CRC Report No. E-98/A-80

EXHAUST EMISSIONS OF AVERAGE FUEL COMPOSITION

June 2014

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

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CRC Project No. E-98/A-80

FINAL REPORT

SwRI® Project No. 03.17592

Prepared for:

Dr. Christopher J. Tennant
Coordinating Research Council
5755 North Point Parkway, Suite 265
Alpharetta, GA 30022
ctennant@crcao.org

Prepared by:

Eugene Jimenez, Research Engineer
Janet P. Buckingham, Staff Analyst
Southwest Research Institute®
6220 Culebra Road
San Antonio, TX 78238

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ctennant@crcao.org

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Prepared by:

Eugene Jimenez, Research Engineer
Light-Duty Vehicle Emissions
Department of Engine & Vehicle R&D

Reviewed by:

Kevin A. Whitney, Manager
Light-Duty Vehicle Emissions
Department of Engine & Vehicle R&D

Prepared by:

Janet P. Buckingham
Staff Analyst
Fuels & Lubricants Research Division

Approved by:

TA

Bruce B. Bykowski, Vice President
Engine, Emissions and Vehicle
Research Division

ENGINE, EMISSIONS AND VEHICLE RESEARCH DIVISION

FOREWORD

This report covers testing conducted by the Department of Engine and Vehicle R&D of Southwest Research Institute® (SwRI®) for the Coordinating Research Council (CRC). The test program authorized by CRC Contract No. E-98, began in April 2012, and concluded in November of 2013. Vehicle testing was conducted from January 14, 2013 to March 22, 2013. The project was based on SwRI Proposal 03-64833 to CRC. The overall program was identified within SwRI as Project 03.17592. The project was monitored by Dr. Christopher J. Tennant of CRC. The SwRI Project Manager was Mr. Kevin A. Whitney, and the project leader was Mr. Gene Jimenez. Ms. Janet P. Buckingham of SwRI conducted the statistical analyses for the emissions results. Mr. Robert Vara, Laboratory Supervisor, was responsible for the emissions testing.

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EXECUTIVE SUMMARY

This report documents a test program run at Southwest Research Institute (SwRI) for the Coordinating Research Council (CRC). The program objective was to generate data with the EPAct Fleet vehicles used in the EPAct/V2/E-89 program with three fuels over the LA-92 test cycle. One of the fuels was a re-blend of Fuel 13 used in the EPAct/V2/E-89 program and the other two fuels had properties that exist inside the “envelope” of the properties defined by the EPAct fuels.

The 15 vehicles used in the EPAct/V2/E-89 were provided by CRC for this program. Upon receipt of the vehicles, SwRI performed thorough inspections and made repairs on the vehicles which required attention. Following vehicle inspections and repairs, a single checkout test over the LA-92 test cycle was conducted on each vehicle to ensure its regulated emissions and particulate matter emissions were acceptable. The results of the check out tests showed that nine of the vehicles had emissions similar to those seen in the EPAct program. The vehicles which were approved for testing had an oil change and 2,000 miles of EPA Standard Road Cycle (SRC) using the SwRI mileage accumulation dynamometers (MADs). Six vehicles had higher emissions than expected including Vehicle #1, Vehicle #7, Vehicle #8, Vehicle #10, Vehicle #12 and Vehicle #13. A second check-out test was then conducted on these six vehicles. Emissions from the Vehicle #10 and Vehicle #12 decreased to within acceptable levels and were approved for an oil change and 2,000 miles of EPA Standard Road Cycle (SRC) using the SwRI mileage accumulation dynamometers (MADs). The remaining four vehicles went through additional conditioning with a fuel containing a Top Tier additive package and a bottle of fuel injector clean-up additive; then ran mileage accumulation sufficient to use up the tank of fuel. Once this was completed, each vehicle received an oil change with OEM oil and the 2,000 miles of EPA Standard Road Cycle (SRC) using fuel containing a Top Tier additive package. SwRI carried out the recommended procedure and then moved these vehicles into the main test program without any further testing.

CRC supplied the three fuels in unopened drums. These drums were kept in temperature-controlled facilities over the duration of the program. The three fuels had varying levels of ethanol content of E0, E10 and E15 and were designated Fuel 1, Fuel 2 and Fuel 3, respectively. The vehicle fuel change and conditioning procedure used for this program was adopted from the EPAct/V2/E-89 program. This program used the same vehicle chassis dynamometer settings as the EPAct/V2/E-89 program. The test matrix was designed to be randomized for each vehicle/fuel combination. Duplicate tests were conducted “back-to-back”, with the option for a third test based on repeatability criteria provided by CRC.

The emissions measured and reported were THC, NMHC (by FID), NMOG, NO_X, NO_2, CO, CO_2, PM, alcohols, carbonyl compounds, and speciated hydrocarbons. In addition to the dilute bagged exhaust samples, continuous raw exhaust mass emissions were measured on a second-by-second basis for THC, CH_4, CO, NO_X, CO_2 and O_2 at the tailpipe. Measured phase-level (bag-by-bag) speciated VOCs included C_1 - C_{12} hydrocarbons, light alcohols, aldehydes, and ketones. Specifically, carbonyls and C_2-C_{12} speciation were determined on the first test of all vehicles for all fuels, while benzene, 1,3-butadiene, formaldehyde, acetaldehyde and alcohols were determined for all tests. Carbonyls and C_2-C_{12} speciation were determined on the second test for all fuels, if the first test was void. Additional available vehicle data were acquired at 1 Hz from each vehicle's onboard diagnostic (OBD) system during all emissions tests.

Several comparisons were made from the test results generated. Fuel 1 tested in this program was a reformulation of Fuel 13 used in the EPAct program. Therefore, the test results from Fuel 1 were compared back to Fuel 13 results of the EPAct program. The test results show that in most cases THC, CO and NO_X emissions were higher for Fuel 1 compared to Fuel 13. Additionally, chemistry compounds which were measured in both programs were compared. These included formaldehyde, acetaldehyde, benzene, and 1,3-butadiene. In most cases the results of the four compounds repeated well between the two fuels.

A detailed statistical analysis of the test results for all 15 vehicles was performed that included an analysis of variance (ANOVA) used to examine the changes in the average log-transformed emissions from Fuel 1 to Fuel 2 and, secondly, from Fuel 1 to Fuel 3 for THC, CO, NO_X, and PM of the Composite, Phase 1, Phase 2 and Phase 3 test results. The ANOVA model examined the average LOG(emissions) across the fuels and vehicles. Dunnett's multiple-comparison techniques were used to compare the emissions least-squares means (LSMeans) between Fuel 1 and Fuel 2 and also between Fuel 1 and Fuel 3 in order to determine statistical significance.

A summary of the test results comparing Fuel 1 to Fuel 2 and Fuel 1 to Fuel 3 are given below.

- Most vehicles showed a decrease in THC when tested on Fuel 2 and Fuel 3 compared to Fuel 1. Note that statistically significant differences were observed in the average composite THC results when comparing Fuel 1 vs. Fuel 2 across the 15 vehicles.
- Most vehicles show a decrease in CO when tested on Fuel 2 and Fuel 3 compared to Fuel 1. Note that statistically significant differences were observed in the average composite CO results when comparing Fuel 1 vs. Fuel 2 and Fuel 1 vs. Fuel 3, across the 15 vehicles.
- Most vehicles show varying trends in NO_x when tested on Fuel 2 and Fuel 3 compared to Fuel 1. Note that no statistically significant differences were observed in the average composite NO_X results when comparing Fuel 1 vs. Fuel 2 and Fuel 1 vs. Fuel 3, across the 15 vehicles.
- Most vehicles show varying trends in PM when tested on Fuel 2 and Fuel 3 compared to Fuels 1. Note that statistically significant differences were observed in the average composite PM results when comparing Fuel 1 vs. Fuel 2; however, no statistically significant differences were observed for Fuel 1 vs. Fuel 3, across the 15 vehicles.

The results of acetaldehyde show an increasing trend with increased ethanol concentrations on all vehicles. The results of formaldehyde are typically lower for Fuel 2 compared to Fuel 1 and Fuel 3 for the majority of the vehicles. The results of benzene and 1,3-butadiene are higher in most cases for Fuel 1 when compared to Fuel 2 and Fuel 3. This is expected due to the higher overall aromatic content of Fuel 1.

Several emissions predictive models have been developed in order to assess the fuel effects on exhaust emissions from light-duty vehicles certified to Tier-2 standards. These models were based on the emissions tests from the EPAct/V2/E-89 fleet of 15 model year 2008 vehicles using 27 fuels with varying levels of five fuel properties: ethanol, T_{50}, T_{90}, RVP and aromatics. Emissions model predictions compared in this study include THC, NMHC, CH_4, CO, NO_X and PM for the Composite, Phase 1, Phase 2 and Phase 3 tests. The five models used in comparing the three test fuels in the E-98 study are listed below. Note that there was no composite phase for the EPA 11-term predictive model.

1. Gunst 17-term (National Renewable Energy Laboratory Report, July 2011)
2. Gunst 16-term (National Renewable Energy Laboratory Report, July 2011)
3. Gunst Reduced (National Renewable Energy Laboratory Report, July 2011)
4. EPA 11-term (US EPA Report April 2013)
5. EPA 16-term (US EPA Report April 2013)

The results of the predictive models are shown in Figures ES-1 through ES-4 for NMHC, CO, NO_X, and PM. A negative percent change indicates that the predicted emission using Fuel 1 was higher than the predicted emission using Fuel 2 or Fuel 3. The GLM Model LSMeans represent the relative percent change in the average emission from the E-98 tests. A summary of the composite results detailing how the predictive models compare is given below.

- Composite NMHC Emissions
    - Fuel 1 vs. Fuel 2 – The Models predict reductions in NMHC emissions and the E-98 Fleet LSMeans demonstrate reductions in the average NMHC emissions
    - Fuel 1 vs. Fuel 3 – The Models predict reductions in NMHC emissions and the E-98 Fleet LSMeans demonstrate reductions in the average NMHC emissions

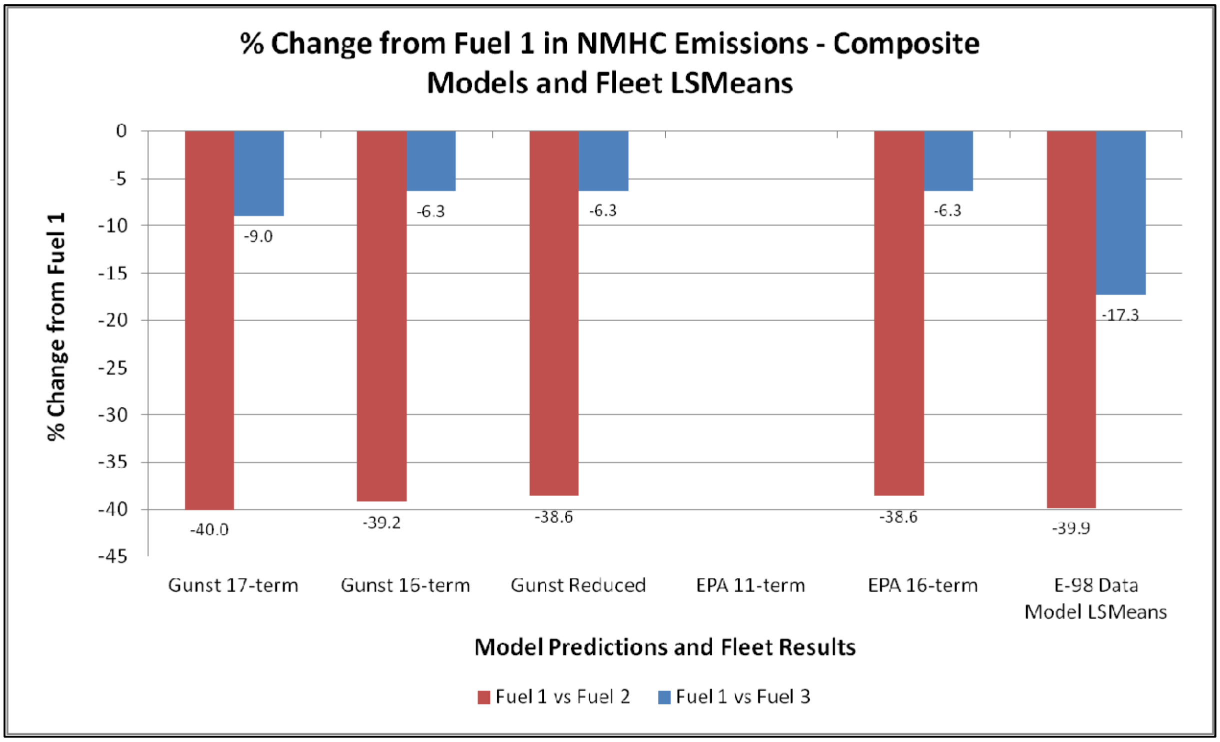

FIGURE ES-1. NMHC COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

- Composite CO Emissions
  - Fuel 1 vs. Fuel 2 – The Models predict reductions in CO emissions and the E-98 Fleet LSMeans demonstrate reductions in the average CO emissions

  - Fuel 1 vs. Fuel 3 – The Models predict reductions in CO emissions and the E-98 Fleet LSMeans demonstrate reductions in the average CO emissions

Note that for Phase 1, the models for both Fuel 1 vs. Fuel 2 and Fuel 1 vs. Fuel 3 do not agree with the E-98 Fleet LSMeans and predict in opposite directions.

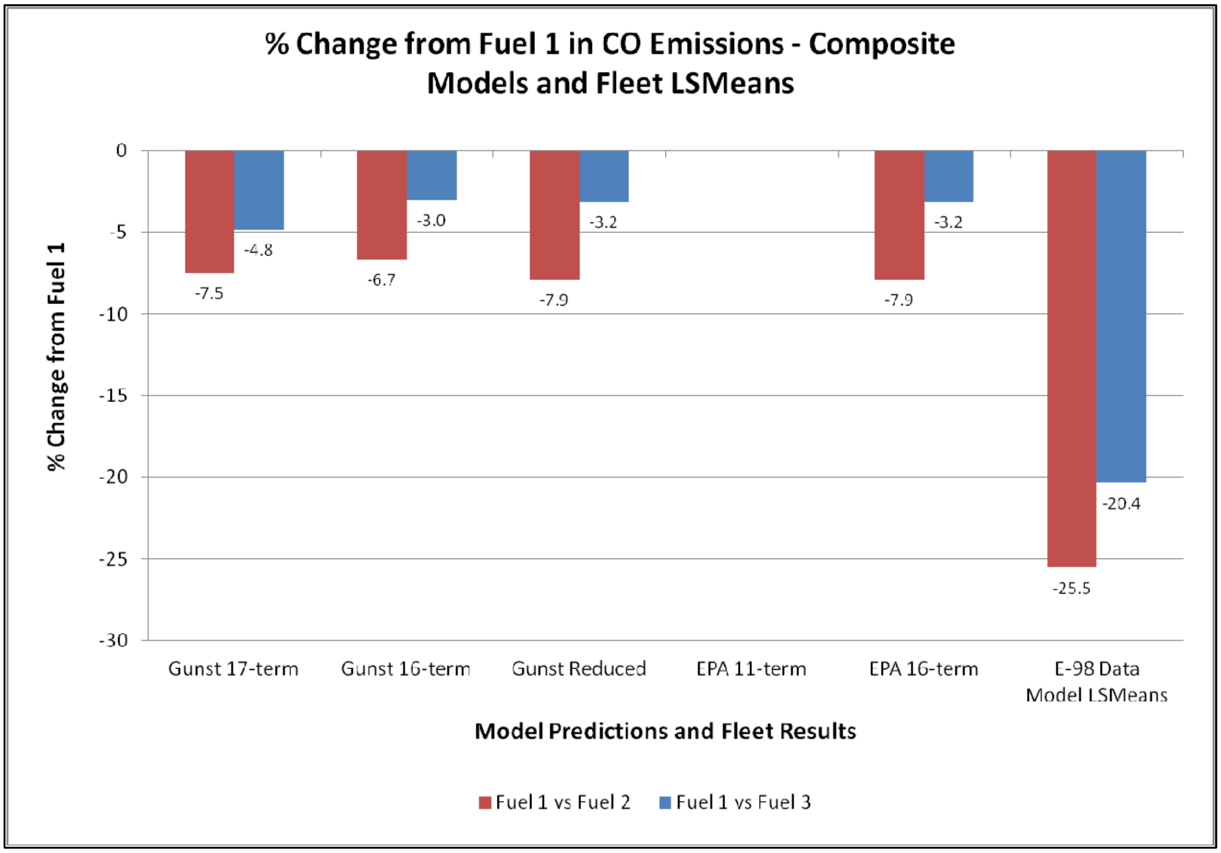

FIGURE ES-2. CO COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

- Composite NO_X Emissions
  - Fuel 1 vs. Fuel 2 – The E-98 Fleet LSMeans demonstrate decreases in average NO_X emissions whereas two models predict increases in NO_X and two models predict decreases in NO_X
  - Fuel 1 vs. Fuel 3 – The E-98 Fleet LSMeans demonstrate a decrease in the average NOx emissions whereas all four models predict increases in NO_X emissions

Note that for Phase 1 and Phase 3, the models for both Fuel 1 vs. Fuel 2 and Fuel 1 vs. Fuel 3 agree and predict the same directions as the E-98 Fleet LSMeans. In Phase 2, all but the Gunst 17-term and 16-term models predicted higher NO_X for Fuel 2 vs. Fuel 1. The Gunst 17-term and 16-term models predicted lower NO_X for Fuel 2 than Fuel 1.

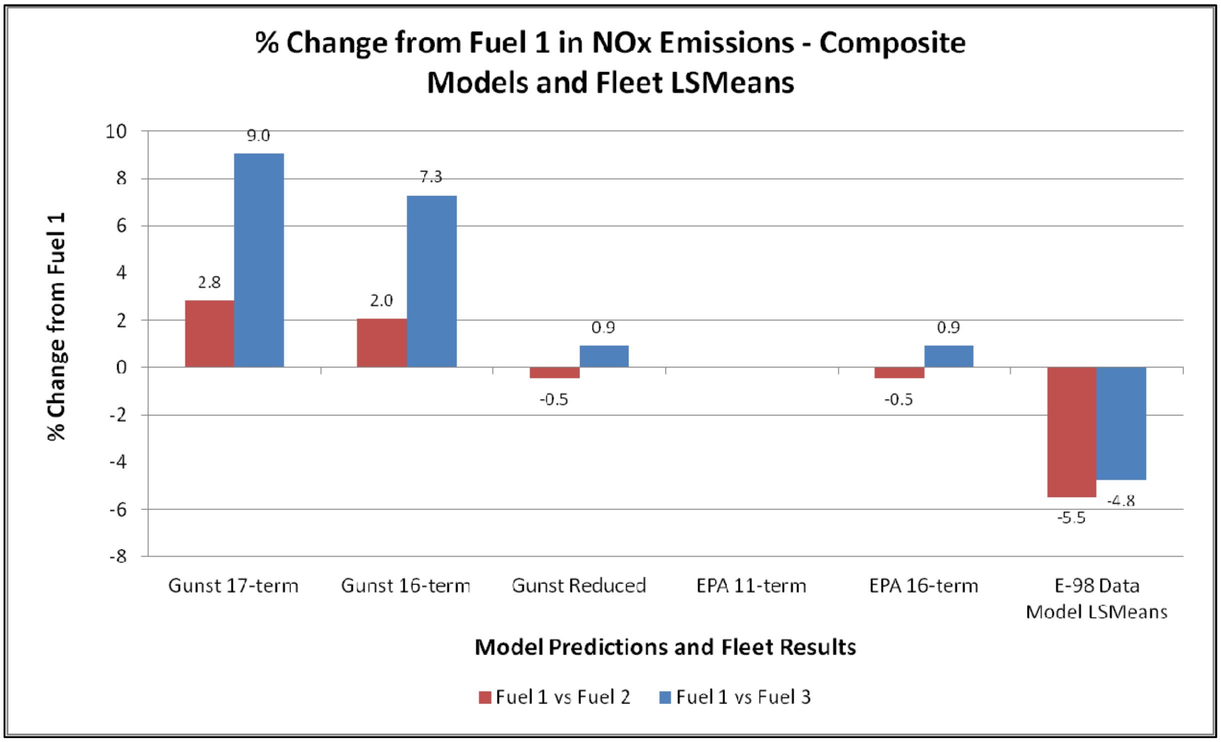

FIGURE ES-3. NO_X COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

- Composite PM Emissions
    - Fuel 1 vs. Fuel 2 – The Models predict reductions in PM emissions and the E-98 Fleet LSMeans demonstrate reductions in the average PM emissions

    - Fuel 1 vs. Fuel 3 – The E-98 Fleet LSMeans demonstrate an increase in average PM emissions whereas the models predict reductions in PM

Note that for Phase 1, Phase 2, and Phase 3, the models for both Fuel 1 vs. Fuel 2 and Fuel 1 vs. Fuel 3 all predict a reduction in predicted PM from Fuel 1. Additionally, the E-98 Fleet LSMeans for Phases 2 and 3 do not agree with the Models when comparing Fuel 1 vs. Fuel 3 where the LSMeans demonstrate an increase in the average PM emissions.

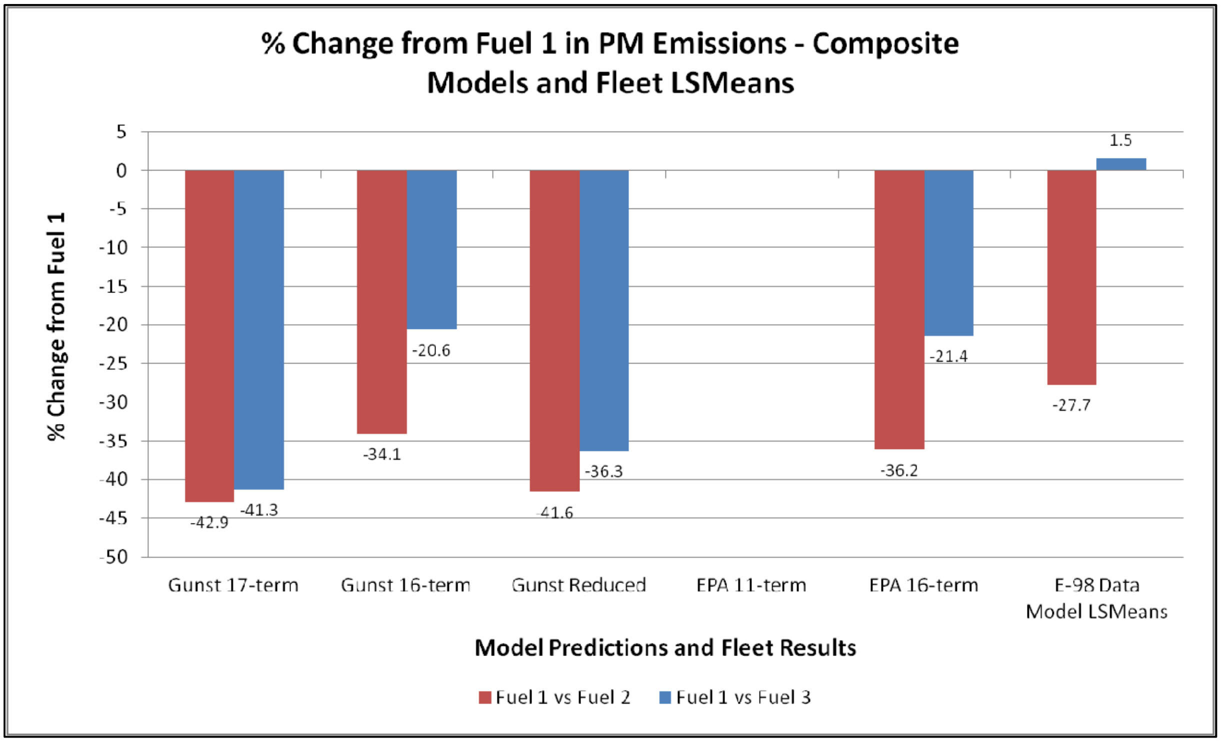

FIGURE ES-4. PM COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

1.0 INTRODUCTION

Current Federal and California regulations for reformulated gasolines include sets of equations (i.e., the Complex Model (EPA) and the Predictive Model (CARB)) which describe the impact of fuel properties and composition on emissions. The coefficients in these models are based largely on the Auto/Oil Air Quality Improvement Research Program studies. The Energy Policy Act of 2005 (EPAct) requires that EPA update the Complex Model to reflect the latest information on fuel and vehicle effects. CARB staff periodically revises their Predictive Model, so they are also interested in more recent information on fuel effects for use in the next model update.

