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2008 CRC COLD-START AND WARMUP E85 COLD AMBIENT TEMPERATURE DRIVEABILITY PROGRAM

Final Report

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COORDINATING RESEARCH COUNCIL, INC.
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2008 CRC Cold-Start and Warmup E85 Cold Ambient Temperature Driveability Program

(CRC Project No. CM-138-08-2)

Prepared by the

CRC Volatility Group

July 2009

CRC Performance Committee
of the
Coordinating Research Council

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ABSTRACT

The 2008 CRC Cold-Start and Warm-Up E85 Cold Ambient Temperature Driveability Program was conducted at the Imperial Oil automotive test centre in Sarnia, Ontario, Canada from September 25 through December 18, 2008. The objective of the program was to determine the effect of vapor pressure and hydrocarbon content of E75/E85 fuel ethanol on cold-start and warm-up driveability performance under cold ambient conditions in a large group of late-model E85 flexible-fuel (flex-fuel) vehicles equipped with fuel injection systems. There were twenty late-model (2007 – 2008) E85 flex-fuel vehicles in the program.

The test fuel design consisted of eight test fuels: six E75/E85 blends and two hydrocarbon-only fuels. The E75/E85 blends varied in vapor pressure and hydrocarbon content. Two of the E75/E85 blends met the minimum vapor pressure requirements of ASTM Specification D5798 volatility Class 3 but with different hydrocarbon levels. Two E75/E85 blends met midrange Class 2 vapor pressure limits with two hydrocarbon levels. One E85 blend was prepared to represent the volatility of blending the lowest vapor pressure gasoline found in north-central states during the wintertime with denatured fuel ethanol. The last blend, which was not tested, was prepared as a center point fuel to assist in determining linearity of vehicle response. The two gasolines varied in vapor pressure from the maximum vapor pressure (15 psi) allowed in ASTM Specification D4814 to the lowest vapor pressure found in north-central states during the wintertime. It should also be noted that this study is not comprehensive in representing the entire fleet and may not reflect all situations that may be encountered in the legacy fleet.

For E75/E85 fuels, cold-start and warm-up driveability improved with increasing ambient temperature, increasing vapor pressure, and increasing hydrocarbon content. For hydrocarbon gasoline (E0), cold-start and warm-up driveability improved with increasing ambient temperature and increasing vapor pressure. The effects of ambient temperature on cold-start and warm-up driveability were more pronounced on the E75/E85 fuels than for E0 fuels. The effects of vapor pressure on cold-start and warm-up driveability were more pronounced at the coldest temperatures with the E75/E85 fuels. At +20°F, there was no difference in vapor pressure sensitivity between E75/E85 and E0 fuels. Total weighted demerits for the current program at +20°F were comparable to the total weighted demerits from the 2008 E85 Yakima Program at a similar ambient temperature.

I. INTRODUCTION

The Coordinating Research Council (CRC) conducted a program in late 2008 to investigate cold-start and warm-up driveability of flexible fuel vehicles on nominal 75 to 85 volume percent denatured ethanol blends (E75/E85) with varying vapor pressures and hydrocarbon contents, and compared their performance to hydrocarbon gasoline.

The ASTM D5798 Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines[(1)] specifies minimum vapor pressure limits for three volatility classes. The volatility classes are assigned based on the six-hour minimum ambient temperature expected for the month. For the warmer ambient temperature Class 1, the amount of hydrocarbon is allowed to range from 17 to 21 volume percent (includes denaturant). For the intermediate temperature Class 2, the amount of hydrocarbon is allowed to range from 17 to 26 volume percent (includes denaturant). For the coldest ambient temperature Class 3, the amount of hydrocarbon is allowed to range from 17 to 30 volume percent (includes denaturant). Early in 2008, the CRC conducted a cold-start and warm-up driveability of flexible fuel vehicles under ASTM D5798 Classes 1 and 2 ambient conditions[(2)]. This earlier program was conducted on a test track in Yakima, Washington. The current cold-weather driveability program was conducted at Class 3 ambient temperatures in an All-Weather Chassis Dynamometer facility. It has been reported that for cold-start driveability studies, a good correlation exists between on-road and chassis dynamometer data.

The 2008 CRC Cold-Start and Warm-Up E85 Cold Ambient Temperature Driveability Program was conducted at the Imperial Oil automotive test centre in Sarnia, Ontario, Canada from September 25 through December 18, 2008. Members of the Data Analysis Panel and on-site participants in the program are listed in Appendices A and B, respectively. Appendix C outlines the program as originally approved by the CRC Performance Committee. Appendix D includes the driveability test procedure along with the specifically developed E85 flex-fuel vehicles draining and flushing procedure which was modified based on the findings of the earlier 2008 E85 Yakima program.

It should be noted that the study described in this report is not comprehensive in representing the entire fleet and may not reflect all situations that may be encountered in the legacy fleet.

II. CONCLUSIONS

The conclusions of the 2008 CRC Cold-Start and Warm-Up E85 Cold Ambient Temperature Driveability Program are as follow:

- For E75/E85 fuels, cold-start and warm-up driveability improved with:
  - increasing ambient temperature
  - increasing vapor pressure
  - increasing hydrocarbon content

- For hydrocarbon gasoline (E0), cold-start and warm-up driveability improved with:
  - increasing ambient temperature
  - increasing vapor pressure

- The effects of ambient temperature on cold-start and warm-up driveability were more pronounced on the E75/E85 fuels than for E0 fuels.

- The effects of vapor pressure on cold-start and warm-up driveability were more pronounced at the coldest temperatures with the E75/E85 fuels. At +20°F, there is no difference in vapor pressure sensitivity between E75/E85 and E0 fuels.

- There were no no-starts with any of the fuels at +20°F. There were increasing no-starts with decreasing temperature for the E75/E85 fuels. It should be noted that E0 fuels had higher vapor pressures than the E75/E85 fuels.

- Increased fuel flushing and filling volume decreased the fuel carryover from the previous test when compared to the 2008 E85 Yakima program.

- Total weighted demerits for the current program at +20°F were comparable to the total weighted demerits from the 2008 E85 Yakima Program at a similar ambient temperature.

III. RECOMMENDATIONS

Recommendations for future programs include:

- Use of scan tools is imperative to monitor ethanol percent concentration during the flushing procedure.

- With the introduction of vehicle pre-programmed cranking duration of 10 seconds, the demerit calculation formulae need to be revised to allow increased cranking times.

- Methodology for calculating demerits must be developed for unacceptably poor performance during which maneuvers must be aborted (e.g., excessive backfire during accelerations).

- Testing on a chassis dynamometer may be considered for future cold-start and warm-up driveability testing. Dynamometer testing poses both advantages and disadvantages. Some of the advantages are ideal ambient temperature and weather control, and multiple channel vehicle instrumentation. Some of the disadvantages include the decreased number of vehicles that can be tested per day, difference in traction, background noise, different "seat of the pants" feel from the road, and disconnection of the four-wheel-drive systems and stability controls. Additional environmental conditions and limitations may need to be considered for other than cold-start and warm-up driveability testing.

- Use of an 8-gallon flush should be considered as standard practice since it was more effective than the 4-gallon flush in this program; however, it must be weighed against the extra cost of fuel and time.

- Adaptability during the test is necessary. For example, the test temperatures, the cranking times, and the initial idle times in Neutral had to be adjusted from the planned program during this test.

- OEM technical support is critical to ensure proper vehicle operation.

- The current CRC driveability procedure is not viable for use for extreme cold conditions (lower than -20°F). A new procedure should be developed to more closely represent real-world operation.

IV. TEST VEHICLES

There were twenty late-model (2007 – 2008) E85 flex-fuel vehicles used in the program. The test fleet was obtained from a Canadian rental agency and were all Canadian registered vehicles. General Motors, Ford, and Chrysler vehicles comprised the E85 fleet. There were four 2007 and sixteen 2008 E85 flex-fuel vehicles. All twenty vehicles were equipped with air-conditioning and automatic transmissions. Eight different engine designs with displacements ranging from 2.7 to 5.4 liters were in the test fleet. Some of the engines were equipped with block heaters which were not used during the testing. The vehicle fleet is described in Table 1.

When the test vehicles were received from the rental agencies, each was physically prepared for testing on the dynamometer, and operationally checked out to ensure that learning by the powertrain control module of fuel ethanol level changes could be monitored by scan tools available to Imperial Oil. After the test vehicles were operationally checked out, valves were installed in the fuel-rails of vehicles without Schrader valves to enable the draining of test fuel between tests. The engine oil was also changed on each vehicle with the OEM recommended viscosity grade oil for the test program temperatures. Air filters were checked and replaced if necessary. Engine coolant was also checked for low temperature operations.

Due to observations during the first few days of testing, two vehicle manufacturers sent engineers to install the latest engine calibrations on two vehicle types to ensure proper performance of the test vehicles. Tests already conducted prior to the adjustment were all repeated, and the original test data for those vehicles were deleted from the data set.

V. TEST FUELS

The test fuel matrix consisted of eight test fuels: six E75/E85 blends and two hydrocarbon-only fuels. The E75/E85 blends varied in vapor pressure and hydrocarbon content. Two of the E75/E85 blends met the minimum vapor pressure requirements of ASTM Specification D5798 volatility Class 3 (9.5 psi)—one with near the minimum level of hydrocarbon content and the other at or near the maximum limit of hydrocarbon content (Fuels 4 and 5). Two E75/E85 blends met midrange Class 2 vapor pressure limits at near minimum and maximum hydrocarbon contents (Fuels 2 and 6). One E85 blend was prepared to represent the volatility of blending the lowest vapor pressure hydrocarbon-only gasoline found in north-central states during the wintertime with denatured fuel ethanol (Fuel 1). The last blend was prepared as a center point fuel to assist in determining linearity of vehicle response (Fuel 3). This fuel was not tested during the program. One of the gasolines represented the maximum vapor pressure (15 psi) allowed in ASTM Specification D4814 (Fuel 8)[(3)]. The other gasoline represented the lowest vapor pressure found in surveys for the north-central states during the wintertime (Fuel 7).

Average dry vapor pressure equivalent (DVPE), distillation temperatures, ethanol content, and other property inspection results as determined by the supplier (Laboratory A) and Fuel Acceptance Panel (Laboratories B, C, D, and E) are shown in Table 2. Individual test results obtained by each inspecting laboratory are shown in Appendix E. Figure 1 graphically shows the corresponding vapor pressures and ethanol contents for the E75/E85 test fuels. As described later, not all fuels were tested at all temperatures. The figure shows which temperatures were tested for each fuel. ASTM D5501 is the specified test method for determining ethanol content. Two laboratories used a modification of ASTM Test Method D4815 to measure the ethanol content. The results show that ASTM Test Method D4815 provided higher results. For the data analysis, ASTM D5501 results were used.

VI. TEST SITE

The test program was conducted in the All Weather Chassis Dynamometer (AWCD) facility of Imperial Oil Research in Sarnia, Ontario, Canada, which has a test temperature range from -40°F to 109°F. The AWCD test cell houses the dynamometer, and there is a pre-soak room adjacent to the dynamometer that can hold up to five vehicles. The test cell and the pre-soak room can be controlled at different temperatures simultaneously, and are capable of overnight soaking and testing five vehicles per day. Test vehicles can be a mixture of Front-Wheel-Drive (FWD), Rear-Wheel-Drive (RWD), or Four-Wheel-Drive (4WD) vehicles. The computerized data acquisition system can record up to 250 channels of data at 10 times per second. The dynamometer has a Road-Load Simulation Module that was used to provide the appropriate acceleration, deceleration, and steady-state tractive forces to the vehicles to match real-world operation. The EPA-published parameters for emissions certification tests for the makes and models of the appropriate test vehicles were used to determine dynamometer settings.

Testing in the AWCD provided an opportunity to test at controlled temperatures; however, it also required some changes to the typical on-site physical preparation of the vehicles. Anti-lock brake systems and traction control systems were disabled if the vehicles were so equipped because of the interference of these systems with the dynamometer operation. These systems were, of course, re-enabled prior to return to the rental agency. On some vehicles, the rear bumper covers were constructed of polymer instead of solid metal. Since they were susceptible to breakage when being pushed in very cold temperatures, the bumper covers were removed for storage and re-installed at the conclusion of the program. The following sensors were also installed on the test vehicles to capture parameters during testing to complement other parameters being collected from the facility: optical sensor for engine speed (rpm); thermocouple for engine oil temperature at the oil dipstick; thermocouple for engine coolant temperature at the heater inlet hose; thermocouple for fuel tank temperature inserted through the filler neck; and pressure transducer to determine the intake manifold vacuum.

VII. TEST PROGRAM

A. Test Procedure

Vehicle driveability was evaluated as prescribed in the CRC Cold-Start and Warm-Up Driveability Procedure (E-28-94). The CRC Cold-Start and Warm-Up Driveability Procedure as modified for use on a chassis dynamometer in this test program is presented in Appendix D. 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 as possible on a cold-soaked engine. Malfunctions are recorded and evaluated as being trace, moderate, heavy, or extreme. The demerit rating details used in this program are shown in Appendix D of this report.

Five E85 vehicles were tested each day in the chassis dynamometer using a single rater. The five vehicles were positioned either in the test cell or the pre-soak room on the previous day after having been preconditioned with a warm-up cycle. If the vehicles were testing the same fuel at a different temperature the next day, the preconditioning cycle was conducted on the dynamometer immediately following the test cycle, and the vehicles remained in the soak area overnight. If there was a fuel change involved, the fuel-change procedure described in Appendix D was conducted, followed by a preconditioning cycle conducted on public roads at ambient temperature. The purpose of the first ten-mile drive when vehicles were being flushed from one ethanol content to another was for calibration of the vehicles' ethanol content systems. The purpose of the final preconditioning was to allow for the test vehicle adaptive learning function to load data on the new fuel, and to clear the fuel system of the previous test fuel.

A warm booster battery was always used to assist engine cranking in order to eliminate the influence of vehicle battery conditions from the low temperatures. Modifications were made to the CRC procedure to extend the allowed engine cranking time from 5 seconds to 10 seconds to accommodate pre-programmed cranking duration in some vehicles. The engine idle time in "Park" immediately after starting was also extended to approximately 30 seconds to allow the engine oil pressure to stabilize, and to move the booster battery out of the way before the test maneuvers were begun.

B. Defueling and Fueling

When a fuel change was required, the mechanical team at Imperial Oil removed the gas cap from the vehicle, and the remaining test fuel was drained from the vehicle fuel tank and fuel system through the fuel rail system by activation of the fuel pump. The vehicle fuel system was then flushed and fueled with the next test fuel.

Two different flushing procedures were used: one procedure for the E85 vehicles flushing fuels with nearly constant ethanol content (e.g., E0 – E10 and E70 – E85), and one procedure for the E85 vehicle flushing from gasoline (E0 – E10) to high alcohol blends (E70 – E85) or vice versa. All vehicles were flushed and fueled with eight gallons of test fuel. Eight gallons is double the amount traditionally used for fuel flushing and refueling; this doubling of volume was calculated to reduce the contamination rate from the previous fuel by up to 80 percent.

An evaluation of the fuel flushing and refueling procedures was conducted to evaluate the efficiency of the procedures used in this program. All of the vehicles were sampled after completion of the test with hydrocarbon-only fuel, which was immediately preceded with an E85 blend. The analysis was performed by an outside contract laboratory, and the results are presented in Table E-2 of Appendix E.

Experience from the previous E85 test program conducted in Yakima, Washington, showed that it is critical to ensure that a flex-fuel vehicle has properly recognized the change in ethanol level after refueling. Imperial Oil used a generic scan tool supplied by AutoEnginuity, Inc. Since the learning process is different for different makes and models, AutoEnginuity provided customized software compatible with each of the test vehicles to indicate the learned percent ethanol. The Imperial Oil mechanical team verified that the learning process had occurred in each test vehicle prior to the cold-soak conditioning.

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 for each test. Information included 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 D. A summary of the complete data set is presented in Appendix F.

D. Test Design

The original test matrix was designed for twenty vehicles to be tested on eight test fuels at two temperatures. The matrix did not include duplicate tests. The two temperatures in the original design were -30°F and -10°F. After testing ten vehicles on Fuel 8 and five vehicles on Fuel 5 at both of these temperatures, it was apparent that most of the test vehicles would not be expected to perform well, if at all, under such low operating temperatures.

The CRC Volatility Group thus decided to change the test temperatures to -20°F and 0°F. Later in the test, it was decided to not test Fuel 3 in favor of adding a warmer temperature of +20°F to the matrix in order to compare with the previous outdoor Class 1 and Class 2 E85 program conducted in Yakima, Washington.

VIII. DISCUSSION OF RESULTS

A. Data Set Analysis

The final data set 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. In this report, the term “significant” refers to a confidence level of greater than or equal to 95%. The term “marginally significant” refers to a confidence level of between 90% and 95%. The confidence level is defined as (1 minus the p-value) x 100.

The initial analysis model included fuel, vehicle, fuel x vehicle interactions, temperature, and vehicle x temperature interactions. Rater was not a variable since a single rater did all of the evaluations. As is common with driveability data, a natural log transformation was done on the total weighted demerits (TWD) values due to the wide range of vehicle/fuel TWDs (10 – 500, where "no-start" is assigned 500 demerits). Transforming the data leads to a data set that is approximately normally distributed and has approximately constant variance. Because of the tight control on the temperature in the soak room and on the chassis dynamometer, the data did not have to be corrected for temperature. There were significant vehicle and fuel effects within each test temperature groupings (-20°F, 0°F, and +20°F), but this did not require any correction of the transformed data. Single tests were conducted for each vehicle/fuel/temperature combination. Five E75/E85 fuels and two gasolines were tested in all vehicles, but not at all temperatures. The lower vapor pressure E85 fuels were not tested at the lowest temperature because based on the observations of the high vapor pressure E75/E85 fuel many no-starts would have been encountered and the time available for testing would have been wasted. The individual vehicle ratings for each temperature, fuel, and vehicle are shown in the Table F-1 in Appendix F. Table F-2 shows the early partial data collected at -30°F and -10°F which were not used in the analysis. The individual vehicle plots showing the response to temperature and to fuel vapor pressure are presented in Appendix G and Appendix H.

Table 3 presents the least-squares mean Ln TWD and TWD values for each fuel across the vehicle fleet at each temperature where tested. Table 4 shows the Ln TWD and TWD values for each vehicle across all fuel sets for each temperature where tested. The regression analyses are on file at the CRC offices and are available upon request.

The least-squares mean TWD data from Table 3 averaged across all vehicles for each fuel and temperature are shown graphically in Figure 2. The statistical significance (p-values) differences between fuels within each temperature group are shown in Table 5. Figure 3 shows the plot of the mean corrected TWD for each vehicle averaged across all temperatures and fuels. The statistical significance (p-values) differences between vehicles are shown in Table 6.

Nine of the vehicle models were matched pairs. The remaining two vehicles were single vehicles. Two pairs have similar bodies and engines, but were of different makes by the same manufacturer. Figure 4 pairs up the matched vehicles and compares their overall performance across all fuels and temperatures. The matched vehicles performed similarly which was not the case for the earlier program conducted at Yakima. The closer performance in this latest program likely is due to the very close and repeatable temperature control of the chassis dynamometer compared to unconventional daily temperatures on the test track.

There were several instances where, in the rating team's judgment, it was necessary to abort some test maneuvers to prevent engine damage. A review of the data showed that aborting these maneuvers did not have a noticeable effect on the data, since the vehicle had already been given an extreme level of severity prior to aborting the maneuver. It is also worth noting that there were also numerous instances in which the vehicles ran very roughly either during or between maneuvers, although the test procedure does not call for rating these occurrences.

B. No-Starts

When a test vehicle wouldn't start after six tries, a 500 TWD driveability rating was assigned for that test. The numbers of no-starts for each fuel and test temperature summed across the entire vehicle fleet are shown in Figure 5. Both E0 (gasoline) fuels started every time for all vehicles and all temperatures. Two E75/E85 fuels (Fuels 4 and 5) met the D5798 Class 3 minimum vapor pressure limits, but the one with the higher gasoline content (E75--lower ethanol content) had fewer no-starts at -20°F. For the E75/E85 fuels tested at -20°F, Fuel 2 with a lower vapor pressure, but with the maximum gasoline content (E75--lowest ethanol content) encountered the most no-start problems. Because of encountering so many no-start conditions, it was decided not to test the lower volatility E85 fuels at -20°F. Fuels 2, 4, and 5 had no starting problems at 0°F as did the two E0 fuels (Fuels 7 and 8). Because Fuel 6 had some starting problems at 0°F, it was decided not to test the lowest vapor pressure E85 (Fuel 1) at 0°F.

Figure 6 shows the number of no-start encounters across all fuels and temperatures for each flex-fuel test vehicle. At -20°F, 14 of the test vehicles encountered at least one no-start. At 0°F, only four vehicles recorded one no-start test. There were no no-starts encountered by any vehicle at +20°F.

C. Temperature Analysis

The testing temperatures used in this program were -20°F, 0°F, and +20°F. All fuels were tested in all vehicles, but not all fuels were tested at all three temperatures. The Ln TWD least squares mean data averaged for each fuel are plotted as a function of temperature for the 20 flex-fuel vehicles in Figure 7. For all fuels the slopes show a negative trend with TWD increasing with a decrease in temperature. Statistical analyses could only be conducted for Fuels 2 and 7 since the other fuels were only tested at two temperatures. The slope of E75 Fuel 2 was marginally significant ($p = 0.10$) and was significant ($p = 0.05$) for E0 Fuel 7.

For each test and vehicle, the intake air temperature, the fuel tank temperature, the crankcase oil temperature, and the coolant temperature were recorded. Ninety-seven percent of the samples were less than 1.1, 2.0, 1.4, and 2.1°F different from the target temperatures for the air, tank, oil, and coolant temperatures. The maximum deviations were 2.3, 3.1, 1.8, and 3.4°F for the air, tank, oil, and coolant temperatures, respectively.

D. Vapor Pressure Analysis

For the five E75/E85 fuels the vapor pressure ranged from 6.8 psi to 9.8 psi. The ASTM D5798 minimum vapor limits are 9.5 psi for Class 3 and 7.0 psi for Class 2. Two blends were E75 (70.7 to 72.7 volume % ethanol) and three were E85 (80.3 to 81.2 volume % ethanol) blends. The two E0 (gasoline) fuels had vapor pressures of 10.4 psi and 15.1 psi. The ASTM D4814 Class 5 maximum vapor pressure limit is 15.0 psi. The Ln mean corrected TWD is plotted against vapor pressure for each fuel and temperature in Figure 8. All slopes were negative (increase in TWD with decrease in vapor pressure), but no vapor pressure regression analyses could be conducted because only single or two-point data were available.

