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2013 CRC INTERMEDIATE-TEMPERATURE E15 COLD-START AND WARM-UP VEHICLE DRIVEABILITY PROGRAM

Final Report

April 2014

COORDINATING RESEARCH COUNCIL, INC.
5755 NORTH POINT PARKWAY · SUITE 265 · ALPHARETTA, GA 30022

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COORDINATING RESEARCH COUNCIL, INC.
5755 NORTH POINT PARKWAY, SUITE 265
ALPHARETTA, GA 30022
TEL: 678/795-0506 FAX: 678/795-0509
WWW.CRCAO.COM

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(CRC Project No. CM-138-11-3)

Prepared by the

CRC Volatility Group

April 2014

CRC Performance Committee
of the
Coordinating Research Council

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ABSTRACT

An intermediate-temperature test program was conducted by the Coordinating Research Council, Inc. in response to a request from ASTM to determine the effect of higher ethanol contents on cold-start and warm-up driveability performance under cool ambient conditions in a group of high US sales volume, late model vehicles that were measured to be responsive to high Driveability Index (DI) fuels. The test program was conducted from February 4, 2013, through March 22, 2013, in Yakima, Washington. The program involved testing ten fuels: a high DI (1250) hydrocarbon base fuel with a nominal 8 psi vapor pressure, three splash blended fuels (10, 15, and 20 volume percent ethanol), three hydrocarbon only fuels with DIs matched to the splash blended fuels, and three fuels containing 10, 15, and 20 percent ethanol with DI matched to the splash blended 20 volume percent ethanol blend.

The program determined that for fuels containing up to 10 volume percent ethanol the current ASTM D4814 Driveability Index (DI) equation fit the data with a correlation coefficient, R^2, of 0.906. The program determined that for fuels containing ethanol concentrations at 15 or 20 volume percent the current DI equation fit the data with correlation coefficients, R^2, 0.557 and 0.538 respectively for the fleet of vehicles tested. A new DI coefficient for ethanol was determined for fuels containing 0 to 20 volume percent ethanol. This new coefficient fit the 0 to 20 volume percent ethanol data with a correlation coefficient, R^2, of 0.886. Vehicle design characteristics were also evaluated in this study, some of which were found to have statistically significant effects on driveability.

An ancillary program was conducted to evaluate the AVL-DRIVE™ System for automated driveability ratings. Results will be included in a separate CRC report.

I. INTRODUCTION

In 1998 a Driveability Index (DI) was incorporated into ASTM D4814 Specification for Automotive Spark-Ignition Engine Fuel[1]. The DI equation was developed using cold-start and warm-up data from a number of Coordinating Research Council (CRC) reports, from SAE International technical papers, and from company proprietary vehicle studies. It was published as SAE Technical Paper 881668[2]. The distillation terms in the equation determined by ASTM D86 were the 10% evaporated point (T10), 50% evaporated point (T50), and the 90% evaporated point (T90). In 2007 the ASTM modified the DI equation to adjust it for the addition of up to 10 volume percent ethanol in automotive spark-ignition engine fuel[3]. The basis for this adjustment was CRC Report 638 which reported on a cold-start and warm-up driveability program investigating 0, 3, 6, and 10 volume percent ethanol (E0, E3, E6, and E10)[4]. The DI equation currently contained in ASTM D4814 is:

$$DI = 1.5*T_{10} + 3.0*T_{50} + 1.0*T_{90} + 2.4*\text{Ethanol Volume \%}$$

Where T_{10} is the 10% evaporated point, T_{50} is the 50% evaporated point, and T_{90} is the 90% evaporated point from an ASTM D86 distillation in °F.

In January 2011, EPA granted the final version of a partial waiver to allow fuel and fuel additive manufacturers to introduce into commerce gasoline-ethanol blends that contain greater than 10 volume percent ethanol and up to 15 volume percent ethanol for use in model year 2001 and newer light-duty motor vehicles, subject to several conditions. The waiver does not apply to model year 2000 and older light-duty motor vehicles, as well as all heavy-duty gasoline engines and motor vehicles, highway and off-highway motorcycles, and non-road engines, vehicles, and equipment.

Increasing the ethanol content from 10 volume percent to 15 volume percent increases the oxygen content of the fuel, increases its latent heat of vaporization, and lowers the mid range of the distillation curve. It is unknown how these changes affect vehicle cold-start and warm-up driveability. ASTM approached CRC to determine an ethanol offset factor for the DI equation for fuel blends ranging from 10 to 20 volume percent ethanol and include new engine technology such as direct injection spark-ignition (DISI) engines.

The aim of this program is to determine the effect of higher ethanol contents on cold-start and warm-up driveability performance under cool ambient conditions in a large group of high U.S. sales volume, late model, SULEV / ULEV California Emissions and Federally certified Tier 2 Bin 4 and 5 vehicles using a specified fuel matrix containing ethanol blends. The vehicle fleet needed to contain some latest technology direct injection spark-ignition (DISI) engines and some turbocharged engines. The test fleet of 18 was selected from a group of 40 vehicles using a screening technique to determine the vehicles that responded to a high DI, high ethanol test fuel during the screening process.

The fuel set consisted of 10 fuels ranging in ethanol content from zero to 20 volume percent (E0 – E20) with uncorrected DI (no ethanol correction) as the primary control variable. DI for the fuel matrix was designed to match the current U.S. market and generally ranged from 1008 – 1250 °F. The ambient testing temperature range target was 40 °F ± 5 °F with an acceptable overnight soak range of 40 °F ± 10 °F.

An ancillary program was conducted to evaluate the AVL-DRIVE System for automated driveability ratings. Six test vehicles were instrumented during the screening process. Two of the test vehicles were instrumented during the entire test program and saw all ten test fuels. Post-test correlations were developed between the CRC driveability raters and the AVL-DRIVE System.

Members of the Data Analysis Panel for this summary analysis and report are shown in Appendix A. Participants on-site in the test program are shown in Appendix B. Appendix C outlines the program as approved by the CRC Performance Committee.

II. SUMMARY AND CONCLUSIONS

All of the conclusions presented in this report refer to the specific test vehicles used in the 2013 CRC Volatility Program. As with previous programs, these vehicles were screened from a larger fleet primarily based upon their response to the screening fuels. It is noted that some of the original 40 test vehicles were not sensitive to the test screening fuels; however, this protocol was designed to safeguard the more responsive vehicles for consumer protection.

- The program data analysis determined a correlation coefficient, R^2, of 0.906 for the current ASTM D4814 Driveability Index (DI) equation for fuels containing up to 10 volume percent ethanol;

- The program data analysis determined correlation coefficients, R^2, for the current DI equation of 0.557 for fuels containing ethanol concentrations of 0 and 15 volume percent and 0.538 for fuels containing ethanol concentrations of 0 and 20 volume percent for the fleet of vehicles tested.

- The data indicate that the following equation for fuels containing 0 to 20 volume percent ethanol had a correlation coefficient, R^2, of 0.886:

  $$DI = 1.5*T_{10} + 3.0*T_{50} + 1.0*T_{90} + 9.49*\text{Ethanol Volume \%}$$

  Where T_{10} is the 10% evaporated point, T_{50} is the 50% evaporated point, and T_{90} is the 90% evaporated point from an ASTM D86 distillation in °F.

- The T10, T50, and T90 coefficients for this equation were not determined by this 2013 study because the program design basis was uncorrected DI.

- The exact ethanol content at which the current DI equation deviates from the data is unknown since there were no fuels tested between 10 and 15 volume percent ethanol content.

- Several vehicle characteristics were evaluated. The following were determined to be statistically significant:

- Passenger cars had higher TWDs than light-duty trucks.

- Direct-injected spark-ignition vehicles had higher TWDs than port-fuel-injected vehicles.

- Higher load factor vehicles (Vehicle Mass / Engine Displacement) had higher TWDs for two of the three raters.

- Passenger cars certified for SULEV / PZEV emission requirements had higher TWDs than those certified to the less stringent Tier 2 Bin 5 requirements.

- The trained raters and driveability observers on the test track have commented that most laymen could be able to start to feel poor performance greater than the 15 – 20 demerit level.

III. TEST VEHICLES

Eighteen vehicles were selected from a larger group of forty 2011 – 2013 vehicles to comprise the final test fleet. All forty vehicles were provided by a rental agency. The forty vehicles were screened by CRC for fuel sensitivity by testing them first on their tank fuel and then testing them on the highest Driveability Index ethanol fuel (designated as Fuel B3). Fuel sensitivity was determined by the difference in total weighted demerits when tested on the two fuels. Sixteen vehicles exhibited fuel sensitivity and were obvious choices for the final fleet; two vehicles were selected for inclusion in the final fleet to widen the representation of makes and models tested. The remaining vehicles were returned to the rental agency. Those vehicles not considered for the final test fleet did not exhibit fuel sensitivity by showing little, if any, difference in total weighted demerits between tank fuel and Fuel B3.

The fleet of forty vehicles was primarily composed of 2012 models, with two 2011 models and two 2013 models. General Motors, Ford, Chrysler, Kia, Volkswagen, Mazda, Fiat, Nissan, Toyota, Jeep, and Infinity were represented in the fleet. An attempt was made to find older vehicles to include in the program. A request was sent to CRC Performance Committee members, but no vehicles in acceptable mechanical condition were located. All vehicles were equipped with air conditioning and automatic transmissions. Engine displacements ranged from 1.4 to 5.3 liters. Of the eighteen vehicles selected for testing, three were flexible-fuel vehicles (FFVs). The eighteen vehicles in the final fleet are shown in Table 1, and a complete description of the full forty-vehicle fleet is presented in Appendix D.

IV. TEST FUELS

The fuel matrix used for this program consisted of ten fuels; a high DI (1250) hydrocarbon base fuel (B0) with a nominal 8 psi vapor pressure, three splash blended (10, 15 and 20 volume percent—B1, B2, and B3) into B0 blends, three hydrocarbon only fuels (H1, H2, and H3) with DIs matched to B1, B2, and B3, and B4, B5, and B6 containing 10, 15, and 20 volume percent ethanol with DI matched to B3. The test fuel matrix focuses on the higher DI fuels available in the market, because it is anticipated that low DI fuels are more favorable for cold-start driveability performance. The DI for all test fuels used the uncorrected DI = 1.5*T10+3.0*T50+1.0*T90.

Average dry vapor pressure equivalent (DVPE), uncorrected DI, ethanol content, distillation temperatures, gravity, and composition as determined by the supplier (Laboratory A) and Fuel Acceptance Panel (Laboratories B, C, and D) are shown in Table 2. Shown in Table 2 are fuel codes for each fuel consisting of its uncorrected DI/ethanol content (e.g., 1161/10) which are used in the figures. Individual test results obtained by each inspecting laboratory are shown in Table E-1 of Appendix E. Table E-2 shows additional inspections provided by the supplier and some acceptance laboratories. Standard ASTM test methods were used to determine all of the properties. Table E-3 shows detailed hydrocarbon analyses for the test fuels.

Blending a neat molecule (ethanol) having a single boiling point with a mixture of hydrocarbons with a range of boiling points makes the creation of test fuels with a wide distribution of T50 increasingly difficult as the percentage of the neat molecule (ethanol) increases in the finished fuel. For this reason, the E15 and E20 test fuels blended with typical refinery components resulted in an uncorrected DI range that was narrower than intended in the original design of the study.

V. TEST SITE

The test program was conducted at the Renegade Raceway near Yakima, Washington, in the valley of the Yakima River. The raceway is at an altitude of 990 feet. The test site was a 0.7-mile long, 60-foot wide, flat paved, two-lane drag strip, along with several adjacent single-lane, paved auxiliary roads normally used for racecar preparation. A large, rectangular, paved area suitable for defueling/refueling and vehicle storage also was utilized. The race staging area at the base of the track was used for soaking the vehicles overnight.

The program was conducted from February 12, 2013, through March 22, 2013. Site set-up, vehicle preparation, and vehicle screening for fuel sensitivity began on February 4, 2013. Vehicles were de-instrumented and the site shut down during the last few days of the program.

Testing was conducted from 38 °F to 47 °F, with 97.3 percent of the tests falling inside the planned ambient temperature window of 35 °F to 45 °F. Overnight soak temperatures were from 28 °F to 50 °F, with 96.4 percent of the tests falling inside the planned soak temperature range of 30 °F to 50 °F. Overnight soak temperatures were determined by measuring the coolant temperatures of four selected vehicles using a Master Tech instrument and averaging the coolant temperatures together. This method gave results that were consistent with data obtained from a nearby weather station. Run order of the test vehicles was purposely randomized each day in an attempt to reduce the effect of temperature on the test. The data were also corrected to a single temperature during the data analysis to reduce this effect.

VI. TEST PROGRAM

A. Test Procedure

The test fuels were evaluated as prescribed in the CRC Cold-Start and Warmup Driveability Procedure (E-28-94). Duplicate tests were performed on every vehicle and fuel combination, with triplicates performed in some cases. Temperature conditions at the test site made it possible to also conduct some limited testing using Fuel B3 at 45 ° to 55 °F to investigate whether that was a more critical test window than the planned 35 °F to 45 °F range. Results looked very similar at both ranges; therefore, it was decided to test at the original 35 °F to 45 °F range.

The CRC Cold-Start and Warmup Driveability Procedure is presented in Appendix C. Briefly stated, the procedure consists of a series of light, moderate, and wide-open-throttle maneuvers mixed in with idles to obtain as many evaluations of driveability in a cold engine as possible. Malfunctions are recorded and evaluated as being trace, moderate, heavy, or extreme. The demerit rating details used in this program are shown in Appendix C of this report.

For this program, the driveability raters were instructed to turn the traction control feature off during the wide-open-throttle maneuvers to prevent interference from the traction control system. The rating teams were also instructed to follow the written procedure by recording a “no-start” if the vehicle failed to start after 5 seconds of cranking. For pre-programmed ignition systems, which continue cranking for a pre-determined length of time, the rating teams were directed to continue timing the cranking for however long the system automatically cranked. If the system cranked for over 5 seconds, it would be recorded as a no-start, but the cranking time would also be written on the data sheet for information. There were no instances of this happening.

All vehicles were tested each day using three raters. All three raters were constant throughout the program. The test fleet was divided into three sub-fleets, with each of the sub-fleets being assigned a color—blue, red, or yellow, which was indicated by colored tape on the windshield, rear window, side window, and gas cap. Each sub-fleet was assigned its own fuel each day. The fueling facility limited the availability of fuels to three a day. The test matrix had been statistically designed prior to execution of the program, assigning each vehicle/rater/fuel combination that was tested each day.

The three rating teams tested the eighteen vehicles in just over an hour. The ability to test during a short period of time was integral to maintaining the planned temperature window. Once the sun rose, the temperature often increased quickly. Staying within the test temperature window would potentially not have been possible if fewer than three raters had been used. Generally, three vehicles were on the track simultaneously, separated by approximately 0.3 miles. No problems with vehicles impeding one another were encountered using this schedule, even though stalls and severe malfunctions did occur.

B. <u>Fueling and Warm-up</u>

After the rating teams finished testing a vehicle, they dropped it off at the fueling/defueling area. The gas cap was removed, and the remaining test fuel was drained from the vehicle fuel tank through the fuel rail system by activation of the fuel pump with the engine running. The vehicle fuel system was then flushed and fueled with the next day's test fuel. Separate dispensing pumps were used for the different fuels being pumped each day to prevent test fuel contamination. All vehicles were fueled with a nominal four gallons of test fuel.

Upon completion of defueling, flushing and fueling, all vehicles were warmed up on the test track in caravans. This ensured that all vehicles traveled at the same speeds during the warm-up. It also eliminated their exposure to the public road system. The purpose of this warm-up was to allow for the test vehicle adaptive learning function to load data on the new fuel. Thirteen laps of the track (8.2 miles) were driven at 55 mph, followed by 0.65 mile at 45 mph, 0.65 mile at 35 mph, and operation on the return road for 0.25 mile at 25 mph and 0.25 miles at 15 mph. The vehicles were then parked for overnight cold soak prior to the next day's testing.

As a fuel conservation measure, if the same fuel was scheduled for the same vehicle several days in a row, the fuel was not drained from the vehicle. If necessary, the fuel level was topped off with a gallon of fresh fuel. When this occurred, the full preconditioning cycle was not followed, but the vehicles were driven three full laps of the track at cruise conditions to warm up the spark plugs and preclude their effect on the start time during testing the next morning. A review of TWDs showed that average demerits were about the same between the two warm-up cycles.

Midway through the program, it was noticed that three of the test vehicles were flexible-fuel vehicles (FFVs). This necessitated a review of the flushing procedure being used for those three vehicles, as the flushing procedure used when changing between fuels with significantly different ethanol percentages (e.g., 0 and 20 volume percent) can impact the FFV's ability to learn the ethanol content. On-site availability of a GM-specific scan tool (Tech II) allowed investigation of the GM FFV's ability to learn ethanol content, and it was determined that adding one gallon of fuel after the second flush and driving the vehicle for 10 meters before the final fill activated the learning capacity for that vehicle. OEM-specific scan tools were not available for the other two FFVs; however, cursory investigation with a Master Tech scan tool indicated that the same flushing and fueling procedure as used with the GM FFV most likely activated their learning capacities, as well. All three FFVs were thus treated the same for the remainder of the program.

C. Data Worksheets

The data from the vehicle driveability rating sheets were reviewed and summarized each day by the program manager and entered into an Excel spreadsheet. Information includes vehicle number, fuel code, rater, date, time, overnight soak temperature, test run temperature, odometer reading, and the driveability ratings of the prescribed vehicle accelerations, decelerations, idles, and starts. Later the data in the spreadsheet were confirmed on-site to ensure correct information would be used in the data analysis. A sample worksheet is shown in Appendix C. A summary of the complete data set is shown in Table F-1 of Appendix F.

VII. DISCUSSION OF RESULTS

A. Data Set Analysis

A statistician was consulted to design the program. The design specified that each car/fuel combination be tested in duplicate with the two tests being conducted by two of the three raters. This resulted in 360 scheduled tests. Another 36 tests were scheduled where another test (triplicate) was run using the rater that was not used for the duplicate ratings to determine rater differences. This involved testing Fuel B3 in all vehicles. Because of good weather at the test site, there was time to run a total of 501 tests. Most of these tests involved triplicate ratings using three raters testing Fuel B3 to better define relative rater performance. Fuel B5 was also assessed in five vehicles. Fuel B2 was tested in three vehicles and Fuel B1 in one vehicle. Repeats with the same rater were done for most vehicles using Fuel B3 and some with other fuels.

The final data set shown in Table F-1 was analyzed using the SAS® System to calculate least square mean values for each vehicle and all vehicles, as well as for each fuel and all fuels. The final model included fuel, vehicle, rater, vehicle x rater interaction, fuel x vehicle interactions, and ambient run temperature. As is common with driveability data, the total weighted demerits (TWD) values were log transformed due to the wide range of vehicle/fuel TWDs (0 - 139). Log transforming the data leads to a data set that is more normally distributed and has approximately constant variance. The data set was initially inspected for outliers and two data points (3 and 156.5 TWD) were removed. Two issues had to be addressed before settling on the final data set. The first issue was the impact on changing the flushing and learning procedure for the FFVs. There was no significant effect of the procedural change (p-value = 0.24), so the FFV data remained in the data base. The second issue involved Vehicle 19 where two raters used two-wheel drive throughout the entire program, while the third rater predominantly used four-wheel drive, while several of his early tests on this vehicle were in two-wheel drive. Two-wheel drive testing resulted in significantly higher TWD than four-wheel drive (p-value = 0.02) and more scatter which bracketed the four-wheel drive data. It was decided to keep this vehicle in the data base because of the bracketing scatter, the vehicle had an average response which would not have a large effect on the results, and it was one of the vehicles equipped throughout the program with the AVL-DRIVE System.

The final data were corrected using the model variables. A rater correction was applied to the data (the raters were statistically significantly different from each other as discussed later). The rater-vehicle interaction effect is statistically significant (p-value = <0.0001).

Table 3 presents the least-squares mean corrected natural log TWD and mean TWD for each fuel across all vehicles. Table 4 presents the least-squares mean corrected natural log TWD and mean TWD for all fuels for each vehicle. The regression analyses are on file at the CRC offices and are available upon request.

B. Run Temperature

The data were corrected to 40 °F with 97.3 percent of the tests falling inside the planned temperature window of 35 °F to 45 °F. The effect of run (ambient) temperature was a significant decrease in Ln TWD with a linear increase in temperature by -0.0159 per °F.

C. Fuel and Vehicle Response

Figure 1 graphically presents the TWD least-squares mean from Table 3 for each fuel averaged across all the vehicles and ranged from 14.0 to 38.1. The TWD least-squares mean data from Table 4 averaged across the 10 test fuels for each vehicle are shown graphically in Figure 2 and ranged from 12.9 to 45.7 TWD.

Figure 3A is a plot of each vehicle's TWD across the 10 fuels. The fuels are ordered in decreasing uncorrected DI for E0, E10, E15, and E20. The all vehicle average for each fuel is also shown. This is a very busy chart and the following five charts compare various subsets of vehicles. Figure 3B shows the results for the ten passenger cars in the program and the all vehicle average. Figure 3C presents the results for the eight trucks in the program. Comparing Figures 3B and 3C results in Figure 4 shows that cars have a significantly higher TWD than trucks (p-value = <0.0001). Figure 3D shows the results for vehicles equipped with port fuel injection (PFI) while Figure 3E shows the results for DISI vehicles. DISI vehicles had higher TWD than PFI vehicles (p-value = 0.02) as shown in Figure 5. Figure 3F presents results for FFVs. Conventional vehicles have marginally higher TWD than FFVs (p-value = 0.15) as shown in Figure 6.

Another vehicle property studied was the load factor as shown in Table 1. Figure 7 shows a plot how Ln TWD changes per load factor unit as determined by each of the three raters. Two of the raters show a significant increase in Ln TWD with increasing load factor while the third rater shows a marginal decrease.

Table 1 also shows the emissions category for each of the test vehicles. Figure 8 compares for cars and trucks emission categories and show the mean Ln TWD and 95% upper and lower confidence limits for each category. Also shown are the significant differences between the categories. For cars a regression of Ln TWD versus emissions categories showed a marginally significant effect (p-value = 0.15) with Ln TWD increasing with the lowering of limits.

D. Driveability Index

The Driveability Index (DI) was calculated for each test fuel using the current D4814 equation[3]:

$$DI = 1.5*T_{10} + 3.0*T_{50} + 1.0*T_{90} + 2.4*\text{Ethanol Volume }\%$$

Where T_{10} is the 10% evaporated point, T_{50} is the 50% evaporated point, and T_{90} is the 90% evaporated point from an ASTM D86 distillation in °F.

Using the calculated current DI and the mean corrected TWDs for each fuel, Figure 9 was developed. The resulting best-fit regression line for E0 fuels (4 data points) shows R^2 = 0.887 for a linear relationship and R^2 = 0.998 for a two order polynomial fit. The E10, E15, and E20 fuels could not be regressed individually as each only had two data points. A further assessment was undertaken to determine how well the ASTM equation worked for the combination of E0 and E10 fuels for which it is currently applicable (6 data points). The results shows R^2 = 0.885 for a linear relationship and R^2 = 0.924 for a two order polynomial fit. TWDs for E15 and E20 do not correlate well with the current ASTM DI equation, R^2 = 0.557 and 0.538 for E0 and E15 and E0 and E20, as shown in Figure 9.

E. Data Analysis

To develop a proper fitting cold-start and warm-up driveability prediction equation to cover ethanol contents up to 20 volume percent, SAS GLM regression analyses were undertaken. The program fuel design and objective were to develop an ethanol effect adjustment to the old uncorrected DI equation as was done earlier[4]. The fuel set design and range in distillation properties for the current program were such that using individual distillation terms in a regression would not result in usable findings and would require a larger program.