The recent EPAct/V2/E-89 study evaluated effects of T_{50}, T_{90}, ethanol content, aromatics content, and RVP. The work began under the direction of the U.S. Environmental Protection Agency (EPA) to fulfill the requirements of Section 1506 of the EPAct to produce an updated fuel effects model representing recent-model light-duty gasoline vehicles and including an assessment of the emissions impacts of increased renewable fuel use. However, this program only tested extreme combinations of fuel properties and were not necessarily representative of current and future commercial fuels.

Significant work has been done to develop statistical models of the EPAct data set to represent relationships between exhaust emissions and fuel properties. However, because the properties of the EPAct fuels were at the extreme edges of the fuel blending "envelope," it has been difficult to assess the ability of the models to predict exhaust emissions effects of fuels with properties more representative of commercial fuels.

This study was undertaken to generate data that can be used by government and industry stakeholders to assess the ability of different EPAct models to predict exhaust emissions effects of current and future "real world" fuels.

The objective of this project was to measure exhaust emissions from the "EPAct fleet" of fifteen vehicles while operating on three fuels. One fuel was a re-blend of one of the EPAct fuels, while the other two fuels had properties that exist inside the "envelope" of properties defined by the EPAct fuels. Regulated emissions as well as speciated emissions were measured using the LA-92 chassis dynamometer driving cycle. The results were analyzed statistically to compare the measured emissions from the re-blended EPAct fuel with the other two fuels in this study, and to determine if the fuels tested in this program fall within the predictions of existing statistical models.

2.0 TECHNICAL APPROACH

2.1 Test Fuels

Three fuels were evaluated in this program. One fuel was a re-blend of one of the EPAct fuels, while the other two fuels had properties that exist inside the "envelope" of the properties defined by the EPAct fuels.

Thirty drums of each fuel were shipped to SwRI. All unopened drums were kept in a temperature-controlled facility. The storage temperature for unopened drums was maintained at 68°F ±5°F. As needed, unopened fuel drums were transported to a dedicated cold-storage facility located behind the emissions laboratory. Prior to opening, each drum was conditioned to a temperature of less than 50°F. Once a drum was opened, it was stored at 45°F ±5°F. The temperatures of both fuel storage facilities were continuously recorded, and were manually verified on a regular basis.

The three fuels had varying levels of ethanol content of E0, E10 and E15 and were designated Fuel 1, Fuel 2 and Fuel 3, respectively. Additionally, all three fuels received an independent identifier which included a SwRI fuel code and a project-specific supplementary three-letter code. All fuel drums and corresponding work requests included all three designators in an effort to assure the correct fuel was being used at any point in the test program. Also, each drum was numbered numerically.

Fuel samples were taken from random drums of each fuel by SwRI and delivered to three laboratories for analysis. CRC provided the averaged results from the laboratories which were used for exhaust emissions calculations and statistical analyses of the results. Fuel properties from the three fuels tests in the E-98 program were provided to SwRI by CRC and are listed in Table 1. Note that Fuel 1 is blended to be the same as a fuel tested in the EPAct/V2/E-89 study and is used in the statistical analyses as the comparison fuel against Fuels 2 and 3.

When a vehicle received a fuel change, the appropriate fuel drum was removed from the cold box. The SwRI fuel code and supplemental three-letter fuel name were verified by two individuals prior to a refueling event. Each vehicle/fuel combination was prepared, preconditioned, and tested as specified in the Fuel Change, Conditioning and Test Procedure (Appendix A) and the Catalyst Sulfur Purge Cycle (Appendix B), and the individual fuel drum number was recorded. In an effort to ensure correct drum labeling by the fuel supplier, when each new drum of fuel was opened, a sample was collected in order to verify select fuel properties with a Petrospec portable gasoline analyzer.

2.2 Test Vehicles

Fifteen test vehicles previously used in the EPAct/V2/E-89 study were provided by CRC for this program and are shown in Table 2. Prior to the E-98 program and following the EPAct/V2/E-89 program the vehicles were sent to the Center for Environmental Research and Technology (CE-CERT) in California for testing. Approximately a year after the completion of testing at CE-CERT, the vehicles were then returned to SwRI for the E-98 program.

TABLE 1. E-98 FUELS ROUND ROBIN FUEL PROPERTY DATA

Property	Unit	Fuel 1	Fuel 2	Fuel 3
SwRI Fuel Code		CGA-8409	CGA-8410	CGS-8411
SirI Fuel Name		EDW	WRB	RND
Density, 60°F	g/cm^3	0.7574	0.7463	0.7539
API Gravity, 60°F	°API	55.2	57.9	55.9
Ethanol	vol. %	0.0	10.1	15.8
Total Content of Oxygenates Other Than Ethanol	vol. %	0.0	0.0	0.0
Distillation, IBP	°F	94.0	93.5	102.6
5% evap	°F	125.1	115.1	133.6
10% evap	°F	140.9	122.9	142.9
20% evap	°F	166.0	133.7	153.8
30% evap	°F	189.9	210.5	159.6
40% evap	°F	210.8	150.7	164.6
50% evap	°F	225.5	175.5	215.1
60% evap	°F	238.3	217.6	230.4
70% evap	°F	254.1	236.8	242.4
80% evap	°F	291.8	259.5	267.9
90% evap	°F	340.5	304.2	331.1
95% evap	°F	354.9	323.0	345.9
FBP	°F	382.1	349.2	374.4
DVPE (EPA equation)	psi	7.21	9.64	7.55
Aromatics	vol. %	35.4	27.4	24.6
Olefins	vol. %	6.2	6.7	6.7
Saturates	vol. %	58.4	55.8	52.9
Benzene	vol. %	0.49	0.51	0.51
S	mg/kg	21	21	21
RON	-	95.6	98.6	101.9
MON	-	85.9	87.2	89.2
(RON+MON)/2	-	90.8	92.9	95.5
C	mass %	86.95	83.74	81.79
H	mass %	12.75	12.95	12.93
O	mass %	0.00	3.7	5.8
Net Heat of Combustion	MJ/kg	43.780	43.005	42.118
Water	mass %	0.005	0.061	0.084
Lead	g/l	<0.01	<0.01	<0.01
Copper Strip Corrosion	-	1a	1a	1a
Solvent Washed Gum Content	mg/100ml	<0.5	<0.5	<0.5
Oxidation Stability	min.	1440	1440	1440

* Corrected for oxygenate

** Method adapted by individual laboratories to testing of gasoline's; alternatively, data can be provided from a DHA analysis

TABLE 2. PHASE 3 TEST VEHICLES

Make	Model Year	Brand	Model	Vehicle Name	Engine	Engine Family	T2 Bin	Starting Odometer
GM	2008	Chevrolet	Cobalt	CCOB	2.4L I4	8GMXV02.4025	5	12,743
GM	2008	Chevrolet	Impala FFV	CIMP	3.5L V6	8GMXV03.9052	5	12,356[a]
GM	2008	Saturn	Outlook	SOUT	3.6L V6	8GMXT03.6151	5	13,002[a]
GM	2008	Chevrolet	Silverado FFV	CSIL	5.3L V8	8GMXT05.3373	5	14,579
Toyota	2008	Toyota	Corolla	TCOR	1.8L I4	8TYXV01.8BEA	5	13,005
Toyota	2008	Toyota	Camry	TCAM	2.4L I4	8TYXV02.4BEA	5	12,239
Toyota	2008	Toyota	Sienna	TSIE	3.5L V6	8TYXT03.5BEM	5	13,151
Ford	2008	Ford	Focus	FFOC	2.0L I4	8FMXV02.0VD4	4	12,377
Ford	2008	Ford	Explorer	FEXP	4.0L V6	8FMXT04.03DB	4	14,989[a]
Ford	2008	Ford	F-150 FFV	F150	5.4L V8	8FMXT05.44HF	8	15,273[a]
Chrysler	2008	Dodge	Caliber	DCAL	2.4L I4	8CRXB02.4MEO	5	12,308
Chrysler	2008	Jeep	Liberty	JLIB	3.7L V6	8CRXT03.7NE0	5	12,480
Honda	2008	Honda	Civic	HCIV	1.8L I4	8HNXV01.8LKR	5	13,441
Honda	2008	Honda	Odyssey	HODY	3.5L V6	8HNXT03.54KR	5	12,641
Nissan	2008	Nissan	Altima	NALT	2.5L I4	8NSXV02.5G5A	5	12,823[a]

[a] These vehicles had additional miles on MAD lane with a fuel additive. See Section 3.1 for details.

2.3 Test Vehicle Inspections

When the vehicles arrived at SwRI a check-in inspection was performed. The inspection included the items noted in each vehicle's owner's manual at a major maintenance interval. The following items were conducted:

1. Document vehicle odometer.
2. Visually check for any leaks or damage.
3. Discharged batteries were charged and the battery voltage was checked.
4. Weak batteries or batteries that would not hold a charge were replaced with the OEM battery.
5. Each vehicle was checked with a scanner for active and/or pending codes.
6. The following fluid levels were checked and topped off if below the "add" line using the appropriate OEM fluid:
    a. Brake fluid level
    b. Coolant recovery reservoir
    c. Automatic transmission fluid
    d. Power steering fluid
    e. Differential oil level
7. With the vehicle on a hoist and the transmission in neutral, wheels were rotated to check for potential brake drag.
8. The tires tread and side walls were inspected for cracks, cupping, and/or excessive wear.
9. The tire pressure was set the "cold-tire" pressure specification for the vehicle.
10. The air cleaner element was replaced
11. Vehicle inspection:
    a. Brake linings/drums and brake pads/discs

b. Suspension and steering components
c. Ball joints and dust covers
d. Brake lines and hoses
e. Drive shaft boots
f. Engine cooling system
g. Wiper blades
h. Restraint system components
i. Exhaust pipes and mountings
j. Fuel lines and hoses
k. Fuel cap gasket
l. Radiator cap gasket
m. Throttle system

12. Check Technical Service Bulletins (TSBs) for engine/emissions systems: Using the International Automotive Technicians Network, Alldata®, Mitchell1®, and SwRI's local automotive dealer contacts, TSBs involving engine/emission systems for the program vehicles will be researched. If there were any TSB(s) that would potentially affect the program, the SwRI project manager notified the CRC technical contact to decide upon the best course of action.

A total of ten vehicles needed OEM replacement batteries. A front tire and a gas cap were replaced on the Dodge Caliber (See Incident No. 1 in Appendix C). The Saturn Outlook had an electrical short in the fuse box and was repaired (See Incident No. 2 in Appendix C).

2.4 Crankcase Lubricant

Prior to testing, SwRI changed the engine oil in all the vehicles and accumulated 2,000 miles of EPA Standard Road Cycle (SRC) using the SwRI mileage accumulation dynamometers (MADs). An engine oil drain and fill with a new OEM oil filter was performed on each of the fifteen vehicles using the same batch of oil that was used for the EPAct/V2/E-89 test program. The engine oil used for each vehicle was based on the manufacture's recommended viscosity grade.

2.5 Test Procedures

All vehicle/fuel combinations were tested using the California Unified Cycle, also known as the LA92. For this program, the LA92 was conducted as a three-phase, cold-start test in a manner similar to the FTP, and FTP weighting factors were used to calculate composite emission rates.

All tests were conducted during a day shift using a single driver and support staff. It should be noted that a different driver was used during the EPAct/V2/E89 program. The vehicle preparations, fuel changes, sulfur purges, and conditioning were conducted during a second shift. All vehicle soaks and tests were conducted at a nominal temperature of 72°F. The representative bulk oil temperature of a vehicle's sump was stabilized to 72°F ± 3°F prior to conducting any emission test.

SwRI made a good faith effort to maintain intake air humidity during testing at 75 ± 5 grains H_2O/lb dry air. SwRI was typically able to maintain absolute humidity during testing within the desired range 95 percent of the time. It should be noted that in cases where outdoor ambient conditions were rapidly changing, the system was not able to meet the 95-percent target. SwRI flagged these tests in a test log and provided a humidity quality check metric within each individual test file.

2.6 Test Matrix

Testing started with nine vehicles and all three fuels. Additional vehicles were added to the test matrix as they were approved for testing. The test matrix was designed to be randomized for each vehicle/fuel combination. Duplicate tests were conducted "back-to-back", with the option for a third test based on repeatability criteria. After two tests were completed and the acquired data passed all quality control verifications, the need for a third test was determined by following the variability criteria shown in Table 3. If the ratio of any of the criteria pollutants (THC, NO_X, or CO) on a pair of tests for a given vehicle/fuel combination exceeded the levels shown in Table 6, a third test was conducted.

TABLE 3. REPEATABILITY CRITERIA FOR TRIPLICATE TESTING

Dilute Gaseous Emission	Criteria For Requiring A Third Test (Composite Cycle Emissions)
CO	|(Test 1- Test 2) / Test1| > 70%
NO_X	|(Test 1- Test 2) / Test1| > 29%
THC	|(Test 1- Test 2) / Test1| > 33%

2.7 Vehicle Conditioning

The vehicle fuel change and conditioning procedure used for this program was adopted from the EPAct/V2/E-89 program. All vehicles were conditioned with three (3) successive two-phase LA92s except for the #5, #1, #4, #12, and #3 vehicles, which were all conditioned with five (5) successive 2-phase LA92s. The vehicle fuel change and conditioning sequence is given in Table 4. Example test requests for vehicle conditioning and testing are given in Appendix A.

2.8 Chassis Dynamometer

All tests were conducted using a Horiba 48-inch single-roll electric chassis dynamometer. The dynamometer electrically simulates inertia weights up to 12,000 lb over the FTP, and provides programmable road load simulation of up to 150 hp continuous at 65 mph. This program used the same chassis dynamometer settings as the EPAct/V2/E-89 program. They were originally derived from target road load coefficients as reported in EPA's on-line Test Car List Data Files (Table 5). A single test site and a single test driver were used for this entire program. Different drivers were used for sulfur purges and vehicle conditioning.

TABLE 4. FUEL CHANGE, CONDITIONING, AND TEST EXECUTION SEQUENCE

Step	Description
1	Drain vehicle fuel completely via fuel rail whenever possible.
2	Turn vehicle ignition to RUN position for 30 seconds to allow controls to allow fuel level reading to stabilize. Confirm the return of fuel gauge reading to zero.
3	Turn ignition off. Fill fuel tank to 40% with next test fuel in sequence. Fill-up fuel temperature must be less than 50°F.
4	Start vehicle and execute catalyst sulfur removal procedure described in Appendix B. Apply side fan cooling to the fuel tank to alleviate the heating effect of the exhaust system.
5	Perform four vehicle coast downs from 70 to 30 mph, with the last two measured. If the individual run fails to meet the repeatability criteria, the vehicle will be checked for any obvious and gross source of change in the vehicle's mechanical friction.
6	Drain fuel and refill to 40% with test fuel. Fill-up fuel must be less than 50°F.
7[a]	Drain fuel again and refill to 40% with test fuel. Fill-up fuel must be less than 50°F.
8	Soak vehicle for at least 12 hours to allow fuel temperature to stabilize to the test temperature.
9[b]	Move vehicle to test area without starting engine. Start vehicle and perform three 2-phase (bags 1 and 2) LA92 cycles. During these prep cycles, apply side fan cooling to the fuel tank to alleviate the heating effect of the exhaust system. Following the first two prep cycles, allow vehicle to idle in park for two minutes, then shut-down the engine for 2-5 minutes. Following the last prep cycle, allow the vehicle to idle for two minutes, then shut down the engine in preparation for the soak.
10	Move vehicle to soak area without starting the engine.
11	Park vehicle in soak area at proper temperature (72 °F) for 12-36 hours. During the soak period, maintain the nominal charge of the vehicle's battery using an appropriate charging device.
12	Move vehicle to test area without starting engine.
13	Perform LA92 cycle emissions test.
14	Move vehicle to soak area without starting the engine.
15	Park vehicle in soak area of proper temperature for 12-36 hours. During the soak period, maintain the nominal charge of the vehicle's battery using an appropriate charging device.
16	Move vehicle to test area without starting the engine.
17	Perform LA92 emissions test.
18	Determine whether third replicate is necessary, based on data variability criteria (see Table 5).
19	If a third replicate is required, repeat steps 14, 15, 16 and 17.
20	If third replicate is not required, return to step 1 and proceed with next vehicle in test sequence.

a – Some vehicles received only two fuel drains and fills, i.e. Step 7 was skipped. See Section 3.4 for details.
b – Conduct five 2-phase LA92 test cycles for the following vehicles: #5, #1, #4, #12, and #3.

TABLE 5. VEHICLE CHASSIS DYNAMOMETER SETTINGS

Model Year	Make	Brand	Model	Name	ETW, lbs	Target Coefficients A, lbs	Target Coefficients B, lbs/mph	Target Coefficients C lbs/mph^2	Set Coefficients A, lbs	Set Coefficients B, lbs/mph	Set Coefficients C lbs/mph^2	Road Load HP @ 50 mph
2008	GM	Chevrolet	Cobalt	CCOB	3,125	21.51	0.5409	0.01521	4.22	0.20100	0.017055	11.5
2008	GM	Chevrolet	Impala FFV	CIMP	3,875	19.87	0.4397	0.01752	8.320	0.11210	0.018601	11.4
2008	GM	Saturn	Outlook	SOUT	5,000	38.61	0.3921	0.02818	19.860	0.07430	0.030294	17.2
2008	GM	Chevrolet	C1500 Silverado	CSIL	5,500	28.80	0.8005	0.03219	18.130	0.31630	0.035662	19.9
2008	Toyota	Toyota	Corolla	TCOR	2,875	22.10	0.1500	0.01886	8.080	-0.02580	0.020902	10.2
2008	Toyota	Toyota	Camry	TCAM	3,625	29.16	0.1659	0.01844	10.110	-0.15630	0.019592	11.1
2008	Toyota	Toyota	Sienna	TSIE	4,500	38.41	0.0249	0.02946	16.270	-0.12110	0.029718	15.1
2008	Ford	Ford	Focus	FFOC	3,000	27.66	0.2892	0.01697	15.240	0.07660	0.018743	11.3
2008	Ford	Ford	Explorer	FEXP	4,750	32.35	0.6076	0.02716	14.350	0.43360	0.028153	17.4
2008	Ford	Ford	F150 FFV	F150	5,250	27.26	0.9495	0.02932	4.300	0.83540	0.029383	19.7
2008	Chrysler	Dodge	Caliber	DCAL	3,500	52.75	-0.3153	0.02826	15.990	-0.20400	0.025692	14.4
2008	Chrysler	Jeep	Liberty	JLIB	4,250	29.53	0.4040	0.02955	9.410	0.13330	0.031781	16.5
2008	Honda	Honda	Civic	HCIV	3,000	23.18	0.1904	0.01699	8.120	0.05150	0.017724	10.0
2008	Honda	Honda	Odyssey	HODY	4,750	28.70	0.6915	0.02167	11.170	0.24850	0.024710	15.7
2008	Nissan	Nissan	Altima	NALT	3,500	47.47	-0.4531	0.02414	19.710	-0.30660	0.021358	11.4

2.9 Regulated and Unregulated Emissions

The emissions measured and reported were THC, NMHC (by FID), NMOG, NO_X, NO_2, CO, CO_2, PM, alcohols, carbonyl compounds, and speciated hydrocarbons.

2.9.1 Regulated Emissions

Gaseous emissions were determined in a manner consistent with EPA protocols for light-duty emission testing as given in the CFR, Title 40, Part 86. A constant volume sampler was used to collect proportional dilute exhaust in Kynar bags for analysis of carbon monoxide (CO), carbon dioxide (CO_2), total hydrocarbons (THC), methane (CH_4), and oxides of nitrogen (NO_X). For the determination of particulate matter (PM) mass emissions, a proportional sample of dilute exhaust was drawn through Whatman Teflon membrane filters. The PM sampling method was consistent with CFR, Title 40, Part 1065.

In addition to the dilute, bagged exhaust samples, continuous raw exhaust mass emissions were measured on a second-by-second basis for THC, CH_4, CO, NO_X, CO_2 and O_2 at the tailpipe. These measurements were performed during the first test of each vehicle/fuel combination at a sampling frequency of 1 Hz. Dilution air flow was measured with a smooth approach orifice, and a critical flow venturi measured bulkstream dilute exhaust flow. Measured dilution air flow was subtracted from the bulkstream flow to calculate raw exhaust flow in order to determine continuous raw mass emission rates.

2.9.2 Speciation of Volatile Organic Compounds

Phase-level (bag-by-bag) speciated VOCs included C_1 - C_{12} hydrocarbons, light alcohols, aldehydes, and ketones. Sampling and analysis of C_2-C_{12} hydrocarbons was conducted in a manner similar to CARB method 1002/1003, "Procedure for the Determination of C_2-C_{12} Hydrocarbons in Automotive Exhaust Samples by Gas Chromatography". Sampling and analysis of alcohols was done in a manner similar to CARB method 1001, "Determination of Alcohols in Automotive Source Samples by Gas Chromatography". Sampling and analysis of carbonyl compounds was conducted in a manner similar to CARB method 1004, "Determination of Aldehyde and Ketone compounds in Automotive Source Samples by High Performance Liquid Chromatography". Analysis of C_2 - C_4 HC samples was conducted within one hour of completion of an emissions test. Subsequent analysis of the additional compounds of interest was done within 4 hours of emission test completion.

