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2003 CRC INTERMEDIATE-TEMPERATURE VOLATILITY PROGRAM

February 2004

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(CRC Project No. CM-138-02)

Prepared by the

CRC Volatility Group

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CRC Performance Committee
of the
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ABSTRACT

An intermediate-temperature test program was conducted by the Coordinating Research Council, Inc. to determine the effect of ethanol content on cold-start and warm-up driveability performance under cool ambient conditions in late-model vehicles equipped with fuel injection systems. The core test program was conducted from January 27 through February 28, 2003, in Yakima, Washington, with vehicle screening conducted in early January in Sonoma County, California. The program involved testing ten fuels: a hydrocarbon-only high Driveability Index (DI of 1300) base fuel; three blends of different concentrations of ethanol (3, 6, and 10 volume percent) that were splash-blended into the base fuel; three blends of the base fuel, each blended with a light hydrocarbon mix, but no ethanol, to match the DIs of the three ethanol blends just described; and three blends of ethanol and hydrocarbon blendstocks each blended to a fixed, high DI (1300) level, matching the base fuel DI. The program revealed that there continues to be an effect of both ethanol and fuel volatility (DI). Two approaches for data analysis were performed. Performance prediction models for ethanol-containing gasolines developed by this fuel volatility research program cannot be distinguished between each other. The fixed ethanol offset model (presence of ethanol) and the variable ethanol offset model (concentration of ethanol) are of equal predictive accuracy. The Analysis Panel was unable to develop a model using evaporated distillation points that improved upon the ethanol concentration model. The vehicle screening, the improved fuel flushing procedure, and the 2002 rater-training workshop resulted in significant improvement in data quality and accuracy.

I. INTRODUCTION

In 2000, the Coordinating Research Council conducted a cold-start and warm-up driveability program at intermediate temperatures[1]. The objective of the program was to determine the relationship between oxygenate type and concentration. The program involved testing three concentrations each of ethanol and MTBE along with four hydrocarbon-only fuels. No conclusive effect of Driveability Index (DI) or oxygenate effect on the average cold-start and warm-up driveability performance of the fleet was found.

For ASTM to adopt any oxygenate adjustment to its current DI equation or to adopt a new driveability equation for the ASTM D 4814 specification for automotive spark-ignition engine fuel, the driveability response to oxygenate concentration needs to be known. The aim of this program is to determine the effect of ethanol content on cold start and warm-up driveability performance under cool ambient conditions in a large group of late model vehicles equipped with fuel injection systems.

Several testing approaches were considered to increase severity to provide sufficient scale to obtain any effects of ethanol on cold-start and warm-up driveability. Testing at colder ambient temperatures with the same fuel set as used in the 2000 program was discussed. This approach was dropped since the intended effect would not occur because of engine calibration enrichment with decreasing temperature. For the 2001 CRC Hot-Fuel-Handling Program[2], increased severity was obtained by screening vehicles for sensitivity and only testing the selected screened vehicles in the program. An intermediate-temperature study with screened vehicles was decided by the CRC Volatility Group to be of the most interest for studying ethanol concentration effects. It was also decided to increase the highest DI test fuels up to a maximum of 1300. The planned ambient temperature range was between 30°F and 40°F, because this range was perceived to cover the most severe vehicle operating conditions. The program involved testing ten fuels: a hydrocarbon-only high Driveability Index (DI of 1300) base fuel; three blends of different concentrations of ethanol (3, 6, and 10 volume percent) that were splash-blended into the base fuel; three blends of the base fuel, each blended with a light hydrocarbon mix, but no ethanol, to match the DIs of the three blends just described; and three blends of ethanol and hydrocarbon blendstocks each blended to a fixed, high DI (1300) level, matching the base fuel DI. The core test program was conducted from January 27 through February 28, 2003, in Yakima, Washington.

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

II. SUMMARY AND CONCLUSIONS

- The 2003 CRC Volatility Program revealed there continues to exist an effect of ethanol as measured by vehicle cold-start and warm-up driveability demerits.
- This program revealed there continues to exist a fuel volatility effect (Driveability Index) as measured by vehicle cold-start and warm-up driveability demerits.
- Driveability demerits were greater on high Driveability Index (DI) fuels than on the lower DI fuels.
- Two approaches for data analysis were performed. Performance prediction models for ethanol-containing gasolines developed by this fuel volatility research program cannot be distinguished between each other. The fixed ethanol offset model (presence of ethanol) and the variable ethanol offset model (concentration of ethanol) are of equal predictive accuracy.
- The Analysis Panel was unable to develop a model using evaporated distillation points that improved upon the fixed ethanol offset model with DI.
- The pre-screened test vehicles utilized in this program exhibited considerable variation in driveability demerits among vehicles.
- The CRC fuel flushing procedure which was developed during 2001 again demonstrated its effectiveness in minimizing fuel carryover from test to test.
- The vehicle screening, the recently developed CRC fuel flushing procedure, and the 2002 rater training workshop[(3)] resulted in significant improvement in data quality and accuracy.

III. TEST VEHICLES

For the test fleet, a group of 27 sensitive vehicles was required. This is the same approach used for the 2001 CRC Hot-Fuel-Handling Program.[2] Twenty-seven vehicles with 10 test fuels comprised the largest population that could be logistically handled with the resources and time available. Prior to vehicle selection it was suggested that vehicles certified to California emission standards, especially SULEV and ULEV vehicles, would be more sensitive. Therefore, it was decided to do the bulk of the vehicle screening for sensitive vehicles using California vehicles. The California screening was done on the drag strip at the Infineon Raceway in Sonoma County. A group of 61 fuel-injected vehicles was obtained in California and screened for sensitivity to high-DI and high ethanol-content fuel. To find the sensitive vehicles, all 61 vehicles were first tested using tank fuel to indicate there were no mechanical problems. Then they were tested using the highest DI (1300), 10 volume percent ethanol blend. The vehicles producing the highest level of total weighted demerits (TWD) were selected, except no more than two of the same manufacturer and model were included in the test fleet. Also, the total of any given make was limited. Non-sensitive or duplicate vehicles were returned to the rental agency. Upon completion of the screening process, 20 test vehicles were finally chosen and transported to Yakima. It proved difficult to obtain SULEV and ULEV vehicles. Seven additional vehicles were chosen in Yakima from a group of 22 using the same screening process as was used in Sonoma County. The TWD ratings for all of the vehicles screened are shown in Figure 1. The darker bars indicate the selected vehicles.

All but one of the selected vehicles came from a rental agency. Honda provided the Civic vehicle. Thirteen of the 27 selected vehicles were 2003 model year vehicles and 14 were 2002 models. All vehicles had automatic transmissions and air conditioning. All were equipped with various types of fuel injection. These vehicles were set up to drain the fuel tank through a Schrader or other valve on the fuel rail. No carbureted vehicles were in the program. Engine displacement ranged from 1.6 to 5.9 liters. Starting odometer readings ranged from 481 to 27,553 miles. The fleet consisted of 11 cars and 16 light-duty trucks or vans. Vehicles were manufactured by DaimlerChrysler, Ford, General Motors, Honda, Mitsubishi, Toyota, and Suzuki. A complete description of the 27-vehicle test fleet is presented in Table 1. A description of the 83 vehicles and their screening fuel and tank fuel TWDs are presented in Table D-1 of Appendix D.

Also shown in Table D-1 are the four hybrid vehicles cooperatively tested with the CRC Advanced Vehicles/Fuels/Lubricants (AVFL) Committee. A separate report will be issued by the CRC AVFL Committee summarizing the findings of testing hybrid vehicles using the CRC driveability test procedure developed for conventional vehicles.

IV. TEST FUELS

The fuel matrix used for this program consisted of ten fuels; a high DI (1300) hydrocarbon base fuel with a nominal 7 psi vapor pressure and nine different blended test fuels. Three test fuels were prepared by splash blending 3, 6, and 10 volume percent ethanol into the base fuel (E1, E2, and E3). Three hydrocarbon-only test fuels (H1, H2, and H3) were prepared by adding a light hydrocarbon mixture to the base fuel to roughly match the DIs (10%, 50% and 90% evaporated points) of the three splash ethanol blends. The final three fuels were prepared by mixing 3, 6, and 10 volume percent ethanol with hydrocarbon gasoline components to meet a constant 1300 maximum DI limit for all three fuels (E4, E5, and E6) to be similar to the hydrocarbon-only base fuel.

Average dry vapor pressure equivalent (DVPE), distillation temperatures, gravity, and ethanol content as determined by the supplier (Laboratory A) and Fuel Acceptance Panel (Laboratories B, C, D, E, and F) are shown in Table 2. Individual test results obtained by each inspecting laboratory are shown in Table E-1 of Appendix E. Distillation results from one laboratory were not included in the average because they were statistically different from the other laboratories' results. Table E-2 shows additional inspections provided by the supplier. Standard ASTM test methods were used to determine all of the properties.

Samples for a volunteer laboratory (Laboratory G) were obtained from drums or dispensing pumps on-site and shipped to the laboratory's facility for inspection. These inspections are shown in Table E-3 of Appendix E. Base fuel samples were also drawn once from each test vehicle following an E6 (10 volume percent ethanol) test and flushing the vehicle first with base fuel. This was performed to determine the efficiency of the CRC fuel flushing procedure. The results of this testing are shown in Table E-4 of Appendix E.

V. <u>TEST SITE</u>

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

The California screening portion of the program was done on January 8 and 9, 2003. The Yakima screening portion was done on January 25, 2003. Vehicle testing was conducted from January 27, 2003, through February 28, 2003. Site set-up and vehicle preparation was done during the first week beginning January 20, 2003. The last few days of the test program were required to deinstrument the vehicles and shut the site down.

Temperatures at this location were stable for around three to four hours bracketing dawn. The overnight soak temperatures ranged from 22° F to 37° F (with the exception of one night at 15°F). All tests were carried out in the test-temperature range of 30° F to 42° F and 97.3 percent of the tests fell inside the planned temperature window of 30° F to 40° F.

VI. TEST PROGRAM

A. Test Procedure

The test fuels were evaluated as prescribed in the CRC Cold-Start and Warmup Driveability Procedure (E-28-94). Duplicate tests were performed on every vehicle and fuel combination.

The CRC Cold-Start and Warmup Driveability Procedure is presented in Appendix C. In September 2002, a workshop was held to train new raters and to calibrate experienced existing raters.[3] Briefly stated, the procedure consists of a series of light, moderate, and wide-open-throttle maneuvers mixed in with idles to obtain as many evaluations of driveability in a cold engine as possible. Malfunctions are recorded and evaluated as being trace, moderate, heavy, or extreme. The demerit rating details used in this program are shown in Appendix C of this report. During set-up week, the raters were provided with all the test vehicles to set individual vehicle vacuum targets and more importantly to allow them to agree on a similar definition of malfunction severity.

All vehicles were tested each day using three raters, with each rater assigned to exclusively test the same one-third of the fleet for the entire program. All three raters were constant throughout the program. The nine-vehicle sub-fleets were balanced as to vehicle/engine size and manufacturer. Each of the nine-vehicle sub-fleets was assigned a color—blue, red, or yellow, which was indicated by colored tape on the windshield, rear window, and gas cap. Each subfleet was assigned its own fuel each day. The fueling facility limited the availability of fuels to three a day. The fuel selections for each day were random.

The three rating teams tested the 27 vehicles in three hours. Generally, three vehicles were on the track simultaneously, separated by approximately 0.3 miles. No problems with vehicles impeding one another were encountered using this schedule, even though stalls and severe malfunctions did occur.

B. Fueling and Warm-up

After the rating teams finished testing a vehicle, they dropped it off at the fueling/defueling area. The gas cap was removed, and the remaining test fuel was drained from the vehicle fuel tank through the fuel rail system by activation of the fuel pump. Some of the test vehicles required the engine to be operated until empty of fuel. The vehicle fuel system was then flushed using the procedure developed for the CRC 2001 volatility program. It is presented in Appendix C. The vehicles were flushed and fueled with the next day's test fuel. Three separate dispensers were used, one for each fuel being pumped that day. Passenger cars were fueled with four gallons of test fuel; trucks were fueled with six gallons.

An evaluation of the fuel flushing and refueling procedure was conducted to evaluate the efficiency of the procedure in this test program. The vehicles were sampled after completion of testing with a hydrocarbon-only fuel, which was immediately preceded with the 10 volume percent ethanol fuel. The analysis was performed by Laboratory G, and the results are presented in Appendix E. The laboratory analyzed 27 vehicle samples and 10 drum or dispenser samples for ethanol. The drum and dispenser inspections shown in Table E-3 confirm that the proper fuels were being dispensed. Review of the flushing data reported in Table E-4 indicated that except for two vehicles, the ethanol level was less than 0.5 volume percent ethanol carryover. Those two vehicles were shown to have 0.53 and 0.65 volume percent ethanol. This is an improvement over the 2000 volatility program where several samples exceeded 1 volume percent ethanol carryover. A carryover of 0.5 volume percent ethanol corresponds to about 5 volume percent dilution of the test fuel with the previous test fuel.

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

C. Data Worksheets

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

VII. DISCUSSION OF RESULTS

A. Data Set Analysis

The final data set was analyzed using the SAS® System to calculate least square mean values for each test fuel. The model included vehicle, fuel, day, soak temperature, fuel by vehicle, vehicle by day, and vehicle by soak temperature. As is common with driveability data, the total weighted demerit (TWD) values ranged widely from 6 to 294 with increasing variance with the value of TWD. Log transforming the data leads to a data set that is normal and has approximately constant variance. All final data were used to determine the correction factors for individual TWDs. All regression variables were significant ($p<0.05$) except for the single variable day. The data were corrected using the variables stated above utilizing this model. All test fuels were tested twice in all of the vehicles. Appendix G presents the corrected 270 average data points by vehicle and fuel in Table G-1 for the natural log values and in Table G-2 for antilog transformation values. The least square mean natural log (ln) corrected TWDs for each fuel is listed in Table 3. The least square mean natural log corrected TWD for each vehicle is listed in Table 4. Also shown in the tables are the corresponding antilog values for each fuel and vehicle. The regression analyses are on file at the CRC offices and are available upon request.

B. Fuel and Vehicle Response

Figure 2 graphically presents the mean corrected TWD (antilog of ln TWD) performance for each of the 27 test vehicles. This figure reveals a wide range in cold-start and warm-up performance among the test vehicles. Figure 3 presents the mean TWD (antilog of ln TWD) fuel response for each of the 10 test fuels.

C. Driveability Index

The Driveability Index (DI) was calculated for each test fuel using the equation:

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

Where T_{10} is the 10% evaporated point, T_{50} is the 50% evaporated point, and T_{90} is the 90% evaporated point from an ASTM D 86 distillation.

Using the calculated DI and the mean corrected ln TWDs for each fuel, Figure 4 was developed. The resulting best-fit regression line shows some degree of correlation between DI and ln TWD ($R^2 = 0.745$). The ethanol content of each fuel is shown in parentheses in Figure 4. All of the ethanol blends are above the regression line and the hydrocarbon-only fuels are below the line.

D. Data Analysis Approaches

To develop a better fitting cold-start and warm-up driveability prediction equation, SAS GLM regression programs were undertaken. The program objective was to develop an ethanol effect adjustment to the current DI equation. Two separate approaches were investigated, both showing an effect of ethanol on cold-start and warm-up driveability and yielding similar R^2 values of accuracy. The first regression model involved DI with linear ethanol content terms. The second regression model involved DI with a constant ethanol offset term. The following discussions present the details of these approaches.

E. Ethanol Concentration Offset Model

1. Driveability Index Modifications

For the first analytical approach, a driveability prediction equation using a SAS GLM regression program was undertaken. The program objective was to develop an ethanol content adjustment to the current DI equation. The first regression model involved DI and linear ethanol content terms. Adding a linear ethanol term to DI greatly improved the adjusted correlation coefficient R^2 to 0.944 as shown in Figure 5. Ethanol content relationships other than linear did not improve the correlation. The resulting coefficients with DI set to unity by dividing the regression equation coefficients by the DI coefficient are shown in Table 5. This is done to simplify the equations and so comparisons can more easily be made among the various regressions. Also shown in Table 5 are the adjusted R^2 and root mean squared error (RMSE). Figure 6 shows the same correlation plotted using normal coordinates (antilog of mean corrected ln TWD). As would be expected, as DI decreases to some lower level, driveability performance will level out to some testing noise level. This effect is sometimes shown with two linear relationships as presented in Figure 7. The upper line results from the regression of all data, except for lowest DI hydrocarbon-only fuel H3. The lower line is a regression of Fuels H1, H2, and H3.

A regression also was conducted using as variables T_{10}, T_{50}, T_{90}, and ethanol content. The resulting coefficients with T_{10} set at unity are shown in Table 5. For this regression, the T_{50} coefficient is not significant at the 90% confidence level. A further regression without the T_{50} term results in the ethanol coefficient not being significant as shown in Table 5. For a T_{10}, $T_{50,}$ and ethanol content regression, the T_{10} term is not significant. These poor correlations likely result from the small individual range in T_{10}, T_{50}, and T_{90} properties in the fuel set.

2. E158, E250 Driveability Equation Modifications

CRC Report No. 613[4] provides several equations based on evaporative driveability indices (EDI) in addition to conventional driveability indices. One of the EDI equations evaluated utilized the volatility terms E158 and E250 (percent evaporated at 158°F and at 250°F). The equation using these terms weighted E158 and E250 as follows:

$$EDI = E158 + 2.08*E250$$

Using the calculated EDI and the mean corrected ln TWDs for each fuel, a regression showed a poor correlation between EDI and ln TWD (adjusted $R^2 = 0.003$) as shown in Table 5. However, when a linear ethanol content term was added to the regression, the correlation greatly improved (adjusted $R^2 = 0.956$) as shown in Table 5. A plot showing the correlation is presented in Figure 8. A regression was also undertaken using E158, E250, and ethanol content as variables. As shown in Table 5, the E250 coefficient was similar to the one above, but the E158 coefficient was not significant and the correlation (adjusted $R^2 = 0.950$) was not quite as good. Eliminating E158 as a variable resulted in a poorer correlation (adjusted $R^2 = 0.933$).

3. E158, E200, E300 Driveability Equation Modifications

As shown in Table 5, various combinations of E158, E200, and E300 along with ethanol content were studied. Including all variables resulted in the best correction (adjusted as shown $R^2 = 0.965$), but the E300 coefficient was not significant. The best equation using the percent evaporated values with significant coefficients was E158, E200, and ethanol (adjusted $R^2 = 0.964$) as plotted in Figure 9. Figure 10 shows the same correlation plotted using normal coordinates (antilog of mean corrected ln TWD).

F. Fixed Ethanol Offset Model

1. Driveability Index Modifications

Visual analysis of the graphs plotting TWD versus fuel type suggested a non-linear correlation corresponding to the demerit level increasing as a function of progressively higher ethanol content. A second analysis was thus performed based on a fixed ethanol concentration model. This was done using the same data set as in the previous model, with the exception of eliminating the varying concentrations of ethanol and replacing them with the presence of ethanol as a class variable. The model was performed using SAS data analysis and the offset number was established to be 21.0, used as a single offset for the presence of ethanol in concentrations from 3 volume percent through 10 volume percent. A further regression analysis was performed to see how well the single number offset fit the regression model and the results (Figure 11). The results show an R^2 of 0.949 (Table 6), which was a slight numeric improvement over the previous model. Figure 12 shows the same correlation plotted using normal coordinates (antilog of mean corrected ln TWD).

A regression also was conducted using as variables T_{10}, T_{50}, T_{90}, and ethanol presence. The resulting coefficients with T_{10} set at unity are shown in Table 6. For this regression, the T_{90} coefficient is not significant at the 90% confidence level. A further regression without the T_{90} term results in an equation with a high R^2. However, this equation with coefficients near unity is not meaningful because of the small individual range in T_{10}, T_{50}, and T_{90} properties in the fuel set.

2. E158, E250 Driveability Equation Modifications

As was the case for the ethanol concentration model, the constant offset model analysis was applied to several equations based on evaporative driveability indices. Using the calculated EDI and ethanol and the mean corrected ln TWDs for each fuel, a regression showed a poorer correlation between EDI with a constant ethanol offset and ln TWD (adjusted $R^2 = 0.676$) as shown in Table 6 as compared to the ethanol content model (Table 5). Other evaporative combinations provided even poorer correlations, except for E250 and ethanol which showed the best evaporative correlation as shown in Table 6. A plot showing the E250 with a constant ethanol offset correlation is presented in Figure 13. The same correlation on a normal coordinates (antilog of mean corrected ln TWD) is shown in Figure 14. The Analysis Panel was unable to develop a model using evaporated distillation points that improved on the fixed ethanol offset model with DI.

G. Standard Deviation of Vehicle Response

All vehicles were tested on each fuel twice, which allowed the ability to determine standard deviation. Figure 15 shows how the TWDs vary with the set of fuels on each vehicle. In general, the vehicles that performed poorly were more sensitive to the variations in the fuel set, than the vehicles that performed better; however, the data show there is a wide variation of fuel response. There were several vehicles that averaged between 50 and 70 TWDs for the entire fuel set, but the standard deviation for different vehicles varied from 10 to almost 60 TWDs. This means that the vehicles with the lower standard deviation did not have a great ability to separate fuels by performance. The vehicles with the higher standard deviation discriminated among fuels.

Although there is a wide variation in the data, Figure 16 shows that, in general, the standard deviation of TWDs among vehicles is greater on the poorer performing fuels than on the better performing fuels. For fuels that show a mean of about 40 to 50 TWDs, the standard deviation for the fleet of vehicles is about 20 TWDs. For fuels that show a mean of about 80 to 100 TWDs, the standard deviation for the fleet of vehicles is about 30 TWDs. One fuel that averaged about 100 TWDs for the 27 vehicles, however, had a standard deviation of about 50.

V. REFERENCES

1) Coordinating Research Council, Inc., 2000 CRC Intermdiate-Temperature Volatility Program, CRC-626, June 2001.

2) Coordinating Research Council, Inc., 2001 CRC Hot-Fuel-Handling Program, CRC-629, June 2002.

3) Coordinating Research Council, Inc., 2002 CRC Driveability Workshop, CRC-631, November 2002.

4) Coordinating Research Council, Inc., 1995-1997 CRC Study of Fuel Volatility Effects on Cold-Start and Warmup Driveability with Hydrocarbon, MTBE, and Ethanol Gasolines: Summary Report for Phases 1, 2, and 3, CRC-613, December 1998.