F. Ethanol Concentration Offset Model

The first regression model involved uncorrected DI (no ethanol offset term). Table 5 shows a poor correlation coefficient (R^2 = 0.250) and a non-significant DI term (p-value = 0.1413). The next regression used the current D4814 equation with the 2.4*Ethanol Volume % offset term which as shown in Table 5 resulted in a poor R^2 = 0.478 and a modest equation fit (p-value = 0.0257). The third regression used uncorrected DI and a linear ethanol content term. Adding the linear ethanol term to DI greatly improved the correlation coefficient R^2 to 0.886 as shown in Table 5. The resulting 9.49 ethanol coefficient was very significant (p-value = 0.0004) as was the DI coefficient (p-value = 0.0006). In Table 5 the DI coefficients were set to unity by dividing the regression equation coefficients by the DI coefficient. The ethanol coefficients similarly were divided by the regression DI coefficient. This is done to simplify the equations and so comparisons can more easily be made among the various regressions. Also shown in Table 5 are root mean squared error (RMSE) values. The resulting regression equation is:

$$DI = 1.5*T_{10} + 3.0*T_{50} + 1.0*T_{90} + 9.49*\text{Ethanol Volume }\%$$

Where T_{10} is the 10% evaporated point, T_{50} is the 50% evaporated point, and T_{90} is the 90% evaporated point from an ASTM D86 distillation in °F

Figure 10 shows how well the newly-developed equation for "All" fuels correlates with the test program driveability results. The data points are labeled to show their ethanol contents (i.e., E0, E10, E15, and E20). Figure 11 shows the same correlation plotted using normal coordinates (antilog of mean corrected Ln TWD). Figure 11 shows the same correlation plotted using normal coordinates (antilog of mean corrected Ln TWD). The vehicle response was determined to be non-linear with respect to ethanol concentration however the exact ethanol content at which the current DI equation begins to no longer fit the data is unknown since there were no fuels tested between 10 volume percent and 15 volume percent ethanol content. As would be expected, as DI decreases to some lower level, driveability performance will level out to some testing noise level. The best fit curve to the data uses a two order polynomial regression with R^2 = 0.914.

To determine how well the new DI equation works compared to the ASTM DI **e**quation for E10, E15, or E20, a regression study using Ln TWD LS Mean data was undertaken. Table 6 compares the correlation coefficients for the fuels as a function of the ethanol offset value. Figures 12 and 13 graphically show how E10, E15, and E20 data points relate to the E0 Ln TWD regression line for the ASTM DI equation and the new DI equation.

G. <u>Rater Comparison</u>

All vehicles were tested on each fuel twice by different driveability raters (varied between three raters). In addition the test plan had a third test done by a third rater for all vehicles using Fuel B3. Because more testing days were available than expected, some third tests were run on Fuels B1, B2, and B5. In addition, duplicate tests by the same rater were run on some vehicle/fuel combinations. This expanded data base allowed for a better assessment of rater severity and precision. Figure 14 shows for each rater their Ln TWD LS mean and their upper and lower 95% confidence limits. Rater B reported much higher Ln TWD LS Means than Raters A and C. Raters A and C were closer together, but were statistically significantly different as shown in Figure 12. The repeatability as shown by the spread in 95% confidence limits was about the same for the three raters.

VIII. AVL-DRIVE SYSTEM

The AVL-DRIVE System utilizes a series of engine control module (ECM) output signals, vehicle accelerometers, and proprietary software algorithms to assess the vehicle driveability quality. These data were captured for six screening vehicles and two test vehicles for the entire program. A full CRC report addresses the details of this equipment and the analysis.

Figure 15 shows the schematic of the AVL-DRIVE System. Figure 16 shows the correlation between CRC ratings and AVL-DRIVE ratings. There is a significant inverse relationship between the two ratings and the correlation is significantly different among raters (p-value = 0.0045). The correlation is not significantly affected by the RUN or SOAK temperatures, VEHICLE, and FUEL. The CRC rating must be log-transformed to meet normality and constancy of variance assumptions of regression analysis. Results from this study will be included in a separate CRC report.

IX. RECOMMENDATIONS

Below are some recommendations for consideration when planning and executing future test programs, based on actions that were successful during this program.

1. A minimum of one, and preferably two, days should be allowed during set-up for rater familiarization with the procedure and agreement among raters on the test procedure. Most raters prefer the opportunity to drive each of the test vehicles and become familiar with the typical operation of each vehicle prior to testing it. A full practice day before beginning testing has been used in the past and has been successful in smoothing out the early test operations.

2. The vehicles should be screened twice, with two different raters being used. The same rater should rate the same vehicles on both fuels when screening the test fleet for fuel sensitivity. An average of the TWDs for each fuel will yield the average response for the vehicle.

3. If possible, assigning the testing order of the fleet each day will help randomize the testing. This sounds contradictory; however, the natural flow of the work schedule tends to keep the vehicles in mostly the same relative testing order each day. Generally speaking, vehicles tested earlier in the day will see the cooler temperatures of the test window, while vehicles tested toward the end will see the higher temperatures. By assigning the order of the vehicles throughout the test program, it is possible to spread their testing sequence and potential exposure to temperatures more evenly. It should be noted that since there is no way to predict exact test temperatures when parking the vehicles for overnight soak, this is not a guaranteed method, but only a step in the right direction.

4. When test vehicles are equipped with four-wheel drive, it should be specified prior to the start of the program and followed whether they should be tested in two-wheel or four-wheel drive. It is recommended that all vehicles be tested in two-wheel drive. It is noted that some vehicles cannot be switched from all-wheel drive to two-wheel drive.

5. The flushing procedure was specifically developed to minimize the carryover from one fuel to the next and has been verified in numerous CRC test programs. It is recommended that no deviation from this procedure be allowed. If there are flexible-fuel vehicles in the program, make sure that the proper

flushing procedure is being used and that they are learning the oxygen content of the fuel.

6. For this test, the amount used to estimate the fuel quantity necessary per test was 14 gallons. This allows for two 4-gallon flushes and a 4-gallon final fill. The remaining 2 gallons in the estimate allow for flushing the dispensing pump and for the remnant at the bottom of the fuel drum which cannot be pumped.

7. Although test fuel is expensive, it is imperative that the amount of test fuel ordered not be reduced to the bare minimum required. Ordering the required amount plus at least a 50 percent overage is strongly recommended. The additional fuel on-hand covers such contingencies as mistakes in flushing and/or fueling, mistakes in calculating necessary fuel quantities, shipping errors, modifications to the flushing / fueling procedures, additional fuel requirements for large fuel tanks, re-tests in case of bad tests, and investigation into areas of interest discovered during the test program, among other situations. Constraints imposed by limited fuel quantities on-site can severely limit the successful execution of a test program.

X. ACKNOWLEDGEMENTS

CRC would like to express appreciation to Growth Energy and the Renewable Fuels Association for their financial support and assistance with the conduct of this program. Without their support, it would not have been possible to conduct this research.

CRC would also like to thank Jo Martinez of Chevron Oronite Company for the statistical work done on this study, and Marathon Petroleum Company, BP Global Fuels Technology, and Chevron USA, Inc. for providing fuel inspection data for the test fuels.

XI. REFERENCES

1) ASTM D4814-98 Standard Specification for Automotive Spark-Ignition Engine Fuel, ASTM International, West Conshohocken, PA, August 1998

2) Barker, D. A., Gibbs, L. M., and Steinke, E. D., The Development and Proposed Implementation of the ASTM Driveability Index for Motor Gasolines, SAE Paper 881668, Warrendale, PA, October 1988.

3) ASTM D4814-07 Standard Specification for Automotive Spark-Ignition Engine Fuel, ASTM International, West Conshohocken, PA, May 2007

4) Coordinating Research Council, Inc., 2003 CRC Intermediate-Temperature Volatility Program, CRC-638, February 2004.

TABLES

AND

FIGURES

Table 1
Test Fleet

Year	Make	Model	Core 18 Vehicles	Car / Truck	PFI / DI	NA / Turbo	Load Factor (kg/L)[1]	FFV/Conventional	Drivetrain	License #
2012	Chevrolet	Camaro	X	C	DI	NA	470	Conv	RWD	AHR5003
2012	Chevrolet	Captiva	X	T	DI	NA	710	Conv	FWD	AJY3565
2012	Chevrolet	Impala	X	C	DI	NA	448	Conv	FWD	897FMA
2012	Chevrolet	Silverado	X	T	PFI	NA	514	Conv	4x4	110FMA
2012	Chevrolet	Sonic LTZ	X	C	PFI	NA	700	Conv	FWD	AHH9429
2012	Chevrolet	Suburban	X	T	PFI	NA	549	FFV[2]	4x4	AIM9939
2012	Chrysler	Town & Country	X	T	PFI	NA	586	FFV[2]	FWD	AFL3989
2012	Chrysler	200LX	X	C	PFI	NA	643	Conv	FWD	721FTJ
2012	Chrysler	200	X	C	PFI	NA	643	Conv	FWD	AFV7520
2012	Dodge	Durango	X	T	PFI	NA	628	FFV[2]	AWD	AHP5364
2012	Fiat	500	X	C	PFI	NA	766	Conv	FWD	AFE0750
2012	Ford	Flex Limited	X	T	PFI	NA	602	Conv	FWD	1A3J963
2012	Ford	F150	X	T	DI	T	708	Conv	4x4[3]	B29098V
2012	Ford	Taurus	X	C	PFI	NA	529	Conv	FWD	AFL2719
2012	KIA	Optima	X	C	DI	NA	606	Conv	FWD	AKV4625
2013	KIA	Soul	X	C	PFI	NA	635	Conv	FWD	327YBT
2012	KIA	Sportage	X	T	PFI	NA	603	Conv	FWD	6WPN409
2012	Nissan	Sentra	X	C	PFI	NA	678	Conv	FWD	AFV55U
Summary				10 Cars	13 PFI	1 Turbo		3 FFV	13 FWD	
				8 Trucks	5 DI	17 NA		15 Conv	1 RWD	
									1 AWD	
									3 4X4	

[1]Load Factor = Vehicle Mass (kg) / Engine Displacement (L)
[2]Modified refueling procedure began on Feb. 27th for ECM ethanol content learning -
[3]Modified 4x4 Traction position for WOT Maneuvers Mar 3rd, Test Day = 14 for PVA
Days 12 & 13 were in 2WD, Day 14 started in 4WD for PVA only
Raters A and B used 2WD throughout the program

Table 1 Cont'd.
Test Fleet

Make	Mileage	Displacement, L	Configuration	Valve Train	Calibration	Emissions Category[4]	VIN
Chevrolet	19,561	3.6	V-6	DOHC	LDV Tier2 PC ULEV	B	2G1FB1E3XC9191345
Chevrolet	17,550	2.4	I-4	DOHC	LDT Tier2 ULEV	B	3GNAL2EK7CS563388
Chevrolet	21,374	3.6	V-6	DOHC	LDV Tier2 PC PZEV	A	2G1WF5E3XC1199505
Chevrolet	20,495	4.3	V-6	SOHC	LDT Tier2 LDT LEV	D	1GCNKPEX5CZ116681
Chevrolet	21,169	1.8	I-4	DOHC	LDV Tier2 PC ULEV	C	1G1JE6SH9C4165126
Chevrolet	19,352	5.3	V-8	SOHC	LDT Tier2 ULEV	B	1GNSKJE72CR314108
Chrysler	27,233	3.6	V-6	DOHC	T2B4 LDV OBD 2	B	2C4RC1BG9CR137513
Chrysler	20,491	2.4	I-4	DOHC	SULEV2 PC	A	1C3CCBAB6CN256736
Chrysler	31,776	2.4	I-4	DOHC	SULEV2 PZEV	A	1C3CCBBB9CN135259
Dodge	17,427	3.6	V-6	DOHC	T2B4 LDT OBD2 ULEV2	B	1C4RDJDGOCC284919
Fiat	29,008	1.4	I-4	SOHC	T2B5 LDV CA 2	D	3C3CFFAR5CT123963
Ford	16,511	3.5	V-6	DOHC	T2B5 LDV ULEV 2PC	C	21FMHKDCXCBDO7629
Ford	18,919	3.5	V-6	DOHC	T2B5 LDT4 LEV2 LDT	D	1FTFX1ET7CFB65429
Ford	24,605	3.5	V-6	DOHC	T2B5 LDV UL2 PC	D	1FAHP2EW4CG103155
KIA	13,850	2.4	I-4	DOHC	SULEV 2 PZEV PC	A	5XXGM4A70CG056299
KIA	13,393	2.0	I-4	DOHC	T2B5 LDV ULEV2 PC	D	KNAFU4A25C5591713
KIA	12,525	2.4	I-4	DOHC	SULEV 2 PZEV LDT1	A	KNDPB3A29C7345775
22	25,905	2.0	I-4	DOHC	T2B5 LDV LEV2 LEVPC	D	3NIAB6AP4CL628327

[4]Rank	Category	Car NMOG + NOx
D	LEV / Tier2 Bin 5	160
C	ULEV	125
B	Tier 2 Bin 4	110
A	PZEV/SULEV	30

Table 2
Fuel Inspections

Fuel Description			B0	B1	B2	B3	B4	B5	B6	H1	H2	H3
Property	Method	Units	1251/0	1161/10	1051/15	1055/20	1045/10	1063/15	1046/20	1164/0	1042/0	999/0
DVPE	ASTM D5191	psi	8.13	9.36	9.02	9.00	8.78	7.93	8.17	8.24	8.71	8.78
DI Uncorrected*			1250.7	1161.0	1050.7	1055.3	1045.3	1062.5	1046.0	1163.9	1042.1	999.0
Ethanol	ASTM D4815	vol %	0	10.16	15.66	21.04	9.80	15.33	20.27	0	0	0
Gravity	ASTM D4052	°API	55.1	54.6	54.0	53.6	57.0	53.8	53.8	58.3	60.5	60.6
Relative Density 60/60°F	ASTM D4052		0.7584	0.7603	0.6910	0.7644	0.7505	0.7637	0.7638	0.7454	0.7374	0.7367
FIA	ASTM D1319											
Aromatics		vol %	30.3	28.1	26.2	25.8	25.9	29.9	27.4	28.3	23.4	20.8
Olefins		vol %	3.5	3.1	3.1	2.8	3.8	4.6	3.2	3.8	2.7	2.9
Saturates		vol %	66.1	58.7	55.1	50.4	60.5	50.2	49.2	67.9	73.9	76.3
Distillation	ASTM D86											
Initial Boiling Point		°F	93.1	95.2	94.0	94.0	96.3	99.9	98.2	92.3	96.7	98.2
5% Evaporated		°F	123.4	119.2	121.6	123.8	118.4	124.9	124.9	118.6	115.7	115.7
10% Evaporated		°F	138.0	128.5	130.9	132.7	124.0	132.5	131.6	128.8	122.0	120.7
20% Evaporated		°F	159.7	139.8	142.3	143.8	131.5	143.6	141.8	142.9	130.0	126.9
30% Evaporated		°F	178.0	147.3	149.8	151.2	139.2	152.7	150.6	157.6	138.5	133.7
40% Evaporated		°F	197.7	152.3	155.4	157.0	147.0	159.5	157.5	177.2	149.9	142.7
50% Evaporated		°F	222.5	198.1	160.4	161.6	168.7	168.4	163.2	202.6	166.8	156.2
60% Evaporated		°F	253.3	237.7	225.7	167.6	220.5	241.8	172.3	232.9	193.6	178.8
70% Evaporated		°F	296.1	278.4	271.6	262.7	252.9	271.3	258.0	266.5	236.6	222.4
80% Evaporated		°F	348.2	337.1	331.3	324.1	297.1	313.6	306.6	314.9	293.5	277.1
90% Evaporated		°F	376.3	374.1	373.2	371.4	353.2	358.5	359.1	363.1	358.8	349.4
95% Evaporated		°F	387.9	386.8	386.6	386.8	376.0	375.4	378.2	379.6	375.3	374.7
End Point		°F	431.0	425.9	423.8	424.2	404.7	406.2	407.9	411.3	401.1	403.1
Recovery		vol %	97.9	97.7	97.7	98.1	98.3	98.0	98.3	98.2	97.7	98.0
Residue		vol %	1.1	1.2	1.1	1.2	1.1	1.1	1.1	1.1	1.1	1.1
Loss		vol %	1.1	1.1	1.2	0.7	0.7	1.0	0.6	0.7	1.2	1.0
Benzene	ASTM D3606	vol %	0.34	0.32	0.31	0.28	0.36	0.42	0.35	0.38	0.25	0.27
Benzene	DHA	vol %	0.33	0.3	0.28	0.26	0.34	0.39	0.33	0.35	0.26	0.25
Ethanol	DHA	vol %	0	10.61	16.53	21.98	10.35	16.2	21.69	0	0	0
Hydrocarbon	DHA	vol %	100	89.39	83.47	78.02	89.65	83.80	78.31	100	100	100
Aromatics	DHA	vol %	31.47	28.16	26.40	24.68	24.76	29.17	25.52	27.84	22.11	20.08
Olefins	DHA	vol %	3.95	3.51	3.32	3.00	4.14	4.77	3.87	4.31	3.11	3.05
Saturates	DHA	vol %	60.67	54.22	50.54	47.32	58.56	47.31	46.62	65.28	72.62	75.00
Not Classified	DHA	vol %	3.91	3.49	3.22	3.02	2.18	2.56	2.30	2.57	2.15	1.87
MTBE	D4815	vol %	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lead	D3237	g/gal	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Unwashed Gum	D381	mg/100mL	12.6	10.2	9.8	9.2	10.2	7.8	8.6	8.6	12.6	12.4
Solvent Washed Gum	D381	mg/100mL	0.6	0	0	2	0	0.8	1	<0.5	0.4	0
Research Octane Number	D2699	RON	92.6	96.2	97.7	99.1	97.1	98.6	99.6	93.2	94.4	96.5
Motor Octane Number	D2700	MON	84.1	85.8	86.5	87.3	86.1	86.7	87.4	84.3	85.1	90.6
(R+M)/2 Octane Rating	(R+M)/2	(R+M)/2	88.3	91.0	92.1	93.2	91.6	92.7	93.5	88.7	89.8	91.0

*$DI = 1.5*T_{10}+3.0*T_{50}+1.0*T_{90}$

Table 3
LS Mean by Fuel

Fuel Code	Uncorrected DI	EtOH	Ln TWD LS Mean	TWD LS Mean
B0	1250.7	0	3.44	31.1
H1	1163.9	0	3.12	22.7
H2	1042.1	0	2.93	18.8
H3	999.0	0	2.93	18.7
B1	1161.1	10.2	3.36	28.7
B4	1045.3	9.8	3.01	20.3
B2	1050.7	15.7	3.33	27.8
B5	1062.5	15.3	3.33	28.0
B3	1055.3	21.0	3.40	30.1
B6	1046.0	20.3	3.31	27.5

Values shown are rounded from more significant digits

Table 4
LS Mean by Vehicle

Vehicle No.	Ln TWD LS Mean	TWD LS Mean
1	3.45	31.6
2	2.85	17.3
3	3.18	24.1
5	3.24	25.5
6	3.13	22.9
10	3.40	29.9
16	3.43	30.9
17	2.80	16.4
19	3.14	23.1
21	3.82	45.7
22	2.94	18.9
26	3.08	21.8
28	3.08	21.9
30	3.74	42.2
31	3.08	21.7
33	3.51	33.5
34	3.46	31.9
35	2.56	12.9

Values shown are rounded from more significant digits

Table 5
Coefficients for Ethanol Concentration Offset Models

Model Variables	Fuels	R^2	RMSE	DI Coef.	DI p-value	EtOH Content Coef.	EtOH Content p-value
Uncorrected DI	All	0.250	0.182	1.00	0.1413	-	-
ASTM DI	All	0.478	0.152	1.00	0.0267	-	-
Uncorrected DI, EtOH Vol %	All	0.886	0.076	1.00	0.0006	9.49	0.0004

Uncorrected DI = 1.5*T10 + 3.0*T50 + 1.0*T90
ASTM DI = 1.5*T10 + 3.0*T50 + 1.0*T90 + 2.4*Ethanol Volume %

Table 6
Fit Comparison of Ethanol Offsets for Various Fuel Combinations

Fuel	Ethanol Offset	Correlation Coefficient R^2
E0	NA	0.919
E0, E10	2.4	0.906
E0, E10	9.49	0.875
E0, E15	2.4	0.557
E0, E15	9.49	0.933
E0, E20	2.4	0.538
E0, E20	9.49	0.940
E0, E10, E15	2.4	0.613
E0, E10, E15	9.49	0.871
All	2.4	0.483
All	9.49	0.886

