10th percentile
Average
Median
90th percentile

In addition, the percentage of fuels in each volatility class that failed to meet one or more of the requirements of ASTM D 5798 is reported, along with the reasons for failure to meet the requirements.

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

- Sample size <10: 10th percentile = minimum value, 90th percentile = maximum value
- Sample size >50 and <60: 10th percentile = sixth lowest value, 90th percentile = sixth highest value

RESULTS

The data for vapor pressure are shown graphically in Figures 1a and 1b on page 7, ethanol + higher alcohol content in Figure 2 on page 8, and sulfur content in Figure 3 on page 8. The ASTM D 5798-06 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 0.3 percent.

Table 1 presents the results for the fuels required to meet Volatility Class 2. Two of the three Class 2 fuels (67 percent) did not meet the requirements of ASTM D 5798 due to both high vapor pressure and low ethanol content.

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

Property	Units	Test Method	Volatility Class 2			
			10th_pctl	average	median	90th_pctl
Vapor pressure	kPa	ASTM D 5191	53.5	65.4	70.7	71.9
Vapor pressure	psi	ASTM D 5191	7.8	9.5	10.3	10.4
Ethanol	vol.%	ASTM D 6729 mod	59.3	68.9	67.7	79.3
Higher alcohols	vol.%	ASTM D 5599	<0.01	0.13	0.11	0.27
Ethanol+higher alcohols	vol.%		59.6	68.9	67.7	79.4
Methanol	vol.%	ASTM D 5599	<0.01	<0.01	<0.01	<0.01
Sulfur	mg/kg	ASTM D 5453	7	13	14	17
Unwashed gum	mg/100 mL	ASTM D 381	3.0	5.6	5.8	8.0
Solvent washed gum	mg/100 mL	ASTM D 381	<1.0	1.0	1.0	2.0
Acidity as acetic acid	mg/L	ASTM D 1613	<1	3	<1	8
pHe		ASTM D 6423	7.4	7.6	7.6	7.7
Water	mg/kg	ASTM E 1064	4242	4832	4349	5905
Total chlorine	mg/kg	ASTM D 4929/B	0.2	0.3	0.2	0.4
Inorganic chloride	mg/kg	Ion Chromatography	0.2	0.2	0.2	0.2
Sulfate	mg/kg	Ion Chromatography	0.7	0.7	0.7	0.7
Number of Samples	3					
Percent of fuels not meeting ASTM D 5798: 67%						
Reasons for not meeting ASTM D 5798: High vapor pressure, low ethanol.						

Note: mg/kg = ppm (mass)



Table 2 presents the results for the fuels required to meet Volatility Class 3. Two-thirds of the fuels failed to meet one or more of the requirements of ASTM D 5798. Fifty-eight percent of the fuels did not meet the vapor pressure requirements. One fuel exceeded the maximum vapor pressure limit of 83 kPa (12.0 psi), and 29 fuels had vapor pressures below the minimum limit of 66 kPa (9.5 psi).

Fifteen percent of the fuels did not meet the minimum ethanol + higher alcohol requirement of 70 volume-percent. Other properties that caused one or more fuels to fail D 5798 were high total chlorine, high inorganic chloride, high unwashed gum, and low pHe.

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

Property	Units	Test Method	Volatility Class 3			
			10th pctl	average	median	90th pctl
Vapor pressure	kPa	ASTM D 5191	54.6	64.0	64.5	71.5
Vapor pressure	psi	ASTM D 5191	7.9	9.3	9.4	10.4
Ethanol	vol.%	ASTM D 6729 mod	68.8	71.5	70.6	80.9
Higher alcohols	vol.%	ASTM D 5599	<0.01	0.07	0.07	0.14
Ethanol+higher alcohols	vol.%		68.9	71.6	70.7	81.1
Methanol	vol.%	ASTM D 5599	<0.01	<0.01	<0.01	0.02
Sulfur	mg/kg	ASTM D 5453	6	12	12	20
Unwashed gum	mg/100 mL	ASTM D 381	2.0	8.3	5.7	9.2
Solvent washed gum	mg/100 mL	ASTM D 381	<1.0	0.8	1.0	1.6
Acidity as acetic acid	mg/L	ASTM D 1613	2	8	5	16
pHe		ASTM D 6423	7.2	7.5	7.6	7.8
Water	mg/kg	ASTM E 1064	4495	5327	5318	6338
Total chlorine	mg/kg	ASTM D 4929/B	<0.2	0.4	0.3	0.8
Inorganic chloride	mg/kg	Ion Chromatography	<0.1	0.3	0.2	0.3
Sulfate	mg/kg	Ion Chromatography	0.6	0.8	0.7	1.0
Number of Samples	52					
Percent of fuels not meeting ASTM D 5798: 67%						
Reasons for not meeting ASTM D 5798: Low or high vapor pressure, low ethanol, high total chlorine, high inorganic chloride, high unwashed gum, low pHe.						