E. Multiple Variable Analysis

The assessment of the effects of temperature and vapor pressure as shown in Figures 7 and 8 are compounded by the fact that the test fuels vary in ethanol content as well as in vapor pressure. Regression analyses were undertaken investigating the variables of vapor pressure, temperature, and ethanol content. The regression results are shown in Table 7. Line 1 shows a regression against all three variables; only temperature was significant ($p = 0.0002$) and ethanol content was marginally significant ($p = 0.0819$). The correlation coefficient, R^2, was not good at 0.754. Adding an ethanol*temperature interaction term to the regression equation, as shown in Line 2, resulted in temperature ($p = 0.0071$) and the ethanol*temperature interaction ($p = 0.039$) being significant and the vapor pressure and ethanol content being marginally significant (p = 0.1089 and 0.0606). The correlation coefficient, R^2, was improved to 0.863. Figure 9 shows a correlation plot of the predicted Ln TWD using the four-term regression equation versus the actual Ln TWD. The E0 gasoline correlation line is plotted separately from the E75/E85 correlation line. The poor fits of the two lines compared to each other and with the 1:1 perfect correlation line suggests that separate regressions for E75/E85 and E0 might be in order. Two different regressions were tried for the E75/E85 fuel set, as shown in Lines 3 and 4 in Table 7. The regression shown in Line 3 included temperature, vapor pressure, and ethanol content independently and resulted in an $R^2 = 0.937$. Adding a vapor pressure*temperature interaction term, shown in Line 4, provided an $R^2 = 0.983$. The resulting best-fit regression equations and statistics are shown in Lines 4 and 5 of Table 7. For these regressions all terms are statistically significant and the correlation coefficient, R^2, was 0.983 for E75/E85 and 0.924 for E0. Figure 10 shows the correlation plots of predicted versus actual Ln TWD for the two equations. The two lines fit better with each other and with the 1:1 perfect correlation line which indicates that the two fuel types are too different to include in a single regression. This is further confirmed by a final regression of only the E75/E85 data alone using the ethanol*temperature interaction term where only the ethanol content term was significant. This is shown in Line 6 of Table 7.

The best-fit equations are:

E75/E85: Ln TWD = 0.4634 – 0.1393*Temp – 0.2564*VP + 0.0829*EtOH + 0.0093*VP*Temp

E0: Ln TWD = 4.8010 – 0.0198*Temp – 0.1008*VP

F. Model Application

Using the two separate regression equations, the effect of vapor pressure can be shown for varying ethanol content for a given temperature. Figure 11 shows the effect of vapor pressure at -20°F for E0, E75, and E85 as predicted by the equations. It illustrates the benefits of increasing vapor pressure and/or increasing the gasoline content to improve cold-start and warm-up driveability. Figure 12 is a similar plot for 0°F and Figure 13 is for +20°F. At +20°F the model shows little difference between E75/E85 and E0.

Referring to the equations in Section E above, sensitivity of Ln TWDs to temperature and vapor pressure for E75/E85 and E0 can be compared. It should be noted that the vapor pressure range for the E0 fuels was higher than the range for the E75/E85 fuels. The Ln TWDs for E75/E85 show greater temperature sensitivity than for E0 for the range of conditions tested. The Ln TWDs for E75/E85 show greater vapor pressure sensitivity than for E0 as the temperatures decreased for the range of vapor pressures tested as shown in Figures 11 through 13. Figure 13 shows at +20°F, there is no difference in sensitivity of Ln TWDs to vapor pressure between E75/E85 and E0 fuels. In addition, the Ln TWDs for E75/E85 fuels include a cross-term for vapor pressure*temperature as well as a coefficient for sensitivity to ethanol content.

G. Program Comparison

After it was observed that the less volatile E85 fuels were encountering driveability problems at 0°F, it was decided to test the least volatile E85 fuels at +20°F which is a Class 2 temperature. Results at this temperature can be compared with those at a similar temperature from the earlier CRC 2008 E85 program conducted at Yakima. The 7.0 psi E85 fuel in the earlier program at 23°F produced a fleet Ln TWD mean of 3.01 (20 TWDs). The current program at +20°F temperature tested E75/E85 fuels with vapor pressures of 6.4 psi and 8.2 psi which bracketed the earlier fuel. The Ln TWD means were 3.92 (50 TWDs) and 3.80 (45 TWDs). Differences of less than 20 TWDs are generally considered insignificant.

H. Individual Vehicle Performance

The individual flex-fuel vehicle plots of TWD versus temperature are shown in Figures G1 through G20. Similar plots for TWD versus vapor pressure are shown in Figures H1 through H20.

Figures G1 through G20 show that except for three vehicles (9, 10, and 18) there is a trend for E75/E85 fuels in having increasing TWD with a decrease in temperature. There was less of an effect of temperature for gasoline for all vehicles.

Because there were three temperatures used in the program and not all fuels were tested at all temperatures and there were two levels of ethanol in the E75/E85 fuels, visually inspecting the individual vehicles raw results showed mixed responses to vapor pressure. In general, E75/E85 driveability performance was more sensitive to vapor pressure than E0 gasoline. There appeared to be vehicle-to-vehicle variability in driveability response, as has been seen in previous programs.

I. Fuel Flushing Efficiency

The earlier 2008 E85 program showed more contamination of the E0 gasoline sample that followed an E85 test than desired when using the newly developed flushing procedure for flex-fuel vehicles. To reduce this carryover effect, the amount of new fuel used for flushing and filling was increased from four gallons to eight gallons. A mechanical devise was constructed to make it ergonomic and more repeatable to rock the vehicle during the flushing procedure. To assess the flushing efficiency of the modified flex-fuel vehicle flushing procedure, the ethanol content was determined for a gasoline (E0) sample following an E85 fuel. The level of detection for the analysis procedure is 0.18 volume percent ethanol. These data are shown in Table E-2. Figure 14 shows graphically for each vehicle the residual amount of ethanol found in the gasoline. Eleven of the samples had ethanol contents below the 0.18 volume percent detection level. The average amount across all flex-fuel vehicles was <0.37 volume percent ethanol which compares with 2.27 volume percent ethanol for the earlier 2008 E85 program. This time the ethanol level ranged from <0.18 to 1.06 volume % compared to the earlier range from 0.29 to 4.61 volume percent. Four vehicles (3, 8, 12, and 17) with the same fuel tank system and two other vehicles (15 and 20) with another tank system consistently show the highest levels of contamination. This suggests that tank design has a strong effect on how efficiently a tank can be flushed and refilled.

The new flushing procedure for flex-fuel vehicles does not allow pump suction to draw vapors; otherwise, the malfunction indicator light (MIL) will frequently trip. If the MIL trips, in many vehicles the tank has to be filled with gasoline before the MIL can properly be reset using a scan tool. Both flushing procedures for the E85 vehicles call for the vehicle engines to be turned off 30 seconds after the "low fuel" light illuminates. This is to prevent the vehicle from running out of fuel which will affect the ethanol content calibration; however, it also prevents a thorough drain of the fuel system in many cases. The residual volume of the previous fuel can significantly affect the flushing efficiency. It is recommended that the E85 flushing procedure be reviewed to determine what modifications should be made so there is less carryover of ethanol from the previous run.

J. Lessons Learned During This Program

Since the E85 technology is new to the CRC volatility research programs, this test program provided an opportunity to learn more about both fuel and vehicle technology. Some of the lessons learned include:

- With the introduction of vehicle pre-programmed cranking duration of 10 seconds, the demerit calculation formulae need to be addressed to increase the cranking times allowed.

- Methodology for calculating demerits must be developed for unacceptably poor performance during which maneuvers must be aborted (e.g., excessive backfire during accelerations).

- Use of scan tools is imperative to monitor ethanol percent concentration during the flushing procedure.

- Testing on a chassis dynamometer poses both advantages and disadvantages. Some of the advantages are ideal ambient temperature and weather control, and multiple channel vehicle instrumentation. Some of the disadvantages include the decreased number of vehicles that can be tested per day, difference in traction, background noise, and different "seat of the pants" feel from the road, disconnection of the four-wheel-drive systems and stability controls.

- Use of an 8-gallon flush was considerably more effective than the 4-gallon flush; however, it used double the amount of fuel and time.

- Adaptability during the test is necessary. For example, the test temperatures, the cranking times, and the initial idle times in Neutral had to be adjusted from the planned program during this test.

- OEM technical support is critical to ensure proper vehicle operation.

- The current CRC driveability procedure is not viable for use for extreme cold conditions (lower than -20°F). A new procedure should be developed to more closely represent real-world operation.

REFERENCES

1. ASTM International, ASTM D5798 Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines, 2008 Annual Book of ASTM Standards.

2. Coordinating Research Council, Inc., 2008 CRC Cold-Start and Warmup E85 and E15/E20 Driveability Program, CRC Report No. 652, October 2008.

3. ASTM International, ASTM D4814 Specification for Automotive Spark-Ignition Engine Fuel, 2008 Annual Book of ASTM Standards.

4. Automotive Test Section Imperial Oil Research, Cold Start and Warm-Up E85 Cold Ambient Temperature Driveability Program, CRC Project Number CM-138-08-2, January 2009

TABLES

AND

FIGURES

Table 1
2008 CRC E85 Class 3 Driveability Program Test Vehicle List

Year	Make	Model	Mileage	Engine	Drive	VIN
2007	Chevrolet	Impala	27,503	3.5L V6	Front	2G1WB58K579388309
2008	Chevrolet	Impala	24,205	3.5L V6	Front	2G1WB58K181231263
2008	Chevrolet	Uplander	10,784	3.9L V6	Front	1GNDV23W88D170696
2008	Chevrolet	Suburban	14,580	5.3L V8	Rear	1GNFK16348J140142
2008	Chevrolet	Uplander	45,768	3.9L V6	Front	1GNDV33W98D127927
2008	Chevrolet	Silverado	14,586	5.3L V8	Rear	1GCEK140X8Z135607
2008	Chrysler	Grand Caravan	26,643	3.3L V6	Front	2D8HN44H98R714899
2008	Chrysler	Sebring	11,409	2.7L V6	Front	1C3LC56R38N170122
2008	Chrysler	Grand Caravan	25,610	3.3L V6	Front	2D8HN44H78R733449
2007	Dodge	Dakota	51,414	4.7L V8	Rear	1D7HW48P675201660
2007	Dodge	Durango	61,485	4.7L V8	Rear	1D8HB48P37F562733
2008	Dodge	Avenger	19,998	2.7L V6	Front	1B3LC56RX8N170387
2008	Dodge	Dakota	19,995	4.7L V8	Rear	1D7HW38N485596044
2007	Ford	F150	23,166	5.4L V8	Rear	1FTPW14V87FB11105
2008	Ford	F150	11,109	5.4L V8	Rear	1FTPW14V48FB20742
2008	Ford	Grand Marquis	18,153	4.6L V8	Rear	2MEFM75V48X619997
2008	GMC	Yukon	31,439	5.3L V8	Rear	1GKFK13098R314891
2008	GMC	Sierra	24,074	5.3L V8	Rear	2GTEK190681197894
2008	Pontiac	Montana	36,495	3.9L V6	Front	1GMDV23W780125141
2008	Pontiac	Montana	42,426	3.9L V6	Front	1GMDV23W98D124573

Table 2
CRC 2008 E85 Class 3 Driveability Program Fuel Inspections

Fuel Description			1	2	3	4	5	6	7	8
Property	**Method**	**Units**	**E85-6.4**	**E75-7.9**	**E80-8.9**	**E85-9.8**	**E75-9.7**	**E85-8.2**	**E0-10.4**	**E0-15.1**
Gravity	ASTM D4052	°API	48.4	50.8	49.5	49.5	49.9	49.1	62.3	62.5
Relative Density		60/60°F	0.7836	0.7762	0.7814	0.7814	0.7788	0.7835	0.7298	0.7293
Uncorrected Ethanol	ASTM D5501	wt %	83.4	72.3	80.3	83.2	74.6	82.7	-	-
Ethanol	ASTM D5501	vol %	81.2	70.7	77.2	80.7	72.7	80.3	-	-
Methanol	ASTM D5501	vol %	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Ethanol	ASTM D4815	wt %	83.6	73.5	80.3	84.3	75.7	83.1	0.0	0.0
Ethanol	ASTM D4815	vol %	82.6	71.8	79.2	83.1	74.4	82.1	0.0	0.0
Water	ASTM E203	wt. %	1.029	0.927	0.978	0.926	0.866	1.014	-	-
Water	ASTM E203	vol %	0.780	0.689	0.723	0.696	0.641	0.752	0.010	0.005
Estimated Hydrocarbon		vol %	17.4	28.2	21.3	17.6	26.0	18.2	-	-
DVPE	ASTM D5191	psi	6.40	7.88	8.85	9.80	9.68	8.20	10.38	15.14
Distillation	ASTM D86									
Initial Boiling Point		°F	120.0	108.7	102.1	99.0	95.9	106.9	87.1	76.2
5% Evaporated		°F	148.4	137.7	132.4	128.1	122.7	140.1	108.0	85.4
10% Evaporated		°F	162.5	154.0	154.1	155.7	144.5	160.2	123.0	95.6
20% Evaporated		°F	168.6	165.3	167.8	169.2	165.7	169.7	153.1	109.6
30% Evaporated		°F	170.3	168.2	170.6	171.4	170.1	171.5	185.5	126.4
40% Evaporated		°F	171.3	170.0	171.5	172.1	171.4	172.3	210.1	156.4
50% Evaporated		°F	171.9	171.2	172.0	172.3	172.0	172.7	224.8	190.4
60% Evaporated		°F	172.4	172.0	172.4	172.6	172.3	173.0	235.7	226.4
70% Evaporated		°F	172.7	172.8	172.8	172.8	172.6	173.2	247.9	248.3
80% Evaporated		°F	173.1	173.4	173.2	173.1	173.0	173.6	269.1	266.9
90% Evaporated		°F	173.9	174.6	174.2	173.7	174.0	174.4	315.3	292.2
95% Evaporated		°F	176.4	177.9	176.5	174.7	175.4	176.2	346.9	317.1
End Point		°F	215.9	245.6	222.4	197.6	251.4	234.2	399.1	351.3
Recovery		vol %	96.6	96.3	96.9	97.1	97.2	97.3	96.8	95.7
Residue		vol %	1.5	2.2	1.4	0.9	1.4	1.1	1.1	1.1
Loss		vol %	1.9	1.6	1.8	1.8	1.5	1.5	2.1	3.2
Benzene	DHA	vol %	0.12	0.18	0.13	0.10	0.16	0.14	0.36	0.70
Ethanol	DHA	vol %	84.4	76.0	83.1	86.3	80.2	85.7	0.0	0.0
Methanol	DHA	vol %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hydrocarbon**	DHA	vol %	15.6	24.0	16.9	13.7	19.8	14.3	100.0	100.0
Aromatics	DHA	vol %	3.8	6.1	6.1	5.1	8.2	4.8	24.2	36.5
Olefins	DHA	vol %	0.6	0.9	0.5	0.7	0.6	0.5	4.3	3.2
Saturates	DHA	vol %	10.6	16.5	10.3	8.2	11.0	9.0	69.4	60.1

Table 3
Least-Squares Mean Natural Log and Mean TWD Values
Fuel by Temperature Results

Fuel	Description	Temperature, °F	Ln TWD LS Mean	TWD LS Mean
1	6.4 psi E85	+20	3.92	50.4
2	7.9 psi E75	+20	3.13	22.9
2	7.9 psi E75	0	4.07	58.6
2	7.9 psi E75	-20	5.75	313.4
4	9.8 psi E80	0	4.59	98.8
4	9.8 psi E80	-20	5.70	298.6
5	9.7 psi E75	0	3.99	54.0
5	9.7 psi E75	-20	4.93	139.1
6	8.2 psi E85	0	4.99	146.4
6	8.2 psi E85	+20	3.80	44.7
7	10.4 psi E0	+20	3.34	28.1
7	10.4 psi E0	0	3.72	41.1
7	10.4 psi E0	-20	4.21	67.4
8	15.1 psi E0	0	3.36	28.7
8	15.1 psi E0	-20	3.59	36.2

Table 4
Least-Squares Mean Natural Log and Mean TWD Values
Vehicle by Temperature Results

Temperature	-20°F					0°F						+20°F					
Fuel Number	4	2	5	7	8	6	4	2	5	7	8	1	6	2	7		
Description	E85	E75	E75	E0	E0	E85	E85	E75	E75	E0	E0	E85	E85	E75	E0		
Vapor Pressure, psi	9.8	7.9	9.7	10.4	15.1	8.2	9.8	7.9	9.7	10.4	15.1	6.4	8.2	7.9	10.4	Ln TWD	TWD
Vehicle Number	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	Ln TWD	LS Mean	LS Mean
1	6.21	6.21	5.09	4.00	3.53	5.10	5.40	3.53	4.34	2.80	3.14	3.82	2.94	3.45	2.56	4.15	63.19
2	6.21	6.21	6.21	4.27	3.84	4.63	3.66	4.16	3.69	3.89	3.77	3.74	3.78	3.86	3.47	4.36	78.62
3	6.21	6.21	5.57	4.09	3.91	5.69	5.24	4.15	4.28	3.89	3.40	3.93	3.40	3.20	3.68	4.46	86.59
4	6.21	6.21	5.48	4.56	4.13	6.21	5.37	5.14	4.29	3.48	3.98	4.00	4.61	3.37	2.94	4.67	106.68
5	5.88	4.95	4.28	4.47	3.53	3.99	4.23	3.87	3.00	3.42	3.62	3.73	3.57	2.40	2.80	3.85	47.11
6	6.21	6.21	6.21	4.75	4.19	6.21	4.49	4.49	5.53	4.39	4.30	4.70	4.59	3.62	3.89	4.92	137.57
7	5.76	5.40	5.10	4.58	3.58	5.24	5.40	4.85	4.77	3.60	3.66	4.58	5.06	2.83	3.00	4.50	89.84
8	6.21	6.21	5.62	3.70	3.68	5.51	4.47	4.35	3.51	3.24	3.00	3.88	3.07	2.86	3.77	4.21	67.30
9	4.92	4.42	4.37	4.48	3.85	3.68	3.50	3.50	3.74	4.05	3.16	4.05	3.33	2.89	3.76	3.85	46.98
10	4.77	4.37	4.32	4.21	4.02	4.19	3.91	3.77	3.70	3.92	3.91	3.73	3.51	2.64	3.18	3.88	48.46
11	6.21	6.21	4.79	4.77	3.53	5.34	4.71	4.14	4.12	4.59	4.12	4.95	4.66	3.76	4.44	4.69	109.10
12	6.21	6.21	5.30	3.57	3.45	6.21	5.67	4.15	3.65	3.33	3.00	4.14	3.38	3.20	3.76	4.35	77.73
13	6.21	6.21	6.21	3.89	3.33	5.54	5.55	5.18	5.25	3.83	2.80	3.54	3.38	2.71	2.83	4.44	84.47
14	5.58	4.76	3.62	4.34	3.51	4.18	3.83	3.54	3.43	3.82	2.60	3.73	3.74	2.86	2.67	3.75	42.60
15	3.97	6.21	3.61	3.93	3.14	4.10	4.23	3.65	3.47	3.07	3.30	4.12	3.95	2.74	2.80	3.76	42.81
16	6.21	6.21	4.49	4.16	3.37	4.68	4.83	4.06	3.70	4.32	3.51	4.09	4.09	3.26	3.62	4.31	74.58
17	6.21	6.21	5.36	4.03	3.42	6.21	5.58	4.32	4.80	3.70	3.33	2.74	3.09	3.31	3.22	4.37	79.31
18	4.29	4.05	3.84	3.71	3.22	3.93	2.97	3.11	3.31	3.00	2.94	3.09	3.78	2.77	3.62	3.45	31.43
19	6.21	6.21	5.37	4.84	3.22	5.02	4.84	3.73	4.03	4.47	2.89	4.05	3.94	3.80	3.92	4.44	84.70
20	4.23	6.21	3.85	3.89	3.35	4.03	3.97	3.75	3.16	3.53	2.71	3.81	4.12	3.07	2.77	3.77	43.24
Ln TWD LS Mean	5.70	5.75	4.93	4.21	3.59	4.99	4.59	4.07	3.99	3.72	3.36	3.92	3.80	3.13	3.34		

Table 5
Significant Differences Between Fuels
For Each Temperature

-20°F p-Value Statistics					
	2	4	5	7	8
2		-	0.05	0.05	0.05
4	-		0.05	0.05	0.05
5	0.05	0.05		0.05	0.05
7	0.05	0.05	0.05		0.05
8	0.05	0.05	0.05	0.05	

0°F p-value Statistics						
	2	4	5	6	7	8
2		0.10	-	0.05	-	0.05
4	0.10		0.05	-	0.05	0.05
5	-	0.05		0.05	-	0.05
6	0.05	-	0.05		0.05	0.05
7	-	0.05	-	0.05		0.05
8	0.05	0.05	0.05	0.05	0.05	

+20°F p-value Statistics				
	1	2	6	7
1		-	0.05	0.05
2	-		0.05	-
6	0.05	0.05		-
7	0.05	-	-	

Table 6
Significant Differences Between Vehicles (p-values)

Vehicle	LnTWD LSMEAN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4.15		-	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-
2	4.36	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	-
3	4.46	-	-		-	-	-	-	-	0.05	-	-	-	-	0.05	0.05	-	-	0.05	-	0.05
4	4.67	-	-	-		0.05	-	-	-	0.05	0.05		-	-	0.05	0.05	-	-	0.05	-	0.05
5	3.85	-	-	-	0.05		0.05	0.10	-	-	-	0.05	-	-	-	-	-	-	-	-	-
6	4.92	0.05	-	-	-	0.05		-	0.05	0.05	0.05	-	-	-	0.05	0.05	-	-	0.05	-	0.05
7	4.50	-	-	-	-	0.10	-		-	-	-	-	-	-	0.05	0.05	-	-	0.05	-	0.05
8	4.21	-	-	-	-	-	0.05	-		-	-	-	-	-	-	-	-	-	0.05	-	-
9	3.85	-	-	0.05	0.05	-	0.05	0.05	-		-	0.05	-	-	-	-	-	-	-	-	-
10	3.88	-	-	-	0.05	-	0.05	-	-			0.05	-	-	-	-	-	-	-	-	-
11	4.69	-	-	-	-	0.05	-	-	-	0.05	0.05		-	-	0.05	0.05	-	-	0.05	-	0.05
12	4.35	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	0.05	-	-
13	4.44	-	-	-	-	-	-	-	-	-	-	-	-		0.05	0.05	-	-	0.05	-	0.05
14	3.75	-	-	0.05	0.05	-	0.05	0.05	-	-	-	0.05	-	0.05		-	-	0.10	-	0.05	-
15	3.76	-	-	0.05	0.05	-	0.05	0.05	-	-	-	0.05	-	0.05	-		-	-	-	0.05	-
16	4.31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	0.05	-	-
17	4.37	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-	-		0.05	-	-
18	3.45	0.05	0.05	0.05	0.05	-	0.05	0.05	0.05	-	-	0.05	0.05	0.05	-	-	0.05	0.05		0.05	-
19	4.44	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.05	-	-	0.05		0.05
20	3.77	-	-	0.05	0.05	-	0.05	0.05	-	-	-	0.05	-	0.05	-	-	-	-	-	0.05	

Table 7
2008 CRC E85 Class 3 Program Regression Models

Line	Regression Variables	R^2	RMSE	Constant	Temperature		Vapor Pressure		Ethanol Content		Ethanol*Temperature		Vapor Pressure*Temperature	
					Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
1	All Fuels--Temperature, Vapor Pressure, Ethanol Content	0.753	0.4078	4.8026	-0.0415	0.0002	-0.1102	0.1463	0.0084	0.0819	-	-	-	-
2	All Fuels--Temperature, Vapor Pressure, Ethanol Content, Ethanol*Temperature	0.862	0.3418	4.8049	-0.2130	0.0071	-0.1042	0.1089	0.0078	0.0606	0.6589	0.0390	-	-
3	E85 Fuels--Temperature, Vapor Pressure, Ethanol Content	0.937	0.2140	1.0190	-0.0601	3.8E-05	-0.2276	0.0259	0.0711	0.0035	-	-	-	-
4	**E85 Fuels--Temperature, Vapor Pressure, Ethanol Content, Vapor Pressure*Temperature**	**0.983**	**0.1488**	**0.4634**	**-0.1393**	**0.005**	**-0.2564**	**0.0054**	**0.0829**	**0.0008**	**-**	**-**	**0.00929**	**0.0002**
5	**E0 Fuels--Temperature, Vapor Pressure**	**0.924**	**0.0979**	**4.8010**	**-0.0198**	**0.0236**	**-0.1008**	**0.0368**	**-**	**-**	**-**	**-**	**-**	**-**
6	E85--Temperature, Vapor Pressure, Ethanol Content, Ethanol*Temperature	0.925	0.2344	1.0266	-0.0565	0.5491	-0.2295	0.0632	0.0713	0.0085	-4.89E-05	0.9686	-	-

