CRC Report No. 658

2009-2010 CRC/ASTM HOT-FUEL-HANDLING PROGRAM

(For Classes D-4 and E-5 Gasoline)

CRC Project No. CM-138-09-2

Final Report

October 2010

COORDINATING RESEARCH COUNCIL, INC.

3650 MANSELL ROAD·SUITE 140·ALPHARETTA, GA 30022

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Prepared by the

CRC Volatility Group

October 2010

CRC Performance Committee
of the
Coordinating Research Council

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ABSTRACT

The 2009-2010 CRC/ASTM Hot-Fuel-Handling Program was conducted at Southwest Research Institute (SwRI) in San Antonio, Texas with screening of vehicles from September 15 through September 28, 2009, actual driveability ratings from September 30 through November 11, 2009 and again from April 23 through June 4, 2010. The objective of the program was to determine the effect at sea level under hot ambient temperature conditions (nominal 85°F for ASTM D4814 Volatility Class D-4 and nominal 69°F for Class E-5) of fuel front-end volatility and ethanol content on hot-fuel-handling driveability performance in a large group of late-model vehicles and one older vehicle, all equipped with fuel-injection systems. There were 20 late-model vehicles selected from a larger fleet of 44 1999 – 2010 vehicles for the Class E-5 testing, based on sensitivity to the screening fuels and on market share. Two additional 2009-2010 latest technology vehicles were added to the fleet for the Class D-4 evaluations by request. The test fuel design consisted of 16 test fuels with varying TVL20, fifty percent evaporated distillation, and levels of ethanol.

For Class E-5 fuels, it is noted that as ethanol content increases from 0 to 10 volume percent, the demerits increase by a minimal amount. This minimal increase in demerits is also observed as fifty percent distillation decreases from 170°F to 140°F. A single E15 fuel was also tested on all the fleet vehicles.

There are no significant fuel property effects (TVL20, T_{50}, ethanol content) observed on vehicle performance for Class D-4 fuels. A single E15 fuel was also tested on three vehicles.

Based on TWDs, relative individual vehicle performances run on the two sets of fuels appear consistent between ASTM D4814 Classes D-4 and E-5.

I. INTRODUCTION

The CRC Volatility Group managed a two-part program in 2009 and 2010 for ASTM to determine the effect under hot ambient temperature conditions of fuel front-end volatility and ethanol content on hot-fuel-handling driveability performance in a large group of late-model vehicles and a single vehicle nominally ten-years-old equipped with fuel-injection systems. The ASTM Driveability Task Force had developed a test matrix to examine the effects of TVL20, the 50 volume percent evaporated distillation point (T_{50}), and ethanol content of ASTM D4814 Volatility Classes D-4 and E-5 gasoline on modern vehicle performance. When ethanol is blended with base petroleum gasoline that meets current ASTM D4814 specifications, the resulting fuel can fall below the TVL20 and 50 volume percent evaporation limits of the current D4814 specification. It was agreed that driveability data were needed to assess vehicle performance at these levels. The ASTM proposal was presented to CRC on April 15, 2009 with a request that CRC manage the program while certain ASTM members provided all funds needed to complete the project through contract at SwRI. The original proposal as presented to CRC contained two phases, one for "winter" gasoline Classes D-4 and E-5, and one for "summer" gasoline Classes A-1 through C-3. It should be noted that the data generated and the discussion presented in this report deal only with Classes D-4 and E-5 fuels and that subsequent testing of "summer" gasoline is planned for a later date. CRC accepted the proposal for management in July 2009. ASTM membership provided nine of the sixteen fuels used in the program with the remaining fuels produced by and purchased from a specialty fuels blender.

Southwest Research Institute (SwRI) in San Antonio, Texas was contracted by CRC to conduct the driveability project with Beth Evans and Harold Archibald serving as the CRC independent raters, Lew Gibbs of Chevron as the CRC liaison, Russ Lewis of Marathon as the ASTM liaison, and Kevin Brunner of SwRI as the on-site coordinator. The project commenced on September 15, 2009 and was completed on June 4, 2010 with no testing conducted from November 12, 2009 through April 23, 2010 due to ambient temperatures being below target range.

Members of the Data Analysis Panel and participants in the program are shown in Appendices A and B, respectively. Appendix C outlines the program as approved by the CRC Performance Committee. Also included in Appendix C are the draining and flushing procedures used in this project[4].

II. CONCLUSIONS

The conclusions of the 2009-2010 CRC/ASTM Hot-Fuel-Handling Program for ASTM D4814 Volatility Classes D-4 and E-5 at nominal sea level are as follows:

- Individual vehicle performance appears consistent between fuel Classes D-4 and E-5 with TWD varying from 7 to 32 for the combined classes.
- The vehicle fleet average TWD ranged from 14.8 to 22.5 for E-5 fuels and from 15.3 to 22.0 for D-4 fuels.
- Class E-5 Fuel 14 (102/140/10) gave marginally statistically significant higher TWDs when compared to Fuel 8 (105/170/0) or Fuel 9 (105/150/0).
- For Class E-5 fuels, no significant effect was found for TVL20.
- For Class E-5 fuels, increasing ethanol content from 0 to 10 volume percent, increased the TWDs by approximately 3.4 or less.
- For Class E-5 fuels, as T_{50} decreases from ~170°F to ~140°F, the demerits increase by approximately 4.4 or less,.
- For Class E-5 fuels, the single E15 fuel, tested in all fleet vehicles, shows no discernable performance differences when compared to the E0 and E10 fuels.
- Class D-4 Fuel 6 (107/150/10) yielded statistically significant higher TWDs than almost all of the other Class D-4 fuels.
- For Class D-4 fuels, no significant fuel property effects (TVL20, T_{50}, or ethanol content) were observed on vehicle performance.
- For Class D-4 fuels, the single E15 fuel tested on only three vehicles shows no discernable performance impacts compared to the E0 and E10 fuels.
- One possible explanation for differences in significant fuel effects for Class E-5 fuels when compared to Class D-4 fuels is that the vehicle calibrations are tighter in the range of the Class E-5 ambient test temperatures that vehicle sensitivity may be increased at these temperatures.

III. TEST VEHICLES

The original design of the program was to obtain a vehicle fleet of twenty vehicles, nominally covering model years 1998 through 2009 with an emphasis on 2005 and newer models. The final fleet was to be selected from an initial group of approximately fifty vehicles. A total of forty-four vehicles were screened with most of these being obtained from a local rental agency in San Antonio, a few obtained from a local used car agency, and one vehicle from an SwRI employee. Two additional vehicles were discarded prior to testing due to mechanical issues not associated with the fuels being evaluated. Vehicles, older than 2007, were very difficult to obtain from the available sources. The forty-four vehicles screened with "severe" and "mild" fuels included one 2010, nineteen 2009, sixteen 2008, seven 2007, and one 1999 model. From this screening, twenty test vehicles were selected. These were used to evaluate the Class E-5 fuels in the program. Two additional vehicles, representing the latest General Motors technology, were added at the request of General Motors to the Class D-4 fuel evaluations in the spring of 2010, bringing the final test fleet to a total of twenty-two. The additions include vehicles that contain a turbo-charger and a direct-injected-spark-ignition (DISI) engine.

The manufacturer mix of the final test fleet is as follows: six Chevrolets, four Fords, four Chryslers, two Hondas, two Toyotas, one Nissan, one Mazda, one Hyundai, and one Kia. All were equipped with air conditioning, fuel injection, and automatic transmissions (except for a 2008 Dodge Caliber which was equipped with a continuously variable transmission). Engine displacements of the test fleet ranged from 1.6 to 5.3 liters and up to 6.0 liters in the screening fleet. All of the final fleet had returnless fuel systems. The 22 vehicles in the final fleet are shown in Table 1, and a complete description of the 44-vehicle fleet is presented in Appendix D.

IV. TEST FUELS

The test fuel matrix consisted of sixteen test fuels in two volatility classes. Both the Class D-4 and E-5 fuels consist of four fuels without ethanol, three with a nominal 10 volume percent ethanol, and one with 15 volume percent ethanol in each class. Targeted volatility limits for the Class D-4 fuels include TVL20 at 116°F and 107°F for all fuels except for the 15% ethanol blend which targeted 109°F for TVL20. The 50 volume percent evaporated distillation targets (T_{50}) for Class D-4 fuels are 170°F, 150°F, and 140°F, respectively. The Class E-5 fuels TVL20 targets are 105°F and 102°F, respectively with the T_{50} targets at 170°F, 150°F, and 140°F, respectively.

Nine of the sixteen fuels were produced at various refineries to meet the desired specifications with samples obtained and sent to Marathon's Catlettsburg laboratory for testing and comparison against the laboratory at the production facility. The fuels were shipped to SwRI in drums for storage in a climate controlled facility. Some of the fuels required blending with ethanol and/or addition of butane to meet the final parameters for the test fuels as outlined in the program. This blending was conducted at SwRI by Marathon personnel with the fuels having been chilled for 24 hours at 40°F prior to blending. The remaining seven fuels were produced by and purchased from a specialty fuels blender. Samples of the test fuels were then obtained and submitted to the four volunteer laboratories for confirmation of fuel properties. After blending,

the fuels were returned to controlled temperature storage until the program commenced. Table 2 list the average of the fuel properties as determined by four independent laboratories. The individual laboratory inspections are shown in Appendix E-1.

Fuel 14 was utilized as the primary "severe" screening fuel for the forty-four original vehicles with Fuels 10 and 13 also used as "severe" screening fuels to supplement when it was determined that there was not enough of Fuel 14 to complete all of the screening. The use of alternative "severe" screening fuels was approved by the CRC liaison for the project. The "severe" fuels contain a nominal 10 volume percent ethanol, have TVL20 ranging from 103°F to 105°F, and T_{50} ranging from 143°F to 155°F. A commercially available "mild" screening fuel was obtained from a Top Tier supplier. This fuel was used to confirm that any driveability problems experienced on the "severe" screening fuels were actually fuel related and not mechanical in nature. This "mild" fuel was a Class A "summer" gasoline that contained no ethanol, had a vapor pressure of ~7.6 psi, a T_{50} of 216°F, and a TVL20 of 154°F. This fuel is designated as Screening Fuel 1 with the analytical values as determined by SwRI for this material found in Table 3.

V. TEST SITE

The test program was conducted at the Southwest Research Institute (SwRI) in San Antonio, Texas. An asphalted test track, approximately one-half mile in length, located at SwRI was used as the test site with public roads used to condition the vehicles for testing. The altitude of the test track is approximately 750 feet above sea level. Two roofless wooden sheds for hot-soaking a vehicle were built at the test track. Each shed was 20 feet wide by 20 feet deep with the initial walls built to 8 feet. The west walls were later lowered to 4 feet to allow more evening sun into the soak sheds. By doing this, the testing could be extended into the late afternoon. The CRC refrigerated fuel storage container that had been used in the Yakima, Washington studies was delivered to SwRI and modified with an insulated garage-style overhead roll-up door to allow easy access inside. The refrigeration unit was kept at 68°F throughout the testing period and was located at the SwRI Fuel Blend Facility, approximately 1.5 miles from the test track. The defueling/flushing/refueling/sampling area was located by the refrigeration unit.

VI. TEST PROGRAM

A. Test Procedure

The test procedure used in this program is the protocol from the 2006 CRC Hot-Fuel-Handling Program (CRC Report No. 648). In this test procedure, after switching fuels, the test vehicle is warmed up for approximately 30 minutes over 15 miles of public roads near SwRI. Both CRC independent raters drove the conditioning route and verified its acceptance. At the start of the conditioning, the vehicle is driven on the SwRI campus at speeds of 15 and 25 mph. Once off campus, the vehicle is driven at 30 and 35 mph to reach the service entrance of an Interstate Highway. The vehicle is driven at 45 mph on the service entrance and then at 55 mph on the highway while making a loop of approximately 11 miles with two turnarounds. The vehicle is returned to SwRI campus in reverse order and driven to the test track at speeds of 25 and 15 mph. The conditioning route is completed when the vehicle is placed into the designated rater's hot-soak shed at the test track. (In the event of a delay due to traffic, the vehicle is driven at 65 mph on the highway when possible to make up time.)

The test vehicle is then parked in a soak shed for 20 minutes with the ignition off. The engine is then restarted after the 20-minute soak. Recording of data for calculation of total weighted demerits (TWDs) begins when the engine is restarted. The starting time, idle quality, and the occurrences of any stalls are recorded. The vehicle is accelerated at wide-open-throttle (WOT) to 35 mph. Driveability malfunctions, such as hesitation, surge, stumble, stall, or backfire, and their severity are recorded. The test vehicle is then returned and parked in a soak shed. The transmission is shifted into park and the engine is idled for 20 minutes. The idle quality is assessed, and if the engine stalls, the stall is recorded and an attempt to restart the engine is made immediately. If the engine continues to stall after three restarts, the test is aborted. At the end of the 20-minute idle test period, the transmission is shifted into drive, and the idle quality and any stalls are recorded. The vehicle is then slowly driven from the soak shed and accelerated at light-throttle to 35 mph. Driveability malfunctions and their severity are recorded. The vehicle is driven back to the soak shed and parked with the engine off for 20 minutes. The starting time is recorded, and idle quality and number of stalls are recorded. The vehicle is accelerated out of the soak shed at light-throttle to 35 mph. Driveability malfunctions and their severity are recorded. This concludes the testing sequence. In some cases, a repeat driveability evaluation may be delayed. If performed within a 24-hour period, the vehicle was topped-off with two gallons of the same test fuel instead of the fuel tank drain and four-gallon fill procedure being employed. This top-off procedure was completed only at the direction of the driveability rater.

For each evaluation, six ambient temperatures are recorded. The first temperature was the ambient temperature at which the car started the conditioning route. This temperature was recorded by a weather station located at the CRC refrigerated container. The remaining five temperatures are all recorded by rater supplied devices at the test track once a vehicle is delivered to the track. These five temperatures include test start, end of soak for each of the three driveability segments, and end of test. The final test data set includes the maximum ambient temperature recorded and the end-of-test temperature. Since there are discrepancies at times

between the values displayed by the weather station and the temperature measuring devices at the track, the decision by the raters and the CRC liaison was to exclude the temperatures recorded by the weather station when choosing the maximum ambient temperature value.

B. Fueling and Sampling Procedures

All test fuels, prior to being used to supply the test vehicles, were stored in the 68°F refrigerated container for at least 24 hours prior to being used. The fuel was delivered to the test vehicles through electrical drum pumps equipped with fuel meters, supplied by CRC.

The fuel tank flushing procedure used for fuel changes was the same as that which had been developed for the 2006 CRC Hot-Fuel-Handling Program. In the event that a vehicle had been prepared for testing but the evaluation was placed on hold and was rescheduled, then the vehicle fuel tank was drained and another 4-gallon charge of the test fuel was made available when the evaluation commenced.

After each test, the fuel from the vehicle tank was sampled through a valve on the fuel rail by running the discharge through a copper cooling coil in an ice chest. Ice was kept in the coolers to keep the copper coils cold to chill the fuel. Chilled one-quart cans were flushed with the chilled fuel and then filled with the same fuel. No additional testing was planned on these samples as part of the study but the samples are being retained for a period of six months at SwRI.

C. Test Plan and Required Modifications

The program was conducted from September 2, 2009 through June 14, 2010 with no testing between November 12, 2009 and April 23, 2010 due to ambient temperatures in San Antonio being below the targeted range. The weeks of September 2nd and 9th were used to build the soak sheds and to get the refrigerated fuel storage container on site and prepared for use. Vehicle screening for fuel sensitivity commenced on September 15th and concluded on September 29th. Testing of Class D-4 fuels commenced on September 30th with plans to work six days per week until completed. The target ambient testing temperature range for Class D was 80°F to 90°F. Unfortunately, October 2009 was one of the wettest on record for San Antonio. This resulted in only one-quarter of the Class D-4 fuels being completed during the fall of 2009 while ambient temperatures were in the proper target range. A decision was made to suspend Class D-4 testing and commence with Class E-5 fuels with a targeted ambient test temperature of 64°F to 74°F. More rain and cloud cover were experienced during November which resulted in approximately three-quarters of the Class E-5 testing being completed. Testing was halted for the winter on December 10, 2010. After much discussion at the November 2009 CRC meeting in San Antonio, it was decided that to maintain continuity in the program when it could be reconvened, the test vehicles which were being rented from a local agency were to be purchased and held on-site at SwRI in a secure area until the ambient temperatures in spring of 2010 were sufficient to restart testing.

During the ASTM meeting held during the week of December 6, 2009 in Anaheim, California, a group of CRC members attending the meeting from Chevron, BP, Marathon, Flint Hills, ConocoPhillips, ExxonMobil, RFA, General Motors, Chrysler, Ford, and CRC staff got together and reviewed the program data generated up to that point. It was agreed that no additional Class E-5 data were needed as the 75% of completed testing appeared statistically sound. It was further agreed that the remainder of the Class D-4 fuel testing was needed for any review of that data to be meaningful. At that time, General Motors inquired about the possibility of adding more vehicles that represented the most current technologies to the vehicle fleet. A review of fuel inventories was made and it was determined that there were sufficient fuels available to include two more vehicles for the Class D-4 testing. General Motors shipped two vehicles to SwRI in spring of 2010 that were incorporated into the Class D-4 test matrix. Retains of Class D-4 fuels were pulled and screened by SwRI prior to the program starting back to confirm that fuels maintained integrity. SwRI results shown in Table E-2 were within the reproducibility limits for the test methods when compared to the original averages of fuel properties from the four laboratories. Testing of Class D-4 fuels resumed on April 23, 2010 and concluded on June 4, 2010. All Class D-4 work was completed with the exception of the Class D-4 fuel containing 15 volume percent ethanol because the raters were required for preparation of CRC Project CM-138-09-1 in Pueblo, Colorado.

The driveability evaluations were performed by contract raters Beth Evans and Harold Archibald, who have participated as raters in every recent CRC driveability program. In all of the data sets, Harold Archibald was designated Rater A and Beth Evans was designated Rater B. Both raters were available for the work completed in 2009 but only Harold Archibald was available for the work completed in 2010. To complete the tests that were planned, Harold Archibald performed the evaluations that were designated for Beth Evans. Since both of these raters have similar rating histories, based on previous driveability programs, the CRC liaison approved the duplication of evaluations by rater Harold Archibald.

D. Data Worksheets

The data from the vehicle data sheets were summarized each day and entered into an Excel spreadsheet for each test. Information such as testing date, vehicle, fuel, and rater was given, and for each sequence of the test, start-of-test ambient temperature, and driveability malfunctions and their severity were recorded and entered into a computer summary sheet. A summary of the data is presented in Appendix F in Table F-1 for the test vehicles. A summary of the screening data are presented in Table F-2 for all of the vehicles screened on the “severe” fuel which was primarily Fuel 14 with supplemental screening on Fuels 10 and 13. From this information and the raters’ experience, 20 proposed test vehicles were selected after consultation with the CRC liaison. Each of these vehicles was then evaluated with the mild screening fuel (Screening Fuel 1) to verify that there were no operational problems with the vehicles. Table F-2 also contains the “mild” fuel, known as Screening Fuel 1, data. Note that for vehicles CRC-1, CRC-7, CRC-8, CRC-15, CRC-16, CRC-42 and CRC-44, the use of the mild screening fuel resulted in a slightly higher TWD than the severe fuel. Since it was determined that the difference in TWD between the severe and mild screening fuels was not significant by the raters and the CRC liaison, these vehicles were accepted as test vehicles.

The TWD data for each test fuel evaluation is compiled in Appendix F-1. Note that in the cases where evaluations were not completed due to lack of available schedule or upon the direction of the CRC liaison, "N/A" was entered in the data table. The overall data were used to compile several tables.

VII. DISCUSSION OF RESULTS

A. Data Set Analysis

The vehicle fleet was tested under two temperature conditions corresponding to the ASTM D4814 Volatility Class D-4 and E-5. As discussed previously, the Class D-4 testing was done in two parts because the initial testing was stopped on October 20, 2009 because of insufficiently high ambient temperatures. The Class D-4 testing was restarted on April 23, 2010 and completed on June 4, 2010. Duplicate determinations were obtained for each vehicle with each fuel. The Class E-5 testing began on October 16, 2009 and had to be stopped on November 25, 2009 because of insufficient ambient temperature and poor weather conditions. All fuels were tested once in all vehicles and duplicate testing was done in two vehicles. A few additional duplicates were run. A preliminary analysis of the available Class E-5 data determined additional testing would not be required for a final analysis.