TABLES

AND

FIGURES

Table 1
2003 CRC Volatility Program - Test Vehicle List

Year	Make	Model	Disp., L	VIN	Miles	Calibration
2002	Chevrolet	1500	4.8	2GCEC19V221383500	6963	LEV
2002	Chevrolet	Impala	3.4	2G1WF52E929305383	22496	NLEV/LEV
2003	Chevrolet	Impala	3.4	2G1WF52E839111980	11075	Tier 2-Bin 8
2003	Chevrolet	Tracker	2.5	2CNBJ734836903999	8170	NLEV/LEV
2002	Chevrolet	S-10	4.3	1GCCS19W728260937	9962	NLEV/LEV
2003	Chevrolet	Trail Blazer	4.2	1GNDT13S432116507	7823	NLEV/LEV
2002	Dodge	Caravan	3.3	1B4GP44352B657080	22250	LEV I
2002	Dodge	Caravan	3.3	1B4GP44312B657075	24183	LEV I
2002	Dodge	Dakota	5.9	1B7HL48Z02S690036	14588	ULEV I
2002	Dodge	Dakota	5.9	1B7HL48Z62S690039	10391	ULEV I
2003	Dodge	Intrepid	2.7	2B3HD46R73H504356	5798	LEV I
2002	Ford	Explorer	4.0	1FMZU73E52UC42107	27553	LEV
2002	Ford	Explorer	4.0	1FMZU73E02UB00957	10881	LEV
2003	Ford	F-150	4.6	1FTRX17W63NA01129	9280	LEV
2002	Ford	F-150	4.6	1FTRX17W73NA01124	7660	LEV
2002	Ford	Windstar	3.8	2FMZA51472BB65978	18067	ULEV-Federal
2003	GMC	Envoy	4.2	1GKDT13S632140806	10025	NLEV/LEV
2003	GMC	Envoy	4.2	1GKDT13S532145401	6064	NLEV/LEV
2002	Honda	Civic	1.6	1HGEM22972L000856	987	NLEV/ULEV
2003	Jeep	Grand Cherokee	4.0	1J4GW48S93C517336	8896	Tier 2-Bin 9A
2003	Lincoln	Town Car	4.6	1LNHM81W53Y637430	8144	LEV/ULEV
2003	Lincoln	Town Car	4.6	1LNHM81W93Y637446	6563	LEV/ULEV
2003	Mercury	Sable	3.0	1MEFM50U63A600744	14439	LEV1/NLEV, LEV
2003	Mitsubishi	Galant	2.4	4A3AA46G93E045651	13883	SULEV
2003	Suzuki	Aerio	2.0	JS2RA41S635159095	481	
2002	Toyota	Camry	2.4	4T1BE32K12U076229	31046	ULEV
2002	Toyota	Camry	2.4	4T1BE32K12U083391	22190	ULEV

Table 2
CRC 2003 Volatility Test Fuel Inspections

Inspection	Units	Base	E1	E2	E3	H1	H2	H3	E4	E5	E6
API Gravity	°API	53.8	53.7	53.7	53.4	55.2	55.3	55.8	51.8	51.6	50.7
Relative Density	60/60°F	0.7638	0.7638	0.7642	0.7654	0.7578	0.7577	0.7555	0.7721	0.7729	0.7766
DVPE	psi	7.81	8.91	9.02	8.90	8.77	8.81	8.90	7.91	8.00	8.00
Oxygenates--D 4815											
MTBE	vol%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TAME	vol%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EtOH	vol%	0.0	3.2	6.1	10.6	0.0	0.0	0.0	3.3	6.0	10.2
O2	wt%	0.0	1.15	2.19	3.83	0.0	0.0	0.0	1.19	2.13	3.64
D 86 Distillation											
IBP	°F	90.6	94.4	94.1	96.4	87.2	89.0	87.6	94.2	99.4	102.0
5% Evaporated	°F	121.0	116.8	118.0	120.5	114.0	115.5	114.8	122.8	124.5	127.7
10% Evaporated	°F	139.1	126.0	128.3	130.1	128.5	131.4	130.1	132.1	134.1	137.8
20% Evaporated	°F	171.9	147.1	143.0	144.9	157.3	160.6	159.2	155.6	146.9	151.4
30% Evaporated	°F	206.3	192.4	161.3	155.7	192.3	193.0	189.6	202.9	176.3	159.7
40% Evaporated	°F	231.7	226.8	219.8	171.7	224.5	223.4	216.6	232.6	226.1	212.1
50% Evaporated	°F	248.0	244.8	242.8	236.6	244.4	244.5	238.0	250.3	246.3	249.4
60% Evaporated	°F	265.6	262.5	260.3	256.0	264.1	265.7	261.2	271.5	269.9	268.5
70% Evaporated	°F	297.2	292.3	288.8	283.1	296.1	297.3	297.1	280.3	304.4	303.8
80% Evaporated	°F	327.2	325.4	324.5	322.1	325.7	326.1	325.0	332.0	331.4	331.8
90% Evaporated	°F	343.4	342.9	342.3	341.6	341.0	340.3	337.9	346.4	347.2	346.6
95% Evaporated	°F	357.2	356.4	356.2	355.5	353.9	351.9	348.6	361.0	361.5	360.4
EP	°F	386.3	380.7	384.9	382.4	383.0	379.9	376.6	390.8	390.9	386.2
Recovery	vol%	97.9	97.7	97.5	97.8	98.0	97.5	97.6	98.1	98.0	97.9
Residue	vol%	0.9	1.0	1.1	1.0	0.9	1.1	0.9	0.9	0.8	1.0
Loss	vol%	1.2	1.3	1.4	1.2	1.1	1.4	1.5	1.0	1.2	1.0
Percent Evaporated at 158°F	vol%	15.9	22.7	29.2	32.2	20.0	19.2	19.8	20.7	24.6	29.4
Percent Evaporated at 200°F	vol%	28.0	32.1	36.6	44.4	32.3	32.1	33.8	29.4	34.7	37.7
Percent Evaporated at 250°F	vol%	51.3	53.4	54.6	56.4	53.5	53.0	55.5	50.0	52.0	50.2
Percent Evaporated at 300°F	vol%	71.1	72.2	73.3	74.3	71.6	71.0	71.0	74.1	68.7	69.1
Driveability Index		1295.9	1266.4	1263.3	1246.6	1267.1	1270.9	1247.0	1295.4	1287.2	1301.4

Table 3
Corrected Mean TWD by Fuel

Fuel	ln TWD	TWD
Base	4.164	64.3
E1	3.888	48.8
E2	3.818	45.5
E3	3.799	44.6
E4	4.406	82.0
E5	4.284	72.5
E6	4.547	94.4
H1	3.589	36.2
H2	3.666	39.1
H3	3.396	29.9

Table 4
Corrected Mean TWD by Vehicle

Vehicle	ln TWD	TWD
4	4.709	110.9
18	3.913	50.1
21	3.770	43.4
23	4.444	85.1
24	2.948	19.1
26	4.618	101.3
27	3.899	49.3
28	3.588	36.2
29	3.889	48.9
37	4.400	81.5
39	2.932	18.8
41	3.892	49.0
44	3.976	53.3
45	3.729	41.6
47	4.325	75.5
48	4.319	75.1
49	4.298	73.5
51	3.437	31.1
59	4.415	82.6
61	4.464	86.8
64	4.129	62.1
65	3.859	47.4
70	3.159	23.5
74	3.762	43.0
75	3.946	51.7
80	3.965	52.7
82	4.020	55.7

Table 5
Coefficients for Ethanol Concentration Offset Models

Model	Adjusted R^2	RMSE	DI	T10	T50	T90	EDI	E158	E200	E250	E300	EtOH Content
DI	0.745	0.191	1.000									
DI, EtOH %	0.944	0.089	1.000									2.403
T10, T50, T90, EtOH %	0.957	0.078		1.000	<u>1.337</u>	3.183						<u>1.064</u>
T10, T90, EtOH %	0.941	0.092		1.000		4.349						<u>0.197</u>
T10, T50, EtOH %	0.916	0.110		<u>1.000</u>	3.035							2.347
EDI	0.003	0.377					1.000					
EDI, EtOH %	0.956	0.079					1.000					-2.046
E158, E250, EtOH %	0.950	0.085						<u>1.000</u>		2.627		-2.211
E250, EtOH %	0.933	0.098								1.000		-0.311
E158, E200, E300, EtOH %	0.965	0.071						1.000	1.526		<u>0.247</u>	-3.365
E158, E200, EtOH %	0.964	0.072						1.000	1.354			-3.123

Table 6
Coefficients for Fixed Ethanol Offset Models

Model	Adjusted R^2	RMSE	DI	T10	T50	T90	EDI	E158	E200	E250	E300	EtOH Constant
DI	0.745	0.191	1.000									
DI, EtOH	0.949	0.085	1.000									21.010
T10, T50, T90, EtOH	0.982	0.050		1.000	0.761	<u>0.548</u>						8.405
T10, T90, EtOH	0.949	0.085		1.000		2.812						<u>3.700</u>
T10, T50, EtOH	0.982	0.050		1.000	0.846							9.300
EDI	0.003	0.377					1.000					
EDI, EtOH	0.676	0.215					1.000					-18.869
E158, E250, EtOH	0.887	0.127						<u>1.000</u>		-8.191		<u>10.059</u>
E250, EtOH	0.879	0.131								1.000		-2.560
E158, E200, E300, EtOH	0.328	0.310						1.000	-2.300		<u>-2.914</u>	21.881
E158, E200, EtOH	0.267	0.323						<u>1.000</u>	<u>-1.848</u>			<u>11.662</u>