Figure 1
2008 CRC E85 Class 3 Program Test Fuels

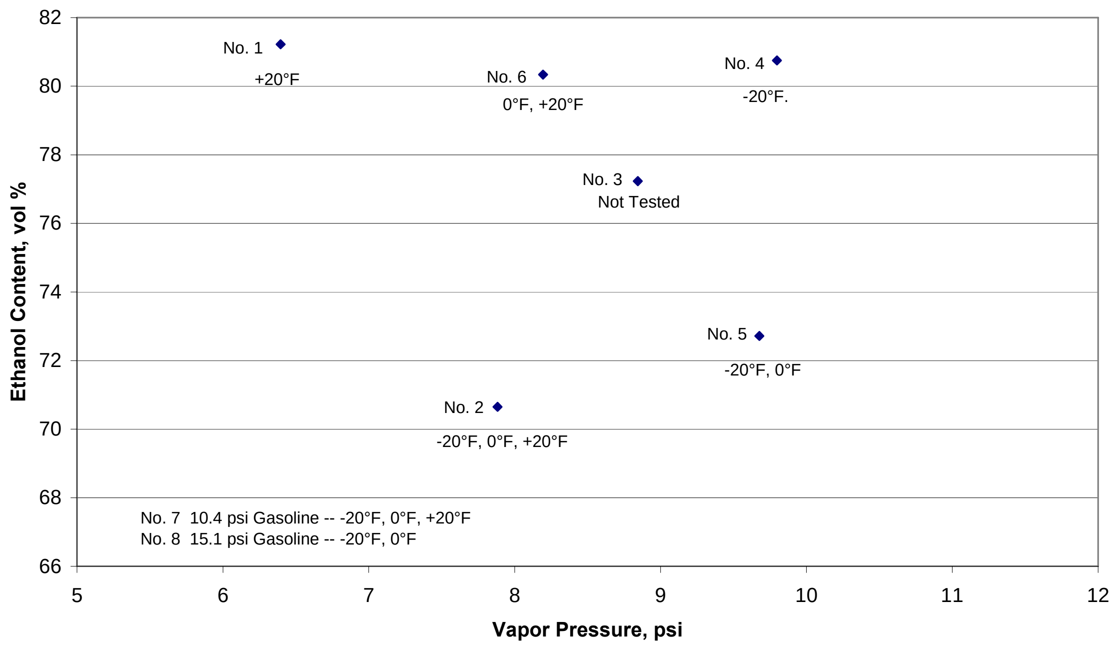


Figure 2
TWD LS Mean vs. Fuel Across All Vehicles and Temperatures

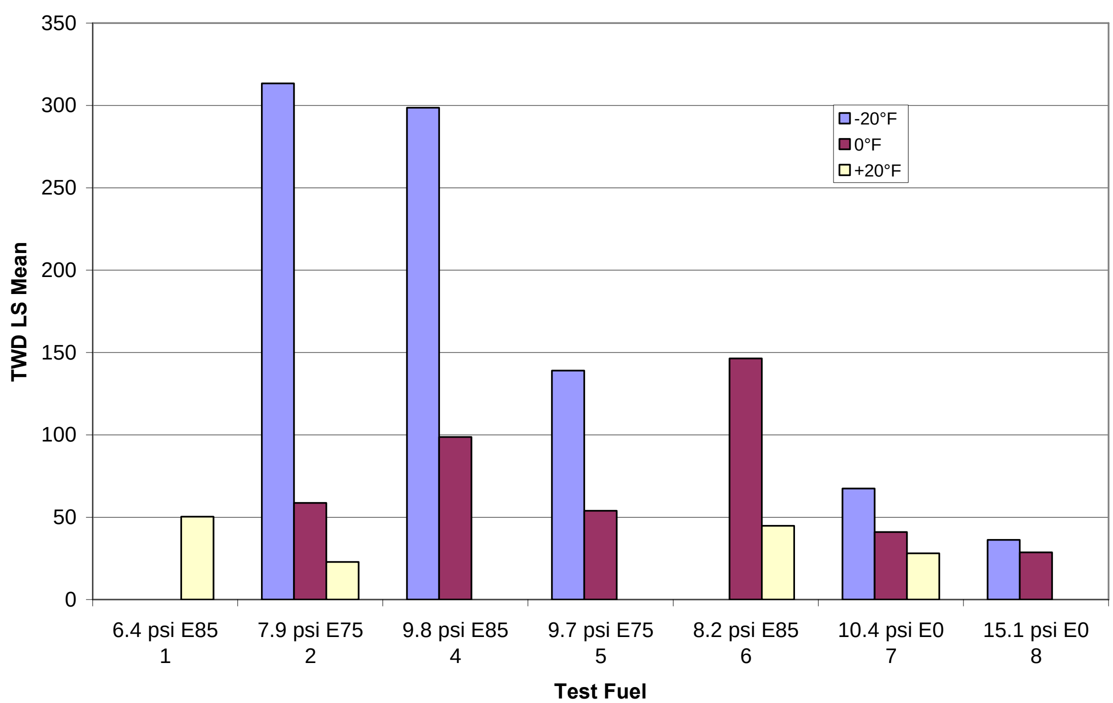


Figure 3
TWD LS Mean vs. Vehicle Across All Fuels and Temperatures

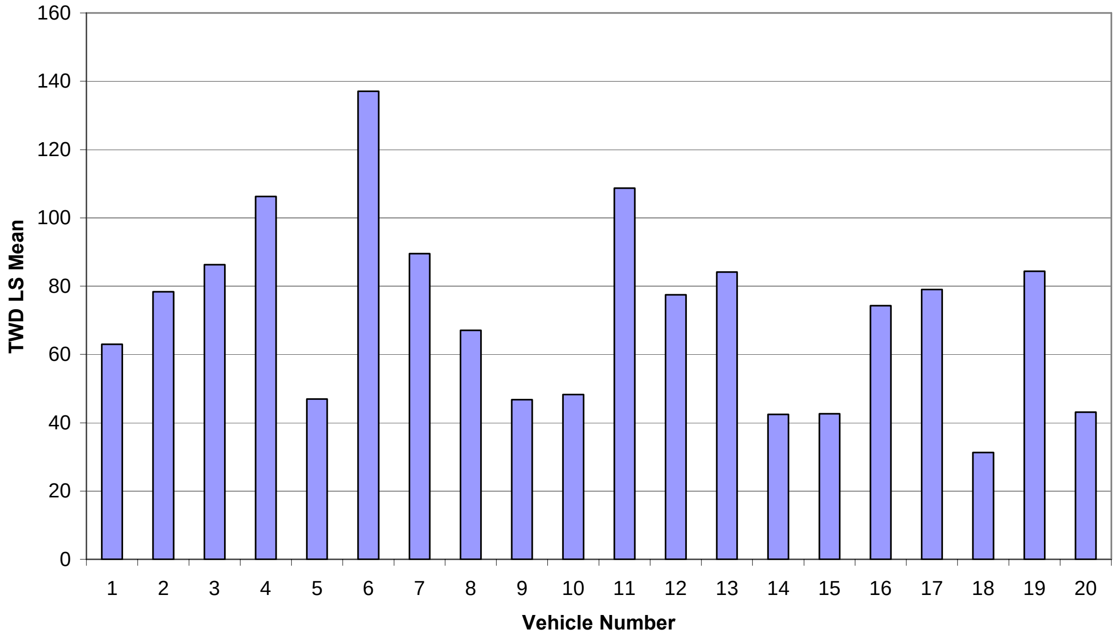


Figure 4
Ln TWD LS Mean by Paired Vehicles

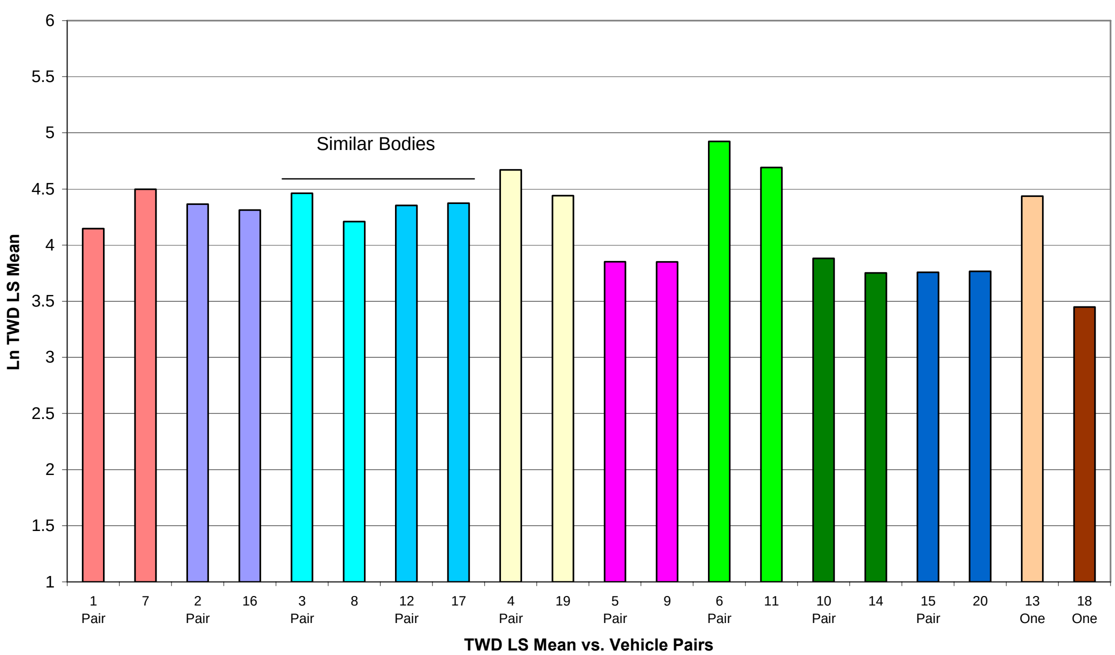


Figure 5
Number of No Starts By Fuel

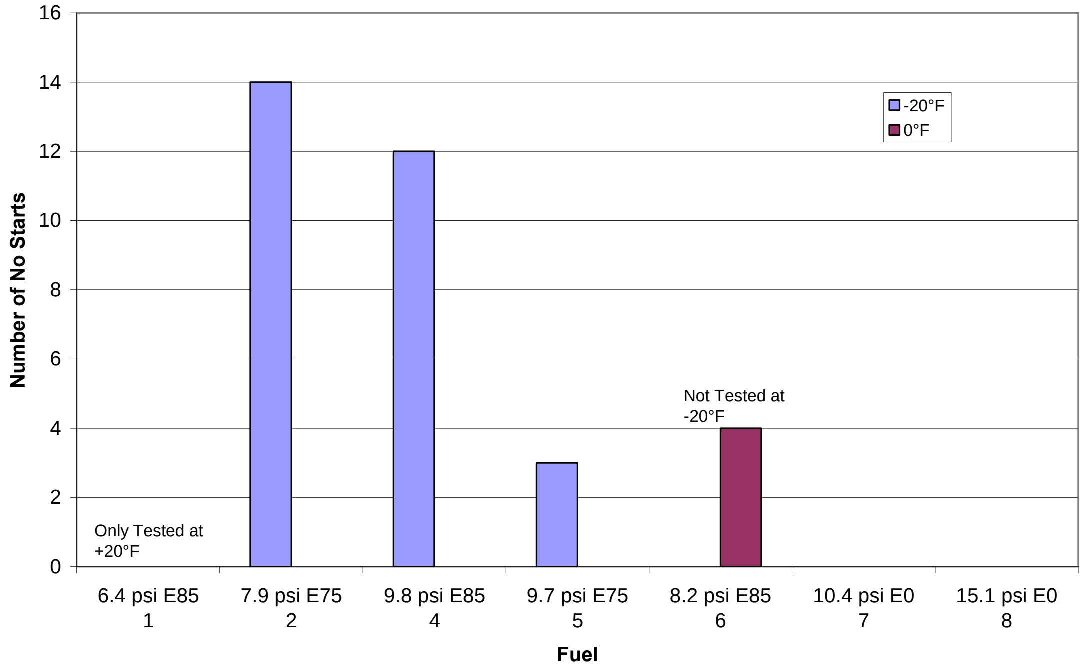


Figure 6
Number of No Starts By Vehicle

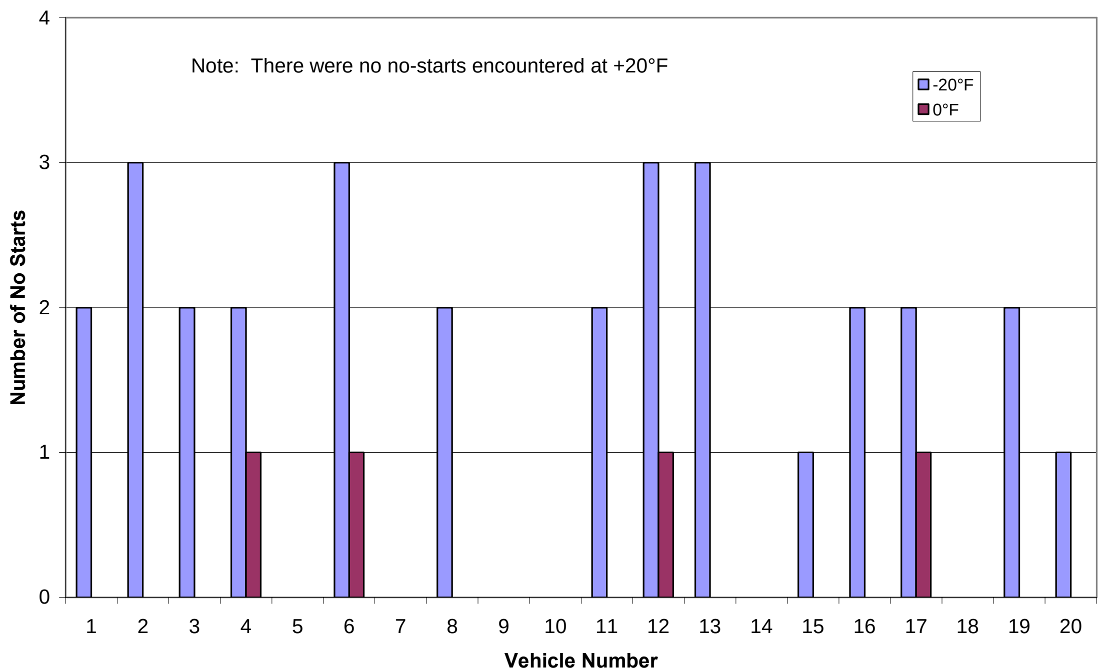


Figure 7
2008 CRC E85 Class 3 Program Ln TWD LS Mean Driveability Results vs. Temperature

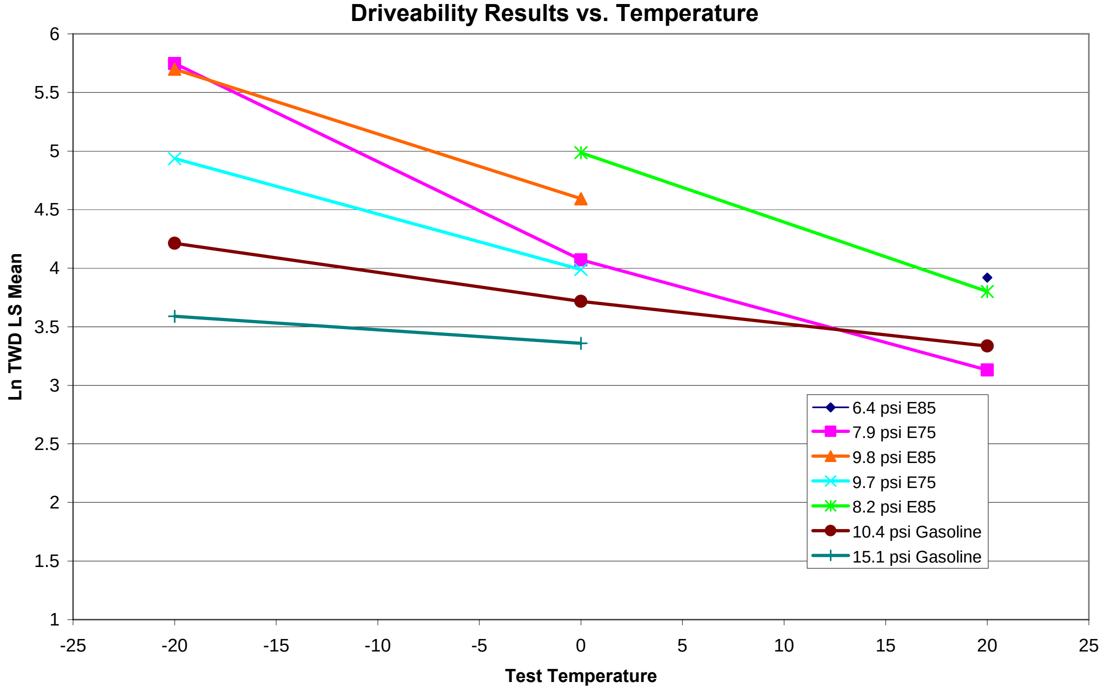


Figure 8
2008 CRC E85 Class 3 Program
All Vehicle Ln TWD LS Mean vs. Vapor Pressure