B. Class E-5 Analysis

Since the Class E-5 testing was completed first, it was analyzed first. The initial model included fuel, vehicle, fuel x vehicle interactions, ambient temperature, vehicle x ambient temperature interactions, and rater. As is common with driveability data, the TWD values were log transformed due to the wide range of vehicle/fuel TWDs (6 - 60). Log transforming the data generates a data set that is more normally distributed and one that has approximately constant variance. The data were corrected using the ambient temperature variable. There were two raters and where duplicate tests were run, each rater tested the vehicle. No rater correction was needed because they rated similarly. Table 4 presents the least-squares mean corrected natural log and mean TWD for each fuel across all vehicles. The results were corrected to the 73°F average temperature. Table 5 presents the least-squares mean corrected natural log TWD for each fuel and for each vehicle. The regression analyses are on file at the CRC offices and are available upon request.

The least-squares mean corrected TWD data from Table 4 averaged across all vehicles are shown in Figure 1. The mean corrected TWD from Table 5 for each fuel averaged across all the vehicles are shown graphically in Figure 2. The statistical significance for differences between fuels is shown in Table 6. Statistically significant differences have p-values of 0.05 or less. Differences with p-values of 0.10-0.06 are considered marginally statistically significant. Table 6 shows marginally significant differences between Fuel 14 and Fuels 8 and 9. The statistical significant (p-values) differences between vehicles are shown in Table 7. Many vehicles show significant differences from others with Vehicle 28 preforming better than most.

C. Class E-5 Ambient Temperature

The testing ambient temperatures ranged from 66°F to 79°F versus the nominal target temperature 69°F for program. Although the data were corrected to 73°F, the effect of ambient temperature was not significant.

D. Class E-5 Fuel Property Effect Analysis

Using the TWD data from Table 4, regression analyses were initially undertaken against TVL20, 50% evaporated distillation point (T_{50}), and ethanol content. DVPE had too narrow range for a meaningful regression. The regression results are shown in Table 8. Regressing against three variables showed that only T_{50} and ethanol content have potential. TVL20 alone and with the other variables was not significant. As shown in Table 8, adding an ethanol content squared term resulted in statistically significant three-term equation with p-values less then 0.05 and an adjusted R^2 of 0.858.

The mean corrected natural log TWD is plotted against T_{50} in Figure 3 using the correlation equation. The adjusted R^2 was 0.061 indicating a poor correlation. Separate lines with actual data points are shown for E0 and E10 along with a single point shown for E15. There is a significant difference between E0 and E10 (p=0.01). A similar plot for ethanol concentration is shown in Figure 4. Three levels of T_{50} (140°F, 150°F, and 170°F) are shown in the plot. The slopes are marginally significant (p=0.07) and the difference between lines are significant (p=0.02). The actual data points are shown in the figure. While the effect of changes in ethanol content and T_{50} on driveability are statistically significant, the increase in TWD ranges from 2.7 at 170°F to 3.4 at 140°F for an ethanol content change of 10 volume percent and for a 30°F change in T_{50} ranges from 3.7 at E0 to 4.4 at E10.

E. Class D-4 Analysis

The same data analysis model was used to analyze the Class D-4 data as was used for the Class E-5 data analysis. The data were corrected using the ambient temperature variable. There were two raters for the 2009 portion of the program and only one rater for the 2010 portion. Where duplicate tests were run, each rater tested the vehicle. No rater correction was needed because they rated similarly. Table 9 presents the least-squares mean corrected natural log and mean TWD for each fuel across all vehicles. The results were corrected to the 90°F average temperature. Table 10 presents the least-squares mean corrected natural log TWD for each fuel and for each vehicle. Two additional vehicles were added to the program for the Class D-4 study. The regression analyses are on file at the CRC offices and are available upon request.

The least-squares mean corrected TWD data from Table 9 averaged across all vehicles are shown in Figure 5. The mean corrected TWD from Table 10 for each fuel averaged across all the vehicles are shown graphically in Figure 6. Comparing Figure 6 with Figure 2 shows a similar vehicle response for both the Class D-4 and Class E-5 studies. The statistical significance for differences between fuels is shown in Table 11. Statistically significant differences have p-values of 0.05 or less. Differences with p-values of 0.10-0.06 are considered marginally statistically significant. Table 11 shows Fuel 6 to be significantly different from all

the other fuels except for Fuel 2. The statistically significant (p-values) differences between vehicles are shown in Table 12. Many vehicles show significant differences from others with Vehicles 4 and 28 performing better than most and vehicles 15 and 48 performing worse than most.

F. Class D-4 Ambient Temperature

The testing ambient temperatures ranged from 80°F to 95°F versus the nominal target temperature 85°F for program. Although the data were corrected to 90°F, the effect of ambient temperature was not significant.

G. Class D-4 Fuel Property Effect Analysis

Using the TWD data from Table 9, regression analyses were initially undertaken against TVL20 and 50% evaporated distillation point (T_{50}), and ethanol content. DVPE had too narrow range for a meaningful regression. The regression results are shown in Table 13. Regressing against three variables showed no significant properties. TVL20, T_{50}, or ethanol content alone and with the other variables including ethanol content squared were not significant.

The mean corrected natural log TWD is plotted against T_{50} in Figure 7 and regressing the E0 and E10 data separately. The adjusted R^2 were low indicating a poor correlation. Separate lines with actual data points are shown for E0 and E10 along with a single point shown for E15 (3 vehicles). The corresponding TVL20 is shown next to each data point. The slopes and ethanol concentration differences are not significant with $p>0.5$. TVL20 is plotted against mean corrected natural log TWD in Figure 8. Again E0 and E10 data were grouped and regressed separately. The adjusted R^2 were low indicating a poor correlation. Separate lines with actual data points are shown for E0 and E10 along with a single point shown for E15. The corresponding T_{50} is shown next to each data point. The slopes and ethanol concentration differences are not significant with $p>0.5$. A similar plot for ethanol concentration is shown in Figure 9. Individual data points are shown with the corresponding TVL20 and T_{50}. The slope is not significant ($p=0.47$).

The Class E-5 ambient test temperatures were within those used for vehicle emissions certification testing where fuel air ratio calibrations may be more exacting. This may explain the increased vehicle sensitivity observed at these temperatures, as compared to those in the Class D-4 range.

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3. Coordinating Research Council, Inc., 2006 CRC Hot-Fuel-Handling Program, CRC Report No. 648, January 2007.

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5. ASTM International, ASTM D 4814 Specification for Automotive Spark-Ignition Engine Fuel, 2010 Annual Book of ASTM Standards.

TABLES

AND

FIGURES

Table 1
2009-2010 CRC/ASTM Driveability Program Test Vehicle List

Year	Make	Model	Displacement (Liters)	VIN
2008	Chevrolet	Cobalt	2.2	1G1AK58F487315870
2008	Chevrolet	Aveo	1.6	KL1TD56658B225791
2009	Chevrolet	Silverado	4.8	2GCEC23C791137629
2009	Chevrolet	Tahoe	5.3	1GNEC23319R231696
2009	Chevrolet	Equinox	3	2CNFLDEY0A6200484
2009	Chevrolet	HHR	2	3GNCA63X49S561143
2007	Chrysler	PT Cruiser	2.4	3A4FY581387T629213
2008	Chrysler	Sebring	2.4	1C3LC46K28N218996
2007	Chrysler	Pacifica	4.0	2A8GM68X67R346084
2008	Dodge	Caliber	2.4	1B3HB78K48D757565
2008	Ford	SE Focus	2.0	1FAHP35N68W255190
2009	Ford	F150	4.6	1FTRW128X9FA55757
2009	Ford	Escape XLT	3.0	1FMCU03689KA12422
2009	Ford	Taurus	3.5	1FAHP25W99G111809
2007	Honda	Odyssey	3.5	5FNRL38477B048291
2008	Honda	Accord	2.4	1HGCP26408A072872
2009	Hyundai	Sonata	2.4	5NPET46C69H427558
2008	KIA	Rio	1.6	KNADE123886379383
2008	Mazda	6	2.3	1YVHP80C985M37592
2009	Nissan	Pathfinder	4.0	5N1AR18U29C610190
2008	Toyota	Rav 4	2.4	JTMED33V386072243
2009	Toyota	Corolla	1.8	1NXBU40E792066661

Table 2
2009-2010 CRC/ASTM Driveability Program Fuel Inspections for Class D-4 Fuels

Fuel Code			1	2	3	4	5	6	7	28
Property	**Method**	**Units**	**116/170/0**	**116/150/0**	**116/150/10**	**116/140/0**	**107/150/0**	**107/150/10**	**107/140/10**	**109/150/15**
T V/L=20	ASTM D5188	°F	113.4	113.9	111.1	113.3	105.9	105.9	105.9	108.4
DVPE	ASTM D5191	psi	12.2	12.3	12.7	12.4	13.9	14.0	13.5	13.0
Gravity	ASTM D4052	°API	70.7	67.0	61.1	65.0	71.7	61.4	68.7	66.9
Relative Density		60/60°F	0.6997	0.7127	0.7347	0.7202	0.6963	0.7336	0.7069	0.7132
Ethanol	ASTM D4815	wt %	0.0	0.0	10.5	0.0	0.0	10.5	10.8	17.5
Ethanol	ASTM D4815	vol %	0.1	0.0	9.7	0.0	0.1	9.7	9.8	15.5
FIA	ASTM D1319									
Aromatics		vol %	12.7	9.0	23.2	6.9	10.8	23.9	11.0	10.8
Olefins		vol %	6.8	1.6	6.8	1.2	18.6	4.9	6.1	5.1
Saturates		vol %	80.6	89.4	60.4	91.9	70.5	61.6	73.2	68.8
Distillation	ASTM D86									
Initial Boiling Point		°F	79.0	84.6	82.7	85.6	77.6	79.0	82.0	81.3
5% Evaporated		°F	96.5	101.0	101.7	103.9	92.4	95.8	96.1	98.2
10% Evaporated		°F	103.7	108.2	109.5	111.2	99.5	103.9	102.7	104.7
20% Evaporated		°F	115.0	118.7	122.1	121.5	111.3	117.7	111.9	114.6
30% Evaporated		°F	128.0	128.2	133.6	129.3	124.0	131.8	122.0	125.4
40% Evaporated		°F	145.8	138.1	144.1	135.6	138.8	144.2	133.4	137.6
50% Evaporated		°F	171.9	150.5	152.5	142.2	155.7	153.8	145.9	150.3
60% Evaporated		°F	208.9	169.4	197.2	152.0	176.2	196.4	159.4	159.9
70% Evaporated		°F	234.3	201.7	232.9	170.9	201.9	239.6	224.9	165.6
80% Evaporated		°F	264.1	233.3	265.9	215.5	235.5	273.7	258.2	250.1
90% Evaporated		°F	322.6	263.5	309.1	247.1	298.6	314.9	316.7	310.3
95% Evaporated		°F	351.3	316.5	343.4	298.8	358.3	341.8	347.7	344.8
End Point		°F	401.2	383.7	397.7	376.0	415.7	385.9	397.6	393.3
Recovery		vol %	97.8	97.1	97.6	96.9	97.1	97.4	96.5	97.3
Residue		vol %	1.1	1.4	1.3	1.7	1.5	1.4	1.9	1.6
Loss		vol %	1.1	1.5	1.2	1.4	1.4	1.3	1.6	1.2
Benzene	DHA	vol %	0.8	0.42	1.6	0.3	0.5	1.7	0.7	0.6
Ethanol	DHA	vol %	0.0	0.0	9.85	0.00	0.00	9.74	10.2	16.9
Hydrocarbon	DHA	vol %	100.0	100.0	90.2	100.0	100.0	90.3	89.9	83.1
Aromatics	DHA	vol %	12.8	7.0	24.3	5.5	8.8	26.1	11.7	10.9
Olefins	DHA	vol %	6.1	1.21	5.9	0.9	17.5	4.1	5.4	5.1
Saturates	DHA	vol %	81.1	91.8	60.0	93.6	73.6	60.1	72.8	67.1
Unwashed Gum	ASTM D381	°F		4.2		2.4				
Solvent Washed Gum	ASTM D381	psi		1.4		0.8				
Research ON	ASTM D2699	°API		98.6		101.0				
Motor ON	ASTM D2700	60/60°F		88.6		88.8				
(R+M)/2	Calc.	60/60°F		93.6		94.9				

Table 2 Continued
2009-2010 CRC/ASTM Driveability Program Fuel Inspections for Class E-5 Fuels

Fuel Code			8	9	10	11	12	13	14	29
Property	Method	Units	105/170/0	105/150/0	105/150/10	105/140/0	102/150/0	102/150/10	102/140/10	102/150/15
T V/L=20	ASTM D5188	°F	106.0	104.7	104.8	104.6	102.2	102.6	103.4	102.9
DVPE	ASTM D5191	psi	14.2	14.2	14.4	13.9	14.7	14.9	14.4	14.4
Gravity	ASTM D4052	°API	71.9	73.3	60.1	73.2	73.8	59.8	68.2	67.8
Relative Density		60/60°F	0.6959	0.6910	0.7383	0.6912	0.6892	0.7398	0.7087	0.7100
Ethanol	ASTM D4815	wt %	0.0	0.0	10.0	0.0	0.0	10.5	11.2	17.1
Ethanol	ASTM D4815	vol %	0.0	0.0	9.4	0.0	0.0	9.9	10.0	14.9
FIA	ASTM D1319									
Aromatics		vol %	11.6	10.8	24.5	10.4	9.1	29.3	11.9	7.8
Olefins		vol %	1.8	1.7	6.0	1.5	1.7	4.1	4.6	1.5
Saturates		vol %	86.6	87.6	60.2	88.1	89.2	56.8	73.5	81.1
Distillation	ASTM D86									
Initial Boiling Point		°F	77.8	76.9	77.9	78.9	77.3	77.0	78.5	79.1
5% Evaporated		°F	89.5	88.8	93.3	90.4	88.3	91.3	93.6	93.3
10% Evaporated		°F	97.7	95.9	102.9	96.5	94.8	100.1	100.9	100.2
20% Evaporated		°F	110.4	105.8	118.2	104.4	104.2	114.0	111.8	110.5
30% Evaporated		°F	124.4	116.1	133.4	112.6	114.3	129.4	122.6	121.6
40% Evaporated		°F	143.5	129.6	146.5	123.6	127.4	143.4	133.3	134.9
50% Evaporated		°F	173.0	152.0	155.6	142.5	148.9	154.5	143.5	149.9
60% Evaporated		°F	212.2	193.7	213.7	179.4	189.1	193.7	153.1	160.5
70% Evaporated		°F	229.5	223.9	249.4	220.3	223.3	246.0	208.9	167.6
80% Evaporated		°F	243.7	240.8	286.5	239.1	240.1	280.1	241.5	235.0
90% Evaporated		°F	281.2	272.8	329.9	269.0	271.5	317.1	296.2	266.6
95% Evaporated		°F	336.5	329.9	367.4	325.9	329.0	343.6	338.7	325.8
End Point		°F	397.8	386.5	414.1	386.9	391.6	391.4	392.1	382.8
Recovery		vol %	96.5	96.9	96.6	96.9	97.0	96.7	96.8	97.1
Residue		vol %	1.5	1.4	2.0	1.4	1.2	1.9	1.5	1.4
Loss		vol %	2.0	1.7	1.5	1.6	1.8	1.4	1.7	1.5
Benzene	DHA	vol %	0.5	0.5	1.6	0.5	0.5	2.1	0.5	0.4
Ethanol	DHA	vol %	0.0	0.0	9.4	0.0	0.0	10.0	10.2	16.9
Hydrocarbon	DHA	vol %	100.0	100.0	90.6	100.0	100.0	90.0	89.8	83.1
Aromatics	DHA	vol %	9.2	8.2	25.5	7.8	8.1	29.9	12.9	7.5
Olefins	DHA	vol %	1.5	1.4	5.8	1.3	1.3	4.4	5.5	1.2
Saturates	DHA	vol %	89.4	90.5	59.3	90.9	90.6	55.7	71.4	74.4
Unwashed Gum	ASTM D381	°F	2.6	6.8		5.8	2.0			4.2
Solvent Washed Gum	ASTM D381	psi	7.4	2.2		2.0	5.4			1.6
Research ON	ASTM D2699	°API	93.0	93.0		92.6	93.0			100.0
Motor ON	ASTM D2700	60/60°F	88.3	88.0		88.0	88.0			90.0
(R+M)/2	Calc.	60/60°F	90.6	90.5		90.3	90.5			95.0

Table 3
2009-2010 CRC/ASTM Volatility Program
Additional Test Fuel Inspections for Screening Fuel 1

CRC Screening Fuel 1 Analyses			
SwRI Fuel Code			GA-7223
Analysis Location			SwRI
TEST	**METHOD**	**UNITS**	
T V/L=20	ASTM D5188	°F	153.7
DVPE	ASTM D5191	psi	7.58
Gravity	ASTM D4052	°API	56.1
Density	ASTM D4052	60/60°F	0.7541
Distillation	ASTM D86		
Initial Boiling Point		°F	93
5% Evaporated		°F	121
10% Evaporated		°F	132
20% Evaporated		°F	149
30% Evaporated		°F	167
40% Evaporated		°F	189
50% Evaporated		°F	216
60% Evaporated		°F	248
70% Evaporated		°F	279
80% Evaporated		°F	308
90% Evaporated		°F	341
95% Evaporated		°F	365
End Point		°F	409
Recovery		vol %	98.2
Residue		vol %	0.8
Loss		vol %	1
DIPE	ASTM D5599	vol%	<0.1
ETBE		vol%	<0.1
EtOH		vol%	<0.1
iBA		vol%	<0.1
iPA		vol%	<0.1
MeOH		vol%	<0.1
MTBE		vol%	<0.1
nBA		vol%	<0.1
nPA		vol%	<0.1
sBA		vol%	<0.1
TAME		vol%	<0.1
tBA		vol%	<0.1
tPA		vol%	<0.1
Total Oxygen Weight		wt%	<0.1
Sulfur	ASTM D5453	ppm	41.9

Table 4
2009-2010 CRC/ASTM Driveability Program--Class E-5
Fuel Least-Squares Mean Natural Log and Mean TWD Values

Fuel	Description, Nominal TVL20/T50/ EtOH	Ln TWD LS Mean	TWD LS Mean
8	105/170/0	2.70	14.81
9	105/150/0	2.79	16.28
10	105/150/10	2.96	19.22
11	105/140/0	2.89	17.91
12	102/150/0	2.85	17.27
13	102/150/10	2.92	18.58
14	102/140/10	3.12	22.54
29	102/150/15	2.88	17.73

Table 5
2009-2010 CRC/ASTM Driveability Program--Class E-5
Least Square Mean Natural Log and Mean TWD Values

Fuel	8	9	10	11	12	13	14	29		
Description	105/170/0	105/150/0	105/150/10	105/140/0	102/150/0	102/150/10	102/140/10	102/150/15	Ln TWD	TWD
Vehicle	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	LS Mean	LS Mean
CRC1	2.53	2.44	2.84	3.03	2.41	2.49	3.37	2.45	2.70	14.81
CRC2	2.78	2.57	2.59	3.08	3.25	3.39	2.49	3.11	2.91	18.33
CRC3	2.85	3.48	2.84	2.86	2.65	3.02	3.85	2.92	3.06	21.26
CRC4	2.98	2.07	2.08	2.49	3.54	2.60	2.49	3.23	2.68	14.66
CRC7	3.32	3.32	3.39	3.16	3.33	3.45	3.51	3.23	3.34	28.18
CRC8	3.35	3.22	3.27	3.48	2.86	3.14	3.69	3.64	3.33	27.94
CRC9	3.07	3.07	2.89	3.33	1.90	3.27	3.25	3.85	3.08	21.76
CRC12	2.56	2.93	2.43	2.62	2.32	2.78	3.00	2.87	2.69	14.72
CRC15	3.31	3.26	3.65	3.39	3.22	3.26	4.13	3.53	3.47	32.08
CRC16	1.54	2.72	2.93	2.99	3.17	3.04	3.58	2.31	2.79	16.23
CRC18	3.18	2.05	2.74	2.39	3.05	2.61	2.72	3.33	2.76	15.80
CRC21	2.83	3.13	3.52	3.29	3.59	3.10	3.20	2.88	3.19	24.28
CRC23	2.37	3.14	3.01	2.91	2.92	3.32	2.80	3.23	2.96	19.38
CRC28	2.09	2.25	2.37	1.68	1.01	2.24	2.53	1.84	2.00	7.40
CRC34	2.76	2.73	2.93	2.64	2.73	2.62	2.64	3.18	2.78	16.09
CRC36	2.02	3.24	3.32	2.93	3.16	3.25	2.78	2.95	2.96	19.24
CRC40	1.70	2.42	3.29	2.86	3.19	2.21	2.96	2.34	2.62	13.75
CRC42	3.01	2.59	2.47	2.50	2.68	2.80	2.48	1.87	2.55	12.81
CRC44	2.53	2.23	2.86	2.82	3.08	2.70	3.46	1.63	2.66	14.36
CRC46	3.10	2.93	3.70	3.28	2.91	3.14	3.37	3.13	3.20	24.42
Ln TWD LS Mean	2.70	2.79	2.96	2.89	2.85	2.92	3.12	2.88		