During the analysis of C_2 - C_4 hydrocarbons, special consideration was given to 1,3-butadiene. Because of the instability of 1,3-butadiene, the analysis of C_2 - C_4 hydrocarbon samples collected during Bag 1 of a test cycle was initiated within one hour of collection. The speciation of C_5 - C_{12} hydrocarbon samples collected in Bag 1 of the test cycle was completed within 4 hours of collection.

Sampling and analysis of light alcohols was accomplished by bubbling exhaust through glass impingers containing deionized water, and samples were analyzed with a gas chromatograph. Analysis included the following compounds: methanol, ethanol, isopropanol, and n-propanol. Alcohol samples were sealed and stored at a temperature below $40^{o}F$

immediately following collection. Most of these samples were analyzed on the day they were collected, but no later than within six calendar days.

The aldehyde sampling system consists of liquid impingers in series, each containing DNPH absorbing solution, used to collect exhaust samples for the analysis of aldehydes and ketones. The two impingers trap approximately 99+ percent of the carbonyl compounds.

The speciation schedule was conducted as shown in Table 6. Alcohols were determined for all tests. Carbonyls and C_2-C_{12} speciation were determined on the first test of all vehicles for all fuels while benzene, 1,3-butadiene, formaldehyde, acetaldehyde and alcohols were determined for all tests and fuels. Carbonyls and C_2-C_{12} speciation were determined on the second test for all fuels if the first test was void. These data were provided to CRC electronically following the completion of the program and are available for download from the CRC web site.

TABLE 6. VOC SPECIATION SCHEDULE

Measurement	Test 1	Test 2	Test 3, if needed
Alcohol Benzene 1,3-butadiene Formaldehyde Acetaldehyde	E0 Fuel: yes E10 Fuel: yes E15 Fuel: yes	E0 Fuel: yes E10 Fuel: yes E15 Fuel: yes	E0 Fuel: yes E10 Fuel: yes E15 Fuel: yes
C_2-C_{12} Speciation with carbonyls	E0 Fuel: yes E10 Fuel: yes E15 Fuel: yes	E0 Fuel: if T1 void E10 Fuel: if T1 void E15 Fuel: if T1 void	E0 Fuel: no E10 Fuel: no E15 Fuel: no

The following daily sequence was used for the analysis of VOC samples:

- VOC samples collected during Bag 1 of the test cycle were analyzed first, in the sequence of vehicle tests.
- If a vehicle requiring VOC sampling during all three bags of the test cycle was tested, the Bag 1 was analyzed first, followed immediately by the Bag 3 sample and finally by the Bag 2 sample.
- Background samples were analyzed last, in the sequence of vehicle tests.

Exhaust emissions were determined as shown below.

Constituent	Analysis Method
Total Hydrocarbon	Heated Flame Ionization Detector (bag, modal)
Methane	Gas Chromatography (bag, modal)
Carbon Monoxide	Non-Dispersive Infrared Analysis (bag, modal)
Carbon Dioxide	Non-Dispersive Infrared Analysis (bag, modal)
Oxides of Nitrogen	Chemiluminescence Analysis (bag, modal)
Nitric Oxide	Chemiluminescence Analysis (bag only)
Oxygen	Magnetopneumatic Detector (modal only)
Particulate Matter	Part 1065 Gravimetric Measurement (bag only)
Non-methane Hydrocarbons	Calculated from THC and CH_4 (bag, modal)
Non-methane Organic Gases	Calculated as specified in Section 2.5.2 (bag only)
Nitrogen Dioxide	Calculated from difference of NO_X and NO (bag only)
C1 – C12 HC Speciation	Gas Chromatography (bag only)
Alcohols	Gas Chromatography (bag only)
Carbonyls	Liquid Chromatography (bag only)

2.9.3 Determination of NMOG

An EPA-provided protocol for calculating NMHC and NMOG, developed during the EPAct/V2/E-98 study, (Appendix D) was followed. Bag-level NMHC and NMOG were calculated for all bags where the required measurements were available. In cases where one or more components of the bag-level NMHC and NMOG calculation were not measured (for example, when alcohols and carbonyls were not measured in Bags 2 and 3), bag-level NMHC and NMOG mass emissions were calculated assuming the missing measurements were below method detection limits. These bag-level NMHC and NMOG calculations were then used to calculate composite weighted NMHC and NMOG mass emissions.

2.10 OBD Data

Additional available data were acquired at 1 Hz from each vehicle's onboard diagnostic (OBD) system during all emissions tests using a DBK70 data acquisition system. These data were provided to CRC in electronic format via the FTP site. The data, when available, included:

- Engine Coolant temperature
- Manifold absolute pressure
- Engine RPM
- Vehicle speed
- Intake Air Temperature
- Air flow rate from mass air flow sensor
- Intake Air Temperature
- Absolute throttle position
- Oxygen Sensor Bank 1 Sensor 1
- Oxygen Sensor Bank 1 Sensor 2
- Oxygen Sensor Bank 2 Sensor 1
- Oxygen Sensor Bank 2 Sensor 2
- Fuel/air commanded equivalence ratio
- Long term fuel trim-bank 1
- Long term fuel trim-bank 2
- MIL status
- Spark advance

3.0 ANALYSIS OF RESULTS

3.1 Check-Out Tests

Following vehicle inspections and repairs, a single checkout test was conducted on each vehicle to ensure its emissions were acceptable. The LA-92 test cycle was used for each check-out test and results were then compared back to previous EPAct tests using E0 fuels. These tests were conducted using a single batch of Haltermann EEE-Lube Oil Certification Gasoline. It should be noted that the properties of this fuel were different from the E0 EPAct fuels to which they were compared. Phase-level measurements of total hydrocarbon (THC), non-methane hydrocarbon (NMHC), oxides of nitrogen (NO_X), carbon monoxide (CO), carbon dioxide (CO_2), and particulate matter (PM) emissions was compared to EPAct data and submitted to the CRC for review to determine each vehicle's acceptability prior to testing.

Results of the check-out tests showed that nine of the vehicles had emissions similar to those seen in the EPAct program. Six vehicles had higher emissions than expected including Vehicle #1, Vehicle #7, Vehicle #8, Vehicle #10, Vehicle #12 and Vehicle #13. The emission results from those check-out tests are shown in Figures 1 through 6.

At the request of CRC, a second check-out test was conducted on the six vehicles with questionable emissions. Emissions from Vehicle #10 and Vehicle #12 decreased to within acceptable levels. The remaining vehicles continued to have high emissions. In an effort to understand the high emission levels from these four vehicles, CRC recommended a sulfur purge procedure be conducted on only Vehicle #1 followed by three, 2-phase LA92 prep cycles and a cold start LA-92 test with emissions. The results of the Vehicle #1 test showed that emission levels remained high. CRC then recommended that SwRI fill all four vehicles with a fuel containing a Top Tier additive package and add a bottle of fuel injector clean-up additive; then run mileage accumulation sufficient to use up the tank of fuel. Once this was completed, an oil change with OEM oil and the 2,000 miles of EPA Standard Road Cycle (SRC) using fuel containing a Top Tier additive package were completed. SwRI carried out the recommended procedure and then moved these vehicles into the main test program without any further testing.

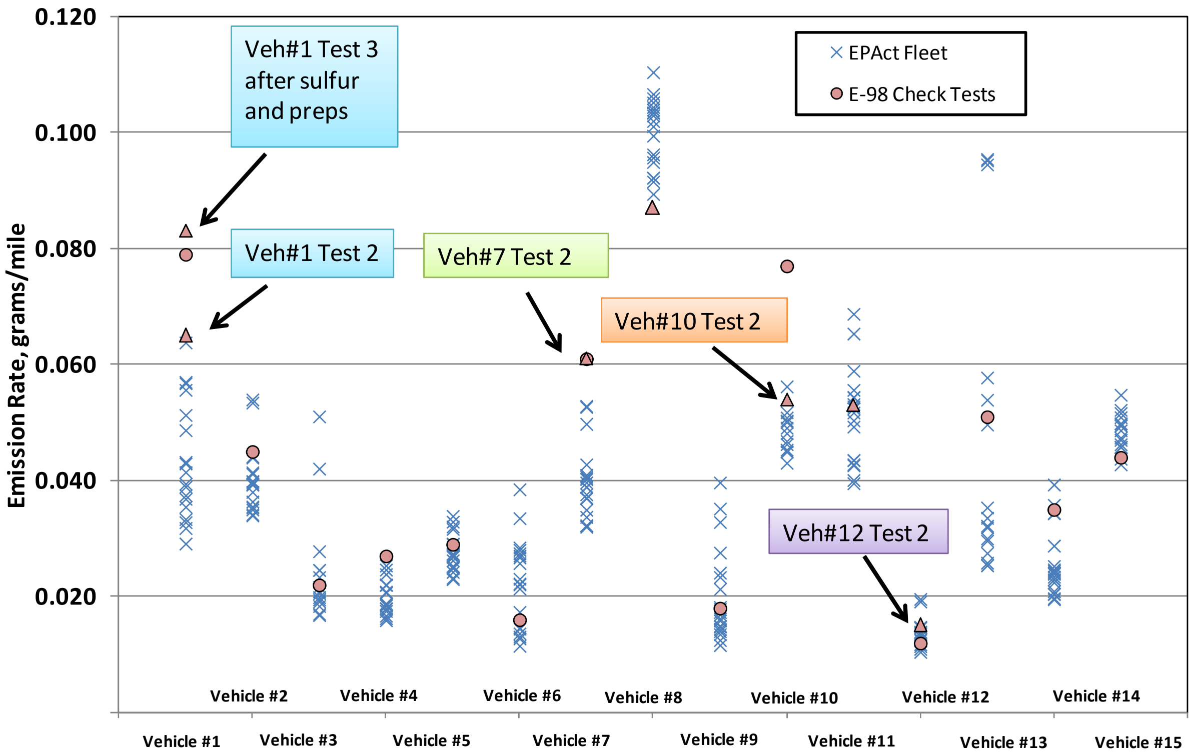

FIGURE 1. THC - CHECK-OUT TEST RESULTS

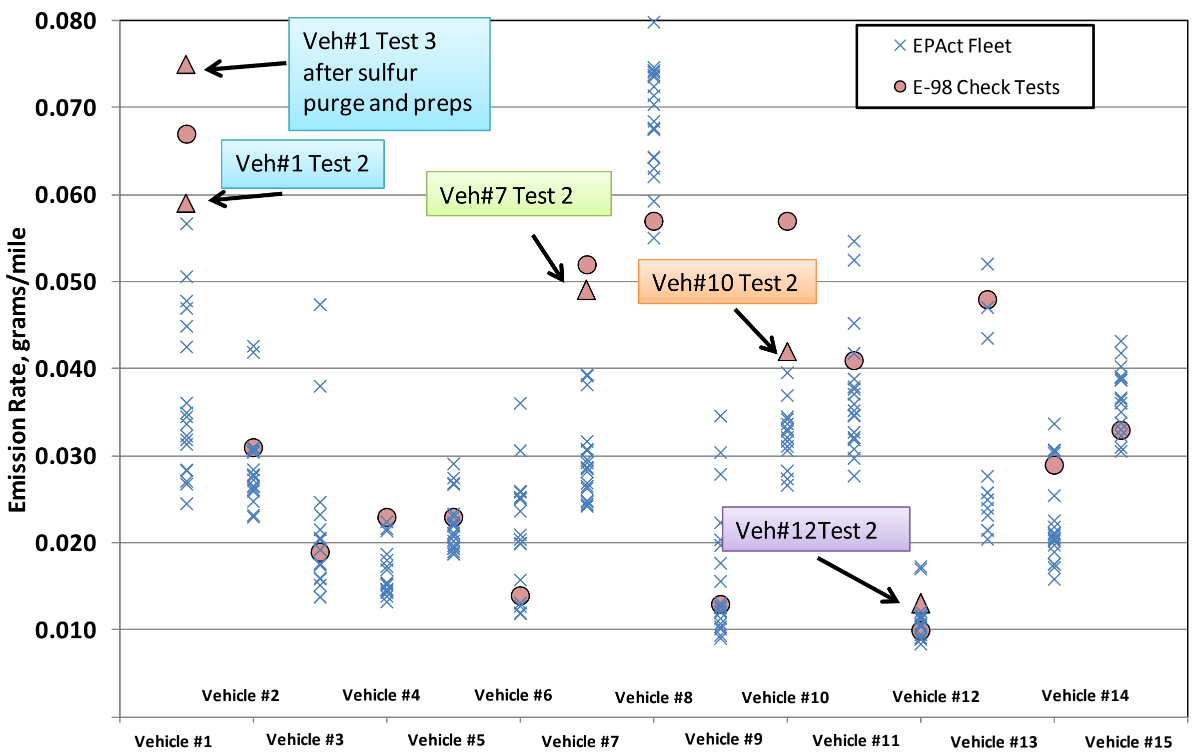

FIGURE 2. NMHC - CHECK-OUT TEST RESULTS

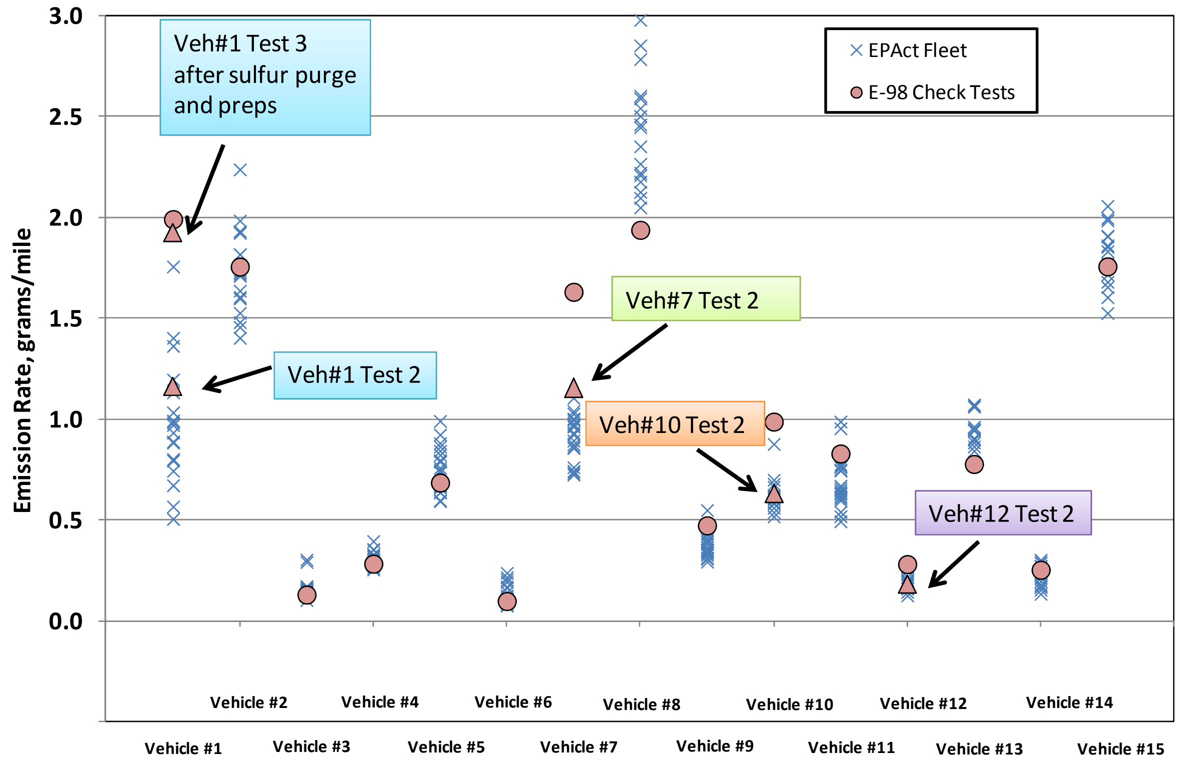

FIGURE 3. CO - CHECK-OUT TEST RESULTS

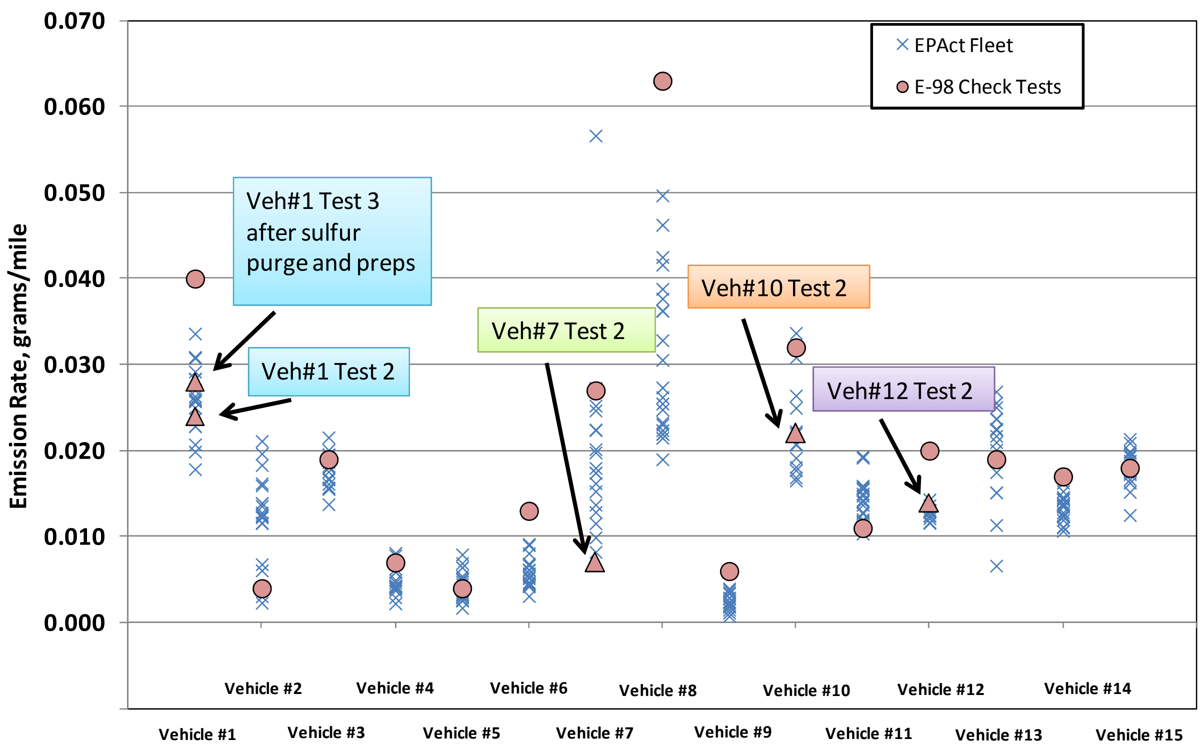

FIGURE 4. NO_X - CHECK-OUT TEST RESULTS

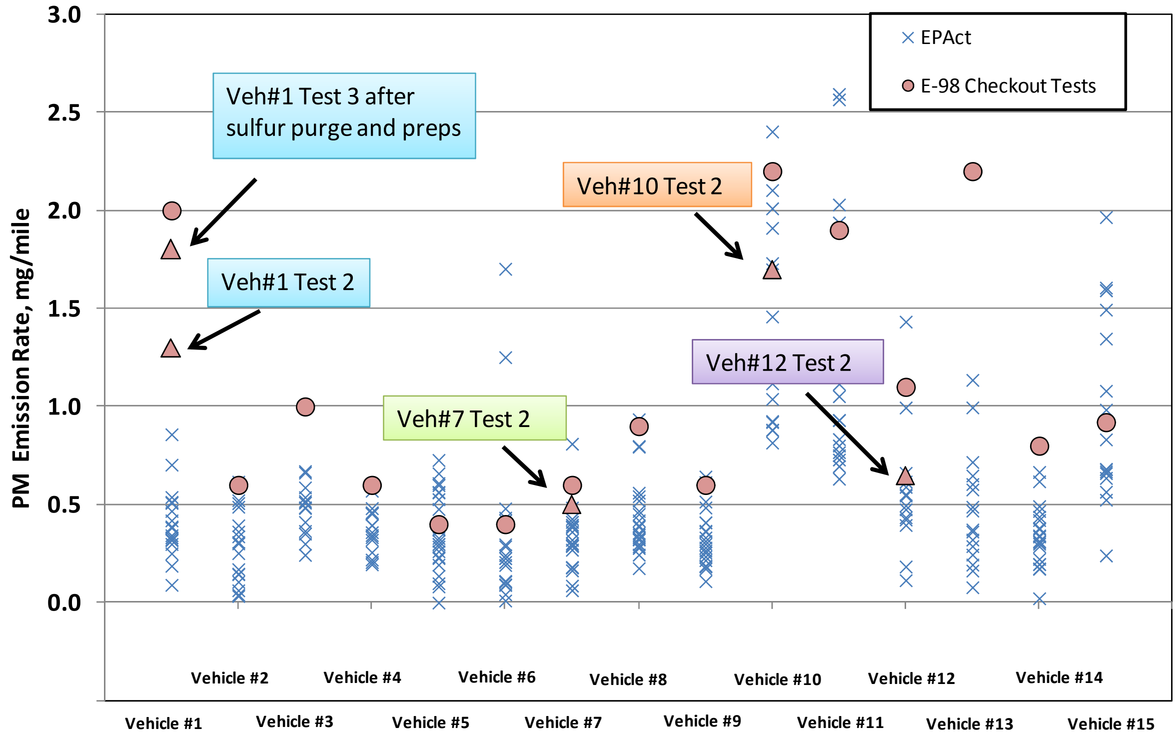

FIGURE 5. PM - CHECK-OUT TEST RESULTS

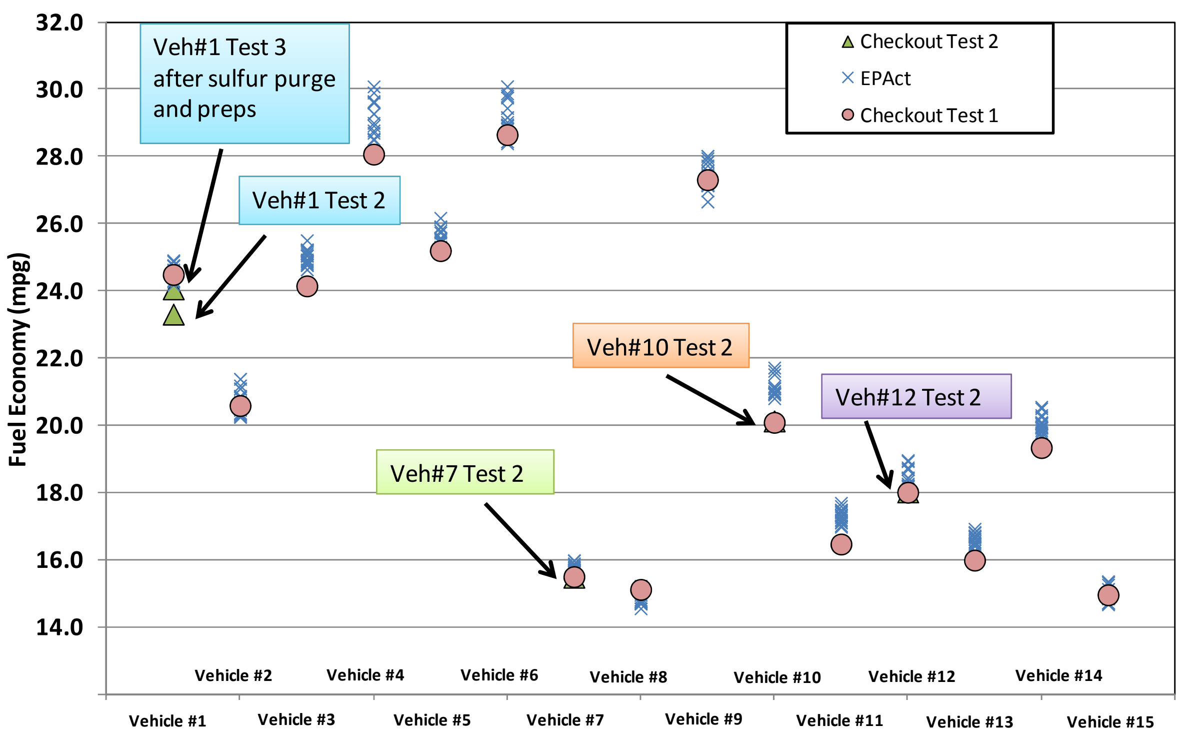

FIGURE 6. FUEL ECONOMY - CHECK-OUT TEST RESULTS

3.2 Test Results

Emission results on the three fuels tested on each of the fifteen vehicles are shown in the figures below. Composite emissions of THC, CO, NO_X, and PM are shown in Figures 7 through 10. The bar graphs show Tests 1 and 2 of each vehicle and fuel combination. The emissions results of third tests for vehicle fuel combinations which failed the repeatability criteria are shown in Appendix E. Descriptive statistics for all emissions by phase, fuel and vehicle are provided in Appendix F. Appendix G provides similar emissions descriptive statistics by phase and fuel (e.g. combining all vehicle results). All test results including phase-by-phase exhaust emissions were uploaded to a secure ftp site upon completion of the program. Additional statistical analyses are given in Section 5.0 of this report. A summary of the statistical analysis follows:

- Most vehicles showed a decrease in THC when tested on Fuel 2 and Fuel 3 compared to Fuel 1 as shown in Figure 7. Note that statistically significant differences were observed in the composite THC results when comparing Fuel 1 vs. Fuel 2 and Fuel 1 vs. Fuel 3, across the 15 vehicles.
- Most vehicles showed a decrease in CO when tested on Fuel 2 and Fuel 3 compared to Fuel 1 as shown in Figure 8. Note that statistically significant differences were observed in the composite CO results when comparing Fuel 1 vs. Fuel 2 and Fuel 1 vs. Fuel 3, across the 15 vehicles.
- Most vehicles showed varying trends in NO_x when tested on Fuel 2 and Fuel 3 compared to Fuel 1 as shown in Figure 9. Note that no statistically significant differences were observed in the composite NO_X results when comparing Fuel 1 vs. Fuel 2 and Fuel 1 vs. Fuel 3, across the 15 vehicles.
- Most vehicles showed varying trends in PM when tested on Fuel 2 and Fuel 3 compared to Fuels 1 as shown in Figure 10. Note that statistically significant differences were observed in the composite PM results when comparing Fuel 1 vs. Fuel 2, however they were not observed for Fuel 1 vs. Fuel 3, across the 15 vehicles.