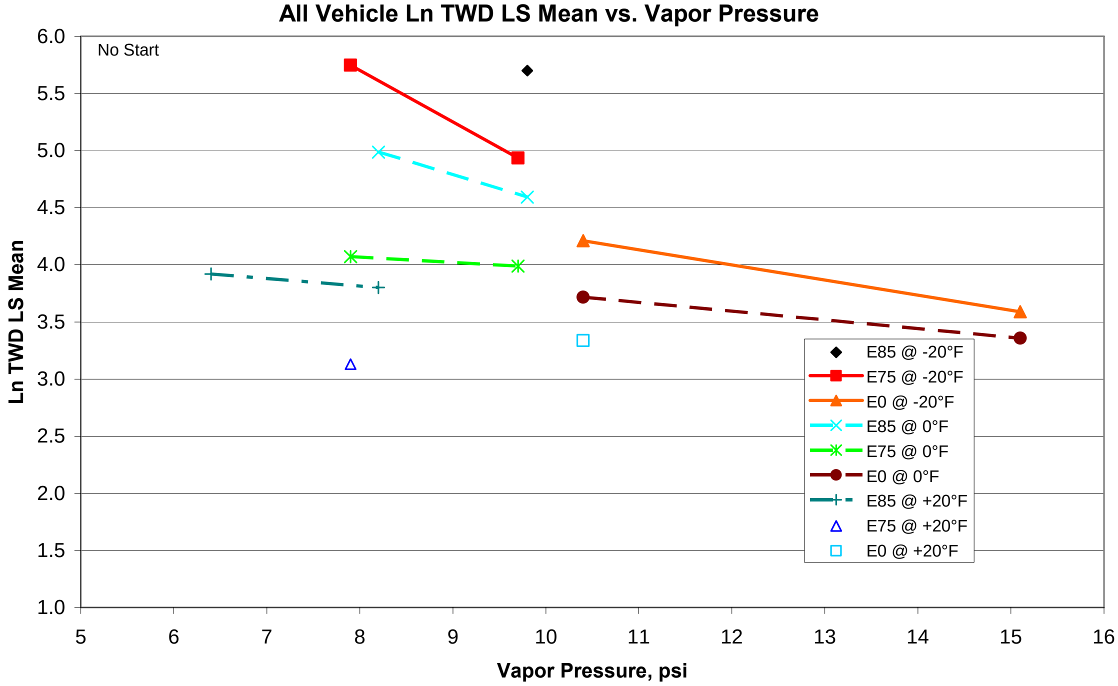


Figure 9
All Fuels Correlation for Four Variable Prediction Equation

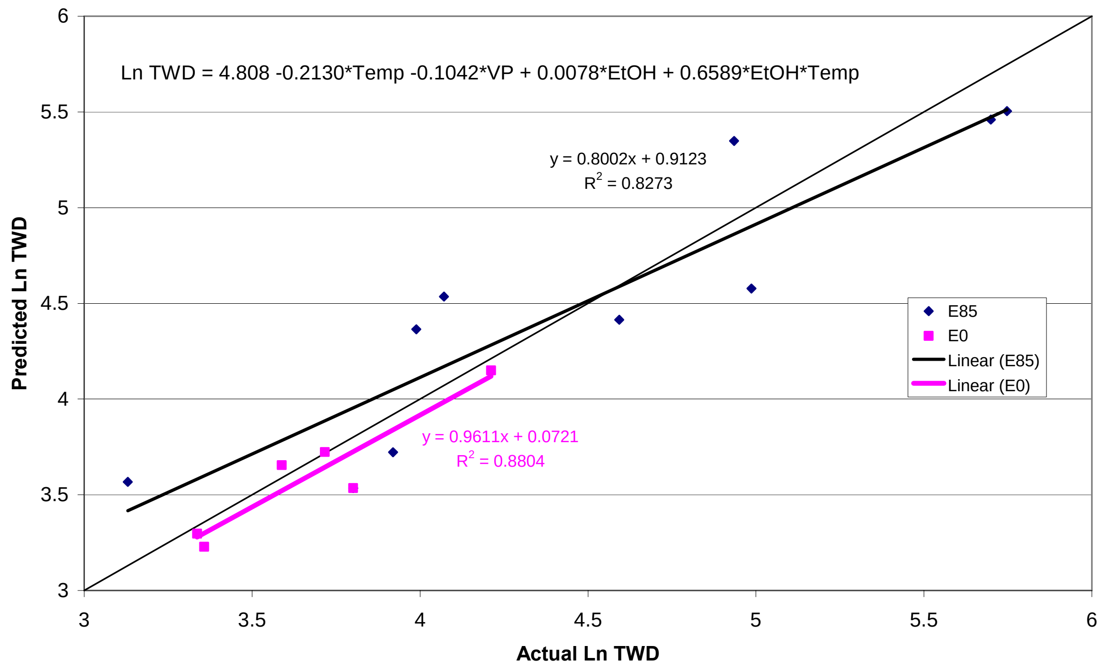


Figure 10
E85 and E0 Separate Correlation for Three Variable Prediction Equation

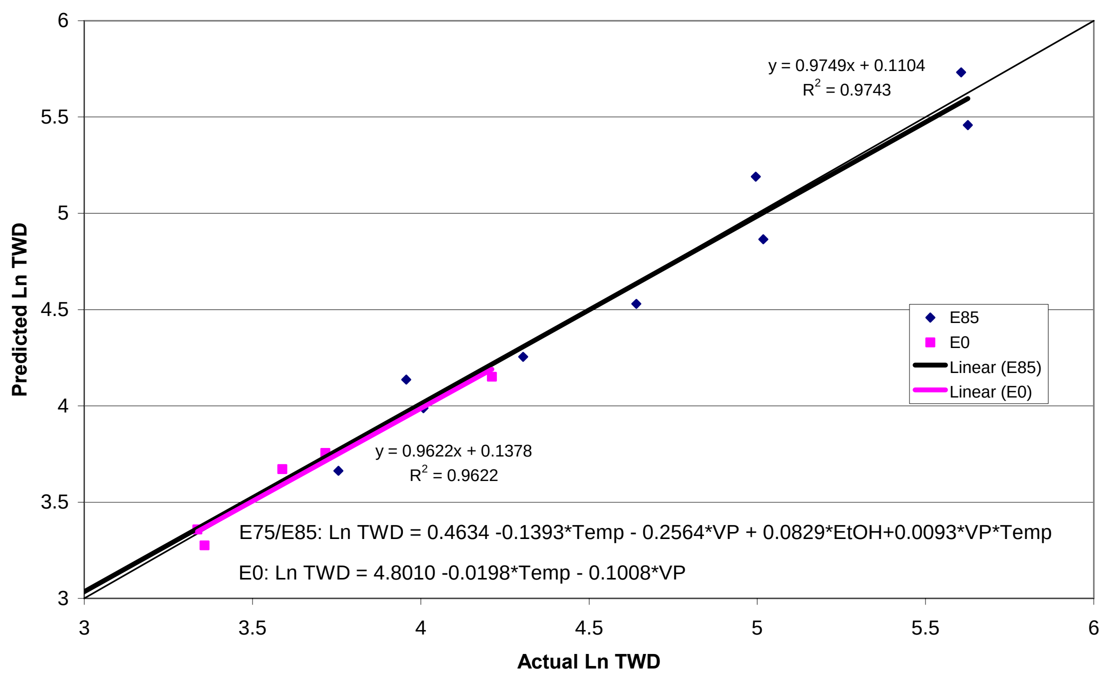


Figure 11
2008 CRC E85 Class 3 Program Regression Models at -20°F

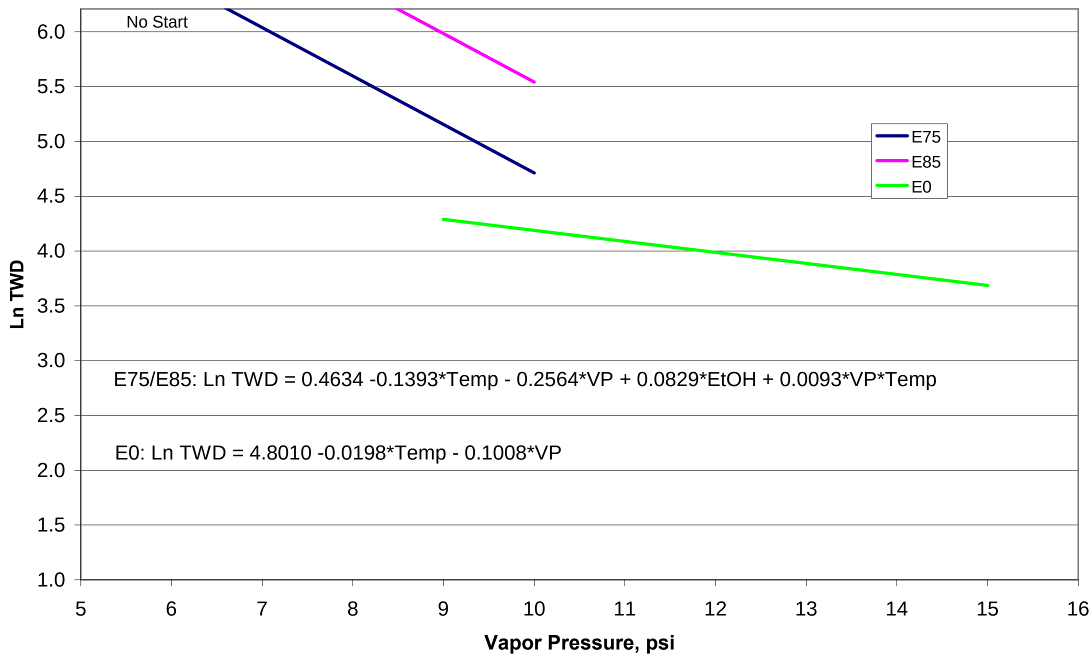


Figure 12
2008 CRC E85 Class 3 Program Regression Models at 0°F

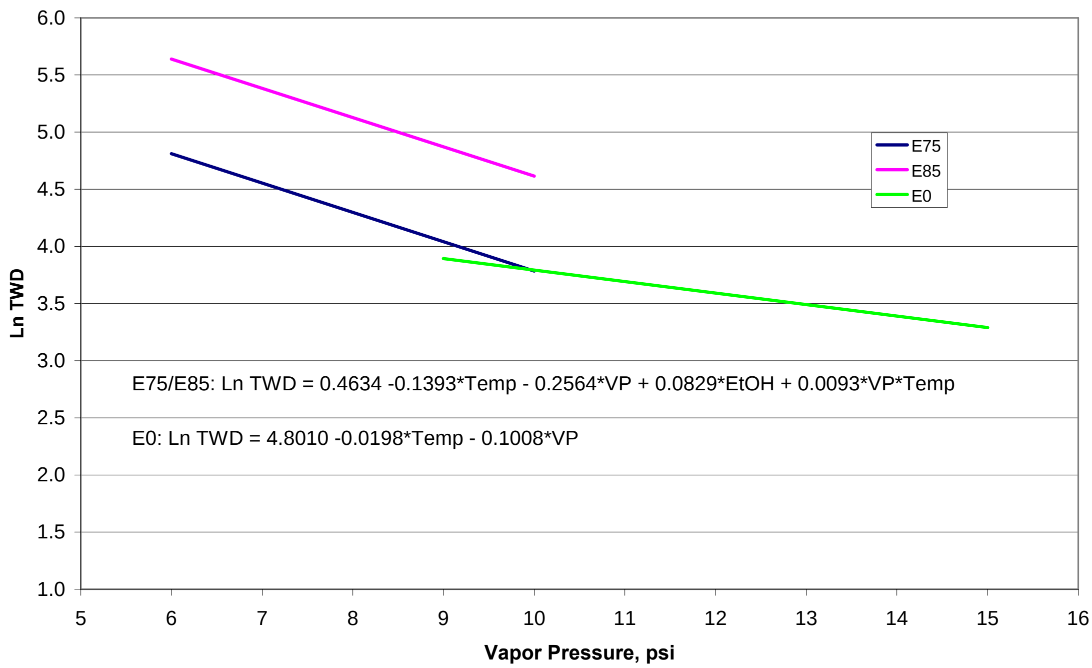


Figure 13
2008 CRC E85 Class 3 Program Regression Models at +20°F

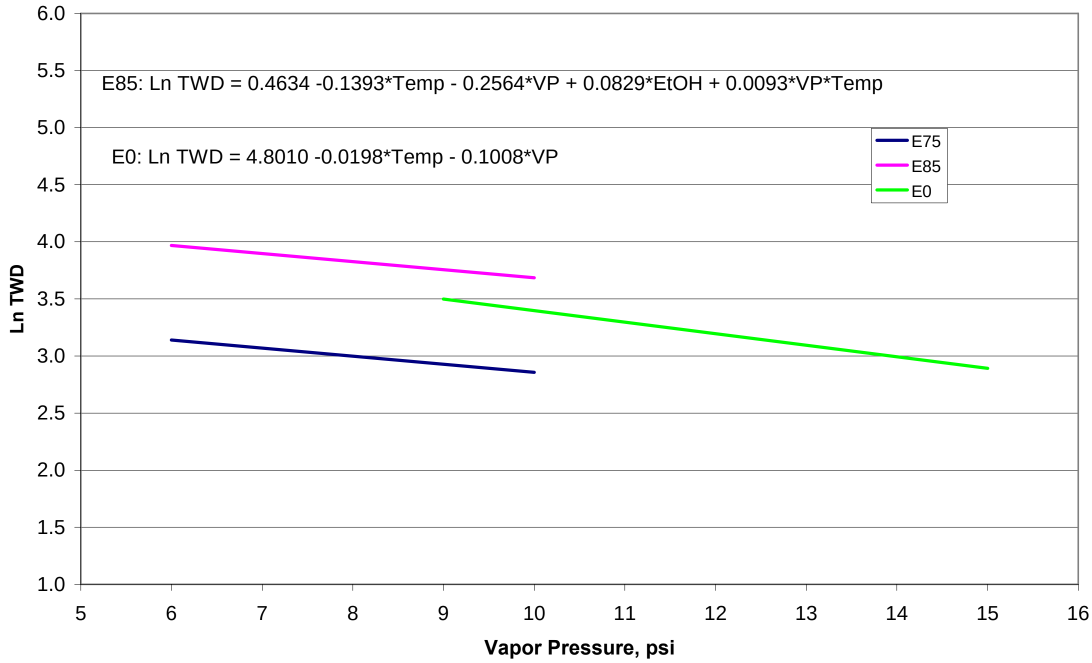
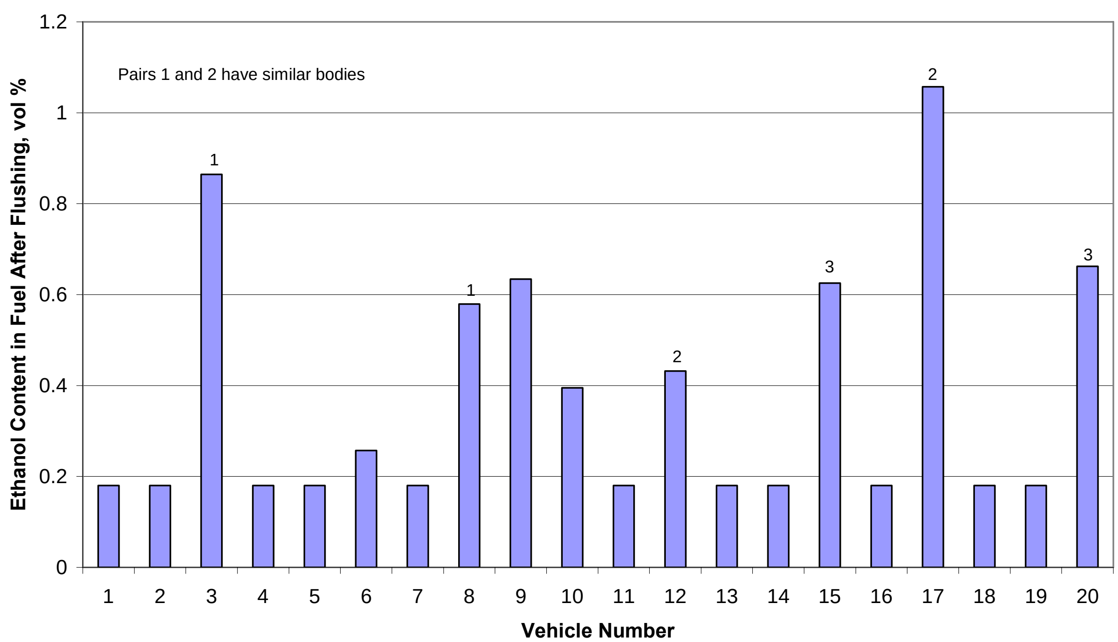


Figure 14
Ethanol Carry-Over After Flushing with Hydrocarbon-Only Fuel 7



APPENDIX A

MEMBERS OF THE 2008 CRC COLD-START AND WARM-UP E85 COLD AMBIENT TEMPERATURE DRIVEABILITY PROGRAM DATA ANALYSIS PANEL

Appendix A

Members Of The 2008 CRC Cold-Start And Warm-Up E85 Cold Ambient Temperature Driveability Program Data Analysis Panel

Name	Affiliation
Lew Gibbs, Leader	Chevron Global Downstream LLC
Bruce Alexander	BP Global Fuels Technology
Harold "Archie" Archibald	Evans Research Consultants
King Eng	Shell Global Solutions (US) Inc.
Beth Evans	Evans Research Consultants
Jeff Farenback-Brateman	ExxonMobil Research & Engineering
Pat Geng	General Motors
Keith Knoll	National Renewable Energy Laboratory
Kristy Moore	Renewable Fuels Association

APPENDIX B

ON-SITE PARTICIPANTS IN THE

2008 CRC COLD-START AND WARM-UP E85 COLD AMBIENT TEMPERATURE DRIVEABILITY PROGRAM

Appendix B

On-Site Participants in the 2008 CRC Cold-Start And Warm-Up E85 Cold Ambient Temperature Driveability Program

Name	Affiliation
Harold “Archie” Archibald	Evans Research Consultants
Beth Evans	Evans Research Consultants
Patrick Lai	Imperial Oil

APPENDIX C

2008 CRC COLD START AND WARM-UP

E85 COLD AMBIENT TEMPERATURE DRIVEABILITY PROGRAM

2008 CRC COLD-START AND WARM-UP E85 COLD AMBIENT TEMPERATURE DRIVEABILITY PROGRAM

Objective

The objective of this program is to determine the effect of vapor pressure and the hydrocarbon content of E85 Fuel Ethanol on cold start and warm-up driveability performance under cold ambient conditions in a large group of late model flexible-fuel vehicles equipped with fuel injection systems.

Deliverables

The minimum vapor pressure and hydrocarbon content required for the cold ambient condition (Class 3) of the three volatility classes in ASTM Specification D5798 for acceptable cold start and warm-up driveability will be determined.

Introduction

ASTM D5798 Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines specifies minimum vapor pressure limits for three volatility classes. The volatility classes are assigned based on the minimum ambient temperature expected for the month. For the warmer ambient temperature class, the amount of hydrocarbon is allowed to range from 17 to 21 vol % (includes the denaturant). For the intermediate temperature class, the amount of hydrocarbon is allowed to range from 17 to 26 vol % (includes the denaturant). For the coldest ambient temperature class, the amount of hydrocarbon is allowed to range from 17 to 30 vol % (includes the denaturant). The data base used to develop the volatility and compositional limits is over 14 years old. Limited field surveys of wintertime E85 shows significant non-compliance with Class 3 minimum vapor pressure requirements. This illustrates that it is difficult to meet the minimum vapor pressure limit of 9.5 psi using commercially available winter gasolines. Vehicle designs have changed since the early work was undertaken and today's design dates back about seven years.

This is a follow-on program to the 2008 program which investigated cold-start and warm-up driveability for D5798 volatility Classes 1 and 2.

Test Program

Vehicle cold start and warm-up driveability performance will be determined using the test procedure from the 2003 CRC volatility test program and as used in the 2008 program. This program will be conducted in 2008.

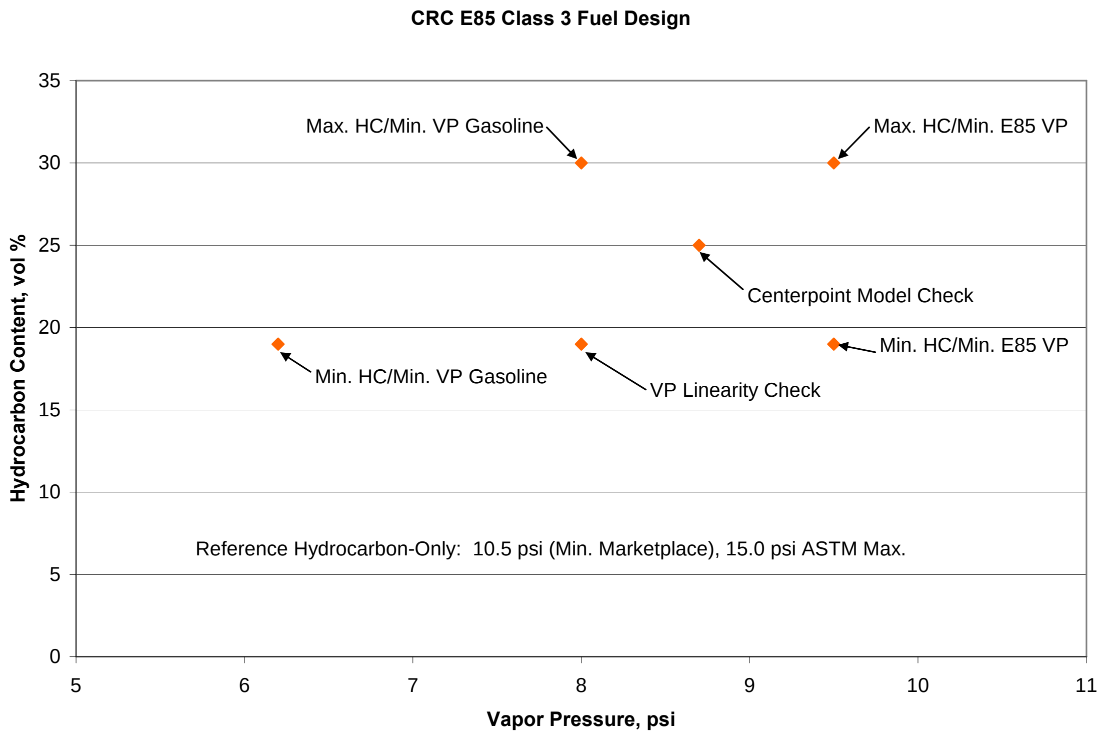
Test Fuels

The test fuel design will vary the vapor pressure and the hydrocarbon content for E85 fuel ethanol in ASTM Specification D5798. To minimize blending costs, commercial gasolines without oxygenate and butane will be utilized as much as possible. A special batch of denatured ethanol with 4-5 vol % of a natural gasoline denaturant will be used in this program and it must meet ASTM D4806 specification limits. Estimated compositions have been developed, but will have to be adjusted when actual stocks are on hand. Two commercial hydrocarbon-only gasoline stocks will be obtained. One will have a vapor pressure of 10.5 psi (the lowest level found in northern states during the wintertime) and the other will have a vapor pressure of 15.0 psi (the maximum vapor pressure allowed by D4814). A third blendstock will be made by adding butane to the 15.0 psi stock to make a 16.5 psi blendstock. These three stocks along with butane will be blended to make the target E85 vapor pressures. The first E85 blend will be 85 vol % denatured ethanol and 15 vol % 10.5 psi gasoline (total hydrocarbon content will be 19 vol %). This E85 will have a vapor pressure of approximately 6.2 psi which is about the lowest observed in the field surveys for Class 3 E85 fuels. The second blend will use the same two components, but will be a 75 vol % denatured ethanol and 25 vol % gasoline blend with a vapor pressure around 7.9 psi (total hydrocarbon content will be 30 vol %). The third blend is an 80 vol % denatured ethanol and 20 vol % of a mixture of the 10.5 psi and 15.0 psi gasolines. An adjustment to the blend of the two gasolines may be required to obtain the target E85 vapor pressure of 8.7 psi (total hydrocarbon content will be 25 vol %). The fourth blend is 85 vol % denatured ethanol with 15 vol % of a 16.5 psi gasoline (15.0 psi plus butane) with a target E85 vapor pressure of 9.5 psi (total hydrocarbon content will be 19 vol %). More butane addition to the 16.5 psi gasoline may be needed to meet the limits. The fifth E85 blend consists of 75 vol % denatured ethanol and 25 vol % 15.0 psi gasoline with a target E85 vapor pressure of 9.5 psi (total hydrocarbon content will be 30 vol %). The sixth E85 blend consists of 85 vol % denatured ethanol and 15 vol % of a nominal 13.5 psi gasoline (mix of 10.5 and 15.0 psi stocks) with an E85 vapor pressure of 8.0 psi (total hydrocarbon content will be 25 vol %). For referencing the program will have two gasolines. They will have vapor pressures of 10.5 and 15.0 psi. The 10.5 psi vapor pressure is the low vapor pressure fuel used in blends 1 and 2 and the 15 psi vapor pressure is the maximum allowed in D4814. The table below shows the fuel compositions and required properties. The fuel plan is shown graphically below.

2008 CRC E85 Class 3 Volatility Program Test Fuel Compositions and Properties

Blend No.		1	2	3	4	5	6	7	8
Composition, vol %									
Denatured Fuel EtOH		85.0	75.0	80.0	85.0	75.0	85.0	0.0	0.0
10.5 psi Conventional Hydrocarbon-Only		15.0	25.0	4.5	0.0	0.0	5.0	100.0	0.0
15.0 psi Conventional Hydrocarbon-Only		0.0	0.0	15.5	0.0	25.0	10.0	0.0	100.0
16.5 psi Conventional Hydrocarbon-Only		0.0	0.0	0.0	15.0	0.0	0.0	0.0	0.0
Required Properties	Test Method								
Vapor Pressure, psi	D5191	Report*	Report**	8.6-8.9	9.5-9.9	9.5-9.9	7.8-8.2	10.3-10.7	14.8-15.2
Distillation, °F	D86	Report	Report	Report	Report	Report	Report	-	-
10% Evaporated		-	-	-	-	-	-	100-130	90-115
50% Evaporated		-	-	-	-	-	-	170-235	170-230
90% Evaporated		-	-	-	-	-	-	285-345	285-340
End Point		-	-	-	-	-	-	437 Max	437 Max
Driveavility Index	D4814							1200	1200
EtOH Content, vol %	D5501/D4814	79.0 - 83.0	70.0-73.0	74.0 - 77.0	79.0 - 83.0	70.0-73.0	79.0 - 83.0	0.0	0.0

*Around 6.2 psi
**Around 7.9 psi



After reviewing hand blend data, the compositions are subject to adjustments to meet the required vapor pressures. A Fuel Blending and Analysis Task Force will be formed to assist in the analyses of the fuels.

Test Vehicles

Approximately 20 late model flexible-fuel vehicles will be used in the E85 portion of the test program to evaluate the cold start and warm-up driveability performance of the E85 and hydrocarbon-only gasoline test fuels. The selected flexible-fuel vehicles must represent several makes of compact, midsize, and large cars, pickup trucks, and sport utility vehicles listed in the 2006, 2007, and 2008 DOE/EPA Fuel Economy Guide. No more than two of the same make and models will be in the test fleet. The vehicles will nominally cover 2006-2008 model years and will have stabilized mileages at over 6,000 odometer miles, and be in good mechanical condition with functional air conditioning systems. It will be the responsibility of the contract laboratory to obtain and prepare the test vehicles.

Test Procedure

The Test Procedure used in the 2003 CRC volatility program (CRC Report No. 638) and the 2008 E85 program will be used in this program. The vehicles will undergo an overnight soak at the test temperature before each test. Single tests will be conducted on each vehicle and fuel combination. Each vehicle will be flushed with test fuel following the latest E85 flushing procedure and filled with 10 gallons of the next test fuel. The flushing procedure is a modification of recent flushing procedures and is based on information from the vehicle manufacturers and on experience in the 2008 E85 program.

Test Temperatures

The program plans are to cover the low and intermediate ambient test temperature of D5798 volatility Class 3. The two testing temperature will be -30°F (-34.4°C) and -10°F (-23.3°C) and were selected based on a study of minimum temperature published in the "Doner Report" for Class 3 months (January and March 10th percentile minimum temperature maps).

Test Location: The test program will be conducted on the all-weather cold-soak and chassis dynamometer facility at the Imperial Oil Sarnia Research Center in Ontario, Canada where recent diesel fuel cold flow program were conducted for the CRC. The planned testing period is not yet determined.

Timing

The timing will be as follows:

This is a contract program where five vehicles can be tested each day. The program will require a minimum of 64 testing days to evaluate 20 vehicles and eight fuels at two temperatures.

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

Personnel Requirements

The contract laboratory is responsible for providing the mechanic and technician personnel to run the program except for the trained raters which CRC will provide.