Table 6
2009-2010 CRC/ASTM Driveability Program--Class E-5
Significant Differences Between Fuels

p-value Statistics								
	8	9	10	11	12	13	14	29
8		-	-	-	-	-	0.08	-
9	-		-	-	-	-	0.08	-
10	-	-		-	-	-	-	-
11	-	-	-		-	-	-	-
12	-	-	-	-		-	-	-
13	-	-	-	-	-		-	-
14	0.08	0.09	-	-	-			-
29	-	-	-	-	-			

Table 7
2009-2010 CRC/ASTM Driveability Program--Class E-5
Significant Differences Between Vehicles (p-values)

Vehicle	LnTWD LSMEAN	1	2	3	4	7	8	9	12	15	16	18	21	23	28	34	36	40	42	44	46
1	2.70		-	-	-	0.05	-	-	-	0.05	-	-	-	-	0.05	-	-	-	-	-	-
2	2.91	-		-	-	0.05	0.05	-	-	0.05	-	-	-	-	0.05	-	-	-	-	-	0.10
3	3.06	-	-		-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	-	-	-
4	2.68	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	3.34	0.05	0.05	-	-		-	-	0.05	-	-	-	-	-	0.05	-	-	0.05	0.05	0.05	-
8	3.33	-	0.05	-	-	-		-	-	-	-	-	-	-	0.05	-	-	0.05	0.05	0.05	-
9	3.08	-	-	-	-	-	-		-	-	-	-	-	-	0.05	-	-	-	-	-	-
12	2.69	-	-	-	-	0.05	-	-		0.05	-	-	-	-	0.05	-	-	-	-	-	-
15	3.47	0.05	0.05	-	-	-	-	-	0.05		0.10	-	-	-	0.05	0.05	-	0.05	0.05	0.05	-
16	2.79	-	-	-	-	-	-	-	-	0.10		-	-	-	0.05	-	-	-	-	-	-
18	2.76	-	-	-	-	-	-	-	-	-	-		-	-	0.05	-	-	-	-	-	-
21	3.19	-	-	-	-	-	-	-	-	-	-	-		-	0.05	-	-	0.10	0.05	0.10	-
23	2.96	-	-	-	-	-	-	-	-	-	-	-	-		0.05	-	-	-	-	-	-
28	2.00	0.05	0.05	0.05	-	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05		0.05	0.05	0.10	-	0.10	0.05
34	2.78	-	-	-	-	-	-	-	-	0.05	-	-	-	-	0.05		-	-	-	-	-
36	2.96	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-		-	-	-	-
40	2.62	-	-	-	-	0.05	0.05	-	-	0.05	-	-	0.10	-	0.10	-	-		-	-	-
42	2.55	-	-	-	-	0.05	0.05	-	-	0.05	-	-	0.05	-	-	-	-	-		-	0.10
44	2.66	-	-	-	-	0.05	0.05	-	-	0.05	-	-	0.10	-	0.10	-	-		-		-
46	3.20	-	0.10	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-	-	0.10	-	

Table 8
2009-2010 CRC/ASTM Driveability Program Class E-5 Regression Models

	Adjusted			T V/L=20		T50		Ethanol Content		(Ethanol Content)^2	
Regression Variables	R^2	RMSE	Constant	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
T V/L=20, T50, EtOH	0.445	0.092	2.677	0.0137	0.711	-0.0083	0.130	0.0107	0.163	-	-
T50, EtOH	0.539	0.084	3.962	-	-	-0.0074	0.080	0.0097	0.123	-	-
T50, EtOH, EtOH^2	0.858	0.046	3.954	-	-	-0.0075	0.016	0.0457	0.013	-0.00288	0.025
T50	0.352	0.099	4.200	-	-	-0.0086	0.071	-	-	-	-
EtOH	0.247	0.107	2.820	-	-	-	-	0.0119	0.071	-	-
T V/L=20	0.061	0.119	7.171	-0.0412	0.273	-	-	-	-	-	-

Table 9

2009-2010 CRC/ASTM Driveability Program--Class D

Fuel Least-Squares Mean Natural Log and Mean TWD Values

Fuel	Description, Nominal TVL20/T50/ EtOH	Ln TWD LS Mean	TWD LS Mean
1	116/170/0	2.82	16.74
2	116/150/0	2.92	18.59
3	116/150/10	2.78	16.14
4	116/140/0	2.73	15.31
5	107/150/0	2.85	17.27
6	107/150/10	3.09	22.02
7	107/140/10	2.83	17.01
28*	109/150/15	2.62	13.76

*Tested in only three vehicles

Table 10
2009-2010 CRC/ASTM Driveability Program--Class D-4
Least Square Mean Natural Log and Mean TWD Values

Fuel	1	2	3	4	5	6	7	28		
Description	116/170/0	116/150/0	116/150/10	116/140/0	107/150/0	107/150/10	107/140/10	109/150/15	LN TWD	TWD
Vehicle	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	LS Mean	LS Mean
CRC1	2.79	2.55	2.63	2.64	3.03	2.98	2.93	-	2.79	16.33
CRC2	3.15	2.96	3.08	3.24	3.39	3.31	3.11	-	3.18	23.97
CRC3	2.76	3.26	3.06	2.92	2.94	3.03	3.11	-	3.01	20.30
CRC4	2.13	2.20	2.03	1.57	1.17	1.94	2.26	-	1.90	6.68
CRC7	2.73	3.03	2.94	2.72	3.37	3.10	3.07	-	2.99	19.97
CRC8	3.01	3.25	3.21	3.21	3.15	3.25	3.21	-	3.18	24.15
CRC9	2.50	2.91	1.91	2.77	2.31	3.12	2.45	-	2.57	13.04
CRC12	2.49	2.94	2.77	2.44	2.64	3.49	2.50	-	2.75	15.70
CRC15	3.55	3.45	3.36	3.11	3.13	3.75	3.50	3.49	3.42	30.48
CRC16	3.21	3.05	3.00	2.83	3.24	3.35	3.01	-	3.10	22.19
CRC18	2.40	2.89	2.02	2.63	2.80	2.82	2.63	-	2.60	13.44
CRC21	3.02	3.03	2.72	2.63	2.99	3.25	2.93	-	2.94	18.92
CRC23	3.11	2.97	3.19	2.73	3.01	3.11	3.07	-	3.03	20.65
CRC28	2.31	1.79	2.15	1.82	2.74	2.72	2.23	-	2.25	9.49
CRC34	3.07	2.31	2.63	2.72	2.82	3.19	3.12	-	2.84	17.07
CRC36	3.05	3.20	2.77	2.85	2.64	3.26	2.28	-	2.86	17.50
CRC40	2.98	2.72	2.75	2.26	2.49	2.48	2.75	-	2.63	13.91
CRC42	2.72	3.33	2.66	2.65	3.06	2.65	2.62	-	2.81	16.64
CRC44	2.95	3.13	2.50	2.88	2.69	3.10	2.54	-	2.83	16.88
CRC46	2.85	2.93	3.32	3.17	3.12	3.45	3.08	-	3.13	22.89
CRC47	1.75	2.87	2.61	2.40	2.39	2.83	2.11	1.92	2.36	10.58
CRC48	3.21	3.44	3.54	3.36	3.39	3.65	3.32	3.35	3.41	30.24
Ln TWD LS Mean	2.82	2.92	2.78	2.73	2.85	3.09	2.83	2.62		

Table 11
Significant Differences Between Fuels--Class D-4

p-value Statistics							
	1	2	3	4	5	6	7
1		-	-	-	-	0.002	-
2	-		-	0.075	-	-	-
3	-	-		-	-	0.0002	-
4	-	0.075	-		-	0.0001	-
5	-	-	-	-		0.009	-
6	0.002	-	0.0002	0.0001	0.009		0.0091
7	-	-	-	-	-	0.0091	

Table 12
Significant Differences Between Vehicles (p-values)--Class D-4

Vehicle	LnTWD LSMEAN	1	2	3	4	7	8	9	12	15	16	18	21	23	28	34	36	40	42	44	46	47	48
1	2.79		-	-	0.05	-	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	-	0.05
2	3.18	-		-	0.05	-	-	0.05	-	-	-	-	-	-	0.05	-	-	-	-	-	-	0.05	-
3	3.01	-	-		0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-
4	1.90	0.05	0.05	0.05		0.05	0.05	-	-	0.05	0.05	0.10	0.05	0.05	-	0.05	0.05	0.05	0.05	0.05	0.05	-	0.05
7	2.99	-	-	-	0.05		0.05	0.10	-	-	-	-	-	-	0.10	-	-	-	-	-	-	0.05	-
8	3.18	-	-	-	0.05	0.05		0.10	-	-	-	-	-	-	0.10	-	-	-	-	-	-	0.05	-
9	2.57	-	0.05	-	-	0.10	0.10		-	0.05	0.10	-	-	-	-	-	-	-	-	-	0.10	-	0.05
12	2.75	-	-	-	-	-	-	-		0.05	-	-	-	-	-	-	-	-	-	-	-	-	0.05
15	3.42	0.05	-	-	0.05	-	-	0.05	0.05		-	0.05	-	-	0.05	0.05	0.05	0.05	0.05	0.05	-	0.05	-
16	3.10	-	-	-	0.05	-	-	0.10	-	-		-	-	-	0.10	-	-	-	-	-	-	0.05	-
18	2.60	-	-	-	0.10	-	-	-	-	0.05	-		-	-	-	-	-	-	-	-	-	-	0.05
21	2.94	-	-	-	0.05	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
23	3.03	-	-	-	0.05	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	0.05	-
28	2.25	-	0.05	-	-	0.10	0.10	-	-	0.05	0.05	-	-	-		-	-	-	-	-	0.10	-	0.05
34	2.84	-	-	-	0.05	-	-	-	-	0.05	-	-	-	-	-		-	-	-	-	-	-	0.05
36	2.86	-	-	-	0.05	-	-	-	-	0.05	-	-	-	-	-	-		-	-	-	-	0.05	0.05
40	2.63	-	-	-	0.05	-	-	-	-	0.05	-	-	-	-	-	-	-		-	-	-	-	0.05
42	2.81	-	-	-	0.05	-	-	-	-	0.05	-	-	-	-	-	-	-	-		-	-	-	0.05
44	2.83	-	-	-	0.05	-	-	-	-	0.05	-	-	-	-	-	-	-		-		-	-	0.05
46	3.13	-	-	-	0.05	-	-	0.10	-	-	-	-	-	-	0.10	-	-	-	-	-		0.05	-
47	2.36	-	0.05	0.05	-	0.05	0.05	-	-	0.05	0.05	-	-	0.05	-	-	0.05	-	-	-	0.05		0.05
48	3.41	0.05	-	-	0.05	-	-	0.05	0.05	-	-	0.05	-	-	0.05	0.05	0.05	0.05	0.05	0.05	-	0.05	

Table 13
2009-2010 CRC/ASTM Driveability Program Class D-4 Regression Models

	Adjusted			T V/L=20		T50		Ethanol Content		(Ethanol Content)^2	
Regression Variables	R^2	RMSE	Constant	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
T V/L=20, T50, EtOH	-0.489	0.144	3.711	-0.0118	0.566	0.00281	0.691	0.00387	0.799	-	-
T50, EtOH	-0.271	0.133	2.405	-	-	0.00274	0.668	0.00869	0.466	-	-
T50, EtOH, EtOH^2	-0.574	0.148	2.537	-	-	0.00188	0.801	0.90418	0.663	-0.0920	0.666
T50	-0.181	0.128	2.622	-	-	0.00156	0.789	-	-	-	-
EtOH	-0.071	0.122	2.830	-	-	-	-	0.00746	0.472	-	-
T V/L=20	0.038	0.116	4.361	-0.0137	0.317	-	-	-	-	-	-

Figure 1
2009-2010 CRC/ASTM Driveability Program--Class E-5
LS Mean TWD vs. Fuel

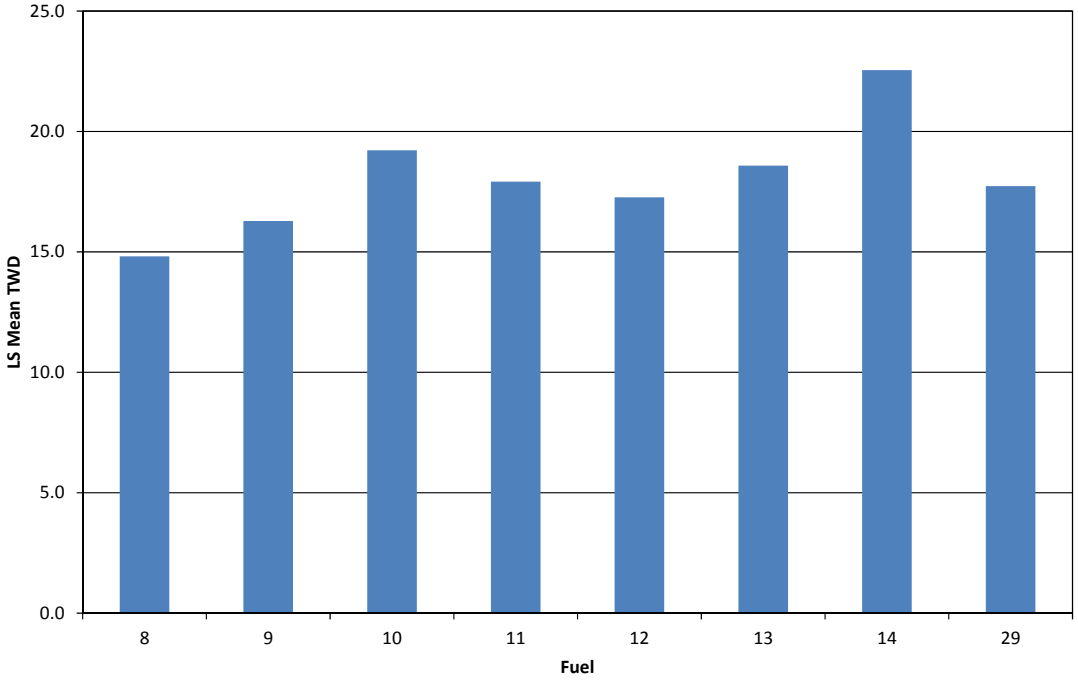


Figure 2
2009-2010 CRC/ASTM Driveability Program--Class E-5
LS Mean TWD vs. Vehicle

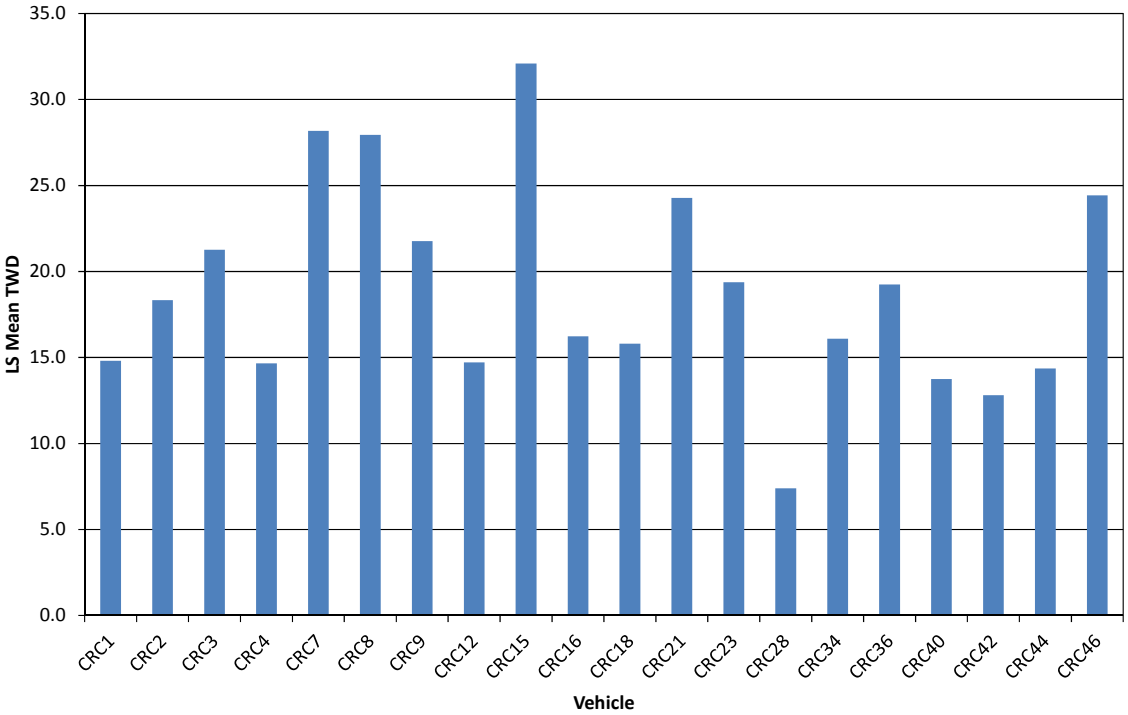


Figure 3
2009-2010 CRC/ASTM Driveability Program Class E-5 Regression Model
Driveability Results vs. 50% Evaporated Distillation Temperature

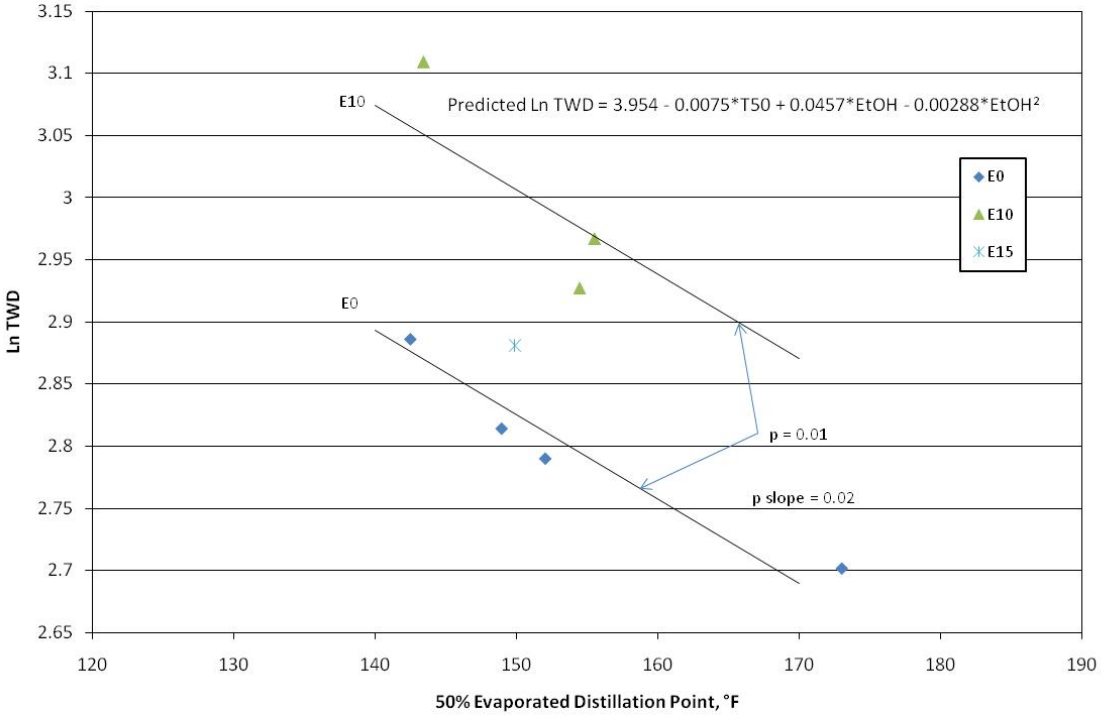


Figure 4
2009-2010 CRC/ASTM Driveability Program--Class E-5
Driveability Results vs. Ethanol Content