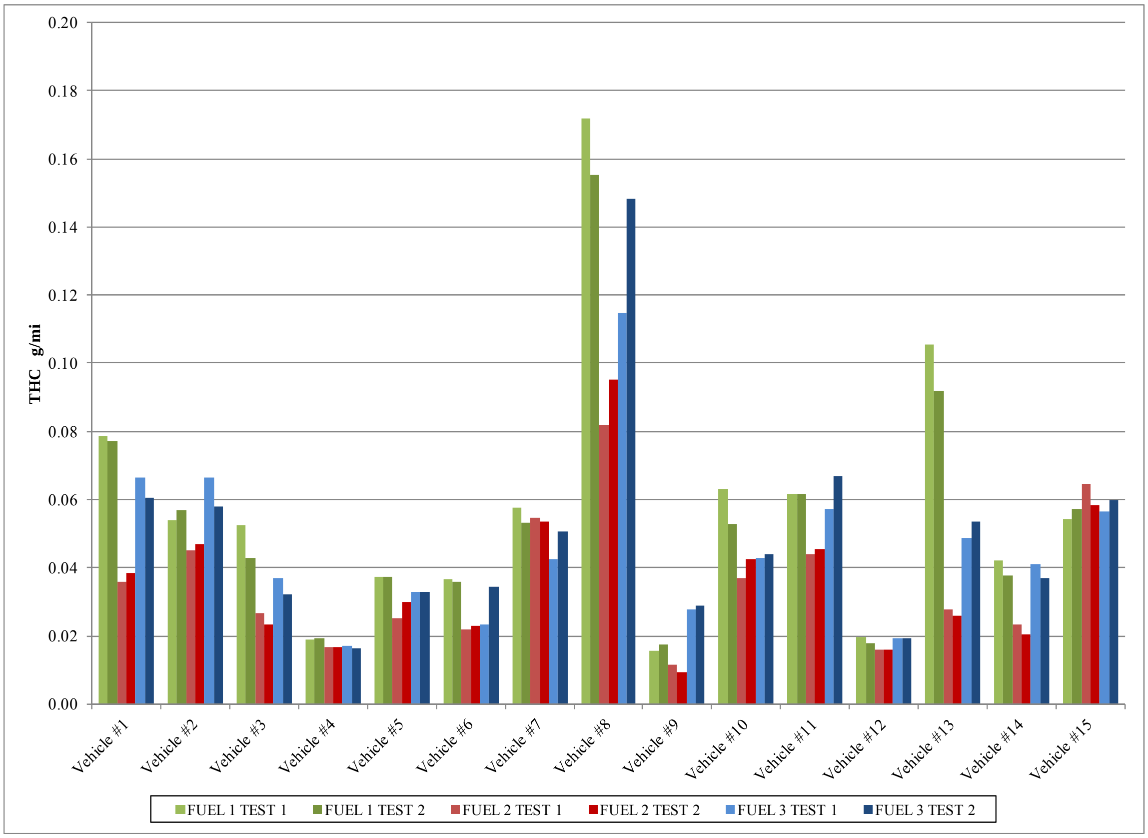

FIGURE 7. LA-92 COMPOSITE THC TEST RESULTS

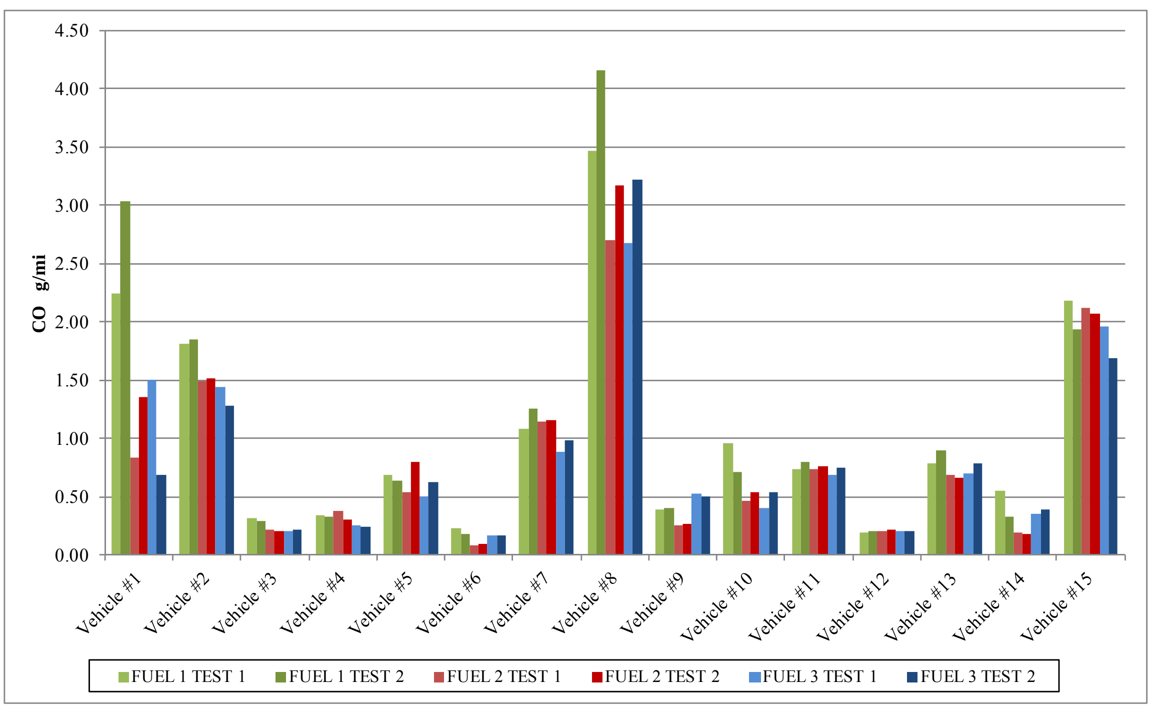

FIGURE 8. LA-92 COMPOSITE CO TEST RESULTS

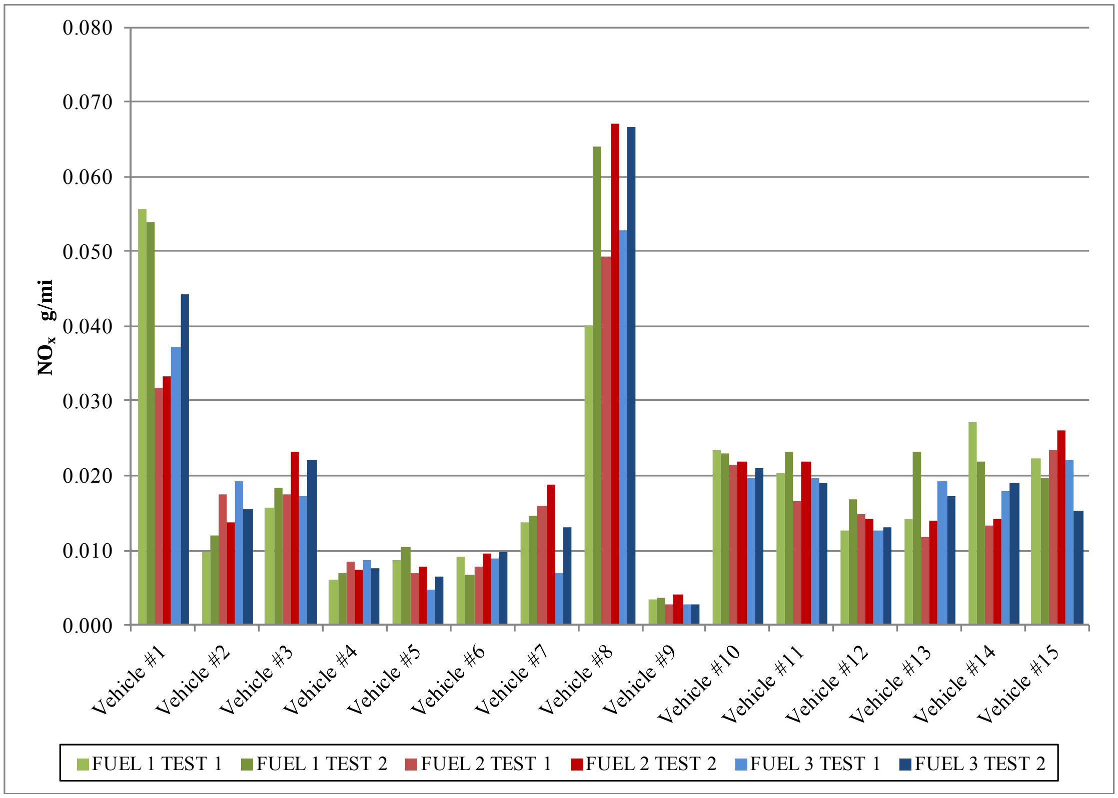

FIGURE 9. LA-92 COMPOSITE NO_X TEST RESULTS

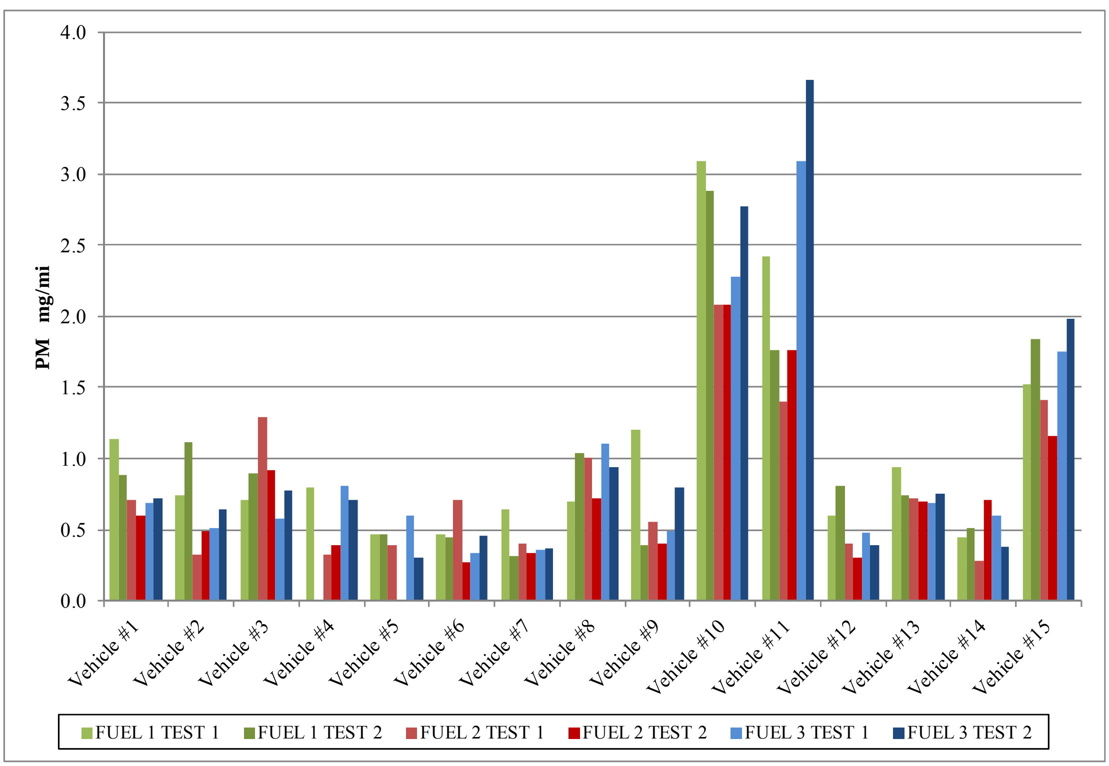

FIGURE 10. LA-92 COMPOSITE PM TEST RESULTS

The Phase 1 results of the LA-92 cycle for ethanol, methanol, acetaldehyde, formaldehyde, benzene, and 1,3-butediene are shown in Figures 11 through 16. The Phase 1 results show much higher values than Phase 2, Phase 3 and composite results. In an effort to identify any trends of the six compounds, the Phase 1 results are shown in the graphs below as opposed to the composite results. The composite results of all six compounds are given in tables in Appendix F. The additional C_2-C_{12} speciation results including phase-by-phase exhaust emission rates were uploaded to a secure ftp site upon completion of review.

The ethanol results are shown in Figure 11. The Fuel 1 ethanol results are given in the chart, however since it was an E0 fuel, ethanol values in most cases below the detection limit. Fuel 2 and Fuel 3 show increasing ethanol trend as expected. While testing Vehicle #7 with Fuel 3, the Phase 1 ethanol result from Test 2 was high compared to Test 1. A third test was performed due to failed NO_X repeatability. The ethanol results from Test 3 showed similar results as Test 1.

The results for methanol do not show any distinct trends between the three fuels. The values on a few tests were lower than the detection limit and could not be quantified. While testing Vehicle #1 with Fuel 1, the Phase 1 methanol result from Test 2 was high compared to Test 1. Additionally, Phase 2 and Phase 3 had slightly higher results compared to Test 1. These results were double-checked and found to be correct. A third test was not performed since the third test criteria checks were within the repeatability limits.

The acetaldehyde results are shown in Figure 13. The results of acetaldehyde show an increasing trend with increased ethanol concentrations on all vehicles. While testing Vehicle #1 with Fuel 3, the Phase 1 methanol result from Test 2 was low compared to Test 1. These results were double-checked and found to be correct. A third test was not performed since the third test criteria checks were within the repeatability limits.

The formaldehyde results are shown in Figure 14. The results of formaldehyde are typically lower for Fuel 2 compared to Fuel 1 and Fuel 3 for the majority of the vehicles. The results of benzene and 1,3-butadiene shown in Figures 15 and 16, respectively, are higher in most cases for Fuel 1 when compared to Fuel 2 and Fuel 3. This is expected due to the higher overall aromatic content in fuel 1.