APPENDIX D

CRC COLD-START AND WARM-UP
DRIVEABILITY TEST PROCEDURE
AND FUEL SYSTEM
DRAINING AND FLUSHING PROCEDURES

REVISED CRC CHASSIS DYNAMOMETER COLD-START AND WARM-UP DRIVEABILITY PROCEDURE

A. Record all necessary test information at the top of the data sheet. Set the trip-meter to zero. In very low test temperatures, it may be desirable to use a warm booster battery to start the vehicle to eliminate the influence of vehicle battery conditions from the low temperatures.

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 six starting attempts recorded. If the engine fails to start within 10 seconds on any of these attempts, stop cranking at 10 seconds and record "NS" (no start) in the appropriate starting time box on the data sheet. (The 10-second crank accommodates vehicles with pre-programmed cranking duration.) 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 6 attempts, the test is aborted with a pre-determined number of demerits (500) recorded for the test.

Once the engine starts on any of the first six attempts, idle in park for 30 seconds to allow the engine oil pressure to stabilize in very low test temperatures and to move the booster battery out of the way before beginning the test maneuvers. Record the idle quality. If the engine stalls during this 30-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 six no-starts and Idle Park stalls.

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

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. Idle in "Drive" for 5 seconds and record idle quality.

K. Repeat Steps E through J.

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 test.

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 5. 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 7, 28, 50, and 100 for idle and maneuvering stalls 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.

Other malfunctions, such as hesitation, stumble, surge, idle roughness, and backfire, are rated subjectively by the driver on a scale of trace, moderate, heavy, or extreme. For these malfunctions, a certain number of demerits is assigned to each of the subjective ratings. Since all malfunctions are not of equal importance, however, 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.

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)

Idle-in- Park	Starting-in-Drive	Other Idle
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.

After six attempts, if vehicle does not start, record 500 demerits.

CRC Driveability Data Sheet

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

Starting time, Sec. Initial	Restart 1	Restart 2	Idle Park Ruf Stls	Idle Drive 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
HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC

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
HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC

0.0 Idle Dr.	0.0 0-45 Crowd	0.4 25-35 Detent	0.5 Idle Dr.	Idle Dr.
	HES TSM SG BKF AC DC	HES TSM SG BKF AC DC	5 sec.	30 sec.
Ruf Stls			Ruf Stls	Ruf Stls

Flex Fuel Tank Flushing Procedure for CRC Driveability Programs

Precautionary notes:

1. ***Use a UL approved ground strap to ground defueling equipment to the fuel injector rail or fuel line fitting for all fuel draining.***
2. ***This procedure should be used for driveability testing only; it is not appropriate for emissions testing.***

<u>Flushing procedure for fuels with nearly constant ethanol content (E0 – E10 and E70 – E85):</u>

1. Obtain a fuel sample (if needed) by hooking up the chilled sampling system and drawing the required fuel sample through the Schrader valve or adapter line fitting with the engine on. Once the sample has been obtained, shut off the engine.
2. Remove the sampling system and install the drain line. Clamp the drain line about halfway closed to keep adequate pressure in the fuel rail during draining. Remove the fill cap. Start the engine and drain the fuel tank through the Schrader valve or adapter line fitting. Once the low fuel light comes on, continue engine operation for 30 seconds, and then turn off the engine. <u>Do not allow the vehicle to completely run out of fuel.</u>
3. Add eight gallons of the next test fuel to the vehicle fuel tank.
4. Start the engine and after 15 seconds, rock the vehicle for about 30 seconds while the fuel drains. Once the low fuel light comes on, continue engine operation for 30 seconds, and then turn off the engine. <u>Do not allow the vehicle to completely run out of fuel.</u>
5. Add another eight gallons of fuel to the vehicle fuel tank.
6. Start the engine and after 15 seconds, rock the vehicle for about 30 seconds while the fuel drains. Once the low fuel light comes on, continue engine operation for 30 seconds, and then turn off the engine. <u>Do not allow the vehicle to completely run out of fuel.</u>
7. Remove the drain line, and replace the fill cap.
8. Start the engine and **DRIVE** the vehicle at least 10 meters.
9. Add another eight gallons of fuel to the vehicle fuel tank, and replace the fill cap.
10. Start the engine and idle for 15 seconds. Drive the vehicle for 10 miles using the warm up cycle. Then park the vehicle for its overnight soak period.

Flushing procedure when switching from gasoline (E0 – E10) to high alcohol blends (E70 – E85) or vice versa

1. Obtain a fuel sample (if needed) by hooking up the chilled sampling system and drawing the required fuel sample through the Schrader valve or adapter line fitting with the engine running. Once the sample has been obtained, shut off the engine.
2. Remove the sampling system and install the drain line. Clamp the drain line about halfway closed to keep adequate pressure in the fuel rail during draining. Remove the fill cap. Start the engine and drain the fuel tank through the Schrader valve or adapter line fitting. Once the low fuel light comes on, continue engine operation for 30 seconds, and then turn off the engine. Do not allow the vehicle to completely run out of fuel.
3. Remove the drain line, and replace the fill cap.
4. Start the engine and **DRIVE** the vehicle at least 10 meters.
5. Add eight gallons of the next test fuel to the vehicle fuel tank. Replace the fill cap.
6. Start the engine and idle for 15 seconds. Drive the vehicle for 10 miles using the warm up cycle. Return the vehicle to the de-fueling area, and shut off the engine.
7. Attach the drain line and remove the fill cap. Clamp the drain line about halfway closed to keep adequate pressure in the fuel rail during draining. Drain the fuel tank through the Schrader valve or adapter line fitting with the engine on. Once the low fuel light comes on, continue engine operation for 30 seconds, and then turn off the engine. Do not allow the vehicle to completely run out of fuel.
8. Add another four gallons of fuel to the vehicle fuel tank.
9. Start the engine and after 15 seconds, rock the vehicle for about 30 seconds while the fuel drains. Once the low fuel light comes on, continue engine operation for 30 seconds, and then turn off the engine. Do not allow the vehicle to completely run out of fuel.
10. Add another eight gallons of fuel to the vehicle fuel tank.
11. Start the engine and after 15 seconds, rock the vehicle for about 30 seconds while the fuel drains. Once the low fuel light comes on, continue engine operation for 30 seconds, and then turn off the engine. Do not allow the vehicle to completely run out of fuel.
12. Remove the drain line, and replace the fill cap.
13. Start the engine and **DRIVE** the vehicle at least 10 meters.
14. Add another eight gallons of fuel to the vehicle fuel tank. Replace the fill cap.
15. Start the engine and idle for 15 seconds. Drive the vehicle for 10 miles using the warm up cycle. Then park the vehicle for its overnight soak period.

APPENDIX E

INDIVIDUAL LABORATORY FUEL INSPECTIONS

AND FLUSHING SAMPLE INSPECTIONS

Table E-1
CRC 2008 E85 Class 3 Volatility Program Fuel Inspections

Fuel Description			1						2					
Property	**Method**	**Units**	E85-6.4						E75-7.9					
Laboratory			**A**	**B**	**C**	**D**	**E**	**Average**	**A**	**B**	**C**	**D**	**E**	**Average**
Gravity	ASTM D4052	°API	49.2	49.15	48.8	48.8	46.21	48.4	50.9	50.89	50.5	50.5	50.97	50.8
Relative Density		60/60°F	0.7831	0.7833	0.7848	0.7848	0.7822	0.7836	0.7759	0.7758	0.7775	0.7774	0.7747	0.7762
Uncorrected Ethanol	ASTM D5501	wt %	-	-	83.37	-	-	83.37	-	-	72.26	-	-	72.26
Ethanol	ASTM D5501	vol %	80.98	-	81.70	80.99	-	81.22	71.25	-	70.20	70.5	-	70.65
Methanol	ASTM D5501	vol %	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	ASTM D4815	wt %	-	82.15	-	-	84.96	83.6	-	72.64	-	-	74.42	73.53
Ethanol	ASTM D4815	vol %	-	81.53	-	-	83.71	82.6	-	70.98	-	-	72.62	71.80
Water	ASTM E203	wt. %	-	1.00	1.10	-	0.986	1.03		0.88	1.02	-	0.882	0.93
Water	ASTM E203	vol %	0.71	0.78	0.86	0.77	0.77	0.78	0.61	0.68	0.79	0.68	0.68	0.69
Estimated Hydrocarbon		vol %	18.3	17.7	17.4	18.2	15.5	17.44	28.1	28.3	29.003	28.8	26.7	28.20
DVPE	ASTM D5191	psi	6.05	6.70	6.20	5.73	6.63	6.40	7.80	8.05	7.75	6.95	7.93	7.88
Distillation	ASTM D86													
Initial Boiling Point		°F	120.9	107.3	128.4	122.1	121.1	120.0	110.3	97.4	117.3	108.9	109.4	108.7
5% Evaporated		°F	132.5	151.8	153.3	151.6	153	148.4	136.0	139.3	142.8	133	137.5	137.7
10% Evaporated		°F	157.2	163.5	165.7	163.1	163	162.5	149.9	155.0	158.3	152	154.6	154.0
20% Evaporated		°F	166.6	168.9	171.1	168.2	168.3	168.6	163.8	165.5	167.9	164.1	165.4	165.3
30% Evaporated		°F	168.8	170.7	172.7	169.6	169.9	170.3	167.2	168.5	170.7	167.4	167.4	168.2
40% Evaporated		°F	169.9	171.6	173.6	170.6	170.8	171.3	168.8	170.1	172.4	169.1	169.7	170.0
50% Evaporated		°F	170.5	172.1	174.3	171.3	171.3	171.9	170.0	171.3	173.4	170.2	171	171.2
60% Evaporated		°F	171.1	172.5	174.7	171.7	171.9	172.4	170.9	172.1	174.2	171.1	171.9	172.0
70% Evaporated		°F	171.4	172.9	175.1	172.1	172.2	172.7	171.6	172.7	174.9	172.1	172.6	172.8
80% Evaporated		°F	171.8	173.2	175.4	172.4	172.6	173.1	172.3	173.4	175.4	172.6	173.3	173.4
90% Evaporated		°F	172.5	174.0	176.1	173.5	173.5	173.9	173.8	174.6	176.7	173.4	174.6	174.6
95% Evaporated		°F		175.8	177.8	176.2	175.6	176.4		177.5	179.7	175.8	178.5	177.9
End Point		°F	178.6	260.8	181.4	179.5	279.3	215.9	179.7	332.2	180.6	180.4	355.3	245.6
Recovery		vol %	95.1	97.9	95.5	95.9	98.5	96.6	95.4	98.3	94.5	95.4	97.7	96.3
Residue		vol %	1.5	1.2	1.8	1.7	1.1	1.5	1.6	1.2	3.6	3.1	1.3	2.2
Loss		vol %	3.4	0.8	2.7	2.4	0.4	1.9	3.1	0.5	1.9	1.5	1	1.6
Benzene	DHA	vol %	-	-	0.12	-	-	0.12	-	-	0.18	-	-	0.18
Ethanol	DHA	vol %	-	-	84.40	-	-	84.40	-	-	76.01	-	-	76.01
Methanol	DHA	vol %	-	-	0	-	-	0.0	-	-	0	-	-	0.0
Hydrocarbon	DHA	vol %	-	-	15.60	-	-	15.60	-	-	23.99	-	-	23.99
Aromatics	DHA	vol %	-	-	3.79	-	-	3.79	-	-	6.12	-	-	6.12
Olefins	DHA	vol %	-	-	0.59	-	-	0.59	-	-	0.94	-	-	0.94
Saturates	DHA	vol %	-	-	10.57	-	-	10.6	-	-	16.49	-	-	16.5

Table E-1 Continued
CRC 2008 Volatility Program Fuel Inspections

Fuel Description			3						4					
Property	**Method**	**Units**	E80-8.9						E85-9.8					
Laboratory			**A**	**B**	**C**	**D**	**E**	**Average**	**A**	**B**	**C**	**D**	**E**	**Average**
Gravity	ASTM D4052	°API	49.8	49.72	49.3	49.1	49.83	49.5	49.7	49.72	49.3	49.1	49.79	49.5
Relative Density		60/60°F	0.7805	0.7808	0.7826	0.7837	0.7796	0.7814	0.7805	0.7808	0.7826	0.7835	0.7797	0.7814
Uncorrected Ethanol	ASTM D5501	wt %	-	-	80.28	-	-	80.28	-	-	83.22	-	-	83.22
Ethanol	ASTM D5501	vol %	75.80	-	78.51	77.39	-	77.23	79.50	-	81.40	81.35	-	80.75
Methanol	ASTM D5501	vol %	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	ASTM D4815	wt %	-	79.71	-		80.94	80.33	-	83.69	-		84.95	84.32
Ethanol	ASTM D4815	vol %	-	78.85	-	-	79.48	79.17	-	82.79	-	-	83.43	83.11
Water	ASTM E203	wt. %		0.96	1.02	-	0.948	0.98		0.91	1.00	-	0.872	0.93
Water	ASTM E203	vol %	0.63	0.75	0.80	0.70	0.74	0.72	0.61	0.71	0.78	0.70	0.68	0.70
Estimated Hydrocarbon		vol %	23.6	20.4	20.69	21.9	19.8	21.27	19.9	16.5	17.82	18.0	15.9	17.61
DVPE	ASTM D5191	psi	8.90	8.93	8.64	7.59	8.91	8.85	9.8	9.92	9.54	8.47	9.98	9.80
Distillation	ASTM D86													
Initial Boiling Point		°F	105.1	92.3	109	102.1	102	102.1	102.0	87.0	110.6	97.4	97.9	99.0
5% Evaporated		°F	123.6	132.1	135.1	135.6	135.5	132.4	122.1	126.5	129.9	136.7	125.2	128.1
10% Evaporated		°F	147.3	153.7	158	156.4	154.9	154.1	154.5	153.9	158.1	159.6	152.6	155.7
20% Evaporated		°F	165.6	168.2	170.4	167.6	167.4	167.8	167.6	169.3	171.6	168.9	168.6	169.2
30% Evaporated		°F	169.4	170.8	172.7	170	169.9	170.6	170.2	171.4	173.6	170.6	171	171.4
40% Evaporated		°F	170.5	171.7	173.8	170.8	170.8	171.5	171.2	172.0	174.3	171.1	171.7	172.1
50% Evaporated		°F	171.2	172.1	174.3	171.3	171.3	172.0	171.7	172.2	174.5	171.3	171.9	172.3
60% Evaporated		°F	171.6	172.5	174.7	171.7	171.7	172.4	172.1	172.4	174.9	171.7	172	172.6
70% Evaporated		°F	172.0	172.8	175.1	172.2	172	172.8	172.4	172.6	175.1	171.4	172.4	172.8
80% Evaporated		°F	172.5	173.2	175.4	172.4	172.4	173.2	172.8	172.8	175.2	172.1	172.6	173.1
90% Evaporated		°F	173.6	174.1	176.1	173.9	173.3	174.2	173.8	173.3	175.8	172.4	173.1	173.7
95% Evaporated		°F	175.4	176.1	177.9	177.6	175.5	176.5	1738	174.3	176.9	174.5	174	174.7
End Point		°F	180.6	269.9	181.9	180.6	299.1	222.4	260.8	177.9	180.1	178	191.1	197.6
Recovery		vol %	96.3	98.0	95.9	95.6	98.5	96.9	97.1	97.9	95.9	97	97.5	97.1
Residue		vol %	1.6	1.1	1.7	1.6	0.8	1.4	0.8	0.8	1.1	0.9	0.8	0.9
Loss		vol %	2.2	0.8	2.4	2.8	0.7	1.8	1.2	1.1	3.0	2.1	1.7	1.8
Benzene	DHA	vol %	-	-	0.13	-	-	0.13	-	-	0.1	-	-	0.10
Ethanol	DHA	vol %	-	-	83.06	-	-	83.06	-	-	86.28	-	-	86.28
Methanol	DHA	vol %	-	-	0.00	-	-	0.0	-	-	0.00	-	-	0.0
Hydrocarbon	DHA	vol %	-	-	16.94	-	-	16.94	-	-	13.72	-	-	13.72
Aromatics	DHA	vol %	-	-	6.07	-	-	6.07	-	-	5.08	-	-	5.08
Olefins	DHA	vol %	-	-	0.54	-	-	0.54	-	-	0.70	-	-	0.70
Saturates	DHA	vol %	-	-	10.31	-	-	10.3	-	-	8.24	-	-	8.2

Table E-1 Continued
CRC 2008 Volatility Program Fuel Inspections

Fuel Description			5						6					
Property	Method	Units	E75-9.7						E85-8.2					
Laboratory			A	B	C	D	E	Average	A	B	C	D	E	Average
Gravity	ASTM D4052	°API	49.4	50.26	49.9	49.7	50.38	49.9	49.1	49.26	48.8	48.9	49.34	49.1
Relative Density		60/60°F	0.7775	0.7785	0.7800	0.7807	0.7772	0.7788	0.7836	0.7828	0.7848	0.7844	0.7817	0.7835
Uncorrected Ethanol	ASTM D5501	wt %	-	-	74.61	-	-	74.61	-	-	82.66	-	-	82.66
Ethanol	ASTM D5501	vol %	72.10	-	72.78	73.27	-	72.72	79.65	-	81.03	80.33	-	80.34
Methanol	ASTM D5501	vol %	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	ASTM D4815	wt %	-	74.21	-	-	77.15	75.68	-	81.93	-		84.18	83.06
Ethanol	ASTM D4815	vol %	-	73.19	-	-	75.53	74.36	-	81.26	-	-	82.89	82.07
Water	ASTM E203	wt. %	-	0.85	0.93	-	0.823	0.87		0.98	1.06	-	1.001	1.01
Water	ASTM E203	vol %	0.55	0.66	0.73	0.63	0.64	0.64	0.65	0.77	0.83	0.73	0.78	0.75
Estimated Hydrocarbon		vol %	27.4	26.2	26.50	26.1	23.8	25.9868	19.7	18.0	18.135	18.9	16.3	18.2157
DVPE	ASTM D5191	psi	9.60	9.79	9.57	8.57	9.75	9.68	8.20	8.33	8.03	7.08	8.22	8.20
Distillation	ASTM D86													
Initial Boiling Point		°F	98.3	87.4	102.2	94.7	97	95.9	109.2	94.9	116.4	106.8	107.2	106.9
5% Evaporated		°F	115.3	124.0	123.4	124.7	126.3	122.7	133.8	138.1	145.9	146.3	136.6	140.1
10% Evaporated		°F	139.2	144.8	146.3	147	145.2	144.5	157.2	158.8	164.1	163.4	157.6	160.2
20% Evaporated		°F	164.3	166.2	168.2	165.2	164.8	165.7	168.2	169.3	171.5	170.8	168.6	169.7
30% Evaporated		°F	169.3	170.3	172.4	169.3	169.2	170.1	170.3	171.2	173.3	172.3	170.6	171.5
40% Evaporated		°F	170.6	171.6	173.6	170.4	170.6	171.4	171.0	171.9	174	173	171.5	172.3
50% Evaporated		°F	171.3	172.2	174.2	171.1	171.1	172.0	171.3	172.2	174.3	173.6	171.9	172.7
60% Evaporated		°F	171.7	172.4	174.5	171.3	171.5	172.3	171.7	172.5	174.7	173.8	172.2	173.0
70% Evaporated		°F	172.0	172.7	174.9	171.7	171.9	172.6	172.0	172.8	174.9	174	172.4	173.2
80% Evaporated		°F	172.6	173.1	175.2	172.1	172.2	173.0	172.3	173.2	175.2	174.5	172.8	173.6
90% Evaporated		°F	173.4	174.0	176.1	173.2	173.1	174.0	173.2	173.9	176	175.5	173.5	174.4
95% Evaporated		°F	174.9	175.4	177.4	174.5	174.9	175.4	174.8	175.3	177.6	177.9	175.3	176.2
End Point		°F	297.9	292.1	179.7	178.6	308.7	251.4	271.1	248.9	181.7	180.5	288.7	234.2
Recovery		vol %	96.7	97.9	94.7	98.1	98.5	97.2	97.2	98.1	95.9	97.7	97.8	97.3
Residue		vol %	1.2	1.2	1.9	1.7	0.8	1.4	0.9	0.9	2	1.1	0.8	1.1
Loss		vol %	2.2	0.8	3.4	0.2	0.7	1.5	1.9	0.9	2.1	1.2	1.4	1.5
Benzene	DHA	vol %	-	-	0.1630	-	-	0.1630	-	-	0.1350	-	-	0.1350
Ethanol	DHA	vol %	-	-	80.1700	-	-	80.1700	-	-	85.7000	-	-	85.7000
Methanol	DHA	vol %	-	-	0.00	-	-	0.0	-	-	0.00	-	-	0.0
Hydrocarbon	DHA	vol %	-	-	19.83	-	-	19.83	-	-	14.30	-	-	14.30
Aromatics	DHA	vol %	-	-	8.19	-	-	8.19	-	-	4.80	-	-	4.80
Olefins	DHA	vol %	-	-	0.63	-	-	0.63	-	-	0.51	-	-	0.51
Saturates	DHA	vol %	-	-	11.01	-	-	11.01	-	-	8.96	-	-	8.96

Table E-1 Continued
CRC 2008 Volatility Program Fuel Inspections

Fuel Description			7						8					
Property	**Method**	**Units**	E0-10.4						E0-15.1					
Laboratory			**A**	**B**	**C**	**D**	**E**	**Average**	**A**	**B**	**C**	**D**	**E**	**Average**
Gravity	ASTM D4052	°API	62.5	62.47	62.1	62.0	62.64	62.3	62.8	62.73	62.0	61.9	63.01	62.5
Relative Density		60/60°F	0.7294	0.7295	0.7309	0.7311	0.7281	0.7298	0.7283	0.7285	0.7313	0.7318	0.7268	0.7293
Uncorrected Ethanol	ASTM D5501	wt %	-	-	-	-	-	-	-	-	-	-	-	-
Ethanol	ASTM D5501	vol %	-	-	-	-	-	-	-	-	-	-	-	-
Methanol	ASTM D5501	vol %	0	0	0	0	0	0	0	0	0	0	0	0
Ethanol	ASTM D4815	wt %	0	<0.1	0	0	0.02		0	<0.1	0	0	0	0.0
Ethanol	ASTM D4815	vol %	0	<0.1	0	0	0.02	0.0	0	<0.1	0	0	0	0.0
Water	ASTM E203	wt. %		0.01		-	0.0024	0.0039		0.01		-	0.003	0.0051
Water	ASTM E203	vol %	0.02			0.00		0.01	0.01			0.00		0.01
Estimated Hydrocarbon		vol %												
DVPE	ASTM D5191	psi	10.30	10.49	10.26	10.3	10.57	10.38	15.00	15.26	14.98	14.21	15.32	15.14
Distillation	ASTM D86													
Initial Boiling Point		°F	88.9	82.2	89.4	86.1	88.7	87.1	75.4	72.3	77.8	77.6	77.7	76.2
5% Evaporated		°F	104.4	107.4	111.5	108.7	108	108.0	84.4	85.0	86.1	91.3	80.4	85.4
10% Evaporated		°F	119.5	121.1	127	124.4	122.9	123.0	93.9	93.6	96.9	99.4	94.1	95.6
20% Evaporated		°F	148.5	151.4	158.1	155.5	151.9	153.1	101.3	108.0	112.6	117.1	108.9	109.6
30% Evaporated		°F	181.9	183.0	191.1	187.2	184.1	185.5	108.5	127.2	132.3	137.4	126.7	126.4
40% Evaporated		°F	207.9	207.7	215.2	210.9	208.9	210.1	152.4	153.1	158.4	166.1	152.1	156.4
50% Evaporated		°F	223.3	221.9	229.8	225.2	223.7	224.8	185.5	185.6	193.0	202.6	185.2	190.4
60% Evaporated		°F	234.5	233.8	240.4	235.7	234.1	235.7	223.3	221.4	229.2	235.4	222.6	226.4
70% Evaporated		°F	246.4	246.1	252.6	248.1	246.4	247.9	246.0	245.6	250.5	252.7	246.6	248.3
80% Evaporated		°F	266.9	267.0	274.4	269.2	267.8	269.1	264.2	264.2	268.3	273.1	264.6	266.9
90% Evaporated		°F	312.1	313.0	321.2	316.1	313.9	315.3	289.6	285.8	292.4	304.1	289.2	292.2
95% Evaporated		°F	344.8	344.1	350.6	351.8	343.4	346.9	307.8	306.2	312.3	352.2	307.2	317.1
End Point		°F	397.8	397.6	413.4	385.6	401.2	399.1	349.2	347.9	354.2	352.7	352.6	351.3
Recovery		vol %	96.7	97.3	96.3	96.8	96.9	96.8	96.0	97.1	95.4	94.4	95.6	95.7
Residue		vol %	1.0	1.1	1.2	1.4	0.8	1.1	1.5	0.8	1.4	1	0.7	1.1
Loss		vol %	2.3	1.4	2.5	1.8	2.3	2.1	2.5	1.8	3.2	4.6	3.7	3.2
Benzene	DHA	vol %	-	-	0.36	-	-	0.36	-	-	0.70	-	-	0.70
Ethanol	DHA	vol %	-	-	0.00	-	-	0.00	-	-	0.00	-	-	0.00
Methanol	DHA	vol %	-	-	0.00	-	-	0.0	-	-	0.00	-	-	0.0
Hydrocarbon	DHA	vol %	-	-	100.00	-	-	100.00	-	-	100.00	-	-	100.00
Aromatics	DHA	vol %	-	-	24.22	-	-	24.22	-	-	36.48	-	-	36.48
Olefins	DHA	vol %	-	-	4.28	-	-	4.28	-	-	3.22	-	-	3.22
Saturates	DHA	vol %	-	-	69.36	-	-	69.36	-	-	60.07	-	-	60.07