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

EDI = E158 + 2.08*E250

Note: Underlined coefficients not significant at the 90% confidence level

Figure 1
Vehicle Screening Results on Fuel E6
No Temperature Correction

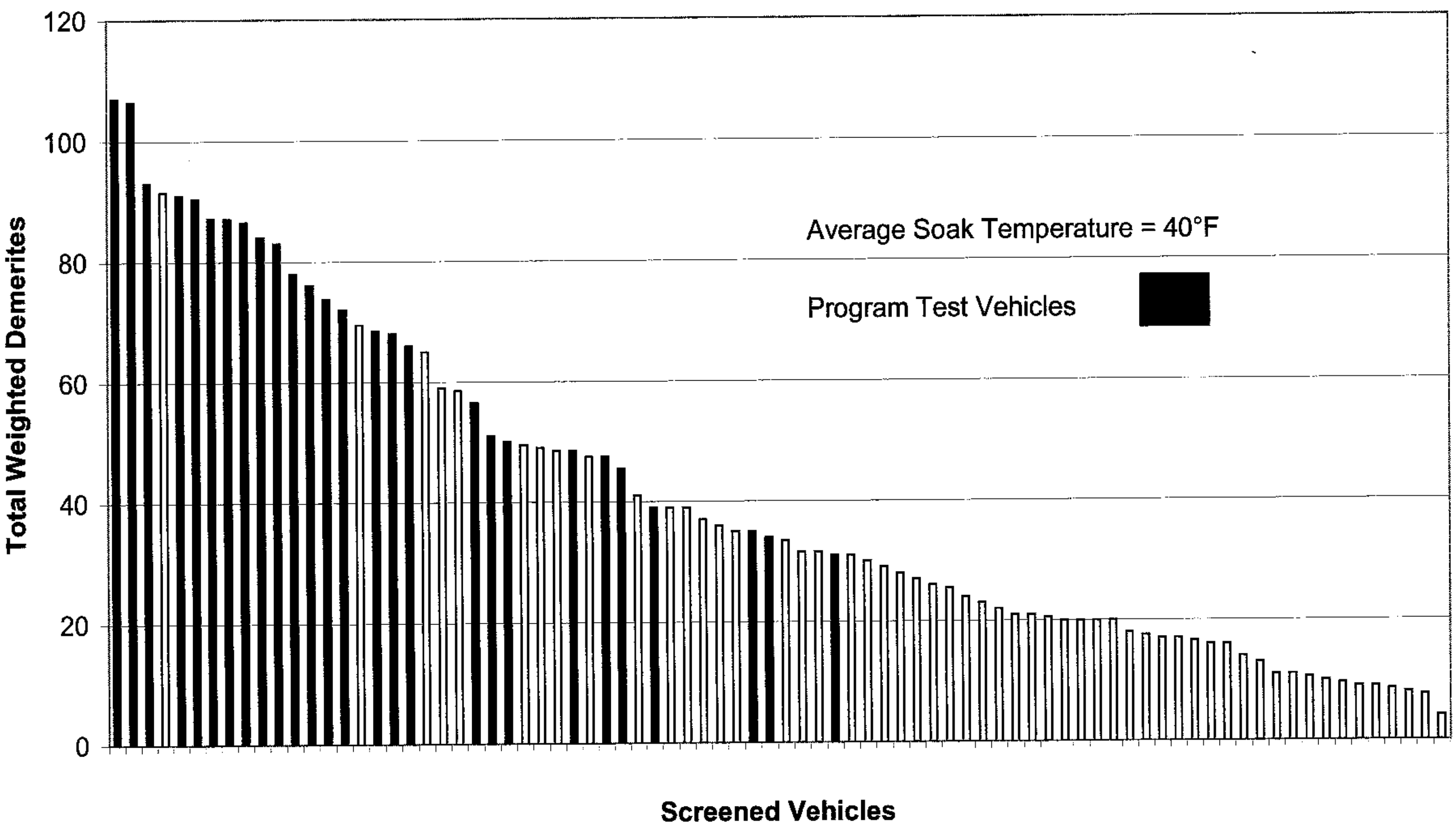


Figure 2
Mean Corrected TWD vs. Vehicle

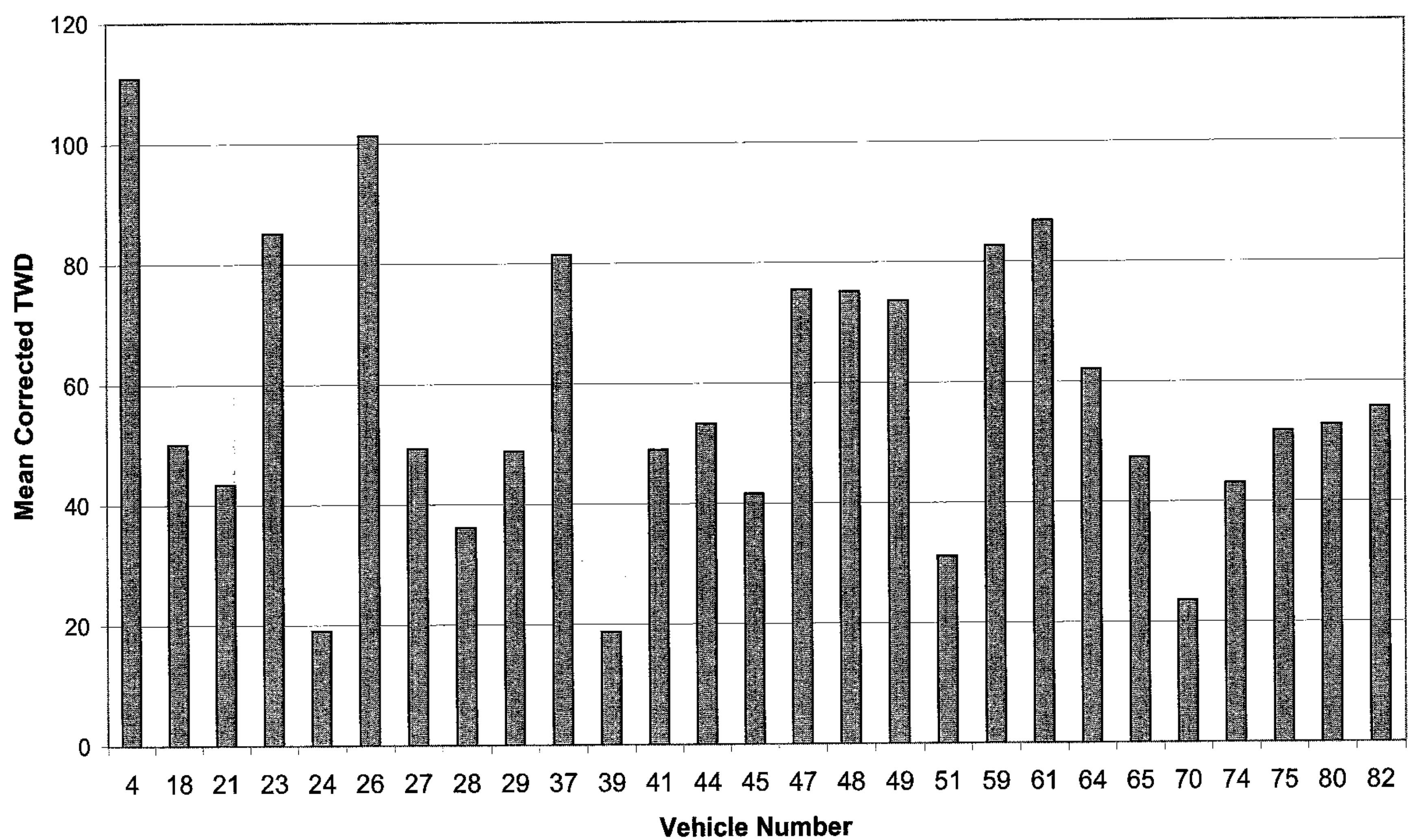


Figure 3
Mean Corrected TWD vs. Fuel

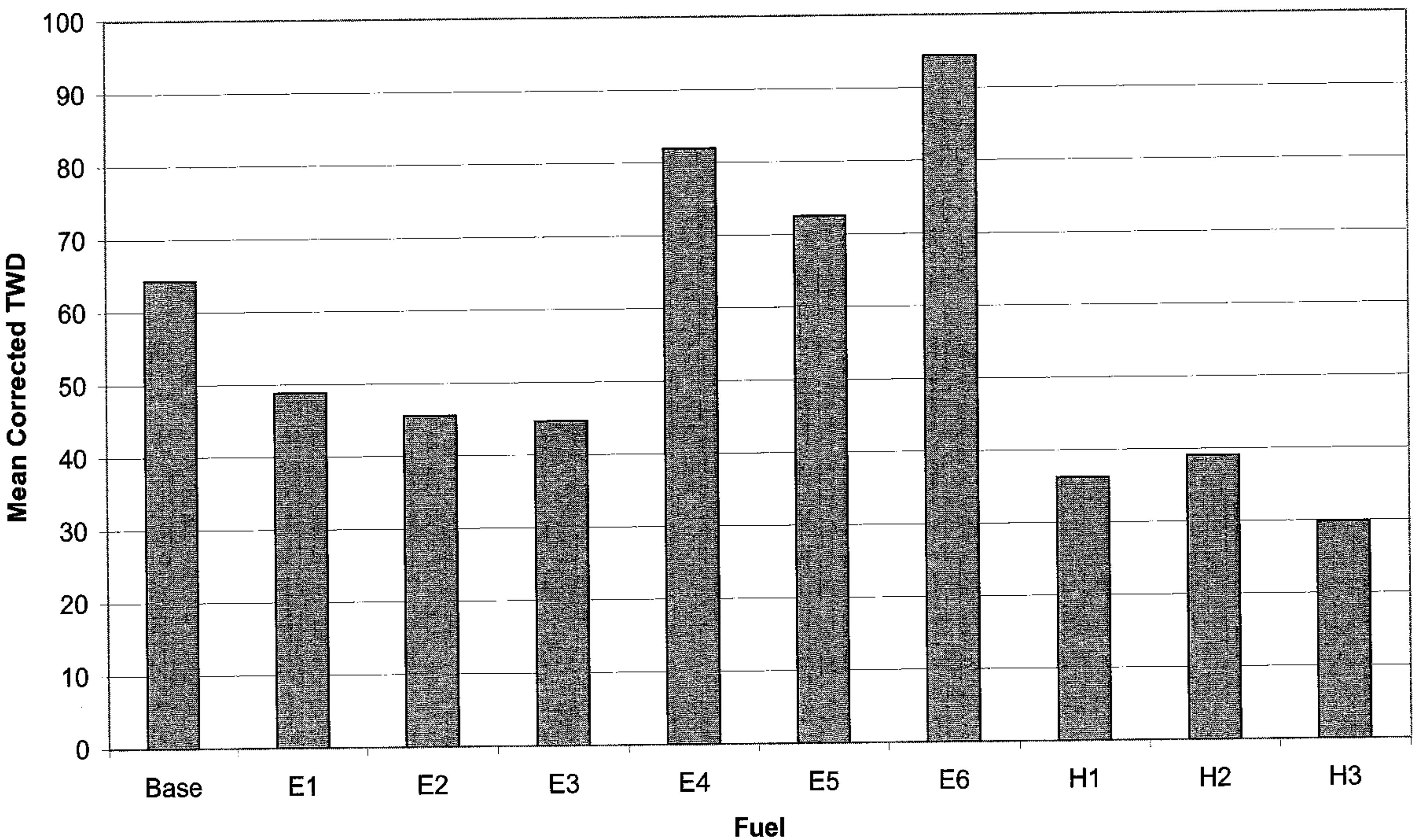


Figure 4
Relationship Between Ln TWD and DI

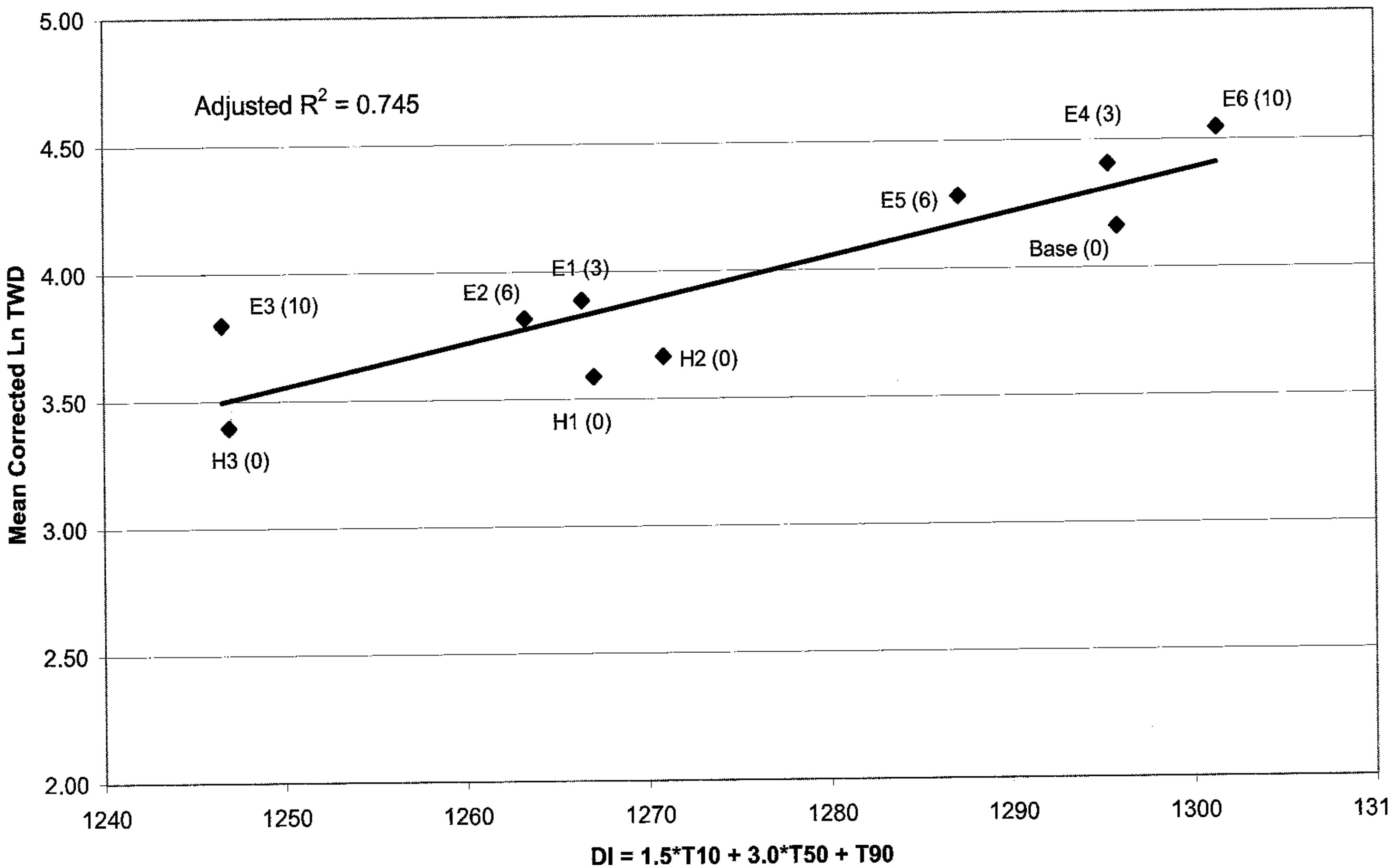


Figure 5
Relationship Between Ln TWD and DI Adjusted for Ethanol Content

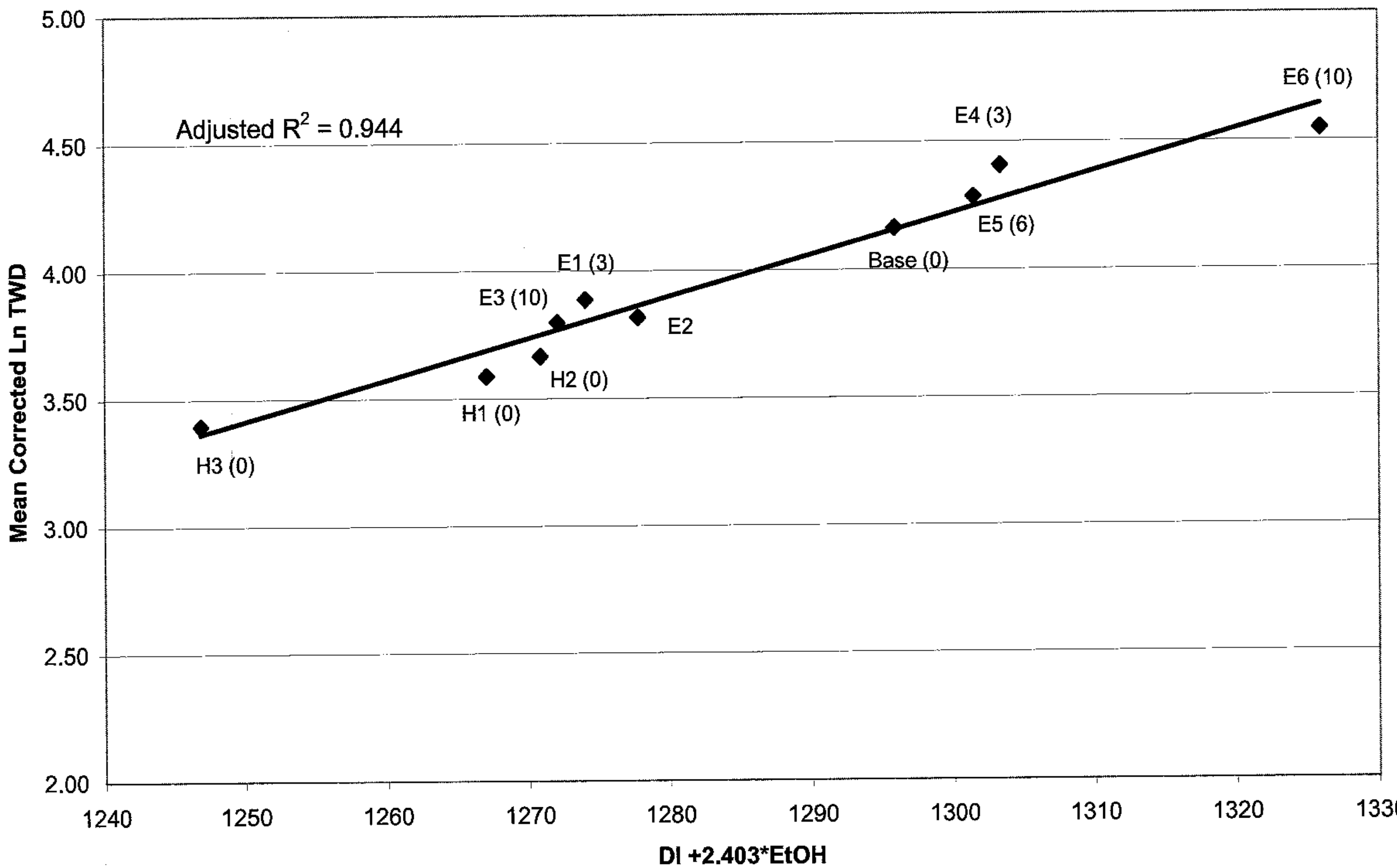


Figure 6
Relationship Between TWD and DI Adjusted for Ethanol Content

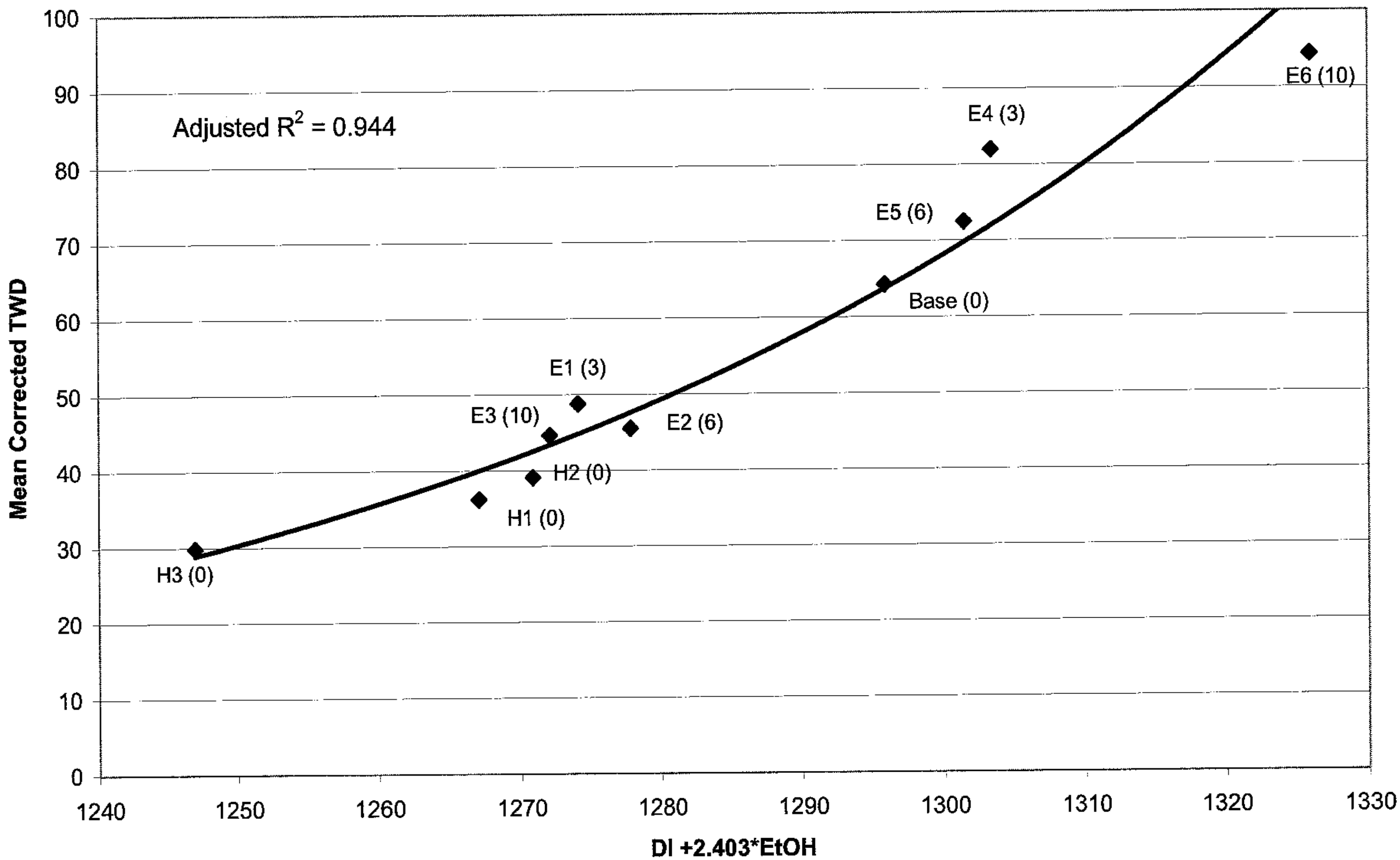


Figure 7
Relationship Between TWD and DI Adjusted for Ethanol Content
Dual Curve Fit

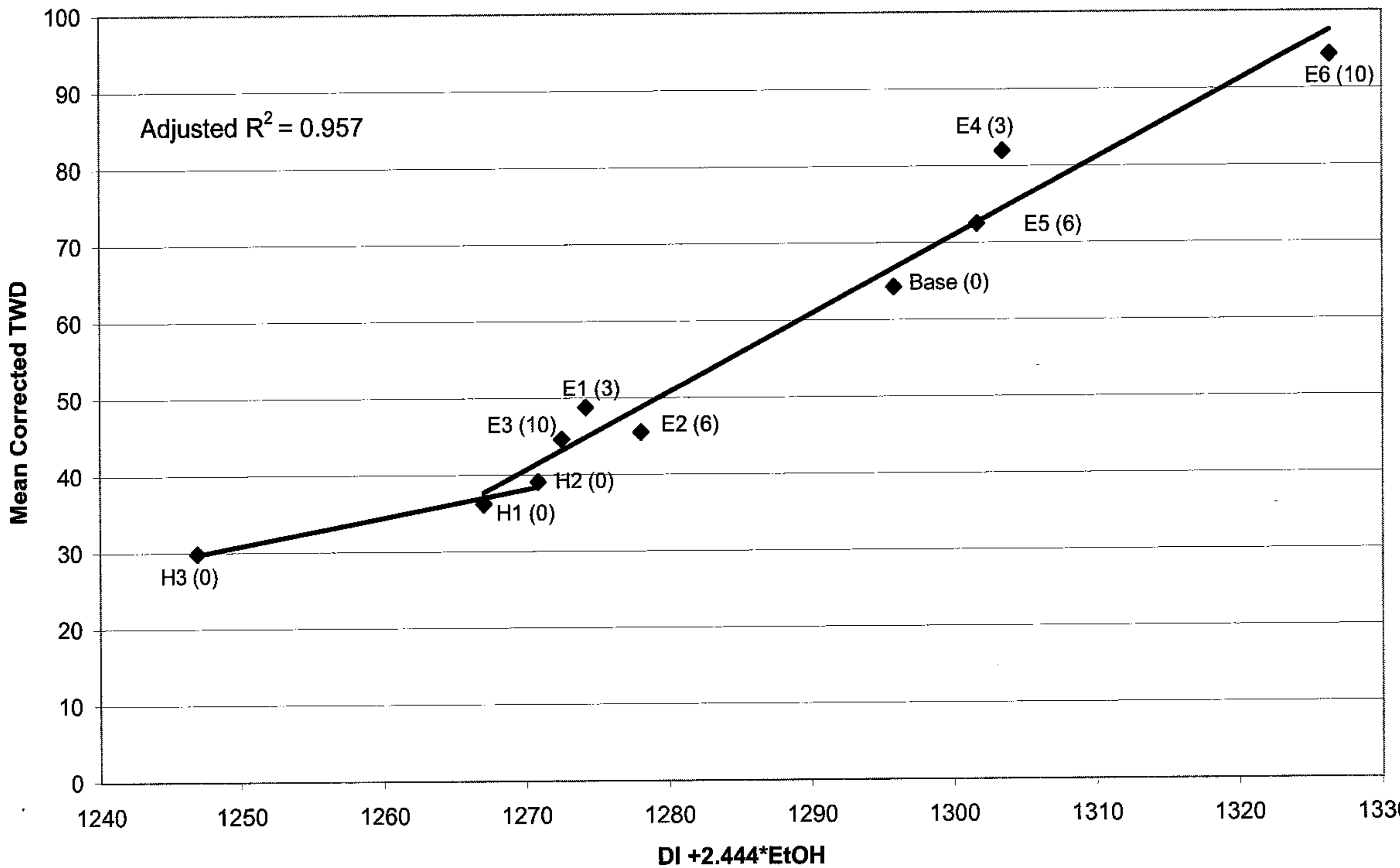


Figure 8
Relationship Between Ln TWD and EDI Adjusted for Ethanol Content

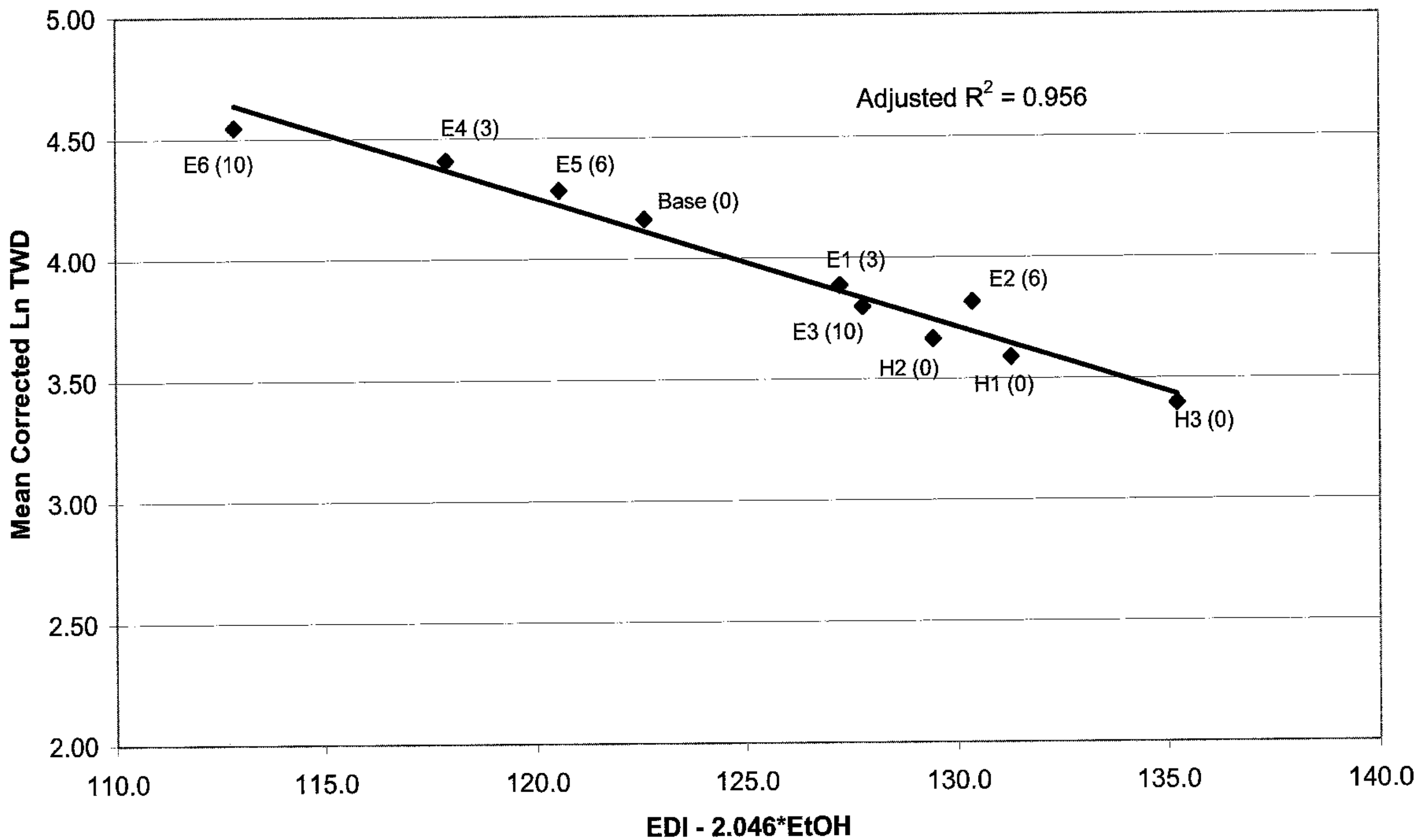


Figure 9
Relationship Between Ln TWD and E158 and E200 Adjusted for Ethanol Content

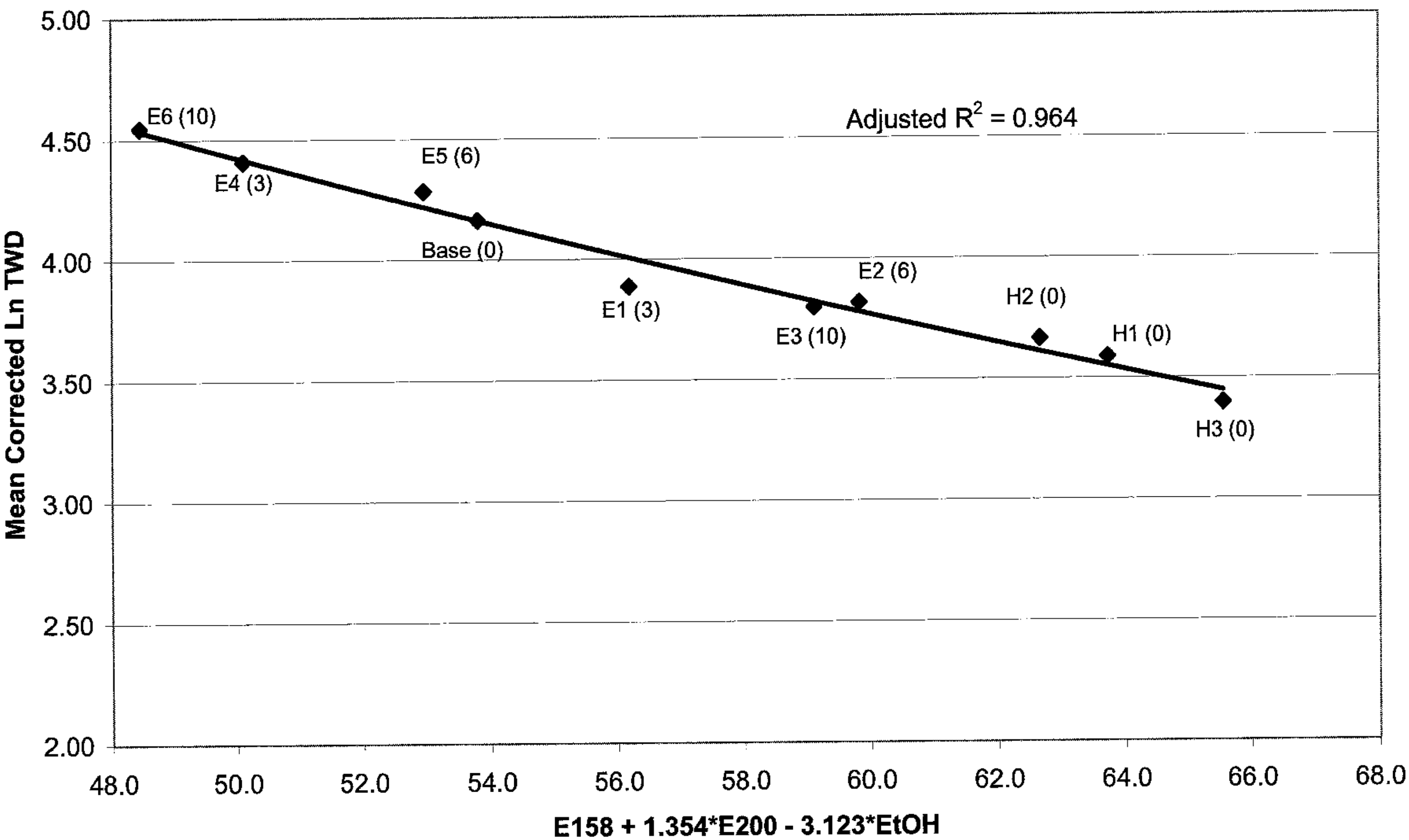


Figure 10
Relationship Between TWD and E158 and E200 Adjusted for Ethanol Content