Figure 1
Fuel Total Weighted Demerit Comparison

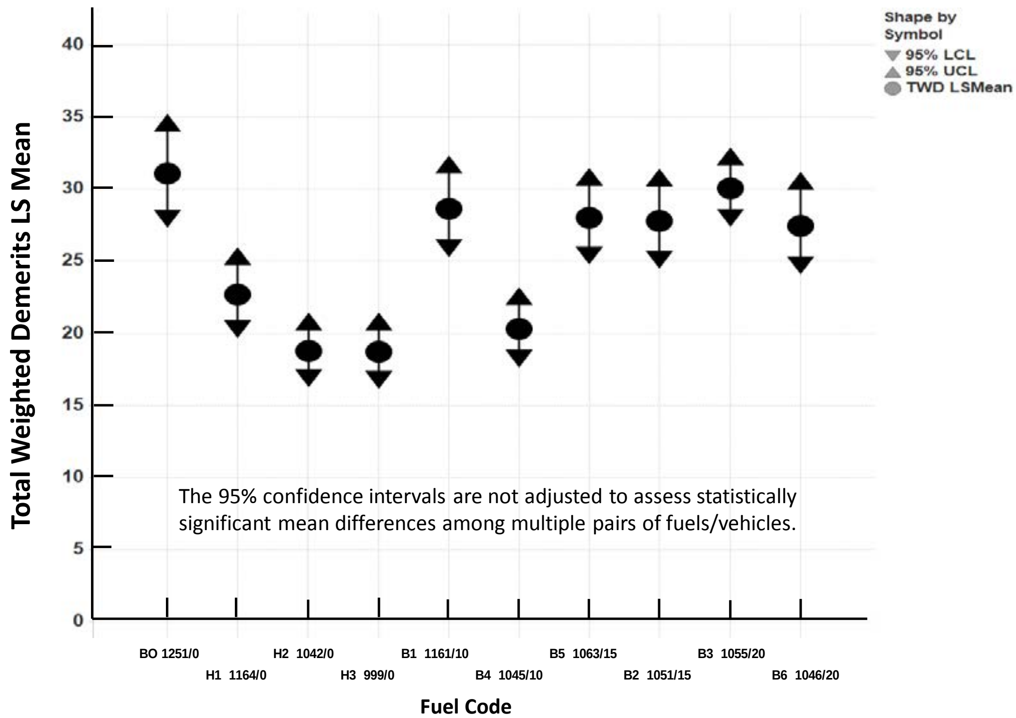


Figure 2
Vehicle Total Weighted Demerit Comparison

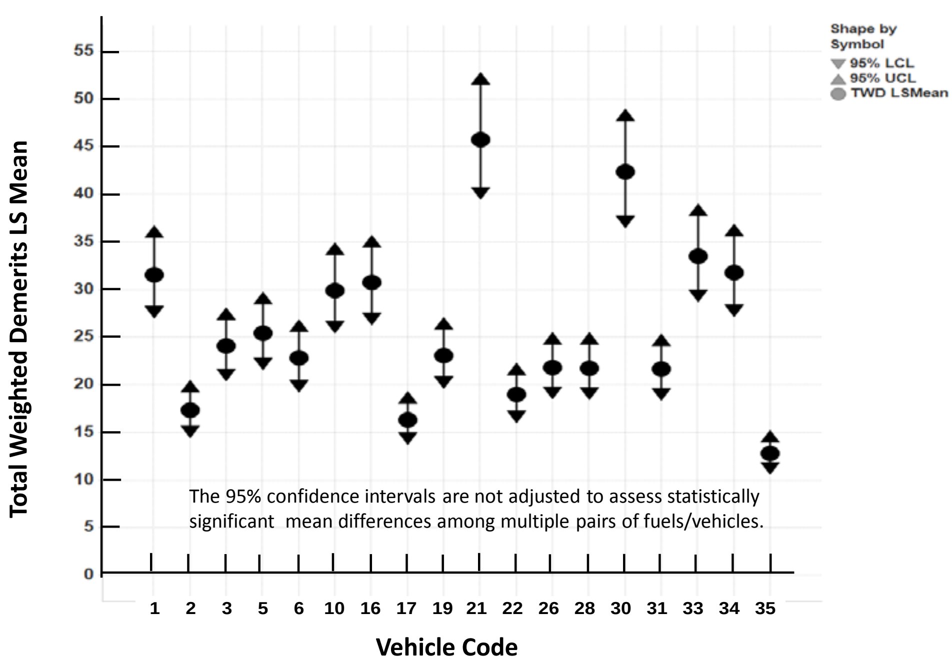


Figure 3A
Vehicle By Fuel Comparison

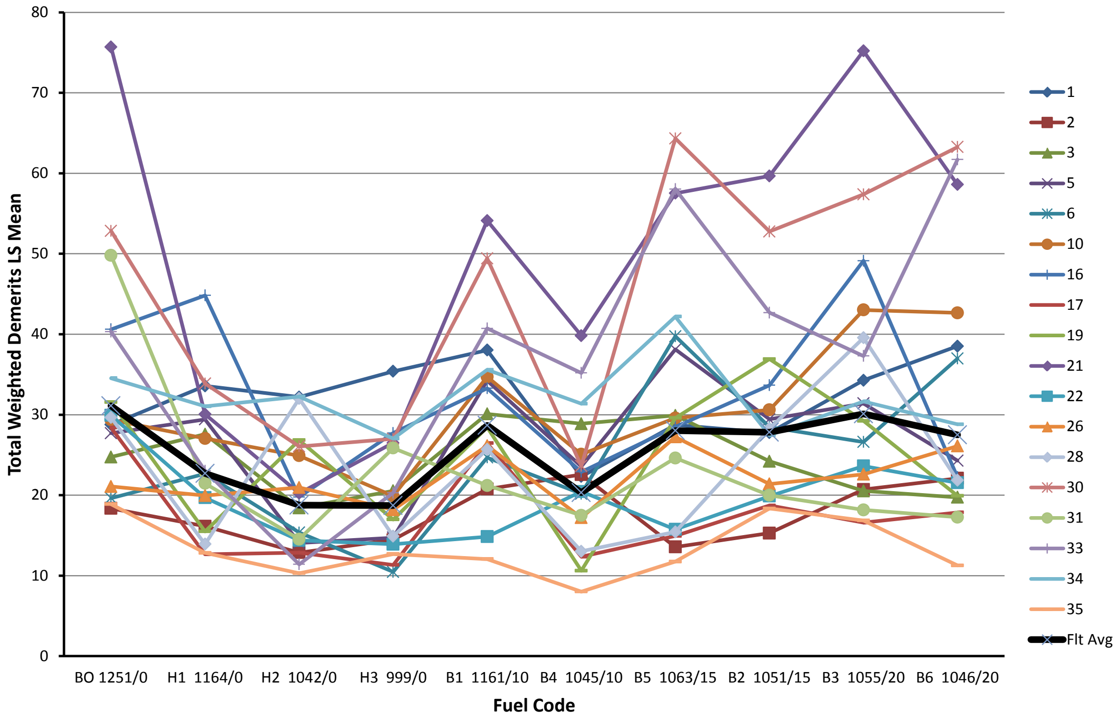


Figure 3B
Car By Fuel Comparison

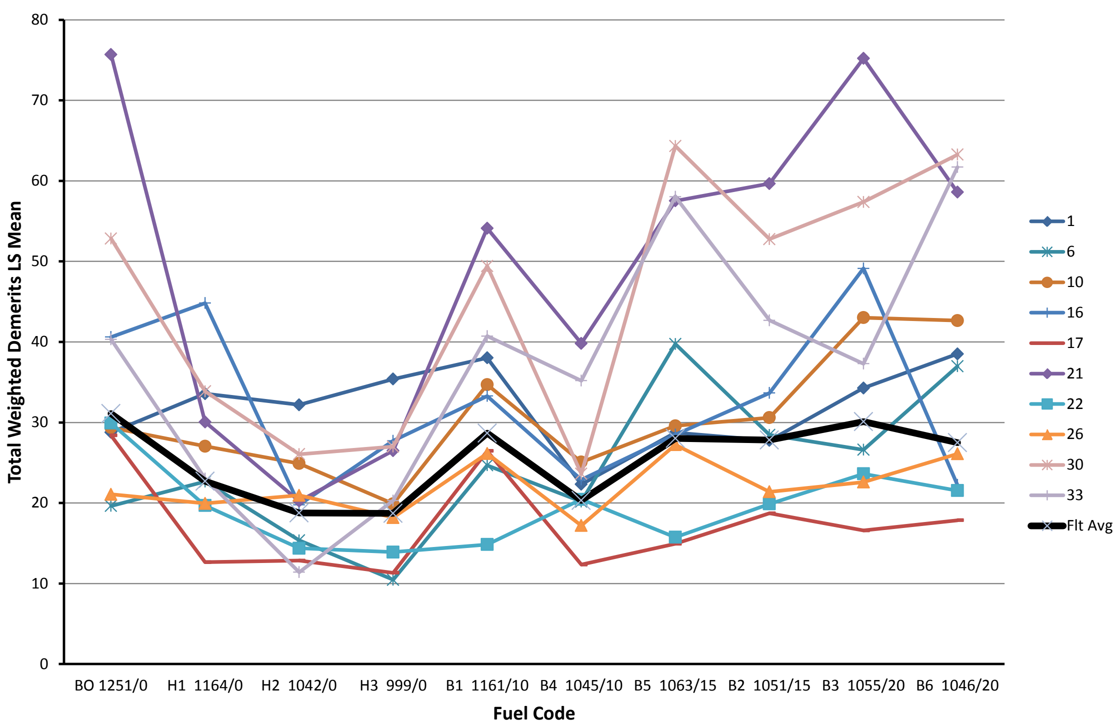


Figure 3C
Truck By Fuel Comparison

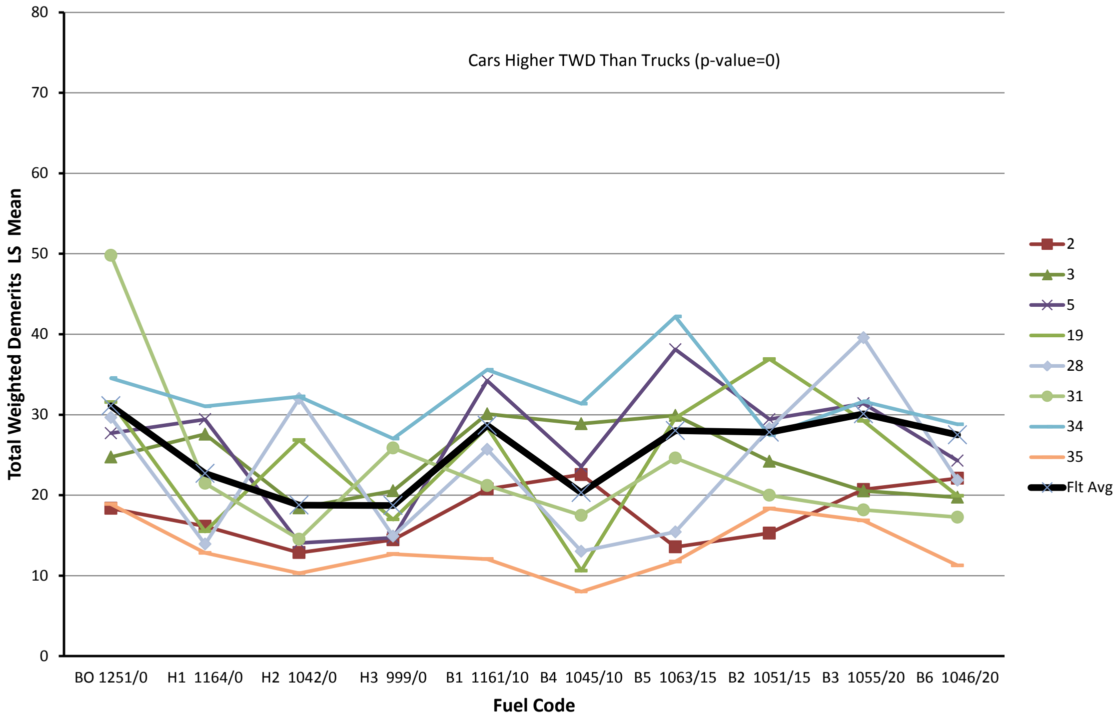


Figure 3D
PFI Vehicle By Fuel Comparison

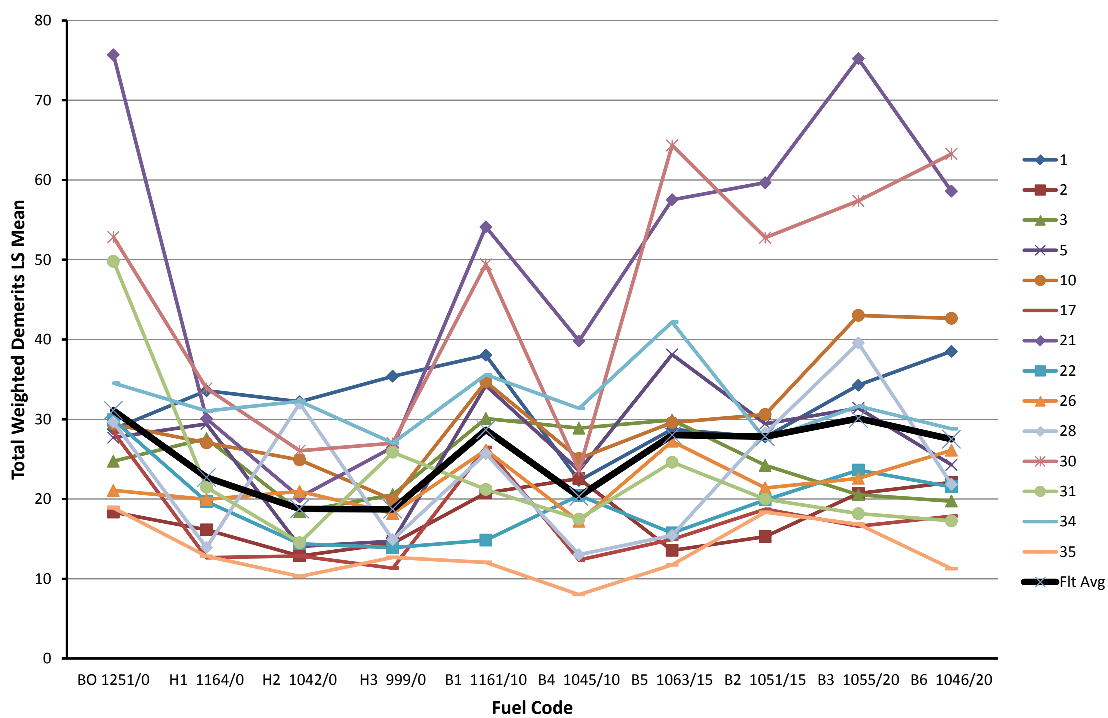


Figure 3E
DISI Vehicle By Fuel Comparison

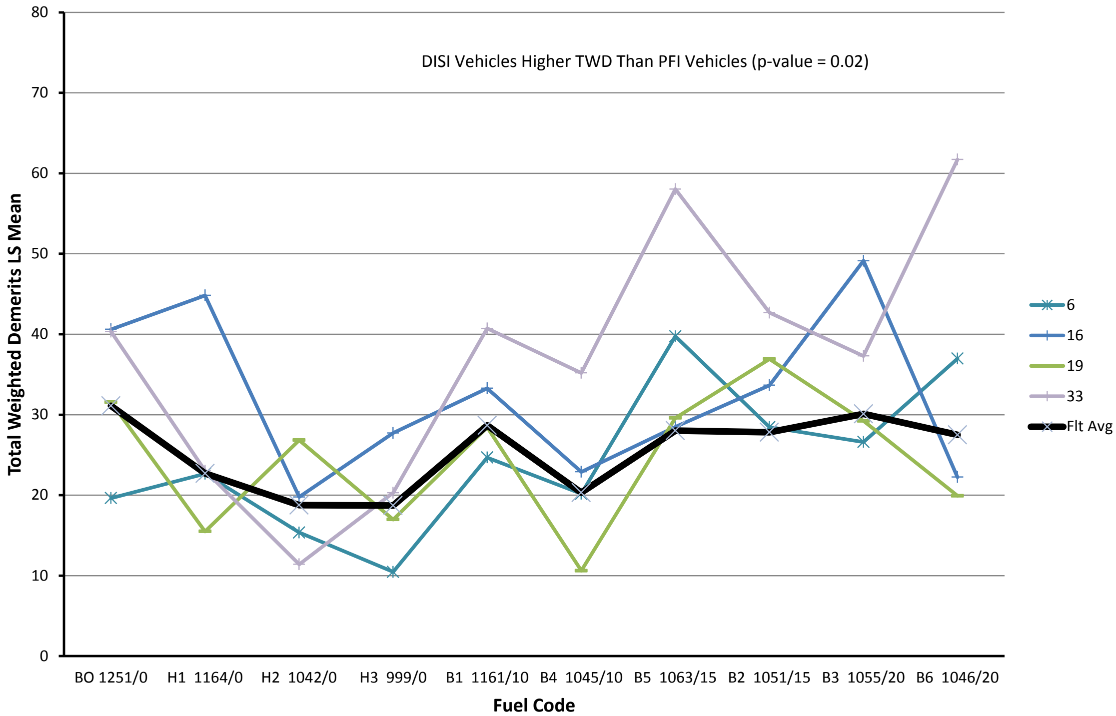


Figure 3F
FFV Vehicle By Fuel Comparison

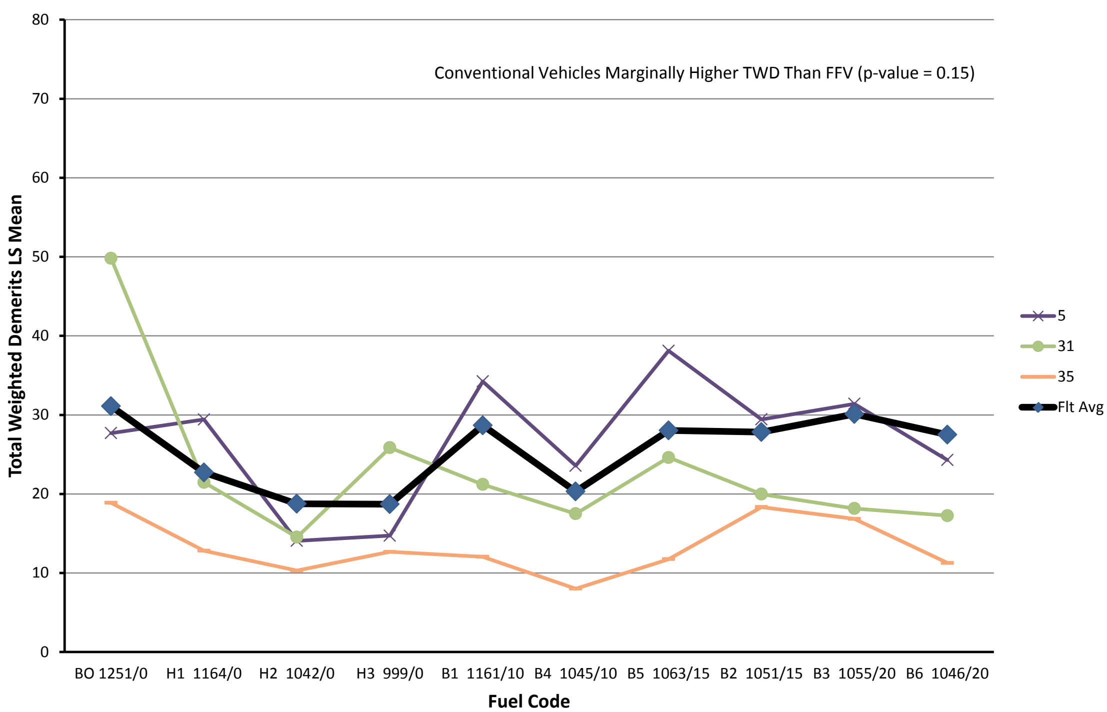


Figure 4
Comparison of Cars vs. Trucks

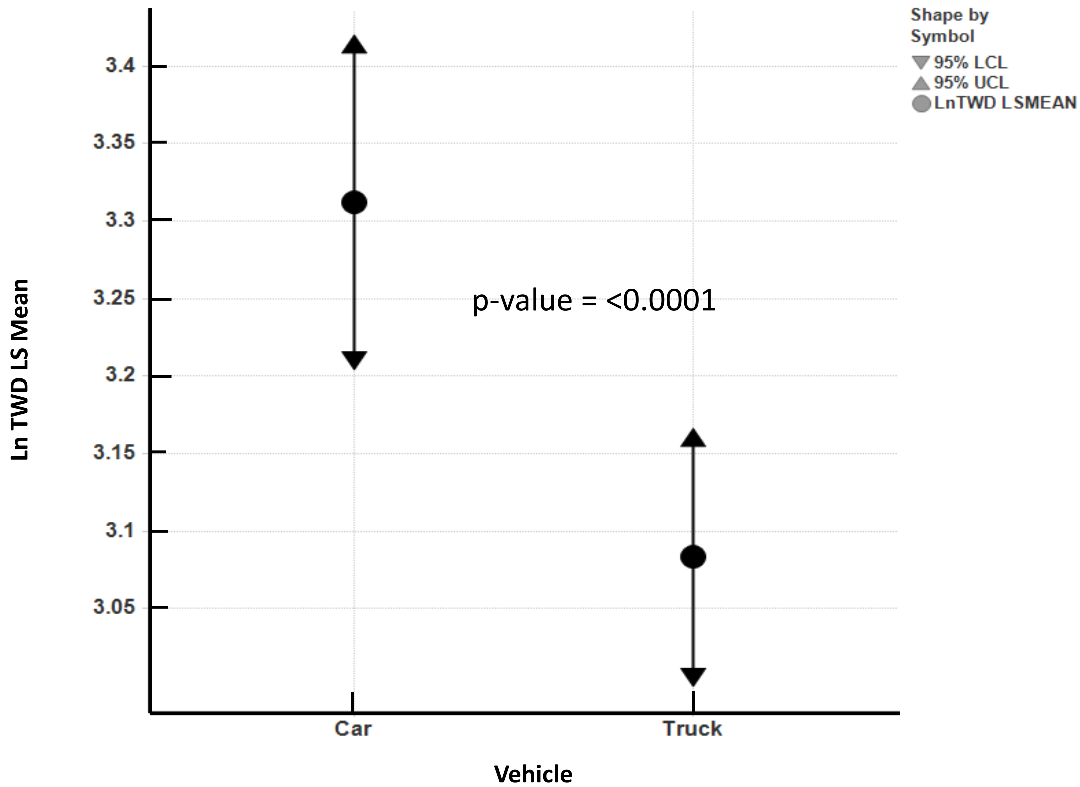


Figure 5
Comparison of Fuel System Types

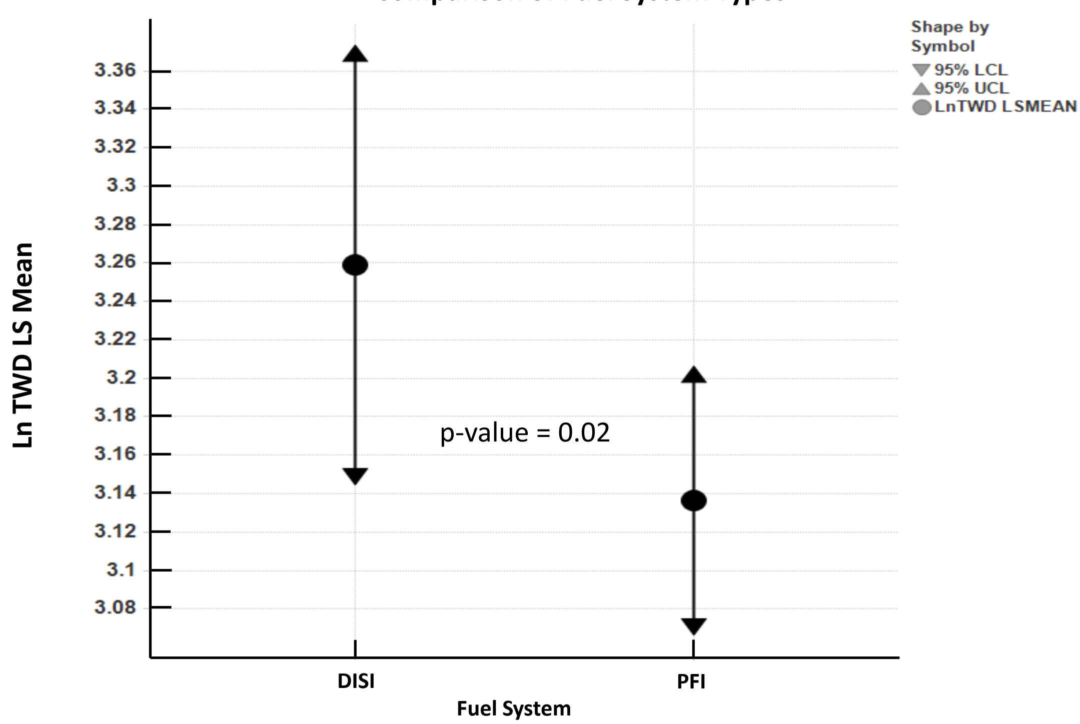


Figure 6
Comparison of Conventional Vehicles vs. FFV

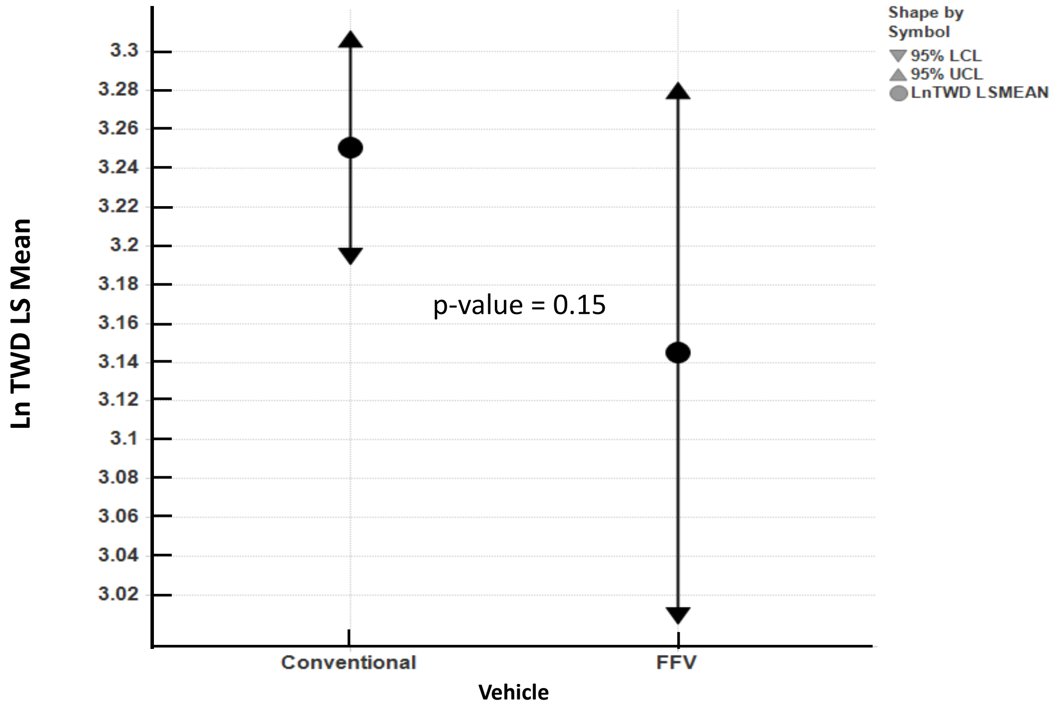


Figure 7
Effect of Load Factor on Ln TWD LS Mean