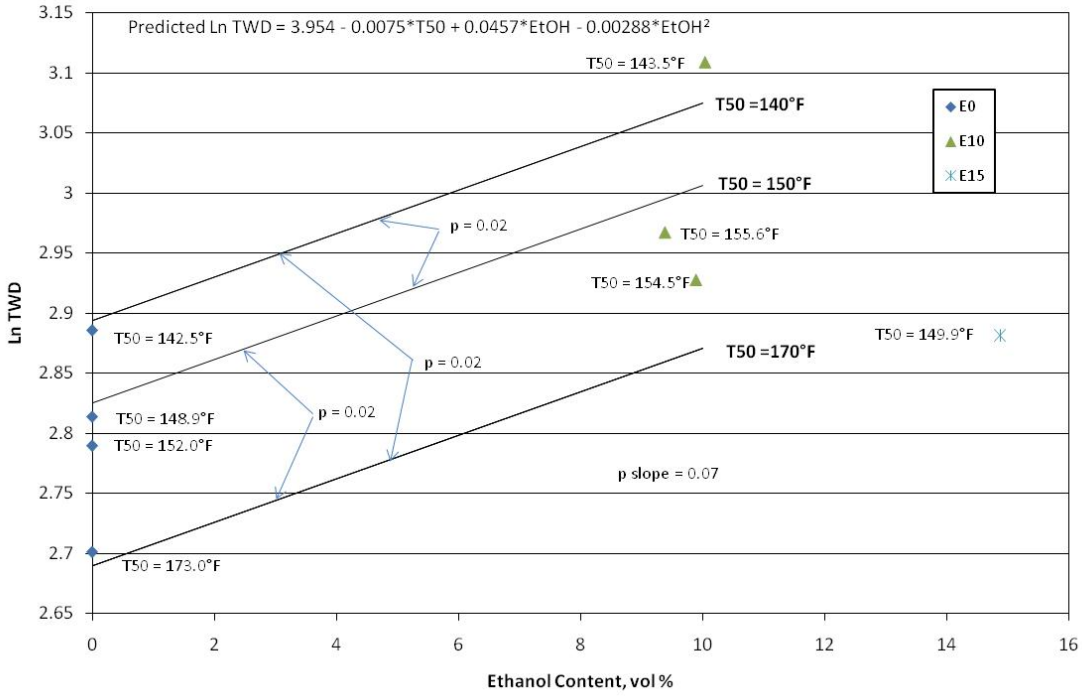
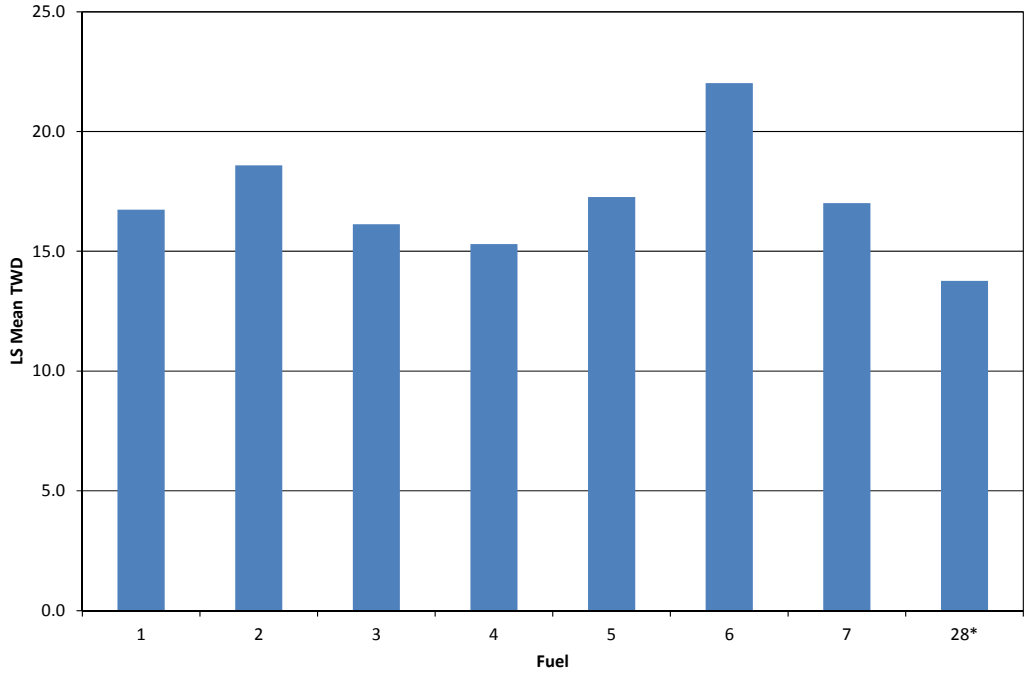


Figure 5
LS Mean TWD vs. Fuel--Class D-4



*Tested in only 3 vehicles

Figure 6
LS Mean TWD vs. Vehicle--Class D-4

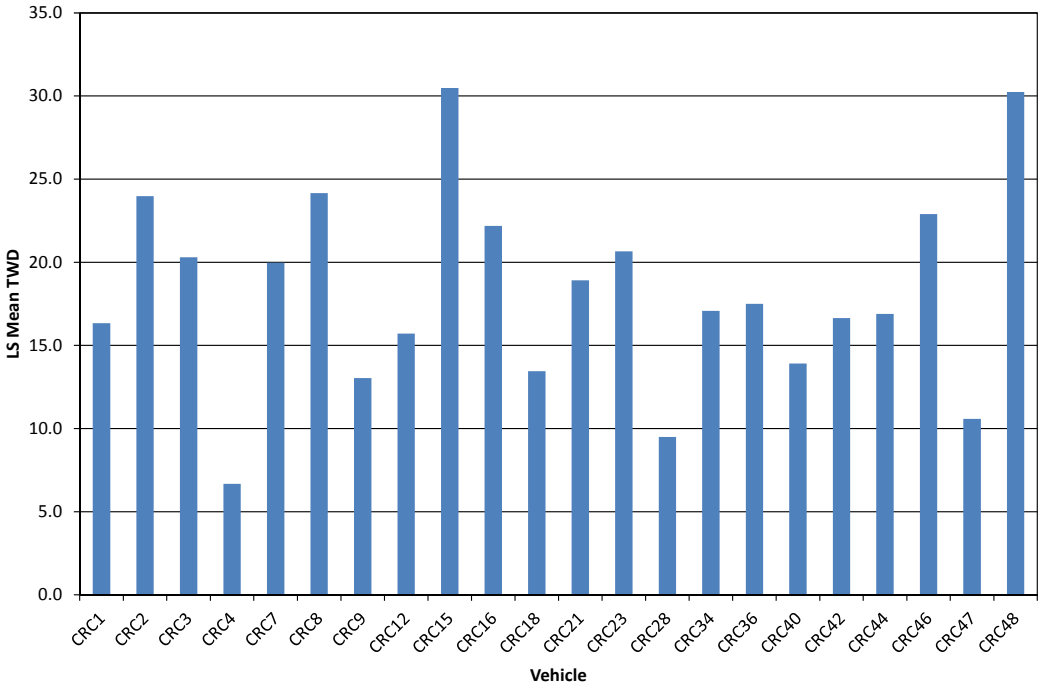


Figure 7
2009-2010 CRC/ASTM Program
Class D-4 Driveability Results vs. 50% Evaporated Distillation Temperature

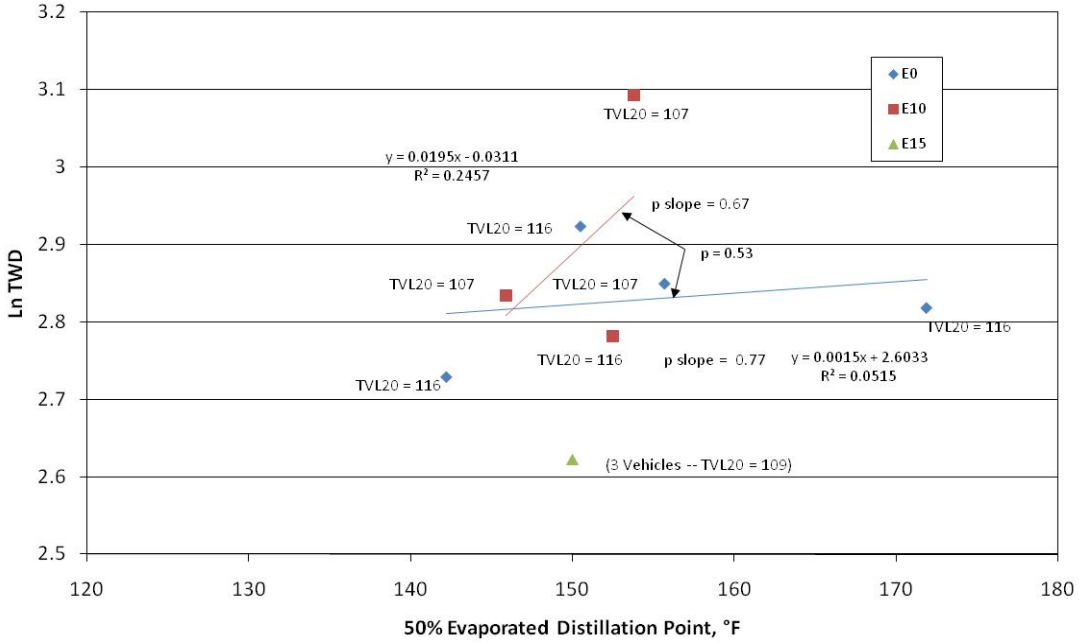


Figure 8
2009-2010 CRC/ASTM Program
Class D-4 Driveability Results vs. T V/L=20

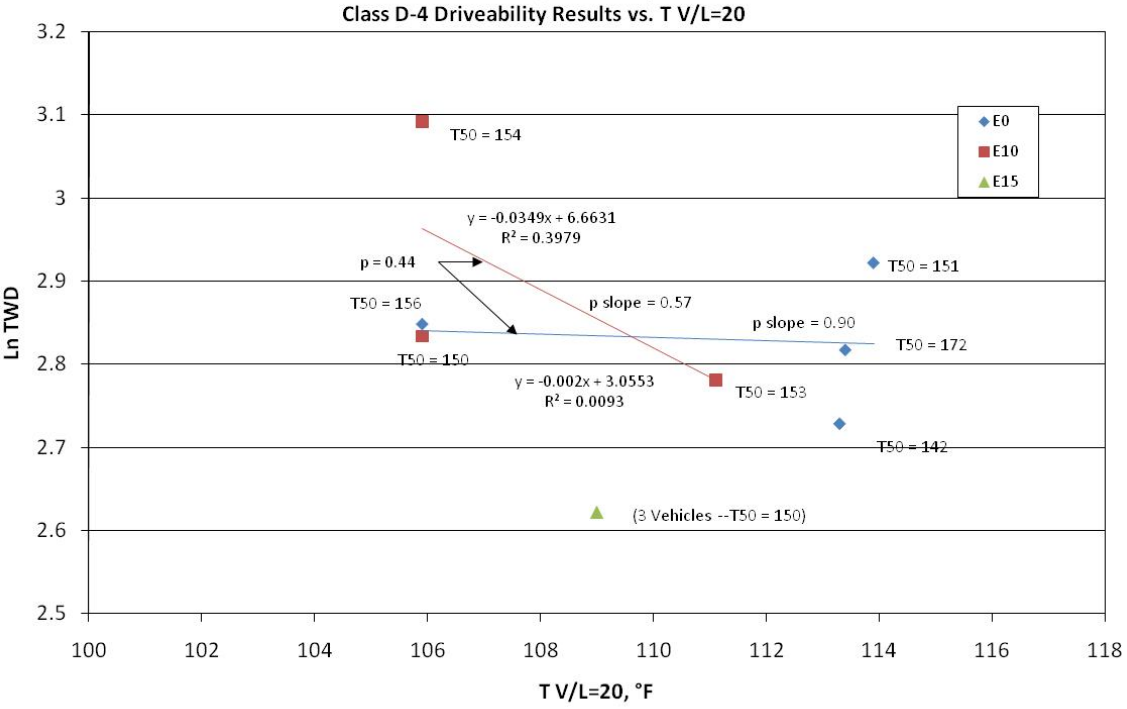
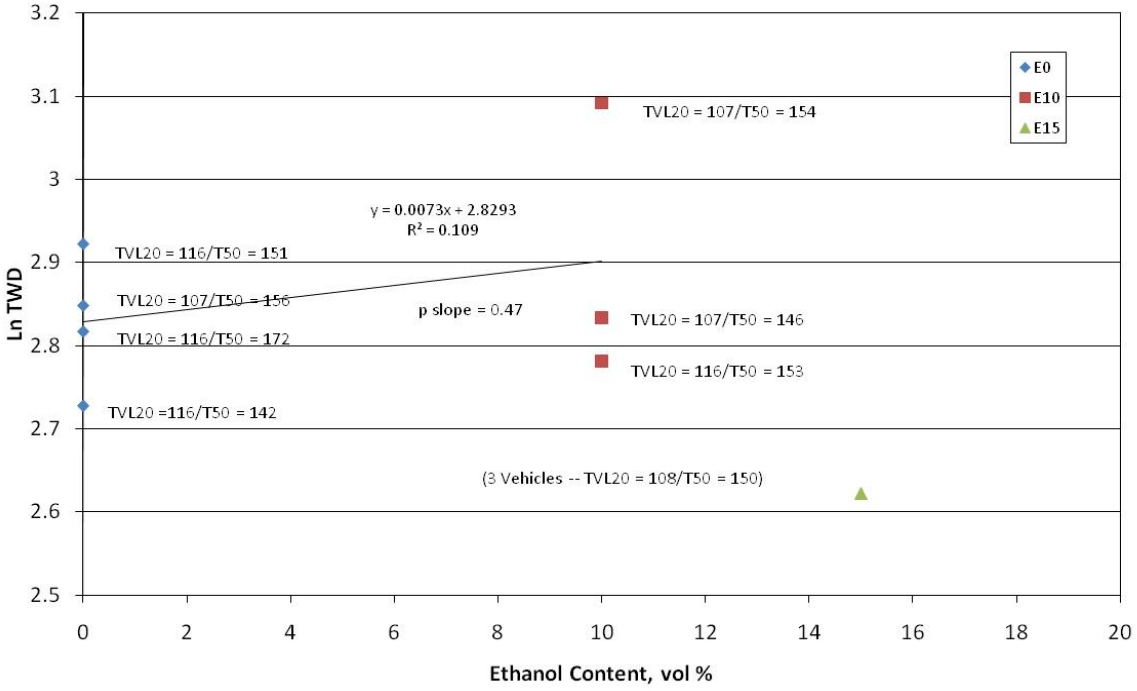


Figure 9
2009-2010 CRC/ASTM Program
Class D-4 Driveability Results vs. Ethanol Content



APPENDIX A

MEMBERS OF THE

2009-2010 CRC/ASTM HOT-FUEL-HANDLING PROGRAM
CM-138-09-2

DATA ANALYSIS PANEL

Appendix A

Members of the
2009-2010 CRC/ASTM Hot-Fuel-Handling Program
CM-138-09-2
Data Analysis Panel

Name	Affiliation
Lew Gibbs, Leader	Chevron (retired)
Russ Lewis	Marathon Petroleum Company RAD
Beth Evans	Evans Research Consultants
Jeff Farenback-Brateman	ExxonMobil Research & Engineering
Ron Osman	Flint Hills Resources
Jim Simnick	BP Global Fuels Technology
Kristy Moore	Renewable Fuels Association
Pat Geng	General Motors Powertrain Division

APPENDIX B

PARTICIPANTS IN THE

2009-2010 CRC/ASTM HOT-FUEL-HANDLING PROGRAM CM-138-09-2

ON-SITE AT SAN ANTONIO, TEXAS

Appendix B

Participants in the
2009-2010 CRC/ASTM Hot-Fuel-Handling Program CM-138-09-2
On-Site at San Antonio, Texas

Name	Affiliation
Harold “Archie” Archibald	Evans Research Consultants
Beth Evans	Evans Research Consultants
Kevin Brunner	Southwest Research Institute
SwRI Support Staff	Southwest Research Institute
Brent Bailey	Coordinating Research Council
Lew Gibbs	Chevron
Russ Lewis	Marathon Petroleum Company RAD
Shawn Broughton	Marathon Petroleum Company RAD

APPENDIX C

Proposal as Submitted to CRC for Consideration
and
Fueling/Defueling Procedure from CRC No. 638

TO: CRC Performance Committee Co-Chairs – Jeff Jetter and Jim Simnick
FROM: ASTM Volatility Task Force Chair – Russ Lewis
SUBJECT: ASTM Proposal for CRC Consideration
DATE: April 24, 2009

Jeff and Jim-

Thanks for the opportunity to present this proposal for a testing program at the 2009 Spring CRC Performance Committee and Volatility Group Meeting in Detroit. At that time, the proposal was approved by the Volatility Group for further consideration and the decision was made by majority vote of the Performance Committee members in attendance to ballot the proposal to the full Performance Committee so that those members not in attendance could review and comment.

The attached document was developed by the ASTM Volatility Task Force during the December 2008 ASTM D2 Meeting using the CRC-style format. Twenty-one entities were involved in the initial development of the proposal with review by more than fifty entities since the inception that resulted in some minor modifications. The membership of this ASTM Task Force requests that CRC consider management of this project on behalf of ASTM. Due to the delay in getting this project started and the anticipated temperatures to be encountered during the proposed testing dates, the program proposal required modification from the original dates. The attached document reflects the modified dates.

All financial obligations for the project will be the responsibility of the ASTM participants and not CRC. Many of the fuels needed for the project are being provided by the ASTM participants with the remainder to be blended by a contract specialty blending laboratory.

ASTM Task Force member companies will provide personnel and laboratory testing support for the project. It is requested that CRC provide the technical expertise to administer the program in order to provide sound scientific data that will determine volatility effects of ethanol, T_{50} and Tv/l=20 on the performance of modern vehicles. Administration by CRC would include project communications, procurement processes, contracting, funds disbursement, banking, data analysis and reporting. The ASTM Task Force understands that for this to be recognized as a CRC project, the data and summary report will have to be approved by the CRC Performance Committee after appropriate review. It is further understood that status reports can be given during the course of such a study if approved by the committee when there are appropriate phases of the work that are ready for release. Information release could include general descriptions of the project plan, but release of data and other results require final committee approval.

Comments and suggestions on how to improve upon the proposed program are welcome. The ASTM Volatility Task Force looks forward to working with the membership of CRC in this program implementation.

Sincerely,

Russell P. Lewis
ASTM D02.A0.3 Volatility Task Force Chair

Revised Proposal for
2009-2010 ASTM HOT-FUEL-HANDLING PROGRAM for CRC CONSIDERATION

Objective

Determine under hot ambient temperature conditions below 5,000 feet altitude the effect of fuel front-end volatility (i.e. TVL20), 50% evaporated distillation point, and ethanol content on hot-fuel-handling driveability performance in a large group of late model vehicles equipped with fuel injection systems.

Deliverables

An assessment of modern vehicle performance of hydrocarbon-only and 10 - 15 vol% concentrations of gasoline-ethanol blends under hot temperature ambient conditions below 5,000 feet altitude will be undertaken. The fuel variables studied will be the front-end volatility parameter involving the temperature for a vapor-liquid ratio of 20 (TVL20), the 50% evaporated distillation point, and the ethanol content. The test procedure that was developed in the 2001 CRC Hot-Fuel-Handling Program (CRC Report No. 629) and used in the 2006 CRC Hot-Fuel-Handling Program (CRC Report No. 648) will be used in this study. A new correlation for these parameters with vehicle performance may be developed if necessary. Some 15 vol% ethanol blends may be included, depending upon availability of funds, time, and interest.

Introduction

In late spring 2008, Marathon Oil conducted a driveability study at SwRI in an effort to generate data on vehicle performance to determine the influence of the vapor lock parameter (TVL20) and 50% distillation temperature (T_{50}) for Vapor Pressure/Distillation Classes D and E. While the data generated were encouraging and well received by ASTM, a statistical review of the data using CRC protocol indicated that the ambient test temperatures were not severe enough to be considered for Vapor Lock Protection Class 4 and not enough fuels were completed that met the Class 5 requirements. Additionally, the CRC Cold Start/Warm-Up protocol was used in this initial screening.

In addition to evaluating fuels similar to those previously tested by Marathon, Vapor Pressure/Distillation Classes A, B, and C may be considered where T_{50} is below 170°F and with the TVL20 minimum limits that are currently being balloted at ASTM for these classes. Four gasoline blends containing 15% ethanol that cover Classes A, C, D, and E are listed as optional test fuels, if funding, timing, and interest dictates.

Test Program

Vehicle hot-fuel-handling performance will be determined using the test procedure from the 2001 CRC volatility test program including the fuel flushing procedure. This program will likely be conducted in the fall of 2009 for “winter” fuels and the summer of 2010 for “summer” fuels. If preparation can be made in a timely fashion, then the “summer” fuels could be run in late summer 2009 with the “winter” fuels to follow during the fall.

Test Fuels

The test fuel design will evaluate hydrocarbon-only fuel and ethanol blends at 10 volume percent with fourteen (14) "winter" fuels (Classes D and E) at four (4) TVL20 levels and three (3) T_{50} levels for Phase I of this project. Thirteen (13) "summer" fuels (Classes A, B, and C) at eight (8) TVL20 and three (3) T_{50} levels for Phase II. Four (4) gasoline blends that contain 15 vol% ethanol (Classes A, B, D, and E), having four (4) TVL20 and one (1) T_{50} level are included as potential test fuels. The fuel matrix is shown below.