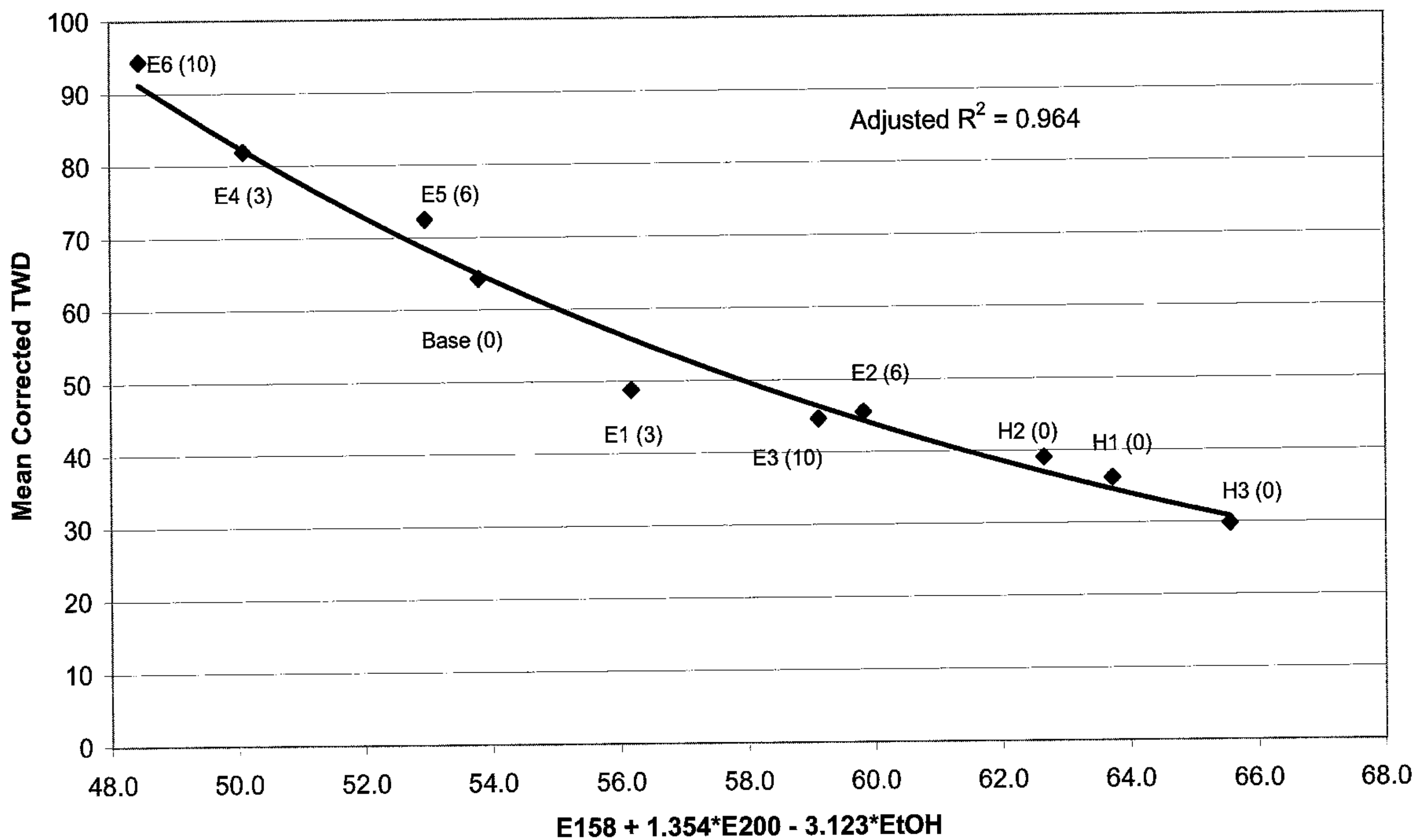
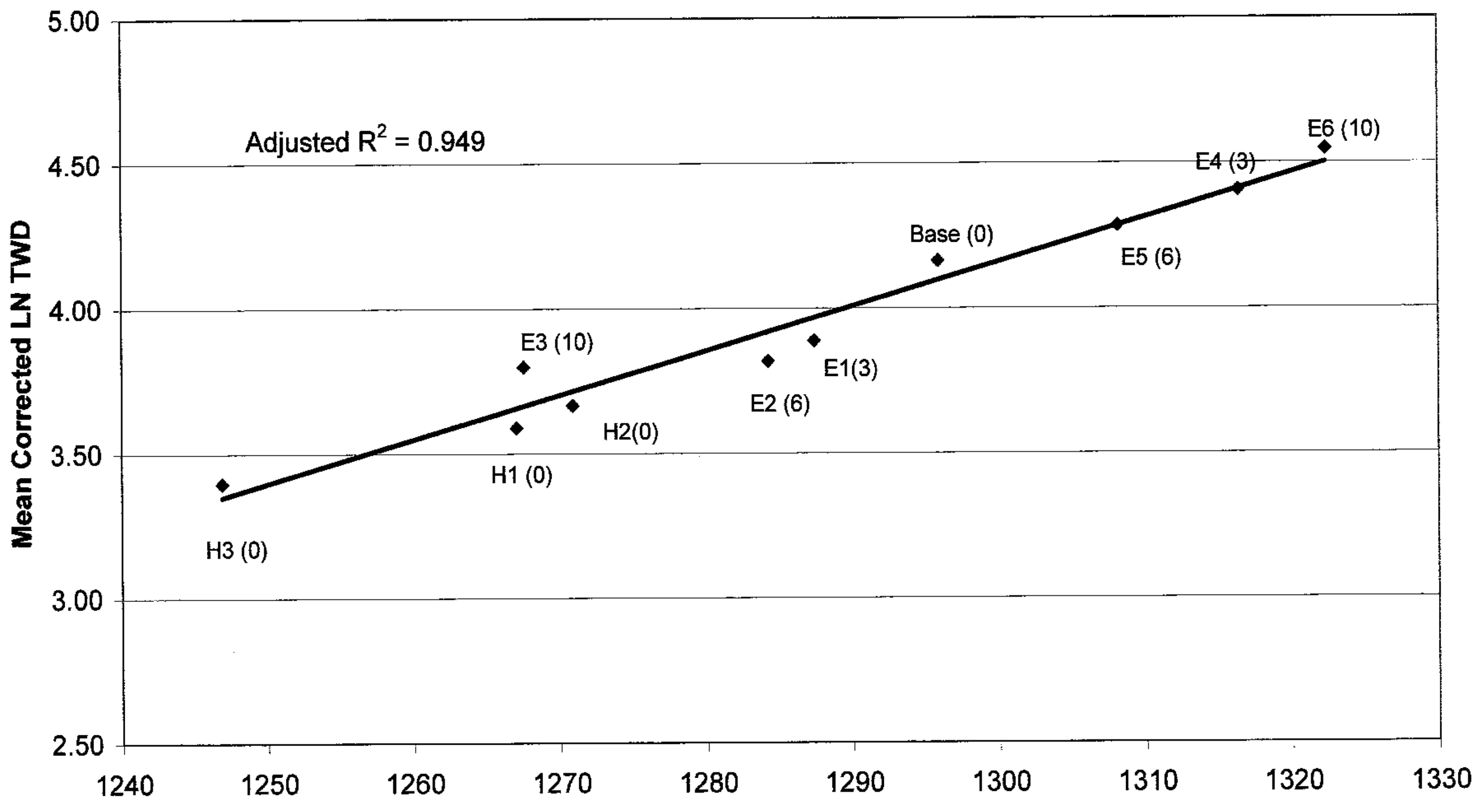


Figure 11
Relationship Between Ln TWD and DI Adjusted for Constant Ethanol Effect



DI + α
Where α = 0 for Hydrocarbon-Only Fuel and α = 21.0 for Ethanol Blends

Figure 12
Relationship Between TWD and DI Adjusted for Constant Ethanol Effect

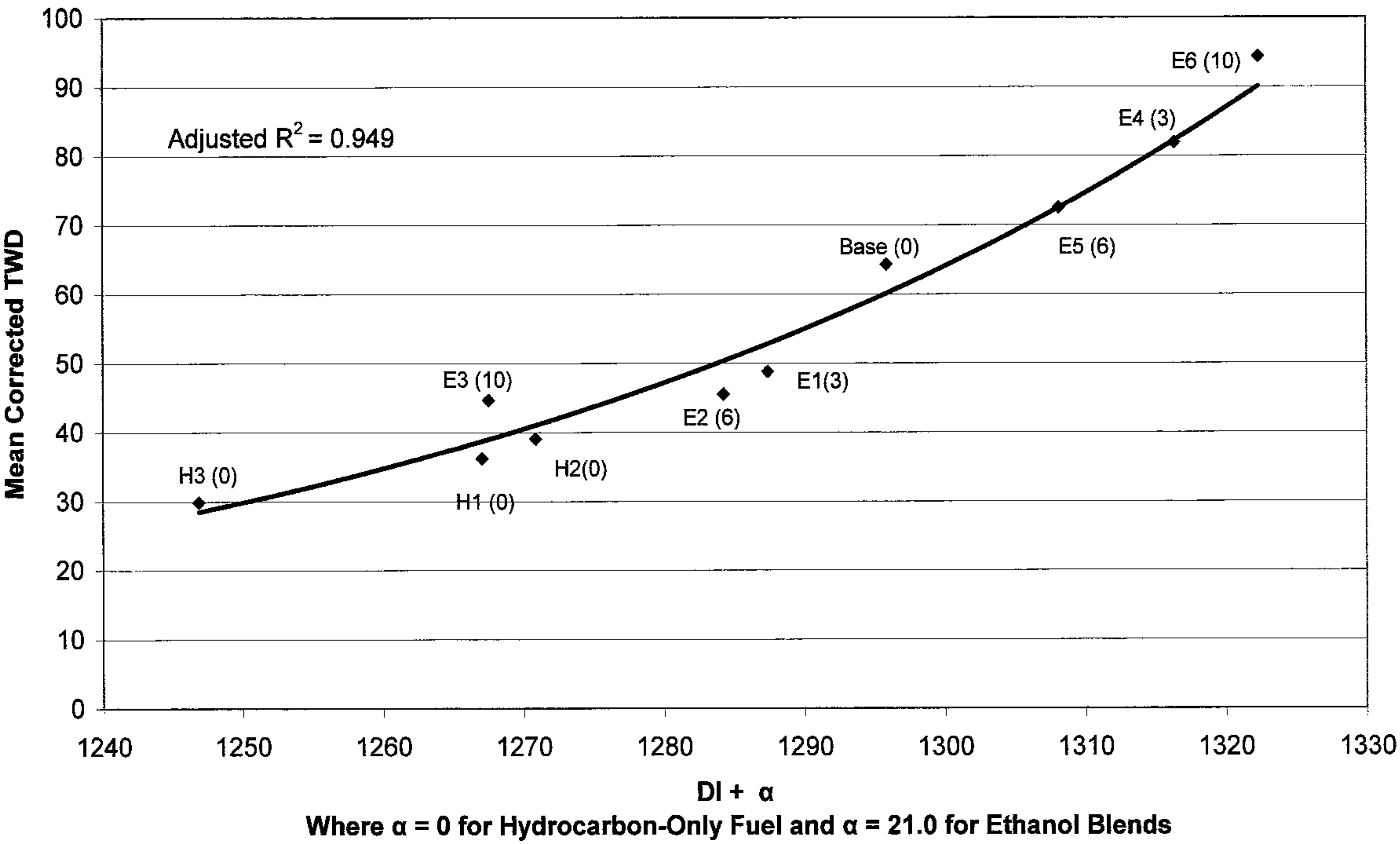


Figure 13
Relationship Between Ln TWD and E250 Adjusted for Constant Ethanol Effect

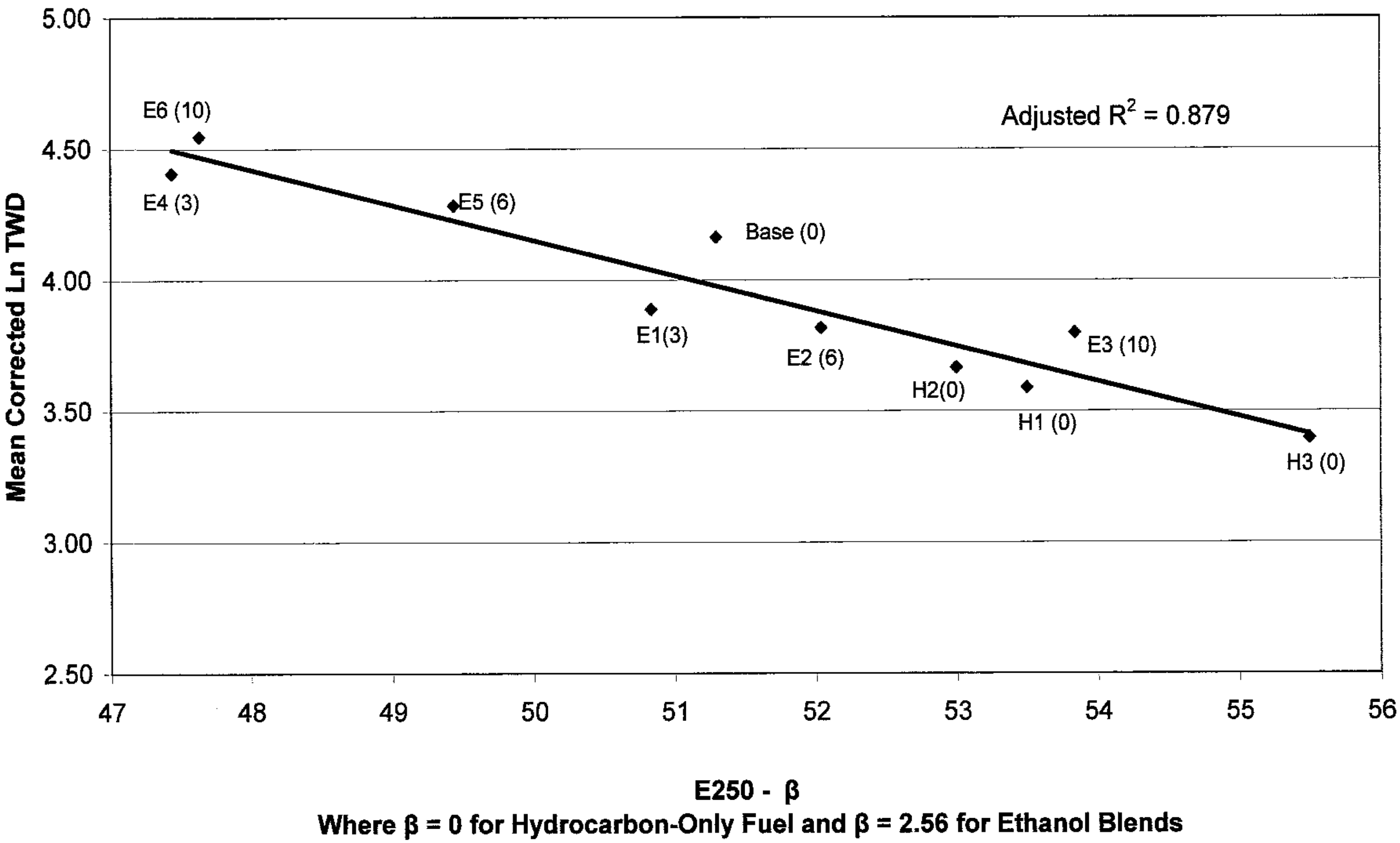


Figure 14
Relationship Between TWD and E250 Adjusted for Constant Ethanol Effect

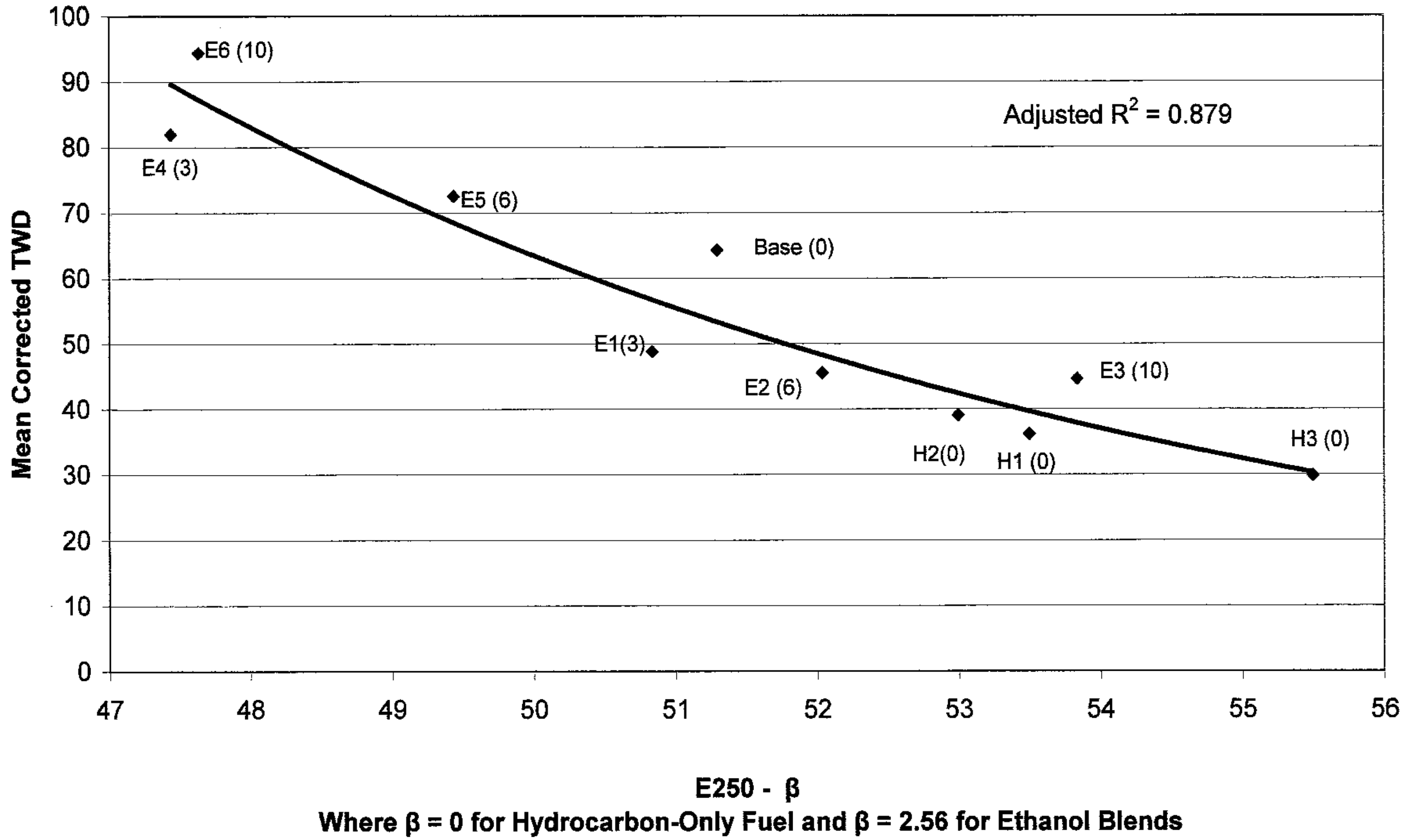


Figure 15
Standard Deviation by Vehicle Across All Fuels
Uncorrected Data

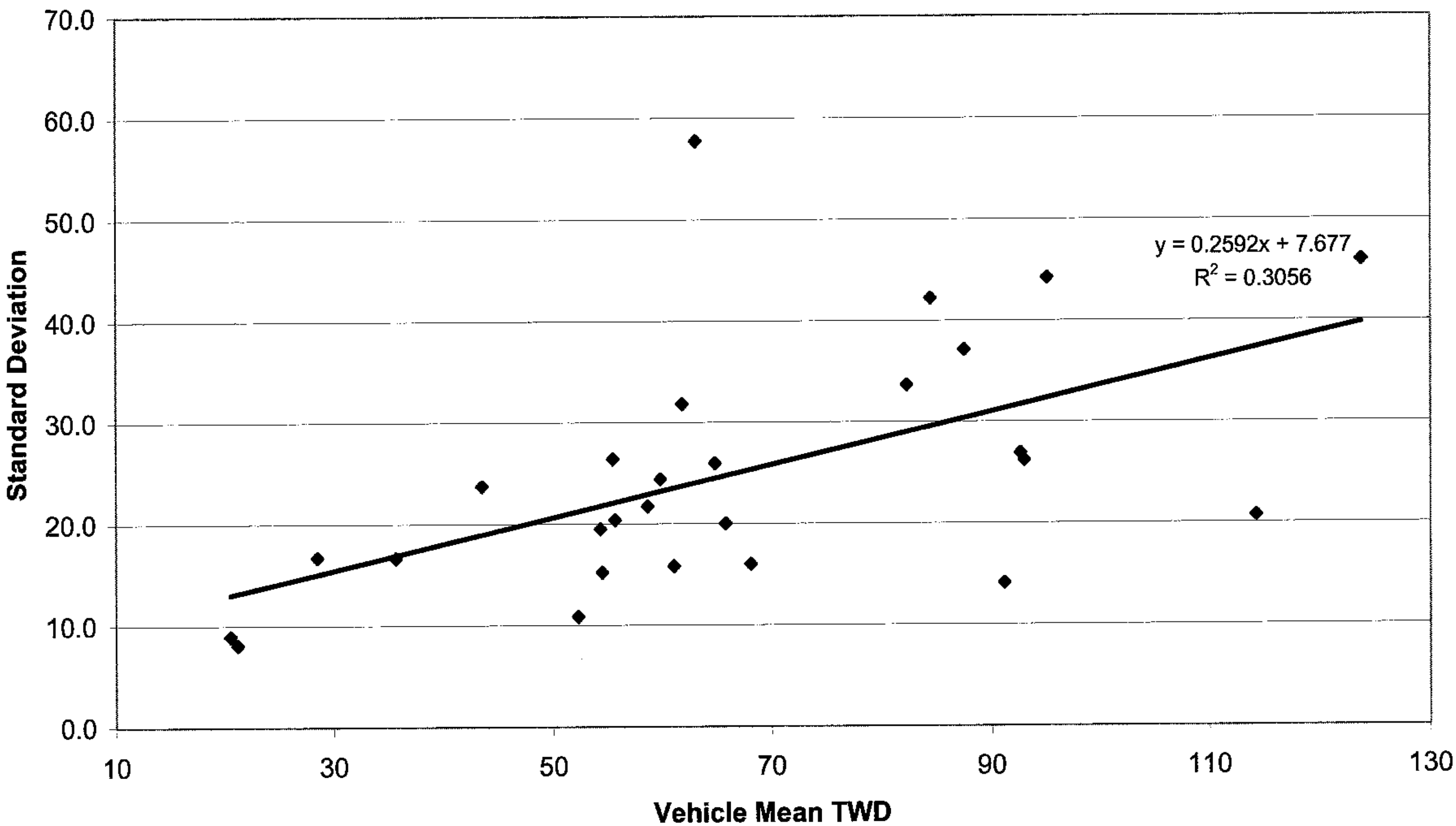
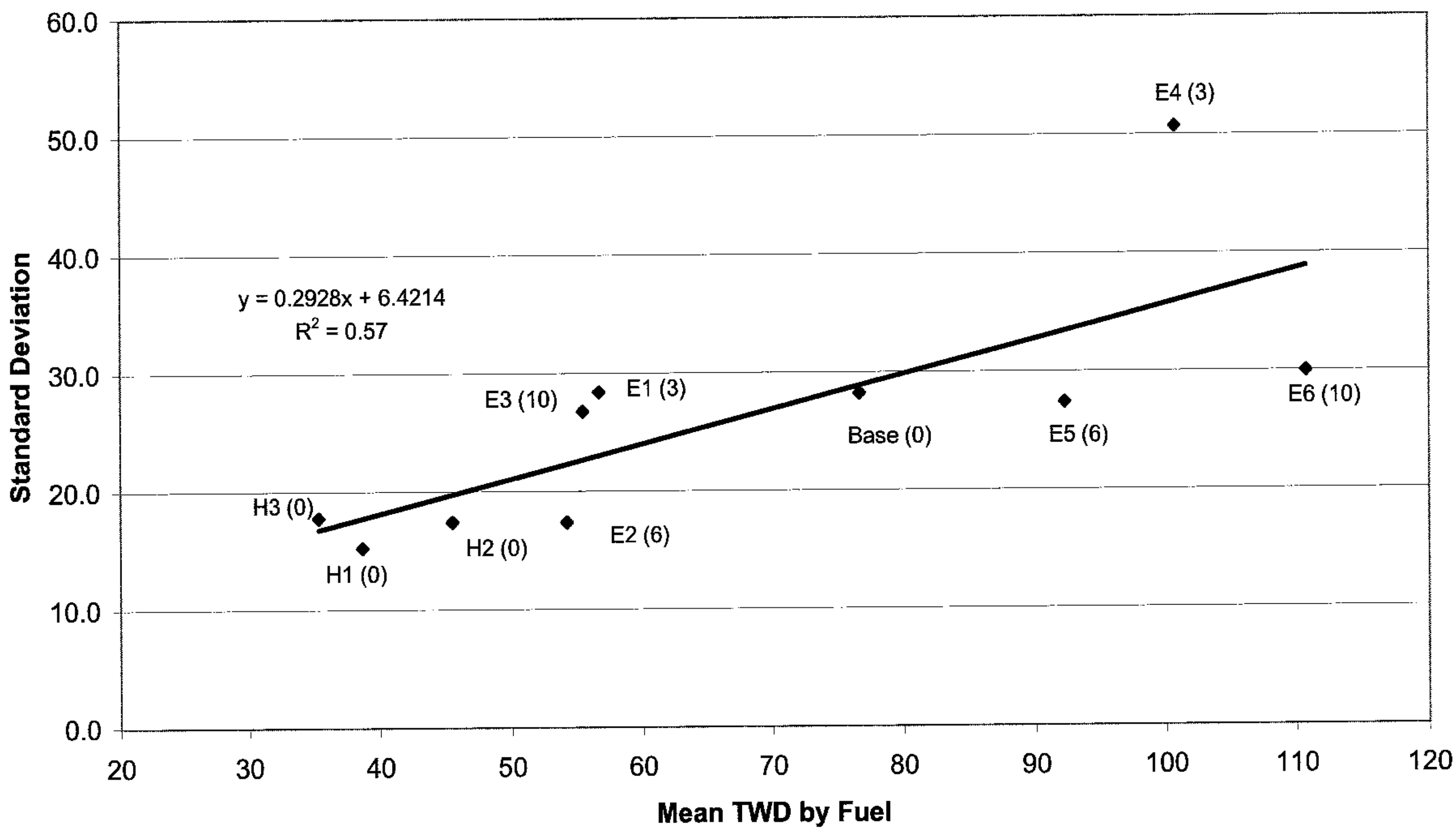