Note: mg/kg = ppm (mass)

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

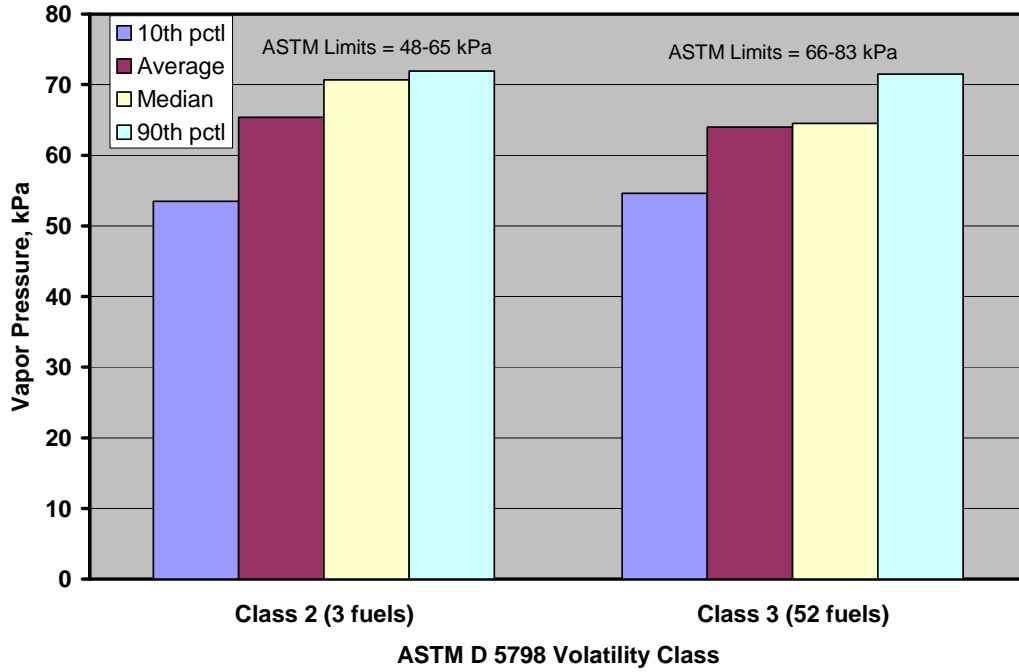


Figure 1b. Vapor Pressure (psi) of E85 Fuels

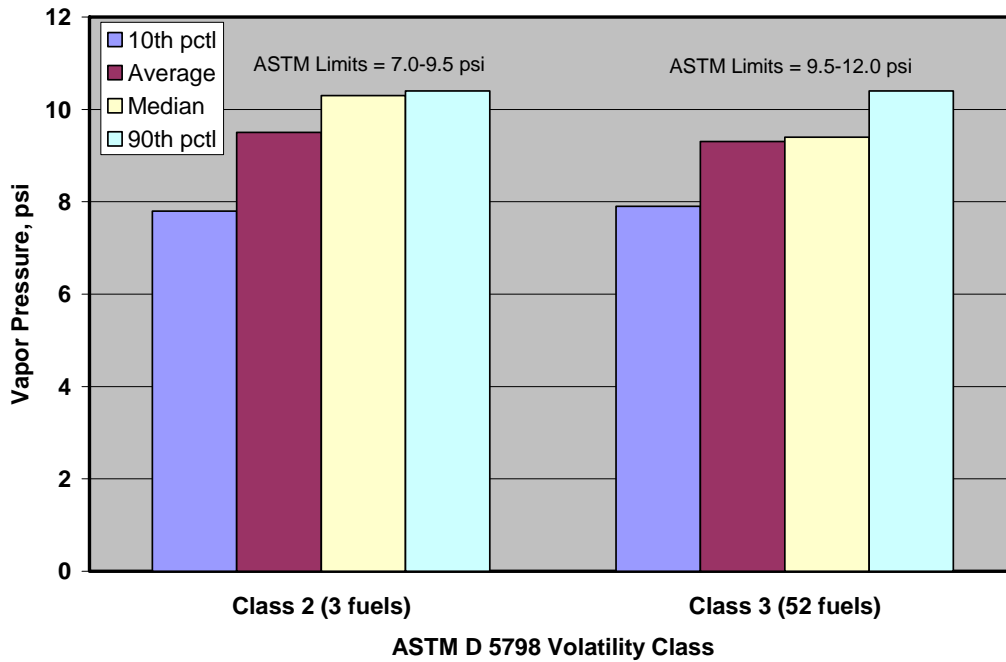