Note: Vapor pressure measurements more than two standard deviations from the Mean were not included in the final Mean

Table E-2
Assessment of Flushing Procedure

Sample Number	Date Sampled	Vehicle	Previous Fuel	Flush Fuel	Ethanol, wt %	Ethanol vol %	Contamination %
851101	11/25/2008	1	2	7	<0.2	<0.18	<0.25
851102	11/25/2008	2	2	7	<0.2	<0.18	<0.25
851103	11/25/2008	3	2	7	0.94	0.86	1.18
851104	11/25/2008	4	2	7	<0.2	<0.18	<0.25
851105	11/25/2008	5	2	7	<0.2	<0.18	<0.25
851106	11/25/2008	6	2	7	0.28	0.26	0.35
851107	11/25/2008	7	2	7	<0.2	<0.18	<0.25
851108	11/25/2008	8	2	7	0.63	0.58	0.79
851109	11/25/2008	9	2	7	0.69	0.63	0.87
851110	11/25/2008	10	2	7	0.43	0.40	0.54
851111	11/25/2008	11	2	7	<0.2	<0.18	<0.25
851112	11/25/2008	12	2	7	0.47	0.43	0.59
851113	11/25/2008	13	2	7	<0.2	<0.18	<0.25
851114	11/25/2008	14	2	7	<0.2	<0.18	<0.25
851115	11/25/2008	15	2	7	0.68	0.63	0.86
851116	11/25/2008	16	2	7	<0.2	<0.18	<0.25
851117	11/25/2008	17	2	7	1.15	1.06	1.45
851118	11/25/2008	18	2	7	<0.2	<0.18	<0.25
851119	11/25/2008	19	2	7	<0.2	<0.18	<0.25
851120	11/25/2008	20	2	7	0.72	0.66	0.91
851121	11/25/2008	Drum	-	7	<0.2	<0.18	<0.25

APPENDIX F

VEHICLE TOTAL WEIGHTED DEMERIT SUMMARY

Table F-1
Vehicle Total Weighted Demerit Summary

Fuel 1

					Temperature, °F		
Vehicle	Run #	Fuel	Date	Time	Soak	Run	TWD
1	3	1	12/9/08	8:50	20	20	45.5
2	5	1	12/9/08	10:00	20	20	42
3	4	1	12/9/08	9:30	20	20	51
4	2	1	12/9/08	8:15	20	20	54.5
5	1	1	12/9/08	7:40	20	20	41.5
6	4	1	12/10/08	9:45	20	20	109.5
7	3	1	12/10/08	9:05	20	20	98
8	5	1	12/10/08	10:25	20	20	48.5
9	2	1	12/10/08	8:30	20	20	57.5
10	1	1	12/10/08	7:50	20	20	41.5
11	5	1	12/5/08	10:05	20	20	140.5
12	4	1	12/5/08	9:35	20	20	62.5
13	3	1	12/5/08	8:55	20	20	34.5
14	1	1	12/5/08	7:40	20	20	41.5
15	2	1	12/5/08	8:15	20	20	61.5
16	5	1	12/8/08	9:35	20	20	59.5
17	4	1	12/8/08	9:10	20	20	15.5
18	2	1	12/8/08	8:10	20	20	22
19	3	1	12/8/08	8:40	20	20	57.5
20	1	1	12/8/08	7:40	20	20	45

Fuel 2

					Temperature, °F		
Vehicle	Run #	Fuel	Date	Time	Soak	Run	TWD
1	3	2	11/11/08	9:00	20	20	31.5
2	1	2	11/11/08	7:50	20	20	47.5
3	2	2	11/11/08	8:35	20	20	24.5
4	4	2	11/11/08	9:35	20	20	29
5	5	2	11/11/08	10:00	20	20	11
6	2	2	11/10/08	8:10	20	20	37.5
7	3	2	11/10/08	8:35	20	20	17
8	1	2	11/10/08	7:45	20	20	17.5
9	4	2	11/10/08	9:10	20	20	18
10	5	2	11/10/08	9:40	20	20	14
11	5	2	11/7/08	11:15	20	20	43
12	4	2	11/7/08	10:35	20	20	24.5
13	3	2	11/7/08	9:15	20	20	15
14	1	2	11/7/08	7:55	20	20	17.5
15	2	2	11/7/08	8:40	20	20	15.5
16	5	2	11/12/08	11:05	20	20	26
17	4	2	11/12/08	10:30	20	20	27.5
18	2	2	11/12/08	8:45	20	20	16
19	3	2	11/12/08	9:30	20	20	44.5
20	1	2	11/12/08	7:45	20	20	21.5

Table F-1 Continued
Vehicle Total Weighted Demerit Summary

Fuel 2

Vehicle	Run #	Fuel	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD
1	3	2	11/3/08	10:00	0	0	34
2	5	2	11/3/08	11:50	0	0	64
3	4	2	11/3/08	11:15	0	0	63.5
4	2	2	11/3/08	8:55	0	0	171
5	1	2	11/3/08	8:10	0	0	48
6	2	2	11/5/08	8:35	0	0	89
7	3	2	11/5/08	9:25	0	0	127.5
8	1	2	11/5/08	7:45	0	0	77.5
9	4	2	11/5/08	11:10	0	0	33
10	5	2	11/5/08	11:55	0	0	43.5
11	5	2	11/8/08	10:00	0	0	62.5
12	4	2	11/8/08	9:30	0	0	63.5
13	3	2	11/8/08	9:00	0	0	177
14	1	2	11/8/08	8:00	0	0	34.5
15	2	2	11/8/08	8:30	0	0	38.5
16	5	2	11/13/08	10:50	0	0	58
17	4	2	11/13/08	10:00	0	0	75
18	2	2	11/13/08	8:40	0	0	22.5
19	3	2	11/13/08	9:25	0	0	41.5
20	1	2	11/13/08	7:40	0	0	42.5

Fuel 2

Vehicle	Run #	Fuel	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD
1	3	2	11/4/08	9:15	-20	-20	500
2	5	2	11/4/08	11:00	-20	-20	500
3	4	2	11/4/08	10:20	-20	-20	500
4	2	2	11/4/08	8:35	-20	-20	500
5	1	2	11/4/08	8:00	-20	-20	141
6	5	2	11/6/08	11:25	-20	-20	500
7	4	2	11/6/08	10:55	-20	-20	221
8	3	2	11/6/08	9:45	-20	-20	500
9	2	2	11/6/08	9:10	-20	-20	83
10	1	2	11/6/08	8:25	-20	-20	79
11	5	2	11/9/08	9:45	-20	-20	500
12	4	2	11/9/08	9:30	-20	-20	500
13	3	2	11/9/08	8:50	-20	-20	500
14	1	2	11/9/08	7:45	-20	-20	116.5
15	2	2	11/9/08	8:07	-20	-20	500
16	4	2	11/14/08	10:45	-20	-20	500
17	5	2	11/14/08	11:15	-20	-20	500
18	2	2	11/14/08	8:30	-20	-20	57.5
19	3	2	11/14/08	9:45	-20	-20	500
20	1	2	11/14/08	7:45	-20	-20	500

Table F-1 Continued
Vehicle Total Weighted Demerit Summary

Fuel 4

Vehicle	Run #	Fuel	Date	Time	Temperature, °F Soak	Run	TWD
1	3	4	10/24/08	9:05	0	0	222.5
2	5	4	10/24/08	10:55	0	0	39
3	4	4	10/24/08	10:25	0	0	188.5
4	2	4	10/24/08	8:25	0	0	214
5	1	4	10/24/08	7:40	0	0	69
6	5	4	10/26/08	11:35	0	0	89.5
7	4	4	10/26/08	10:45	0	0	220.5
8	3	4	10/26/08	9:20	0	0	87
9	2	4	10/26/08	8:30	0	0	33
10	1	4	10/26/08	7:45	0	0	50
11	5	4	10/28/08	10:35	0	0	111
12	4	4	10/28/08	10:50	0	0	291
13	3	4	10/28/08	9:30	0	0	257
14	1	4	10/28/08	8:00	0	0	46
15	2	4	10/28/08	8:50	0	0	69
16	4	4	10/30/08	10:10	0	0	125
17	5	4	10/30/08	11:10	0	0	266
18	2	4	10/30/08	8:20	0	0	19.5
19	3	4	10/30/08	9:30	0	0	126
20	1	4	10/30/08	7:40	0	0	53

Fuel 4

Vehicle	Run #	Fuel	Date	Time	Temperature, °F Soak	Run	TWD
1	3	4	10/25/08	9:30	-20	-20	500
2	5	4	10/25/08	11:06	-20	-20	500
3	4	4	10/28/08	10:30	-20	-20	500
4	2	4	10/25/08	8:45	-20	-20	500
5	1	4	10/25/08	7:55	-20	-20	356.5
6	5	4	10/27/08	8:24	-20	-20	500
7	4	4	10/27/08	9:40	-20	-20	318
8	3	4	10/27/08	9:00	-20	-20	500
9	2	4	10/27/08	8:30	-20	-20	137
10	1	4	10/27/08	7:50	-20	-20	118.5
11	5	4	10/29/08	7:50	-20	-20	500
12	4	4	10/29/08	7:50	-20	-20	500
13	3	4	10/29/08	7:50	-20	-20	500
14	1	4	10/29/08	7:50	-20	-20	266
15	2	4	10/29/08	7:50	-20	-20	53
16	4	4	10/31/08	9:25	-20	-20	500
17	5	4	10/31/08	9:55	-20	-20	500
18	2	4	10/31/08	8:05	-20	-20	73
19	3	4	10/31/08	8:50	-20	-20	500
20	1	4	10/31/08	7:25	-20	-20	68.5

Table F-1 Continued
Vehicle Total Weighted Demerit Summary

Fuel 5

Vehicle	Run #	Fuel	Date	Time	Temperature, °F		TWD
					Soak	Run	
1	3	5	10/3/08	9:20	0	0	77
2	6	5	11/12/08	14:25	0	0	40
3	6	5	11/17/08	15:00	0	0	72.5
4	4	5	10/3/08	10:40	0	0	73
5	5	5	10/3/08	11:20	0	0	20
6	5	5	10/13/08	11:15	0	0	252
7	4	5	10/13/08	10:35	0	0	117.5
8	3	5	10/13/08	9:20	0	0	33.5
9	2	5	10/13/08	8:40	0	0	42
10	1	5	10/13/08	8:00	0	0	40.5
11	3	5	10/20/08	9:30	0	0	61.5
12	2	5	10/20/08	8:45	0	0	38.5
13	4	5	10/20/08	11:00	0	0	191.5
14	1	5	10/20/08	7:55	0	0	31
15	5	5	10/20/08	11:40	0	0	32
16	4	5	10/22/08	10:45	0	0	40.5
17	5	5	10/22/08	11:35	0	0	121.5
18	2	5	10/22/08	8:45	0	0	27.5
19	3	5	10/22/08	9:25	0	0	56
20	1	5	10/22/08	7:55	0	0	23.5

Fuel 5

Vehicle	Run #	Fuel	Date	Time	Temperature, °F		TWD
					Soak	Run	
1	3	5	10/2/08	9:55	-20	-20	162
2	6	5	11/14/08	14:20	-20	-20	500
3	6	5	11/18/08	14:50	-20	-20	262
4	2	5	10/2/08	8:40	-20	-20	241
5	1	5	10/2/08	7:50	-20	-20	72.5
6	5	5	10/4/08	10:00	-20	-20	500
7	4	5	10/4/08	9:30	-20	-20	164
8	6	5	11/11/08	14:30	-20	-20	275
9	2	5	10/4/08	8:25	-20	-20	79
10	1	5	10/4/08	7:45	-20	-20	75
11	3	5	10/21/08	9:35	-20	-20	120
12	2	5	10/21/08	8:40	-20	-20	199.5
13	4	5	10/21/08	10:55	-20	-20	500
14	1	5	10/21/08	8:00	-20	-20	37.5
15	5	5	10/21/08	12:00	-20	-20	37
16	4	5	10/23/08	10:40	-20	-20	89.5
17	5	5	10/23/08	11:12	-20	-20	212
18	2	5	10/23/08	8:30	-20	-20	46.5
19	3	5	10/23/08	9:05	-20	-20	214
20	1	5	10/23/08	7:50	-20	-20	47

Table F-1 Continued
Vehicle Total Weighted Demerit Summary

Fuel 6

Vehicle	Run #	Fuel	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD
1	3	6	12/16/08	8:45	0	0	164.5
2	5	6	12/16/08	9:45	0	0	103
3	4	6	12/16/08	9:15	0	0	296
4	2	6	12/16/08	8:05	0	0	500
5	1	6	12/16/08	7:40	0	0	54
6	4	6	12/18/08	8:30	0	0	500
7	3	6	12/18/08	8:15	0	0	188
8	5	6	12/18/08	8:45	0	0	247
9	2	6	12/18/08	7:50	0	0	39.5
10	1	6	12/18/08	7:30	0	0	66
11	5	6	12/12/08	9:30	0	0	209
12	4	6	12/12/08	9:05	0	0	500
13	3	6	12/12/08	8:35	0	0	255
14	1	6	12/12/08	7:40	0	0	65.5
15	2	6	12/12/08	8:10	0	0	60.5
16	5	6	12/14/08	9:40	0	0	108
17	4	6	12/14/08	9:20	0	0	500
18	2	6	12/14/08	8:15	0	0	51
19	3	6	12/14/08	8:45	0	0	152
20	1	6	12/14/08	7:45	0	0	56.5

Fuel 6

Vehicle	Run #	Fuel	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD
1	3	6	12/15/08	9:15	20	20	19
2	5	6	12/15/08	10:40	20	20	44
3	4	6	12/15/08	10:00	20	20	30
4	2	6	12/15/08	8:30	20	20	100
5	1	6	12/15/08	7:50	20	20	35.5
6	4	6	12/17/08	9:50	20	20	98.5
7	3	6	12/17/08	9:10	20	20	158
8	5	6	12/17/08	10:35	20	20	21.5
9	2	6	12/17/08	8:25	20	20	28
10	1	6	12/17/08	7:40	20	20	33.5
11	5	6	12/11/08	11:00	20	20	105.5
12	4	6	12/11/08	10:15	20	20	29.5
13	3	6	12/11/08	9:30	20	20	29.5
14	1	6	12/11/08	7:50	20	20	42
15	2	6	12/11/08	8:40	20	20	52
16	5	6	12/13/08	10:50	20	20	60
17	4	6	12/13/08	10:10	20	20	22
18	2	6	12/13/08	8:30	20	20	44
19	3	6	12/13/08	9:25	20	20	51.5
20	1	6	12/13/08	7:45	20	20	61.5

Table F-1 Continued
Vehicle Total Weighted Demerit Summary

Fuel 7

Vehicle	Run #	Fuel	Date	Time	Temperature, °F		TWD
					Soak	Run	
1	3	7	11/20/08	9:05	20	20	13
2	5	7	11/20/08	10:20	20	20	32
3	4	7	11/20/08	9:50	20	20	39.5
4	2	7	11/20/08	8:25	20	20	19
5	1	7	11/20/08	7:45	20	20	16.5
6	4	7	11/17/08	10:15	20	20	49
7	3	7	11/17/08	9:35	20	20	20
8	5	7	11/17/08	11:20	20	20	43.5
9	2	7	11/17/08	8:50	20	20	43
10	1	7	11/17/08	8:05	20	20	24
11	5	7	11/25/08	11:15	20	20	84.5
12	4	7	11/25/08	10:25	20	20	43
13	3	7	11/25/08	9:20	20	20	17
14	1	7	11/25/08	7:40	20	20	14.5
15	2	7	11/25/08	8:20	20	20	16.5
16	5	7	11/28/08	11:00	20	20	37.5
17	4	7	11/28/08	10:10	20	20	25
18	2	7	11/28/08	8:30	20	20	37.5
19	3	7	11/28/08	9:20	20	20	50.5
20	1	7	11/28/08	7:50	20	20	16

Fuel 7

Vehicle	Run #	Fuel	Date	Time	Temperature, °F		TWD
					Soak	Run	
1	3	7	11/21/08	8:30	0	0	16.5
2	5	7	11/21/08	9:30	0	0	49
3	4	7	11/21/08	9:00	0	0	49
4	2	7	11/21/08	7:55	0	0	32.5
5	1	7	11/21/08	7:30	0	0	30.5
6	4	7	11/18/08	9:50	0	0	80.5
7	3	7	11/18/08	9:20	0	0	36.5
8	5	7	11/18/08	11:00	0	0	25.5
9	2	7	11/18/08	8:40	0	0	57.5
10	1	7	11/18/08	7:55	0	0	50.5
11	5	7	11/26/08	11:25	0	0	98.5
12	4	7	11/26/08	10:30	0	0	28
13	3	7	11/26/08	9:45	0	0	46
14	1	7	11/26/08	8:00	0	0	45.5
15	2	7	11/26/08	9:00	0	0	21.5
16	5	7	11/29/08	11:15	0	0	75.5
17	4	7	11/29/08	10:35	0	0	40.5
18	2	7	11/29/08	9:45	0	0	20
19	3	7	11/29/08	9:30	0	0	87
20	1	7	11/29/08	7:45	0	0	34

Table F-1 Continued
Vehicle Total Weighted Demerit Summary

Fuel 7

Vehicle	Run #	Fuel	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD
1	3	7	11/24/08	8:55	-20	-20	54.5
2	5	7	11/24/08	10:00	-20	-20	71.5
3	4	7	11/24/08	9:30	-20	-20	59.5
4	2	7	11/24/08	8:20	-20	-20	95.5
5	1	7	11/24/08	7:50	-20	-20	87
6	4	7	11/19/08	9:20	-20	-20	115.5
7	3	7	11/19/08	8:50	-20	-20	98
8	5	7	11/19/08	9:50	-20	-20	40.5
9	2	7	11/19/08	8:25	-20	-20	88
10	1	7	11/19/08	7:45	-20	-20	67.5
11	5	7	11/27/08	10:20	-20	-20	117.5
12	4	7	11/27/08	9:40	-20	-20	35.5
13	3	7	11/27/08	9:00	-20	-20	49
14	1	7	11/27/08	7:45	-20	-20	76.5
15	2	7	11/27/08	8:25	-20	-20	51
16	5	7	11/30/08	9:45	-20	-20	64
17	4	7	11/30/08	9:25	-20	-20	56
18	2	7	11/30/08	8:15	-20	-20	41
19	3	7	11/30/08	8:50	-20	-20	126
20	1	7	11/30/08	7:45	-20	-20	49

Fuel 8

Vehicle	Run #	Fuel	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD
1	3	8	12/1/08	9:00	0	0	23
2	5	8	12/1/08	10:10	0	0	43.5
3	4	8	12/1/08	9:35	0	0	30
4	2	8	12/1/08	8:15	0	0	53.5
5	1	8	12/1/08	7:40	0	0	37.5
6	4	8	12/3/08	9:45	0	0	74
7	3	8	12/3/08	9:00	0	0	39
8	5	8	12/3/08	10:20	0	0	20
9	2	8	12/3/08	8:30	0	0	23.5
10	1	8	12/3/08	7:40	0	0	50
11	3	8	10/14/08	10:30	0	0	61.5
12	2	8	10/14/08	9:00	0	0	20
13	4	8	10/14/08	11:25	0	0	16.5
14	1	8	10/14/08	8:05	0	0	13.5
15	5	8	10/14/08	13:45	0	0	27
16	4	8	10/16/08	12:30	0	0	33.5
17	5	8	10/16/08	13:50	0	0	28
18	2	8	10/16/08	10:05	0	0	19
19	3	8	10/16/08	11:00	0	0	18
20	1	8	10/16/08	7:55	0	0	15

Table F-1 Continued
Vehicle Total Weighted Demerit Summary

Fuel 8

Vehicle	Run #	Fuel	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD
1	3	8	12/2/08	8:30	-20	-20	34
2	5	8	12/2/08	9:50	-20	-20	46.5
3	4	8	12/2/08	9:15	-20	-20	50
4	2	8	12/2/08	8:05	-20	-20	62
5	1	8	12/2/08	7:40	-20	-20	34
6	4	8	12/4/08	9:25	-20	-20	66
7	3	8	12/4/08	8:50	-20	-20	36
8	5	8	12/4/08	10:00	-20	-20	39.5
9	2	8	12/4/08	8:25	-20	-20	47
10	1	8	12/4/08	7:45	-20	-20	55.5
11	5	8	10/15/08	13:00	-20	-20	34
12	4	8	10/15/08	11:40	-20	-20	31.5
13	3	8	10/15/08	10:35	-20	-20	28
14	2	8	10/15/08	9:10	-20	-20	33.5
15	1	8	10/15/08	8:05	-20	-20	23
16	4	8	10/17/08	10:10	-20	-20	29
17	5	8	10/17/08	11:05	-20	-20	30.5
18	2	8	10/17/08	8:50	-20	-20	25
19	3	8	10/17/08	9:30	-20	-20	25
20	1	8	10/17/08	7:50	-20	-20	28.5

Table F-2
Vehicle Total Weighted Demerit Summary
Early Test Data Not Used in Analysis

Fuel 8

Vehicle	Run #	Fuel	Date	Time	Temperature, °F		TWD
					Soak	Run	
1	5	8	9/25/08	13:30	-30	-30	46.5
2	4	8	9/25/08	11:40	-30	-30	500
3	3	8	9/25/08	10:30	-30	-30	53
4	2	8	9/28/08	9:38	-30	-30	33.5
5	1	8	9/25/08	8:40	-30	-30	31
6	5	8	9/29/08	17:20	-30	-30	500
7	4	8	9/29/08	16:45	-30	-30	24.5
8	3	8	9/29/08	15:55	-30	-30	30.5
9	2	8	9/29/08	15:05	-30	-30	51.5
10	1	8	9/29/08	14:25	-30	-30	40.5