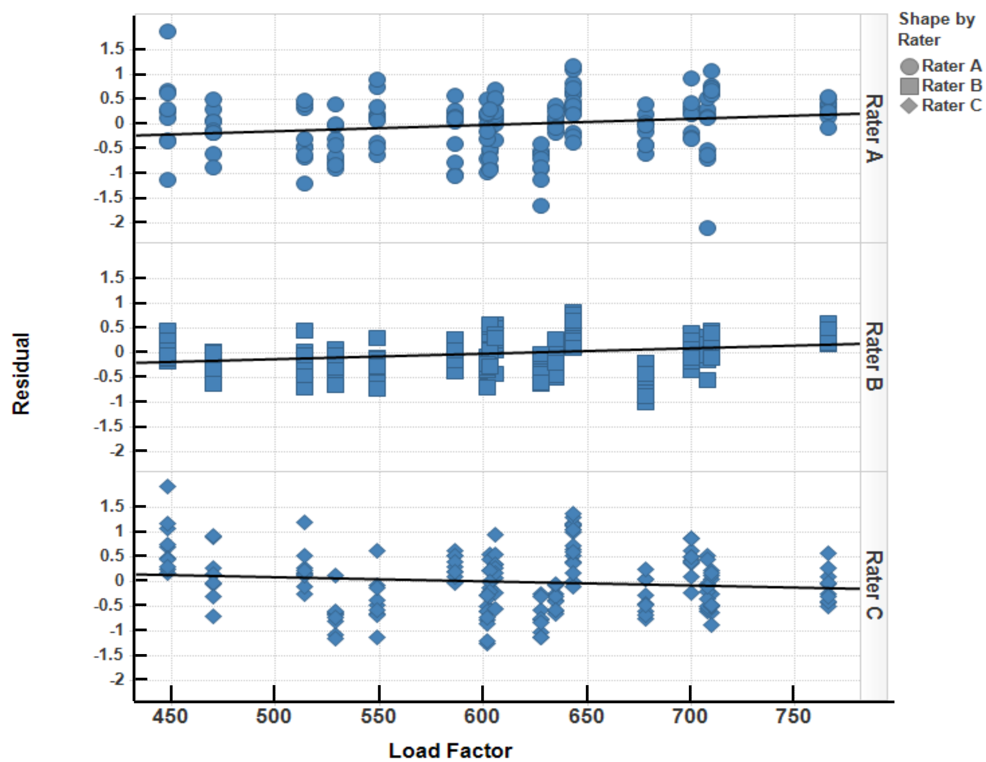


Figure 8
Effect of Emissions Category on Ln TWD LS Mean

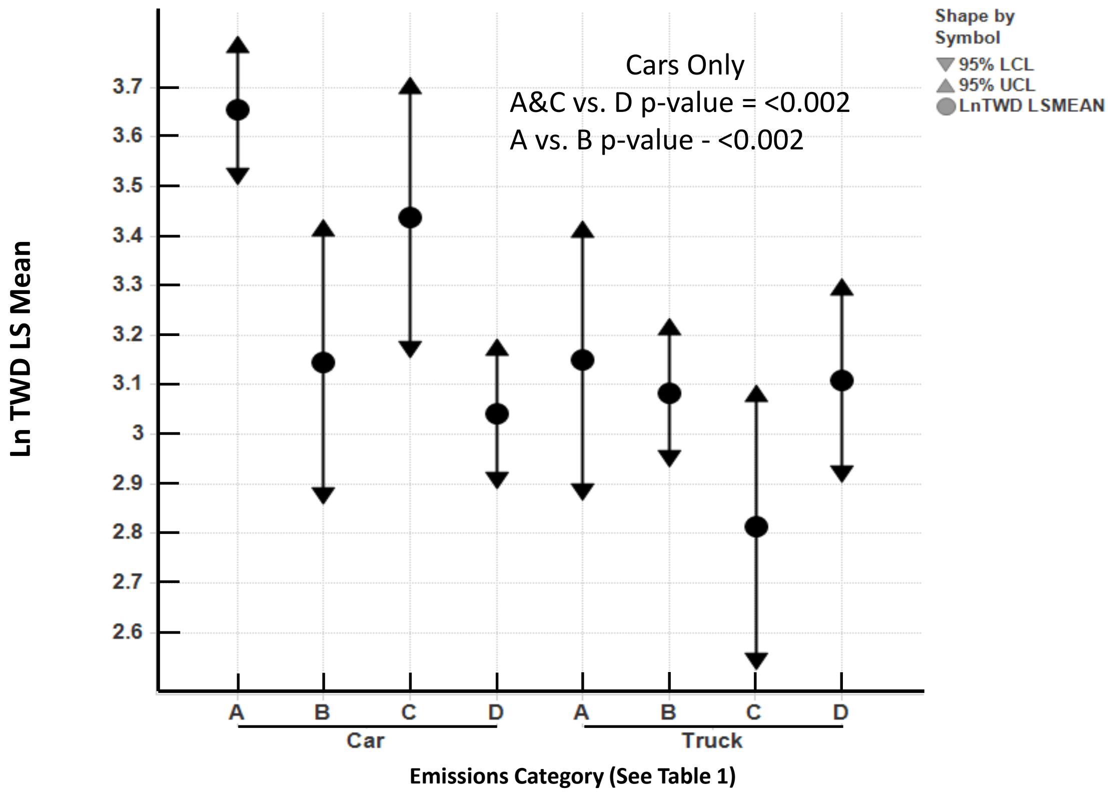


Figure 9
Driveability Results vs. Current ASTM D4814 Driveability Index

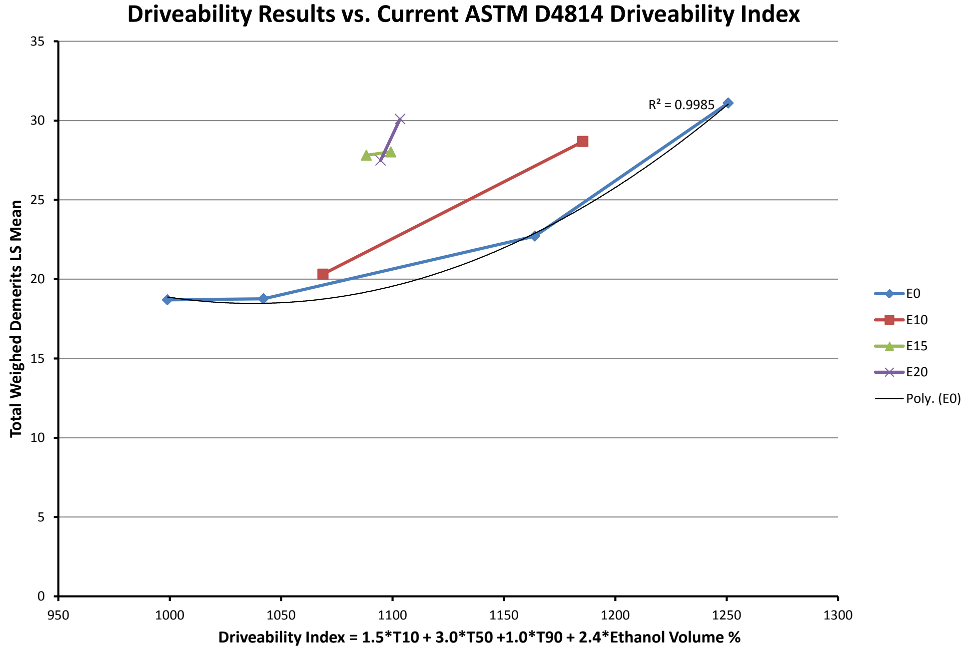


Figure 10
Relationship Between Ln TWD
and New DI Equation with Ethanol Content

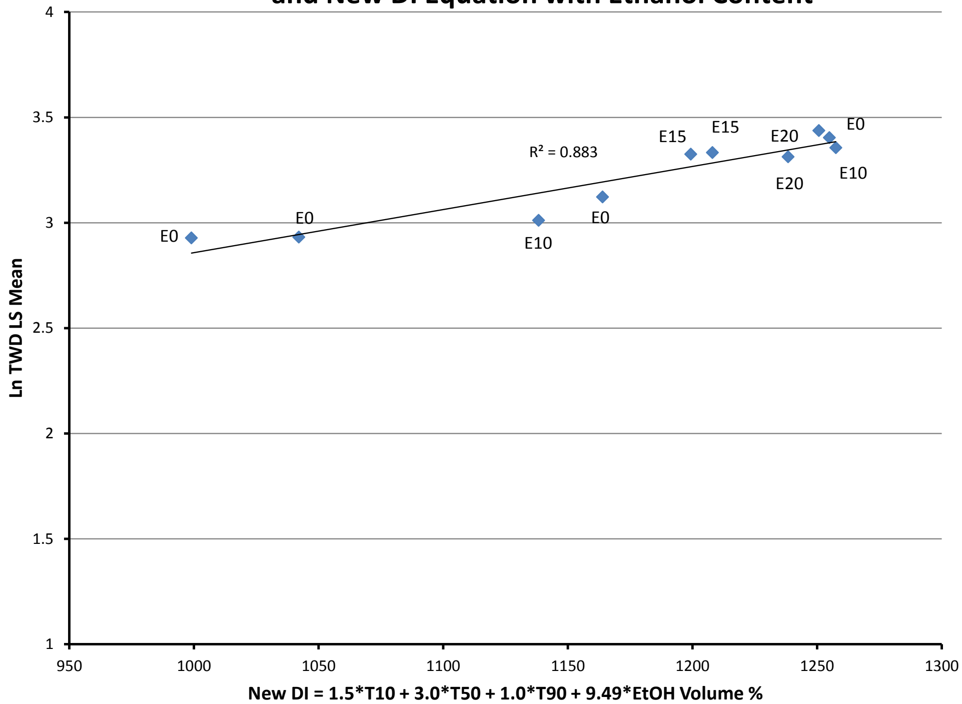


Figure 11
Relationship Between TWD
and New DI Equation With Ethanol Content

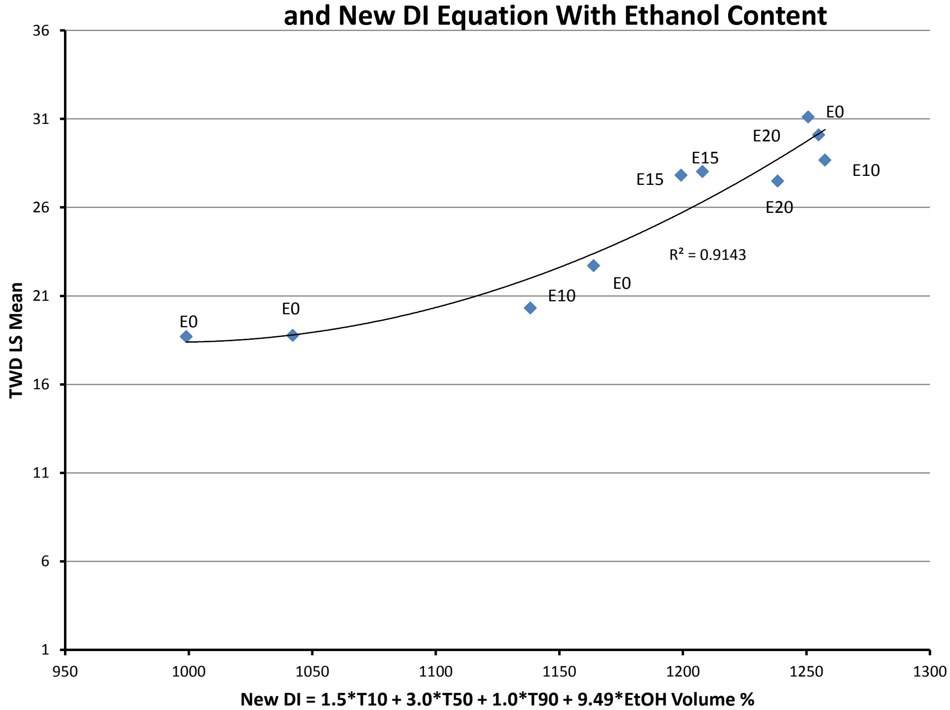


Figure 12
Relationship Between Ln TWD
and ASTM 2.4 DI Equation for All Ethanol Contents

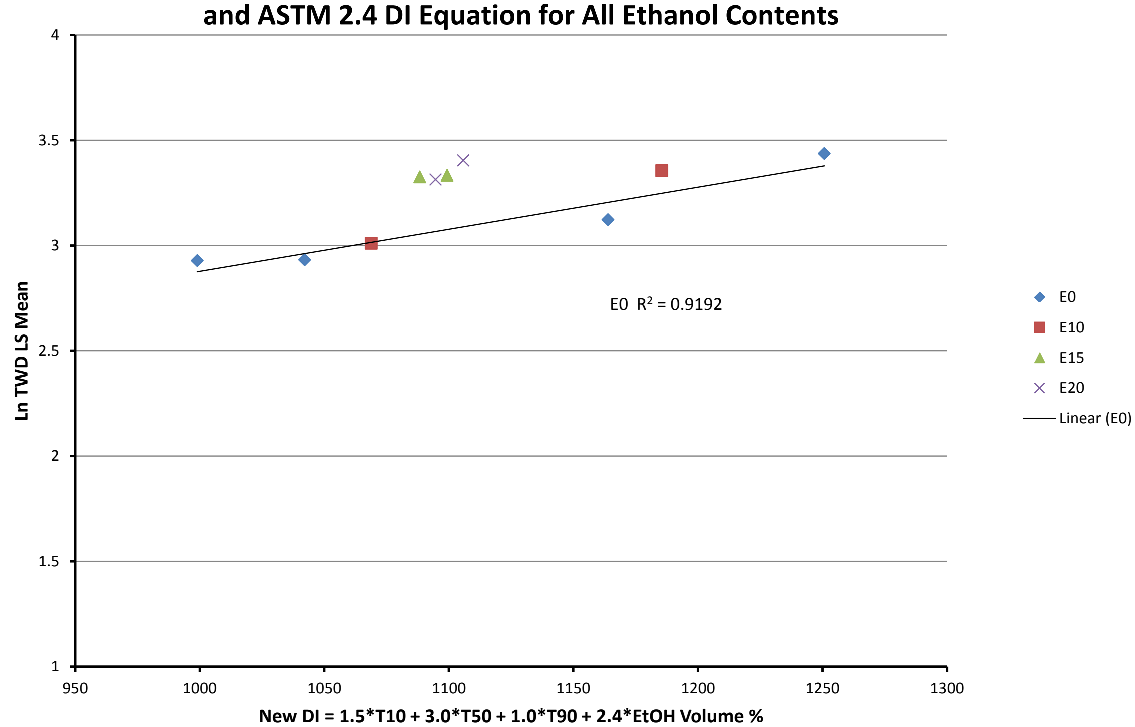


Figure 13
Relationship Between Ln TWD
and New 9.49 DI Equation for All Ethanol Contents

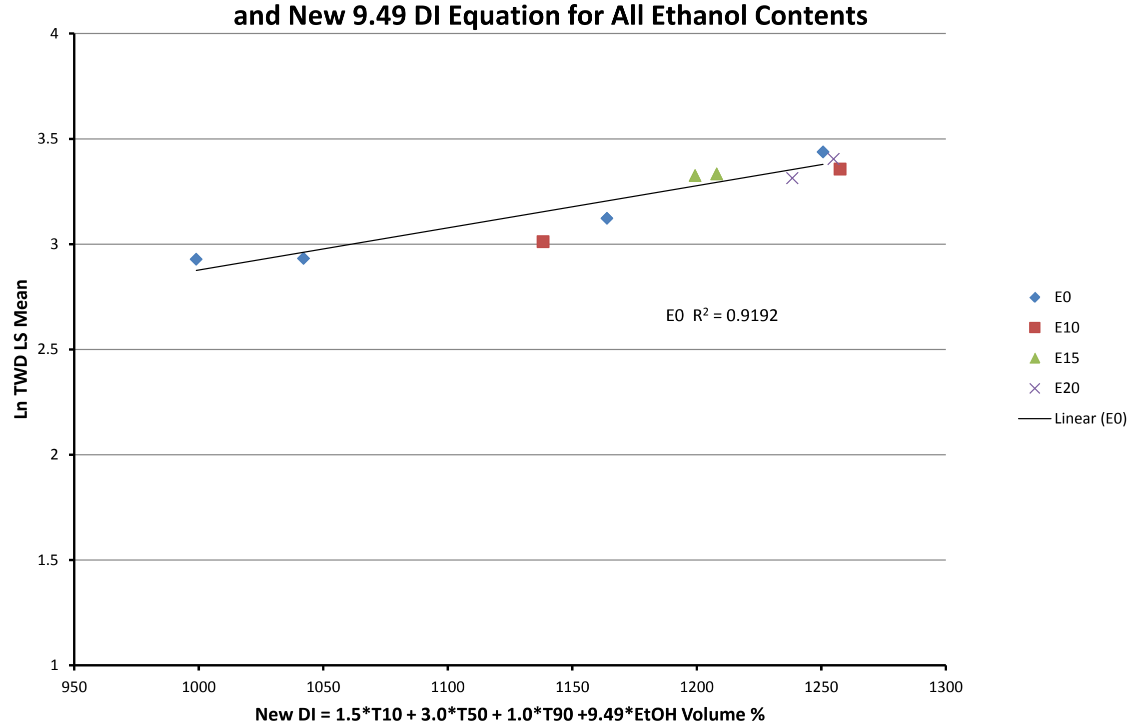


Figure 14
Rater Ln TWD LS Mean Comparison and Precision

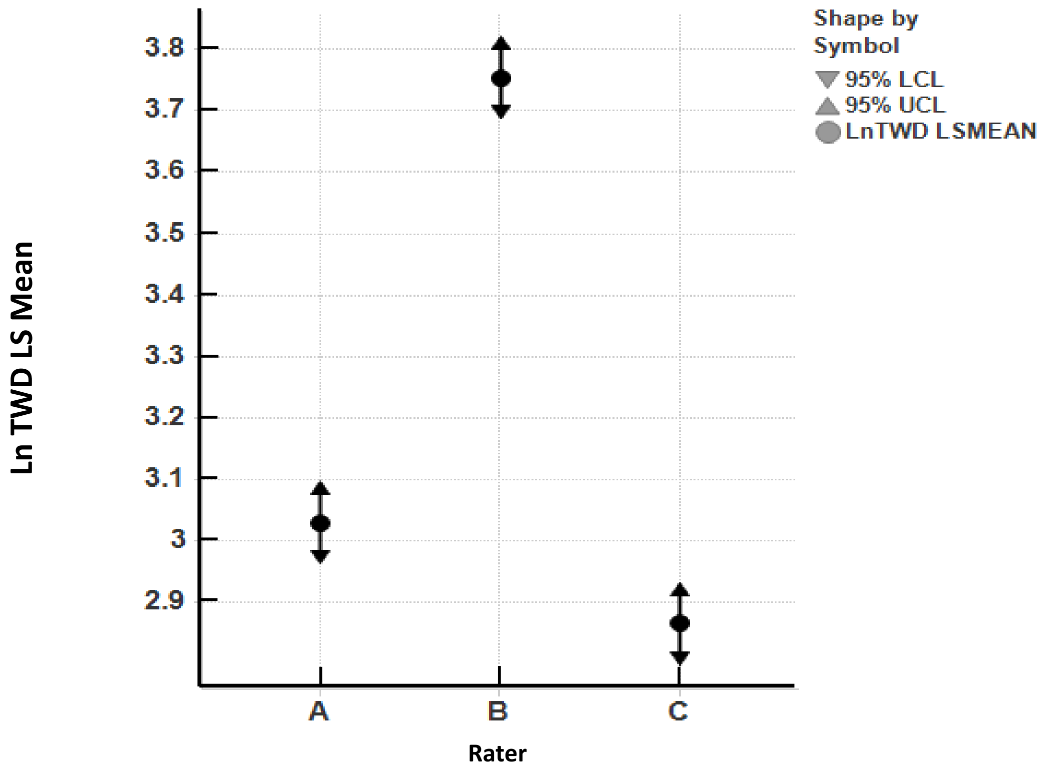
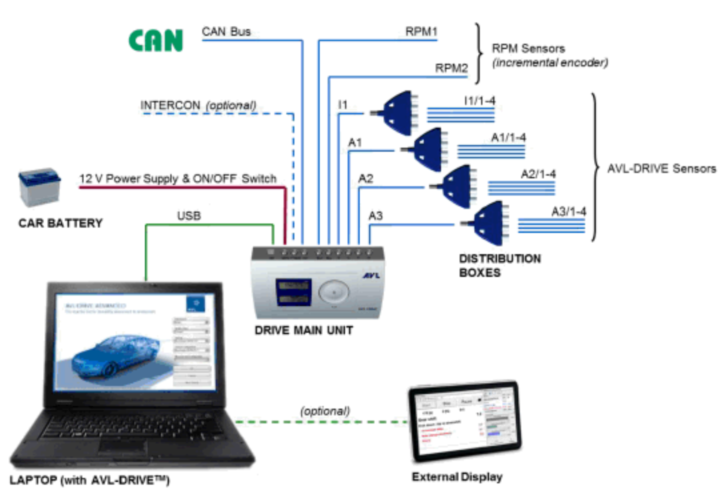


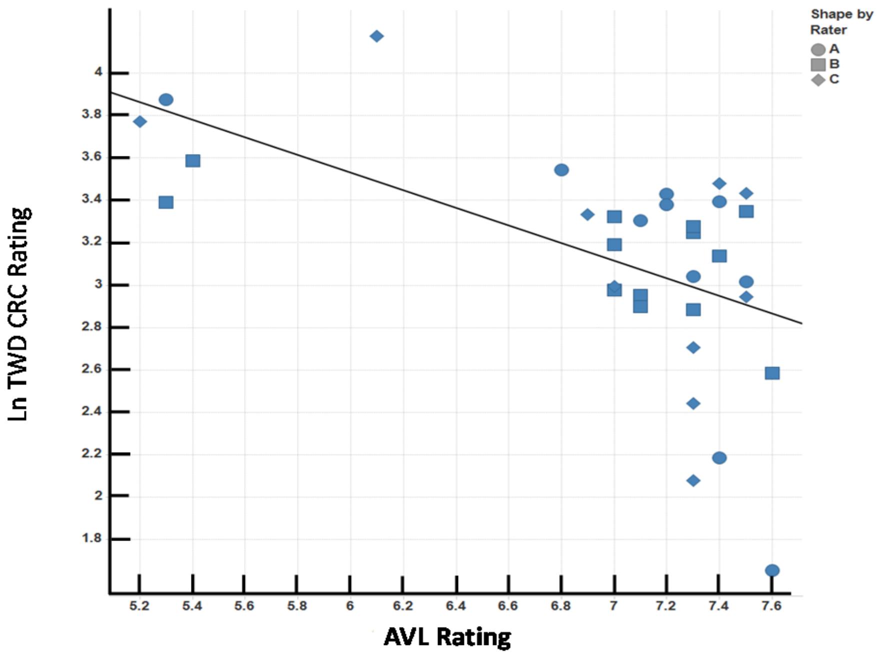
Figure 15
Schematic of AVL-DRIVE Installation