Figure 16
Standard Deviation as a Function of Mean Fuel TWD
Uncorrected Data



APPENDIX A

MEMBERS

OF THE

2003 CRC VOLATILITY PROGRAM

DATA ANALYSIS PANEL

MEMBERS OF THE 2003 CRC VOLATILITY PROGRAM DATA ANALYSIS PANEL

Name	Affiliation
L. M. Gibbs, Leader	Chevron Products Company
D. A. Barker	Shell Global Solutions
Beth Evans	Evans Research Consultants
B. E. Goodrich	BP Oil Company
C. H. Jewitt	Renewable Fuels Association
L. C. Kuta	General Motors Research and Development Center
Yeong Kwon	ExxonMobil Research and Engineering
M. Valentine	Toyota Technical Center

APPENDIX B

ON-SITE PARTICIPANTS

IN THE

2003 CRC VOLATILITY PROGRAM

ON-SITE PARTICIPANTS IN THE 2003 CRC VOLATILITY PROGRAM

Name	Affiliation
Ted Adcock	Shell Global Solutions
Harold "Archie" Archibald	Consultant
Gorka Aurre	ExxonMobil Research and Engineering
Mike Briggs	Consultant
Greg Cochran	Chevron Products Company
James Coley	Shell Global Solutions
Beth Evans	Evans Research Consultants
Steve Hardin	Chevron Products Company
Carl Jewitt	Renewable Fuels Association
Teri Kowalski	DaimlerChrysler Corporation
Phil Krysinski	DaimlerChrysler Corporation
Lloyd McGill	Shell Global Solutions
Bill Most	Consultant
Dave Newell	Chevron Oronite Company
Jimmy Pitta	Chevron Oronite Company
Clive Pyburn	Consultant
Rick Riley	Consultant
Steve Simms	BP Global Fuels Technology
Dave Sporleder	Shell Canada
Ron Stone	Consultant
Mathew Thornton	National Renewable Energy Laboratory
Bill Studzinski	General Motors R&D Center
Marie Valentine	Toyota Technical Center
Phil Van Acker	BP Global Fuels Technology
Ken Wright	ConocoPhillips

APPENDIX C

2003 CRC VOLATILITY PROGRAM

2003 CRC COLD-START AND WARMUP DRIVEABILITY PROGRAM

Objective

Determine the effect of ethanol content on cold-start and warm-up driveability performance under cool ambient conditions in late-model vehicles equipped with fuel injection systems.

Deliverables

Concentration-dependent cold-start and warm-up driveability equations for the oxygenate offset of ethanol at cool ambient temperature.

Introduction

In 2000, the CRC Volatility Group conducted a cold-start and warm-up driveability program in 45 vehicles to develop oxygenate offset equations for Driveability Index (DI) for various concentrations of MTBE and ethanol. The findings of the program as reported in CRC Report No. 626 showed no conclusive effect of DI or oxygenates on cold-start and warm-up driveability, because few driveability problems were observed.

In an attempt to develop oxygenate concentration-dependent equations, some changes are being made to the 2003 program design. Approximately 75 percent of the test vehicle fleet will be calibrated for California emissions standards, because the California calibrations are more restrictive (thus possibly causing more driveability malfunctions) and because emissions standards similar to California's may be applied to the 49-state vehicle population in the future. An effort will be made to concentrate on the SULEV and ULEV vehicle models available. The vehicle fleet will be pre-screened for vehicles sensitive to fuel properties using the highest ethanol concentration and highest DI fuel.

Test Program

Vehicle cold-start and warm-up driveability performance will be determined using the test procedure from the 2000 CRC volatility test program. Hydrocarbon-only fuels and various concentrations of ethanol blends will be evaluated in a group of 27 late-model fuel-injected vehicles selected through a screening process to represent sensitive vehicles. This program will be conducted in late January and February of 2003.

Test Fuels

The test fuel design involves ten fuels which include two sets of ethanol-containing gasolines at 3, 6, and 10 volume percent. One driveability assessment fuel set is made by splash blending the three levels of ethanol into a hydrocarbon-only base fuel with a nominal DI of 1300 and 7.0 psi DVPE. These ethanol blends are compared with three similar DI level fuels prepared by splash blending the same base fuel with a mixture of C6/C7 paraffinic hydrocarbons. The second ethanol concentration assessment involves three ethanol blends containing 3, 6, and 10 volume percent ethanol all with a DI level of the hydrocarbon-only base fuel used for the splash blends. The test fuel blend design, property specifications, and required inspections are shown in the attached Table 1. The fuels are to be made using refinery gasoline components covering a full range of carbon number hydrocarbons and types of hydrocarbons.

A Fuel Blending and Analysis Task Force will be formed to provide guidance on the blend formulations and to assist in fuel analyses. The hydrocarbon-only base fuel will be assessed before the splash blends are made.

Test Vehicles

Approximately 27 late-model fuel-injected-equipped vehicles will be used in the 2003 program to evaluate the cold-start and warm-up driveability performance of the test fuels. Approximately 75 percent of the fleet will be calibrated for California emissions standards, concentrating on the SULEV vehicle models available. The vehicles will be selected from a total fleet of about 80 vehicles based their response to DI. The vehicles will have stabilized mileages at over 6,000 odometer miles, and be in good mechanical condition with functional air conditioning systems. The vehicles will nominally cover the 2000-2003 model years. The overall 80-vehicle fleet will be screened for driveability malfunctions on the ethanol blend with the highest ethanol concentration and highest DI, and then those vehicles giving driveability problems on that fuel will be tested on the lowest hydrocarbon-only DI fuel to verify sensitivity to fuel properties. Since the California-calibrated vehicles will most likely be pre-screened in California, it may be possible to substitute tank fuel for the low-DI hydrocarbon-only fuel for those vehicles.

Test Procedure

The fuels will be tested using the CRC Cold-Start and Warm-up Driveability Test Procedure (E-28-94). Duplicate tests will be conducted on each vehicle and fuel combination. The fuel flushing procedure developed for the CRC 2001 volatility program will be used in the 2003 program.

Test Temperatures

The fuels will be evaluated at cool ambient temperatures. Every attempt will be made to perform testing from 30°F to 40°F; however, if weather conditions are not cooperative, it may be necessary to expand the upper end of the range to 45°F.

Test Location

The test program will be conducted at the same location as the 2000 program (Renegade Raceways) in Yakima, Washington, where the desired ambient conditions occur in late January and February.

Timing

The timing will be for a one-week set-up and a five-week testing program in late January and February 2003. The five-week testing period allows for some rain delays/out-of-range temperatures. Trained raters will pre-screen the vehicles prior to set-up. It is planned that the data analysis and report-writing activities can be completed within about nine months following the completion of the testing portion of the program.

Personnel Requirements

The program will require 10 people on-site for each testing week for a total of 50 person-weeks. Required will be three rating teams, three fueling personnel, and one program leader. Set-up people will be required for the week prior to the start of testing for another 6 person-weeks. An additional two person-weeks of trained rater time will be required for the pre-screening prior to the program, and three person-weeks of mechanics will be required to prep all the vehicles and de-prep the non-sensitive vehicles during the pre-screening process.

July 9, 2002

Table 1
2003 CRC Volatility Program Test Fuel Specifications

Composition	Test Methods	Base	Ethanol Splash Blends			Hydrocarbon-Only Splash Blends			Ethanol Blended Fuels		
		B	E1	E2	E3	H1	H2	H3	E4	E5	E6
Base B, Vol %		100	97	94	90	97	92.5	85	0	0	0
Ethanol, Vol %	D 4815	0	3	6	10	0	0	0	3	6	10
C6/C7 Mix, Vol %		0	0	0	0	3	7.5	15	0	0	0
Property											
DVPE, psi	D 5191	7.0-8.0	Report	Report	Report	Report	Report	Report	7.0-8.0	7.0-8.0	7.0-8.0
10% Evaporated, °F	D 86	130-140	Report	Report	Report	Report	Report	Report	130-140	130-140	130-140
50% Evaporated, °F	D 86	240-250	Report	Report	Report	Report	Report	Report	240-250	240-250	240-250
90% Evaporated, °F	D 86	335-355	Report	Report	Report	Report	Report	Report	335-355	335-355	335-355
Driveability Index	D 4814	1290-1300	Report	Report	Report	Report	Report	Report	1290-1300	1290-1300	1290-1300
Aromatics, vol %	D 1319	20-45	Report	Report	Report	Report	Report	Report	20-45	20-45	20-45
Olefins, vol %	D 1319	3-10	Report	Report	Report	Report	Report	Report	3-10	3-10	3-10
Saturates, vol %	D 1319	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Benzene, vol %	D 3606	<1.0	Report	Report	Report	Report	Report	Report	<1.0	<1.0	<1.0
MTBE, vol %	D 4815	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lead, g/gal	D 3237	<0.05	Report	Report	Report	Report	Report	Report	<0.05	<0.05	<0.05
Washed Gum, mg/100mL	D 381	<2	Report	Report	Report	Report	Report	Report	<2	<2	<2
RON	D 2699	>90	Report	Report	Report	Report	Report	Report	>90	>90	>90
MON	D 2700	>80	Report	Report	Report	Report	Report	Report	>80	>80	>80
(R+M)/2	Calculation	>87	Report	Report	Report	Report	Report	Report	>87	>87	>87
API Gravity	D 4052	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report

Note 1 - Blend B and the three ethanol blends, E4, E5, and E6, are to be made using refinery gasoline blending components.
Note 2 - Blend B is to be certified by the Fuel Acceptance Panel before splash blends are to be prepared.
Note 3 - Blend B and the three ethanol blends, E4, E5, and E6, to be at the same nominal DI level.

REVISED CRC COLD-START AND WARMUP DRIVEABILITY PROCEDURE

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

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

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

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

D. Apply brakes (right foot), shift to "Drive" ("Overdrive" if available) for 5-second idle, and record idle quality. If engine stalls, restart immediately. 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 and to maintain vehicle spacing on the test track.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

DEFINITIONS AND EXPLANATIONS

Test Run

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

Maneuver

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

Cruise

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

Wide Open Throttle (WOT) Acceleration

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

Part-Throttle (PT) Acceleration

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

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

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

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

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

Malfunctions

1. Stall

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

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

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

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

2. Idle Roughness

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

3. Backfire

An explosion in the induction or exhaust system.

4. Hesitation

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

5. Stumble

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

6. Surge

Cyclic power fluctuations.

Malfunction Severity Ratings

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

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

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

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

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

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

DEMERIT CALCULATION SYSTEM

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

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

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

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

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

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

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

For Idle Roughness

	Extreme	Heavy	Medium	Trace	Clear
	8	4	2	1	0

For Idle Stalls

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

For Starting

No Start	Slow Start
25 each	t-1*5

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

CRC Driveability Data Sheet

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

0.5 Idle Dr.
Ruf Stls

0.5 0-15 LT TH	0-15 LT TH	0.6 0-20 WOT	0.7 0-15 LT TH	0-15 LT TH	0.8 10-20 LT TH	0.9 0-20 MD TH
H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C

0.0 Idle Dr.	0.0 0-45 Crowd	0.4 25-35 Detent	0.5 Idle Dr.	Idle Dr.
Ruf Stls	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	5 sec. Ruf Stls	30 sec. Ruf Stls

Fuel Tank Flushing Procedure

Precautionary notes:

1. ***When draining the vehicle fuel tank, leave the fuel pump on until no drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***
2. ***Use a UL approved ground strap to ground defueling equipment to the fuel injector rail or fuel line fitting for all fuel draining.***

Flushing Procedure:

1. When a vehicle comes in from testing, hook up the chilled sampling system, and draw the required fuel sample through the Schrader valve or adapter line fitting using the vehicle fuel pump.
2. Remove the sampling system. Immediately prior to testing, install drain line, and then completely drain the fuel tank through the Schrader valve or adapter line fitting using the vehicle fuel pump.
3. Remove the fill cap, add four gallons of the next test fuel to the vehicle fuel tank, and replace the fill cap.
4. Start and idle the vehicle for a total of 2 minutes.
5. Completely drain the fuel tank through the Schrader valve or adapter line fitting using the vehicle fuel pump.
6. Remove the fill cap, add four gallons of the next test fuel to the vehicle fuel tank, and replace the fill cap.
7. Start and idle the vehicle for a total of 2 minutes. From approximately 15 seconds into the idle for a period of 30 seconds, rock the rear end of the vehicle from side to side. This task will require one person on each side of the vehicle.
8. Completely drain the fuel tank through the Schrader valve or adaptive line fitting using the vehicle fuel pump.
9. When the rating crew is ready, remove the fill cap, add four or five gallons as required of the test fuel to the vehicle fuel tank, and replace the fill cap.

APPENDIX D

LISTING OF SCREENED VEHICLES

Table D-1
2003 CRC Volatility Program - Test Vehicle List

	Year	Make	Model	Disp. L	VIN	Miles	E6 TWD	Tank TWD
	2003	Ford	Taurus	3.0	1FAFP58U03A166131	2882	28	11
	2003	Ford	Taurus	3.0	1FAFP58U53A166125	1796	17	8
	2002	GMC	Safari	4.3	1GKDM19X82B504822	27772	4	5
*	2002	Ford	Explorer	4.0	1FMZU73E52UC42107	27553	90.4	8
	2003	Ford	Taurus	3.0	1FAFP58U13A104656	5951	31.5	13
	2002	GMC	Safari	4.3	1GKDM19X22B500491	39458	27	9
	2002	Saturn	L200	2.2	1G8JU54F62Y579286	15555	16	14
	2002	Dodge	Caravan	3.3	2B4GP44342R753672	15971	7.5	7
	2002	Pontiac	Sunfire	2.2	1G2JB124827324963	15881	20	15
	2003	Ford	Expedition	4.6	1FMPU16W13LA24259	12722	25.5	5
	2002	GMC	Safari	4.3	1GKDM19X62B500607	41721	10.5	11
	2002	Chevy	Cavalier	2.2	1G1JC524527421742	14078	9.5	7
	2003	Ford	Focus	2.0	1FAFP33P23W109082	6479	9	6.5
	2002	Chevy	1500	4.8	2GCEC19V321383425	16926	35	11.5
	2003	Toyota	Corolla	1.8	1NXBR32E93Z028431	16400	31.5	11
	2003	Buick	Le Sabre	3.8	1G4HE52K23111023	11774	8.5	5.5
	2002	Chevy	Cavalier	2.2	1G1JC524927380807	11969	13	9
*	2003	Ford	F-150	4.6	1FTRX17W63NA01129	9280	50	4
	2002	Volvo	V70	2.4	YV1FW61R522242775	15611	18	19.5
	2002	Volvo	S-60	2.4	YV1RS61R522154707	13053	21	9
*	2002	Ford	F-150	4.6	1FTRX17W73NA01124	7660	34	8
	2003	Ford	Windstar	3.8	2FMZA51433BA02200	16182	14	6
*	2003	GMC	Envoy	4.2	1GKDT13S632140806	10025	72	19
*	2002	Chevy	Impala	3.4	2G1WF52E929305383	22496	35	7
	2003	Ford	F-150	4.6	1FTRX17W83NA01133	12230	47.5	0
*	2002	Dodge	Dakota	5.9	1B7HL48Z02S690036	14588	93	18
*	2003	Chevy	Trail Blazer	4.2	1GNDT13S432116507	7823	66	4
*	2003	GMC	Envoy	4.2	1GKDT13S532145401	6064	68.5	13
*	2003	Mercury	Sable	3.0	1MEFM50U63A600744	14439	51	8
	2002	Saturn	L200	2.2	1G8JU54F12Y579342	16402	11	20
	2002	Volvo	V70	2.4	YV1SW61R322236957	12870	20	5
	2002	Pontiac	Sunfire	2.2	1G2JB124427302359	16667	10	10
	2003	Toyota	Corolla	1.8	1NXBR32E73Z014785	6484	37	18.5
	2002	Pontiac	Sunfire	2.2	1G2JB124527352591	16739	20	15
	2003	Ford	Focus	2.0	1FAFP33P93W109080	4375	8	8
	2003	Ford	Focus	2.0	1FAFP33P13W109087	6021	17	4
*	2002	Dodge	Caravan	3.3	1B4GP44352B657080	22250	87.1	8
	2002	Volvo	S60	2.4	YV1RS61R122165400	12193	24	27
*	2003	Chevy	Impala	3.4	2G1WF52E839111980	11075	47.5	8
	2002	Buick	Le Sabre	3.8	1G4HP54KX24183485	22786	56.5	9.5
*	2003	Lincoln	Town Car	4.6	1LNHM81W53Y637430	8144	39	8
	2002	Ford	Explorer	4.0	1FMZU73EX2ZC46785	18562	49	12
	2003	Ford	Windstar	3.8	2FMZA51473BA02233	18166	9	6.5
*	2002	Dodge	Caravan	3.3	1B4GP44312B657075	24183	73.8	15
*	2002	Chevy	1500	4.8	2GCEC19V221383500	6963	56.5	5
	2002	Chevy	1500	4.8	2GCEC19V821388667	15865	49.5	5
*	2003	Lincoln	Town Car	4.6	1LNHM81W93Y637446	6563	45.5	11

Table D-1 Cont'd.
2003 CRC Volatility Program - Test Vehicle List

	Year	Make	Model	Disp. L	VIN	Miles	E6 TWD	Tank TWD
*	2002	Dodge	Dakota	5.9	1B7HL48Z62S690039	10391	83	0
*	2002	Toyota	Camry	2.4	4T1BE32K12U076229	31046	68	19
	2003	Jeep	Grand Cherokee	4.0	1J4GW48S03C517340	13117	22	14.5
*	2003	Jeep	Grand Cherokee	4.0	1J4GW48S93C517336	8896	31	11.5
	2002	Chevy	Impala	3.4	2G1WF52E129179827	18697	17.5	14
	2003	Chevy	Trail Blazer	4.2	1GNDT13S832113190	8348	31	20
	2003	Ford	Expedition	4.6	1FMPU16W13LA24262	16745	33.5	11.5
	2002	Chevy	Cavalier	2.2	1G1JC524927436468	11537	16	18
	2002	Saturn	L200	2.2	1G8JU54F12Y579504	22234	11	17
	2002	Dodge	Dakota	5.9	1B7HG48Z42S670134	19547	58.5	10
	2002	Toyota	Camry	2.4	4T1BE32KX211598258	16570	36	15
*	2002	Ford	Explorer	4.0	1FMZU73E02UB00957	10881	107	5.5
	2003	Toyota	Corolla	1.8	1NXBR32E33Z058427	11418	30	10.5
*	2002	Toyota	Camry	2.4	4T1BE32K12U083391	22190	84	20
	2003	Buick	LeSabre	3.8	1G4HP52K234116478	12799	16.5	13
	2002	Chrysler	Town & Country	3.3	2C4GP44392R665266	32101	59	6
*	2003	Mitsubish	Galant	2.4	4A3AA46G93E045651	13883	87.2	33
*	2002	Chevy	S-10	4.3	1GCCS19W728260937	9962	86.5	13
	2003	Jeep	Liberty	3.7	1J4GL48K23W511594	11700	48.5	10
	2003	Chevy	Venture	3.4	1GNDX03E23D111965	8404	23	28
	2003	Toyota	Camry	2.4	JTDBE32K630171124	478	91.5	19.5
	2002	Chevy	Impala	3.4	2G1WF52E529344357	16139	41	4
*	2002	Ford	Windstar	3.8	2FMZA51472BB65978	18067	91	5
	2002	Pontiac	Sunfire	2.2	1G2JB524827196702	24875	20	11
	2002	Ford	Taurus	3.0	1FAFP53U03G106113	8982	29	10
	2002	Buick	Century	3.1	2G4WS52J431117396	6318	26	0
*	2003	Chevy	Tracker	2.5	2CNBJ734836903999	8170	106.5	6
*	2003	Suzuki	Aerio	2.0	JS2RA41S635159095	481	76.1	14
	2003	Mitsubish	Lancer	2.0	JA3AJ26E63U007398	14468	39	19.5
	2002	Buick	Regal	3.8	2G4WB52K731117689	10713	20.5	10.5
	2002	Dodge	Dakota	5.9	1B7HL48Z32S689981	12486	69.5	6
	2002	Chrysler	PT Cruiser	2.4	3C4FY58B72T331900	17768	65	6
*	2003	Dodge	Intrepid	2.7	2B3HD46R73H504356	5798	48.5	13.5
	2002	Chevy	Malibu	3.1	1G1ND52JX3M544833	8890	21	9
*	2002	Honda	Civic	1.6	1HGEM22972L000856	987	78	22.5
	2001	Honda	Acura	3.2	19UUA56751A021276	27842	39	4

Hybrid Vehicles

	Year	Make	Model	Disp. L	VIN	Miles
	2000	Honda	Insight	1.0	JHMZE1376YT000763	3206
	2000	Toyota	Prius	1.5	JT2BK12U010006951	6636
	2000	Honda	Insight	1.0	JHMZE1372YT000159	16637
	2003	Honda	Civic	1.3	JHMES96623S003702	13074