Figure 2. Ethanol + Higher Alcohol Content of E85 Fuels

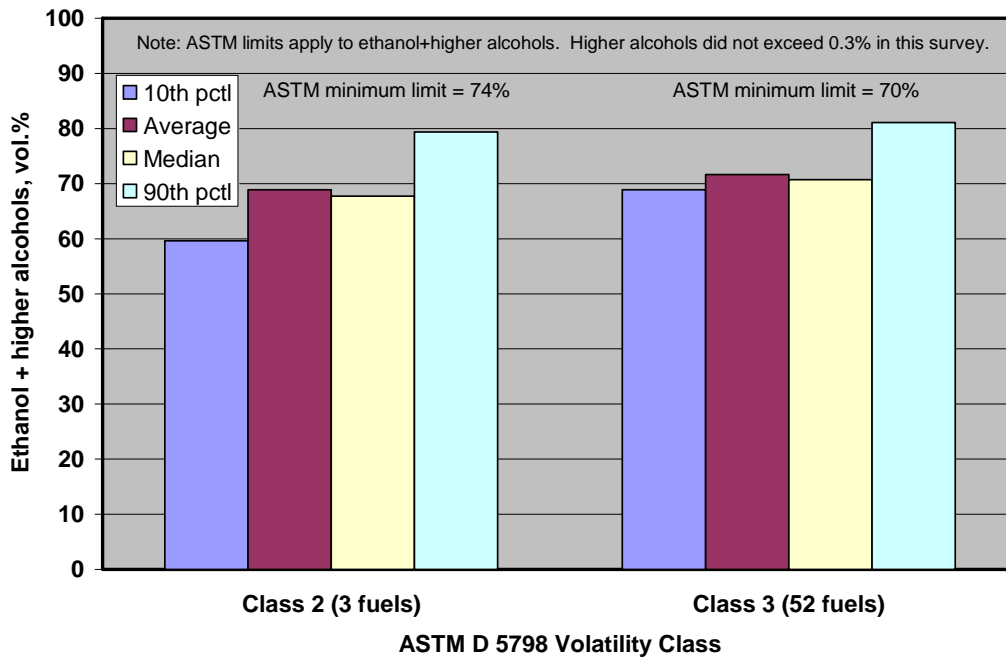
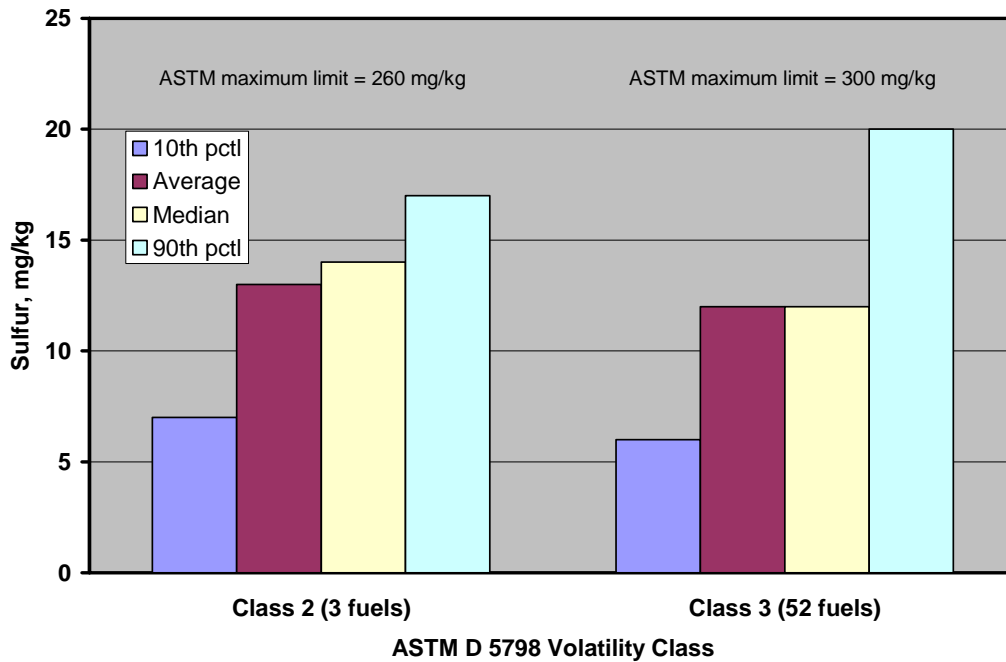


Figure 3. Sulfur Content of E85 Fuels





ACKNOWLEDGEMENT

This project was conducted for the CRC Emissions Committee.