Label	Sensor
A1/1	1-axis accelerometer (Seat)
A1/2	3-axis accelerometer (Chassis longitudinal)
A1/3	3-axis accelerometer (Chassis lateral)
A1/4	3-axis accelerometer (Chassis vertical)
A2/1	Clamp on ammeter (Electric load)
A2/2	1-axis accelerometer (Wheel carrier)
A2/3	Draw wire sensor (Clutch pedal)
I1/1	Vibration sensor (Gear lever)
I1/2	Vibration sensor (Steering wheel)
I1/3	Vibration sensor (Seat rail)
I1/4	Microphone (Seat)
RPM1	RPM sensor (Engine speed)

Figure 16

CRC Rating (Corrected to Rater C) – AVL Rating



APPENDIX A

MEMBERS

OF THE

2013 CRC E15 DRIVEABILITY INDEX VOLATILITY PROGRAM

DATA ANALYSIS PANEL

Members of the
CRC 2013 E15 Driveability Index Program
Data Analysis Panel

Name	Affiliation
Lew Gibbs, Leader	Consultant
Bruce Alexander	BP Global Fuels Technology
Beth Evans	Evans Research Consultants
Jeff Farenback-Brateman	ExxonMobil Research & Engineering
Pat Geng	General Motors Powertrain
Jerry Horn	Chevron U.S.A.
Ron Osman	Flint Hills Resources
Bill Studzinski	General Motors Powertrain
Shon Van Hulzen	POET

APPENDIX B

ON-SITE PARTICIPANTS

IN THE

2013 CRC E15 DRIVEABILITY INDEX VOLATILITY PROGRAM

Appendix B
Participants in the
CRC 2013 E15 Driveability Index Program
On-Site at Yakima, Washington

Name	Affiliation
Harold"Archie" Archibald	Evans Research Consultants
Brent Austin	Chevron U.S.A.
Alexa Beaver	BP
Scott Berkhous	Exxon Mobil
Kevin Brogan	General Motors Powertrain
Bret Dawson	POET
Mike Davidson	BP
Kelly Davis	Renewable Fuels Association
Beth Evans	Evans Research Consultants
Pat Geng	General Motors Powertrain
Bryan Giran	Sunoco
Mark Hartman	Consultant
Bruce Henderson	BP
Kenneth Kar	Exxon Mobil
Josh Karaus	POET
Phil Krysinski	Consultant
Michael Lynch	Exxon Mobil
Steve Martinsky	POET
Bob Muhleck	General Motors Powertrain
Ron Osman	Flint Hills Resources
Sam Saelee	Chevron U.S.A.
Jenny Sigelko	VW
Steve Simms	BP
Bill Studzinski	General Motors Powertrain
Phil Van Acker	BP

APPENDIX C

2013 CRC E15 DRIVEABILITY INDEX VOLATILITY PROGRAM

CRC VOLATILITY GROUP PROGRAM

Title: 2013 CRC INTERMEDIATE-TEMPERATURE E15 COLD-START AND WARM-UP VEHICLE DRIVEABILITY PROGRAM

Project No:

Objective: Determine an accurate ethanol offset factor for the Driveability Index equation referenced in ASTM D4814, "Standard Specification for Automotive Spark-Ignition Engine Fuel" for ethanol gasoline blends ranging from 10 – 20 volume % ethanol.

Deliverables: CRC Volatility Group Report with Conclusions and Data to support a revised ethanol offset parameter, if necessary, for ASTM D4814.

Test plan: As a result of EPA's approval of Growth Energy's E15 partial waiver for conventional motor vehicle fuels with Model Year's newer than 2001, the proposed CRC Volatility Group test program will evaluate the Cold-Start and Warm-up Vehicle Driveability behavior of high U.S. sales volume, late model, SULEV / ULEV California Emissions and Federally certified Tier 2 Bin 4&5 vehicles using a specified fuel matrix containing ethanol blends. The fuel set will consist of 10 fuels ranging in ethanol content from E0 – E20 with Driveability Index (DI) as the primary control variable. DI for the fuel matrix will match the current U.S. market and generally range from 1008 – 1250°F. The ambient testing temperature range target is 40°F +/- 5°F with an acceptable overnight soak range of 40°F +/- 10°F.

(i) Develop a statistically designed 10 Blend fuel set ranging in ethanol content from 0 – 20 volume % and DI from 1008 – 1250°F. Fuel Matrix design based on 2003 Intermediate Temperature Volatility Program (Report 638). The table of test fuels is shown below.

(ii) Screen a large number, approximately 40, of SULEV and ULEV emissions certification vehicles containing both Port and Direct Injection Fuel Systems using a high DI/ high ethanol fuel blend from the specified matrix (below) to select 18 sensitive vehicles for the test program. The vehicles do not necessarily need to be California Certified vehicles. California SULEV vehicles may have Secondary Air systems on the exhaust that enable slightly richer cold starts. As a general rule, model year (MY) 2007 and newer federally certified Tier 2 Bin 4 & 5 passenger cars should be selected and MY 2009 and newer Full Size Light-Duty Trucks should be selected. Particular attention should be paid to each vehicle's exhaust system hardware content regardless if it is a California or Federally Certified vehicle. Vehicles with Secondary Air Injection system should not be selected. If a large enough population (18) of federally certified Tier 2

Bin 4&5 sensitive vehicles can be identified, then shipping vehicles from California won't be necessary.

Program Timing Gates

- July 1, 2012 Funding Commitment from Co-Sponsors: RFA and Growth Energy
- July 15, 2012 Begin blending fuels
- Aug. 1, 2012 Personnel – Determine contractors & volunteers
- Aug. 15, 2012 Form Fuel Analysis Team
- Oct. 1, 2012 Move Container and Crane to Yakima, WA
- Feb. 2013 Begin Screening Test Vehicles in Yakima

Vehicle Screening – Additional Information

- Vehicles will be screened using two Fuels
- Screening Fuel 1 = Marketplace Gasoline in Rental Tank ("good reference")
- Screening Fuel 2 = Highest DI / E20 Ethanol Fuel ("B3" – DI ~ 1056 "corrected")
- Screening can take place directly in Yakima and require 2 Raters, 2 Observers, and 2 Mechanical Techs. No need to transfer vehicles from California.

Fuel Matrix and Fuel Drum Quantity Worksheets (Below)

E15 Cold Start Driveability Program Ethanol Offset-Fuel Matrix

Fuel No.		B0	B1	B2	B3	H1	H2	H3	B4	B5	B6
		Base	Splash Blends			Matched DIs of Splash Blends			Constant DI		
DVPE	psi	8-9	9-10	9-10	9-10	8-9	8-9	8-9	8-9	8-9	8-9
EtOH	vol %	0	9.5-10.5	14.5-15.5	19.5-20.5	0	0	0	9.5-10.5	14.5-15.5	19.5-20.5
T10	°F	130-140	Report	Report	Report	120-130	120-130	120-130	120-130	120-135	125-140
T50	°F	215-220	Report	Report	Report	205-215	170-180	155-165	155	155	155
T90	°F	370-380	Report	Report	Report	360-370	360-370	350-360	350-360	350-360	350-360
EP	°F	<437	Report	Report	Report	<437	<437	<437	<437	<437	<437
DI Uncorrected*	-	1235-1250	Report	Report	Report	Match B1	Match B2	Match B3	Match B3	Match B3	Match B3
Aromatics	vol %	15-35	Report	Report	Report	15-35	15-35	15-35	15-35	15-35	15-35
Olefins	vol %	0-15	Report	Report	Report	0-15	0-15	0-15	0-15	0-15	0-15
Saturates	vol %	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Benzene	vol %	<1.0	Report	Report	Report	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
MTBE	vol %	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lead	vol %	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Washed Gum	mg/100mL	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
RON		>90	Report	Report	Report	>90	>90	>90	>90	>90	>90
MON		>80	Report	Report	Report	>80	>80	>80	>80	>80	>80
(R+M)/2		>87	Report	Report	Report	>87	>87	>87	>87	>87	>87
API Gravity	°	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report

*DI Uncorrected = 1.5*T10 + 3.0*T50 + 1.0*T90

All blends are to be made using refinery gasoline blending components

Fuels are to contain all of the appropriate carbon numbers for each hydrocarbon type to represent commercial gasoline

Blend B0 is to be made first

Blends B1, B2, and B3 are made by adding the specified volume of ethanol to B0.

The DI limits for H1, H2, H3, B4, B5, and B6 will be determined from the inspections of B1, B2, and B3 +/- 5°F.

Drum Quantities Required

40 vehicle screening and 18 Vehicle test

Fuel Number	Ethanol Vol. %	Gallons of Fuel Per Test	Number of Vehicles	Gallons used per test	Number of Tests / Veh	Total Fuel used Per Test	Gallons per drum	Drum Quantity	Final Drum Count
B0	0	14	18	252	2	504	50	**10.08**	**12**
B1	10	14	18	252	2	504	50	**10.08**	**12**
B2	15	14	18	252	2	504	50	**10.08**	**12**
B3	20	14	40	560	1.5	840	50	**16.8**	**18**
H1	0	14	18	252	2	504	50	**10.08**	**12**
H2	0	14	18	252	2	504	50	**10.08**	**12**
H3	0	14	18	252	2	504	50	**10.08**	**12**
B4	10	14	18	252	2	504	50	**10.08**	**12**
B5	15	14	18	252	2	504	50	**10.08**	**12**
B6	20	14	18	252	2	504	50	**10.08**	**12**
							Total	**107.52**	**126**

REVISED CRC COLD-START AND WARMUP DRIVEABILITY PROCEDURE

A. Record all necessary test information at the top of the data sheet.

B. Turn key on for 2 seconds before cranking to pressurize fuel system. Make sure defrost is on and fan is in "low" position. Start engine per Owner's Manual Procedure. Record start time.

C. There may be a total of three starting attempts recorded. If the engine fails to start within 5 seconds on any of these attempts, stop cranking at 5 seconds and record "NS" (no start) in the appropriate starting time box on the data sheet. After the first and second unsuccessful attempts to start, turn the key to the "off" position before attempting to restart per the Owners Manual procedure. If the engine fails to start after 5 seconds during the third attempt, record an "NS" in the Restart2 box, then start the engine any way possible and proceed as quickly as possible to Step D without recording any further start times.

Once the engine starts on any of the first three attempts, idle in park for 5 seconds and record the idle quality. If the engine stalls during this 5-second idle, record a stall in the Idle Park "Stls" box, then restart per the above paragraph, subject to a combined maximum (in any order) of three no-starts and Idle Park stalls. After all the start-time boxes are filled, no further starts should be recorded.

D. Apply brakes (right foot), shift to "Drive" ("Overdrive" if available) for 5-second idle, and record idle quality. If engine stalls, restart immediately. <u>Do not record restart time.</u> Record number of stalls.

A maximum of three Idle Drive stalls may be recorded; however, only one stall contributes to demerits. If the engine stalls a fourth time, restart and proceed to the next maneuver as quickly as possible. It is important to complete the start-up procedure as quickly as possible to prevent undue warmup before the driving maneuvers and to maintain vehicle spacing on the test track.

E. After idling 5 seconds (Step D), make a brief 0-15 mph light-throttle acceleration. Light-throttle accelerations will be made at a constant throttle opening beginning at a predetermined manifold vacuum. This and all subsequent accelerations throughout the procedure should be "snap" maneuvers: the throttle should be depressed immediately to the position that achieves the pre-set manifold vacuum, rather than easing into the acceleration. Once the throttle is depressed, no adjustment should be made, even if the pre-set vacuum is not achieved. Use moderate braking to stop. Idle for approximately 3 seconds without rating it. Make a brief 0-15 mph light-throttle acceleration. Both accelerations together should be made within 0.1-mile. If both accelerations are completed before the 0.1-mile marker, cruise at 15 mph to the 0.1-mile marker. Use moderate braking to stop; idle for approximately 3 seconds without rating it.

F. Make a 0-20 mph wide-open-throttle (WOT) acceleration beginning at the 0.1-mile marker. Use moderate braking to achieve 10 mph and hold 10 mph until the 0.2-mile marker (approximately 5 seconds). Use moderate braking to stop; idle for approximately 3 seconds without rating it.

G. At the 0.2-mile marker, make a brief 0-15 mph light-throttle acceleration. Use moderate braking to stop. Idle for approximately 3 seconds without rating it. Make a brief 0-15 mph light-throttle acceleration. If accelerations are completed before the 0-3-mile marker, cruise at 10 mph to the 0.3-mile marker.

H. At the 0.3-mile marker, make a light-throttle acceleration from 10-20 mph. Use moderate braking to make a complete stop at the 0.4-mile marker in anticipation of the next maneuver. Idle for approximately 3 seconds at the 0.4-mile marker without rating the idle.

I. Make a 0-20 mph moderate acceleration beginning at the 0.4-mile marker.

J. At the 0.5-mile marker, brake moderately and pull to the right side of the roadway. Idle in "Drive" for 5 seconds and record idle quality. Slowly make a U-turn.

K. Repeat Steps E through J. At the 0.0-mile marker, brake moderately and slowly make a U-turn.

NOTE: Items L-N may be useful only at colder temperatures.

L. Make a crowd acceleration (constant predetermined vacuum) from 0-45 mph. Four-tenths of a mile is provided for this maneuver. Decelerate from 45 to 25 mph before the 0.4-mile marker.

M. At the 0.4-mile marker, make a 25-35 mph detent position acceleration.

N. At the 0.5-mile marker, brake moderately. Idle for 30 seconds in "Drive," recording idle quality after 5 seconds and after 30 seconds, and record any stalls that occur. This ends the driving schedule. Proceed to the staging area.

Definitions of light-throttle, detent, and WOT accelerations are attached. During the above maneuvers, observe and record the severity of any of the following malfunctions (see attached definitions):

1. Hesitation
2. Stumble
3. Surge
4. Stall
5. Backfire

It is possible that during a maneuver, more than one malfunction may occur. Record all deficiencies observed. Do not record the number of occurrences. If no malfunctions occur during a maneuver, draw a horizontal line through all boxes for that maneuver. Also, in recording subjective ratings (T, M, or H), be sure the entry is legible. At times, M and H recordings cannot be distinguished from each other.

Record maneuvering stalls on the data sheet in the appropriate column: accelerating or decelerating. If the vehicle should stall before completing the maneuver, record the stall and restart the car as quickly as possible. Bring the vehicle up to the intended final speed of the maneuver. Any additional stalls observed will not add to the demerit total for the maneuver, and it is important to maintain the driving schedule as closely as possible.

DEFINITIONS AND EXPLANATIONS

Test Run

Operation of a car throughout the prescribed sequence of operating conditions and/or maneuvers for a single test fuel.

Maneuver

A specified single vehicle operation or change of operating conditions (such as idle, acceleration, or cruise) that constitutes one segment of the driveability driving schedule.

Cruise

Operation at a prescribed constant vehicle speed with a fixed throttle position on a level road.

Wide Open Throttle (WOT) Acceleration

"Floorboard" acceleration through the gears from prescribed starting speed. Rate at which throttle is depressed is to be as fast as possible without producing tire squeal or appreciable slippage.

Part-Throttle (PT) Acceleration

An acceleration made at any defined throttle position, or consistent change in throttle position, less than WOT. Several PT accelerations are used. They are:

1. Light Throttle (Lt. Th) - All light-throttle accelerations are begun by opening the throttle to an initial manifold vacuum and maintaining *constant throttle position* throughout the remainder of the acceleration. The vacuum selected is the vacuum setting necessary to reach 25 mph in 9 seconds. The vacuum setting should be determined when the vehicle is cold. The vacuum setting is posted in each vehicle.

2. Moderate Throttle (Md. Th) - Moderate-throttle accelerations are begun by immediately depressing the throttle to the position that gives the pre-specified vacuum and maintaining a *constant throttle position* throughout the acceleration. The moderate-throttle vacuum setting is determined by taking the mean of the vacuum observed during WOT acceleration and the vacuum prescribed for light-throttle acceleration. This setting is to be posted in the vehicle.

3. Crowd - An acceleration made at a constant intake manifold vacuum. To maintain *constant vacuum*, the throttle-opening must be continually increased with increasing engine speed. Crowd accelerations are performed at the same vacuum prescribed for the light-throttle acceleration.

4. Detent - All detent accelerations are begun by opening the throttle to just above the downshift position as indicated by transmission shift characteristic curves. Manifold vacuum corresponding to this point at 25 mph is posted in each vehicle. *Constant throttle position* is maintained to 35 mph in this maneuver.

Malfunctions

1. Stall

   Any occasion during a test when the engine stops with the ignition on. Three types of stall, indicated by location on the data sheet, are:

   a. Stall; idle - Any stall experienced when the vehicle is not in motion, or when a maneuver is not being attempted.

   b. Stall; maneuvering - Any stall which occurs during a prescribed maneuver or attempt to maneuver.

   c. Stall; decelerating - Any stall which occurs while decelerating between maneuvers.

2. Idle Roughness

   An evaluation of the idle quality or degree of smoothness while the engine is idling. Idle quality may be rated using any means available to the lay customer. The rating should be determined by the worst idle quality experienced during the idle period.

3. Backfire

   An explosion in the induction or exhaust system.

4. Hesitation

   A temporary lack of vehicle response to opening of the throttle.

5. Stumble

   A short, sharp reduction in acceleration after the vehicle is in motion.

6. Surge

Cyclic power fluctuations.

Malfunction Severity Ratings

The number of stalls encountered during any maneuver are to be listed in the appropriate data sheet column. Each of the other malfunctions must be rated by severity and the letter designation entered on the data sheet. The following definitions of severity are to be applied in making such ratings.

1. Trace (T) - A level of malfunction severity that is just discernible to a test driver but not to most laymen.

2. Moderate (M) - A level of malfunction severity that is probably noticeable to the average laymen.

3. Heavy (H) - A level of malfunction severity that is pronounced and obvious to both test driver and layman.

4. Extreme (E) - A level of malfunction severity more severe than "Heavy" at which the lay driver would not have continued the maneuver, but taken some other action.

Enter a T, M, H, or E in the appropriate data block to indicate both the occurrence of the malfunction and its severity. More than one type of malfunction may be recorded on each line. If no malfunctions occur, enter a dash (-) to indicated that the maneuver was performed and operation was satisfactory during the maneuver.

DEMERIT CALCULATION SYSTEM

A numerical value for driveability during the CRC test is obtained by assigning demerits to operating malfunctions as shown. Depending upon the type of malfunction, demerits are assigned in various ways. Demerits for poor starting are obtained by subtracting one second from the measured starting time and multiplying by 4. The number of stalls which occur during idle as well as during driving maneuvers are counted separately and assigned demerits as shown. The multiplying x factors of 8 and 32 for idle and maneuvering stalls, respectively, account for the fact that stalls are very undesirable, especially during car maneuvers. A maximum of three total Idle Park stalls and No-Starts are permitted. A maximum of three Idle Drive stalls are permitted.

Other malfunctions, such as hesitation, stumble, surge, idle roughness, and backfire, are rated subjectively by the driver on a scale of trace, moderate, or heavy. For these malfunctions, a certain number of demerits is assigned to each of the subjective ratings. However, since all malfunctions are not of equal importance, the demerits are multiplied by the weighting factors shown to yield weighted demerits.

Finally, weighted demerits, demerits for stalls, and demerits for poor starting are summed to obtain total weighted demerits (TWD), which are used as an indication of driveability during the test. As driveability deteriorates, TWD increases.

A restriction is applied in the totaling of demerits to insure that a stall results in the highest possible number of demerits within a given maneuver. When more than one malfunction occurs during a maneuver, demerits are counted for only the malfunction which had the largest number of weighted demerits. Another restriction is that for each idle period, no more than 3 idle stalls are counted.

When all the factors are multiplied together the following chart of demerit levels is generated.

Demerit levels for: Hesitation/Stumble/Surge/Backfire/Stall

Maneuver	Stall	Extreme	Heavy	Medium	Trace	Clear
Light Throttle	50	16	8	4	2	0
Medium Throttle	100	32	16	8	4	0
WOT	100	32	16	8	4	0
Detent	50	16	8	4	2	0
Crowd	50	16	8	4	2	0

For Idle Roughness

Extreme	Heavy	Medium	Trace	Clear
8	4	2	1	0

For Idle Stalls

Idle-in- Park	Starting-in-Drive	Other Idle (after moderate throttle or at end of test)
7 each	28	7

For Starting

No Start	Slow Start
25 each	t-1*5

The Start time, t, is in seconds.
Only the results (start, start + stall, no-start) of the first three starting attempts in park count toward demerits.
Only the first stall in drive prior to maneuvering counts toward demerits
Only the first stall in each maneuver, or in each idle subsequent to the start of the maneuver is counted toward demerits.
Only the highest weighted demerit score from each maneuver is counted.

CRC Driveability Data Sheet

No.	Run Car	Fuel	Rater	Date	Time	Soak	Run	Temperatures Odometer

Starting time, Sec.			Idle Park	Idle Drive
Initial	Restart 1	Restart 2	Ruf Stls	Ruf Stls

0.0 0-15 LT TH 0-15 LT TH 0.1 0-20 WOT 0.2 0-15 LT TH 0-15 LT TH 0.3 10-20 LT TH 0.4 0-20 MD TH

H S B
E T S K A D
S M G F C C

0.5 Idle Dr.
Ruf Stls

0.5 0-15 LT TH 0-15 LT TH 0.6 0-20 WOT 0.7 0-15 LT TH 0-15 LT TH 0.8 10-20 LT TH 0.9 0-20 MD TH

H S B
E T S K A D
S M G F C C

0.0 Idle Dr.
Ruf Stls

0.0 0-45 Crowd
H S B
S M G F C C

0.4 25-35 Detent
H S B
E T S K A D
S M G F C C

0.5 Idle Dr.
5 sec.
E T S K A D
Ruf Stls

Idle Dr.
30 sec.
Ruf Stls

Fuel Tank Flushing Procedure

Precautionary notes:

1. ***When draining the vehicle fuel tank, leave the fuel pump on until no drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***
2. ***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, hook up the chilled sampling system, and draw the required fuel sample through the Schrader valve or adapter line fitting using the vehicle fuel pump.
2. Remove the sampling system. Immediately prior to testing, install drain line, and then completely drain the fuel tank through the Schrader valve or adapter line fitting using the vehicle fuel pump.
3. Remove the fill cap, add four gallons of the next test fuel to the vehicle fuel tank, and replace the fill cap.
4. Start and idle the vehicle for a total of 2 minutes.
5. Completely drain the fuel tank through the Schrader valve or adapter line fitting using the vehicle fuel pump.
6. Remove the fill cap, add four gallons of the next test fuel to the vehicle 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. Completely drain the fuel tank through the Schrader valve or adaptive line fitting using the vehicle fuel pump.
9. When the rating crew 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.