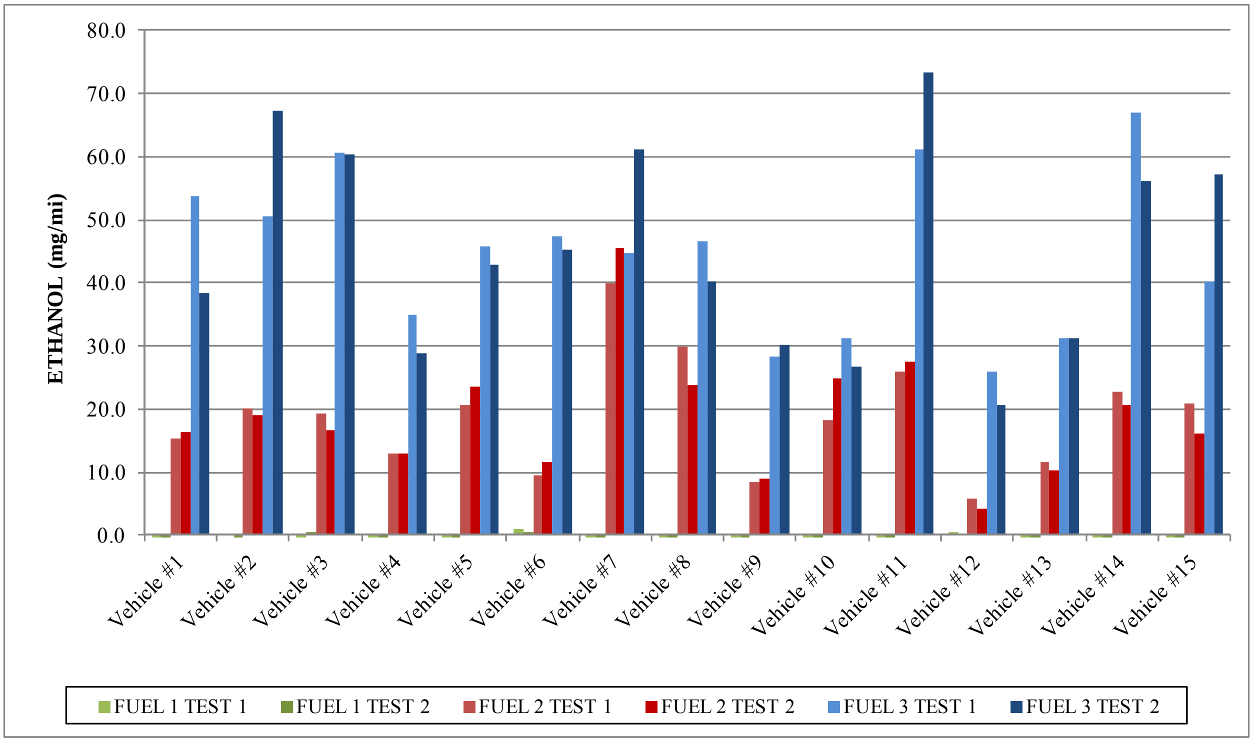

FIGURE 11. LA-92 PHASE 1 ETHANOL TEST RESULTS

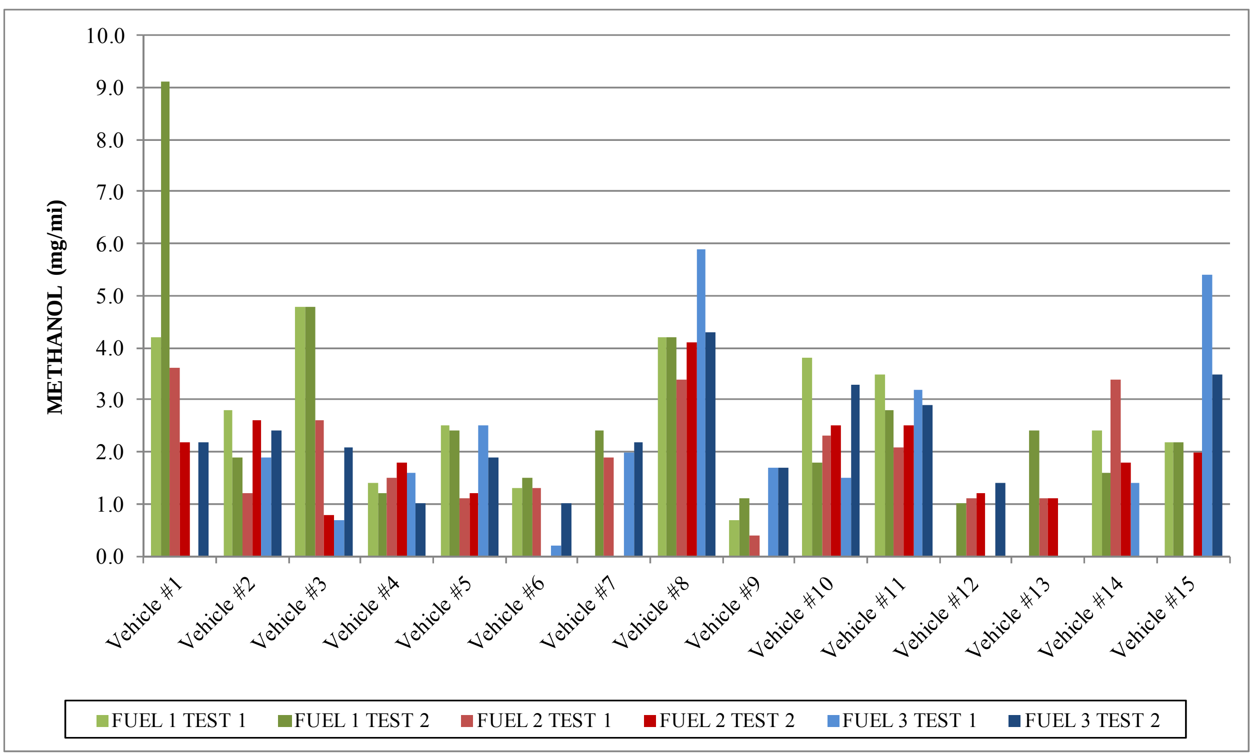

FIGURE 12. LA-92 PHASE 1 METHANOL TEST RESULTS

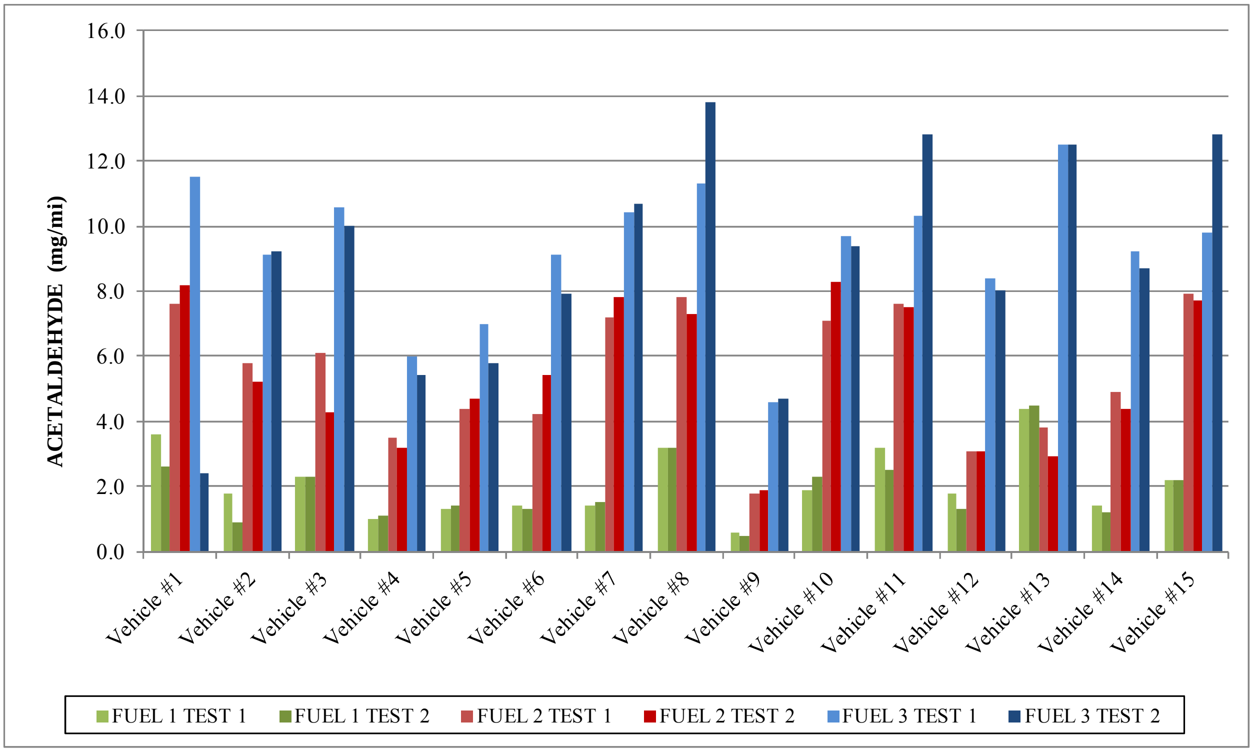

FIGURE 13. LA-92 PHASE 1 ACETALDEHYDE TEST RESULTS

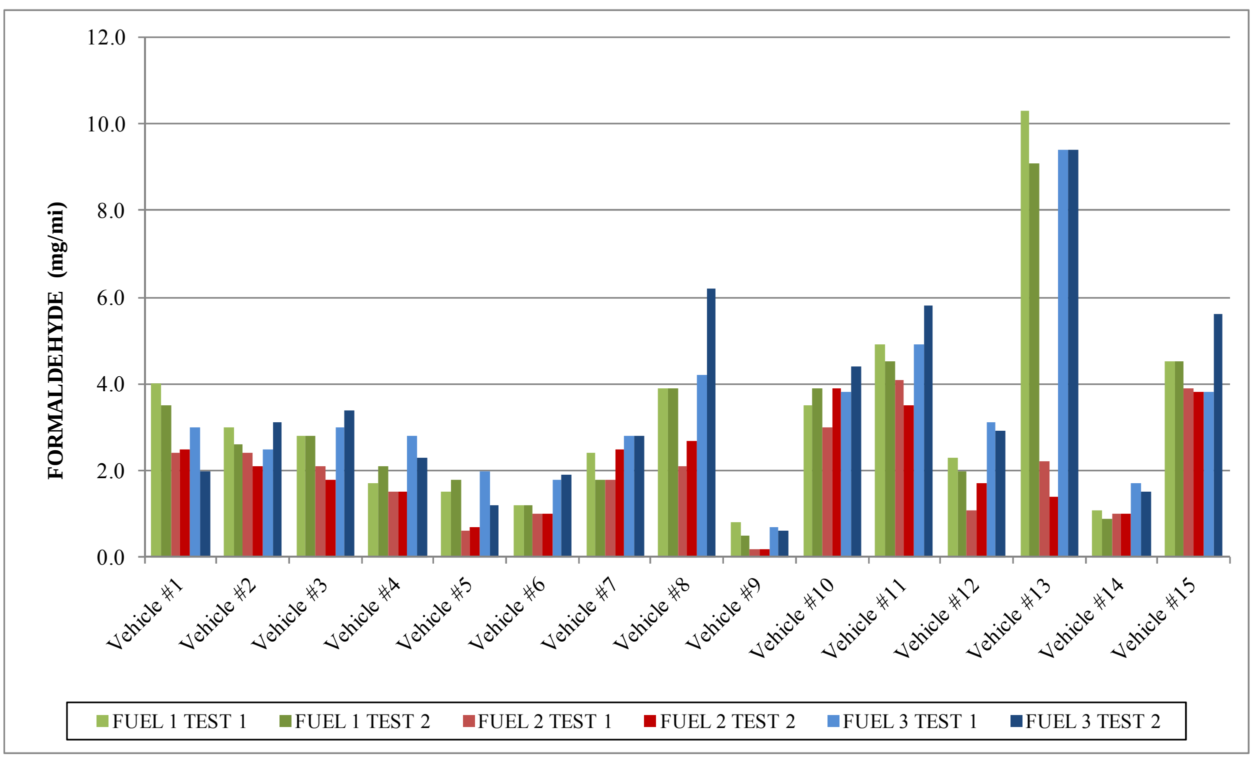

FIGURE 14. LA-92 PHASE 1 FORMALDEHYDE TEST RESULTS

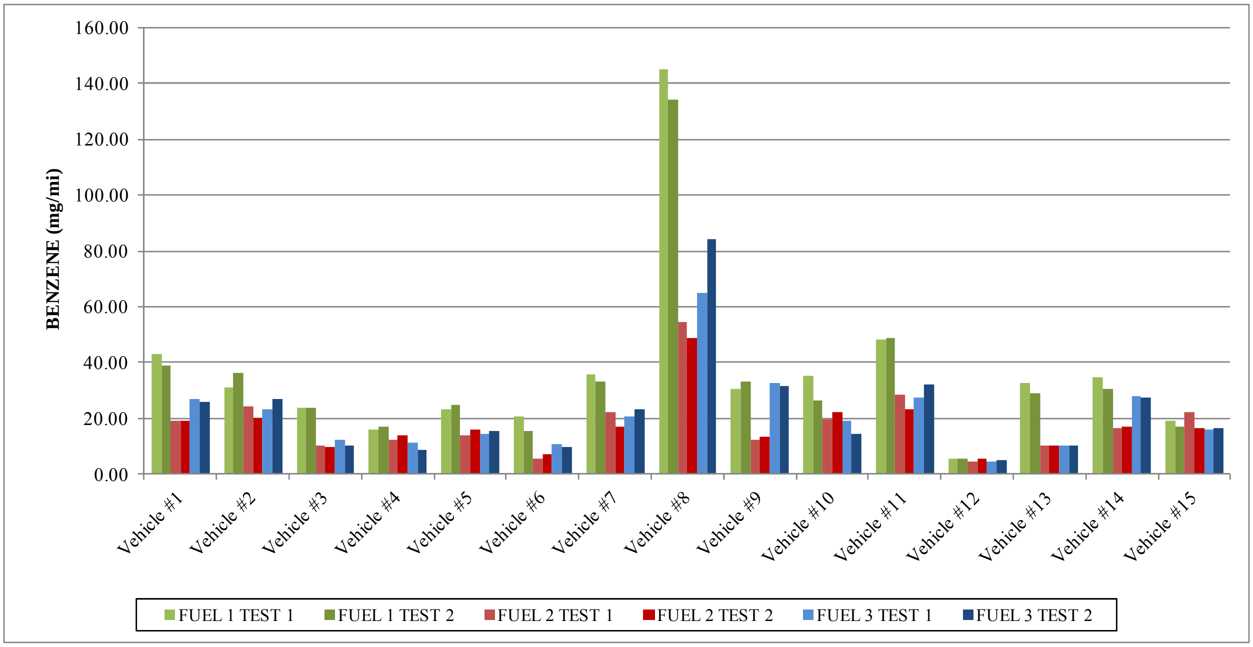

FIGURE 15. LA-92 PHASE 1 BENZENE TEST RESULTS

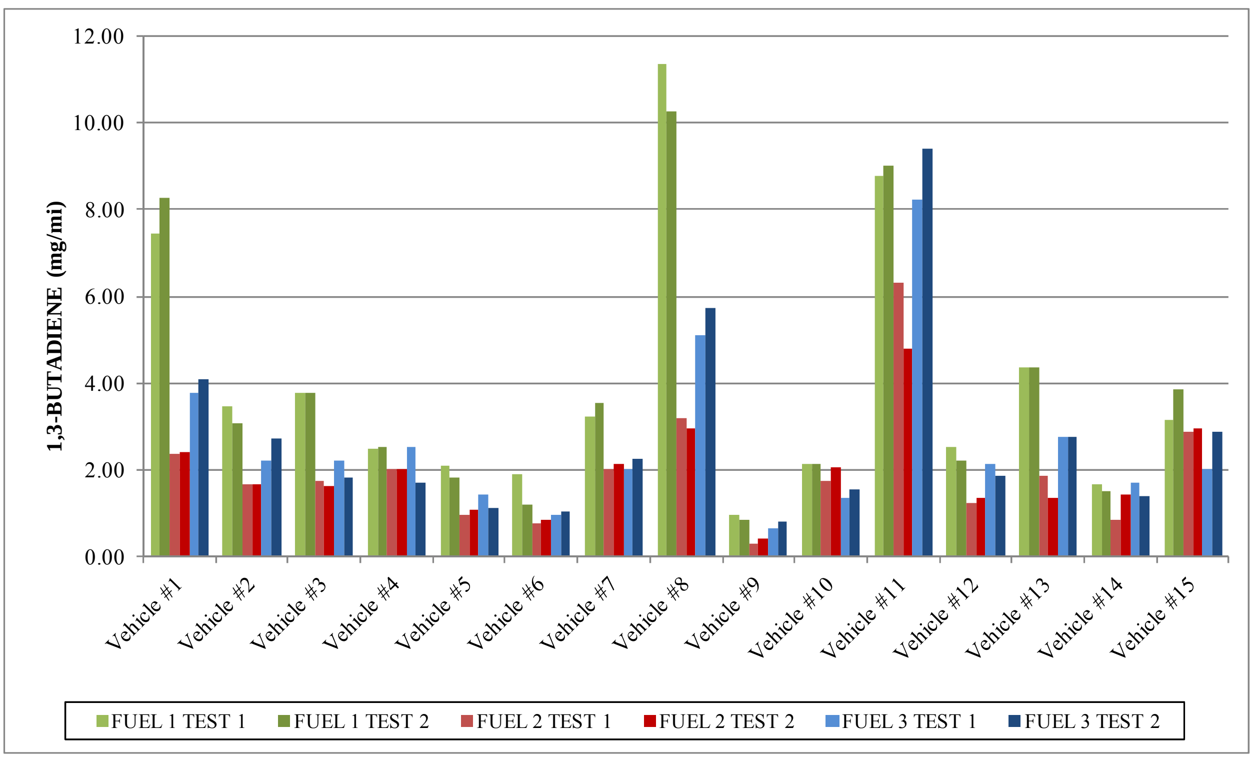

FIGURE 16. LA-92 PHASE 1 1,3-BUTADIENE TEST RESULTS

3.3 E-98 Fuel 1 vs. EPAct Fuel 13

Fuel 1 tested in this program was a reformulation of Fuel 13 used in the EPAct/V2/E-89 study. The fuel properties of both fuels are shown in the Table 7 below.

TABLE 7. FUEL 1 AND FUEL 13 PROPERTIES

Property	Unit	Fuel	
		E-98 Fuel 1	EPAct Fuel 13
Density, 60°F	**g/cm^3**	**0.7574**	**0.7544**
API Gravity, 60°F	°API	55.2	56
Ethanol	**vol. %**	**0.0**	**0.0**
Total Content of Oxygenates Other Than Ethanol	vol. %	0.0	
Distillation, IBP	ºF	94.0	97
5% evap	ºF	125.1	123
10% evap	ºF	140.9	137
20% evap	ºF	166.0	157
30% evap	ºF	189.9	177
40% evap	ºF	210.8	198
50% evap	**ºF**	**225.5**	**222**
60% evap	ºF	238.3	245
70% evap	ºF	254.1	270
80% evap	ºF	291.8	303
90% evap	**ºF**	**340.5**	**339**
95% evap	ºF	354.9	355
FBP	ºF	382.1	377
DVPE (EPA equation)	**psi**	**7.21**	**6.65**
Aromatics	**vol. %**	**35.4**	**40.0**
Olefins	vol. %	6.2	7.0
Saturates	vol. %	58.4	61.4
Benzene	vol. %	0.49	0.62
S	mg/kg	21	25
RON	-	95.6	93.0
MON	-	85.9	85.0
(RON+MON)/2	-	90.8	89.0
C	**mass %**	**87.21**	**86.43**
H	**mass %**	**12.79**	**13.57**
O	**mass %**	**0.00**	**0.00**
Net Heating Value	**Btu/lb**	**18861.4**	**18572.0**

A comparison of emission results for the 15 vehicle fleet tested on Fuel 1 from this program and on Fuel 13 in the EPAct program is shown in Tables 8 through 22. In most cases THC, CO and NO_X emissions were higher for Fuel 1 compared to Fuel 13. This program was conducted at the same test site used for the EPAct program, but a different driver was used.

TABLE 8. VEHICLE #1 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC g/mi	PM mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	13823	0.079	2.239	0.056	370.6	0.069	1.1	24.44
Test 2	E-98 Fuel 1	13834	0.077	3.028	0.054	371.5	0.067	0.9	24.30
Test 1	EPAct Fuel 13	6241	0.064	1.035	0.026	363.0	0.057	0.5	24.77
Test 2	EPAct Fuel 13	6252	0.057	0.745	0.021	363.6	0.051	0.7	24.76

TABLE 9. VEHICLE #2 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC g/mi	PM mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	12319	0.057	1.852	0.012	419.9	0.043	1.1	21.63
Test 2	E-98 Fuel 1	12308	0.054	1.813	0.010	423.1	0.042	0.7	21.47
Test 1	EPAct Fuel 13	5132	0.041	1.528	0.018	423.9	0.031	0.3	21.19
Test 2	EPAct Fuel 13	5121	0.036	1.482	0.007	420.1	0.027	0.5	21.38

TABLE 10. VEHICLE #3 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC g/mi	PM mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	12391	0.053	0.319	0.016	358.6	0.048	0.7	25.47
Test 2	E-98 Fuel 1	12402	0.043	0.298	0.018	361.6	0.038	0.9	25.26
Test 1	EPAct Fuel 13	5354	0.025	0.152	0.020	357.8	0.022	0.5	25.23
Test 2	EPAct Fuel 13	5972	0.028	0.166	0.019	353.9	0.025	0.4	25.51
Test 3	EPAct fuel 13	7620	0.023	0.128	0.019	358.2	0.020	0.7	25.21

TABLE 11. VEHICLE #4 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC g/mi	PM mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	13543	0.019	0.340	0.006	308.1	0.017	0.8	29.64
Test 2	E-98 Fuel 1	13554	0.019	0.325	0.007	308.0	0.016	0.9	29.65
Test 1	EPAct Fuel 13	6190	0.016	0.264	0.006	304.6	0.013	0.4	29.62
Test 2	EPAct Fuel 13	6201	0.016	0.274	0.004	304.3	0.014	0.6	29.65

TABLE 12. VEHICLE #5 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC g/mi	PM mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	12743	0.037	0.683	0.009	357.3	0.031	0.5	25.52
Test 2	E-98 Fuel 1	12755	0.037	0.642	0.010	355.9	0.031	0.5	25.63
Test 1	EPAct Fuel 13	6369	0.032	0.599	0.004	347.7	0.027	0.3	25.91
Test 2	EPAct Fuel 13	6380	0.034	0.595	0.003	349.3	0.029	0.7	25.79

TABLE 13. VEHICLE #6 CE E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC g/mi	PM mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	13130	0.036	0.225	0.009	313.5	0.034	0.5	29.15
Test 2	E-98 Fuel 1	13141	0.036	0.186	0.007	314.8	0.033	0.4	29.03
Test 1	EPAct Fuel 13	5489	0.022	0.103	0.009	303.5	0.020	0.5	29.75
Test 2	EPAct Fuel 13	5500	0.021	0.077	0.004	302.9	0.020	0.0	29.81

TABLE 14. VEHICLE #7 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC g/mi	PM mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	15186	0.058	1.080	0.014	578.2	0.047	0.6	15.77
Test 2	E-98 Fuel 1	15197	0.053	1.252	0.015	575.7	0.043	0.3	15.83
Test 1	EPAct Fuel 13	6966	0.037	0.858	0.022	568.2	0.029	0.3	15.86
Test 2	EPAct Fuel 13	6977	0.050	0.999	0.020	563.8	0.039	0.4	15.98

TABLE 15. VEHICLE #8 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC g/mi	PM mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	15353	0.172	3.465	0.040	592.4	0.138	0.7	15.29
Test 2	E-98 Fuel 1	15374	0.155	4.160	0.064	597.4	0.119	1.0	15.14
Test 3	E-98 Fuel 1	15395	0.140	3.443	0.060	598.3	0.105	0.8	15.15
Test 1	EPAct Fuel 13	6131	0.102	2.222	0.023	597.7	0.074	0.3	15.02
Test 2	EPAct Fuel 13	6142	0.095	2.127	0.027	598.2	0.068	0.8	15.01

TABLE 16. VEHICLE #9 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC, g/mi	PM, mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	12457	0.016	0.394	0.003	333.4	0.013	1.2	27.39
Test 2	E-98 Fuel 1	12468	0.017	0.397	0.004	330.9	0.014	0.4	27.59
Test 1	EPAct Fuel 13	6197	0.035	0.437	0.006	321.7	0.030	0.4	28.02
Test 2	EPAct Fuel 13	6208	0.023	0.351	0.001	322.7	0.020	0.4	27.95

TABLE 17. VEHICLE #10 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC, g/mi	PM, mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	12356	0.063	0.957	0.023	426.5	0.047	3.1	21.37
Test 2	E-98 Fuel 1	12664	0.053	0.713	0.023	423.3	0.038	2.9	21.55
Test 1	EPAct Fuel 13	5986	0.046	0.519	0.022	418.9	0.031	2.1	21.52
Test 2	EPAct Fuel 13	5997	0.056	0.562	0.022	426.9	0.039	2.4	21.11

TABLE 18. VEHICLE #11 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC, g/mi	PM, mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	12480	0.062	0.741	0.020	521.7	0.048	2.4	17.49
Test 2	E-98 Fuel 1	12491	0.062	0.793	0.023	519.3	0.048	1.8	17.57
Test 1	EPAct Fuel 13	5117	0.054	0.619	0.015	515.3	0.042	2.6	17.50
Test 2	EPAct Fuel 13	5129	0.059	0.660	0.019	515.4	0.045	3.3	17.49

TABLE 19. VEHICLE #12 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC, g/mi	PM, mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	12641	0.020	0.189	0.013	486.3	0.002	0.017	0.6
Test 2	E-98 Fuel 1	12652	0.018	0.206	0.017	496.7	0.003	0.015	0.8
Test 1	EPAct Fuel 13	5666	0.020	0.175	0.012	476.9	0.002	0.017	0.6
Test 2	EPAct Fuel 13	5677	0.019	0.145	0.013	483.0	0.002	0.017	0.5

TABLE 20. VEHICLE #13 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC, g/mi	PM, mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	13193	0.105	0.780	0.014	540.4	0.099	0.9	16.88
Test 2	E-98 Fuel 1	13204	0.092	0.898	0.023	532.9	0.085	0.7	17.12
Test 3	E-98 Fuel 1	13225	0.103	0.835	0.028	536.3	0.097	0.6	17.01
Test 1	EPAct Fuel 13	7481	0.050	1.063	0.025	535.2	0.043	1.0	16.83
Test 2	EPAct Fuel 13	7492	0.054	1.074	0.022	535.8	0.047	1.1	16.81

TABLE 21. VEHICLE #14 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC, g/mi	PM, mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	13440	0.042	0.550	0.027	456.1	0.038	0.4	20.02
Test 2	E-98 Fuel 1	13451	0.038	0.332	0.022	456.0	0.034	0.5	20.04
Test 1	EPAct Fuel 13	6637	0.029	0.156	0.015	444.6	0.025	0.6	20.31
Test 2	EPAct Fuel 13	6648	0.022	0.136	0.015	450.1	0.020	0.3	20.06

TABLE 22. VEHICLE #15 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer	THC, g/mi	CO, g/mi	NO_X, g/mi	CO_2, g/mi	NMHC, g/mi	PM, mg/mi	Fuel Economy, mi/gal
Test 1	E-98 Fuel 1	14683	0.054	1.938	0.020	594.5	0.042	1.8	15.31
Test 2	E-98 Fuel 1	14694	0.057	2.185	0.022	595.9	0.043	1.5	15.26
Test 1	EPAct Fuel 13	7844	0.043	1.862	0.021	594.0	0.032	1.6	15.13
Test 2	EPAct Fuel 13	7856	0.047	1.681	0.013	599.7	0.037	1.6	15.00

Additional comparisons of formaldehyde, acetaldehyde, benzene, and 1,3-butadiene results for the 15 vehicle fleet tested on Fuel 1 from this program and on Fuel 13 in the EPAct program is shown in Tables 23 through 37. In most cases the results of the four compounds repeated well between the two fuels.

TABLE 23. CHEMISTRY COMPOUNDS FOR VEHICLE #1 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#1-1-T1	E-98 Fuel 1	13823	7.44	43.17	4.0	3.6
E98-Veh#1-1-T2	E-98 Fuel 1	13834	8.26	39.16	3.5	2.6
EPA-Veh#1-P3-13-T1	EPAct Fuel 13	6241	6.03	35.75	2.4	4.0
EPA-Veh#1-P3-13-T2	EPAct Fuel 13	6252	NA	NA	3.2	4.8
NA – Not applicable, measurements were not taken for this test.						