Phase I - "Winter" Gasoline

	Testing Temp °F	Fuel Source:	Fuel	TVL20, °F	T50, °F	EtOH, vol %	Est VP, psi
D-4	Nominal 85°F	Flint Hills	1	116	170	0	12.5
D-4		Blend Lab	2	116	150	0	13
D-4		ConocoPhil	3	116	150	10	13
D-4		Blend Lab	4	116	140	0	13.5
D-4		Marathon	5	107	150	0	13.5
D-4		Marathon	6	107	150	10	13.5
D-4		Flint Hills	7	107	140	10	13.5
E-5	Nominal 69°F	Blend Lab	8	105	170	0	14
E-5		Blend Lab	9	105	150	0	14.5
E-5		Marathon	10	105	150	10	14.5
E-5		Blend Lab	11	105	140	0	15
E-5		Blend Lab	12	102	150	0	15
E-5		Marathon	13	102	150	10	15
E-5		Marathon	14	102	140	10	15

Phase II - "Summer" Gasoline

	Testing Temp °F	Fuel Source:	Fuel	TVL20, °F	T50, °F	EtOH, vol %	Est VP, psi
A-1	Nominal 95°F	Request to industry participants will be made for fuels with those not obtained to be blended by a specialty blending lab.	15	140	170	0	9
A-1			16	129	150	0	9
A-1			17	129	150	10	10
A-1			18	129	140	10	10
A-3			19	124	170	0	9
A-3			20	116	140	10	10
B-2			21	133	170	0	9
B-2			22	122	150	0	10
B-2			23	122	140	10	10
C-3			24	124	170	0	10.5
C-3			25	116	150	0	11.5
C-3			26	116	150	10	11.5
C-3			27	116	140	10	11.5

Additional E15 Fuels for Possible Inclusion (if funding, timing, and interest dictates)

	Testing Temp °F	Fuel Source:	Fuel	TVL20, °F	T50, °F	EtOH, vol %	Est VP, psi
D-4	~85°F	Flint Hills	28	109	150	15	13.2
E-5	~69°F	Blend Lab	29	102	150	15	14.5
A-1	~95°F	?	30	131	150	15	9.9
C-3		?	31	118	150	15	11.4

*

Fuels with same color codes may possibly be made from the same base hydrocarbon.

A Fuel Blending and Analysis Sub-team will be formed to develop the final detailed specifications for the test fuels and to assist in the analyses of the fuels. Industry participants' laboratories will be used to verify fuel properties with a minimum of four laboratories involved.

Test Vehicles

Approximately 20 late model fuel injected equipped vehicles will be used in this test program to evaluate the hot-fuel-handling driveability performance of the test fuels. The late model vehicles will be selected from a total fleet of about 50 vehicles based on their response to the lowest TVL20 of 102°F on 10 vol % ethanol with a T_{50} of 140°F (Fuel 14). Those vehicles showing driveability problems will then be tested on Fuel 1 to confirm the driveability problems are fuel related and not mechanical condition related. The late model vehicles will nominally cover 1998-2009 model years, with an emphasis on 2005+ vehicles, and will have stabilized mileages at over 6,000 odometer miles, and be in good mechanical condition with functional air conditioning systems.

Test Procedure

The Test Procedure used in the 2006 CRC volatility program will be used in this. Each vehicle will be flushed with test fuel following the latest flushing procedure and filled to 40 percent of tank capacity. The most volatile fuel will be tested in each vehicle at increasing ambient temperatures until malfunctions are reported. If no problems are observed at the highest available temperature with the most volatile fuel, the vehicle will be parked and eliminated from the test fleet. If driveability problems are observed, lower volatility fuels will be tested at several ambient temperatures.

On-site inspection of the test fuels to confirm they have not weathered and to evaluate fuels after vehicle testing may be undertaken.

Test Temperatures

The ambient test temperature will be a nominal 85°F for Class 4 fuels and 69°F for Class 5 fuels.

The fuels at Classes 1, 2, and 3 will be tested at a temperature of at least 95°F.

Test Location

Since this testing is being conducted below 5,000 feet and requires test temperatures at relatively wide ranges extending from 69°F to >100°F, it is recommended that testing be conducted in San Antonio, Texas or similar location that would offer the desired ambient test temperatures.

Timing

The timing is projected to be as follows:

The weeks of September 6 and 13, 2009 – 2 to 3 people will be required on-site to receive delivery of equipment, build soak sheds, etc. An additional 2-3 mechanics will be required on-site to prepare the vehicles for testing.

The weeks of September 20 and 27, 2009 – 5 to 7 people will be required on-site for vehicle screening.

October 1 through 15, 2009 – the core test program with the 20 selected vehicles and 6 test fuels of Class D-4 will be conducted.

October 16 through 31, 2009 - the core test program with the 20 selected vehicles and 6 test fuels of Class E-5 will be conducted.

July 1 through 31, 2010 - the core test program with the 20 selected vehicles and 12 test fuels of Classes C-3, B-2, A-3, and A-1 will be conducted.

Dates may be adjusted to achieve the desired ambient test temperatures.

It is planned that the data analysis and report-writing activities can be completed within six-months following the completion of each portion of the testing programs.

Personnel Requirements

The program will require an average of 5 contract people (3 from testing facility; 2 independent raters) on-site for each testing week for a total of 10 person-weeks. Mechanics and set-up people will be required for several weeks prior to the start of testing. Evans Research Consultants will be utilized on this project for assessing the driveability performance of the vehicles. Additional "volunteer" personnel will be provided by ASTM industry groups committed to this project as needed.

Program Cost

The estimated cost for the test program will be outlined below: To be determined after consultation with contract lab. All costs for this program will be the responsibility of the ASTM industry groups committed to this project.

Item	Cost
Vehicle Rental	$
Test Fuel	$
Freight to Move Test Equipment to/from San Antonio	$
TTCI Test Controller ($1,425 Daily Rate)	$
Modifying TTCI Test Site to Accommodate CRC Testing	$
Purchase of Second Container and Refrigeration Unit	$
Material to Construct Soak Sheds	$
Miscellaneous	$
Contract Personnel	$
Total	$Projected ~$1MM to $1.5 MM

FUELING AND DEFUELING PROCEDURE

VEHICLE PREPARATION

Used test fuel from the vehicle is drained just before the fuel rail. The fuel line is disconnected at the OEM quick-disconnect to the fuel rail, and a Hansen fitting with hose is inserted between the fuel line and the fuel rail. During defueling, a tee is inserted between the two fittings, with one end of the tee leading to the "slop" fuel drum.

The next step in vehicle preparation is to install voltmeter leads to either the throttle-position-sensor (TPS) or the accelerator pedal, whichever is appropriate. The wires are routed into the passenger compartment of the vehicle to allow the rater to attach a voltmeter during testing. These wires should be long enough to allow either the rater or the observer to be able to read the voltmeter.

DEFUELING PROCEDURE

The fuel is drained into a "slop" drum. This draining system is a closed system, and requires the vehicle engine to be running during the draining procedure. The large bung of the "slop" drum is removed and replaced with a bung that has a two-foot stainless steel tube welded through it. The top of the tube has a Swedgelock fitting on it which attaches to a Hansen coupler. Atop the coupler is an apparatus which has a pressure gauge, a regulating valve, and a sight glass, along with an extra Hansen fitting to obtain fuel samples. During defueling, this apparatus is connected to the vehicle's fuel line via the tee inserted as described above.

The small bung of the drum is removed and replaced by a bung with a float arrangement fabricated to indicate when the drum is full. This float arrangement has corks mounted on a rod on the underside of the small bung and a flag mounted on the same rod on the top-side of the small bung. As the fuel level in the drum rises, it pushes the corks up, which in turn pushes the flag up. This notifies the defueling personnel that the drum is full and must be changed.

Following is the procedure for draining and flushing the fuel system:

FUEL TANK FLUSHING PROCEDURE

Precautionary notes:

1. ***When draining the vehicle fuel tank, the vehicle engine is running, and the pressure to keep the engine running is regulated at the "slop" drum.***
2. ***Some vehicles require that the accelerator pedal be depressed to keep the engine running. An adjustable rod may be used to do this.***
3. ***Use a UL approved ground strap to ground defueling equipment to the fuel injector rail or fuel line fitting for all fuel draining.***

Flushing Procedure:

1. When a vehicle comes in from testing, the defueling apparatus is connected to the vehicle, and the engine is started so the fuel will flow. The flow to the "slop" drum is controlled by the regulating valve.

2. If a fuel sample is required, allow fuel to be drained for one minute through the draining apparatus on the "slop" drum before taking a fuel sample. Fuel from the vehicle should also be drained through the sampling line to ensure that the sample is not contaminated. A sample can then be taken from the sampling port on the draining apparatus.

3. Completely drain the vehicle's fuel tank, at which time the engine will shut down.

4. Remove the fill cap, add four gallons of the next test fuel to the vehicle fuel tank, and replace the fill cap.

5. Start and idle the vehicle for a total of 2 minutes.

6. Completely drain the fuel tank through the draining apparatus, at which time the engine will shut down.

7. Remove the fill cap, add four gallons of the next test fuel to the vehicle fuel tank, and replace the fill cap.

8. Start and idle the vehicle for a total of 2 minutes. From approximately 15 seconds into the idle for a period of 30 seconds, rock the rear end of the vehicle from side to side. This task will require one person on each side of the vehicle.

9. Completely drain the fuel tank through the draining apparatus, at which time the engine will shut down.

10. When the vehicle is ready, remove the fill cap, add four or five gallons as required of the test fuel to the vehicle fuel tank, and replace the fill cap.

EXAMPLE OF A CRC FUEL TANK FLUSHING PROCEDURE WORK ORDER

Vehicle Designation Number: CRC-4 Ford F-150 Date:
Fuel Code: **GB-7210 Fuel No. 7** Rater: **ARCH**
Note: Perform Flush with Vehicle Level Project Number 15106.01.100
Precautionary notes:

1. _____Remove the drum of **GB-7210** from the CRC coldbox but return it to the coldbox sealed up as soon as each vehicle is finished being fueled. Do not leave a drum of test fuel outside of the coldbox any more time than is absolutely necessary.
2. _____Only use a drum pump that has been tagged with **GB-7210** (meaning that it had previously been flushed with this fuel and the pump tagged as such).
3. _____When draining the vehicle fuel tank, adjust the regulating valve so as to keep the engine running. Turn the engine off when the slop flow stops.
4. _____Use a UL approved ground strap to ground de-fueling equipment to the fuel injector rail or fuel line fitting for all fuel draining.

Flushing Procedure if temperature is **80F to 90F**:

1. _____Connect the de-fueling apparatus to the vehicle and start the engine so that the fuel will flow. Control the flow to an "excess fuel" drum using a regulating valve.

2. _____Completely drain the vehicle's fuel tank. Turn off the engine.

3. _____Remove the fill cap, add 4.0 gallons of test fuel **GB-7210** to the vehicle's fuel tank, and replace the fill cap.

4. _____Start and idle the vehicle for a total of 2 minutes.

5. _____At the end of the 2 minutes start draining the fuel tank through the draining apparatus. Completely drain the vehicle's fuel tank. Turn off the engine.

6. _____Remove the fill cap, add 4.0 gallons of test fuel **GB-7210** to the vehicle's fuel tank, and replace the fill cap.

7. _____Start and idle the vehicle for a total of 2 minutes. From approximately 15 seconds into the idle for a period of 30 seconds, rock the rear end of the vehicle from side to side. This task will require one person on each side of the vehicle.

8. _____At the end of the 2 minutes start draining the fuel tank through the draining apparatus. Completely drain the vehicle's fuel tank. Turn off the engine.

9. _____Once a driver is ready to take the car, remove the fill cap and add 4.0 gallons of test fuel **GB-7210** to the vehicle's fuel tank, and replace the fill cap.

10. _____Using a paint marker, write **Temp Range: 80F – 90F,GB-7210, ARCH** and **Fuel No. 7** on the front and rear windshields (on the driver's side) of the vehicle. This should be marked just under vehicle designation number.

FUELING PROCEDURE

The vehicles are fueled out of a 55-gallon drum of test fuel, using a portable dispensing pump. This dispensing pump has been fabricated by mounting the motor and gauge on a hand-truck. The dispensing pump is service station quality. The large bung of the drum is removed, and a steel pipe is inserted into the drum. The top of the pipe has the male side of the Hansen coupler on it and is connected to the female side of the coupler on the dispensing pump inlet hose. The small bung is loosened just enough to keep the drum from collapsing while fuel is being pumped out of it.

Ground straps are used throughout the fueling and defueling process to avoid static electricity.

APPENDIX D

LISTING OF SCREENED VEHICLES

Appendix D
SCREENED TEST VEHICLES
2009-2010 CRC/ASTM Hot-Fuel-Handling Program
SwRI, San Antonio, Texas

Year	Make	Model	VIN	Engine Displacement, L
2009	Buick	Lucerne CXL	1G4HD57M99U112682	3.9
1999	Buick	Century	2G4W552M9X1628814	3.1
2007	Buick	Lacrosse	2G4WC552671245419	3.8
2008	Chevrolet	Aveo	KL1TD56658B225791	1.6
2008	Chevrolet	Cobalt	1G1AK58F487315870	2.2
2007	Chevrolet	Express Van	1GAHG39U071226364	6.0
2010	Chevrolet	Equinox	2CNFLDEY0A6200484	3.0
2009	Chevrolet	HHR SS	3GNCA63X495561143	2.0
2009	Chevrolet	Malibu	1G1ZG57B29F152890	2.4
2009	Chevrolet	Silverado	2GCEC23C791137629	4.8
2009	Chevrolet	Tahoe	1GNEC23319R231696	5.3
2009	Chevrolet	T-Blazer	1GND5335492110596	4.2
2007	Chrysler	Pacifica	2A8GM68X67R346084	4.0
2007	Chrysler	PT Cruiser	3A4FY581387T629213	2.4
2008	Chrysler	Sebring	1C3LC46K28N218996	2.4
2008	Dodge	Caliber	1B3HB78K48D757565	2.4
2009	Dodge	Caravan	1D8HN44E89B520788	3.3
2008	Dodge	Dakota	1D7HE38K98S569995	3.7
2008	Dodge	Durango	1D8HD48N78F154875	4.7
2009	Dodge	Grand Caravan	KDBHN54D78R712243	3.8
2009	Dodge	Ram	1D38B18P795783864	4.7
2009	Ford	E350	1FBSS31L09DA51263	5.4
2009	Ford	Escape XLT	1FMCU03689KA12422	3.0
2009	Ford	F150	1FTRW128X9FA55757	4.6
2008	Ford	SE Focus	1FAHP35N68W255190	2.0
2009	Ford	Taurus	1FAHP25W99G111809	3.5
2008	Honda	Accord	1HGCP26408A072872	2.4
2007	Honda	Accord	1HGCM56717A034506	2.4
2007	Honda	Odyssey	5FNRL38477B048291	3.5
2009	Hyundai	Sonata	5NPET46C69H427558	2.4
2009	Jeep	Liberty	1J8GP28K59W504557	3.7
2008	KIA	Optima	KNAGE123285193700	2.4
2008	KIA	Rio	KNADE123886379383	1.6
2009	Lincoln	Town Car	2LNHM82VX9X623991	4.6
2010	Mazda	3	JM1BL1SF9A1111035	2.0
2008	Mazda	5	JM1CR293480316752	2.3
2008	Mazda	6	1YVHP80C985M37592	2.3
2009	Nissan	Pathfinder	5N1AR18U29C610190	4.0
2008	Nissan	Sentra	3N1AB61E28L712586	2.0
2009	Nissan	Versa	3N1BC13E99L426382	1.8
2009	Pontiac	G6/GT	1G2ZH57N994147961	3.5
2007	Saturn	ION	1G8AJ55F17Z139873	2.2
2009	Toyota	Camry LE	4T1BE46K09U323296	2.4
2009	Toyota	Corolla	1NXBU40E792066661	1.8
2008	Toyota	Highlander	JTEDS41A982034671	3.5
2008	Toyota	Rav 4	JTMED33V386072243	2.4

APPENDIX E

DETAILED FUEL INSPECTIONS

Table E-1

CRC/ASTM 2009-2010 Volatility Program Fuel Inspections

Fuel Description			1						2					
Property	Method	Units	116/170/0						116/150/0					
Laboratory			A	B	C	D	E	Average	A	B	C	D	E	Average
T V/L=20	ASTM D5188	°F		112.7	114.1	114.0	112.7	113.4	113.7	113.4	114.2	114	114.1	113.9
DVPE	ASTM D5191	psi		12.42	12.11	12.29	12.13	12.24	12.2	12.31	12.26	12.32	12.23	12.26
Gravity	ASTM D4052	°API		70.2	70.6	71.0	71.1	70.7	67.2	67.4	66.8	67.4	66.5	67.0
Relative Density		60/60°F		0.7016	0.7001	0.6988	0.6984	0.6997	0.7123	0.7115	0.7136	0.7114	0.7148	0.7127
Ethanol	ASTM D4815	wt %			0			0.0	0		0			0.00
Ethanol	ASTM D4815	vol %		0.2	0		0	0.1	0	0	0		0	0.00
FIA	ASTM D1319													
Aromatics		vol %			12.8		12.6	12.7	8.6		10.9		7.5	9.0
Olefins		vol %			7.2		6.3	6.8	1.4		1.8		1.5	1.6
Saturates		vol %			80.0		81.1	80.6	90.0		87.3		91	89.4
Distillation	ASTM D86													
Initial Boiling Point		°F		73	82.8	79.6	80.4	79.0	88.1	81.3	86.3	84.9	82.2	84.6
5% Evaporated		°F		95.3	97.3	96.1	97.1	96.5	102.5	101.6	99.6	99.9	101.3	101.0
10% Evaporated		°F		102.6	104.3	103.6	104.3	103.7	109.5	108.7	107.6	106.9	108.5	108.2
20% Evaporated		°F		114.3	115.4	115.1	115.3	115.0	119.4	119.5	118.4	117.4	118.9	118.7
30% Evaporated		°F		127.8	128.5	127.7	128.1	128.0	128.6	129.1	128.0	127.1	128.4	128.2
40% Evaporated		°F		145.8	146.9	145.4	145.1	145.8	138.2	139.2	137.7	137.2	138.2	138.1
50% Evaporated		°F		172.5	172.1	171.6	171.3	171.9	150.6	151.9	149.0	149.6	151.3	150.5
60% Evaporated		°F		209.9	209.2	208.2	208.4	208.9	169.1	171.6	167.7	168.3	170.2	169.4
70% Evaporated		°F		234.7	237.2	237.0	228.2	234.3	203.2	204.6	199.1	199.0	202.5	201.7
80% Evaporated		°F		263.2	265.4	264.2	263.4	264.1	232.6	235.2	230.1	234.6	233.9	233.3
90% Evaporated		°F		323.3	322.9	322.0	322.2	322.6	264.0	266.0	262.7	262.1	262.7	263.5
95% Evaporated		°F		352.5	351.0	352.7	349.1	351.3	320.3	322.9	314.1	309.4	315.9	316.5
End Point		°F		397.5	404.5	400.9	401.8	401.2	387.2	391.8	382.4	375.2	381.7	383.7
Recovery		vol %		98.0	97.7	97.6	98	97.8	97.3	97.7	96.1	97.0	97.5	97.1
Residue		vol %		0.8	1.1	1.5	1.0	1.1	1.6	1.3	1.0	2.0	1.3	1.4
Loss		vol %		1.2	1.2	0.9	1.0	1.1	1.2	1	2.9	1.0	1.2	1.5
Benzene	DHA	vol %			0.14		1.37	0.76				0.43	0.41	0.42
Ethanol	DHA	vol %			0.00			0.00				0.00		0.00
Hydrocarbon	DHA	vol %			100.00			100.00				100.00		100.00
Aromatics	DHA	vol %			12.76			12.76				6.99		6.99
Olefins	DHA	vol %			6.13			6.13				1.21		1.21
Saturates	DHA	vol %			81.11			81.1				91.80		91.80