APPENDIX D

LISTING OF SCREENED VEHICLES

Table D-1
TEST VEHICLES AND SCREENING RESULTS
2013 CRC E15 Driveability Index Volatility Program
Yakima Washington

Selected	Year	Make	Model	License #	Mileage	Displacement, Liters	Calibration	VIN	Rater	TWD Tank	TWD B3	TWD Warm
*	2012	Chevrolet	Camaro	AHR5003	19,561	3.6	LDV Tier2 PC ULEV	2G1FB1E3XC9191345	C	24.0	47.0	21.5
*	2012	Chevrolet	Captiva	AJY3565	17,550	2.4	LDT Tier2 ULEV	3GNAL2EK7CS563388	B	26.0	45.5	42.5
	2012	Chevrolet	Cruz LTZ	AJT 2217	8,565	1.4	LDV T2 PC ULEV	1G1PG5SB2D7106252	B	49.0	32.0	41.5
	2013	Chevrolet	Equinox	AIZ7270	17,234	2.4	LDT Tier2 LDT PZEV	2GNFLEEK7D6120357	B	65.5	28.5	63.0
	2012	Chevrolet	Impala	AHH8085	17,058	2.4	LDV Tier2 PZ PZEV	1G12A5EO4CF2B6388	C	10.0	18.0	13.5
*	2012	Chevrolet	Impala	897FMA	21,374	3.6	LDV Tier2 PC PZEV	2G1WF5E3XC1199505	C	15.0	69.5	124.0
*	2012	Chevrolet	Silverado	110FMA	20,495	4.3	LDT Tier2 LDT LEV	1GCNKPEX5CZ116681	C	7.5	27.0	14.5
*	2012	Chevrolet	Sonic LTZ	AHH9429	21,169	1.8	LDV Tier2 PC ULEV	1G1JE6SH9C4165126	B	34.0	66.0	46.5
*	2012	Chevrolet	Suburban	AIM9939	19,352	5.3	LDT Tier2 ULEV	1GNSKJE72CR314108	B	18.0	44.0	30.0
	2012	Chevrolet	Traverse	6VBF500	25,604	3.6	T2 ULEV	1GNKVGED1CJ266891	C	24.5	25.0	12.0
*	2012	Chrysler	Town & Country	AFL3989	27,233	3.6	T2B4 LDV OBD 2	2C4RC1BG9CR137513	C	8.5	29.0	17.0
*	2012	Chrysler	200LX	721FTJ	20,491	2.4	SULEV2 PC	1C3CCBAB6CN256736	A	15.5	42.0	25.5
*	2012	Chrysler	200	AFV7520	31,776	2.4	SULEV2 PZEV	1C3CCBBB9CN135259	C	13.5	51.5	21.5
*	2012	Dodge	Durango	AHP5364	17,427	3.6	T2B4 LDT OBD2 ULEV2	1C4RDJDGOCC284919	C	6.0	15.0	6.5
*	2012	Fiat	500	AFE0750	29,008	1.4	T2B5 LDV CA 2	3C3CFFAR5CT123963	B	36.0	93.0	102.0
*	2012	Ford	F150	B29098V	18,919	3.5	T2B5 LDT4 LEV2 LDT	1FTFX1ET7CFB65429	A	5.5	37.5	24.5
	2012	Ford	Fiesta	341XYY	23,045	1.6	T2B4 LDV ULEV	3FADP4CJ6CM187860	C	26.0	17.0	26.5
*	2012	Ford	Flex Limited	1A3J963	16,511	3.5	T2B5 LDV ULEV 2PC	21FMHKDCXCBDO7629	C	6.0	17.0	12.5
	2012	Ford	Focus	A1Z4276	10,684	2.0	T2B3 LDV SULEV PZEV	1FAHP3K2XCL453808	B	114.0	92.0	39.0
*	2012	Ford	Taurus	AFL2719	24,605	3.5	T2B5 LDV UL2 PC	1FAHP2EW4CG103155	B	14.0	35.0	24.5
	2012	GMC	Terrain	AHR4938	20,937	2.4	LDT Tier2 LDT PZEV	2GKFLTEK8C6323693	B	68.0	50.0	35.0
	2012	Infinity	G37x	AHR6261	11,831	3.7	T2B5 LDV LEV2 ULEV	JN1CV6AR0CM679959	B	38.0	28.5	29.0
	2012	Jeep	Compass	6WJJ716	15,591	2.0	T2B4 LDV CAOBD2	1C4NJCBA9CD724129	A	14.5	16.5	18.0
	2011	Jeep	Grand Cherokee	ADJ9027	9,367	3.6	T2B4 LDT ULEV2	1J4RR4GG4BC640442	B	32.5	31.5	33.5
	2012	Jeep	Patriot	921XVA	20,148	2.0	T2B4 LDV CAOBD2	1C4NJPBA2CD722326	C	10.0	6.5	9.5
	2012	KIA	Forte	AJY3383	15,067	2.0	SULEV2 PZEV	KNAFU4A25C5591713	C	8.0	7.0	16.0
*	2012	KIA	Optima	AKV4625	13,850	2.4	SULEV 2 PZEV PC	5XXGM4A70CG056299	A	9.0	45.5	7.0
	2012	KIA	Sedona	6WNA726	16,490	3.5	T2B5 LDT2 ULEV2 LDT2	KNDMG4C73C6487936	C	6.5	6.5	15.0
*	2013	KIA	Soul	327YBT	13,393	2.0	T2B5 LDV ULEV2 PC	KNAFU4A25C5591713	A	7.0	12.0	8.0
*	2012	KIA	Sportage	6WPN409	12,525	2.4	SULEV 2 PZEV LDT1	KNDPB3A29C7345775	C	11.0	19.0	26.0
	2012	Mazda	2	019FPV	20,530	1.5	T2B5 LDV ULEV 2PC	JM1DE1KZXCO144616	B	43.0	46.0	39.0
	2012	Mazda	5	AJK2405	6,326	2.5	T2B5 LDV ULEV2 PC	JM1CW2BLXCO125123	B	23.5	19.0	13.0
	2012	Mazda	6	AHH8368	16,774	2.5	PZEV PC	1YVHZ8DHXC5M38257	A	13.0	16.0	9.5
	2012	Nissan	Altima	AHR7400	27,072	2.5	T2B5 LDV LEV2 LEVPC	IN4AL2AP7CC241923	A	28.5	25.0	18.0
	2012	Nissan	Murano	AIZ6914	5,113	3.5	T2B5 LDT2 LEV2 ULEV	JN8AZ1MWOCW232571	B	35.0	32.5	39.0
	2012	Nissan	Quest	785FPV	23,687	3.5	T2B5 LDT2 LEV2 ULEV	JN8AE2KP2C9040127	B	18.0	17.0	8.5
*	2012	Nissan	Sentra	AFV55U	25,905	2.0	T2B5 LDV LEV2 LEVPC	3NIAB6AP4CL628327	C	9.0	23.5	16.0
	2012	Toyota	Camry	704FTJ	14,800	2.5	T2B5 LDV CA2	4T1BF1FK7CU574562	C	6.0	7.5	6.0
	2012	Toyota	Corolla	6WNB968	19,446	1.8	T2B5 LDV CA3	5YFBU4EE2CP047887	C	8.5	6.5	8.5
	2011	VW	Jetta	AEK 5790	31,608	2.5	T2B3 LDVCA2 PZEV	3VWDZ7AJ9BM354197	B	47.0	31.0	70.0

APPENDIX E

INDIVIDUAL LABORATORY FUEL INSPECTIONS

AND DETAILED HYDROCARBON ANALYSES

Table E-1
2013 CRC E15 Driveability Index Volatility Program Fuel Inspections

Fuel Description			B0					B1				
Property	Method	Units	1251/0					1161/10				
Laboratory			A	B	C	D	Average	A	B	C	D	Average
DVPE	ASTM D5191	psi	8.64	7.87	7.89	8.12	8.13	9.54	9.12	9.24	9.53	9.36
DI Uncorrected*			1244.5	1248.0	1258	1252.4	1250.7	1157.7	1157.6	1162	1166.5	1161.0
Ethanol	ASTM D4815	vol %	0.0	0	0	<0.1	0.0	10.3	9.67	10.6	10.07	10.16
Gravity	ASTM D4052	°API	55.6	54.9	54.8	55.03	55.1	54.8	54.6	54.5	54.51	54.6
Relative Density 60/60°F	ASTM D4052		0.7564	0.7593	0.7595	0.7586	0.7584	0.7596	0.7603	0.7608	0.7607	0.7603
FIA	ASTM D1319											
Aromatics		vol %	26.6	29.0	33.6	32.1	30.3	25.5	29.8	29.56	27.52	28.1
Olefins		vol %	3.2	2.5	3.7	4.7	3.5	2.4	2.6	3.28	3.96	3.1
Saturates		vol %	70.2	68.5	62.7	63.2	66.1	61.8	57.9	56.56	58.45	58.7
Distillation	ASTM D86											
Initial Boiling Point		°F	95.0	92.7	97.4	87.2	93.1	99.1	95	97.0	89.8	95.2
5% Evaporated		°F	122.0	122.3	124.8	124.5	123.4	117.7	118.9	119.8	120.2	119.2
10% Evaporated		°F	136.4	137.5	139.4	138.8	138.0	127.0	128.7	128.7	129.5	128.5
20% Evaporated		°F	159.3	158.9	160.4	160.2	159.7	138.9	140.1	139.9	140.3	139.8
30% Evaporated		°F	177.8	177.5	178.7	178.1	178.0	146.5	147.7	147.8	147.2	147.3
40% Evaporated		°F	196.6	197.2	198.9	198.2	197.7	151.5	151.4	153.0	153.2	152.3
50% Evaporated		°F	221.2	221.7	224.1	222.8	222.5	197.8	196.7	198.4	199.3	198.1
60% Evaporated		°F	252.3	253.4	254.1	253.4	253.3	237.0	238.6	237.4	237.8	237.7
70% Evaporated		°F	295.5	295.3	297.7	295.8	296.1	277.0	278.6	280.0	277.8	278.4
80% Evaporated		°F	347.9	348	349.5	347.2	348.2	336.2	337.1	337.9	337.1	337.1
90% Evaporated		°F	376.3	376.6	376.6	375.8	376.3	373.8	374.4	374.0	374.3	374.1
95% Evaporated		°F	388.0	387.8	387.6	388.2	387.9	386.8	386.9	386.3	387.1	386.8
End Point		°F	431.8	429.5	431.6	431.2	431.0	422.8	425.5	426.4	429.0	425.9
Recovery		vol %	97.8	97.7	97.7	98.3	97.9	97.4	97.9	97.3	98.3	97.7
Residue		vol %	1.1	1	1.1	1.1	1.1	1.0	0.9	1.6	1.1	1.2
Loss		vol %	1.1	1.3	1.2	0.6	1.1	1.6	1.2	1.1	0.6	1.1
Benzene	ASTM D3606	vol %	0.3		0.38		0.34	0.3		0.34		0.32
Benzene	DHA	vol %			0.33	-	0.33		-	0.30	-	0.30
Ethanol	DHA	vol %	-	-	0.00	-	0.00	-	-	10.61	-	10.61
Hydrocarbon	DHA	vol %	-	-	100.00	-	100.00	-	-	89.39	-	89.39
Aromatics	DHA	vol %	-	-	31.47	-	31.47	-	-	28.16	-	28.16
Olefins	DHA	vol %	-	-	3.95	-	3.95	-	-	3.51	-	3.51
Saturates	DHA	vol %	-	-	60.67	-	60.67	-	-	54.22	-	54.22
Not Classified	DHA	vol %	-	-	3.91	-	3.91	-	-	3.49	-	3.49

*DI Uncorrected = 1.5*T10 + 3.0*T50 + 1.0*T90

Table E-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Fuel Inspections

Fuel Description			B2					B3				
Property	Method	Units	1051/15					1055/20				
Laboratory			A	B	C	D	Average	A	B	C	D	Average
DVPE	ASTM D5191	psi	9.38	8.71	8.77	9.21	9.02	9.21	8.81	8.74	9.24	9.00
DI Uncorrected*			1044.9	1054.1	1053.1	1050.6	1050.7	1052.6	1056.8	1058	1053.9	1055.3
Ethanol	ASTM D4815	vol %	15.1	15.4	16.7	15.41	15.7	20.3	21.48	22.2	20.19	21.04
Gravity	ASTM D4052	°API	54.3	53.9	53.7	53.95	54.0	53.9	53.6	53.3	53.66	53.6
Relative Density 60/60°F	ASTM D4052		0.7616	0.7633	0.476	0.7630	0.6910	0.7632	0.7644	0.7656	0.7642	0.7644
FIA	ASTM D1319											
Aromatics		vol %	25.6	24.8	27.90	26.39	26.2	24.4	25.4	27.44	25.78	25.8
Olefins		vol %	2.9	2	3.22	4.23	3.1	2.4	2.1	2.80	4.07	2.8
Saturates		vol %	56.4	57.8	52.18	53.97	55.1	52.9	51.0	47.56	49.96	50.4
Distillation	ASTM D86											
Initial Boiling Point		°F	100.8	95.9	86.8	92.5	94.0	101.1	85	97.3	92.6	94.0
5% Evaporated		°F	120.6	121.7	121.5	122.5	121.6	121.3	125.6	124.4	123.9	123.8
10% Evaporated		°F	129.4	131.7	131.5	130.8	130.9	131.2	133	133.6	132.9	132.7
20% Evaporated		°F	141.8	142.9	142.4	142.0	142.3	143.1	144.1	144.3	143.8	143.8
30% Evaporated		°F	149.0	150.4	149.9	149.7	149.8	150.4	151.7	151.5	151.0	151.2
40% Evaporated		°F	154.8	155.9	155.7	155.0	155.4	156.2	157.5	157.3	157.0	157.0
50% Evaporated		°F	159.1	161	160.9	160.6	160.4	161.2	161.7	162.1	161.5	161.6
60% Evaporated		°F	227.1	225.7	225.6	224.4	225.7	165.4	169.8	168.5	166.7	167.6
70% Evaporated		°F	271.4	272.8	272.7	269.6	271.6	263.8	261.6	265.9	259.4	262.7
80% Evaporated		°F	331.5	330.2	332.4	330.9	331.3	324.9	322.6	325.7	323.0	324.1
90% Evaporated		°F	373.5	373.6	373.1	372.6	373.2	372.2	372.2	371.2	370.0	371.4
95% Evaporated		°F	387.1	387	385.4	387.0	386.6	387.7	386.7	386.2	386.7	386.8
End Point		°F	421.3	424.1	426.1	423.7	423.8	424.0	423.3	425.9	423.4	424.2
Recovery		vol %	97.7	98	96.6	98.4	97.7	97.1	98.9	97.7	98.7	98.1
Residue		vol %	1.2	1.0	1.1	1.1	1.1	1.4	1	1.2	1.1	1.2
Loss		vol %	1.1	1.0	2.3	0.5	1.2	1.5	0.1	1.1	0.2	0.7
Benzene	ASTM D3606	vol %	0.3		0.32		0.31	0.25		0.30		0.28
Benzene	DHA	vol %		-	0.28	-	0.28		-	0.26	-	0.26
Ethanol	DHA	vol %	-	-	16.527	-	16.53	-	-	21.98	-	21.98
Hydrocarbon	DHA	vol %	-	-	83.47	-	83.47	-	-	78.02	-	78.02
Aromatics	DHA	vol %	-	-	26.40	-	26.40	-	-	24.68	-	24.68
Olefins	DHA	vol %	-	-	3.32	-	3.32	-	-	3.00	-	3.00
Saturates	DHA	vol %	-	-	50.54	-	50.5	-	-	47.32	-	47.32
Not Classified	DHA	vol %	-	-	3.22	-	3.22	-	-	3.02	-	3.02

*DI Uncorrected = 1.5*T10 + 3.0*T50 + 1.0*T90

Table E-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Fuel Inspections

Fuel Description			B4					B5				
Property	Method	Units	1045/10					1063/15				
Laboratory			A	B	C	D	Average	A	B	C	D	Average
DVPE	ASTM D5191	psi	8.76	8.71	8.85	8.79	8.78	8.04	7.72	7.99	7.95	7.93
DI Uncorrected*			1051.2	1045.9	1036	1047.8	1045.30	1049.1	1059.9	1061	1079.9	1062.5
Ethanol	ASTM D4815	vol %	9.87	9.29	10.4	9.64	9.8	14.7	14.55	16.5	15.58	15.3
Gravity	ASTM D4052	°API	57.36	57.1	56.5	57.19	57.0	54.0	53.8	53.3	53.9	53.8
Relative Density 60/60°F	ASTM D4052		0.7492	0.7502	0.7526	0.7499	0.7505	0.7627	0.7635	0.7655	0.7632	0.7637
FIA	ASTM D1319											
Aromatics		vol %	25.7	24.5	26.8	26.7	25.9	29.7	27.8	31.13	30.8	29.9
Olefins		vol %	3.4	3.1	4.3	4.2	3.8	5.8	3.5	4.79	4.2	4.6
Saturates		vol %	60.7	63.1	58.5	59.5	60.5	49.8	54.2	47.58	49.4	50.2
Distillation	ASTM D86											
Initial Boiling Point		°F	97.8	95.9	96.6	94.7	96.3	104.5	100.5	96.4	98.0	99.9
5% Evaporated		°F	119.2	118	117.9	118.6	118.4	122.0	123.6	125.5	128.3	124.9
10% Evaporated		°F	124.7	123.7	123.5	124.1	124.0	130.8	131.8	132.7	134.8	132.5
20% Evaporated		°F	131.9	132.2	129.8	132.2	131.5	142.7	143.5	143.7	144.6	143.6
30% Evaporated		°F	139.4	139.7	137.9	139.7	139.2	152.1	152.8	152.6	153.1	152.7
40% Evaporated		°F	146.8	147.4	146.4	147.2	147.0	159.1	159.7	159.6	159.5	159.5
50% Evaporated		°F	170.6	168.9	166.0	169.3	168.7	165.2	167.3	167.5	173.7	168.4
60% Evaporated		°F	218.8	222.6	220.0	220.7	220.5	241.0	241.9	242.8	241.3	241.8
70% Evaporated		°F	252.4	253.4	251.7	253.9	252.9	269.4	272.1	270.8	272.7	271.3
80% Evaporated		°F	296.2	297.5	297.3	297.5	297.1	312.8	315.1	314.0	312.4	313.6
90% Evaporated		°F	352.3	353.6	353.1	353.7	353.2	357.3	360.3	359.6	356.6	358.5
95% Evaporated		°F	374.7	375.8	376.2	377.2	376.0	378.9	379	375.2	368.3	375.4
End Point		°F	406.2	403.1	403.9	405.5	404.7	410.0	409.8	406.1	398.7	406.2
Recovery		vol %	98.1	98.4	97.9	98.6	98.3	97.2	97.7	98.4	98.5	98.0
Residue		vol %	1.1	0.9	1.1	1.1	1.1	1.0	1	1.1	1.1	1.1
Loss		vol %	0.8	0.7	1.0	0.3	0.7	1.8	1.3	0.5	0.4	1.0
Benzene	ASTM D3606	vol %	0.33		0.39		0.36	0.36		0.47		0.42
Benzene	DHA	vol %		-	0.34	-	0.34		-	0.39	-	0.39
Ethanol	DHA	vol %	-	-	10.35	-	10.35	-	-	16.20	-	16.20
Hydrocarbon	DHA	vol %	-	-	89.65	-	89.65	-	-	83.80	-	83.80
Aromatics	DHA	vol %	-	-	24.76	-	24.76	-	-	29.17	-	29.17
Olefins	DHA	vol %	-	-	4.14	-	4.14	-	-	4.77	-	4.77
Saturates	DHA	vol %	-	-	58.56	-	58.6	-	-	47.31	-	47.31
Not Classified	DHA	vol %	-	-	2.18	-	2.18	-	-	2.56	-	2.56

*DI Uncorrected = 1.5*T10 + 3.0*T50 + 1.0*T90

Table E-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Fuel Inspections

Fuel Description			B6					H1				
Property	Method	Units	1046/20					1164/0				
Laboratory			A	B	C	D	Average	A	B	C	D	Average
DVPE	ASTM D5191	psi	8.21	7.94	8.27	8.25	8.17	8.34	8.00	8.32	8.30	8.24
DI Uncorrected*			1048.8	1042.7	1044.0	1048.5	1046.0	1160.1	1171.2	1161	1163.4	1163.9
Ethanol	ASTM D4815	vol %	20.1	18.7	21.9	20.43	20.3	0.0	0	0	<0.1	0.00
Gravity	ASTM D4052	°API	54.2	53.8	53.2	53.88	53.8	58.8	58.4	57.7	58.43	58.3
Relative Density 60/60°F	ASTM D4052		0.7622	0.7637	0.7662	0.7633	0.7638	0.7438	0.7452	0.7477	0.745	0.7454
FIA	ASTM D1319											
Aromatics		vol %	27.6	26.2	27.5	28.2	27.4	27.7	27.8	29.9	27.8	28.3
Olefins		vol %	3.5	1.7	3.8	3.7	3.2	3.5	3.1	4.7	3.9	3.8
Saturates		vol %	48.8	53.4	46.8	47.7	49.2	68.8	69.1	65.4	68.3	67.9
Distillation	ASTM D86											
Initial Boiling Point		°F	101.1	100.3	96.0	95.2	98.2	94.1	98.2	88.8	88.1	92.3
5% Evaporated		°F	127.1	123.6	123.9	125.1	124.9	116.1	125.4	115.7	117.3	118.6
10% Evaporated		°F	133.7	130.2	130.8	131.8	131.6	126.5	134.8	126.5	127.2	128.8
20% Evaporated		°F	143.0	140	141.4	142.6	141.8	141.0	148.4	141.0	141.3	142.9
30% Evaporated		°F	150.9	149.9	150.3	151.4	150.6	156.9	159	156.7	157.6	157.6
40% Evaporated		°F	157.7	156.6	157.4	158.4	157.5	176.8	177.4	176.7	177.8	177.2
50% Evaporated		°F	163.3	162.9	163.0	163.5	163.2	202.6	201.9	202.7	203.1	202.6
60% Evaporated		°F	173.3	173.9	168.4	173.6	172.3	232.6	232.6	233.8	232.5	232.9
70% Evaporated		°F	258.9	252.7	259.9	260.4	258.0	266.6	266.1	267.0	266.1	266.5
80% Evaporated		°F	305.8	307.3	305.6	307.7	306.6	314.1	315.1	315.1	315.2	314.9
90% Evaporated		°F	358.4	358.7	358.8	360.3	359.1	362.6	363.3	363.0	363.3	363.1
95% Evaporated		°F	378.9	378.4	377.3	378.3	378.2	379.4	380.3	378.7	379.9	379.6
End Point		°F	409.5	406.8	406.1	409.2	407.9	412.1	411.1	407.7	414.2	411.3
Recovery		vol %	97.7	98.3	98.4	98.9	98.3	97.7	98.5	98.3	98.4	98.2
Residue		vol %	1.1	1	1.1	1.1	1.1	1.0	1	1.1	1.1	1.1
Loss		vol %	1.2	0.7	0.5	0.0	0.6	1.3	0.5	0.6	0.5	0.7
Benzene	ASTM D3606	vol %	0.32		0.37		0.35	0.34		0.41		0.38
Benzene	DHA	vol %		-	0.33	-	0.33		-	0.35	-	0.35
Ethanol	DHA	vol %	-	-	21.69	-	21.69		-	0.00	-	0.00
Hydrocarbon	DHA	vol %	-	-	78.31	-	78.31	-	-	100.00	-	100.00
Aromatics	DHA	vol %	-	-	25.52	-	25.52	-	-	27.84	-	27.84
Olefins	DHA	vol %	-	-	3.87	-	3.87	-	-	4.31	-	4.31
Saturates	DHA	vol %	-	-	46.62	-	46.6	-	-	65.28	-	65.28
Not Classified	DHA	vol %	-	-	2.30	-	2.30	-	-	2.57	-	2.57