TABLE 24. CHEMISTRY COMPOUNDS FOR VEHICLE #2 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#2-1-T1	E-98 Fuel 1	12308	3.47	31.02	3.0	1.8
E98-Veh#2-1-T2	E-98 Fuel 1	12319	3.09	36.22	2.6	0.9
EPA-Veh#2-P3-13-T1	EPAct Fuel 13	5121	3.37	34.08	2.1	2.1
EPA-Veh#2-P3-13-T2	EPAct Fuel 13	5132	NA	NA	3.7	2.1
NA – Not applicable, measurements were not taken for this test.						

TABLE 25. CHEMISTRY COMPOUNDS FOR VEHICLE #3 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#3-1-T1	E-98 Fuel 1	12391	3.79	23.86	2.8	2.3
E98-Veh#3-1-T2	E-98 Fuel 1	12402	2.92	20.83	2.6	1.7
EPA-Veh#3-P3-13-T3	EPAct Fuel 13	5354	NA	NA	2.8	2.5
EPA-Veh#3-P3-13-T4	EPAct Fuel 13	5972	3.66	21.46	3.0	2.4
EPA-Veh#3-P3-13-T5	EPAct Fuel 13	7620	2.92	14.11	3.4	2.3
NA – Not applicable, measurements were not taken for this test.						

TABLE 26. CHEMISTRY COMPOUNDS FOR VEHICLE #4 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#4-1-T1	E-98 Fuel 1	13543	2.50	15.91	1.7	1.0
E98-Veh#4-1-T2	E-98 Fuel 1	13554	2.53	17.00	2.1	1.1
EPA-Veh#4-P3-13-T1	EPAct Fuel 13	6190	2.87	16.96	2.1	1.4
EPA-Veh#4-P3-13-T2	EPAct Fuel 13	6201	NA	NA	1.7	1.2
NA – Not applicable, measurements were not taken for this test.						

TABLE 27. CHEMISTRY COMPOUNDS FOR VEHICLE #5 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98- Veh#5-1-T1	E-98 Fuel 1	12743	2.08	23.22	1.5	1.3
E98-Veh#5-1-T2	E-98 Fuel 1	12755	1.82	25.05	1.8	1.4
EPA-Veh#5-P3-13-T1	EPAct Fuel 13	6369	6.79	31.15	1.1	1.4
EPA-Veh#5-P3-13-T2	EPAct Fuel 13	6380	NA	NA	1.0	1.3
NA – Not applicable, measurements were not taken for this test.						

TABLE 28. CHEMISTRY COMPOUNDS FOR VEHICLE #6 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#6-1-T1	E-98 Fuel 1	13130	1.90	20.88	1.2	1.4
E98-Veh#6-1-T2	E-98 Fuel 1	13141	1.19	15.36	1.2	1.3
EPA-Veh#6-P3-13-T1	EPAct Fuel 13	5489	2.22	12.30	1.5	1.8
EPA-Veh#6-P3-13-T2	EPAct Fuel 13	5500	NA	NA	1.4	1.9
NA – Not applicable, measurements were not taken for this test.						

TABLE 29. CHEMISTRY COMPOUNDS FOR VEHICLE #7 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#7-1-T1	E-98 Fuel 1	15186.3	3.23	35.63	2.4	1.4
E98-Veh#7-1-T2	E-98 Fuel 1	15197.4	3.54	33.36	1.8	1.5
EPA-Veh#7-P3-13-T1	EPAct Fuel 13	6966.7	5.66	28.89	4.7	2.6
EPA-Veh#7-P3-13-T2	EPAct Fuel 13	6977.8	NA	NA	4.8	2.9
NA – Not applicable, measurements were not taken for this test.						

TABLE 30. CHEMISTRY COMPOUNDS FOR VEHICLE #8 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#8-1-T1	E-98 Fuel 1	15353.1	11.37	144.94	3.9	3.2
E98-Veh#8-1-T2	E-98 Fuel 1	15374	10.27	134.12	3.9	3.2
E98-Veh#8-1-T3	E-98 Fuel 1	15395.9	8.74	125.76	5.1	3.5
EPA-Veh#8-P3-13-T1	EPAct Fuel 13	6131.1	4.30	61.58	4.1	2.7
EPA-Veh#8-P3-13-T2	EPAct Fuel 13	6142.1	NA	NA	3.6	2.5
NA – Not applicable, measurements were not taken for this test.						

TABLE 31. CHEMISTRY COMPOUNDS FOR VEHICLE #9 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#9-1-T1	E-98 Fuel 1	12457.5	0.98	30.65	0.8	0.6
E98-Veh#9-1-T2	E-98 Fuel 1	12468.3	0.85	33.27	0.5	0.5
EPA-Veh#9-P3-13-T1	EPAct Fuel 13	6197.2	2.37	56.20	0.7	1.2
EPA-Veh#9-P3-13-T2	EPAct Fuel 13	6208.1	NA	NA	0.9	1.0
NA – Not applicable, measurements were not taken for this test.						

TABLE 32. CHEMISTRY COMPOUNDS FOR VEHICLE #10 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#10-1-T1	E-98 Fuel 1	12356	2.15	35.33	3.5	1.9
E98-Veh#10-1-T2	E-98 Fuel 1	12664	2.14	26.47	3.9	2.3
EPA-Veh#10-P3-13-T1	EPAct Fuel 13	5986	NA	NA	3.8	2.1
EPA-Veh#10-P3-13-T2	EPAct Fuel 13	5997	3.42	23.67	4.0	2.1
NA – Not applicable, measurements were not taken for this test.						

TABLE 33. CHEMISTRY COMPOUNDS FOR VEHICLE #11 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#11-1-T2	E-98 Fuel 1	12491	9.01	48.55	4.5	2.5
EPA-Veh#11-P3-13-T1	EPAct Fuel 13	5117	12.24	50.92	5.8	2.9
EPA-Veh#11-P3-13-T2	EPAct Fuel 13	5129	NA	NA	5.6	2.9
NA – Not applicable, measurements were not taken for this test.						

TABLE 34. CHEMISTRY COMPOUNDS FOR VEHICLE #12 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#12-1-T1	E-98 Fuel 1	12641	2.54	5.62	2.3	1.8
E98-Veh#12-1-T2	E-98 Fuel 1	12652	2.20	5.78	2.0	1.3
EPA-Veh#12-P3-13-T1	EPAct Fuel 13	5666	3.11	9.17	2.45	1.97
EPA-Veh#12-P3-13-T2	EPAct Fuel 13	5677	NA	NA	2.5	2.1
NA – Not applicable, measurements were not taken for this test.						

TABLE 35. CHEMISTRY COMPOUNDS FOR VEHICLE #13 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#13-1-T1	E-98 Fuel 1	13193	4.35	32.50	10.3	4.4
E98-Veh#13-1-T2	E-98 Fuel 1	13204	4.35	28.95	9.1	4.5
E98-Veh#13-1-T3	E-98 Fuel 1	13225	4.00	33.29	9.3	4.3
EPA-Veh#13-P3-13-T1	EPAct Fuel 13	7481	6.42	19.59	9.7	4.3
EPA-Veh#13-P3-13-T2	EPAct Fuel 13	7492	NA	NA	9.7	4.3
NA – Not applicable, measurements were not taken for this test.						

TABLE 36. CHEMISTRY COMPOUNDS FOR VEHICLE #14 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#14-1-T1	E-98 Fuel 1	13440	1.67	34.78	1.1	1.4
E98- Veh#14-1-T2	E-98 Fuel 1	13451	1.52	30.42	0.9	1.2
EPA-Veh#14-P3-13-T1	EPAct Fuel 13	6637	2.74	29.84	1.0	1.7
EPA-Veh#14-P3-13-T2	EPAct Fuel 13	6648	NA	NA	1.1	1.6
NA – Not applicable, measurements were not taken for this test.						

TABLE 37. CHEMISTRY COMPOUNDS FOR VEHICLE #15 E-98 FUEL 1 vs. EPAct FUEL 13

Test Number	Fuel Name	Odometer, mi	1,3-Butadiene, mg/mi	Benzene, mg/mi	Formaldehyde, mg/mi	Acetaldehyde, mg/mi
E98-Veh#15-1-T1	E-98 Fuel 1	14683	3.17	19.01	4.5	2.2
E98-Veh#15-1-T2	E-98 Fuel 1	14694	3.85	17.11	4.5	2.2
EPA-Veh#15-P3-13-T1	EPAct Fuel 13	7844	3.26	23.13	5.1	3.1
EPA-Veh#15-P3-13-T2	EPAct Fuel 13	7856	NA	NA	5.9	3.7
NA – Not applicable, measurements were not taken for this test.						

4.0 ISSUES ENCOUNTERED WHILE TESTING

Most of the vehicle issues were addressed prior to beginning the test program during the vehicle inspection process. The only issue encountered during the test matrix is discussed in this section.

Dodge Caliber Evaporative System

While performing Test 2 on Fuel 2 of the test matrix, the vehicle's MIL illuminated. The diagnostic trouble code (DTC) was P0455 evaporative emission system leak detected (gross leak/no flow). A leak check of the complete evaporative system was performed with a Smoke Pro® Total-Tech™ device. The smoke was injected from the evaporative hose at the engine and into the fuel tank. No leaks were detected. An evaporative system test was also performed with the Snap-On scanner and no faults occurred. The fuel cap was replaced with a new unit and the code was cleared. The vehicle was placed back into the test matrix and no other MIL instances occurred.

5.0 STATISTICAL ANALYSIS

5.1 Statistical Analysis Methods

Statistical analysis of the test results included (1) comparisons of the emissions test data collected on the three fuels tested on each of the fifteen vehicles from the EPAct/V2/E-89 study[1], and (2) comparisons of the predicted emissions from five different models developed by EPA and Richard Gunst[2] using the three test fuels. Each of these analyses are described in detail in the sections below.

5.2 Fleet Emissions Comparisons Across Three E-98 Test Fuels

A fleet of fifteen vehicles from the EPAct/V2/E-89 study were tested for emissions using the three test fuels listed in Table 1. The emissions studied were selected in consultation with CRC and include the following:

- THC, g/mi (Composite, Phase 1, Phase 2, Phase 3)
- NMHC, g/mi (Composite, Phase 1, Phase 2, Phase 3)
- CH_4, g/mi (Composite, Phase 1, Phase 2, Phase 3)
- CO, g/mi (Composite, Phase 1, Phase 2, Phase 3)
- NO_X, g/mi (Composite, Phase 1, Phase 2, Phase 3)
- PM, mg/mi (Composite, Phase 1, Phase 2, Phase 3)

An analysis of variance (ANOVA) was used to examine the changes in the average emissions from Fuel 2 to Fuel 1 and, secondly, from Fuel 3 to Fuel 1. All statistical analyses were performed in natural LOG transformations of the measured emissions. This transformation has generally been found to help uphold the assumption that the variability of the emissions be constant throughout the range of the measured emissions data. Furthermore, the LOG emissions from the two or three repeat tests for each fuel x vehicle combination were then averaged before fitting the ANOVA model. The ANOVA model examined the average LOG emissions across the following factors:

- Fuel (Fuel 1 vs Fuel 2, Fuel 1 vs. Fuel 3)
- Vehicle (15 vehicle makes/models)

Levels of the factors in this model represent only the levels in which one can make inferences. Multiple-comparison techniques were used to compare the emissions means across the fuels in order to determine statistical significance. Dunnett's multiple comparison procedure[3] was used to assess the significance in the difference in average emissions from Fuel 1 to Fuel 2 and Fuel 1 to Fuel 3. Least-squares means (LSMeans) were used for the emissions comparisons

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[1] *Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles Certified to Tier 2 Standards: Analysis of Data from EPAct Phase 3 (EPAct/V2/E-89) Final Report*, US Environmental Protection Agency, EPA-420-R-13-002, April 2013.

[2] *Statistical Analysis of the Phase 3 Emissions Data Collected in the EPAct/V2/E89 Program Final Report*, Principal Investigator Richard F. Gunst, National Renewable Energy Laboratory Subcontract No. LGC-0-40441-01, July 2011.

[3] "A Multiple Comparisons Procedure for Comparing Several Treatments with a Control," *Journal of the American Statistical Association*, 50, pp.1096-1121, 1955.

across fuels. All statistical tests were performed at α=0.05 level of significance. In all analyses, each emission was examined independently for each phase.

5.3 Fuel Comparisons for THC

An analysis of variance was performed to examine the changes in average LOG(THC) emissions from Fuel 1 to Fuel 2 and from Fuel 1 to Fuel 3. Also included in the ANOVA model were effects due to vehicles. The results of the ANOVA for comparing Fuels 2 and 3 to Fuel 1 are provided in Table 38. The estimated LSMeans (in LOG and original units) are listed by phase and fuel. There were statistically significant differences comparing the THC LSMeans for Fuel 1 vs. Fuel 2 for the Composite and Phase 1 (p-value < 0.05).

TABLE 38. ANOVA RESULTS BY PHASE COMPARING LOG(THC) LSMEANS AGAINST FUEL 1

Emission	Phase	Fuel	LOG(LSMean)	LSMean	P-Value
THC g/mi	Composite	1	-3.0619	0.046801	-
THC g/mi	Composite	2	-3.4838	0.030691	<0.0001
THC g/mi	Composite	3	-3.1670	0.042130	0.3205
THC g/mi	Phase 1	1	-0.4586	0.632149	-
THC g/mi	Phase 1	2	-1.0281	0.357693	<0.0001
THC g/mi	Phase 1	3	-0.6387	0.528005	0.1569
THC g/mi	Phase 2	1	-4.5078	0.011022	-
THC g/mi	Phase 2	2	-4.5188	0.010902	0.9965
THC g/mi	Phase 2	3	-4.4415	0.011778	0.8823
THC g/mi	Phase 3	1	-3.8968	0.020307	-
THC g/mi	Phase 3	2	-4.1943	0.015081	0.2456
THC g/mi	Phase 3	3	-4.2308	0.014541	0.1790

5.3.1 THC - Composite

The results of the ANOVA for the LOG(THC) Composite phase are provided in Table 39. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 17 illustrates the average Composite THC emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Composite THC emission for each of the three fuels by vehicle.

TABLE 39. ANOVA TABLE FOR COMPARING LOG(THC) COMPOSITE TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	1.44722938	0.72361469	15.54	<0.0001
Vehicle	14	12.51827299	0.89416236	19.20	<0.0001

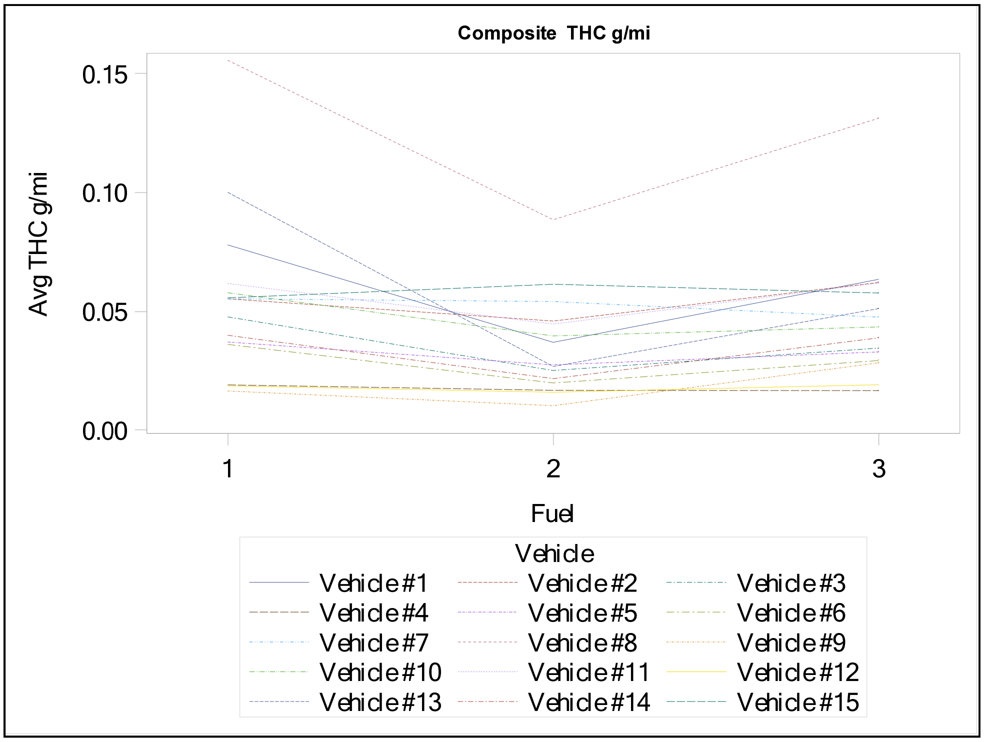

FIGURE 17. PLOT OF AVERAGE THC COMPOSITE TEST RESULTS BY FUEL AND VEHICLE

The LOG(THC) Composite results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 18. The x-axis represents the two fuel comparisons (Fuel 1 vs. Fuel 2 and Fuel 1 vs Fuel 3). The horizontal line within the shaded area is drawn at the Fuel 1 LSMean value. The two vertical lines starting from the Fuel 1 line terminate at the LSMeans for Fuels 2 and 3, respectively. Thus, the lengths of the vertical lines represent the difference in the LSMeans for Fuel 1 vs Fuels 2 and 3. The horizontal shaded area indicates the upper and lower decision limits comparing LSMEANS for Fuels 2 and 3 against Fuel 1. If a vertical line extends beyond the upper or lower decision limits, the corresponding Fuel 2 and/or Fuel 3 LSMean is significantly different from the Fuel 1 LSMean. When the LSMeans for Fuels 2 or 3 are lower than Fuel 1, then there is a reduction in the LOG(THC) Composite. Likewise, when the LSMeans for Fuels 2 or 3 are higher than Fuel 1 there is an increase in LOG(THC) Composite. As shown in Figure 18, the LSMeans for LOG(THC) Composite are significantly different for Fuel 2 vs. Fuel 1. In this comparison, Fuel 2 demonstrated a reduction in LOG(THC) Composite LSMeans.

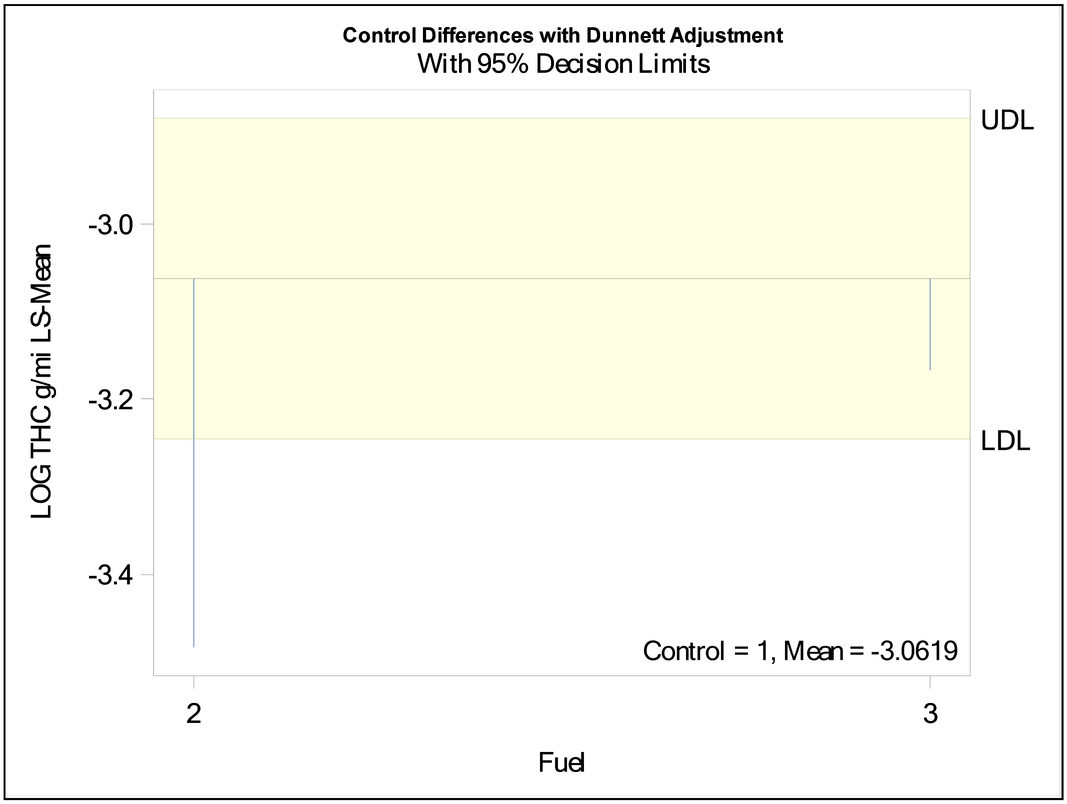

FIGURE 18. PLOT OF LOG(THC) COMPOSITE LSMEAN DIFFERENCES AGAINST FUEL 1

5.3.2 THC – Phase 1

The results of the ANOVA for the LOG(THC) Phase 1 are provided in Table 40. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 19 illustrates the average Phase 1 THC emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 1 THC emission for each of the three fuels by vehicle.

TABLE 40. ANOVA TABLE FOR COMPARING LOG(THC) PHASE 1 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	2.54169808	1.27084904	16.16	<0.0001
Vehicle	14	8.15939949	0.58281425	7.41	<0.0001

The LOG(THC) Phase 1 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 20. As shown in Figure 20, the LSMeans for LOG(THC) Phase 1 are significantly different for Fuel 2 vs. Fuel 1. In this comparison, Fuel 2 demonstrated a reduction in LOG(THC) Phase 1 LSMeans.