* Indicates selected vehicles

APPENDIX E

INDIVIDUAL LABORATORY FUEL INSPECTIONS

AND ON-SITE SAMPLE INSPECTIONS

Table E-1
CRC 2003 Volatility Program Individual Laboratory Fuel Inspections

Inspection	Units	Base							E-1						
Laboratory		A	B	C	D	E	F	Average	A	B	C	D	E	F	Average
API Gravity	°API	53.7	53.8	54.0	53.5	53.8	53.8	53.8	53.7	53.7	54.0	53.6	53.6	53.8	53.7
Relative Density	60/60°F	0.7640	0.7636	0.7628	0.7650	0.7638	0.7638	0.7638	0.7640	0.7640	0.7628	0.7644	0.7643	0.7636	0.7638
DVPE	psi	7.7	7.81	7.89	7.79	7.89	7.76	7.8	8.8	8.90	8.95	8.88	8.94	8.98	8.9
Oxygenates--D 4815															
MTBE	vol%	0	0	0	0	0	0	0.0	0.0	0.0	0	0	0	0.0	0.0
TAME	vol%	0	0	0	0	0	0	0.0	0.0	0.0	0	0	0	0.0	0.0
EtOH	vol%	0	0	0	0	0	0	0.0	3.0	3.26	3.04	3.20	3.3	3.36	3.2
O2	wt%	0	0	0	0	0	0	0.0	1.1	1.2	1.1	1.2	1.2	1.2	1.2
D 86 Distillation															
IBP	°F	93	92.1	89.1	95.0	88	90.8	90.6	97	96.2	91.5	96.6	90	97.3	94.4
5% Evaporated	°F	122	122.9	122.9	113.6	116	121.2	121.0	116	118.4	118.3	110.0	114	117.2	116.8
10% Evaporated	°F	140	141.2	140.1	135.4	135	139.1	139.1	125	127.0	127.5	124.5	124	126.6	126.0
20% Evaporated	°F	173	172.7	173.2	166.5	169	171.6	171.9	150	145.9	147.4	147.2	143	149.4	147.1
30% Evaporated	°F	208	206.2	206.9	199.5	205	205.4	206.3	195	192.7	195.0	187.3	189	190.2	192.4
40% Evaporated	°F	233	232.1	230.7	223.9	232	230.5	231.7	229	227.1	226.7	220.2	226	225.1	226.8
50% Evaporated	°F	249	248.7	246.7	242.2	248	247.5	248.0	246	245.1	244.6	241.2	245	243.4	244.8
60% Evaporated	°F	266	267.4	265.6	261.7	265	264.1	265.6	263	264.0	262.5	259.6	261	261.9	262.5
70% Evaporated	°F	298	296.9	298.3	293.8	296	296.7	297.2	293	293.0	293.3	291.3	290	292.2	292.3
80% Evaporated	°F	327	327.0	327.5	323.2	327	327.4	327.2	326	325.4	325.4	323.0	324	326.2	325.4
90% Evaporated	°F	343	343.5	343.4	343.6	343	344.0	343.4	343	342.8	342.5	343.7	342	344.4	342.9
95% Evaporated	°F	358	356.9	357.3	358.4	356	357.6	357.2	357	355.8	356.0	357.5	355	358.0	356.4
EP	°F	390	387.5	384.7	385.0	384	385.3	386.3	389	385.7	358.8	380.8	383	386.8	380.7
Recovery	vol%	97.7	98.0	98.3	97.2	97.7	98.0	97.9	97.4	97.6	98.3	96.9	97.6	97.6	97.7
Residue	vol%	1.0	1.0	0.4	1.3	1.2	1.0	0.9	1.0	1.4	0.7	1.0	1.0	1.0	1.0
Loss	vol%	1.3	1.0	1.3	1.5	1.1	1.1	1.2	1.6	1.0	1.0	2.1	1.4	1.4	1.3
Driveability Index		1300.0	1301.4	1293.7	1273.4	1289.5	1294.9	1295.9	1268.5	1268.6	1267.6	1254.1	1263.0	1264.5	1266.4

Inspection	Units	E-2							E-3						
Laboratory		A	B	C	D	E	F	Average	A	B	C	D	E	F	Average
API Gravity	°API	53.6	53.6	53.9	53.5	53.6	53.7	53.7	53.4	53.3	53.6	53.1	53.4	53.4	53.4
Relative Density	60/60°F	0.7645	0.7645	0.7634	0.7648	0.7643	0.7640	0.7642	0.7653	0.7657	0.7645	0.7664	0.7655	0.7653	0.7654
DVPE	psi	8.9	9.00	9.05	9.14	9.05	8.99	9.0	8.8	8.90	8.95	8.85	8.94	8.97	8.9
Oxygenates--D 4815															
MTBE	vol%	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0
TAME	vol%	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0
EtOH	vol%	5.8	6.2	6.06	6.04	6.0	6.27	6.1	10.1	10.9	10.40	10.57	10.8	11.01	10.6
O2	wt%	2.1	2.2	2.2	2.2	2.2	2.3	2.2	3.6	3.9	3.8	3.8	3.9	4.0	3.8
D 86 Distillation															
IBP	°F	97	93.9	92.9	97.5	91	95.7	94.1	97	94.2	94.5	98.8	94	102.4	96.4
5% Evaporated	°F	119	118.5	120.1	111.5	116	117.6	118.0	120	119.3	122.0	115.8	120	121.1	120.5
10% Evaporated	°F	129	128.4	129.8	125.8	126	128.4	128.3	130	127.9	131.9	129.4	130	130.8	130.1
20% Evaporated	°F	144	142.7	144.0	142.1	142	142.4	143.0	145	143.0	146.5	143.8	145	145.2	144.9
30% Evaporated	°F	164	157.8	165.2	164.8	158	161.3	161.3	155	155.8	156.5	156.3	156	155.3	155.7
40% Evaporated	°F	223	220.4	219.1	211.3	219	217.3	219.8	177	168.0	175.3	178.7	171	167.2	171.7
50% Evaporated	°F	244	243.6	240.9	237.2	243	242.6	242.8	239	235.9	235.2	230.1	238	234.8	236.6
60% Evaporated	°F	261	260.9	259.9	257.1	260	259.6	260.3	257	255.0	254.0	253.8	259	255.1	256.0
70% Evaporated	°F	289	289.5	290.1	288.2	286	289.5	288.8	285	284.1	282.4	283.2	283	280.8	283.1
80% Evaporated	°F	326	324.1	324.3	319.2	323	324.9	324.5	323	320.9	321.8	319.6	323	322.0	322.1
90% Evaporated	°F	344	342.1	341.8	342.5	341	342.8	342.3	342	340.7	340.8	341.8	342	342.7	341.6
95% Evaporated	°F	358	355.4	356	358.3	354	357.6	356.2	356	353.8	354.6	356.8	356	357.2	355.5
EP	°F	389	384	383.9	381.6	383	384.7	384.9	385	379.4	383.0	378.3	383	381.7	382.4
Recovery	vol%	97.7	97.7	97.8	96.9	97.3	96.9	97.5	97.5	97.9	98.0	97.4	98.5	97.3	97.8
Residue	vol%	1.0	1.3	1.0	1.0	1.0	1.1	1.1	1.0	1.1	0.9	1.1	0.8	1.0	1.0
Loss	vol%	1.3	1.0	1.2	2.1	1.7	2.0	1.4	1.5	1.0	1.1	1.5	0.7	1.7	1.2
Driveability Index		1269.5	1265.5	1259.2	1242.7	1259.0	1263.2	1263.3	1254.0	1240.3	1244.3	1226.1	1251.0	1243.3	1246.6

Distillation and DI Averages Exclude Data From Laboratory D

Table E-1
CRC 2003 Volatility Program Individual Laboratory Fuel Inspections

Inspection	Units	H-1							H-2						
Laboratory		A	B	C	D	E	F	Average	A	B	C	D	E	F	Average
API Gravity	°API	55.2	55.3	55.4	54.9	55.2	55.3	55.2	55.3	55.3	55.5	55.0	55.2	55.3	55.3
Relative Density	60/60°F	0.7579	0.7575	0.7569	0.7592	0.7578	0.7575	0.7578	0.7575	0.7575	0.7568	0.7588	0.7578	0.7575	0.7577
DVPE	psi	8.8	8.90	8.88	8.33	8.94	8.89	8.77	8.7	8.90	8.89	8.44	8.90	9.04	8.81
Oxygenates--D 4815															
MTBE	vol%	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0.0
TAME	vol%	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0.0
EtOH	vol%	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0.0
O2	wt%	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0.0
D 86 Distillation															
IBP	°F	83	88.3	86.9	91.0	84	94.0	87.2	84	83.6	93.4	89.6	85	98.9	89.0
5% Evaporated	°F	115	114.4	116.8	106.5	108	115.7	114.0	116	111.2	121.6	108.5	107	121.8	115.5
10% Evaporated	°F	129	129.3	130.8	126.2	124	129.4	128.5	132	127.0	137.5	127.7	124	136.6	131.4
20% Evaporated	°F	159	158.3	158.1	154.3	154	156.9	157.3	161	156.7	166.9	156.5	154	164.2	160.6
30% Evaporated	°F	195	194.0	192.3	186.5	190	190.1	192.3	195	190.4	196.4	187.9	188	195.3	193.0
40% Evaporated	°F	227	226.4	223.1	217.4	224	221.8	224.5	225	222.0	223.9	216.6	221	225.1	223.4
50% Evaporated	°F	245	245.8	243.4	239.9	245	243.0	244.4	244	242.7	245.8	238.1	243	247.0	244.5
60% Evaporated	°F	265	266.3	263.0	262.2	264	262.4	264.1	265	265.2	266.9	261.5	263	268.2	265.7
70% Evaporated	°F	297	297.5	296.2	294.8	295	294.9	296.1	299	297.3	293.3	296.7	298	300.7	297.3
80% Evaporated	°F	326	326.4	325.6	323.7	324	326.7	325.7	326	325.7	324.3	323.7	325	329.4	326.1
90% Evaporated	°F	342	340.5	340.4	341.6	340	342.1	341.0	341	339.4	340.5	340.0	338	342.4	340.3
95% Evaporated	°F	355	354.2	351.8	356.0	353	355.4	353.9	352	350.9	350.9	353.4	361	354.9	351.9
EP	°F	387	381.5	383.3	382.1	380	383.0	383.0	384	378.1	376.4	379.0	376	385.1	379.8
Recovery	vol%	98.4	97.9	99.3	96.9	97.4	96.9	98.0	98.1	97.6	97.6	97.3	97.0	97.2	97.5
Residue	vol%	1.0	1.2	0.1	0.9	1.1	1.2	0.9	1.0	1.2	1.0	1.0	1.1	1.0	1.1
Loss	vol%	0.6	0.9	0.6	2.2	1.5	1.9	1.1	0.9	1.2	1.1	1.7	1.9	1.8	1.4
Driveability Index		1270.5	1271.9	1266.8	1250.7	1261.0	1265.2	1267.1	1271.0	1258.0	1284.2	1245.8	1253.0	1288.3	1270.9

Inspection	Units	H-3							E-4					
Laboratory		A	B	C	D	E	F	Average	A	B	C	D	E	Average
API Gravity	°API	56.0	55.9	56.1	55.1	55.8	55.9	55.8	51.8	51.9	52.1	51.3	51.8	51.8
Relative Density	60/60°F	0.7547	0.7551	0.7543	0.7584	0.7553	0.7551	0.7555	0.7720	0.7715	0.7707	0.7741	0.7722	0.7721
DVPE	psi	8.9	9.00	9.08	8.44	9.11	8.89	8.90	7.70	8.00	8.01	7.85	8.00	7.91
Oxygenates--D 4815														
MTBE	vol%	0	0	0	0	0	0	0.0	0	0	0	0	0.0	0.0
TAME	vol%	0	0	0	0	0	0	0.0	0	0	0	0	0.0	0.0
EtOH	vol%	0	0	0	0	0	0	0.0	3.2	3.3	3.23	3.38	3.5	3.3
O2	wt%	0	0	0	0	0	0	0.0	1.1	1.2	1.2	1.2	1.2	1.2
D 86 Distillation														
IBP	°F	85	86.9	86.4	92	85	94.8	87.6	103	82.7	95.2	102.0	96	94.2
5% Evaporated	°F	114	117.5	118.2	101	109	115.4	114.8	123	123	125.2	116.6	120	122.8
10% Evaporated	°F	130	130.6	132.5	119	126	131.2	130.1	132	132.4	133.8	129.9	130	132.1
20% Evaporated	°F	160	158.1	160.6	148	157	160.2	159.2	157	154.7	158.8	155.7	152	155.6
30% Evaporated	°F	191	188.6	190.6	177	189	188.8	189.6	203	204.4	204.1	197.1	200	202.9
40% Evaporated	°F	219	215.6	216.4	204	217	215.2	216.6	233	233.4	231.9	226.8	232	232.6
50% Evaporated	°F	239	237.5	238	228	238	237.5	238.0	250	251	250.2	246.8	250	250.3
60% Evaporated	°F	261	261.5	262.2	252	260	261.4	261.2	271	273	272.0	269.7	270	271.5
70% Evaporated	°F	297	295.5	298.2	285	298	296.7	297.1	205	305.4	306.9	304.5	304	280.3
80% Evaporated	°F	325	323.6	325.7	317	324	326.9	325.0	332	332.2	331.7	327.9	332	332.0
90% Evaporated	°F	338	337.1	337.5	335	337	339.7	337.9	347	346.2	346.5	346.5	346	346.4
95% Evaporated	°F	349	347.5	348.4	343	348	350.3	348.6	362	360.5	361.4	363.2	360	361.0
EP	°F	375	377.4	376.3	377	374	380.2	376.6	395	390	391.3	387.9	387	390.8
Recovery	vol%	97.4	98.0	98.6	96.4	97.2	96.9	97.6	97.8	98.4	98.5	96.9	97.7	98.1
Residue	vol%	1.0	1.0	0.2	1.0	1.0	1.1	0.9	1.0	1	0.4	1.2	1.1	0.9
Loss	vol%	1.6	1.0	1.2	2.6	1.8	2.0	1.5	1.2	0.6	1.1	1.9	1.2	1.0
Driveability Index		1250.0	1245.5	1250.3	1196.8	1240.0	1249.0	1247.0	1295.0	1297.8	1297.8	1281.8	1291.0	1295.4

Distillation and DI Averages Exclude Data From Laboratory D

Table E-1
CRC 2003 Volatility Program Individual Laboratory Fuel Inspections

Inspection	Units	E-5							E-6						
Laboratory		A	B	C	D	E	F	Average	A	B	C	D	E	F	Average
API Gravity	°API	51.6	51.6	51.8	51.3	51.6	51.6	51.6	50.6	50.8	50.9	50.5	50.7	50.7	50.7
Relative Density	60/60°F	0.7728	0.7728	0.7720	0.7741	0.7730	0.7729	0.7729	0.7770	0.7762	0.7758	0.7774	0.7766	0.7766	0.7766
DVPE	psi	7.90	8.04	8.06	7.89	8.11	8.00	8.00	8.00	8.01	8.01	7.93	8.11	7.96	8.00
Oxygenates--D 4815															
MTBE	vol%	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
TAME	vol%	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
EtOH	vol%	5.7	6.1	5.97	6.13	5.6	6.2	6.0	10.0	10.4	10.3	10.3	10.2	10.27	10.2
O2	wt%	2.0	2.2	2.1	2.2	2.0	2.22	2.1	3.5	3.7	3.7	3.7	3.6	3.6	3.6
D 86 Distillation															
IBP	°F	101	96.9	95.9	102.4	98	105.2	99.4	101	105.8	97.4	104.4	99	106.7	102.0
5% Evaporated	°F	125	123.6	126.7	117.6	122	125.2	124.5	125	129.7	129.9	120.2	125	129.1	127.7
10% Evaporated	°F	134	133.8	135.7	131.0	133	134.2	134.1	137	138.8	139.3	134.7	136	138.0	137.8
20% Evaporated	°F	147	146.4	147.9	145.7	147	146.0	146.9	150	151.3	152.3	148.9	151	152.5	151.4
30% Evaporated	°F	176	174.9	180.6	179.2	172	177.9	176.3	158	159.5	160.5	158.4	160	160.3	159.7
40% Evaporated	°F	228	226.4	225.6	218.2	228	222.4	226.1	203	214.8	216.2	209.7	215	211.4	212.1
50% Evaporated	°F	249	246.3	246.4	241.7	245	244.6	246.3	247	252.1	249.0	241.2	250	248.7	249.4
60% Evaporated	°F	271	270.6	269.1	266.8	271	267.6	269.9	267	268.0	269.5	265.7	271	266.8	268.5
70% Evaporated	°F	304	303.2	306.2	303.3	306	302.8	304.4	302	305.9	305.0	302.6	302	304.0	303.8
80% Evaporated	°F	332	331.7	332.8	330.4	333	327.7	331.4	330	332.4	332.3	329.8	332	332.2	331.8
90% Evaporated	°F	347	346.8	347.0	347.2	348	347.1	347.2	346	347.3	345.9	346.5	346	347.7	346.6
95% Evaporated	°F	362	360.6	362.2	362.2	362	360.7	361.5	360	360.7	359.9	360.6	360	361.5	360.4
EP	°F	391	389.6	390.5	384.6	393	390.2	390.9	387	385.9	385.1	380.7	388	385.2	386.2
Recovery	vol%	98.3	97.8	98.5	97.2	97.8	97.5	98.0	97.5	97.4	98.5	97.0	98.0	98.0	97.9
Residue	vol%	1.0	1.0	0.4	1.3	0.8	0.9	0.8	1.0	1.8	0.4	1.0	0.9	1.0	1.0
Loss	vol%	0.7	1.2	1.1	1.5	1.4	1.6	1.2	1.0	0.9	1.1	2.0	1.1	1.0	1.0
Driveability Index		1295.0	1286.4	1289.8	1268.8	1282.5	1282.2	1287.2	1292.5	1311.7	1301.9	1272.4	1300.0	1300.8	1301.4

Distillation and DI Averages Exclude Data From Laboratory D

Table E-2
SUPPLIERS ADDITIONAL INSPECTIONS

Fuel	Units	Base	E-1	E-2	E-3	H-1	H-2	H-3	E-4	E-5	E-6
Sulfur	wt %	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.002
Lead	g/gal	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05
Aromatics	vol %	40.4	39.2	39.1	34.1	36.9	37.8	36.4	39.5	39.9	40.2
Olefins	vol %	3.7	4.5	4.8	4.3	3.2	3.3	3.0	4.5	5.4	3.8
Saturates	vol %	55.9	53.1	50.1	51.0	59.9	58.9	60.6	52.6	48.8	45.8
Benzene	vol %	0.9	0.8	0.9	0.8	0.8	0.7	0.6	0.8	0.7	0.7
Gum, washed	mg/100mL	<1	<1	<1	<1	<1	<1	<1	<1	<1	1
Research Octane Number		100.2	100.9	100.5	101.2	99.0	97.8	96.4	100.4	101.2	101.6
Motor Octane Number		88.8	89.2	88.6	89.2	88.1	86.8	85.9	88.9	89.6	90.0
(R+M)/2		94.5	95.1	94.6	95.2	93.6	92.3	91.2	94.65	95.4	95.8

Table E-3
Inspection of On-Site CRC Fuel Samples
Laboratory G Inspections

Sample Description	BASE	H1 DRSM	H2 PUMP	H3 PUMP	E1 PUMP	E2	E3	E4 PUMP	E5	E6 DRSM
Sample Date	2/5/03	2/11/03	2/6/03	2/7/03	2/6/03	2/7/03	2/5/03	2/6/03	2/5/03	2/10/03
Specific Gravity	0.7661	0.7577	0.7576	0.7554	0.7636	0.7641	0.7653	0.7720	0.7729	0.7768
Density, g/ml	0.7653	0.7570	0.7569	0.7547	0.7629	0.7634	0.7645	0.7713	0.7721	0.7760
API Gravity @ 60 F	53.2	55.2	55.3	55.8	53.8	53.7	53.4	51.8	51.6	50.7
Benzene by D3606, vol %	0.91	0.81	0.75	0.66	0.89	0.84	0.84	0.79	0.78	0.77
D 86 Distillation, °F										
IBP	85.5	83.4	93.7	95.4	87.5	90.1	90.9	100.0	110.4	96.6
10% Evaporated	139.5	123.5	141.3	130.4	124.6	127.8	129.3	131.3	137.7	137.1
30% Evaporated	210.0	190.3	192.5	189.8	191.8	162.1	156.9	201.7	182.7	160.4
50% Evaporated	249.3	245.6	242.8	238.1	242.7	243.0	235.1	250.8	247.7	245.5
70% Evaporated	299.8	295.4	298.6	298.0	291.3	289.3	283.8	305.8	306.3	305.4
90% Evaporated	344.1	341.1	339.9	338.6	342.9	342.4	341.8	347.6	348.0	346.6
End Point	387.0	390.7	380.0	378.3	383.5	385.5	380.9	394.0	389.0	384.5
Residue, vol %	1.0	0.7	1.0	0.9	0.8	0.7	0.8	0.8	0.9	0.8
Recovery, vol %	97.9	97.4	96.9	97.2	97.8	97.9	97.7	97.1	98.9	98.2
Loss, vol %	1.1	1.9	2.1	1.9	1.4	1.4	1.5	2.1	0.2	1.0
E 200, %	27.0	32.4	32.3	33.6	31.9	36.0	43.4	29.6	33.0	38.3
E 300, %	70.1	71.3	70.4	70.7	72.2	72.9	74.3	68.4	68.5	68.7
Driveability Index	1301	1263	1280	1248	1258	1263	1241	1297	1298	1289
FIA Aromatics, vol %	38.6	35.9	36.0	35.1	36.9	34.9	33.0	39.5	39.6	39.6
FIA Olefins, vol %	3.5	3.5	3.6	3.3	4.1	4.1	4.3	4.1	6.8	5.5
FIA Saturates, vol %	57.9	60.5	60.4	61.5	55.6	54.6	52.0	52.8	47.5	44.6
Ethanol, vol %	0.00	0.01	0.03	0.08	3.37	6.22	10.66	3.56	6.11	10.22
MTBE, vol%	0.02	0.02	0.02	0.00	0.02	0.08	0.02	0.02	0.02	0.02
EPA Vapor Pressure, psi	7.27	8.63	8.57	8.79	8.75	8.86	8.79	7.73	7.86	7.70
ASTM Vapor Pressure, psi	7.13	8.50	8.46	8.68	8.63	8.74	8.68	7.62	7.74	7.59
Gum,Washed mg/100ML	0	1	0	0	1	0	0	1	0	0
RON	100.1	99.5	98.6	97.4	100.8	101.2	101.8	100.9	101.1	102.0
MON	89.8	89.0	88.2	87.1	89.9	89.9	90.1	89.9	89.9	90.3
(R+M)/2	95.0	94.3	93.5	92.3	95.4	95.6	96.0	95.4	95.5	96.2

Table E-4
Inspection of On-Site Vehicle Tank Fuel Samples
Base Fuel Sample Following E6 Test
Laboratory G Inspections

Vehicle Number	**4**	**18**	**21**	**23**	**24**	**26**	**27**	**28**	**29**	**37**
Specific Gravity	0.7665	0.7675	0.7662	0.7660	0.7661	0.7664	0.7662	0.7661	0.7666	0.7665
Density, g/ml	0.7657	0.7667	0.7655	0.7652	0.7653	0.7656	0.7654	0.7653	0.7658	0.7657
API Gravity @ 60 F	53.1	52.9	53.2	53.2	53.2	53.1	53.2	53.2	53.1	53.1
Ethanol, vol %	0.22	0.06	0.04	0.04	0.07	0.11	0.05	0.03	0.21	0.21
MTBE, vol%	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Vehicle Number	**39**	**41**	**44**	**45**	**47**	**48**	**49**	**51**	**59**	**61**
Sample Date	2/11/03	2/11/03	2/18/03	2/6/03	2/6/03	2/18/03	2/11/03	2/6/03	2/18/03	2/18/03
Specific Gravity	0.7662	0.7661	0.7663	0.7664	0.7660	0.7662	0.7661	0.7662	0.7663	0.7663
Density, g/ml	0.7655	0.7654	0.7656	0.7657	0.7652	0.7655	0.7653	0.7654	0.7656	0.7656
API Gravity @ 60 F	53.2	53.2	53.2	53.1	53.2	53.2	53.2	53.2	53.2	53.2
Ethanol, vol %	0.07	0.02	0.23	0.04	0.02	0.05	0.05	0.03	0.23	0.02
MTBE, vol%	0.02	0.02	0.02	0.02	0.00	0.00	0.02	0.02	0.02	0.02