Table E-1 Cont'd.
CRC/ASTM 2009-2010 Volatility Program Fuel Inspections

Fuel Description			3						4					
Property	Method	Units	116/150/10						116/140/0					
Laboratory			A	B	C	D	E	Average	A	B	C	D	E	Average
T V/L=20	ASTM D5188	°F		111.7	112.2	111.0	109.6	111.1	113.0	113	114.0	113	113.4	113.28
DVPE	ASTM D5191	psi		12.72	12.55	12.69	12.71	12.67	12.3	12.52	12.41	12.53	12.44	12.43
Gravity	ASTM D4052	°API		61.0	60.6	61.3	61.5	61.1	65.2	65.3	64.9		64.5	65.0
Relative Density		60/60°F		0.7349	0.7366	0.7339	0.7332	0.7347	0.7193	0.7190	0.7205		0.7220	0.7202
Ethanol	ASTM D4815	wt %			10.5			10.5	0		0			0.00
Ethanol	ASTM D4815	vol %		9.7	9.7		9.73	9.7	0	<0.1	0		0	0.00
FIA	ASTM D1319													
Aromatics		vol %			24.40		21.9	23.2	7.1		8.7		4.9	6.9
Olefins		vol %			6.9		6.7	6.8	1.1		1.4		1	1.2
Saturates		vol %			59.10		61.67	60.4	91.8		89.9		94.1	91.9
Distillation	ASTM D86													
Initial Boiling Point		°F		78.9	85.5	84	82.3	82.7	90.2	81.8	85.3	86.5	84.1	85.6
5% Evaporated		°F		101.2	102.8	101.7	100.9	101.7	103.4	104.6	104.7	102.5	104.3	103.9
10% Evaporated		°F		109.1	110.4	109.3	109.0	109.5	110.8	111.8	111.7	110.5	111.1	111.2
20% Evaporated		°F		122.0	122.6	122.0	121.7	122.1	121.3	122.0	121.6	121.0	121.5	121.5
30% Evaporated		°F		133.5	133.7	133.8	133.4	133.6	129.1	129.7	129.4	129.2	129.3	129.3
40% Evaporated		°F		144.3	144.4	144.3	143.2	144.1	135.3	135.9	135.7	135.6	135.5	135.6
50% Evaporated		°F		151.5	153.6	152.9	152.0	152.5	141.7	142.7	142.4	142.2	142.1	142.2
60% Evaporated		°F		196.8	196.4	198.0	197.4	197.2	151.1	152.7	152.3	151.9	152.1	152.0
70% Evaporated		°F		234.7	233.7	236.0	227.0	232.9	169.2	172.8	170.6	170.8	171.1	170.9
80% Evaporated		°F		264.6	266.3	264.8	267.8	265.9	216.7	212.7	216.1	214.6	217.4	215.5
90% Evaporated		°F		309.5	309.4	308.3	309.1	309.1	250.0	244.5	246.6	244.4	250.0	247.1
95% Evaporated		°F		345.3	342.0	342.4	343.8	343.4	299.2	304.4	293.9	297.7	298.9	298.8
End Point		°F		387.5	398.8	402.4	402.2	397.7	380.0	374.3	374.0	373.5	378.2	376.0
Recovery		vol %		97.4	97.7	97.4	97.7	97.6	96.7	97.2	97.4	95.8	97.4	96.9
Residue		vol %		1.2	1.0	1.6	1.2	1.3	1.0	1.8	1	3.1	1.4	1.7
Loss		vol %		1.4	1.3	1.0	1.1	1.2	2.3	1	1.6	1.1	1.2	1.4
Benzene	DHA	vol %			1.57		1.6	1.59			0.34		0.32	0.33
Ethanol	DHA	vol %			9.85			9.85			0.00			0.00
Hydrocarbon	DHA	vol %			90.15			90.15			100.00			100.00
Aromatics	DHA	vol %			24.31			24.31			5.49			5.49
Olefins	DHA	vol %			5.85			5.85			0.91			0.91
Saturates	DHA	vol %			59.99			60.0			93.60			93.60

Table E-1 Cont'd.
CRC/ASTM 2009-2010 Volatility Program Fuel Inspections

Fuel Description			5						6					
Property	Method	Units	107/150/0						107/150/10					
Laboratory			A	B	C	D	E	Average	A	B	C	D	E	Average
T V/L=20	ASTM D5188	°F		105.6	106.4	106.0	105.4	105.9		105.8	106.0	106.0	105.6	105.9
DVPE	ASTM D5191	psi		14.08	13.82	13.78	13.93	13.90		14.14	13.97	14.07	13.97	14.04
Gravity	ASTM D4052	°API		71.7	71.5	71.9	71.8	71.7		61.3	61.1	61.5	61.6	61.4
Relative Density		60/60°F		0.6963	0.6970	0.6957	0.696	0.6963		0.7338	0.7347	0.7332	0.7326	0.7336
Ethanol	ASTM D4815	wt %			0			0.0			10.5			10.50
Ethanol	ASTM D4815	vol %		<0.1	0		0.25	0.1		9.79	9.7		9.69	9.73
FIA	ASTM D1319													
Aromatics		vol %			10.8		10.8	10.8			24.5		23.2	23.9
Olefins		vol %			18.5		18.7	18.6			4.7		5.0	4.9
Saturates		vol %			70.7		70.25	70.5			61.1		62.11	61.6
Distillation	ASTM D86													
Initial Boiling Point		°F		70	83.7	79.9	76.7	77.6		75	83.8	80.8	76.3	79.0
5% Evaporated		°F		91.7	93.7	93.1	91.2	92.4		94.6	96.9	97.2	94.6	95.8
10% Evaporated		°F		98.7	101.0	99.9	98.3	99.5		102.2	105.4	104.7	103.2	103.9
20% Evaporated		°F		110.8	112.5	111.3	110.5	111.3		116.9	118.6	118.2	116.9	117.7
30% Evaporated		°F		123.4	125.3	123.6	123.6	124.0		131.1	131.8	132.2	132.1	131.8
40% Evaporated		°F		138.7	139.8	137.9	138.6	138.8		144.0	144.2	144.8	143.7	144.2
50% Evaporated		°F		156.0	156.6	154.4	155.8	155.7		153.5	154.1	154.6	153.1	153.8
60% Evaporated		°F		175.7	177.1	175.2	176.7	176.2		193.3	196.7	198.4	197.0	196.4
70% Evaporated		°F		201.0	203.5	200.3	202.9	201.9		239.2	239.7	239.7	239.6	239.6
80% Evaporated		°F		232.8	238.3	234.7	236.0	235.5		271.1	274.9	274.7	274.2	273.7
90% Evaporated		°F		298.2	299.9	296.1	300.2	298.6		316.1	315.4	315.5	312.4	314.9
95% Evaporated		°F		363.4	355.5	356.3	358.0	358.3		343.1	342.4	339.2	342.4	341.8
End Point		°F		413.7	417.9	414.3	416.7	415.7		380.2	389.9	383.1	390.2	385.9
Recovery		vol %		97.4	96.7	97.1	97.1	97.1		97.3	96.9	97.8	97.4	97.4
Residue		vol %		1.3	1.1	1.9	1.7	1.5		1.5	1.1	1.4	1.5	1.4
Loss		vol %		1.3	2.2	1.0	1.2	1.4		1.2	2.0	0.8	1.1	1.3
Benzene	DHA	vol %			0.50		0.49	0.50				1.73	1.76	1.75
Ethanol	DHA	vol %			0.00			0.00				9.74		9.74
Hydrocarbon	DHA	vol %			100.00			100.00				90.26		90.26
Aromatics	DHA	vol %			8.84			8.84				26.06		26.06
Olefins	DHA	vol %			17.54			17.54				4.06		4.06
Saturates	DHA	vol %			73.62			73.6				60.14		60.14

Table E-1 Cont'd.
CRC/ASTM 2009-2010 Volatility Program Fuel Inspections

Fuel Description			7						8					
Property	Method	Units	107/140/10						105/170/0					
Laboratory			A	B	C	D	E	Average	A	B	C	D	E	Average
T V/L=20	ASTM D5188	°F		105.9	105.8	106.0	105.9	105.9	105.6	105.2	107.0	106	106.4	106.0
DVPE	ASTM D5191	psi		13.69	13.53	13.44	13.5	13.54	14.1	14.18	14.08	14.28	14.12	14.16
Gravity	ASTM D4052	°API		68.2	68.6	68.8	69.0	68.7	71.4	71.5	70.6	74.3	71.5	71.9
Relative Density		60/60°F		0.7084	0.7071	0.7064	0.7056	0.7069	0.6974	0.697	0.7001	0.6876	0.6972	0.6959
Ethanol	ASTM D4815	wt %			10.8			10.8	0		0			0.00
Ethanol	ASTM D4815	vol %		9.96	9.6		9.72	9.8	0	< 0.1	0		0	0.00
FIA	ASTM D1319													
Aromatics		vol %			11.60		10.4	11.0	12.3		13.2		9.3	11.6
Olefins		vol %			6.1		6	6.1	1.6		2		1.9	1.8
Saturates		vol %			72.60		73.88	73.2	86.1		84.8		88.8	86.6
Distillation	ASTM D86													
Initial Boiling Point		°F		76.5	89.4	83.8	78.3	82.0	80.4	72.6	82.8	77.6	75.6	77.8
5% Evaporated		°F		96.0	100.6	93.2	94.5	96.1	88.8	87.6	90.3	91.1	89.5	89.5
10% Evaporated		°F		101.8	107.4	100.6	100.9	102.7	97.3	96.1	98.8	98.6	97.7	97.7
20% Evaporated		°F		110.9	116.4	109.8	110.6	111.9	109.7	109.3	111.6	111.0	110.6	110.4
30% Evaporated		°F		121.2	126.1	119.6	121.2	122.0	122.8	123.6	125.8	125.2	124.6	124.4
40% Evaporated		°F		132.8	136.9	131.5	132.5	133.4	141.0	142.3	145.5	144.8	143.9	143.5
50% Evaporated		°F		145.2	148.5	144.7	145.2	145.9	170.5	170.9	175.1	174.7	173.8	173.0
60% Evaporated		°F		157.1	167.7	156.4	156.4	159.4	210.8	211.7	213.0	212.5	212.8	212.2
70% Evaporated		°F		222.6	232.5	223.7	220.8	224.9	227.9	229.0	230.5	230.2	230.0	229.5
80% Evaporated		°F		255.2	263.3	257.6	256.5	258.2	243.4	240.7	244.3	245.1	244.8	243.7
90% Evaporated		°F		316.8	319.5	316.3	314.3	316.7	279.6	279.7	283.4	281.1	282.0	281.2
95% Evaporated		°F		348.4	348.8	346.4	347.0	347.7	334.2	339.3	340.2	332.6	336.4	336.5
End Point		°F		388.5	404.1	399.8	398.1	397.6	404.8	395.9	405.7	391.1	391.7	397.8
Recovery		vol %		97.8	95.7	94.8	97.8	96.5	96.5	96.5	95.7	96.8	97.1	96.5
Residue		vol %		1.1	1.1	4.1	1.2	1.9	0.8	2.1	1.1	2.1	1.6	1.5
Loss		vol %		1.1	3.2	1.1	1	1.6	2.8	1.4	3.2	1.1	1.3	2.0
Benzene	DHA	vol %			0.13		1.17	0.65			0.57		0.52	0.55
Ethanol	DHA	vol %			10.15			10.15			0.00			0.00
Hydrocarbon	DHA	vol %			89.85			89.85			100.00			100.00
Aromatics	DHA	vol %			11.67			11.67			9.16			9.16
Olefins	DHA	vol %			5.42			5.42			1.47			1.47
Saturates	DHA	vol %			72.76			72.8			89.37			89.37

Table E-1 Cont'd.
CRC/ASTM 2009-2010 Volatility Program Fuel Inspections

Fuel Description			9						10					
Property	Method	Units	105/150/0						105/150/10					
Laboratory			A	B	C	D	E	Average	A	B	C	D	E	Average
T V/L=20	ASTM D5188	°F	104.4	104.6	105.4	104	105	104.7		105.1	105.4	104.0	104.6	104.8
DVPE	ASTM D5191	psi	14.1	14.17	14.12	14.30	14.06	14.16		14.47	14.31	14.33	14.34	14.36
Gravity	ASTM D4052	°API	73.2	73.2	73.1	73.3	73.6	73.3		60.2	59.7	60.2	60.5	60.1
Relative Density		60/60°F	0.6912	0.6914	0.6916	0.6909	0.6900	0.6910		0.7382	0.7401	0.7381	0.7370	0.7383
Ethanol	ASTM D4815	wt %	0		0			0.0			10			10.00
Ethanol	ASTM D4815	vol %	0	0	0		0	0.0		9.43	9.3		9.39	9.38
FIA	ASTM D1319													
Aromatics		vol %	10.5		12.3		9.5	10.8			26.0		22.9	24.5
Olefins		vol %	1.3		1.9		1.8	1.7			6.9		5.1	6.0
Saturates		vol %	88.2		85.8		88.7	87.6			57.8		62.61	60.2
Distillation	ASTM D86													
Initial Boiling Point		°F	80.5	72.0	76.6	79.6	75.9	76.9		72.4	81.1	81.4	76.5	77.9
5% Evaporated		°F	89.9	88.4	88.6	90.0	87.2	88.8		92.5	95.0	93.1	92.5	93.3
10% Evaporated		°F	96.8	95.7	95.7	96.9	94.5	95.9		101.7	104.6	102.8	102.4	102.9
20% Evaporated		°F	106.0	105.9	106.0	106.5	104.7	105.8		117.5	119.5	118.0	117.6	118.2
30% Evaporated		°F	115.6	116.2	116.5	117.0	115.3	116.1		132.9	134.3	133.3	133.1	133.4
40% Evaporated		°F	128.1	130.2	130.7	130.2	129.0	129.6		146.1	146.9	146.6	146.2	146.5
50% Evaporated		°F	149.8	153.3	153.0	152.8	151.3	152.0		154.5	156.3	157.3	154.1	155.6
60% Evaporated		°F	192.8	196.1	193.2	194.1	192.3	193.7		211.3	214.3	215.8	213.5	213.7
70% Evaporated		°F	224.9	224.9	224.6	225.5	219.5	223.9		250.5	251.1	251.6	244.2	249.4
80% Evaporated		°F	240.4	241.9	239.2	243.5	239.2	240.8		285.9	286.8	288.3	285.0	286.5
90% Evaporated		°F	273.2	275.1	271.4	273.1	271.1	272.8		326.8	331.8	330.6	330.5	329.9
95% Evaporated		°F	330.7	331.3	329.3	331.2	326.8	329.9		369.4	366.1	368.9	365.1	367.4
End Point		°F	364.6	400.7	390.6	387.7	389.0	386.5		408.0	418.4	414.6	415.3	414.1
Recovery		vol %	96.6	97.5	97.3	96.5	96.6	96.9		97.1	96.4	95.7	97.1	96.6
Residue		vol %	1.1	1.5	1.0	1.3	2.1	1.4		1.7	1.1	3.1	1.9	2.0
Loss		vol %	2.4	1	1.7	2.2	1.3	1.7		1.2	2.5	1.2	1	1.5
Benzene	DHA	vol %			0.51		0.48	0.50			1.57		1.61	1.59
Ethanol	DHA	vol %			0.00			0.00			9.40			9.40
Hydrocarbon	DHA	vol %			100.00			100.00			90.60			90.60
Aromatics	DHA	vol %			8.19			8.19			25.45			25.45
Olefins	DHA	vol %			1.36			1.36			5.84			5.84
Saturates	DHA	vol %			90.45			90.5			59.31			59.31

Table E-1 Cont'd.
CRC/ASTM 2009-2010 Volatility Program Fuel Inspections

Fuel Description			11						12					
Property	Method	Units	105/140/0						102/150/0					
Laboratory			A	B	C	D	E	Average	A	B	C	D	E	Average
T V/L=20	ASTM D5188	°F	105.0	104.2	105.1	104	104.9	104.6	102.2	101.9	102.8	102	102.3	102.2
DVPE	ASTM D5191	psi	13.7	14.07	13.92	14.09	13.84	13.92	14.5	14.85	14.67	14.74	14.68	14.69
Gravity	ASTM D4052	°API	74.0	74.3	73.6	71.5	72.6	73.2	73.9	73.8	73.6	73.6	74.1	73.8
Relative Density		60/60°F	0.6884	0.6876	0.6899	0.6970	0.6932	0.6912	0.6890	0.6891	0.6899	0.6899	0.6881	0.6892
Ethanol	ASTM D4815	wt %	0		0			0.0	0		0			0.00
Ethanol	ASTM D4815	vol %	0	< 0.1	0		0	0.0	0	< 0.1	0		0	0.00
FIA	ASTM D1319													
Aromatics		vol %	10.1		11.4		9.7	10.4	13.8		11.8		1.8	9.1
Olefins		vol %	1.0		1.8		1.8	1.5	1.1		2.1		1.8	1.7
Saturates		vol %	88.9		86.8		88.5	88.1	85.1		86.1		96.4	89.2
Distillation	ASTM D86													
Initial Boiling Point		°F	82.4	73.5	81.7	79.0	77.7	78.9	82.3	72.8	77.6	77.4	76.5	77.3
5% Evaporated		°F	90.9	89.1	91.5	91.1	89.5	90.4	89.7	87.3	88.3	88.2	88.1	88.3
10% Evaporated		°F	97.3	95.0	97.8	96.9	95.3	96.5	96.1	93.5	94.9	94.8	94.6	94.8
20% Evaporated		°F	104.4	103.1	106.0	104.9	103.8	104.4	104.7	102.9	104.7	104.5	104.3	104.2
30% Evaporated		°F	112.3	111.2	114.1	112.9	112.5	112.6	114.4	113.1	114.9	114.6	114.7	114.3
40% Evaporated		°F	122.7	122.4	125.8	123.9	123.3	123.6	126.5	126.8	128.2	127.9	127.7	127.4
50% Evaporated		°F	140.3	142.2	144.6	142.9	142.5	142.5	147.4	148.7	149.7	149.9	149.0	148.9
60% Evaporated		°F	176.1	177.3	183.8	180.3	179.6	179.4	189.0	186.3	192.0	189.6	188.8	189.1
70% Evaporated		°F	220.9	220.3	223.1	216	221.2	220.3	223.8	221.5	225	224.0	222.4	223.3
80% Evaporated		°F	237.5	238.2	240.1	240.4	239.5	239.1	239.1	236.5	240.9	242.1	241.9	240.1
90% Evaporated		°F	269.6	267.8	270.5	268.1	269.1	269.0	272.5	269.4	271.9	269.7	273.9	271.5
95% Evaporated		°F	325.7	325.7	326.7	325.2	326.3	325.9	329.4	328.2	329.9	327.1	330.5	329.0
End Point		°F	387.4	378.5	392.8	383.5	392.2	386.9	402.0	383	394.9	386.2	392.1	391.6
Recovery		vol %	96.5	97.0	97.0	97.0	97.1	96.9	96.9	97.1	97.0	96.6	97.3	97.0
Residue		vol %	1.1	1.6	1	1.9	1.6	1.4	1.0	1.5	1	1.1	1.5	1.2
Loss		vol %	2.4	1.4	2	1.1	1.3	1.6	2.2	1.4	2	2.3	1.2	1.8
Benzene	DHA	vol %			0.49		0.45	0.47			0.50		0.47	0.49
Ethanol	DHA	vol %			0.00			0.00			0.00			0.00
Hydrocarbon	DHA	vol %			100.00			100.00			100.00			100.00
Aromatics	DHA	vol %			7.80			7.80			8.07			8.07
Olefins	DHA	vol %			1.26			1.26			1.31			1.31
Saturates	DHA	vol %			90.94			90.9			90.62			90.62

Table E-1 Cont'd.
CRC/ASTM 2009-2010 Volatility Program Fuel Inspections

Fuel Description			13						14					
Property	Method	Units	102/150/10						102/140/10					
Laboratory			A	B	C	D	E	Average	A	B	C	D	E	Average
T V/L=20	ASTM D5188	°F		102.6	103.1	102	102.6	102.6		103.3	103.4	103.0	103.9	103.4
DVPE	ASTM D5191	psi		14.95	14.75	14.87	14.87	14.86		14.55	14.29	14.41	14.36	14.40
Gravity	ASTM D4052	°API		59.7	59.3	60.0	60.1	59.8		68.1	67.8	68.4	68.3	68.2
Relative Density		60/60°F		0.7399	0.7416	0.7389	0.7386	0.7398		0.7089	0.7100	0.7079	0.7082	0.7087
Ethanol	ASTM D4815	wt %			10.5			10.5			11.2			11.20
Ethanol	ASTM D4815	vol %		9.99	9.8		9.88	9.9		10.07	10.0		10.04	10.04
FIA	ASTM D1319													
Aromatics		vol %			29.9		28.6	29.3			12.6		11.2	11.9
Olefins		vol %			4.9		3.3	4.1			5.8		3.3	4.6
Saturates		vol %			55.4		58.22	56.8			71.6		75.46	73.5
Distillation	ASTM D86													
Initial Boiling Point		°F		74.5	80.3	80.1	73.1	77.0		74.8	82.4	81.4	75.3	78.5
5% Evaporated		°F		90.8	93.1	90.6	90.6	91.3		93.8	92.3	94.9	93.2	93.6
10% Evaporated		°F		99.2	102.1	99.5	99.6	100.1		100.8	100.4	101.5	100.8	100.9
20% Evaporated		°F		113.6	115.3	113.0	114.1	114.0		111.4	111.4	112.2	112.1	111.8
30% Evaporated		°F		129.3	130.0	128.5	129.9	129.4		122.5	121.8	122.9	123.1	122.6
40% Evaporated		°F		143.4	143.8	142.9	143.6	143.4		133.3	132.8	133.8	133.4	133.3
50% Evaporated		°F		153.8	155.2	154.9	154.1	154.5		143.2	143.2	143.8	143.6	143.5
60% Evaporated		°F		195.5	191.5	193.0	194.7	193.7		153.0	153.0	153.9	152.6	153.1
70% Evaporated		°F		245.7	244.7	246.4	247.3	246.0		208.2	208.9	210.4	208.0	208.9
80% Evaporated		°F		279.0	280.9	279.2	281.3	280.1		241.4	242.8	241.0	240.6	241.5
90% Evaporated		°F		315.2	316.4	318.0	318.7	317.1		296.0	297.7	297.0	294.2	296.2
95% Evaporated		°F		346.2	343.1	344.0	341.2	343.6		334.4	342.1	339.1	339.3	338.7
End Point		°F		387.2	392.8	392.8	392.6	391.4		386.0	396.5	396.8	389.2	392.1
Recovery		vol %		97.2	96.3	95.9	97.4	96.7		97.5	95.5	96.8	97.5	96.8
Residue		vol %		1.7	1.1	3.1	1.6	1.9		1.3	1.1	2.2	1.5	1.5
Loss		vol %		1.1	2.6	1.0	1	1.4		1.2	3.4	1.0	1	1.7
Benzene	DHA	vol %			2.08		2.15	2.12			0.51		0.49	0.50
Ethanol	DHA	vol %			10.00			10.00			10.23			10.23
Hydrocarbon	DHA	vol %			90.00			90.00			89.77			89.77
Aromatics	DHA	vol %			29.93			29.93			12.87			12.87
Olefins	DHA	vol %			4.40			4.40			5.47			5.47
Saturates	DHA	vol %			55.67			55.7			71.43			71.43