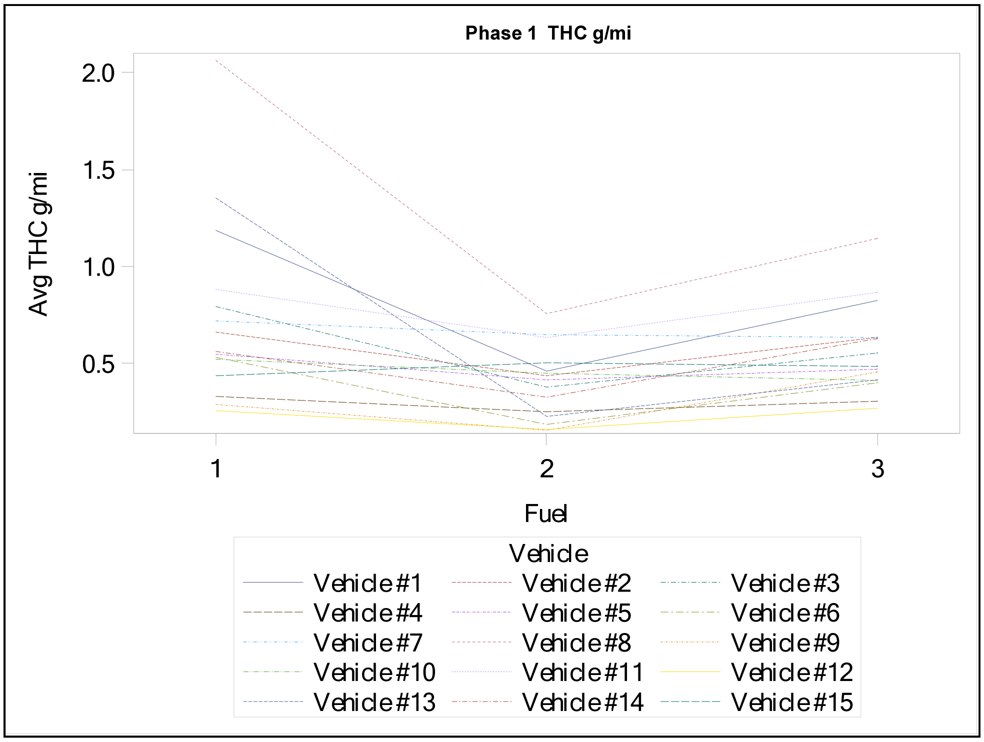

FIGURE 19. PLOT OF AVERAGE THC PHASE 1 TEST RESULTS BY FUEL AND VEHICLE

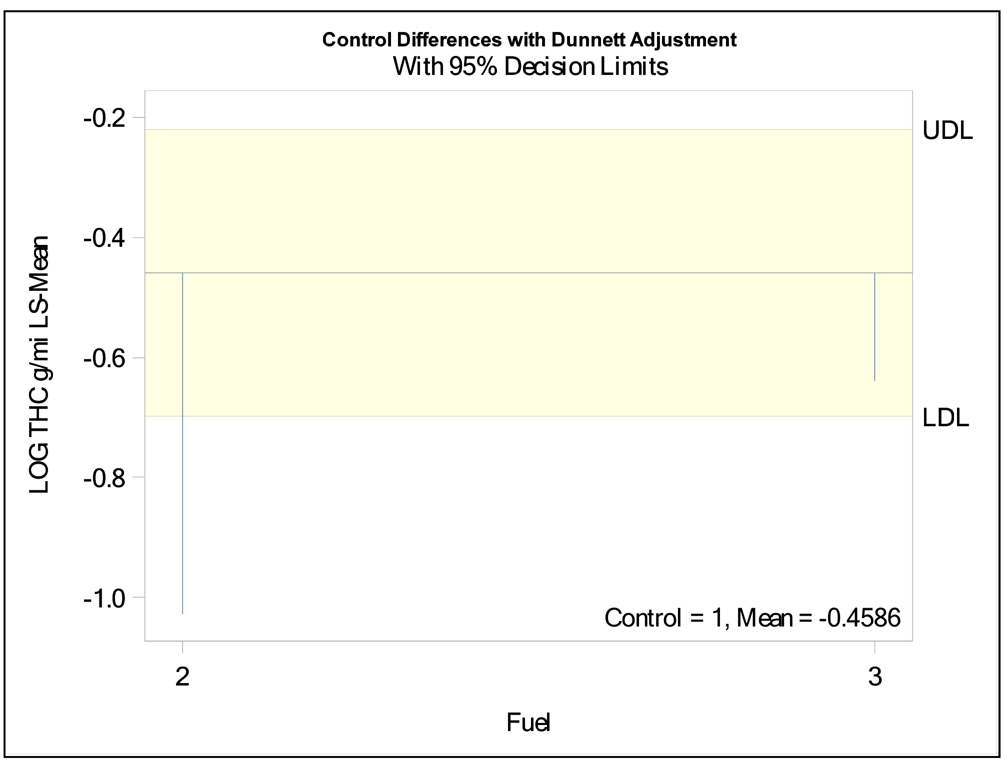

FIGURE 20. PLOT OF LOG(THC) PHASE 1 LSMEAN DIFFERENCES AGAINST FUEL 1

5.3.3 THC – Phase 2

The results of the ANOVA for the LOG(THC) Phase 2 are provided in Table 41. Note that statistically significant differences were observed across the 15 vehicles. Figure 21 illustrates the average Phase 2 THC emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 2 THC emission for each of the three fuels by vehicle.

TABLE 41. ANOVA TABLE FOR COMPARING LOG(THC) PHASE 2 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.05246122	0.02623061	0.14	0.8717
Vehicle	14	43.98364075	3.14168863	16.52	<0.0001

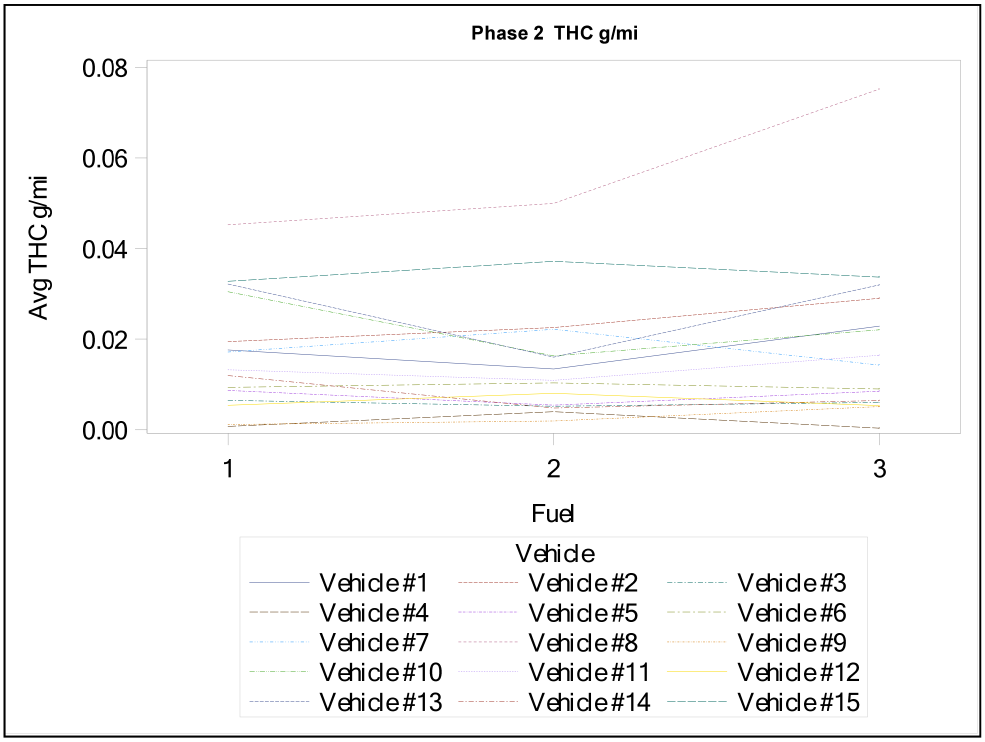

FIGURE 21. PLOT OF AVERAGE THC PHASE 2 TEST RESULTS BY FUEL AND VEHICLE

The LOG(THC) Phase 2 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 22. As shown in Figure 22, the LSMeans for LOG(THC) Phase 2 are not significantly different for Fuel 2 vs. Fuel 1 or Fuel 3 vs. Fuel 1.

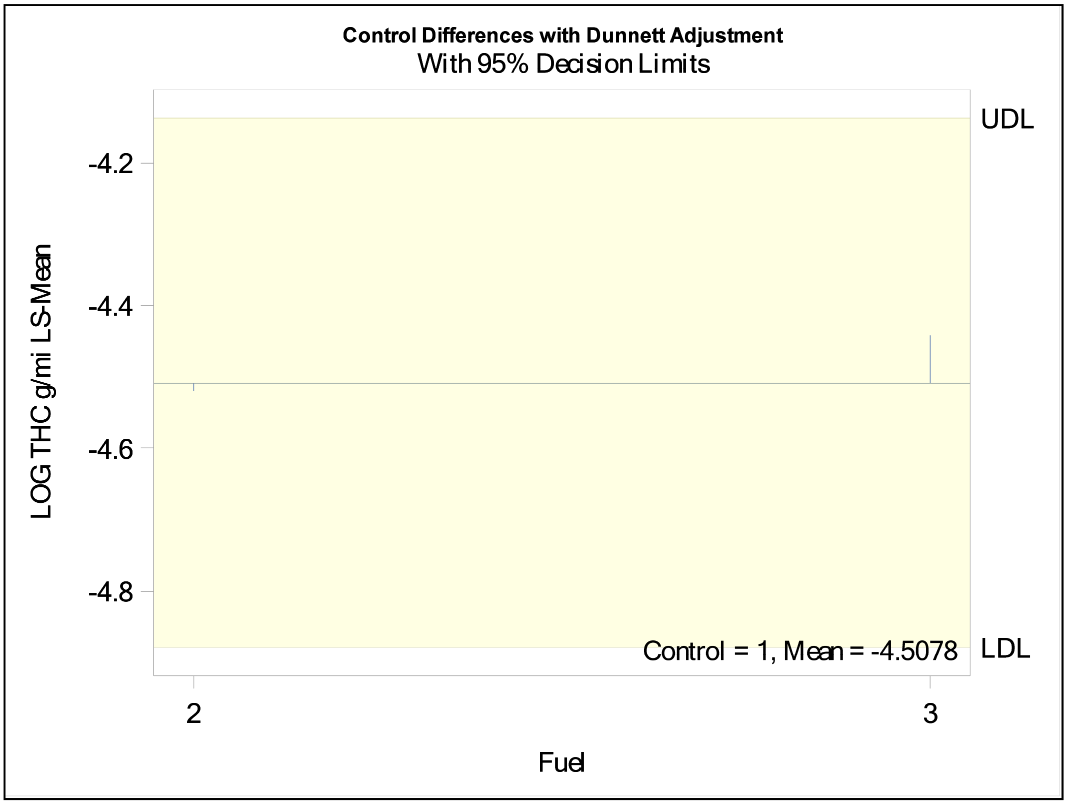

FIGURE 22. PLOT OF LOG(THC) PHASE 2 LSMEAN DIFFERENCES AGAINST FUEL 1

5.3.4 THC – Phase 3

The results of the ANOVA for the LOG(THC) Phase 3 are provided in Table 42. Note that statistically significant differences were observed across the 15 vehicles . Figure 23 illustrates the average Phase 3 THC emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 3 THC emission for each of the three fuels by vehicle.

TABLE 42. ANOVA TABLE FOR COMPARING LOG(THC) PHASE 3 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	1.00711607	0.50355534	1.71	0.1995
Vehicle	14	44.44322468	3.17451605	10.77	<0.0001

The LOG(THC) Phase 3 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 24. As shown in Figure 24 ,the LSMeans for LOG(THC) Phase 3 are not significantly different for Fuel 2 vs. Fuel 1 or Fuel 3 vs. Fuel 1

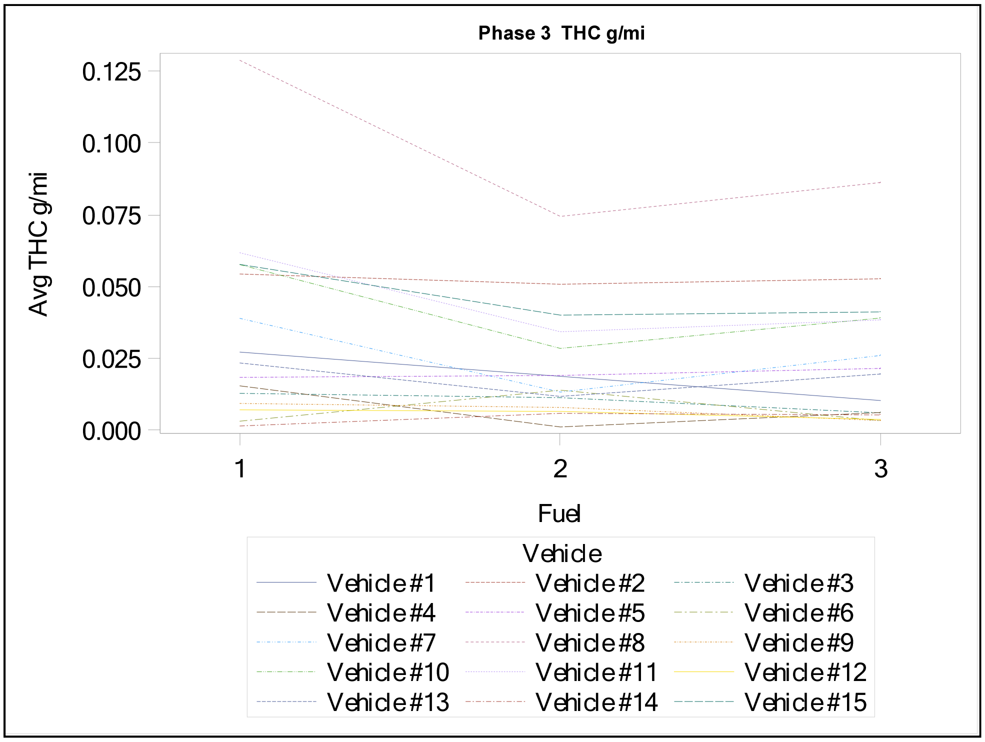

FIGURE 23. PLOT OF AVERAGE THC PHASE 3 TEST RESULTS BY FUEL AND VEHICLE

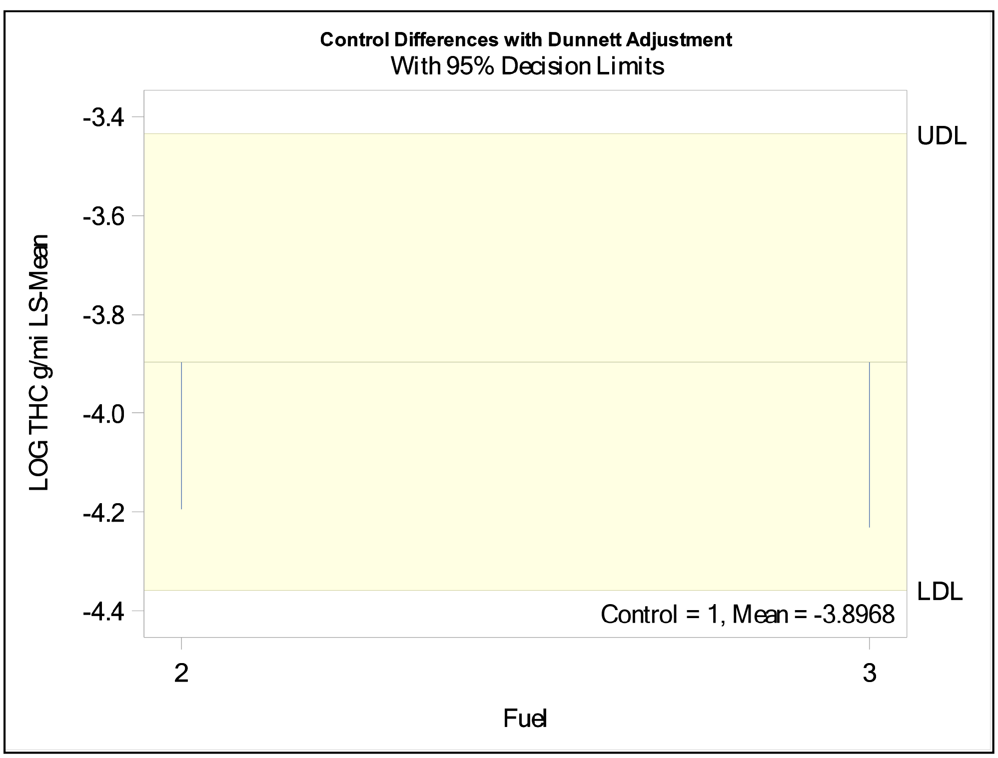

FIGURE 24. PLOT OF LOG(THC) PHASE 3 LSMEAN DIFFERENCES AGAINST FUEL 1

5.4 Fuel Comparisons for NMHC

An analysis of variance was performed to examine the changes in average LOG(NMHC) emissions from Fuel 1 to Fuel 2 and from Fuel 1 to Fuel 3. Also included in the ANOVA model were effects due to vehicles. The results of the ANOVA for comparing Fuels 2 and 3 to Fuel 1 are provided in Table 43. The estimated LSMeans (in LOG and original units) are listed by phase and fuel. There were statistically significant differences comparing the LOG(NMHC) LSMeans for Fuel 1 vs. Fuel 2 for the Composite and Phase 1; also, in comparing Fuel 1 vs. Fuel 3 for Phase 1 and Phase 3 (p-value < 0.05).

TABLE 43. ANOVA RESULTS BY PHASE COMPARING LOG(NMHC) LSMEANS AGAINST FUEL 1

Emission	Phase	Fuel	LOG(LSMean)	LSMean	P-Value
NMHC g/mi	Composite	1	-3.2438	0.039015	-
NMHC g/mi	Composite	2	-3.7522	0.023467	<0.0001
NMHC g/mi	Composite	3	-3.4339	0.032260	0.0638
NMHC g/mi	Phase 1	1	-0.5590	0.571758	-
NMHC g/mi	Phase 1	2	-1.2026	0.300412	<0.0001
NMHC g/mi	Phase 1	3	-0.8233	0.439003	0.0392
NMHC g/mi	Phase 2	1	-5.1525	0.005785	-
NMHC g/mi	Phase 2	2	-4.9710	0.006936	0.7291
NMHC g/mi	Phase 2	3	-4.8510	0.007821	0.4574
NMHC g/mi	Phase 3	1	-4.5799	0.010256	-
NMHC g/mi	Phase 3	2	-5.0208	0.006599	0.1379
NMHC g/mi	Phase 3	3	-5.2714	0.005136	0.0227

5.4.1 NMHC Composite

The results of the ANOVA for the LOG(NMHC) Composite phase are provided in Table 44. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 25 illustrates the average Composite NMHC emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Composite NMHC emission for each of the three fuels by vehicle.

TABLE 44. ANOVA TABLE FOR COMPARING LOG(NMHC) COMPOSITE TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	1.97930970	0.98965485	17.90	<0.0001
Vehicle	14	10.47109062	0.74793504	13.53	<0.0001

The LOG(NMHC) Composite results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 26. As shown in Figure 26, the LSMeans for LOG(NMHC) Composite are significantly different for Fuel 2 vs. Fuel 1. In this comparison, Fuels 2 demonstrated a reduction in LOG(NMHC) Composite LSMeans.

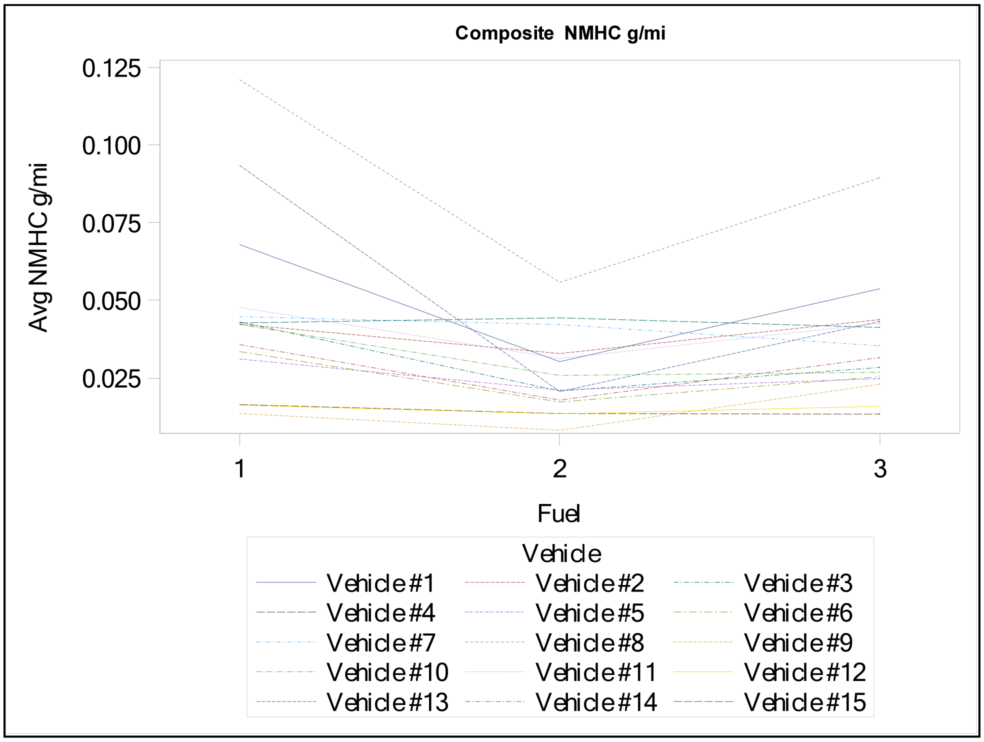

FIGURE 25. PLOT OF AVERAGE NMHC COMPOSITE TEST RESULTS BY FUEL AND VEHICLE

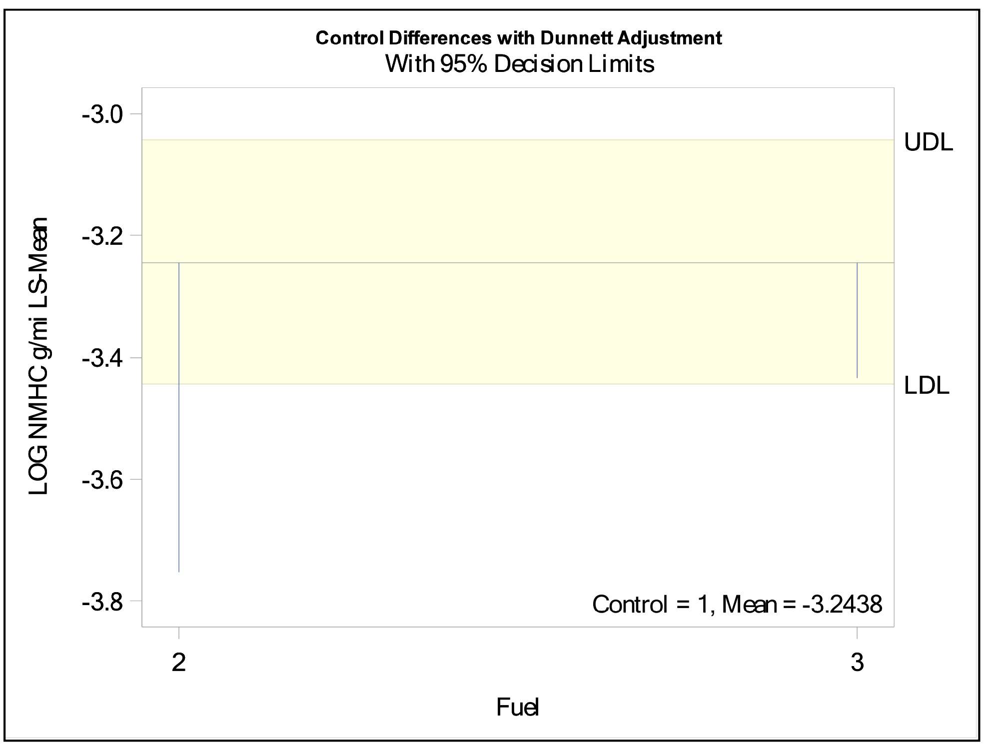

FIGURE 26. PLOT OF LOG(NMHC) COMPOSITE LSMEAN DIFFERENCES AGAINST FUEL 1

5.4.2 NMHC - Phase 1

The results of the ANOVA for the LOG(NMHC) Phase 1 are provided in Table 45. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 27 illustrates the average Phase 1 NMHC emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 1 NMHC emission for each of the three fuels by vehicle.