Fuel 5

Vehicle	Run #	Fuel	Date	Time	Temperature, °F		TWD
					Soak	Run	
1	1	5	9/30/08	8:25	-10	-10	41
2	2	5	9/30/08	9:25	-10	-10	500
3	3	5	9/30/08	10:15	-10	-10	175.5
4	4	5	9/30/08	11:30	-10	-10	217
5	5	5	9/30/08	13:05	-10	-10	15

Fuel 8

Vehicle	Run #	Fuel	Date	Time	Temperature, °F		TWD
					Soak	Run	
1	1	8	9/24/08	8:39	-10	-10	14
2	2	8	9/24/08	10:12	-10	-10	35
3	3	8	9/24/08	11:25	-10	-10	19
4	4	8	9/24/08	12:35	-10	-10	10
5	5	8	9/24/08	14:22	-10	-10	10.5
6	1	8	9/26/08	7:50	-10	-10	41.5
7	2	8	9/26/08	8:52	-10	-10	13.5
8	3	8	9/23/08	9:40	-10	-10	17.5
9	4	8	9/26/08	10:52	-10	-10	14
10	5	8	9/26/08	12:10	-10	-10	29.5

Fuel 5

Vehicle	Run #	Fuel	Date	Time	Temperature, °F		TWD
					Soak	Run	
1	3	5	10/1/08	10:55	-30	-30	137
3	4	5	10/1/08	12:05	-30	-30	500
4	2	5	10/1/08	9:10	-30	-30	500
5	1	5	10/1/08	8:00	-30	-30	159

APPENDIX G

INDIVIDUAL VEHICLE TEMPERATURE RESPONSE CHARTS

Figure G-1
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 1

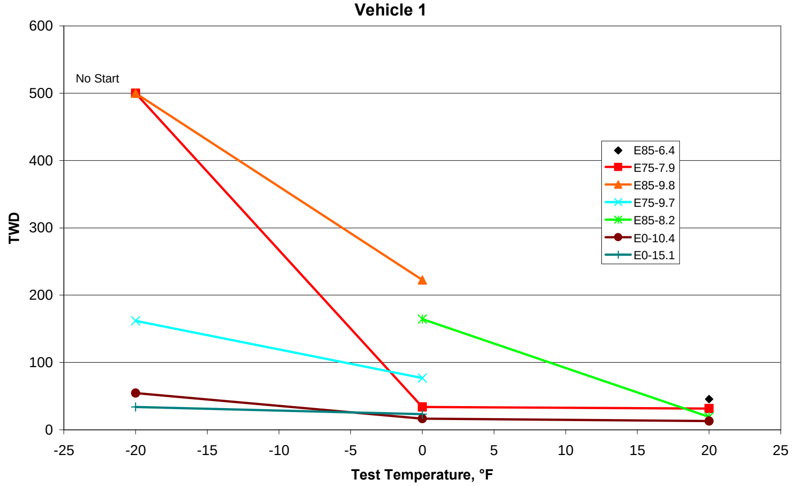


Figure G-2
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 2

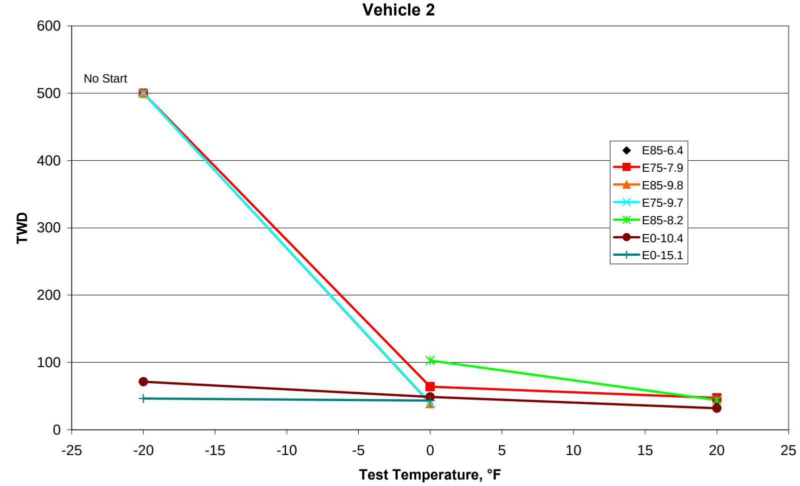


Figure G-3
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 3

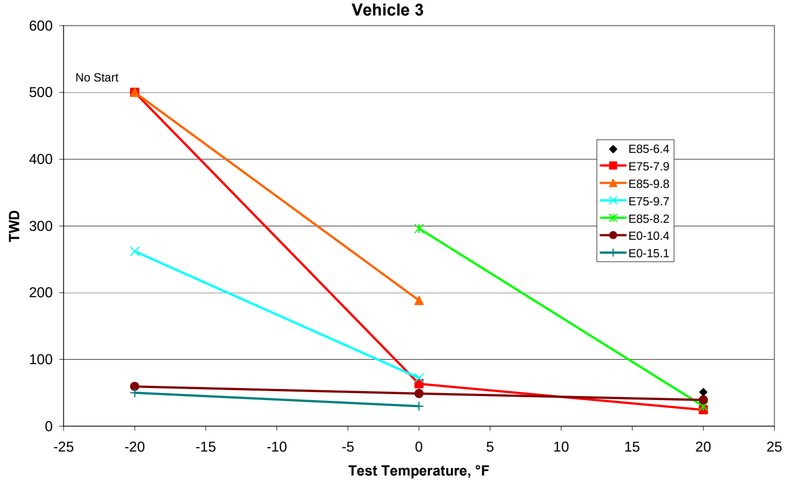


Figure G-4
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 4

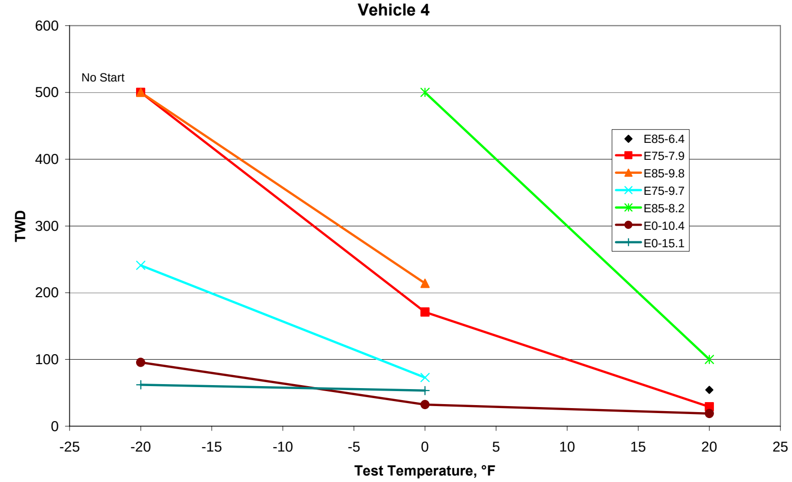


Figure G-5
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 5

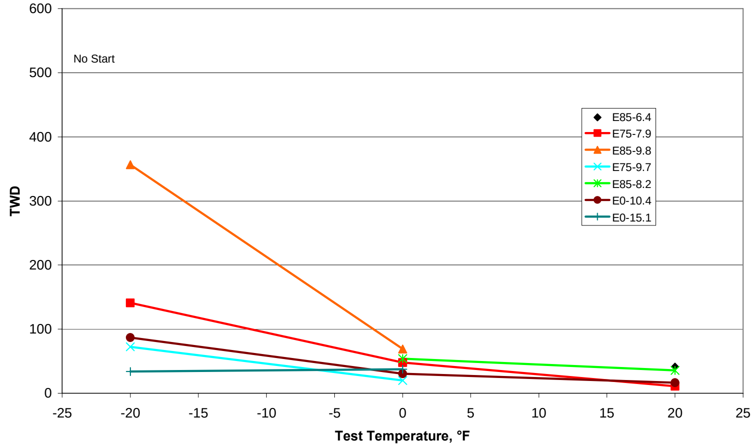


Figure G-6
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 6

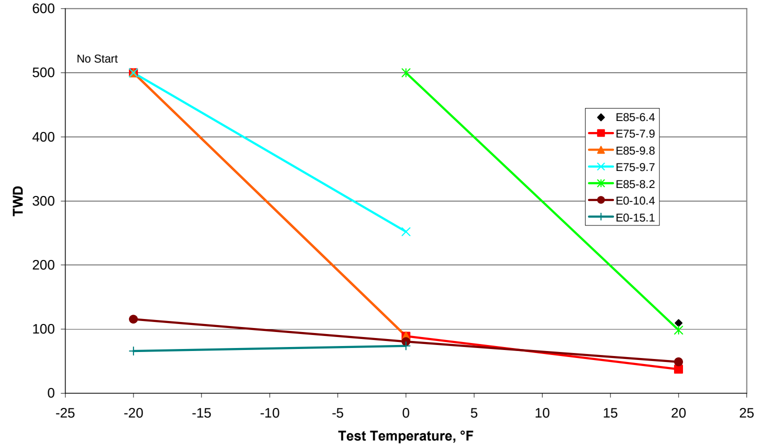


Figure G-7
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 7

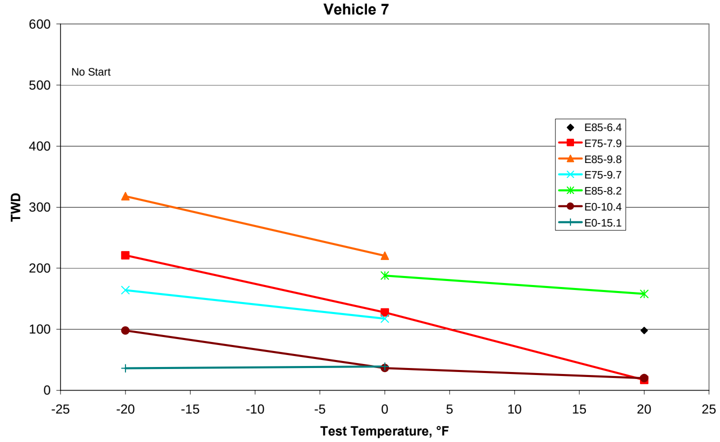
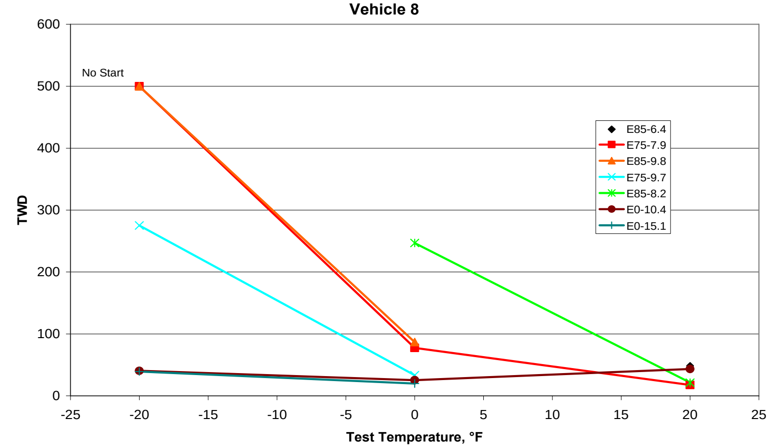


Figure G-8
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 8



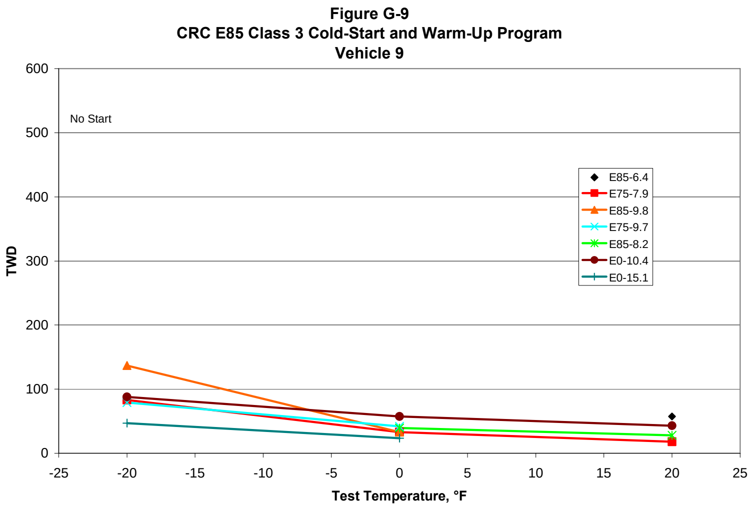


Figure G-9
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 9
No Start
TWD
Test Temperature, °F
E85-6.4
E75-7.9
E85-9.8
E75-9.7
E85-8.2
E0-10.4
E0-15.1

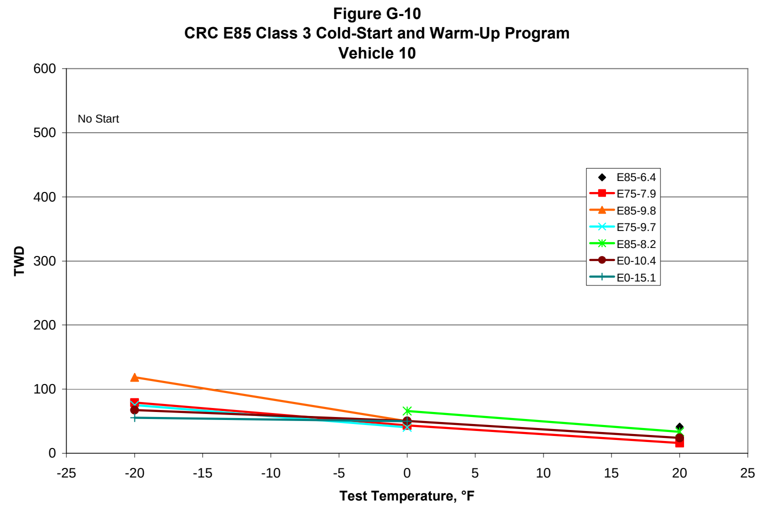


Figure G-10
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 10
No Start
TWD
Test Temperature, °F
E85-6.4
E75-7.9
E85-9.8
E75-9.7
E85-8.2
E0-10.4
E0-15.1

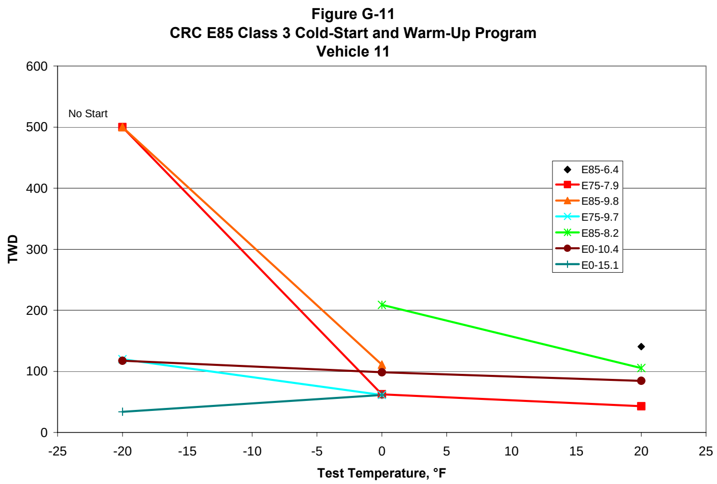


Figure G-11
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 11
No Start
TWD
Test Temperature, °F
E85-6.4
E75-7.9
E85-9.8
E75-9.7
E85-8.2
E0-10.4
E0-15.1

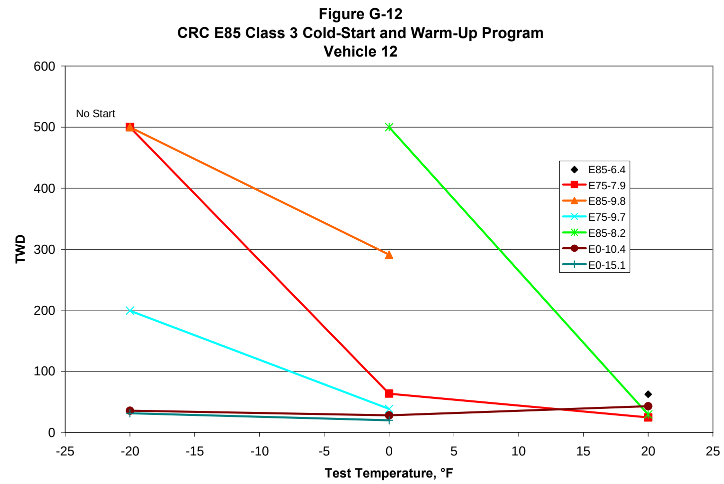


Figure G-12
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 12
No Start
TWD
Test Temperature, °F
E85-6.4
E75-7.9
E85-9.8
E75-9.7
E85-8.2
E0-10.4
E0-15.1

Figure G-13
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 13

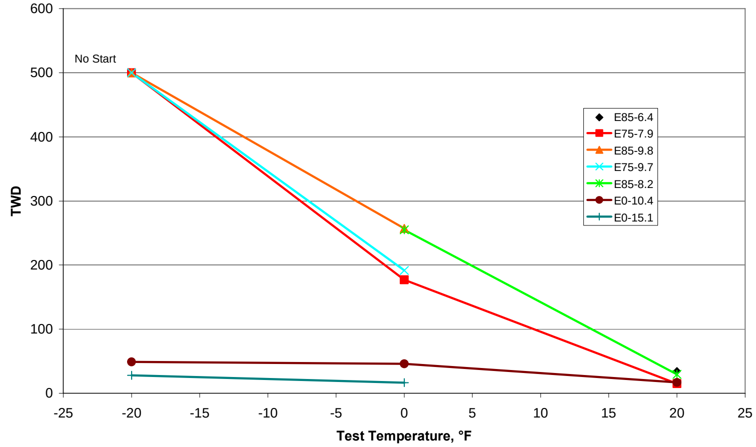


Figure G-14
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 14

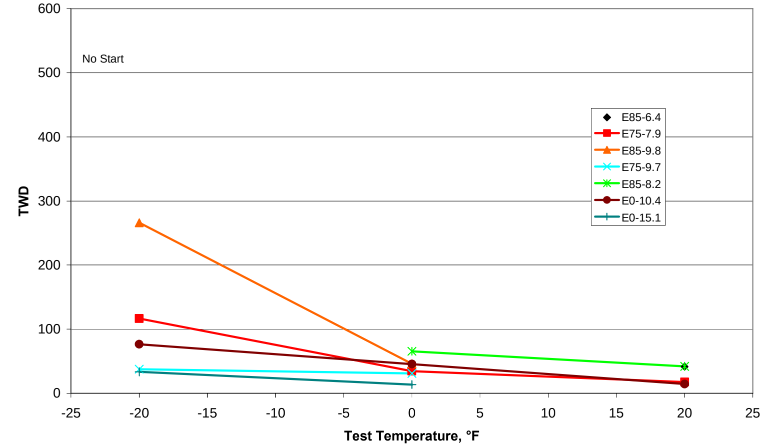


Figure G-15
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 15

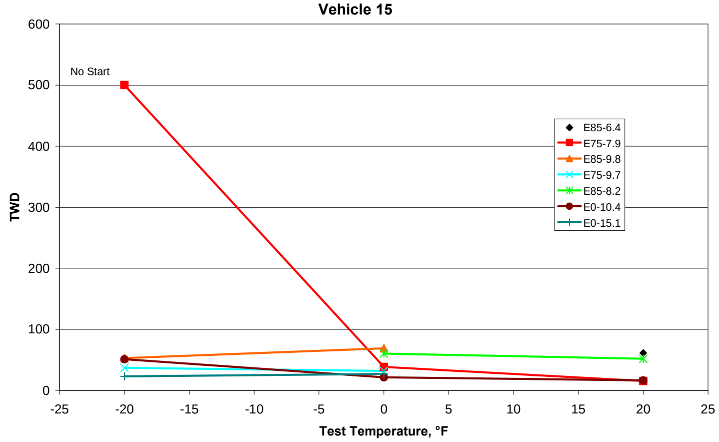


Figure G-16
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 16

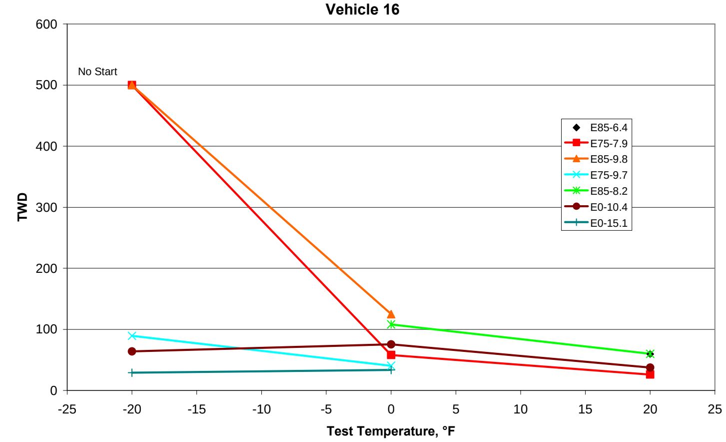


Figure G-17
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 17

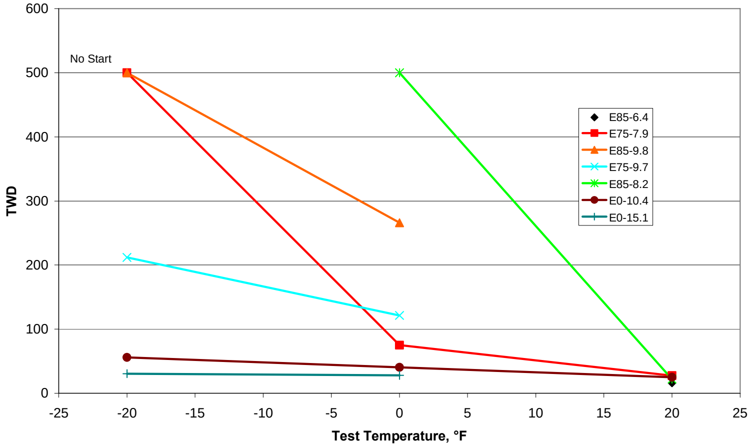


Figure G-18
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 18

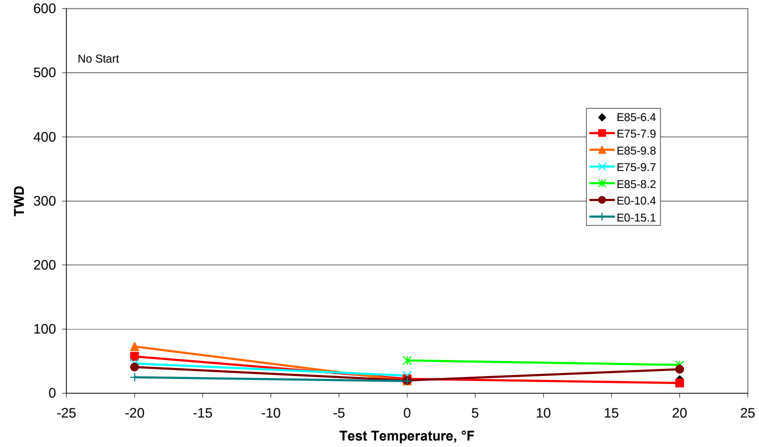


Figure G-19
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 19

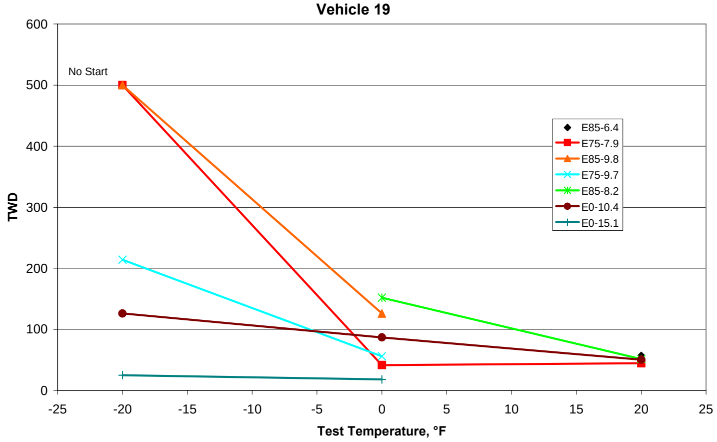
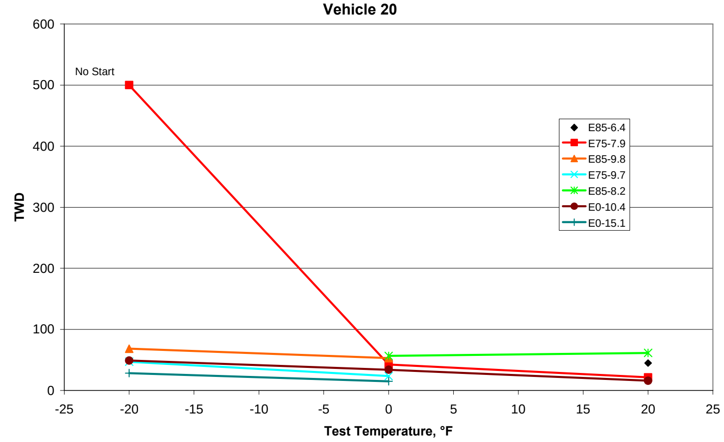