*DI Uncorrected = 1.5*T10 + 3.0*T50 + 1.0*T90

Table E-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Fuel Inspections

Fuel Description			H2					H3				
Property	Method	Units	1042/0					999/0				
Laboratory			A	B	C	D	Average	A	B	C	D	Average
DVPE	ASTM D5191	psi	8.83	8.52	8.77	8.78	8.71	8.76	8.63	8.86	8.87	8.78
DI Uncorrected*			1045.8	1045.8	1034	1043.2	1042.1	1003.8	1001.6	996	995.15	999.0
Ethanol	ASTM D4815	vol %	0.0	0	0	<0.1	0.0	0.0	0	0	<0.1	0.0
Gravity	ASTM D4052	°API	60.7	60.5	60.4	60.49	60.5	60.9	60.7	60	60.7	60.6
Relative Density 60/60°F	ASTM D4052		0.7363	0.7371	0.739	0.737	0.7374	0.7356	0.7363	0.7387	0.7362	0.7367
FIA	ASTM D1319											
Aromatics		vol %	22.3	23.4	24.0	23.8	23.4	19.2	21.7	22.4	19.8	20.8
Olefins		vol %	3.0	0.9	3.6	3.3	2.7	3.0	1.3	4.2	3.2	2.9
Saturates		vol %	74.7	75.7	72.4	72.9	73.9	77.8	77.0	73.5	77	76.3
Distillation	ASTM D86											
Initial Boiling Point		°F	99.5	97.5	94.2	95.4	96.7	99.7	100	95.2	97.7	98.2
5% Evaporated		°F	116.8	116.2	112.9	117.0	115.7	115.7	116.4	115.7	114.9	115.7
10% Evaporated		°F	122.5	122.1	120.4	123.0	122.0	121.4	120.9	120.5	120.1	120.7
20% Evaporated		°F	130.3	130.3	128.6	130.9	130.0	128.1	127.2	126.3	126.1	126.9
30% Evaporated		°F	138.4	138.7	137.1	139.9	138.5	135.0	133.8	132.8	133.3	133.7
40% Evaporated		°F	149.5	150.6	148.5	151.1	149.9	144.0	142.7	141.7	142.3	142.7
50% Evaporated		°F	167.0	167.7	164.8	167.5	166.8	157.2	156.6	155.0	155.9	156.2
60% Evaporated		°F	195.6	194.1	190.9	193.8	193.6	179.7	179.2	177.8	178.6	178.8
70% Evaporated		°F	239.5	236	234.7	236.2	236.6	221.0	222.6	223.2	222.6	222.4
80% Evaporated		°F	296.8	293	291.3	292.7	293.5	276.1	277.5	276.9	278.0	277.1
90% Evaporated		°F	361.0	359.5	358.6	356.2	358.8	350.1	350.4	349.9	347.3	349.4
95% Evaporated		°F	377.8	376.8	376.9	369.8	375.3	374.4	374.5	374.0	375.7	374.7
End Point		°F	406.2	400.7	401.3	396.2	401.1	404.4	401.2	402.0	404.8	403.1
Recovery		vol %	97.7	97.8	97.2	98.2	97.7	97.2	98.1	98.4	98.2	98.0
Residue		vol %	1.0	1.1	1.1	1.1	1.1	1.1	1	1.1	1.1	1.1
Loss		vol %	1.3	1.1	1.7	0.7	1.2	1.7	0.9	0.5	0.7	1.0
Benzene	ASTM D3606	vol %	0.2		0.3		0.25	0.24		0.29		0.27
Benzene	DHA	vol %		-	0.26	-	0.26		-	0.25	-	0.25
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 %	-	-	22.11	-	22.11	-	-	20.08	-	20.08
Olefins	DHA	vol %	-	-	3.11	-	3.11	-	-	3.05	-	3.05
Saturates	DHA	vol %	-	-	72.62	-	72.6	-	-	75.00	-	75.00
Not Classified	DHA	vol %	-	-	2.15	-	2.15	-	-	1.87	-	1.87

*DI Uncorrected = 1.5*T10 + 3.0*T50 + 1.0*T90

Table E-2
2013 CRC E15 Driveability Index Volatility Program Additional Fuel Inspections

Fuel Description			B0			B1			B2			B3			B4		
Laboratory	Method	Units	A	C	Average	A	C	Average	A	C	Average	A	C	Average	A	C	Average
MTBE	D4815	vol %	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1
Lead	D3237	g/gal	<0.004	-	<0.004	<0.004	-	<0.004	<0.004	-	<0.004	<0.004	-	<0.004	<0.004	-	<0.004
Unwashed Gum	D381	mg/100mL	12.6	-	12.6	10.2	-	10.2	9.8	-	9.8	9.2	-		10.2	-	10.2
Solvent Washed Gum	D381	mg/100mL	1.2	0	0.6	<0.5	0	0.0	<0.5	0	0.0	<0.5	2	2.0	<0.5	0	0.0
Research Octane Number	D2699	RON	92.6	92.5	92.6	96.4	96.0	96.2	98.0	97.3	97.7	99.7	98.5	99.1	97.3	96.9	97.1
Motor Octane Number	D2700	MON	84.2	84.0	84.1	86.0	85.5	85.8	87.0	85.9	86.5	88.1	86.4	87.3	86.5	85.7	86.1
(R+M)/2 Octane Rating	(R+M)/2	(R+M)/2	88.4	88.3	88.3	91.2	90.8	91.0	92.5	91.6	92.1	93.9	92.5	93.2	91.9	91.3	91.6

Fuel Description			B5			B6			H1			H2			H3		
Laboratory	Method	Units	A	C	Average	A	C	Average	A	C	Average	A	C	Average	A	C	Average
MTBE	D4815	vol %	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	<0.1	-	<0.1
Lead	D3237	g/gal	<0.004	-	<0.004	<0.004	-	<0.004	<0.004	-	<0.004	<0.004	-	<0.004	<0.004	-	<0.004
Unwashed Gum	D381	mg/100mL	7.8	-	7.8	8.6	-	8.6	13	-	8.6	12.6	-	12.6	12.4	-	12.4
Solvent Washed Gum	D381	mg/100mL	0.6	1	0.8	<0.5	1	1.0	1.4	2	<0.5	0.8	0	0.4	<0.5	0	0.0
Research Octane Number	D2699	RON	98.7	98.5	98.6	99.8	99.3	99.6	93.0	93.4	93.2	94.2	94.6	94.4	96.6	96.3	96.5
Motor Octane Number	D2700	MON	87.2	86.2	86.7	88.2	86.6	87.4	84.0	84.5	84.3	85.3	84.9	85.1	95.8	85.4	90.6
(R+M)/2 Octane Rating	(R+M)/2	(R+M)/2	93.0	92.4	92.7	94	93.0	93.5	88.5	89.0	88.7	89.8	89.8	89.8	91.2	90.9	91.0

Table E-3

2013 CRC E15 Driveability Index Volatility Program Detailed Hydrocarbon Analyses

Compositional Breakdown of Liquid by Class

NOTE: Asterisks mean no compounds of that Class & C# are in the dictionary, e.g., C5 aromatics.
NOTE: A "0" entry means no peaks of Class & C# found; a "0.000" entry means < 10 PPM found.

B0

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.003	****	0.000	****	****	0	****	0.003
C4	0.950	3.055	0.195	****	****	0	****	4.200
C5	1.711	4.355	1.684	5.657	****	0	****	13.406
C6	4.695	10.595	1.279	2.537	0.327	0	****	19.433
C7	1.157	6.818	0.541	1.077	4.751	0	****	14.344
C8	0.469	12.903	0.244	0.527	5.147	0	0.013	19.303
C9	0.196	1.609	0.006	0.257	4.507	0	0.160	6.735
C10	0.095	0.687	0	0.062	12.607	0	0.267	13.719
C11	0.600	0.331	0	0	3.796	0	0.848	5.575
C12+	0.157	0.166	0.005	0	0.334	0	2.620	3.282
Total	10.033	40.519	3.953	10.117	31.469	0.000	3.909	100.000

B1

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.002	****	0	****	****	10.612	****	10.615
C4	0.916	2.585	0.170	****	****	0	****	3.670
C5	1.547	4.158	1.491	4.950	****	0	****	12.147
C6	4.161	9.364	1.140	2.260	0.295	0	****	17.221
C7	1.040	6.069	0.485	0.974	4.282	0	****	12.849
C8	0.423	11.540	0.219	0.500	4.621	0	0.012	17.315
C9	0.192	1.424	0.005	0.234	4.058	0	0.134	6.046
C10	0.085	0.623	0	0.057	11.216	0	0.245	12.227
C11	0.533	0.299	0	0	3.389	0	0.761	4.982
C12+	0.141	0.147	0.004	0	0.297	0	2.341	2.930
Total	9.039	36.208	3.514	8.975	28.159	10.612	3.492	100.000

B2

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.002	****	0	****	****	16.527	****	16.529
C4	0.762	2.388	0.156	****	****	0	****	3.307
C5	1.475	3.643	1.423	4.650	****	0	****	11.190
C6	3.914	8.806	1.067	2.129	0.278	0	****	16.193
C7	0.977	5.693	0.456	0.920	3.998	0	****	12.045
C8	0.397	10.815	0.207	0.470	4.330	0	0.011	16.230
C9	0.179	1.334	0.005	0.218	3.799	0	0.126	5.661
C10	0.080	0.591	0	0.053	10.543	0	0.213	11.480
C11	0.501	0.279	0	0	3.184	0	0.708	4.673
C12+	0.129	0.130	0.003	0	0.269	0	2.162	2.693
Total	8.416	33.681	3.317	8.439	26.401	16.527	3.220	100.000

Table E-3 Cont'd
2013 CRC E15 Driveability Index Volatility Program Detailed Hydrocarbon

B3

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.002	****	0	****	****	21.977	****	21.979
C4	0.688	2.095	0.143	****	****	0	****	2.925
C5	1.410	3.391	1.234	4.401	****	0	****	10.435
C6	3.706	8.295	1.001	2.014	0.262	0	****	15.277
C7	0.916	5.344	0.427	0.867	3.729	0	****	11.284
C8	0.369	10.131	0.191	0.441	4.022	0	0.010	15.164
C9	0.167	1.235	0.005	0.170	3.530	0	0.116	5.221
C10	0.074	0.583	0	0.049	9.896	0	0.197	10.799
C11	0.471	0.262	0	0	2.995	0	0.664	4.391
C12+	0.121	0.122	0.002	0	0.245	0	2.034	2.525
Total	7.923	31.458	3.002	7.942	24.678	21.977	3.020	100.000

B4

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.005	****	0.000	****	****	10.349	****	10.355
C4	1.128	0.195	0.231	****	****	0	****	1.553
C5	1.876	11.902	1.810	6.308	****	0	****	21.897
C6	3.099	9.595	1.286	1.841	0.339	0	****	16.160
C7	1.180	5.840	0.560	1.074	4.863	0	****	13.516
C8	0.474	9.997	0.251	0.541	5.248	0	0.013	16.524
C9	0.199	1.636	0.006	0.260	4.517	0	0.161	6.780
C10	0.095	0.695	0	0.067	7.764	0	0.269	8.891
C11	0.178	0.260	0	0	1.935	0	0.453	2.825
C12+	0.043	0.075	0	0	0.093	0	1.287	1.498
Total	8.277	40.195	4.144	10.092	24.758	10.349	2.184	100.000

B5

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.004	****	0.000	****	****	16.196	****	16.200
C4	1.292	0.205	0.252	****	****	0	****	1.749
C5	2.097	9.935	2.074	0.207	****	0	****	14.314
C6	1.775	5.750	1.502	1.242	0.388	0	****	10.658
C7	1.349	5.376	0.640	1.192	5.636	0	****	14.194
C8	0.551	11.587	0.292	0.663	6.125	0	0.015	19.234
C9	0.232	1.879	0.007	0.305	5.291	0	0.191	7.906
C10	0.112	0.818	0	0.078	9.270	0	0.318	10.597
C11	0.211	0.305	0	0	2.345	0	0.498	3.359
C12+	0.050	0.087	0	0	0.112	0	1.540	1.789
Total	7.675	35.942	4.767	3.688	29.169	16.196	2.563	100.000

Table E-3 Cont'd
2013 CRC E15 Driveability Index Volatility Program Detailed Hydrocarbon

B6

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.004	****	0.000	****	****	21.685	****	21.689
C4	1.614	0.195	0.214	****	****	0	****	2.022
C5	1.815	8.310	1.619	3.062	****	0	****	14.805
C6	2.114	6.884	1.252	1.350	0.329	0	****	11.928
C7	1.141	4.955	0.539	1.026	4.717	0	****	12.378
C8	0.461	9.713	0.243	0.556	5.096	0	0.013	16.082
C9	0.194	1.561	0.006	0.254	4.406	0	0.157	6.578
C10	0.093	0.677	0	0.066	8.665	0	0.262	9.762
C11	0.195	0.256	0	0	2.203	0	0.426	3.079
C12+	0.044	0.081	0	0	0.107	0	1.445	1.676
Total	7.674	32.632	3.872	6.313	25.522	21.685	2.303	100.000

H1

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.010	****	0.000	****	****	0	****	0.010
C4	1.139	1.157	0.233	****	****	0	****	2.529
C5	1.895	14.424	1.868	5.770	****	0	****	23.957
C6	3.999	10.349	1.365	2.282	0.351	0	****	18.346
C7	1.235	6.681	0.578	1.132	5.067	0	****	14.692
C8	0.492	10.415	0.264	0.561	5.479	0	0.014	17.226
C9	0.225	1.711	0.006	0.274	4.741	0	0.154	7.111
C10	0.100	0.729	0	0.070	9.645	0	0.283	10.826
C11	0.216	0.275	0	0	2.425	0	0.505	3.422
C12+	0.049	0.090	0	0	0.127	0	1.615	1.881
Total	9.360	45.832	4.313	10.089	27.835	0.000	2.571	100.000

H2

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.009	****	0.000	****	****	0	****	0.009
C4	0.804	0.616	0.162	****	****	0	****	1.583
C5	1.398	15.445	1.339	15.323	****	0	****	33.505
C6	4.052	14.199	1.006	2.216	0.255	0	****	21.729
C7	0.904	5.733	0.420	0.857	3.663	0	****	11.577
C8	0.356	7.543	0.188	0.425	3.953	0	0.010	12.475
C9	0.162	1.215	0.004	0.168	3.445	0	0.115	5.109
C10	0.072	0.570	0	0.052	8.571	0	0.192	9.458
C11	0.187	0.204	0	0	2.131	0	0.397	2.919
C12+	0.037	0.073	0	0	0.093	0	1.433	1.636
Total	7.982	45.598	3.119	19.040	22.112	0.000	2.148	100.000

Table E-3 Cont'd
2013 CRC E15 Driveability Index Volatility Program Detailed Hydrocarbon

H3

1. By Volume% and Carbon Number:								
C#	N-Para	I-Para	Olefin	Naphth	Aromat	Oxygen-ates	Not Classified	Total Per Carbon
C3-	0.011	****	0.000	****	****	0	****	0.011
C4	0.837	0.168	0.170	****	****	0	****	1.176
C5	1.400	15.030	1.329	21.008	****	0	****	38.767
C6	2.615	15.492	0.958	1.514	0.248	0	****	20.826
C7	0.864	4.554	0.404	0.796	3.567	0	****	10.186
C8	0.346	7.332	0.184	0.415	3.836	0	0.010	12.122
C9	0.157	1.176	0.004	0.213	3.316	0	0.110	4.978
C10	0.070	0.494	0	0.050	7.192	0	0.186	7.991
C11	0.160	0.194	0	0	1.822	0	0.361	2.536
C12+	0.035	0.066	0	0	0.098	0	1.207	1.407
Total	6.496	44.507	3.050	23.995	20.078	0.000	1.874	100.000

APPENDIX F

DATA SUMMARY

Table F-1
2013 CRC E15 Driveability Index Volatility Program Raw Data

Vehicle	Run #	Fuel	Rater	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD
1	6	B3	A	2/12/13	10:45	36	42	19.5
2	1	B3	B	2/12/13	9:44	36	39	26.5
3	4	B3	A	2/12/13	10:20	36	40	10
5	6	B3	B	2/12/13	10:44	36	42	34
6	2	B3	C	2/12/13	9:57	36	39	20
10	3	B3	B	2/12/13	10:08	36	40	79
16	4	B6	B	2/12/13	10:21	36	40	32
17	3	B6	C	2/12/13	10:08	36	39	10.5
19	2	B6	B	2/12/13	9:56	36	39	42
21	1	B6	C	2/12/13	9:40	36	39	57.5
22	1	B6	A	2/12/13	9:45	36	39	20
26	6	B6	C	2/12/13	10:42	36	42	13
28	5	B0	C	2/12/13	10:30	36	40	27
30	3	B0	A	2/12/13	10:08	36	40	39.5
31	4	B0	C	2/12/13	10:19	36	40	42.5
33	5	B0	A	2/12/13	10:33	36	40	19
34	5	B0	B	2/12/13	10:37	36	40	54.5
35	2	B0	A	2/12/13	9:55	36	39	15
1	6	H1	A	2/13/13	9:46	42	47	22
2	2	H1	B	2/13/13	9:05	42	39	28.5
3	5	H1	A	2/13/13	9:35	42	47	16
5	5	H1	B	2/13/13	9:37	42	47	36.5
6	4	H1	C	2/13/13	9:29	42	44	20
10	1	H1	B	2/13/13	8:52	42	39	63
16	6	B1	B	2/13/13	9:48	42	47	46.5
17	5	B1	C	2/13/13	9:38	42	45	10
19	3	B1	B	2/13/13	9:16	42	45	45.5
21	2	B1	C	2/13/13	9:04	42	39	35.5
22	3	B1	A	2/13/13	9:15	42	45	12
26	6	B1	C	2/13/13	9:44	42	47	10
28	1	H3	C	2/13/13	8:51	42	39	17.5
30	2	H3	A	2/13/13	9:05	42	39	13
31	3	H3	C	2/13/13	9:15	42	45	7.5
33	1	H3	A	2/13/13	8:53	42	39	5
34	4	H3	B	2/13/13	9:26	42	45	46.5
35	4	H3	A	2/13/13	9:25	42	44	8
1	5	B5	A	2/14/13	9:21	38	42	27
2	1	B5	B	2/14/13	8:40	38	39	40.5
3	3	B5	A	2/14/13	9:00	38	39	22
5	4	B5	B	2/14/13	9:13	38	42	61.5
6	2	B5	C	2/14/13	8:53	38	39	49.5
10	3	B5	B	2/14/13	9:11	38	39	68.5
16	5	H2	B	2/14/13	9:24	38	42	56
17	5	H2	C	2/14/13	9:24	38	42	6.5
19	2	H2	B	2/14/13	8:52	38	39	45.5

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

21	1	H2	C	2/14/13	8:39	38	39	20
22	2	H2	A	2/14/13	8:49	38	39	19
26	6	H2	C	2/14/13	9:31	38	42	10
28	3	B2	C	2/14/13	8:59	38	39	23.5
30	4	B2	A	2/14/13	9:10	38	42	28.5
31	4	B2	C	2/14/13	9:12	38	42	18
33	1	B2	A	2/14/13	8:38	38	39	46
34	6	B2	B	2/14/13	9:35	38	42	53.5
35	6	B2	A	2/14/13	9:34	38	42	12
1	1	B4	B	2/15/13	9:36	34	40	31
2	2	B4	A	2/15/13	9:47	34	40	26
3	5	B4	C	2/15/13	10:17	34	42	23
5	6	B4	C	2/15/13	10:26	34	42	16.5
6	4	B4	B	2/15/13	10:06	34	42	26
10	5	B4	A	2/15/13	10:17	34	42	22
16	2	B0	C	2/15/13	9:46	34	40	32
17	3	B0	B	2/15/13	9:56	34	40	37.5
19	3	B0	A	2/15/13	9:56	34	40	15.5
21	4	B0	A	2/15/13	10:06	34	42	58
22	1	B0	C	2/15/13	9:38	34	40	24
26	5	B0	B	2/15/13	10:16	34	42	33
28	1	B6	A	2/15/13	9:37	34	40	14.5
30	4	B6	C	2/15/13	10:07	34	42	57.5
31	2	B6	B	2/15/13	9:46	34	40	31.5
33	6	B6	B	2/15/13	10:30	34	42	39
34	6	B6	A	2/15/13	10:27	34	42	47
35	3	B6	C	2/15/13	9:58	34	40	7
1	1	B2	B	2/17/13	9:10	36	39	61
2	6	B2	A	2/17/13	10:06	36	43	11
3	3	B2	C	2/17/13	9:40	36	42	30
5	4	B2	C	2/17/13	9:50	36	42	33
6	3	B2	B	2/17/13	9:39	36	42	46.5
10	1	B2	A	3/17/13	9:21	36	39	34
16	5	H1	C	2/17/13	10:00	36	42	27
17	4	H1	B	2/17/13	9:50	36	42	34.5
19	2	H1	A	2/17/13	9:24	36	39	9.5
21	3	H1	A	2/17/13	9:35	36	42	14
22	2	H1	C	2/17/13	9:25	36	39	12.5
26	5	H1	B	2/17/13	9:55	36	42	33
28	4	H2	A	2/17/13	9:46	36	42	7.5
30	1	H2	C	2/17/13	9:10	36	39	13.5
31	2	H2	B	2/17/13	9:25	36	39	30
33	6	H2	B	2/17/13	10:16	36	43	27
34	5	H2	A	2/17/13	9:56	36	42	29
35	6	H2	C	2/17/13	10:10	36	43	7
1	6	H2	B	2/18/13	10:41	36	43	46.5
2	5	H2	A	2/18/13	10:33	36	41	17.5

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

3	1	H2	C	2/18/13	9:48	36	39	12
5	3	H2	C	2/18/13	10:10	36	41	24
6	2	H2	B	2/18/13	9:55	36	39	20
10	4	H2	A	2/18/13	10:20	36	41	19
16	5	B3	C	2/18/13	10:35	36	41	29
17	4	B3	B	2/18/13	10:15	36	41	34
19	*2*	*B3*	*A*	*2/18/13*	*9:58*	*36*	*39*	*3*
21	3	B3	A	2/18/13	10:10	36	39	73.5
22	4	B3	C	2/18/13	10:25	36	41	21.5
26	1	B3	B	2/18/13	9:45	36	39	33
28	6	B5	A	2/18/13	10:42	36	43	6.5
30	2	B5	C	2/18/13	9:55	36	39	54.5
31	5	B5	B	2/18/13	10:26	36	41	31
33	3	B5	B	2/18/13	10:06	36	41	73.5
34	1	B5	A	2/18/13	9:50	36	39	47
35	6	B5	C	2/18/13	10:45	36	43	6
1	6	H3	B	2/20/13	11:01	28	40	41
2	4	H3	A	2/20/13	10:42	28	40	15
3	1	H3	C	2/20/13	10:10	28	38	17
5	4	H3	C	2/20/13	10:40	28	40	17.5
6	2	H3	B	2/20/13	10:19	28	38	34
10	1	H3	A	2/20/13	10:08	28	38	24
16	2	B4	C	2/20/13	10:20	28	38	15.5
17	5	B4	B	2/20/13	10:50	28	40	35
19	5	B4	A	2/20/13	10:50	28	40	8.5
21	3	B4	A	2/20/13	10:30	28	38	31.5
22	6	B4	C	2/20/13	11:00	28	40	18
26	1	B4	B	2/20/13	10:07	28	38	32
28	6	H1	A	2/20/13	11:03	28	40	11.5
30	3	H1	C	2/20/13	10:30	28	38	32
31	4	H1	B	2/20/13	10:39	28	40	36.5
33	3	H1	B	2/20/13	10:28	28	38	37
34	2	H1	A	2/20/13	10:21	28	38	36
35	5	H1	C	2/20/13	10:50	28	40	7.5
1	3	B6	A	2/21/13	9:23	32	38	33
2	1	B6	B	2/21/13	9:10	32	38	35
3	4	B6	A	2/21/13	9:35	32	40	13
5	3	B6	B	2/21/13	9:30	32	38	50.5
6	3	B6	C	2/21/13	9:30	32	38	50.5
10	4	B6	B	2/21/13	9:40	32	40	89
16	5	B2	B	2/21/13	9:50	32	40	59.5
17	5	B2	C	2/21/13	9:53	32	40	11
19	6	B2	B	2/21/13	10:00	32	40	58
21	4	B2	C	2/21/13	9:40	32	40	63
22	1	B2	A	2/21/13	9:01	32	38	23.5
26	2	B2	C	2/21/13	9:12	32	38	11
28	6	B3	C	2/21/13	10:01	32	40	35