Table E-1 Cont'd.
CRC/ASTM 2009-2010 Volatility Program Fuel Inspections

Fuel Description			28						29					
Property	Method	Units	109/150/15						102/150/15					
Laboratory			A	B	C	D	E	Average	A	B	C	D	E	Average
T V/L=20	ASTM D5188	°F		108.4	108.5	108	108.7	108.4	102.3	102.8	103.0	103	103.6	102.9
DVPE	ASTM D5191	psi		13.11	12.91	13.00	12.91	12.98	14.2	14.53	14.71	14.19	14.4	14.41
Gravity	ASTM D4052	°API		66.7	66.7	67.0	67.2	66.9	67.9	67.8	67.5	67.8	68.0	67.8
Relative Density		60/60°F		0.7139	0.7139	0.7128	0.7121	0.7132	0.7098	0.7100	0.7111	0.7100	0.7092	0.7100
Ethanol	ASTM D4815	wt %			17.5			17.5			17.1			17.10
Ethanol	ASTM D4815	vol %		15.94	15.7		14.84	15.5	15.1	15.11	15.3		14.03	14.88
FIA	ASTM D1319													
Aromatics		vol %			11.30		10.3	10.8	8.7		13.3		1.3	7.8
Olefins		vol %			5.8		4.4	5.1	1.1		2.2		1.3	1.5
Saturates		vol %			67.20		70.46	68.8	75.3		84.5		83.37	81.1
Distillation	ASTM D86													
Initial Boiling Point		°F		78.4	84.6	83.7	78.3	81.3	84.0	75.8	78.5	80.5	76.7	79.1
5% Evaporated		°F		98.1	99.8	98.6	96.1	98.2	94.1	92.6	93.1	94.2	92.5	93.3
10% Evaporated		°F		104.4	106.2	104.7	103.4	104.7	100.2	100.3	100.6	100.3	99.5	100.2
20% Evaporated		°F		114.2	116.0	114.7	113.4	114.6	110.4	111.1	111.2	109.4	110.3	110.5
30% Evaporated		°F		125.4	126.3	125.5	124.4	125.4	121.1	122.9	122.0	120.2	121.6	121.6
40% Evaporated		°F		137.4	138.4	137.4	137.2	137.6	134.1	136.5	134.8	134.1	134.8	134.9
50% Evaporated		°F		150.2	150.3	150.5	150.2	150.3	149.0	151.1	149.6	149.5	150.3	149.9
60% Evaporated		°F		160.0	159.7	159.8	160.1	159.9	160.3	160.2	160.5	160.6	161.1	160.5
70% Evaporated		°F		163.3	167.6	165.5	165.8	165.6	166.5	168.2	168.2	167.0	168.0	167.6
80% Evaporated		°F		251.2	251.3	248.8	249.2	250.1	234.5	233.7	236.2	235.6	235.2	235.0
90% Evaporated		°F		310.9	310.9	309.0	310.2	310.3	264.9	268.3	266.9	264.9	268.1	266.6
95% Evaporated		°F		345.1	345.2	345.7	343.3	344.8	325.6	326.7	334.7	315.2	326.8	325.8
End Point		°F		387.6	399.2	397.9	388.4	393.3	388.8	392.6	383.9	368.0	380.6	382.8
Recovery		vol %		97.4	97.5	96.4	97.7	97.3	96.6	97.3	97.3	96.9	97.2	97.1
Residue		vol %		1.4	1.1	2.6	1.2	1.6	1.1	1.7	1.0	1.9	1.4	1.4
Loss		vol %		1.2	1.4	1.0	1.1	1.2	2.4	1.0	1.7	1.2	1.4	1.5
Benzene	DHA	vol %			0.12		1.04	0.58			0.46		0.43	0.45
Ethanol	DHA	vol %			16.93			16.93			16.87			16.87
Hydrocarbon	DHA	vol %			83.07			83.07			83.13			83.13
Aromatics	DHA	vol %			10.94			10.94			7.46			7.46
Olefins	DHA	vol %			5.08			5.08			1.23			1.23
Saturates	DHA	vol %			67.05			67.1			74.44			74.44

Table E-2

Class D-4 Test Fuel Analyses for Program Restart in 2010										
Laboratory Name: SwRI	**Fuel Description**		**CRC Fuel 1**	**CRC Fuel 2**	**CRC Fuel 3**	**CRC Fuel 4**	**CRC Fuel 5**	**CRC Fuel 6**	**CRC Fuel 7**	**CRC Fuel 28**
Analyses Date: 4/16/2010	**SwRI Code**		GA-7071	GA-7239	GA-7041	GA-7240	GA-7204	GB-7205	GB-7210	GB-7209
Property	**ASTM Method**	**Units**								
T V/L=20	D5188	°F	117.8	117.4	113.2	115.8	107.2	107.7	107.3	109.9
DVPE	D5191	psi	12.22	12.12	12.8	12.43	14.15	13.94	13.43	13.04
API Gravity	D4052	°API	70.8	67.2	61.3	65.3	71.9	61.5	69.2	67.3
Specific Gravity		60/60°F	0.6996	0.7121	0.7341	0.719	0.6958	0.7331	0.705	0.7117
Oxygen and Oxygenates										
Diisopropylether (DIPE)	D5599	vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ethyl *tert*-butylether (ETBE)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ethanol (EtOH)		vol%	<0.1	<0.1	10.16	<0.1	<0.1	10.03	8.48	15.63
Isobutanol (iBA)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Isopropanol (iPA)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Methanol (MeOH)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Methyl *tert*-butylether (MTBE)		vol%	<0.1	<0.1	<0.1	0.60	<0.1	<0.1	<0.1	<0.1
n-Butanol (nBA)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
n-Propanol (nPA)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
sec-Butanol (sBA)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
tert-amyl methylether (TAME)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
tert-Butanol (tBA)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
tert-Pentanol (tPA)		vol%	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Oxygen (wt*%)*		wt%	<0.1	<0.1	3.81	0.11	<0.1	3.77	3.31	6.05
Distillation (°F)										
Initial Boiling Point	D86	°F	82	89	82	89	78	82	84	85
5% Evaporated		°F	98	102	101	105	93	95	96	97
10% Evaporated		°F	105	109	109	112	100	103	102	104
15% Evaporated		°F	111	114	116	117	106	110	106	109
20% Evaporated		°F	116	119	122	122	111	117	111	114
30% Evaporated		°F	129	129	134	130	124	131	121	124
40% Evaporated		°F	147	139	144	136	138	143	132	137
50% Evaporated		°F	173	151	153	143	155	153	144	149
60% Evaporated		°F	211	170	193	152	175	195	175	159
70% Evaporated		°F	236	201	234	172	201	239	225	165
80% Evaporated		°F	265	233	265	217	235	276	256	247
90% Evaporated		°F	323	263	308	252	296	316	315	310
95% Evaporated		°F	351	316	342	298	357	342	349	347
End Point		°F	405	381	395	375	415	386	411	398
Recovered		vol%	97.8	97.2	97.4	94.4	97.3	97.7	97.9	97.4
Residue		vol%	1	1	0.8	1	0.9	1	1	1
Loss		vol%	1.2	1.8	1.8	1.6	1.8	1.3	1.1	1.6

APPENDIX F

VEHICLE TOTAL WEIGHTED DEMERIT SUMMARY

Table F-1
Vehicle Total Weighted Demerit Summary
Class E-5 Temperature

	1st Determination						2nd Determination					
Vehicle	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F
CRC1	8	A	16-Oct-09	20	78	78	No Repeats					
CRC2	8	A	17-Oct-09	14	75	75						
CRC3	8	A	18-Oct-09	20	71	71						
CRC4	8	A	18-Oct-09	9	71	71						
CRC7	8	A	16-Oct-09	33	75	75						
CRC8	8	A	16-Oct-09	28	73	73						
CRC9	8	A	16-Oct-08	15	77	76						
CRC12	8	A	17-Oct-09	16	70	70						
CRC15	8	A	17-Oct-09	31	75	75						
CRC16	8	A	17-Oct-09	6	75	75						
CRC18	8	B	17-Oct-09	24	76	76						
CRC21	8	B	17-Oct-09	18	76	76						
CRC23	8	B	18-Oct-09	8	71	71						
CRC28	8	B	17-Oct-09	9	74	74						
CRC34	8	B	16-Oct-00	14	76	76						
CRC36	8	B	16-Oct-09	10	75	75						
CRC40	8	B	16-Oct-09	10	76	76						
CRC42	8	B	17-Oct-09	24	70	70						
CRC44	8	B	17-Oct-09	20	74	74						
CRC46	8	B	16-Oct-09	20	73	73						
CRC1	9	A	06-Nov-09	18	74	74	9	B	17-Nov-09	7	68	68
CRC2	9	B	07-Nov-09	19	75	75	9	A	18-Nov-09	9	70.6	70.6
CRC3	9	A	06-Nov-09	26	73	73	9	B	17-Nov-09	39	70	70
CRC4	9	B	06-Nov-09	20	74	74	9	A	17-Nov-09	3	68.4	68.4
CRC7	9	A	07-Nov-09	36	75	75	9	B	17-Nov-09	21	70	70
CRC8	9	B	11-Nov-09	26	77	77	9	A	18-Nov-09	24	68.6	68.6
CRC9	9	A	10-Nov-09	14	75	75	9	B	17-Nov-09	33	70	70
CRC12	9	B	06-Nov-09	12	74	74	9	A	13-Nov-09	30	75.1	75.1
CRC15	9	A	11-Oct-09	60	74	74	9	B	17-Nov-09	11	70	70
CRC16	9	B	07-Nov-09	13	74	74	9	A	17-Nov-09	18	72.8	72.5
CRC18	9	A	06-Nov-09	17	74	74	9	B	18-Nov-09	3.5	70	70
CRC21	9	B	10-Nov-09	24	75	75	9	A	17-Nov-09	22	72.6	72.6
CRC23	9	A	10-Nov-09	48	72	72	9	B	18-Nov-09	11	72	72
CRC28	9	B	10-Nov-09	10	73	73	9	A	17-Nov-09	9	72.8	72.8
CRC34	9	A	07-Nov-09	18	74	73						
CRC36	9	B	10-Nov-09	41	74	74	9	A	17-Nov-09	16	72.1	72.1
CRC40	9	A	10-Nov-09	6	77	77	9	B	18-Nov-09	22	71	71
CRC42	9	B	10-Nov-09	18	78	78	9	A	18-Nov-09	10	68.9	68.9
CRC44	9	A	10-Nov-09	6	78	78	9	B	18-Nov-09	15	72	70
CRC46	9	B	10-Nov-09	14	78	78	9	A	17-Nov-09	26	72.6	72.1

Table F-1 Continued
Vehicle Total Weighted Demerit Summary
Class E-5 Temperature

	1st Determination						2nd Determination					
Vehicle	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F
CRC1	10	A	01-Nov-09	26	74	74	10					
CRC2	10	B	11-Nov-09	16	71	71	10					
CRC3	10	A	01-Nov-09	20	72	72	10					
CRC4	10	B	02-Nov-09	17	72	72	10					
CRC7	10	A	02-Nov-09	34	72	72	10					
CRC8	10	B	02-Nov-09	28	73	73	10	A	25-Nov-09	24	71	70.1
CRC9	10	A	02-Nov-09	12	72	72	10					
CRC12	10	B	01-Oct-09	9	74	74	10					
CRC15	10	A	01-Nov-09	43	74	74	10					
CRC16	10	B	01-Nov-09	14	69	69	10	A	25-Nov-09	25	70.7	70.7
CRC18	10	A	01-Nov-09	16	73	73	10					
CRC21	10	B	01-Nov-09	37	73	73	10	A	25-Nov-09	30	71.2	68.9
CRC23	10	A	01-Nov-09	27	74	74	10					
CRC28	10	B	01-Nov-09	12	74	74	10					
CRC34	10	A	01-Nov-09	22	74	74	10					
CRC36	10	B	01-Nov-09	35	74	74	10					
CRC40	10	A	02-Nov-09	15	72	72	10					
CRC42	10	B	01-Nov-09	15	74	74	10					
CRC44	10	A	02-Nov-09	11	72	72	10					
CRC46	10	B	02-Nov-09	35	71	71	10					
CRC1	11	B	23-Oct-09	14	74	74	11	A	18-Nov-09	30	70.7	70.7
CRC2	11	A	23-Oct-09	19	74	74	11	B	18-Nov-09	25	73	71
CRC3	11	B	24-Oct-09	12	70	70	11	A	18-Nov-09	24	70.5	70.5
CRC4	11	A	24-Oct-09	5	73	73	11	B	25-Nov-09	28	70	68
CRC7	11	B	24-Oct-09	18	70	70	11	A	18-Nov-09	30	73.1	71.4
CRC8	11	A	24-Oct-09	32	74	74	11					
CRC9	11	B	24-Oct-09	20	74	74	11	B	25-Nov-09	38	69.9	69
CRC12	11	A	23-Oct-09	16	71	71	11	B	25-Nov-09	11	68	68
CRC15	11	B	24-Oct-09	38	74	74	11	A	18-Nov-09	23	71.3	71
CRC16	11	A	23-Oct-09	24	70	70	11					
CRC18	11	B	23-Oct-09	17	73	73	11	A	18-Nov-09	7	73.6	70.8
CRC21	11	A	22-Oct-09	30	77	77	11	B	18-Nov-09	25	73	71
CRC23	11	B	23-Oct-09	17	70	70	11	A	25-Nov-09	20	71.4	71.4
CRC28	11	A	22-Oct-09	5	77	77	11	B	18-Nov-09	6	74	74
CRC34	11	B	23-Oct-09	12	73	73	11					
CRC36	11	A	23-Oct-09	13	72	72	11	B	25-Nov-09	27	69.1	69
CRC40	11	B	23-Oct-09	27	70	70	11	A	25-Nov-09	11	69.5	69.5
CRC42	11	A	23-Oct-09	10	73	73	11					
CRC44	11	B	23-Oct-09	22	74	74	11	A	25-Nov-09	13	71.4	71.2
CRC46	11	A	23-Oct-09	28	74	74	11	B	18-Nov-09	25	72	72

Table F-1 Continued
Vehicle Total Weighted Demerit Summary
Class E-5 Temperature

	1st Determination						2nd Determination					
Vehicle	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F
CRC1	12	A	18-Oct-09	17	74	74						
CRC2	12	B	20-Oct-09	32	78	78						
CRC3	12	B	20-Oct-09	13	77	77						
CRC4	12	A	20-Oct-09	17	78	78						
CRC7	12	B	19-Oct-09	25	77	77						
CRC8	12	A	19-Oct-09	17	73	73						
CRC9	12	B	19-Oct-09	10	74	74						
CRC12	12	A	18-Oct-09	13	73	73						
CRC15	12	B	18-Oct-09	23	75	75			No Repeats			
CRC16	12	B	19-Oct-09	19	73	73						
CRC18	12	A	20-Oct-09	23	78	78						
CRC21	12	A	19-Oct-09	37	78	78						
CRC23	12	A	19-Oct-09	25	76	76						
CRC28	12	B	19-Oct-09	3	72	72						
CRC34	12	B	18-Oct-09	13	72	72						
CRC36	12	A	18-Oct-09	20	75	75						
CRC40	12	A	18-Oct-09	14	75	75						
CRC42	12	B	18-Oct-09	18	74	74						
CRC44	12	A	19-Oct-09	14	74	74						
CRC46	12	A	19-Oct-09	21	73	73						
CRC1	13	A	24-Oct-09	18	75	75	13	B	12-Nov-09	8	71	71
CRC2	13	A	24-Oct-09	30	75	75	13	B	17-Nov-09	28	66	66
CRC3	13	A	27-Oct-09	28	68	68	13	B	11-Nov-09	15	79	79
CRC4	13	A	27-Oct-09	8	69	69	13	B	12-Nov-09	22	73	73
CRC7	13	A	27-Oct-09	30	71	71	13	B	12-Nov-09	33	75	75
CRC8	13	A	27-Oct-09	22	69	69	13	B	13-Nov-09	23	73	73
CRC9	13	A	27-Oct-09	26	71	68	13	A	13-Nov-09	12	74.1	74.1
CRC12	13	A	24-Oct-09	18	75	75	13	B	12-Nov-09	15	75	75
CRC15	13	A	27-Oct-09	19	69	69	13	B	12-Nov-09	34	72	72
CRC16	13	A	27-Oct-09	25	69	69	13	B	13-Nov-09	17	74	74
CRC18	13	B	27-Oct-09	17	70	70	13	A	12-Nov-09	11	74.5	74.5
CRC21	13	B	27-Oct-09	24	71	71	13	A	11-Nov-09	21	74.8	74.8
CRC23	13	B	24-Oct-09	28	74	74	13	A	12-Nov-09	28	74.1	74.1
CRC28	13	B	24-Oct-09	11	74	74	13	A	13-Nov-09	8	71.7	71.7
CRC34	13	B	24-Oct-09	12	75	75	13	A	11-Nov-09	16	73.3	73.3
CRC36	13	B	27-Oct-09	20	69	69	13	A	12-Nov-09	32	72.3	72.3
CRC40	13	B	27-Oct-09	26	69	69	13	B	13-Nov-09	10	76	76
CRC42	13	B	27-Oct-09	19	70	70	13	A	12-Nov-09	14	72	72
CRC44	13	B	27-Oct-09	28	71	71	13	A	12-Nov-09	8	74.4	74.4
CRC46	13	B	27-Oct-09	23	70	70	13	B	11-Nov-09	24	77.1	77.1

Table F-1 Continued
Vehicle Total Weighted Demerit Summary
Class E-5 Temperature

	1st Determination						2nd Determination					
Vehicle	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F
CRC1	14	B	27-Oct-09	19	71	69						
CRC2	14	B	17-Nov-09	14	72	69						
CRC3	14	B	27-Oct-09	39	71	71						
CRC4	14	B	31-Oct-09	26	74	74						
CRC7	14	B	30-Oct-09	29	74	73						
CRC8	14	B	31-Oct-09	42	76	76						
CRC9	14	B	31-Oct-09	38	72	72						
CRC12	14	B	30-Oct-09	16	74	74						
CRC15	14	B	31-Oct-09	56	73	73						
CRC16	14	B	30-Oct-09	29	74	74						
CRC18	14	A	30-Oct-09	16	74.8	74.8						
CRC21	14	A	30-Oct-09	24	74.6	74.6						
CRC23	14	A	27-Oct-09	21	70.1	70.1						
CRC28	14	A	27-Oct-09	11	70	68.2						
CRC34	14	A	30-Oct-09	16	71	71						
CRC36	14	A	30-Oct-09	13	72.1	72.1						
CRC40	14	A	31-Oct-09	11	74.1	74.1						
CRC42	14	A	31-Oct-09	10	74.9	74.9						
CRC44	14	A	31-Oct-09	20	71.7	71.7						
CRC46	14	A	31-Oct-09	33	73.1	73.1						
CRC1	29	A	02-Nov-09	18	77	74						
CRC2	29	A	06-Nov-09	19	74	74						
CRC3	29	A	05-Nov-09	22	74	74						
CRC4	29	A	05-Nov-09	12	75	75						
CRC7	29	A	05-Nov-09	30	75	75						
CRC8	29	A	17-Nov-09	36	69	69						
CRC9	29	A	06-Nov-09	32	74	74						
CRC12	29	A	05-Nov-09	23	76	76						
CRC15	29	A	06-Nov-09	38	74	73						
CRC16	29	A	02-Nov-09	13	76	76						
CRC18	29	B	02-Nov-09	28	76	75						
CRC21	29	B	02-Nov-09	19	77	76						
CRC23	29	B	05-Nov-09	20	77	77						
CRC28	29	B	05-Nov-09	7	73	73						
CRC34	29	B	05-Nov-09	21	75	75						
CRC36	29	B	05-Nov-09	24	75	75						
CRC40	29	B	06-Nov-09	18	71	71						
CRC42	29	B	06-Nov-09	8	74	74						
CRC44	29	B	06-Nov-09	8	73	73						
CRC46	29	B	06-Nov-09	20	72	72						