Sample Description	**64**	**65**	**70**	**74**	**75**	**80**	**82**	**84**	**86**	**87**
Sample Date	2/18/03	2/6/03	2/11/03	2/11/03	2/6/03	2/18/03	2/18/03	2/11/03	2/11/03	2/6/03
Specific Gravity	0.7665	0.7664	0.7670	0.7661	0.7666	0.7665	0.7666	0.7659	0.7663	0.7667
Density, g/ml	0.7657	0.7656	0.7663	0.7653	0.7658	0.7657	0.7658	0.7652	0.7655	0.7659
API Gravity @ 60 F	53.1	53.1	53.0	53.2	53.1	53.1	53.1	53.2	53.2	53.1
Ethanol, vol %	0.07	0.07	0.36	0.02	0.53	0.07	0.21	0.04	0.11	0.65
MTBE, vol%	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

APPENDIX F

DATA SUMMARY

Table F-1
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F		TWD	Ln TWD
					Soak	Run		
4	Base	A	2/5/03	6:41	30	36	128.5	4.856
4	Base	A	2/11/03	7:13	28	34	219.5	5.391
4	E1	A	2/7/03	8:10	24	30	219.0	5.389
4	E1	A	2/20/03	6:41	34	41	69.5	4.241
4	E2	A	1/29/03	8:10	33	37	105.5	4.659
4	E2	A	2/18/03	6:06	35	34	122.0	4.804
4	E3	A	2/6/03	6:45	26	32	115.0	4.745
4	E3	A	2/19/03	6:18	34	37	63.0	4.143
4	E4	A	1/27/03	7:46	36	40	215.5	5.373
4	E4	A	2/14/03	5:45	35	38	144.0	4.970
4	E5	A	2/4/03	6:52	33	35	137.0	4.920
4	E5	A	2/8/03	8:32	24	32	185.0	5.220
4	E6	A	1/28/03	8:24	36	36	182.5	5.207
4	E6	A	2/10/03	7:22	22	30	174.5	5.162
4	H1	A	2/3/03	7:15	32	33	55.0	4.007
4	H1	A	2/23/03	6:20	36	35	71.0	4.263
4	H2	A	2/1/03	8:03	35	37	67.0	4.205
4	H2	A	2/17/03	6:44	37	35	94.5	4.549
4	H3	A	2/2/03	7:50	32	33	59.0	4.078
4	H3	A	2/22/03	6:02	36	36	49.0	3.892
18	Base	B	2/2/03	7:37	32	32	91.5	4.516
18	Base	B	2/22/03	6:10	36	36	46.0	3.829
18	E1	B	1/27/03	8:24	36	39	22.5	3.114
18	E1	B	2/11/03	7:04	28	33	48.5	3.882
18	E2	B	2/5/03	6:59	30	36	82.5	4.413
18	E2	B	2/25/03	9:35	22	33	114.5	4.741
18	E3	B	2/1/03	7:40	35	35	105.5	4.659
18	E3	B	2/10/03	7:05	22	30	44.5	3.795
18	E4	B	2/7/03	7:07	24	30	104.0	4.644
18	E4	B	2/23/03	5:20	36	37	88.5	4.483
18	E5	B	2/6/03	6:57	26	30	94.5	4.549
18	E5	B	2/24/03	8:40	15	30	106.5	4.668
18	E6	B	2/4/03	8:25	33	38	43.5	3.773
18	E6	B	2/27/03	8:25	24	38	105.0	4.654
18	H1	B	1/29/03	7:28	33	38	13.0	2.565
18	H1	B	2/28/03	8:15	32	36	39.5	3.676
18	H2	B	2/3/03	8:27	32	38	45.0	3.807
18	H2	B	2/26/03	9:15	24	36	45.5	3.818
18	H3	B	1/28/03	8:24	36	36	12.0	2.485
18	H3	B	2/8/03	8:09	24	30	45.5	3.818

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD	Ln TWD
21	Base	A	2/5/03	7:54	30	36	90.0	4.500
21	Base	A	2/11/03	7:57	28	35	24.5	3.199
21	E1	A	2/7/03	9:05	24	35	34.5	3.541
21	E1	A	2/20/03	5:22	34	37	11.5	2.442
21	E2	A	1/29/03	7:59	33	37	35.5	3.570
21	E2	A	2/18/03	5:52	35	34	30.0	3.401
21	E3	A	2/19/03	5:22	34	35	26.0	3.258
21	E3	A	2/24/03	8:42	15	30	89.0	4.489
21	E4	A	1/27/03	8:21	36	39	52.5	3.961
21	E4	A	2/14/03	6:31	35	38	257.0	5.549
21	E5	A	2/4/03	7:40	33	36	17.0	2.833
21	E5	A	2/8/03	8:55	24	35	91.5	4.516
21	E6	A	1/28/03	8:35	36	36	92.5	4.527
21	E6	A	2/10/03	8:10	22	34	167.5	5.121
21	H1	A	2/3/03	8:15	32	37	37.0	3.611
21	H1	A	2/23/03	5:25	36	37	27.5	3.314
21	H2	A	2/1/03	8:24	35	37	31.5	3.450
21	H2	A	2/17/03	6:19	37	36	95.5	4.559
21	H3	A	2/2/03	8:11	32	32	40.0	3.689
21	H3	A	2/22/03	5:17	36	35	13.0	2.565
23	Base	B	2/2/03	8:00	32	32	92.0	4.522
23	Base	B	2/18/03	5:28	35	34	101.0	4.615
23	E1	B	1/27/03	7:47	36	40	75.5	4.324
23	E1	B	2/11/03	6:53	28	32	77.0	4.344
23	E2	B	2/5/03	6:50	30	36	53.0	3.970
23	E2	B	2/20/03	5:34	34	39	94.0	4.543
23	E3	B	2/1/03	8:38	35	38	87.5	4.472
23	E3	B	2/10/03	6:54	22	31	90.5	4.505
23	E4	B	2/7/03	7:41	24	30	120.0	4.787
23	E4	B	2/23/03	5:53	36	36	141.0	4.949
23	E5	B	2/6/03	6:46	26	32	128.5	4.856
23	E5	B	2/22/03	5:35	36	36	122.0	4.804
23	E6	B	2/4/03	7:00	33	35	139.5	4.938
23	E6	B	2/17/03	5:21	37	36	163.5	5.097
23	H1	B	1/29/03	8:37	33	37	58.5	4.069
23	H1	B	2/14/03	5:24	35	38	53.0	3.970
23	H2	B	2/3/03	7:00	32	33	61.5	4.119
23	H2	B	2/19/03	5:12	34	36	46.5	3.839
23	H3	B	1/28/03	8:16	36	36	45.0	3.807
23	H3	B	2/8/03	7:59	24	30	75.0	4.317

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD	Ln TWD
24	Base	C	2/6/03	7:45	26	32	17.5	2.862
24	Base	C	2/23/03	5:17	36	37	40.5	3.701
24	E1	C	2/1/03	8:28	35	37	16.0	2.773
24	E1	C	2/17/03	5:07	37	38	13.5	2.603
24	E2	C	2/2/03	8:36	32	36	26.0	3.258
24	E2	C	2/8/03	8:11	24	30	17.0	2.833
24	E3	C	1/28/03	8:38	36	36	10.0	2.303
24	E3	C	2/14/03	5:37	35	38	12.0	2.485
24	E4	C	2/3/03	8:08	32	36	29.0	3.367
24	E4	C	2/22/03	4:58	36	37	15.0	2.708
24	E5	C	1/29/03	8:39	33	37	29.0	3.367
24	E5	C	2/20/03	5:09	34	37	31.5	3.450
24	E6	C	2/5/03	8:08	30	37	29.5	3.384
24	E6	C	2/11/03	7:17	28	34	39.5	3.676
24	H1	C	1/27/03	8:38	36	39	20.0	2.996
24	H1	C	2/19/03	5:10	34	36	23.5	3.157
24	H2	C	2/7/03	8:21	24	31	8.0	2.079
24	H2	C	2/18/03	5:15	35	34	27.0	3.296
24	H3	C	2/4/03	8:26	33	38	9.0	2.197
24	H3	C	2/10/03	7:28	22	30	13.0	2.565
26	Base	A	2/5/03	8:05	30	37	111.0	4.710
26	Base	A	2/11/03	6:51	28	32	139.5	4.938
26	E1	A	2/7/03	8:20	24	31	90.5	4.505
26	E1	A	2/20/03	6:06	34	39	103.0	4.635
26	E2	A	1/29/03	7:47	33	37	122.0	4.804
26	E2	A	2/18/03	5:15	35	34	125.0	4.828
26	E3	A	2/6/03	7:45	26	32	127.0	4.844
26	E3	A	2/19/03	5:56	34	36	131.0	4.875
26	E4	A	1/27/03	7:58	36	41	111.0	4.710
26	E4	A	2/14/03	5:00	35	37	144.5	4.973
26	E5	A	2/8/03	7:45	24	30	166.5	5.115
26	E5	A	2/24/03	8:51	15	30	216.0	5.375
26	E6	A	1/28/03	7:36	36	36	155.0	5.043
26	E6	A	2/10/03	6:40	22	30	216.0	5.375
26	H1	A	2/3/03	8:05	32	36	69.5	4.241
26	H1	A	2/23/03	5:15	36	37	58.0	4.060
26	H2	A	2/1/03	7:24	35	35	53.0	3.970
26	H2	A	2/17/03	5:20	37	36	53.0	3.970
26	H3	A	2/2/03	8:33	32	36	54.5	3.998
26	H3	A	2/22/03	6:26	36	36	40.5	3.701

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F		TWD	Ln TWD
					Soak	Run		
27	Base	A	2/5/03	7:45	30	36	47.0	3.850
27	Base	A	2/11/03	7:01	28	33	72.0	4.277
27	E1	A	2/7/03	7:10	24	30	49.0	3.892
27	E1	A	2/20/03	5:00	34	36	37.5	3.624
27	E2	A	1/29/03	6:48	33	37	27.5	3.314
27	E2	A	2/18/03	5:27	35	34	49.5	3.902
27	E3	A	2/6/03	7:30	26	31	62.5	4.135
27	E3	A	2/19/03	5:11	34	36	48.0	3.871
27	E4	A	1/27/03	7:11	36	38	87.5	4.472
27	E4	A	2/14/03	5:34	35	38	19.0	2.944
27	E5	A	2/4/03	8:14	33	37	71.0	4.263
27	E5	A	2/8/03	8:00	24	30	63.5	4.151
27	E6	A	1/28/03	7:01	36	37	94.5	4.549
27	E6	A	2/10/03	6:51	22	31	122.0	4.804
27	H1	A	2/3/03	8:25	32	38	45.0	3.807
27	H1	A	2/23/03	5:00	36	37	40.5	3.701
27	H2	A	2/1/03	7:13	35	35	29.0	3.367
27	H2	A	2/17/03	5:31	37	37	35.5	3.570
27	H3	A	2/2/03	7:23	32	32	56.0	4.025
27	H3	A	2/22/03	5:09	36	36	31.5	3.450
28	Base	C	2/6/03	8:07	26	33	18.0	2.890
28	Base	C	2/23/03	5:38	36	36	77.0	4.344
28	E1	C	2/1/03	8:16	35	37	28.5	3.350
28	E1	C	2/17/03	6:05	37	37	56.0	4.025
28	E2	C	2/2/03	8:03	32	33	20.0	2.996
28	E2	C	2/8/03	8:58	24	35	18.5	2.918
28	E3	C	1/28/03	8:10	36	36	34.5	3.541
28	E3	C	2/14/03	6:01	35	38	40.0	3.689
28	E4	C	2/3/03	8:18	32	37	61.5	4.119
28	E4	C	2/22/03	5:54	36	35	116.0	4.754
28	E5	C	1/29/03	8:13	33	37	28.5	3.350
28	E5	C	2/20/03	5:43	34	39	82.5	4.413
28	E6	C	2/5/03	7:35	30	36	59.5	4.086
28	E6	C	2/11/03	7:51	28	35	72.5	4.284
28	H1	C	1/27/03	7:48	36	40	19.0	2.944
28	H1	C	2/19/03	5:55	34	36	36.5	3.597
28	H2	C	2/7/03	8:55	24	34	22.5	3.114
28	H2	C	2/18/03	5:39	35	33	47.0	3.850
28	H3	C	2/4/03	8:05	33	37	12.5	2.526
28	H3	C	2/10/03	8:14	22	34	19.5	2.970

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD	Ln TWD
29	Base	C	2/6/03	7:48	26	32	83.0	4.419
29	Base	C	2/23/03	5:49	36	36	78.0	4.357
29	E1	C	2/1/03	7:42	35	35	43.5	3.773
29	E1	C	2/17/03	6:43	37	35	39.0	3.664
29	E2	C	2/2/03	7:50	32	32	38.5	3.651
29	E2	C	2/8/03	8:46	24	34	47.0	3.850
29	E3	C	1/28/03	8:02	36	35	32.0	3.466
29	E3	C	2/14/03	6:24	35	38	39.0	3.664
29	E4	C	2/3/03	7:25	32	32	62.0	4.127
29	E4	C	2/22/03	6:20	36	37	55.5	4.016
29	E5	C	1/29/03	8:02	33	37	109.0	4.691
29	E5	C	2/20/03	6:29	34	41	69.0	4.234
29	E6	C	2/5/03	6:39	30	36	57.5	4.052
29	E6	C	2/11/03	8:13	28	36	75.0	4.317
29	H1	C	1/27/03	8:01	36	41	32.0	3.466
29	H1	C	2/19/03	6:30	34	36	45.5	3.818
29	H2	C	2/7/03	8:10	24	30	46.0	3.829
29	H2	C	2/18/03	6:41	35	34	38.0	3.638
29	H3	C	2/4/03	6:58	33	35	27.5	3.314
29	H3	C	2/10/03	8:03	22	32	29.5	3.384
37	Base	C	2/6/03	7:22	26	30	115.0	4.745
37	Base	C	2/23/03	6:11	36	35	105.0	4.654
37	E1	C	2/1/03	7:04	35	35	69.5	4.241
37	E1	C	2/17/03	6:30	37	35	89.5	4.494
37	E2	C	2/2/03	7:03	32	32	58.5	4.069
37	E2	C	2/8/03	8:22	24	30	104.0	4.644
37	E3	C	1/28/03	7:02	36	37	42.5	3.750
37	E3	C	2/14/03	6:37	35	38	57.5	4.052
37	E4	C	2/3/03	7:14	32	33	112.5	4.723
37	E4	C	2/22/03	6:04	36	36	294.0	5.684
37	E5	C	1/29/03	7:16	33	37	101.0	4.615
37	E5	C	2/20/03	6:40	34	41	120.0	4.787
37	E6	C	2/5/03	7:12	30	36	183.0	5.209
37	E6	C	2/11/03	7:40	28	35	149.5	5.007
37	H1	C	1/27/03	6:57	36	39	21.5	3.068
37	H1	C	2/19/03	6:17	34	37	58.5	4.069
37	H2	C	2/7/03	8:01	24	33	60.0	4.094
37	H2	C	2/18/03	6:29	35	33	54.5	3.998
37	H3	C	2/4/03	7:33	33	36	42.5	3.750
37	H3	C	2/10/03	7:39	22	30	65.0	4.174

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD	Ln TWD
39	Base	A	2/5/03	7:00	30	36	30.5	3.418
39	Base	A	2/11/03	7:47	28	35	14.0	2.639
39	E1	A	2/7/03	8:30	24	33	13.0	2.565
39	E1	A	2/20/03	5:33	34	39	16.0	2.773
39	E2	A	1/29/03	7:01	33	37	28.0	3.332
39	E2	A	2/18/03	6:30	35	33	6.0	1.792
39	E3	A	2/6/03	7:08	26	31	29.0	3.367
39	E3	A	2/19/03	5:34	34	37	8.0	2.079
39	E4	A	1/27/03	6:55	36	39	18.5	2.918
39	E4	A	2/14/03	5:21	35	38	15.0	2.708
39	E5	A	2/4/03	7:00	33	35	34.5	3.541
39	E5	A	2/8/03	8:45	24	34	22.0	3.091
39	E6	A	1/28/03	7:11	36	36	30.5	3.418
39	E6	A	2/10/03	7:59	22	32	33.5	3.512
39	H1	A	2/3/03	7:35	32	32	22.0	3.091
39	H1	A	2/23/03	5:55	36	36	19.0	2.944
39	H2	A	2/1/03	7:51	35	36	26.0	3.258
39	H2	A	2/17/03	5:39	37	36	13.0	2.565
39	H3	A	2/2/03	7:01	32	32	21.0	3.045
39	H3	A	2/22/03	5:50	36	35	14.0	2.639
41	Base	A	2/5/03	7:10	30	36	44.0	3.784
41	Base	A	2/11/03	8:09	28	36	78.5	4.363
41	E1	A	2/7/03	8:40	24	34	81.0	4.394
41	E1	A	2/20/03	5:45	34	39	36.0	3.584
41	E2	A	1/29/03	8:22	33	37	79.0	4.369
41	E2	A	2/18/03	6:42	35	34	79.5	4.376
41	E3	A	2/6/03	7:20	26	30	46.5	3.839
41	E3	A	2/19/03	5:45	34	36	37.5	3.624
41	E4	A	1/27/03	7:34	36	39	89.0	4.489
41	E4	A	2/14/03	6:09	35	38	45.0	3.807
41	E5	A	2/4/03	7:50	33	37	96.0	4.564
41	E5	A	2/8/03	9:05	24	36	53.5	3.980
41	E6	A	1/28/03	8:12	36	36	78.0	4.357
41	E6	A	2/10/03	8:21	22	35	99.5	4.600
41	H1	A	2/3/03	7:25	32	32	29.0	3.367
41	H1	A	2/23/03	5:35	36	36	51.5	3.942
41	H2	A	2/1/03	7:02	35	35	14.0	2.639
41	H2	A	2/17/03	6:06	37	37	29.5	3.384
41	H3	A	2/2/03	7:36	32	32	20.0	2.996
41	H3	A	2/22/03	5:28	36	36	28.0	3.332

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F		TWD	Ln TWD
					Soak	Run		
44	Base	B	2/2/03	8:23	32	34	107.5	4.677
44	Base	B	2/18/03	6:19	35	34	85.5	4.449
44	E1	B	1/27/03	7:40	36	39	41.5	3.726
44	E1	B	2/11/03	7:50	28	35	66.5	4.197
44	E2	B	2/5/03	7:55	30	37	51.0	3.932
44	E2	B	2/20/03	6:31	34	41	40.5	3.701
44	E3	B	2/1/03	8:16	35	37	16.5	2.803
44	E3	B	2/10/03	8:00	22	32	43.5	3.773
44	E4	B	2/7/03	8:53	24	34	117.0	4.762
44	E4	B	2/23/03	6:05	36	36	60.0	4.094
44	E5	B	2/6/03	8:04	26	33	110.0	4.700
44	E5	B	2/22/03	6:20	36	37	82.0	4.407
44	E6	B	2/4/03	7:53	33	37	134.0	4.898
44	E6	B	2/17/03	6:20	37	36	166.0	5.112
44	H1	B	1/29/03	8:27	33	37	25.0	3.219
44	H1	B	2/14/03	6:00	35	38	32.0	3.466
44	H2	B	2/3/03	7:55	32	35	54.5	3.998
44	H2	B	2/19/03	6:08	34	37	37.5	3.624
44	H3	B	1/28/03	8:38	36	36	36.5	3.597
44	H3	B	2/8/03	8:55	24	35	10.5	2.351
45	Base	C	2/6/03	7:00	26	30	79.0	4.369
45	Base	C	2/23/03	4:54	36	37	76.5	4.337
45	E1	C	2/1/03	7:29	35	35	39.5	3.676
45	E1	C	2/17/03	5:31	37	37	61.5	4.119
45	E2	C	2/2/03	7:16	32	32	44.0	3.784
45	E2	C	2/8/03	7:59	24	30	42.5	3.750
45	E3	C	1/28/03	7:38	36	36	32.0	3.466
45	E3	C	2/14/03	5:14	35	37	27.5	3.314
45	E4	C	2/3/03	7:03	32	33	85.0	4.443
45	E4	C	2/22/03	5:20	36	35	122.0	4.804
45	E5	C	1/29/03	7:40	33	37	57.5	4.052
45	E5	C	2/20/03	4:59	34	36	103.0	4.635
45	E6	C	2/5/03	7:01	30	36	101.0	4.615
45	E6	C	2/11/03	6:55	28	32	125.0	4.828
45	H1	C	1/27/03	7:37	36	39	14.0	2.639
45	H1	C	2/19/03	5:22	34	35	18.0	2.890
45	H2	C	2/7/03	7:58	24	30	10.0	2.303
45	H2	C	2/18/03	5:02	35	36	19.5	2.970
45	H3	C	2/4/03	7:22	33	36	17.5	2.862
45	H3	C	2/10/03	6:44	22	30	15.5	2.741

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F		TWD	Ln TWD
					Soak	Run		
47	Base	C	2/6/03	7:32	26	31	86.0	4.454
47	Base	C	2/23/03	6:01	36	36	95.0	4.554
47	E1	C	2/1/03	7:17	35	35	48.0	3.871
47	E1	C	2/17/05	6:18	37	36	74.5	4.311
47	E2	C	2/2/03	7:32	32	32	32.5	3.481
47	E2	C	2/8/03	9:08	24	36	86.0	4.454
47	E3	C	1/28/03	7:15	36	36	66.0	4.190
47	E3	C	2/14/03	6:13	35	38	107.5	4.677
47	E4	C	2/3/03	7:46	32	33	48.0	3.871
47	E4	C	2/22/03	5:42	36	36	158.0	5.063
47	E5	C	1/29/03	7:02	33	37	80.0	4.382
47	E5	C	2/20/03	5:55	34	39	118.0	4.771
47	E6	C	2/5/03	7:24	30	36	86.0	4.454
47	E6	C	2/11/03	8:02	28	35	211.0	5.352
47	H1	C	1/27/03	7:13	36	38	54.5	3.998
47	H1	C	2/19/03	6:07	34	37	87.5	4.472
47	H2	C	2/7/03	9:05	24	35	95.5	4.559
47	H2	C	2/18/03	6:17	35	34	94.5	4.549
47	H3	C	2/4/03	7:54	33	37	29.0	3.367
47	H3	C	2/10/03	8:26	22	35	32.5	3.481
48	Base	B	2/2/03	8:12	32	32	75.0	4.317
48	Base	B	2/18/03	5:52	35	34	106.0	4.663
48	E1	B	1/27/03	8:35	36	39	91.5	4.516
48	E1	B	2/11/03	7:36	28	35	79.5	4.376
48	E2	B	2/5/03	7:33	30	36	73.0	4.290
48	E2	B	2/20/03	5:45	34	39	90.0	4.500
48	E3	B	2/1/03	8:24	35	37	34.0	3.526
48	E3	B	2/10/03	8:23	22	35	72.0	4.277
48	E4	B	2/7/03	9:03	24	35	216.5	5.378
48	E4	B	2/23/03	6:15	36	35	82.0	4.407
48	E5	B	2/6/03	7:52	26	33	151.0	5.017
48	E5	B	2/22/03	5:58	36	35	144.5	4.973
48	E6	B	2/4/03	7:32	33	36	106.5	4.668
48	E6	B	2/17/03	5:44	37	36	172.0	5.147
48	H1	B	1/29/03	8:11	33	37	42.0	3.738
48	H1	B	2/14/03	6:24	35	38	56.5	4.034
48	H2	B	2/3/03	7:24	32	32	29.0	3.367
48	H2	B	2/19/03	5:45	34	36	55.0	4.007
48	H3	B	1/28/03	7:47	36	35	19.0	2.944
48	H3	B	2/8/03	9:07	24	36	56.5	4.034