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

30	6	B3	A	2/21/13	9:56	32	40	43
31	1	B3	C	2/21/13	9:07	32	38	7
33	*5*	*B3*	*A*	*2/21/13*	*9:45*	*32*	*40*	*156.5*
34	2	B3	B	2/21/13	9:20	32	38	52.5
35	2	B3	A	2/21/13	9:12	32	38	10
1	2	B1	A	2/23/13	9:16	32	40	60
2	4	B1	B	2/23/13	9:40	32	42	36.5
3	4	B1	A	2/23/13	9:40	32	42	21
5	2	B1	B	2/23/13	9:15	32	40	64
6	4	B1	C	2/23/13	9:44	32	42	23
10	6	B1	B	2/23/13	10:00	32	44	70
16	3	B5	B	2/23/13	9:30	32	40	62
17	1	B5	C	2/23/13	9:09	32	38	7
19	1	B5	B	2/23/13	9:05	32	38	52.5
21	5	B5	C	2/23/13	9:52	32	42	61.5
22	1	B5	A	2/23/13	9:05	32	38	15.5
26	3	B5	C	2/23/13	9:29	32	40	18
28	6	B4	C	2/23/13	10:03	32	44	10
30	6	B4	A	2/23/13	10:01	32	44	28
31	2	B4	C	2/23/13	9:17	32	40	9.5
33	3	B4	A	2/23/13	9:27	32	41	29.5
34	5	B4	B	2/23/13	9:50	32	42	49
35	5	B4	A	2/23/13	9:50	32	42	3
1	6	B1	A	2/24/13	9:35	34	42	17.5
2	2	B1	B	2/24/13	8:49	34	42	45
3	4	B1	A	2/24/13	9:10	34	42	14
5	4	B1	B	2/24/13	9:12	34	42	50.5
6	5	B1	C	2/24/13	9:22	34	42	19.5
10	1	B1	B	2/24/13	8:37	34	41	79
16	3	B5	B	2/24/13	9:01	34	43	74.5
17	2	B5	C	2/24/13	8:48	34	42	8.5
19	5	B5	B	2/24/13	9:22	34	42	40
21	4	B5	C	2/24/13	9:11	34	42	59.5
22	5	B5	A	2/24/13	9:20	34	42	22.5
26	1	B5	C	2/24/13	8:36	34	41	13
28	3	B4	C	2/24/13	9:00	34	43	12
30	2	B4	A	2/24/13	8:50	34	42	10.5
31	6	B4	C	2/24/13	9:34	34	42	7
33	1	B4	A	2/24/13	8:35	34	41	20
34	6	B4	B	2/24/13	9:34	34	42	44
35	3	B4	A	2/24/13	9:00	34	43	7.5
1	4	B0	A	2/25/13	8:35	37	40	19.5
2	2	B0	B	2/25/13	8:16	37	39	28.5
3	5	B0	A	2/25/13	8:45	37	42	12.5
5	3	B0	B	2/25/13	8:26	37	39	49
6	6	B0	C	2/25/13	8:58	37	42	16.5
10	1	B0	B	2/25/13	8:04	37	37	70

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

16	4	H3	B	2/25/13	8:37	37	40	46.5
17	3	H3	C	2/25/13	8:24	37	39	6.5
19	5	H3	B	2/25/13	8:48	37	42	36.5
21	1	H3	C	2/25/13	8:06	37	37	12.5
22	3	H3	A	2/25/13	8:25	37	39	23
26	2	H3	C	2/25/13	8:15	37	38	10
28	4	B1	C	2/25/13	8:35	37	40	23
30	2	B1	A	2/25/13	8:15	37	38	33.5
31	5	B1	C	2/25/13	8:46	37	42	17.5
33	1	B1	A	2/25/13	8:05	37	37	28.5
34	6	B1	B	2/25/13	8:59	37	42	62.5
35	6	B1	A	2/25/13	8:55	37	42	9.5
1	1	B4	C	2/26/13	8:43	31	37	21
2	2	B4	C	2/26/13	8:48	31	38	11
3	4	B4	B	2/26/13	9:20	31	38	59
5	2	B4	A	2/26/13	8:55	31	38	20.5
6	4	B4	A	2/26/13	9:20	31	38	18
10	5	B4	C	2/26/13	9:30	31	39	13.5
16	5	B0	A	2/26/13	9:30	31	39	27
17	6	B0	A	2/26/13	9:40	31	40	39.5
19	4	B0	C	2/26/13	9:19	31	38	40
21	3	B0	B	2/26/13	9:07	31	38	108.5
22	1	B0	B	2/26/13	8:43	31	37	34.5
26	3	B0	A	2/26/13	9:10	31	38	25
28	6	B6	B	2/26/13	9:42	31	40	38.5
30	2	B6	B	2/26/13	8:52	31	38	95
31	1	B6	A	2/26/13	8:45	31	37	16.5
33	3	B6	C	2/26/13	9:08	31	38	138.5
34	6	B6	C	2/26/13	9:41	31	40	10.5
35	5	B6	B	2/26/13	9:30	31	39	26.5
1	2	H1	C	2/27/13	8:56	34	40	30
2	3	H1	C	2/27/13	9:04	34	42	8.5
3	1	H1	B	2/27/13	8:44	34	39	36
5	6	H1	A	2/27/13	9:40	34	43	23.5
6	2	H1	A	2/27/13	8:55	34	40	15.5
10	6	H1	C	2/27/13	9:40	34	43	12
16	3	B1	A	2/27/13	9:05	34	41	30
17	5	B1	A	2/27/13	9:30	34	42	17
19	5	B1	C	2/27/13	9:30	34	42	31
21	4	B1	B	2/27/13	9:20	34	42	95.5
22	2	B1	B	2/27/13	8:54	34	40	18.5
26	1	B1	A	2/27/13	8:45	34	39	25
28	5	H3	B	2/27/13	9:31	34	42	49
30	3	H3	B	2/27/13	9:06	34	41	68.5
31	4	H3	A	2/27/13	9:15	34	42	17.5
33	4	H3	C	2/27/13	9:18	34	42	15
34	1	H3	C	2/27/13	8:38	34	39	16.5

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

35	6	H3	B	2/27/13	9:41	34	43	26
1	3	B3	C	3/3/13	8:29	38	38	32.5
2	4	B3	C	3/3/13	8:41	38	38	13
3	5	B3	B	3/3/13	8:52	38	41	63
5	1	B3	A	3/3/13	8:09	38	37	45
6	5	B3	A	3/3/13	8:53	38	41	31.5
10	2	B3	C	3/3/13	8:18	38	37	24
16	6	B6	A	3/3/13	9:03	38	42	16
17	2	B6	A	3/3/13	8:22	38	37	23
19	1	B6	C	3/3/13	8:10	38	37	11.5
21	6	B6	B	3/3/13	9:01	38	42	78
22	4	B6	B	3/3/13	8:41	38	40	38
26	4	B6	A	3/3/13	8:42	38	40	31
28	2	B0	B	3/3/13	8:20	38	37	42.5
30	1	B0	B	3/3/13	8:09	38	37	94
31	3	B0	A	3/3/13	8:32	38	38	58
33	5	B0	C	3/3/13	8:52	38	41	65
34	6	B0	C	3/3/13	9:01	38	42	17
35	3	B0	B	3/3/13	8:31	38	38	37
1	5	B3	C	3/4/13	9:10	34	40	34
2	6	B3	C	3/4/13	9:23	34	40	6
3	2	B3	B	3/4/13	8:43	34	38	48
5	5	B3	A	3/4/13	9:15	34	40	8.5
6	6	B3	A	3/4/13	9:25	34	40	25
10	4	B3	C	3/4/13	9:03	34	40	36.5
16	1	B6	A	3/4/13	8:34	34	37	26.5
17	2	B6	A	3/4/13	8:44	34	38	9.5
19	1	B6	C	3/4/13	8:33	34	37	17
21	6	B6	B	3/4/13	9:24	34	40	96
22	3	B6	B	3/4/13	8:53	34	39	28
26	4	B6	A	3/4/13	9:05	34	40	25
28	4	B0	B	3/4/13	9:03	34	40	52.5
30	5	B0	B	3/4/13	9:13	34	40	93.5
31	3	B0	A	3/4/13	8:55	34	39	31
33	2	B0	C	3/4/13	8:43	34	38	47.5
34	3	B0	C	3/4/13	8:53	34	39	14.5
35	1	B0	B	3/4/13	8:32	34	37	44.5
1	4	H3	C	3/7/13	8:41	37	40	31.5
2	3	H3	C	3/7/13	8:34	37	40	6
3	5	H3	B	3/7/13	8:53	37	40	33.5
5	2	H3	A	3/7/13	8:23	37	39	7
6	1	H3	A	3/6/13	8:17	37	38	8.5
10	2	H3	C	3/7/13	8:28	37	39	13
16	4	B4	A	3/7/13	8:42	37	40	18
17	6	B4	A	3/7/13	9:01	37	40	8
19	6	B4	C	3/7/13	9:03	37	40	8
21	3	B4	B	3/7/13	8:33	37	39	58

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

22	6	B4	B	3/7/13	9:02	37	40	20.5
26	3	B4	A	3/7/13	8:33	37	39	18
28	2	H1	B	3/7/13	8:24	37	39	20
30	4	H1	B	3/7/13	8:43	37	40	50.5
31	5	H1	A	3/7/13	8:52	37	40	21
33	5	H1	C	3/7/13	8:54	37	40	21
34	1	H1	C	3/7/13	8:13	37	38	17.5
35	1	H1	B	3/7/13	8:14	37	38	32.5
1	1	B5	C	3/8/13	8:00	38	38	22.5
2	5	B5	C	3/8/13	8:42	38	40	6
3	2	B5	B	3/8/13	8:13	38	38	63
5	1	B5	A	3/8/13	8:05	38	38	27.5
6	5	B5	A	3/8/13	8:45	38	40	37.5
10	6	B5	C	3/8/13	8:54	38	41	12.5
16	2	H2	A	3/8/13	8:15	38	38	19
17	4	H2	A	3/8/13	8:35	38	40	7
19	4	H2	C	3/8/13	8:32	38	40	8
21	4	H2	B	3/8/13	8:33	38	40	36
22	6	H2	B	3/8/13	8:53	38	41	13.5
26	3	H2	A	3/8/13	8:25	38	39	13
28	3	B2	B	3/8/13	8:24	38	39	32
30	5	B2	B	3/8/13	8:43	38	40	84
31	6	B2	A	3/8/13	8:54	38	41	24.5
33	2	B2	C	3/8/13	8:14	38	38	43.5
34	3	B2	C	3/8/13	8:23	38	39	8.5
35	1	B2	B	3/8/13	8:03	38	38	39
1	4	B5	C	3/9/13	8:19	39	40	29
2	5	B5	C	3/9/13	8:32	39	40	8.5
3	5	B5	B	3/9/13	8:31	39	40	52
5	5	B5	A	3/9/13	8:34	39	40	23.5
6	1	B5	A	3/9/13	7:52	39	39	20.5
10	2	B5	C	3/9/13	8:02	39	40	12
16	6	H2	A	3/9/13	8:44	39	42	24
17	3	H2	A	3/9/13	8:12	39	40	8
19	6	H2	C	3/9/13	8:42	39	42	9
21	2	H2	B	3/9/13	8:01	39	40	53
22	4	H2	B	3/9/13	8:20	39	40	26.5
26	2	H2	A	3/9/13	8:02	39	40	22
28	1	B2	B	3/9/13	7:51	39	39	44.5
30	3	B2	B	3/9/13	8:11	39	40	73.5
31	4	B2	A	3/9/13	8:21	39	40	12.5
33	3	B2	C	3/9/13	8:13	39	40	32.5
34	1	B2	C	3/9/13	7:53	39	39	12.5
35	6	B2	B	3/9/13	8:41	39	42	32.5
1	2	B5	B	3/10/13	7:50	41	37	35.5
2	1	B5	A	3/10/13	7:40	41	37	9
3	2	B2	C	3/10/13	7:40	41	37	12

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

5	4	B5	C	3/10/13	8:12	41	37	34.5
6	3	B5	B	3/10/13	8:00	41	37	52.5
10	3	B5	A	3/10/13	8:08	41	37	40
16	1	H2	C	3/10/13	7:40	41	37	18.5
17	1	H2	B	3/10/13	7:40	41	37	37.5
19	2	H2	A	3/10/13	7:49	41	37	19.5
21	6	H2	A	3/10/13	8:34	41	39	20.5
22	6	H2	C	3/10/13	8:32	41	39	7.5
26	4	H2	B	3/10/13	8:10	41	37	41
28	5	B2	A	3/10/13	8:20	41	37	33.5
30	5	B2	C	3/10/13	8:22	41	37	78
31	5	B2	B	3/10/13	8:20	41	37	28.5
33	6	B2	B	3/10/13	8:30	41	39	60.5
34	4	B2	A	3/10/13	8:10	41	37	47
35	3	B2	C	3/10/13	8:03	41	37	16.5
1	3	B6	B	3/12/13	7:07	45	42	50.5
2	6	B6	A	3/12/13	7:38	45	41	27
3	2	B6	C	3/12/13	7:00	45	42	14
5	3	B6	C	3/12/13	7:08	45	42	18.5
6	6	B6	B	3/12/13	7:40	45	41	36.5
10	3	B6	A	3/12/13	7:08	45	42	38
16	1	B2	C	3/12/13	6:46	45	42	23
17	1	B2	B	3/12/13	6:51	45	43	36.5
19	1	B2	A	3/12/13	6:47	45	43	29.5
21	5	B2	A	3/12/13	7:28	45	41	35.5
22	5	B2	C	3/12/13	7:30	45	41	12.5
26	5	B2	B	3/12/13	7:28	45	41	40
28	2	B3	A	3/12/13	6:59	45	42	34
30	6	B3	C	3/12/13	7:40	45	41	29.5
31	2	B3	B	3/12/13	6:58	45	42	44
33	4	B3	B	3/12/13	7:20	45	42	54
34	4	B3	A	3/12/13	7:17	45	42	47.5
35	4	B3	C	3/12/13	7:25	45	42	15
1	2	B2	C	3/13/13	6:11	50	42	15.5
2	3	B2	C	3/13/13	6:24	50	43	10.5
3	6	B2	B	3/13/13	6:53	50	42	50
5	1	B2	A	3/13/13	6:02	50	42	15
6	3	B2	A	3/13/13	6:24	50	43	18.5
10	5	B2	C	3/13/13	6:47	50	42	13
16	2	H1	A	3/13/13	6:13	50	42	36
17	5	H1	A	3/13/13	6:44	50	42	8
19	4	H1	C	3/13/13	6:36	50	42	15
21	5	H1	B	3/13/13	6:45	50	42	66.5
22	3	H1	B	3/13/13	6:25	50	43	26.5
26	4	H1	A	3/13/13	6:33	50	42	21
28	2	H2	B	3/13/13	6:11	50	42	32.5
30	1	H2	B	3/13/13	6:03	50	42	72.5

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

31	6	H2	A	3/13/13	6:53	50	42	36.5
33	6	H2	C	3/13/13	6:56	50	42	20
34	1	H2	C	3/13/13	6:02	50	42	14.5
35	4	H2	B	3/13/13	6:41	50	42	30.5
1	5	B1	B	3/15/13	7:11	47	37	47.5
2	6	B1	A	3/15/13	7:23	47	39	18
3	6	B1	C	3/15/13	7:24	47	39	26
5	3	B1	C	3/15/13	6:58	47	37	32.5
6	6	B1	B	3/15/13	7:26	47	39	36.5
10	1	B1	A	3/15/13	6:34	47	37	29
16	1	B5	C	3/15/13	6:35	47	37	12
17	1	B5	B	3/15/13	6:36	47	37	38
19	3	B5	A	3/15/13	6:54	47	37	28
21	5	B5	A	3/15/13	7:14	47	38	29
22	5	B5	C	3/15/13	7:12	47	38	9.5
26	4	B5	B	3/15/13	7:02	47	37	45
28	4	B4	A	3/15/13	7:04	47	37	9
30	4	B4	C	3/15/13	7:05	47	37	17.5
31	3	B4	B	3/15/13	6:55	47	37	48.5
33	2	B4	B	3/15/13	6:45	47	36	47
34	2	B4	A	3/15/13	6:44	47	36	50.5
35	2	B4	C	3/15/13	6:45	47	36	7
1	3	B0	B	3/16/13	6:52	45	37	50
2	4	B0	A	3/16/13	7:04	45	37	24
3	6	B0	C	3/16/13	7:25	45	37	24
5	1	B0	C	3/16/13	6:30	45	38	26
6	1	B0	B	3/16/13	6:36	45	38	31
10	6	B0	A	3/16/13	7:25	45	37	26
16	3	H3	C	3/16/13	7:55	45	37	11
17	6	H3	B	3/16/13	7:27	45	37	32.5
19	1	H3	A	3/16/13	6:34	45	38	26
21	2	H3	A	3/16/13	6:44	45	37	23
22	4	H3	C	3/16/13	7:06	45	37	7
26	5	H3	B	3/16/13	7:14	45	37	45
28	5	B1	A	3/16/13	7:14	45	37	18.5
30	5	B1	C	3/16/13	7:15	45	37	44.5
31	2	B1	B	3/16/13	6:45	45	37	26
33	4	B1	B	3/16/13	7:06	45	37	56.5
34	3	B1	A	3/16/13	6:54	45	37	45
35	2	B1	C	3/16/13	6:45	45	37	7
1	4	H2	C	3/17/13	8:32	36	39	32.5
2	5	H2	C	3/17/13	8:40	36	39	6.5
3	3	H2	B	3/17/13	8:22	36	39	59
5	6	H2	A	3/17/13	8:51	36	39	5.5
6	5	H2	A	3/17/13	8:46	36	39	6.5
10	6	H2	C	3/17/13	8:55	36	39	10
16	4	B3	A	3/17/13	8:31	36	39	31

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

17	2	B3	A	3/17/13	8:16	36	39	16
19	3	B3	C	3/17/13	8:25	36	39	19
21	2	B3	B	3/17/13	8:15	36	39	94.5
22	6	B3	B	3/17/13	8:55	36	39	43
26	3	B3	A	3/17/13	8:22	36	39	31.5
28	1	B5	B	3/17/13	8:03	36	39	41.5
30	5	B5	B	3/17/13	8:43	36	39	107
31	1	B5	A	3/17/13	8:03	36	39	32.5
33	1	B5	C	3/17/13	8:07	36	39	65
34	2	B5	C	3/17/13	8:15	36	39	24
35	4	B5	B	3/17/13	8:41	36	39	32
1	1	B3	B	3/18/13	8:43	32	37	48.5
2	1	B3	A	3/18/13	8:42	32	37	31.5
3	1	B3	C	3/18/13	8:40	32	37	18
5	3	B3	C	3/18/13	9:00	32	39	26
6	4	B3	B	3/18/13	9:15	32	40	51
10	4	B3	A	3/18/13	9:17	32	40	31
16	5	B3	B	3/18/13	9:26	32	41	72.5
17	5	B3	C	3/18/13	9:25	32	41	6.5
19	3	B3	B	3/18/13	9:04	32	39	49.5
21	6	B3	C	3/18/13	9:30	32	42	79
22	3	B3	A	3/18/13	9:10	32	39	16
26	2	B3	C	3/18/13	8:50	32	38	12
28	6	B3	B	3/18/13	9:33	32	42	46.5
30	2	B3	B	3/18/13	8:55	32	38	95.5
31	2	B3	A	3/18/13	8:52	32	28	18.5
33	4	B3	C	3/18/13	9:10	32	40	28
34	7	B3	C	3/18/13	9:40	32	42	12.5
35	7	B3	B	3/18/13	9:44	32	42	27
1	1	B3	A	3/19/13	8:30	36	37	30.5
2	1	B3	B	3/19/13	8:30	36	37	42.5
3	2	B3	A	3/19/13	8:41	36	37	10
5	2	B3	B	3/19/13	8:40	36	37	71.5
6	1	B3	C	3/19/13	8:34	36	37	11
10	2	B3	B	3/19/13	8:50	36	37	66
16	2	B3	C	3/19/13	8:39	36	37	57
17	4	B3	B	3/19/13	9:00	36	38	28
19	3	B3	A	3/19/13	8:51	36	37	28.5
21	4	B3	A	3/19/13	9:02	36	38	50.5
22	3	B3	C	3/19/13	8:52	36	37	15
26	5	B3	B	3/19/13	9:10	36	38	43
28	4	B3	C	3/19/13	8:59	36	38	27
30	7	B3	A	3/19/13	9:30	36	40	78
31	5	B3	C	3/19/13	9:10	36	38	11
33	5	B3	A	3/19/13	9:12	36	38	33
34	6	B3	B	3/19/13	9:20	36	40	46.5
35	6	B3	A	3/19/13	9:22	36	40	16

Table F-1 Cont'd.
2013 CRC E15 Driveability Index Volatility Program Raw Data

1	1	B3	C	3/21/13	8:40	35	37	36
2	2	B3	C	3/21/13	8:50	35	38	16.5
3	1	B3	B	3/21/13	8:41	35	37	41
5	2	B3	A	3/21/13	8:54	35	38	28
6	1	B3	A	3/21/13	8:44	35	37	21
10	4	B3	C	3/21/13	9:10	35	42	26
16	3	B3	A	3/21/13	9:03	35	41	40
17	5	B3	A	3/21/13	9:23	35	44	22
19	3	B3	C	3/21/13	9:00	35	41	0
21	3	B3	B	3/21/13	9:00	35	41	96
22	2	B3	B	3/21/13	8:51	35	38	34.5
26	6	B3	A	3/21/13	9:34	35	45	20.5
28	4	B3	A	3/21/13	9:14	35	42	37
30	6	B3	C	3/21/13	9:30	35	45	34.5
31	5	B3	B	3/21/13	9:21	35	44	36.5
33	4	B3	B	3/21/13	9:11	35	42	47
34	7	B3	A	3/21/13	9:43	35	45	42.5
35	5	B3	C	3/21/13	9:20	35	44	8.5
1	1	H1	A	3/22/13	9:11	32	37	30
3	2	H1	A	3/22/13	9:21	32	38	26
5	1	H1	B	3/22/13	9:10	32	37	44
16	2	B1	B	3/22/13	9:20	32	38	70.5
17	1	B1	C	3/22/13	9:11	32	37	24.5
19	3	B1	B	3/22/13	9:30	32	38	30.5
21	2	B1	C	3/22/13	9:21	32	38	60
22	3	B1	A	3/22/13	9:31	32	38	24
26	3	B1	C	3/22/13	9:30	32	38	20
28	4	H3	C	3/22/13	9:40	32	38	45
30	4	H3	A	3/22/13	9:40	32	38	19
31	5	H3	C	3/22/13	9:49	32	39	7.5
33	5	H3	A	3/22/13	9:50	32	38	11
34	4	H3	B	3/22/13	9:40	32	38	50
35	6	H3	A	3/22/13	10:00	32	39	5