No Repeats

No Repeats

Table F-2
Vehicle Total Weighted Demerit Summary
Class D-4 Temperature

	1st Determination						2nd Determination					
Vehicle	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F
CRC1	1	B	07-Oct-09	10	91	89	1	A	01-Jun-10	26	84	84
CRC2	1	B	13-Oct-09	24	87	87	1	A	01-Jun-10	22	86	86
CRC3	1	B	13-Oct-09	13	90	87	1	A	01-Jun-10	20	87	87
CRC4	1	B	13-Oct-09	6	89	86	1	A	01-Jun-10	12	89	89
CRC7	1	B	14-Oct-09	8	89	89	1	A	01-Jun-10	32	89	89
CRC8	1	A	14-Oct-09	24	90	89	1	A	01-Jun-10	28	90	90
CRC9	1	A	14-Oct-09	17	90	89	1	A	01-Jun-10	20	91	91
CRC12	1	A	14-Oct-09	15	89	89	1	A	02-Jun-10	8	89	89
CRC15	1	B	14-Oct-09	41	89	89	1	A	02-Jun-10	32	89	89
CRC16	1	A	07-Oct-09	23	91	90	1	A	02-Jun-10	28	90	90
CRC18	1	A	13-Oct-09	13	88	88	1	A	02-Jun-10	12	91	91
CRC21	1	A	13-Oct-09	24	88	86	1	A	02-Jun-10	24	90	90
CRC23	1	A	13-Oct-09	26	89	85	1	A	02-Jun-10	31	91	91
CRC28	1	A	14-Oct-09	17	90	90	1	A	04-Jun-10	6	83	83
CRC34	1	A	15-Oct-09	21	84	84	1	A	04-Jun-10	22	84	84
CRC36	1	A	14-Oct-09	29	90	90	1	A	04-Jun-10	16	86	86
CRC40	1	B	14-Oct-09	22	90	90	1	A	04-Jun-10	19	87	87
CRC42	1	B	14-Oct-09	15	89	89	1	A	04-Jun-10	17	88	88
CRC44	1	B	14-Oct-09	29	90	90	1	A	04-Jun-10	14	89	89
CRC46	1	B	15-Oct-09	12	84	84	1	A	04-Jun-10	24	89	89
CRC47	1	A	01-Jun-10	6	89	89	1	A	02-Jun-10	6	89	89
CRC48	1	A	01-Jun-10	28	89	89	1	A	02-Jun-10	24	89	89
CRC1	2	A	23-Apr-10	17	89	89	2	A	24-Apr-10	16	85	84
CRC2	2	A	25-Apr-10	17	87	86	2	A	26-Apr-10	19	86	86
CRC3	2	A	23-Apr-10	38	88	87	2	A	24-Apr-10	21	84	83
CRC4	2	A	23-Apr-10	21	89	89	2	A	24-Apr-10	10	85	84
CRC7	2	A	25-Apr-10	26	87	87	2	A	25-Apr-10	38	86	86
CRC8	2	A	23-Apr-10	30	89	88	2	A	24-Apr-10	32	85	85
CRC9	2	A	26-Apr-10	26	88	87	2	A	29-Apr-10	25	84	84
CRC12	2	A	23-Apr-10	22	88	88	2	A	24-Apr-10	12	84	83
CRC15	2	A	29-Apr-10	34	84	83	2	A	02-May-10	34	84	84
CRC16	2	A	02-May-10	21	84	84	2	A	02-May-10	17	84	84
CRC18	2	A	23-Apr-10	18	88	88	2	A	24-Apr-10	19	84	82
CRC21	2	A	25-Apr-10	20	87	86	2	A	26-Apr-10	27	85	85
CRC23	2	A	25-Apr-10	20	87	86	2	A	26-Apr-10	28	86	86
CRC28	2	A	25-Apr-10	6	87	87	2	A	25-Apr-10	6	86	86
CRC34	2	A	25-Apr-10	13	86	86	2	A	26-Apr-10	8	84	84
CRC36	2	A	26-Apr-10	21	87	87	2	A	29-Apr-10	27	84	84
CRC40	2	A	29-Apr-10	18	84	84	2	A	05-May-10	14	84	84
CRC42	2	A	29-Apr-10	21	84	84	2	A	02-May-10	28	85	84
CRC44	2	A	29-Apr-10	15	84	83	2	A	02-May-10	19	85	83
CRC46	2	A	02-May-10	23	84	84	2	A	02-May-10	20	85	85
CRC47	2	A	23-Apr-10	20	88	88	2	A	24-Apr-10	15	85	85
CRC48	2	A	23-Apr-10	31	88	88	2	A	24-Apr-10	31	85	85

Table F-2 Continued
Vehicle Total Weighted Demerit Summary
Class D-4 Temperature

	1st Determination						2nd Determination					
Vehicle	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F
CRC1	3	A	21-May-10	20	89	87	3	A	22-May-10	16	86	86
CRC2	3	A	21-May-10	22	88	87	3	A	22-May-10	19	86	86
CRC3	3	A	22-May-10	22	86	85	3	A	25-May-10	24	85	85
CRC4	3	A	25-May-10	14	84	84	3	A	26-May-10	10	86	86
CRC7	3	A	25-May-10	28	84	84	3	A	26-May-10	28	86	86
CRC8	3	A	25-May-10	36	85	85	3	A	26-May-10	24	87	87
CRC9	3	A	26-May-10	9	85	85	3	A	26-May-10	10	88	88
CRC12	3	A	26-May-10	15	85	85	3	A	26-May-10	13	89	89
CRC15	3	A	26-May-10	34	87	87	3	A	26-May-10	33	89	87
CRC16	3	A	26-May-10	20	89	89	3	A	27-May-10	20	88	88
CRC18	3	A	26-May-10	8	89	89	3	A	27-May-10	9	87	87
CRC21	3	A	26-May-10	15	88	87	3	A	27-May-10	21	88	88
CRC23	3	A	28-May-10	34	87	87	3	A	28-May-10	28	89	89
CRC28	3	A	27-May-10	13	86	86	3	A	27-May-10	6	89	89
CRC34	3	A	27-May-10	13	86	86	3	A	27-May-10	17	89	89
CRC36	3	A	18-May-10	21	86	86	3	A	21-May-10	12	88	88
CRC40	3	A	18-May-10	21	84	84	3	A	18-May-10	13	85	85
CRC42	3	A	18-May-10	11	86	85	3	A	21-May-10	16	89	89
CRC44	3	A	18-May-10	6	85	85	3	A	21-May-10	16	89	89
CRC46	3	A	21-May-10	30	89	88	3	A	22-May-10	38	86	86
CRC47	3	A	18-May-10	16	84	84	3	A	21-May-10	11	88	88
CRC48	3	A	18-May-10	30	84	84	3	A	21-May-10	38	88	88
CRC1	4	A	03-May-10	15	84	84	4	A	03-May-10	21	87	87
CRC2	4	A	03-May-10	26	86	86	4	A	03-May-10	22	87	87
CRC3	4	A	04-May-10	18	85	85	4	A	04-May-10	24	91	88
CRC4	4	A	04-May-10	10	86	86	4	A	04-May-10	6	91	88
CRC7	4	A	04-May-10	28	88	88	4	A	05-May-10	19	85	85
CRC8	4	A	04-May-10	28	88	87	4	A	05-May-10	32	87	87
CRC9	4	A	04-May-10	22	89	89	4	A	05-May-10	24	87	87
CRC12	4	A	04-May-10	9	91	89	4	A	05-May-10	13	90	90
CRC15	4	A	03-May-10	31	85	85	4	A	03-May-10	21	87	87
CRC16	4	A	03-May-10	16	86	86	4	A	03-May-10	17	87	87
CRC18	4	A	05-May-10	14	89	89	4	A	06-May-10	16	85	85
CRC21	4	A	05-May-10	18	91	91	4	A	06-May-10	15	85	85
CRC23	4	A	05-May-10	18	91	91	4	A	06-May-10	22	87	87
CRC28	4	A	06-May-10	6	91	90	4	A	06-May-10	7	87	87
CRC34	4	A	06-May-10	18	90	90	4	A	06-May-10	16	89	89
CRC36	4	A	06-May-10	17	91	90	4	A	06-May-10	20	89	89
CRC40	4	A	07-May-10	14	89	89	4	A	11-May-10	9	90	90
CRC42	4	A	06-May-10	12	90	90	4	A	07-May-10	16	89	89
CRC44	4	A	03-May-10	20	86	86	4	A	04-May-10	9	82	82
CRC46	4	A	03-May-10	30	86	86	4	A	04-May-10	25	83	83
CRC47	4	A	07-May-10	11	87	87	4	A	07-May-10	12	91	91
CRC48	4	A	07-May-10	30	87	87	4	A	07-May-10	30	91	91

Table F-2 Continued
Vehicle Total Weighted Demerit Summary
Class D-4 Temperature

	1st Determination						2nd Determination					
Vehicle	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F
CRC1	5	B	15-Oct-09	21	86	86	5	A	30-May-10	19	85	85
CRC2	5	A	15-Oct-09	30	85	85	5	A	30-May-10	25	87	87
CRC3	5	B	15-Oct-09	18	88	88	5	A	30-May-10	20	87	87
CRC4	5	A	15-Oct-09	5	89	89	5	A	30-May-10	6	90	90
CRC7	5	B	15-Oct-09	26	89	89	5	A	30-May-10	36	90	90
CRC8	5	A	15-Oct-09	28	88	88	5	A	30-May-10	32	91	91
CRC9	5	B	15-Oct-09	8	89	89	5	A	30-May-10	14	90	90
CRC12	5	A	15-Oct-09	15	91	91	5	A	31-May-10	11	88	88
CRC15	5	B	15-Oct-09	15	90	90	5	A	31-May-10	38	88	88
CRC16	5	A	15-Oct-09	21	91	91	5	A	31-May-10	29	85	85
CRC18	5	B	15-Oct-09	19	90	90	5	A	31-May-10	14	84	84
CRC21	5	A	15-Oct-09	26	92	92	5	A	31-May-10	24	90	90
CRC23	5	B	15-Oct-09	15	91	90	5	A	31-May-10	26	82	82
CRC28	5	A	15-Oct-09	19	95	95	5	A	31-May-10	14	82	82
CRC34	5	B	20-Oct-09	13	84	84	5	A	31-May-10	20	87	87
CRC36	5	A	20-Oct-09	23	82	82	5	A	31-May-10	8	89	89
CRC40	5	B	20-Oct-09	10	82	82	5	A	31-May-10	14	88	88
CRC42	5	A	20-Oct-09	32	84	84	5	A	31-May-10	12	89	89
CRC44	5	B	20-Oct-09	18	84	84	5	A	31-May-10	12	90	90
CRC46	5	A	20-Oct-09	26	82	82	5	A	01-Jun-10	25	84	84
CRC47	5	A	30-May-10	9	82	82	5	A	30-May-10	12	88	88
CRC48	5	A	30-May-10	30	85	85	5	A	30-May-10	30	90	90
CRC1	6	A	30-Sep-09	30	90	90	6	A	07-May-10	25	90	90
CRC2	6	A	30-Sep-09	38	90	90	6	A	07-May-10	20	90	90
CRC3	6	A	02-Oct-09	24	83	83	6	A	11-May-10	22	90	90
CRC4	6	A	02-Oct-09	18	84	84	6	A	15-May-10	6	83	83
CRC7	6	A	02-Oct-09	32	85	82	6	A	15-May-10	30	83	83
CRC8	6	A	02-Oct-09	36	86	86	6	A	15-May-10	24	84	83
CRC9	6	A	02-Oct-09	34	87	85	6	A	17-May-10	28	86	86
CRC12	6	A	05-Oct-09	43	90	90	6	A	17-May-10	20	86	86
CRC15	6	B	30-Sep-09	43	90	90	6	A	17-May-10	44	89	87
CRC16	6	B	30-Sep-09	24	88	88	6	A	17-May-10	35	89	87
CRC18	6	B	02-Oct-09	14	85	85	6	A	17-May-10	19	90	87
CRC21	6	B	02-Oct-09	23	87	85	6	A	17-May-10	29	90	88
CRC23	6	B	02-Oct-09	24	88	88	6	A	17-May-10	22	93	88
CRC28	6	B	02-Oct-09	16	88	88	6	A	17-May-10	15	91	88
CRC34	6	B	02-Oct-09	28	87	86	6	A	17-May-10	20	90	86
CRC36	6	A	05-Oct-09	30	90	89	6	A	17-May-10	22	91	84
CRC40	6	A	07-Oct-09	11	90	90	6	A	15-May-10	16	83	83
CRC42	6	B	05-Oct-09	21	90	90	6	A	18-May-10	9	83	82
CRC44	6	B	05-Oct-09	28	90	90	6	A	18-May-10	17	83	83
CRC46	6	B	07-Oct-09	33	90	89	6	A	18-May-10	30	85	84
CRC47	6	A	12-May-10	20	91	91	6	A	13-May-10	15	86	85
CRC48	6	A	12-May-10	38.5	91	91	6	A	13-May-10	40	86	85

Table F-2 Continued
Vehicle Total Weighted Demerit Summary
Class D-4 Temperature

	1st Determination						2nd Determination					
Vehicle	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F	Fuel	Rater	Date	TWD	Max Amb. Temp., °F	EOT Amb. Temp. °F
CRC1	7	B	06-Oct-09	17	90	90	7	A	28-May-10	23	89	89
CRC2	7	B	06-Oct-09	29	91	91	7	A	28-May-10	20	90	90
CRC3	7	B	06-Oct-09	27	92	92	7	A	28-May-10	22	90	90
CRC4	7	B	06-Oct-09	6	92	91	7	A	28-May-10	18	91	91
CRC7	7	B	06-Oct-09	17	92	90	7	A	28-May-10	31	90	90
CRC8	7	B	07-Oct-09	22	88	88	7	A	29-May-10	28	86	86
CRC9	7	B	07-Oct-09	8	85	85	7	A	29-May-10	16	87	87
CRC12	7	B	07-Oct-09	15	88	88	7	A	29-May-10	11	91	91
CRC15	7	B	06-Oct-09	35	90	90	7	A	29-May-10	32	85	85
CRC16	7	B	06-Oct-09	32	90	90	7	A	27-May-10	14	88	88
CRC18	7	A	06-Oct-09	24	92	90	7	A	29-May-10	11	89	89
CRC21	7	A	06-Oct-09	29	91	91	7	A	27-May-10	19	89	89
CRC23	7	A	06-Oct-09	42	92	92	7	A	27-May-10	19	87	87
CRC28	7	A	06-Oct-09	17	92	91	7	A	29-May-10	6	89	89
CRC34	7	A	07-Oct-09	20	86	86	7	A	28-May-10	28	87	87
CRC36	7	A	06-Oct-09	9	92	91	7	A	29-May-10	12	89	89
CRC40	7	A	06-Oct-09	23	90	89	7	A	27-May-10	14	88	88
CRC42	7	A	07-Oct-09	16	89	89	7	A	29-May-10	11	89	89
CRC44	7	A	07-Oct-09	9	89	89	7	A	29-May-10	13	90	90
CRC46	7	A	06-Oct-09	27	90	90	7	A	30-May-10	25	82	82
CRC47	7	A	27-May-10	7	89	88	7	A	28-May-10	10	88	88
CRC48	7	A	27-May-10	26	89	89	7	A	28-May-10	32	89	89
CRC15	28	A	4-Jun-2010	36	80	82						
CRC47	28	A	4-Jun-2010	6	80	80						
CRC47	28	A	4-Jun-2010	7	85	85	No Repeats					
CRC48	28	A	4-Jun-2010	28	81	81						
CRC48	28	A	4-Jun-2010	32	86	86						

Table F-3
Severe Screening Fuel TWD Data

Fuel	Vehicle	Rater	Date	TWD	Maximum Ambient Temperature (°F)	Ending Ambient Temperature (°F)
14	CRC1	A	15-Sep-09	22	84	84
14	CRC2	A	15-Sep-09	40	86	86
14	CRC3	A	15-Sep-09	28	89	89
14	CRC4	A	15-Sep-09	21	94	94
14	CRC5	A	15-Sep-09	18	96	96
14	CRC6	A	15-Sep-09	14	99	98
14	CRC7	A	15-Sep-09	24	100	99
14	CRC8	A	16-Sep-09	30	93	93
14	CRC9	A	16-Sep-09	20	93	93
14	CRC10	A	16-Sep-09	8	95	95
14	CRC11	A	16-Sep-09	17	95	95
14	CRC12	A	16-Sep-09	22	97	97
14	CRC13	A	16-Sep-09	9	99	99
14	CRC14	A	16-Sep-09	8	99	97
14	CRC15	A	16-Sep-09	28	99	96
14	CRC16	B	17-Sep-09	21	86	86
14	CRC17	A	17-Sep-09	10	92	92
14	CRC18	B	17-Sep-09	24	91	91
14	CRC19	A	17-Sep-09	18	96	96
14	CRC20	A	17-Sep-09	7	95	95
14	CRC21	A	17-Sep-09	25	96	96
14	CRC22	A	18-Sep-09	8	89	88
14	CRC23	B	17-Sep-09	38	94	94
14	CRC24	A	17-Sep-09	14	96	96
14	CRC25	B	17-Sep-09	17	94	94
14	CRC26	B	17-Sep-09	14	95	95
14	CRC27	A	26-Sep-09	15	92	92
14	CRC28	B	26-Sep-09	34	93	93
14	CRC29	B	18-Sep-09	6	91	91
14	CRC30	A	18-Sep-09	20	89	89
13	CRC31	B	26-Sep-09	18	95	95
13	CRC32	A	26-Sep-09	13	93	91
13	CRC33	A	26-Sep-09	13	91	91
10	CRC34	B	26-Sep-09	33	94	92
14	CRC35	B	18-Sep-09	56	91	89
14	CRC36	A	21-Sep-09	40	87	87
14	CRC38	B	21-Sep-09	11	87	87
10	CRC39	A	26-Sep-09	5	87	87
10	CRC40	B	26-Sep-09	27	90	90
10	CRC41	A	26-Sep-09	8	88	88
10	CRC42	A	26-Sep-09	22	92	92
10	CRC44	A	26-Sep-09	12	92	92
10	CRC46	B	26-Sep-09	32	88	88

Table F-4
Screening Fuel 1 TWD Data

Fuel	Vehicle	Rater	Date	TWD	Maximum Ambient Temperature (°F)	Ending Ambient Temperature (°F)
Screening Fuel 1	CRC1	A	28-Sep-09	34	87	87
Screening Fuel 1	CRC2	A	21-Sep-09	29	92	92
Screening Fuel 1	CRC3	A	21-Sep-09	25	91	91
Screening Fuel 1	CRC4	A	28-Sep-09	16	88	88
Screening Fuel 1	CRC7	A	28-Sep-09	36	90	90
Screening Fuel 1	CRC8	B	21-Sep-09	32	92	92
Screening Fuel 1	CRC9	B	28-Sep-09	18	91	87
Screening Fuel 1	CRC12	A	28-Sep-09	18	90	89
Screening Fuel 1	CRC15	A	21-Sep-09	34	93	93
Screening Fuel 1	CRC16	B	28-Sep-09	28	87	87
Screening Fuel 1	CRC18	B	28-Sep-09	22	91	91
Screening Fuel 1	CRC21	A	28-Sep-09	23	93	93
Screening Fuel 1	CRC23	A	21-Sep-09	17	95	95
Screening Fuel 1	CRC28	A	28-Sep-09	9	94	94
Screening Fuel 1	CRC34	A	28-Sep-09	5	95	91
Screening Fuel 1	CRC35	A	21-Sep-09	49	92	92
Screening Fuel 1	CRC36	A	28-Sep-09	33	95	95
Screening Fuel 1	CRC40	B	28-Sep-09	4	95	95
Screening Fuel 1	CRC42	A	28-Sep-09	30	94	94
Screening Fuel 1	CRC44	A	28-Sep-09	22	99	99
Screening Fuel 1	CRC46	B	28-Sep-09	18	95	95