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F		TWD	Ln TWD
					Soak	Run		
49	Base	A	2/5/03	7:35	30	36	109.5	4.696
49	Base	A	2/11/03	7:24	28	34	66.0	4.190
49	E1	A	2/7/03	6:55	24	30	97.5	4.580
49	E1	A	2/20/03	5:55	34	39	35.0	3.555
49	E2	A	1/29/03	7:25	33	38	69.0	4.234
49	E2	A	2/18/03	6:40	35	33	39.0	3.664
49	E3	A	2/6/03	6:58	26	30	123.0	4.812
49	E3	A	2/19/03	6:07	34	37	29.5	3.384
49	E4	A	1/27/03	7:23	36	38	135.5	4.909
49	E4	A	2/14/03	6:19	35	38	102.0	4.625
49	E5	A	2/4/03	7:31	33	36	96.0	4.564
49	E5	A	2/8/03	8:10	24	30	86.5	4.460
49	E6	A	1/28/03	7:48	36	35	139.0	4.934
49	E6	A	2/10/03	7:46	22	31	140.0	4.942
49	H1	A	2/3/03	7:55	32	35	107.0	4.673
49	H1	A	2/23/03	5:45	36	36	55.0	4.007
49	H2	A	2/1/03	7:39	35	35	54.0	3.989
49	H2	A	2/17/03	5:55	37	37	41.0	3.714
49	H3	A	2/2/03	7:47	32	32	89.0	4.489
49	H3	A	2/22/03	6:14	36	37	33.0	3.497
51	Base	C	2/6/03	6:35	26	33	35.0	3.555
51	Base	C	2/23/03	6:22	36	35	45.0	3.807
51	E1	C	2/1/03	8:06	35	37	30.0	3.401
51	E1	C	2/17/03	5:19	37	36	30.5	3.418
51	E2	C	2/2/03	8:15	32	32	28.0	3.332
51	E2	C	2/8/03	7:38	24	30	25.5	3.239
51	E3	C	1/28/03	7:26	36	36	24.0	3.178
51	E3	C	2/14/03	5:04	35	37	25.0	3.219
51	E4	C	2/3/03	8:24	32	38	38.0	3.638
51	E4	C	2/22/03	6:29	36	36	62.0	4.127
51	E5	C	1/29/03	7:50	33	37	26.5	3.277
51	E5	C	2/20/03	6:06	34	39	64.5	4.167
51	E6	C	2/5/03	7:46	30	36	51.5	3.942
51	E6	C	2/11/03	6:43	28	33	105.5	4.659
51	H1	C	1/27/03	7:25	36	38	9.5	2.251
51	H1	C	2/19/03	5:44	34	36	29.0	3.367
51	H2	C	2/7/03	7:08	24	30	29.5	3.384
51	H2	C	2/18/03	5:26	35	34	21.5	3.068
51	H3	C	2/4/03	8:15	33	37	12.5	2.526
51	H3	C	2/10/03	6:56	22	31	20.5	3.020

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD	Ln TWD
59	Base	B	2/2/03	7:11	32	32	84.5	4.437
59	Base	B	2/18/03	5:16	35	34	62.0	4.127
59	E1	B	1/27/03	8:05	36	41	69.5	4.241
59	E1	B	2/11/03	7:14	28	34	86.5	4.460
59	E2	B	2/5/03	8:06	30	37	82.0	4.407
59	E2	B	2/20/03	5:23	34	37	84.5	4.437
59	E3	B	2/1/03	7:17	35	35	49.5	3.902
59	E3	B	2/10/03	7:24	22	30	105.5	4.659
59	E4	B	2/7/03	8:30	24	33	176.0	5.170
59	E4	B	2/23/03	5:30	36	37	151.5	5.021
59	E5	B	2/6/03	7:42	26	32	167.5	5.121
59	E5	B	2/22/03	5:25	36	35	96.5	4.570
59	E6	B	2/4/03	8:03	33	37	161.0	5.081
59	E6	B	2/17/03	5:33	37	37	129.5	4.864
59	H1	B	1/29/03	7:09	33	37	30.5	3.418
59	H1	B	2/14/03	5:36	35	38	25.0	3.219
59	H2	B	2/3/03	8:06	32	36	105.5	4.659
59	H2	B	2/19/03	5:24	34	35	73.5	4.297
59	H3	B	1/28/03	7:05	36	37	37.5	3.624
59	H3	B	2/8/03	7:48	24	30	83.5	4.425
61	Base	B	2/2/03	7:01	32	32	106.0	4.663
61	Base	B	2/18/03	6:31	35	33	59.5	4.086
61	E1	B	1/27/03	8:13	36	40	65.5	4.182
61	E1	B	2/11/03	8:11	28	36	105.0	4.654
61	E2	B	2/5/03	7:44	30	36	113.5	4.732
61	E2	B	2/20/03	6:07	34	39	55.0	4.007
61	E3	B	2/1/03	7:04	35	35	113.0	4.727
61	E3	B	2/10/03	8:12	22	34	84.0	4.431
61	E4	B	2/7/03	8:11	24	31	134.0	4.898
61	E4	B	2/23/03	5:40	36	36	129.0	4.860
61	E5	B	2/6/03	7:20	26	30	115.0	4.745
61	E5	B	2/22/03	5:45	36	36	100.5	4.610
61	E6	B	2/4/03	7:43	33	36	129.5	4.864
61	E6	B	2/17/03	6:45	37	35	143.0	4.963
61	H1	B	1/29/03	7:17	33	37	31.0	3.434
61	H1	B	2/14/03	6:38	35	38	85.5	4.449
61	H2	B	2/3/03	7:44	32	33	90.0	4.500
61	H2	B	2/19/03	6:19	34	37	56.0	4.025
61	H3	B	1/28/03	7:28	36	36	47.5	3.861
61	H3	B	2/8/03	8:44	24	34	92.0	4.522

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD	Ln TWD
64	Base	B	2/2/03	7:23	32	32	69.5	4.241
64	Base	B	2/18/03	5:05	35	36	70.5	4.256
64	E1	B	1/27/03	7:00	36	39	71.0	4.263
64	E1	B	2/11/03	6:41	28	33	57.0	4.043
64	E2	B	2/5/03	8:35	30	36	40.5	3.701
64	E2	B	2/20/03	5:01	34	36	39.5	3.676
64	E3	B	2/1/03	7:30	35	35	63.5	4.151
64	E3	B	2/10/03	6:41	22	30	35.0	3.555
64	E4	B	2/7/03	6:56	24	30	84.0	4.431
64	E4	B	2/23/03	5:10	36	37	127.0	4.844
64	E5	B	2/6/03	6:35	26	33	79.5	4.376
64	E5	B	2/22/03	5:00	36	37	122.0	4.804
64	E6	B	2/4/03	7:22	33	36	122.5	4.808
64	E6	B	2/17/03	5:09	37	38	109.5	4.696
64	H1	B	1/29/03	7:50	33	37	34.5	3.541
64	H1	B	2/14/03	5:02	35	37	39.5	3.676
64	H2	B	2/3/03	7:12	32	33	57.5	4.052
64	H2	B	2/19/03	5:01	34	36	47.5	3.861
64	H3	B	1/28/03	7:15	36	36	40.0	3.689
64	H3	B	2/8/03	7:36	24	30	53.5	3.980
65	Base	C	2/6/03	7:55	26	33	138.5	4.931
65	Base	C	2/23/03	5:06	36	37	52.0	3.951
65	E1	C	2/1/03	8:38	35	38	46.0	3.829
65	E1	C	2/17/03	5:54	37	37	38.0	3.638
65	E2	C	2/2/03	8:26	32	34	46.5	3.839
65	E2	C	2/8/03	8:34	24	32	42.0	3.738
65	E3	C	1/28/03	8:26	36	36	20.5	3.020
65	E3	C	2/14/03	5:50	35	38	58.0	4.060
65	E4	C	2/3/03	7:58	32	35	61.5	4.119
65	E4	C	2/22/03	5:31	36	36	74.0	4.304
65	E5	C	1/29/03	8:25	33	37	65.0	4.174
65	E5	C	2/20/03	5:33	34	39	57.5	4.052
65	E6	C	2/5/03	7:58	30	37	106.0	4.663
65	E6	C	2/11/03	7:29	28	34	101.0	4.615
65	H1	C	1/27/03	8:25	36	39	35.0	3.555
65	H1	C	2/19/03	5:33	34	37	23.0	3.135
65	H2	C	2/7/03	8:44	24	34	84.5	4.437
65	H2	C	2/18/03	5:51	35	34	19.0	2.944
65	H3	C	2/4/03	7:00	33	36	12.5	2.526
65	H3	C	2/10/03	7:51	22	31	30.0	3.401

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F		TWD	Ln TWD
					Soak	Run		
70	Base	A	2/5/03	6:50	30	36	41.5	3.726
70	Base	A	2/11/03	6:39	28	33	84.5	4.437
70	E1	A	2/7/03	7:15	24	30	66.0	4.190
70	E1	A	2/20/03	5:10	34	37	11.5	2.442
70	E2	A	1/29/03	7:13	33	37	19.5	2.970
70	E2	A	2/18/03	5:06	35	36	14.0	2.639
70	E3	A	2/6/03	6:35	26	33	21.0	3.045
70	E3	A	2/19/03	5:01	34	36	13.5	2.603
70	E4	A	1/27/03	8:34	36	39	13.5	2.603
70	E4	A	2/14/03	5:11	35	37	22.5	3.114
70	E5	A	2/4/03	7:08	33	34	48.0	3.871
70	E5	A	2/8/03	7:40	24	30	29.5	3.384
70	E6	A	1/28/03	7:24	36	36	38.5	3.651
70	E6	A	2/10/03	7:03	22	30	53.0	3.970
70	H1	A	2/3/03	7:45	32	33	17.5	2.862
70	H1	A	2/23/03	4:50	36	37	13.0	2.565
70	H2	A	2/1/03	8:14	35	37	16.0	2.773
70	H2	A	2/17/03	5:10	37	38	20.5	3.020
70	H3	A	2/2/03	8:22	32	34	16.0	2.773
70	H3	A	2/22/03	5:01	36	37	11.0	2.398
74	Base	A	2/5/03	7:20	30	36	82.5	4.413
74	Base	A	2/11/03	7:36	28	35	80.0	4.382
74	E1	A	2/7/03	8:50	24	34	78.0	4.357
74	E1	A	2/20/03	6:30	34	41	37.0	3.611
74	E2	A	1/29/03	7:37	33	37	43.0	3.761
74	E2	A	2/18/03	6:18	35	34	16.0	2.773
74	E3	A	2/6/03	7:55	26	33	73.0	4.290
74	E3	A	2/19/03	6:30	34	36	19.0	2.944
74	E4	A	1/27/03	8:09	36	40	81.0	4.394
74	E4	A	2/14/03	5:56	35	38	76.5	4.337
74	E5	A	2/4/03	7:20	33	36	89.0	4.489
74	E5	A	2/8/03	8:20	24	30	136.0	4.913
74	E6	A	1/28/03	8:00	36	35	135.5	4.909
74	E6	A	2/10/03	7:36	22	30	111.5	4.714
74	H1	A	2/3/03	7:00	32	33	40.5	3.701
74	H1	A	2/23/03	6:10	36	35	8.5	2.140
74	H2	A	2/1/03	6:52	35	35	12.0	2.485
74	H2	A	2/17/03	6:32	37	35	15.5	2.741
74	H3	A	2/2/03	7:11	32	32	28.5	3.350
74	H3	A	2/22/03	5:39	36	36	12.0	2.485

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F Soak	Temperature, °F Run	TWD	Ln TWD
75	Base	C	2/6/03	7:10	26	31	67.5	4.212
75	Base	C	2/23/03	5:27	36	37	35.0	3.555
75	E1	C	2/1/03	7:54	35	36	66.5	4.197
75	E1	C	2/17/03	5:43	37	36	22.5	3.114
75	E2	C	2/2/03	7:40	32	32	8.0	2.079
75	E2	C	2/8/03	8:00	24	30	45.0	3.807
75	E3	C	1/28/03	7:51	36	35	65.5	4.182
75	E3	C	2/14/03	5:24	35	38	23.5	3.157
75	E4	C	2/3/03	7:35	32	32	126.5	4.840
75	E4	C	2/22/03	5:09	36	36	103.0	4.635
75	E5	C	1/29/03	7:28	33	38	65.0	4.174
75	E5	C	2/20/03	5:22	34	37	57.5	4.052
75	E6	C	2/5/03	7:51	30	36	117.0	4.762
75	E6	C	2/11/03	7:05	28	33	60.0	4.094
75	H1	C	1/27/03	8:14	36	40	64.0	4.159
75	H1	C	2/19/03	4:59	34	36	64.0	4.159
75	H2	C	2/7/03	7:43	24	30	40.0	3.689
75	H2	C	2/18/03	6:03	35	34	68.0	4.220
75	H3	C	2/4/03	7:12	33	34	33.0	3.497
75	H3	C	2/10/03	7:07	22	30	67.0	4.205
80	Base	B	2/2/03	8:33	32	36	104.5	4.649
80	Base	B	2/18/03	6:06	35	34	40.0	3.689
80	E1	B	1/27/03	7:12	36	38	34.0	3.526
80	E1	B	2/11/03	8:00	28	35	76.0	4.331
80	E2	B	2/5/03	7:20	30	36	45.5	3.818
80	E2	B	2/20/03	5:13	34	37	33.5	3.512
80	E3	B	2/1/03	7:54	35	36	106.5	4.668
80	E3	B	2/10/03	7:48	22	31	54.0	3.989
80	E4	B	2/7/03	8:41	24	34	183.0	5.209
80	E4	B	2/23/03	5:00	36	37	98.0	4.585
80	E5	B	2/6/03	7:30	26	31	83.0	4.419
80	E5	B	2/22/03	5:12	36	36	39.5	3.676
80	E6	B	2/4/03	8:14	33	37	62.0	4.127
80	E6	B	2/17/03	6:33	37	35	64.5	4.167
80	H1	B	1/29/03	7:39	33	37	23.0	3.135
80	H1	B	2/14/03	6:12	35	38	21.5	3.068
80	H2	B	2/3/03	8:17	32	37	60.5	4.103
80	H2	B	2/19/03	5:35	34	37	28.0	3.332
80	H3	B	1/28/03	9:52	36	36	23.0	3.135
80	H3	B	2/8/03	8:20	24	30	58.5	4.069

Table F-1 Cont'd.
CRC 2003 Volatility Program Test Data

Vehicle	Fuel	Rater	Date	Time	Temperature, °F		TWD	Ln TWD
					Soak	Run		
82	Base	B	2/2/03	7:47	32	36	78.5	4.363
82	Base	B	2/18/03	5:40	35	33	55.5	4.016
82	E1	B	1/27/03	7:24	36	38	40.5	3.701
82	E1	B	2/11/03	7:26	28	34	55.5	4.016
82	E2	B	2/5/03	7:09	30	36	60.0	4.094
82	E2	B	2/20/03	5:56	34	39	58.5	4.069
82	E3	B	2/1/03	8:04	35	37	39.5	3.676
82	E3	B	2/10/03	7:38	22	30	70.0	4.248
82	E4	B	2/7/03	8:08	24	30	79.5	4.376
82	E4	B	2/23/03	6:25	36	35	97.5	4.580
82	E5	B	2/6/03	6:56	26	31	82.5	4.413
82	E5	B	2/22/03	6:30	36	36	59.5	4.086
82	E6	B	2/4/03	7:11	33	34	141.0	4.949
82	E6	B	2/17/03	5:56	37	37	96.5	4.570
82	H1	B	1/29/03	8:01	33	37	21.5	3.068
82	H1	B	2/14/03	5:13	35	37	37.5	3.624
82	H2	B	2/3/03	7:34	32	32	45.0	3.807
82	H2	B	2/19/03	5:57	34	36	34.5	3.541
82	H3	B	1/28/03	8:03	36	35	29.5	3.384
82	H3	B	2/8/03	8:32	24	32	41.0	3.714

APPENDIX G

AVERAGE CORRECTED TOTAL WEIGHTED DEMERITS

Table G-1
Corrected Mean ln TWD

Vehicle/Fuel	Base	E1	E2	E3	E4	E5	E6	H1	H2	H3
4	5.03	4.73	4.81	4.39	5.29	4.95	5.07	4.23	4.52	4.07
18	4.19	3.57	4.39	4.21	4.45	4.32	4.06	3.07	3.67	3.19
21	3.64	2.75	3.67	3.23	5.07	3.44	4.65	3.61	4.34	3.29
23	4.58	4.37	4.23	4.50	4.81	4.79	5.03	4.05	3.98	4.10
24	3.28	2.54	3.21	2.27	2.94	3.34	3.63	2.97	2.75	2.55
26	4.78	4.51	4.86	4.82	4.92	5.01	5.18	4.18	4.05	3.88
27	4.03	3.78	3.62	4.02	3.70	4.14	4.58	3.82	3.50	3.79
28	3.43	3.60	3.23	3.62	4.25	3.82	4.29	3.24	3.43	2.96
29	4.37	3.80	3.69	3.64	4.11	4.49	4.14	3.70	3.69	3.28
37	4.53	4.53	4.35	4.11	5.20	4.76	5.03	3.72	3.89	3.88
39	2.99	2.79	2.54	2.81	2.72	3.21	3.27	3.15	2.91	2.93
41	4.05	3.94	4.40	3.70	4.20	4.26	4.48	3.66	3.05	3.17
44	4.60	3.93	3.85	3.20	4.44	4.58	5.07	3.36	3.84	2.90
45	4.29	3.83	3.89	3.37	4.54	4.31	4.78	2.73	2.64	2.91
47	4.30	4.24	4.00	4.65	4.43	4.62	4.84	4.39	4.39	3.38
48	4.57	4.55	4.34	3.83	4.70	4.87	5.04	4.04	3.72	3.52
49	4.31	4.11	4.00	4.13	4.79	4.28	4.63	4.56	4.00	4.17
51	3.50	3.56	3.30	3.40	3.86	3.77	4.24	2.96	3.07	2.71
59	4.36	4.37	4.43	4.13	5.01	4.81	5.12	3.43	4.54	3.95
61	4.41	4.43	4.37	4.52	4.84	4.66	4.98	3.99	4.29	4.17
64	4.21	4.15	3.68	3.93	4.67	4.60	4.68	3.56	3.93	3.87
65	4.39	4.07	3.48	3.83	4.40	4.25	4.42	3.60	3.52	2.62
70	3.94	3.21	2.91	2.76	3.02	3.45	3.63	2.85	3.10	2.72
74	4.25	4.01	3.33	3.65	4.40	4.45	4.49	3.16	2.78	3.10
75	3.90	3.85	2.72	3.82	4.88	4.20	4.29	4.30	3.88	3.63
80	4.24	3.86	3.72	4.14	4.92	4.09	4.29	3.15	3.79	3.44
82	4.24	3.89	4.07	3.90	4.40	4.20	4.84	3.42	3.70	3.54

Table G-2
Corrected Mean TWD

Vehicle/Fuel	Base	E1	E2	E3	E4	E5	E6	H1	H2	H3
4	152.3	113.8	122.3	80.9	198.3	140.8	159.1	68.5	92.1	58.7
18	66.0	35.4	80.6	67.6	85.8	75.1	58.2	21.6	39.3	24.4
21	38.1	15.6	39.3	25.4	159.9	31.2	104.4	37.1	77.0	26.8
23	97.4	79.2	69.0	89.9	123.3	120.5	153.0	57.6	53.3	60.0
24	26.6	12.6	24.7	9.7	18.9	28.3	37.9	19.4	15.7	12.8
26	118.8	90.5	129.1	123.7	137.3	149.6	177.9	65.2	57.3	48.5
27	56.1	43.8	37.3	55.7	40.6	62.8	97.8	45.7	33.2	44.2
28	30.9	36.5	25.4	37.4	70.3	45.8	72.9	25.6	30.9	19.3
29	79.0	44.5	39.9	37.9	60.9	89.5	62.5	40.5	40.0	26.4
37	92.9	93.1	77.2	60.9	180.9	116.4	153.4	41.4	49.0	48.4
39	19.9	16.3	12.7	16.6	15.1	24.7	26.3	23.4	18.4	18.7
41	57.5	51.6	81.4	40.5	66.7	70.6	88.3	38.7	21.2	23.9
44	99.0	50.8	46.8	24.5	84.9	97.1	159.3	28.9	46.7	18.1
45	73.2	46.3	49.0	28.9	93.9	74.5	118.9	15.3	13.9	18.3
47	74.1	69.7	54.6	104.1	84.2	101.9	126.9	80.5	80.6	29.2
48	96.7	94.9	77.0	45.9	109.9	130.8	154.8	56.9	41.3	33.8
49	74.4	60.7	54.6	62.4	120.3	72.4	102.8	95.9	54.4	64.5
51	33.2	35.2	27.1	29.9	47.6	43.4	69.2	19.2	21.6	15.1
59	78.6	78.7	84.1	62.2	150.1	122.5	168.2	30.7	93.4	51.7
61	82.2	83.9	79.1	92.0	126.1	105.3	144.8	54.0	72.6	64.4
64	67.4	63.4	39.7	50.7	106.9	99.8	107.8	35.2	50.8	48.2
65	81.0	58.4	32.6	46.1	81.2	70.3	83.2	36.6	33.8	13.8
70	51.4	24.8	18.3	15.8	20.4	31.4	37.8	17.4	22.2	15.1
74	70.1	55.3	27.9	38.4	81.7	85.8	88.9	23.5	16.1	22.3
75	49.6	47.0	15.2	45.5	131.2	66.6	73.1	73.4	48.4	37.5
80	69.4	47.7	41.5	62.7	136.3	59.5	73.1	23.4	44.2	31.3
82	69.1	49.1	58.6	49.3	81.4	67.0	126.5	30.6	40.4	34.3