Figure G-20
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 20



APPENDIX H

INDIVIDUAL VEHICLE VAPOR PRESSURE RESPONSE CHARTS

Figure H-1
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 1

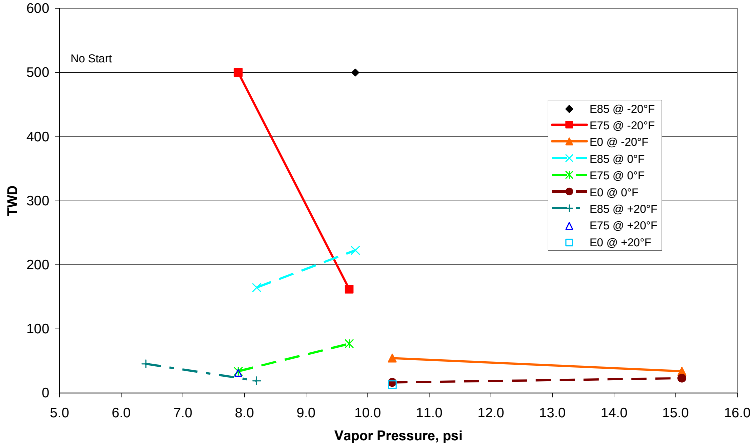


Figure H-2
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 2

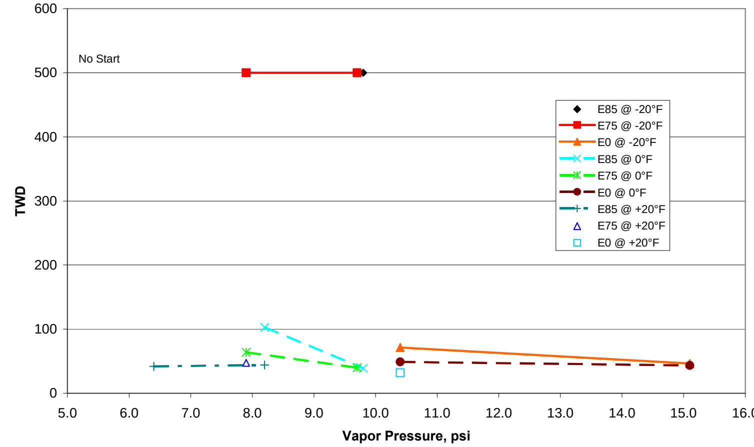


Figure H-3
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 3

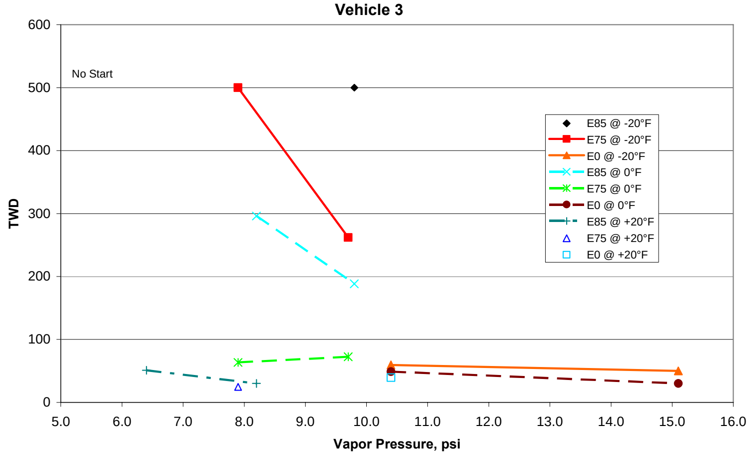


Figure H-4
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 4

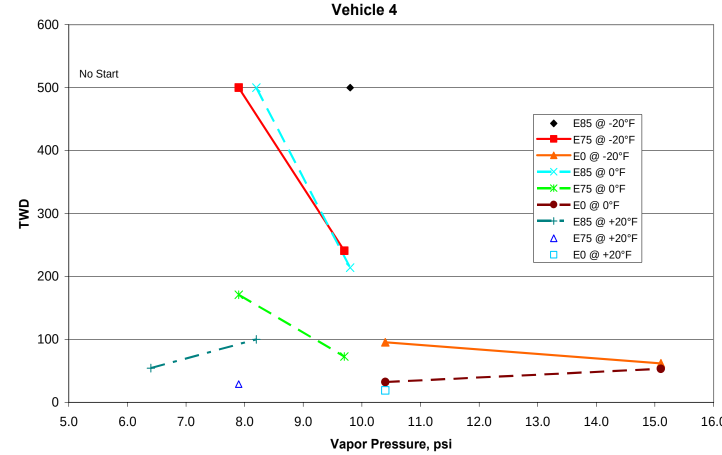


Figure H-5
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 5

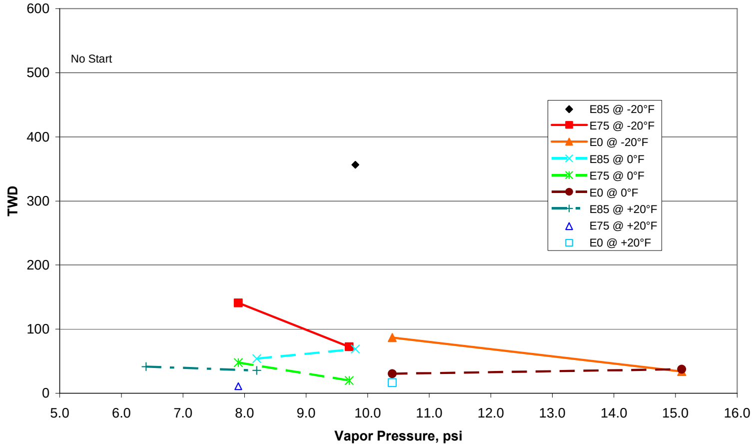


Figure H-6
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 6

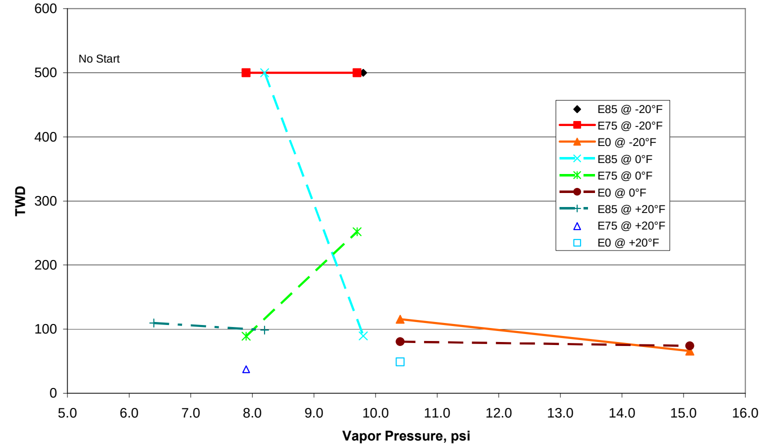


Figure H-7
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 7

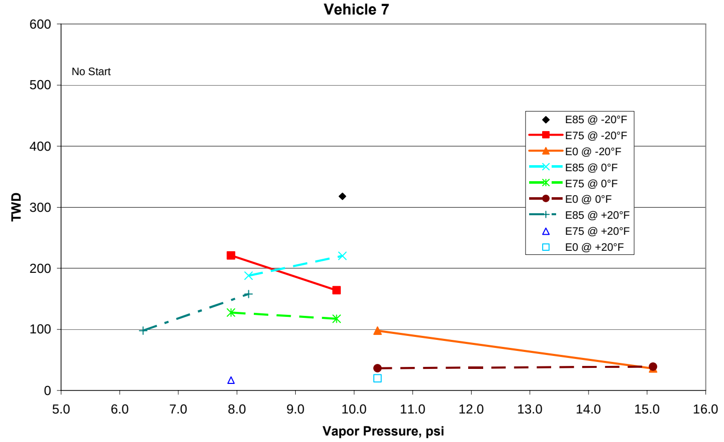


Figure H-8
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 8

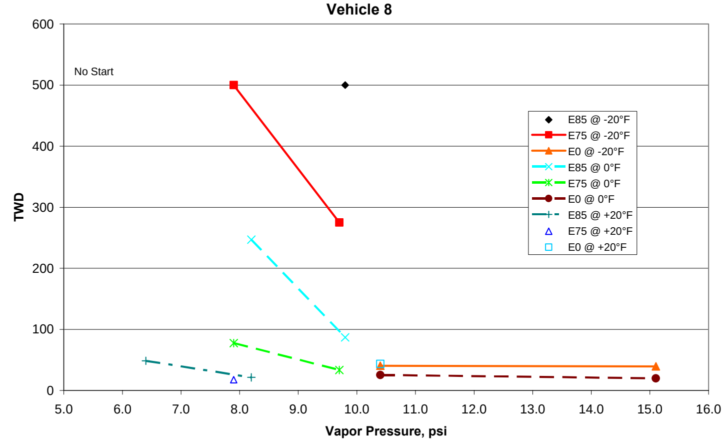


Figure H-9
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 9

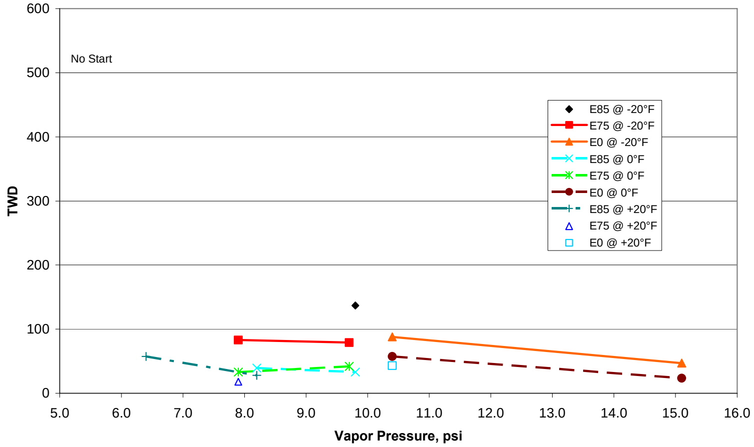


Figure H-10
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 10

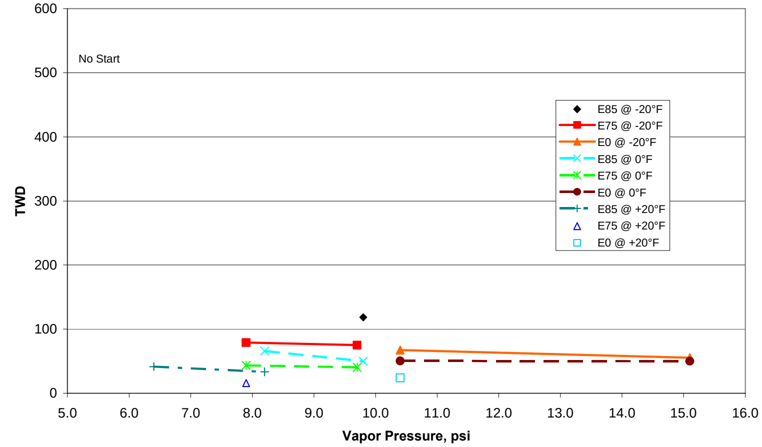


Figure H-11
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 11

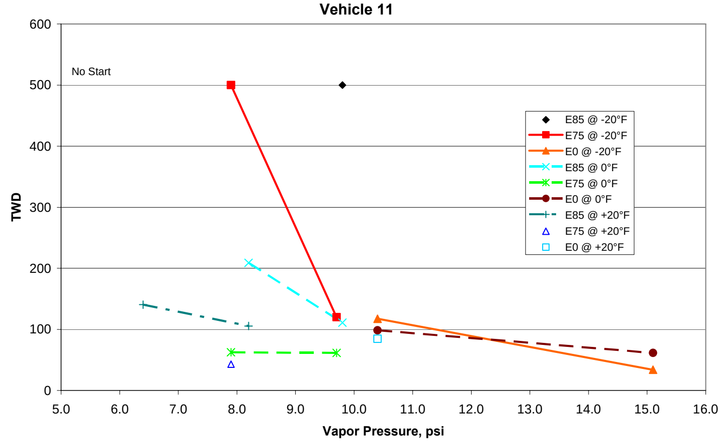


Figure H-12
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 12

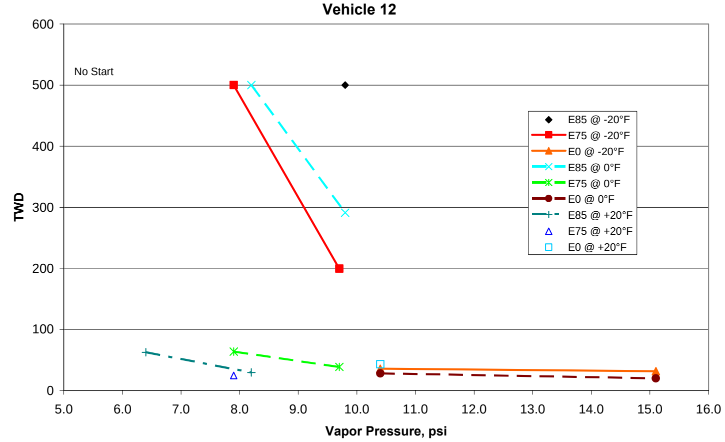


Figure H-13
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 13

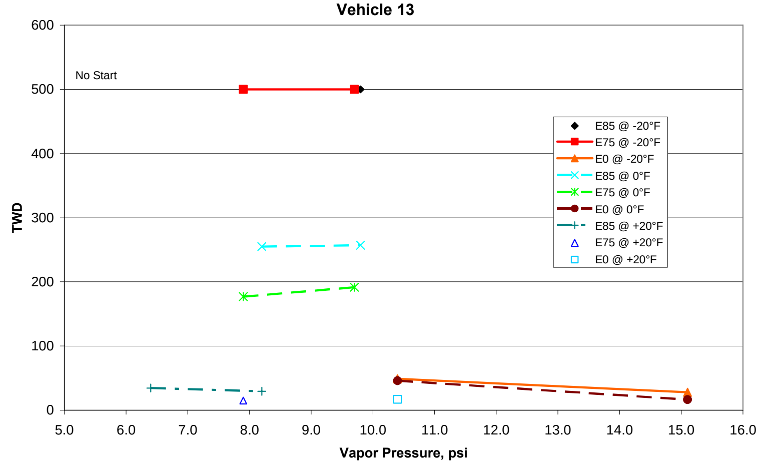


Figure H-14
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 14

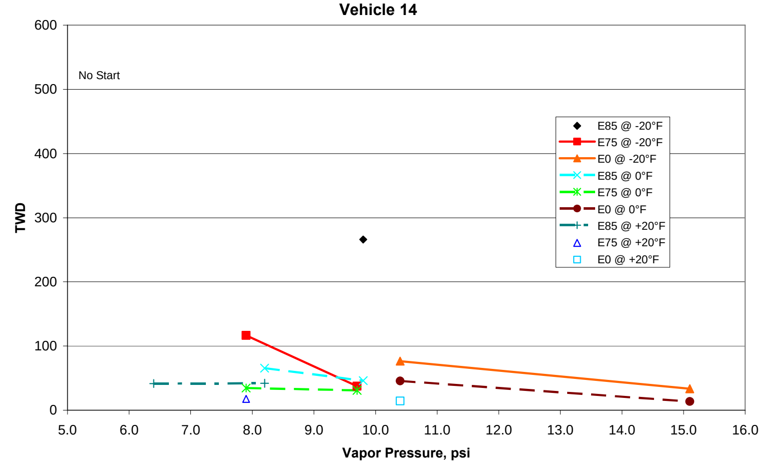


Figure H-15
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 15

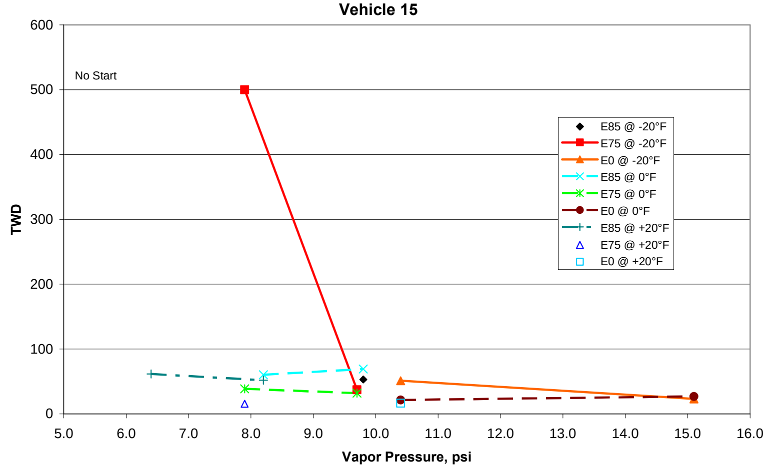


Figure H-16
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 16

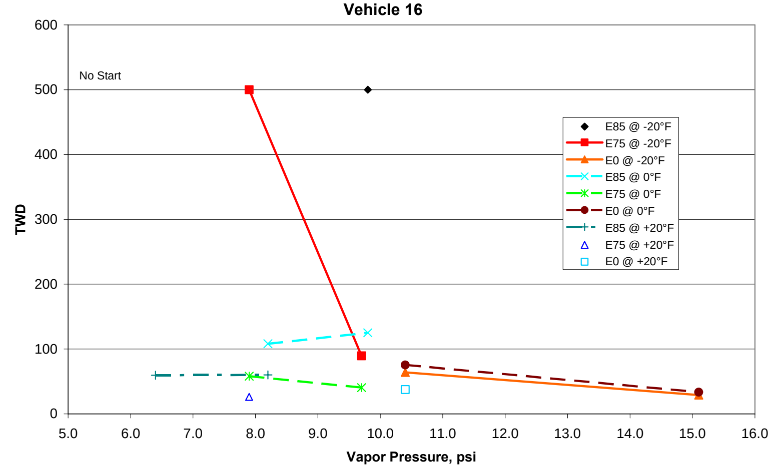


Figure H-17
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 17

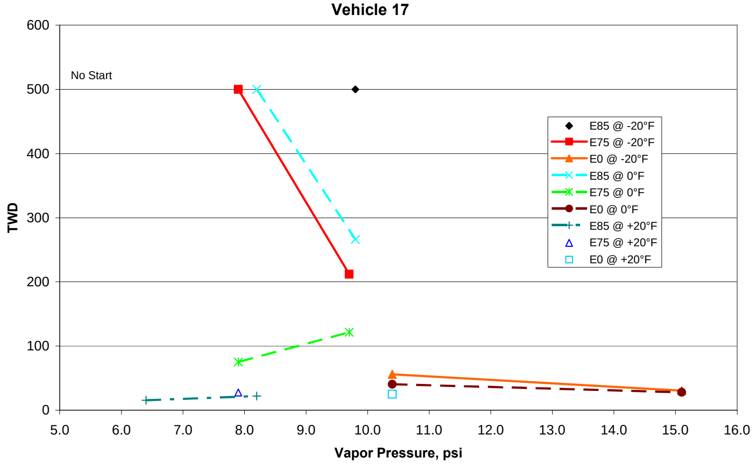


Figure H-18
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 18

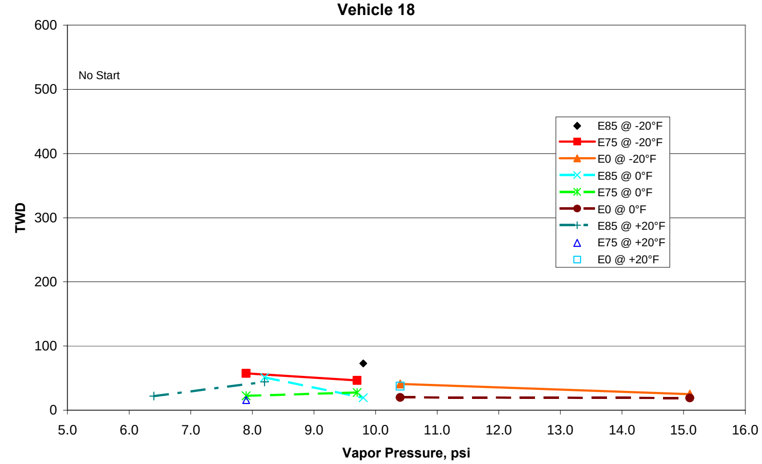


Figure H-19
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 19

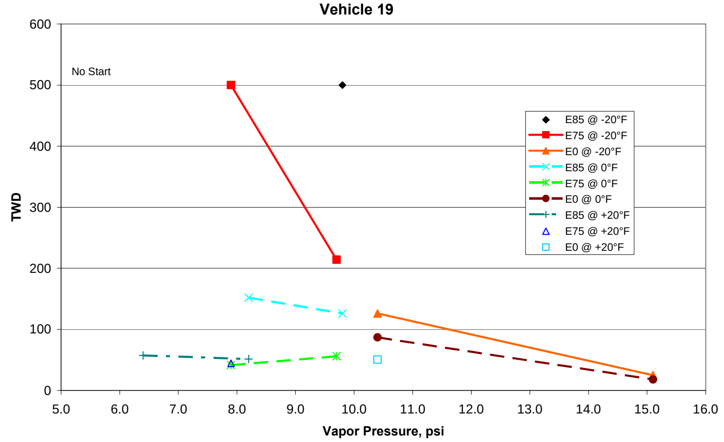


Figure H-20
CRC E85 Class 3 Cold-Start and Warm-Up Program
Vehicle 20