TABLE 45. ANOVA TABLE FOR COMPARING LOG(NMHC) PHASE 1 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	3.13945963	1.56972981	17.85	<0.0001
Vehicle	14	8.08441615	0.57745830	6.56	<0.0001

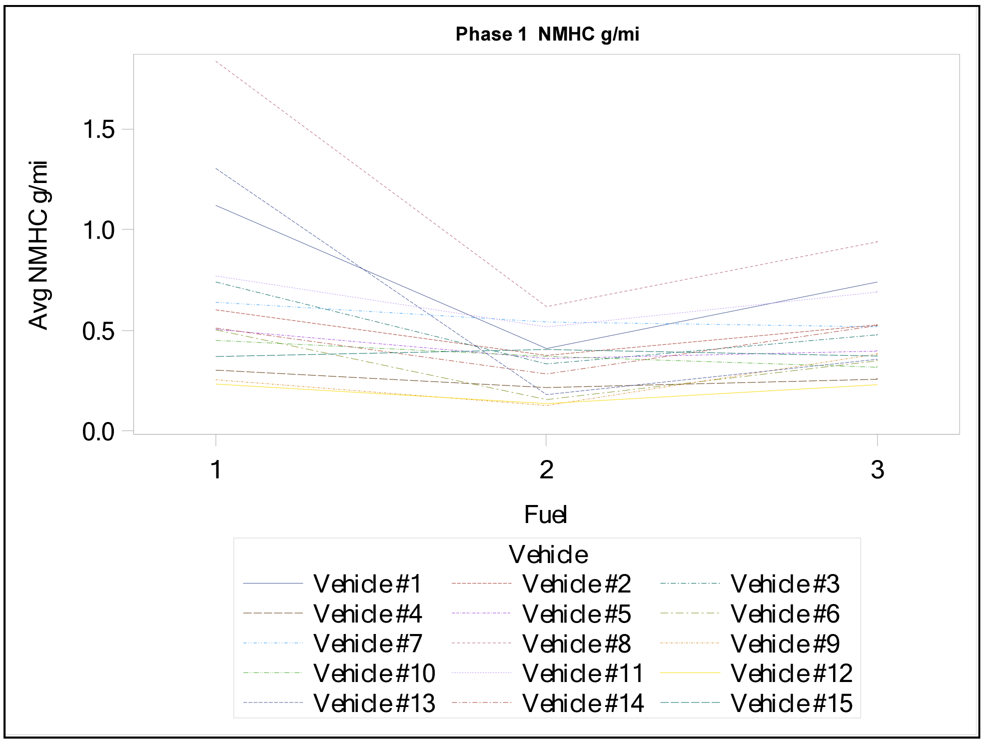

FIGURE 27. PLOT OF AVERAGE NMHC PHASE 1 TEST RESULTS BY FUEL AND VEHICLE

The LOG(NMHC) Phase 1 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 28. As shown in Figure 28, the LSMeans for LOG(NMHC) Phase 1 are significantly different for Fuel 2 vs. Fuel 1 and Fuel 3 vs. Fuel 1. In both of these comparisons, Fuels 2 and 3 demonstrated a reduction in LOG(NMHC) Phase 1 LSMeans.

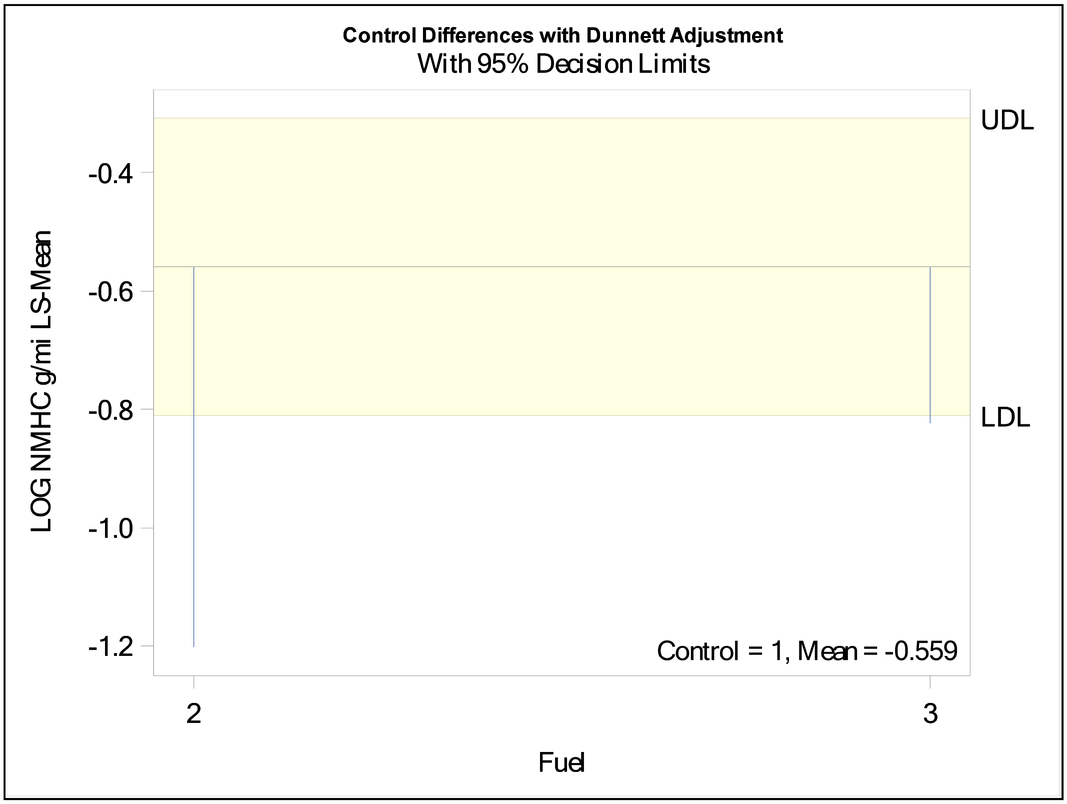

FIGURE 28. PLOT OF LOG(NMHC) PHASE 1 LSMEAN DIFFERENCES AGAINST FUEL 1

5.4.3 NMHC - Phase 2

The results of the ANOVA for the LOG(NMHC) Phase 2 are provided in Table 46. Note that statistically significant differences were observed across the 15 vehicles and. Figure 29 illustrates the average Phase 2 NMHC emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 2 NMHC emission for each of the three fuels by vehicle.

TABLE 46. ANOVA TABLE FOR COMPARING LOG(NMHC) PHASE 2 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.66182467	0.33091234	0.61	0.5528
Vehicle	14	47.71552739	3.40825196	6.24	<0.0001

The LOG(NMHC) Phase 2 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 30. As shown in Figure 30, the LSMeans for LOG(NMHC) Phase 2 are not significantly different for Fuel 2 vs. Fuel 1 or Fuel 3 vs. Fuel 1.

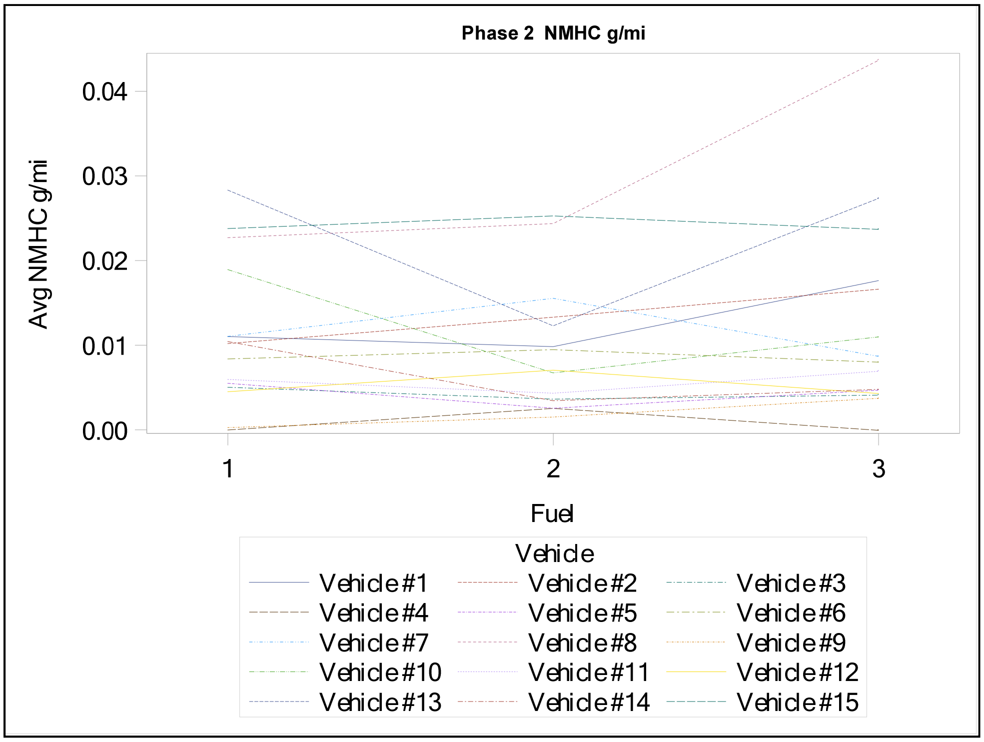

FIGURE 29. PLOT OF AVERAGE NMHC PHASE 2 TEST RESULTS BY FUEL AND VEHICLE

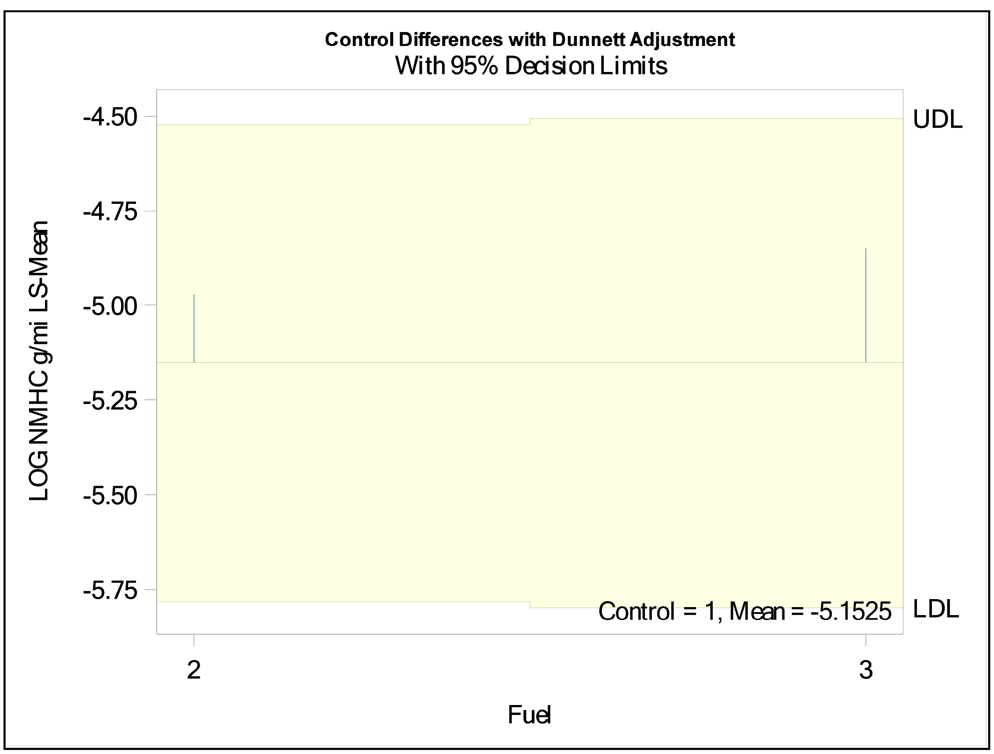

FIGURE 30. PLOT OF LOG(NMHC) PHASE 2 LSMEAN DIFFERENCES AGAINST FUEL 1

5.4.4 NMHC – Phase 3

The results of the ANOVA for the LOG(NMHC) Phase 3 are provided in Table 47. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 31 illustrates the average Phase 3 NMHC emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 3 NMHC emission for each of the three fuels by vehicle.

TABLE 47. ANOVA TABLE FOR COMPARING LOG(NMHC) PHASE 3 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	3.0134587	1.50672928	3.91	0.0344
Vehicle	14	48.48377555	3.46312683	9.00	<0.0001

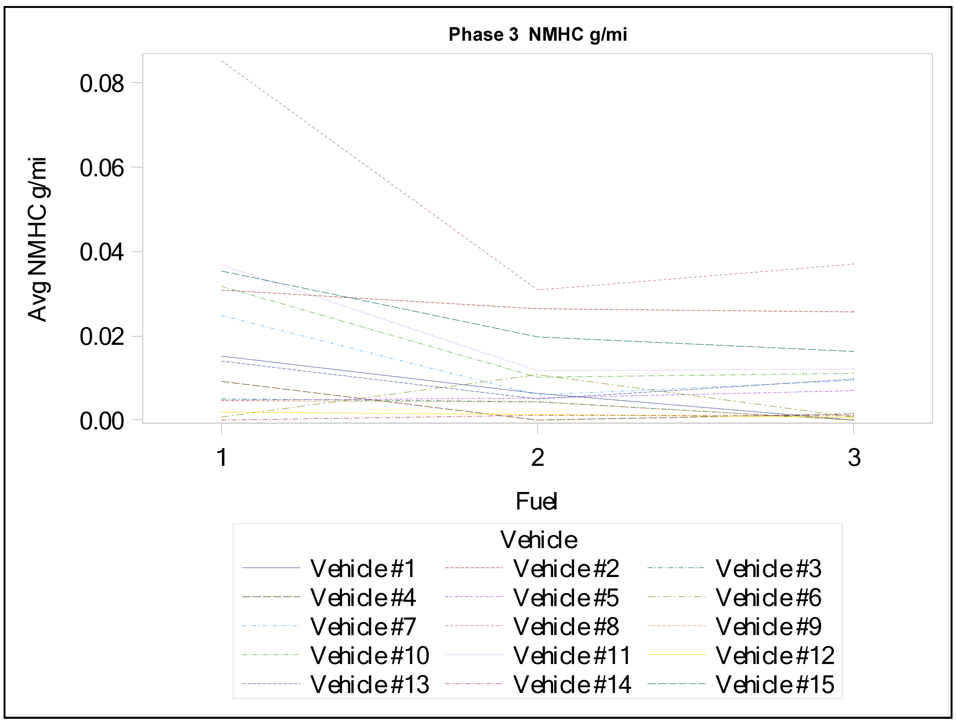

FIGURE 31. PLOT OF AVERAGE NMHC PHASE 3 TEST RESULTS BY FUEL AND VEHICLE

The LOG(NMHC) Phase 3 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 32. As shown in Figure 32, the LSMeans for NMHC Phase 3 are significantly different for Fuel 3 vs. Fuel 1. In this comparison, Fuel 3 demonstrated a reduction in LOG(NMHC) Phase 3 LSMeans.

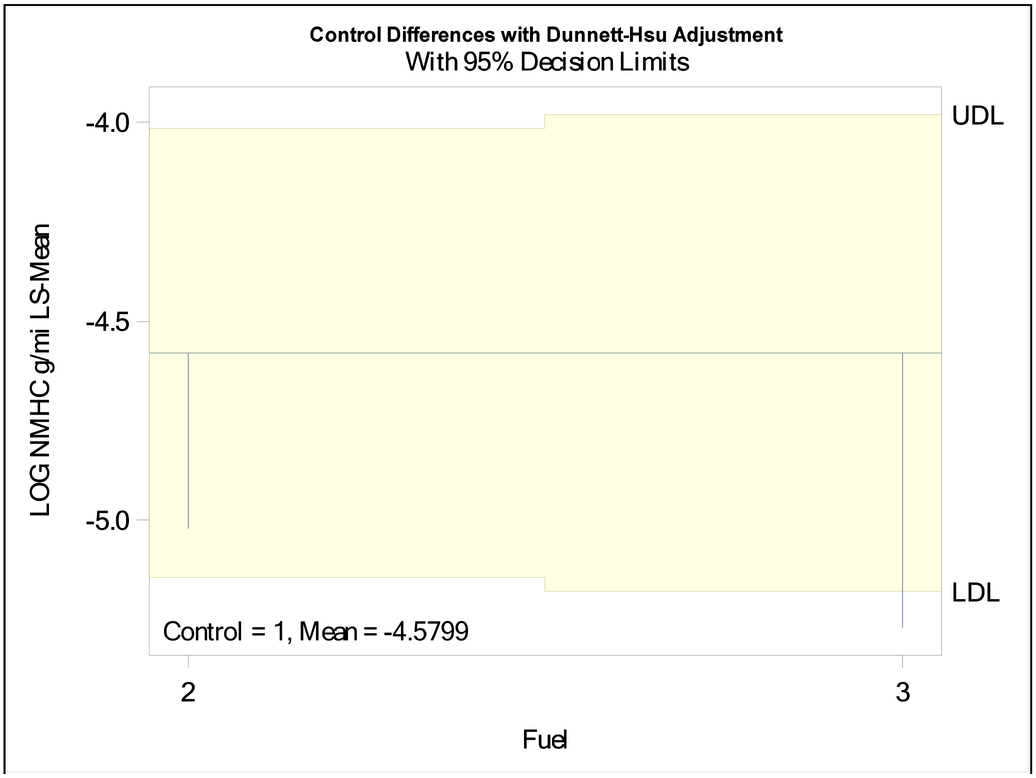

FIGURE 32. PLOT OF LOG(NMHC) PHASE 3 LSMEAN DIFFERENCES AGAINST FUEL 1

5.5 Fuel Comparisons for CH_4

An analysis of variance was performed to examine the changes in average LOG(CH_4) emissions from Fuel 1 to Fuel 2 and from Fuel 1 to Fuel 3. Also included in the ANOVA model were effects due to vehicles. The results of the ANOVA for comparing Fuels 2 and 3 to Fuel 1 are provided in Table 48. The estimated LSMeans are listed by phase and fuel. There were statistically significant differences comparing the CH_4 LSMeans (in LOG and original units) for Fuel 1 vs. Fuel 2 for the Composite and Phase 1 (p-value < 0.05). There was also a significant difference in the Composite and Phase 2 LOG(CH_4) LSMeans in comparing Fuel 3 vs. Fuel 1.

5.5.1 CH_4 - Composite

The results of the ANOVA for the LOG(CH_4) Composite phase are provided in Table 49. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 33 illustrates the average Composite CH_4 emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Composite CH_4 emission for each of the three fuels by vehicle.

TABLE 48. ANOVA RESULTS BY PHASE COMPARING LOG(CH_4) LSMEANS AGAINST FUEL 1

Emission	Phase	Fuel	LOG(LSMean)	LSMean	P-Value
CH_4 g/mi	Composite	1	-4.9433	0.007131	-
CH_4 g/mi	Composite	2	-5.0807	0.006216	0.0052
CH_4 g/mi	Composite	3	-4.8257	0.008021	0.0165
CH_4 g/mi	Phase 1	1	-2.8963	0.055225	-
CH_4 g/mi	Phase 1	2	-3.1035	0.044893	0.0044
CH_4 g/mi	Phase 1	3	-2.7890	0.061485	0.1624
CH_4 g/mi	Phase 2	1	-5.6096	0.003662	-
CH_4 g/mi	Phase 2	2	-5.6873	0.003389	0.1643
CH_4 g/mi	Phase 2	3	-5.4841	0.004152	0.0172
CH_4 g/mi	Phase 3	1	-4.4966	0.011147	-
CH_4 g/mi	Phase 3	2	-4.5811	0.010243	0.1918
CH_4 g/mi	Phase 3	3	-4.4198	0.012037	0.2485

TABLE 49. ANOVA TABLE FOR COMPARING LOG(CH_4) COMPOSITE TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.48847224	0.24423612	18.69	<0.0001
Vehicle	14	26.87966923	1.91997637	146.91	<0.0001

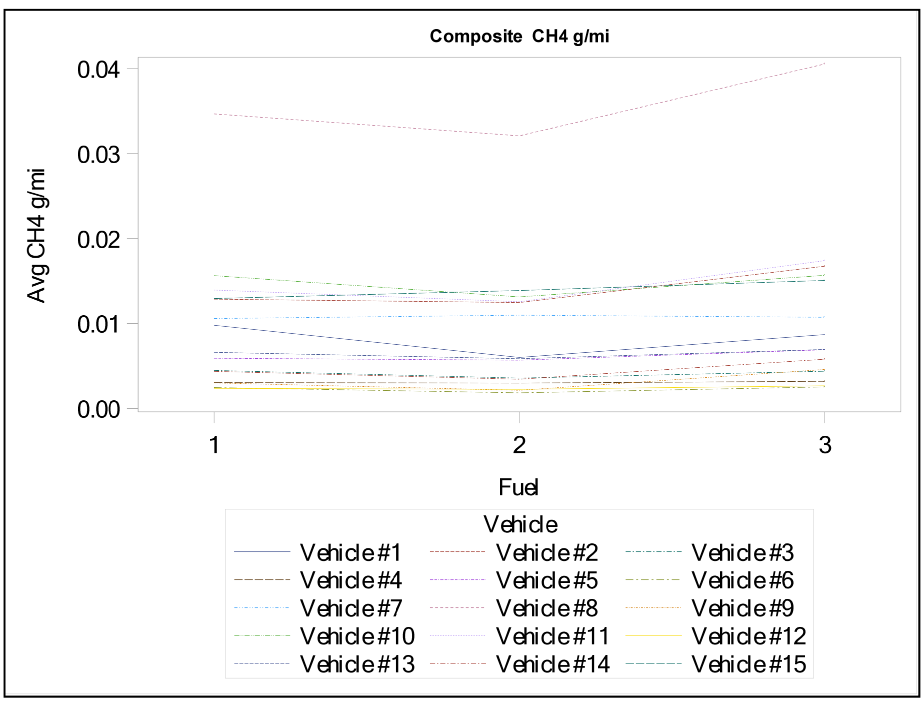

FIGURE 33. PLOT OF AVERAGE CH_4 COMPOSITE TEST RESULTS BY FUEL AND VEHICLE

The $LOG(CH_4)$ Composite results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 34. As shown in Figure 34, the LSMeans for $LOG(CH_4)$ Composite are significantly different for Fuel 2 vs. Fuel 1 and Fuel 3 vs. Fuel 1. In the comparison of Fuel 1 vs. Fuel 2, Fuel 2 demonstrated a reduction in $LOG(CH_4)$ Composite LSMean. Alternatively, in the comparison of Fuel 1 vs. Fuel 3, Fuel 3 showed an increase in $LOG(CH_4)$ Composite LSMean.

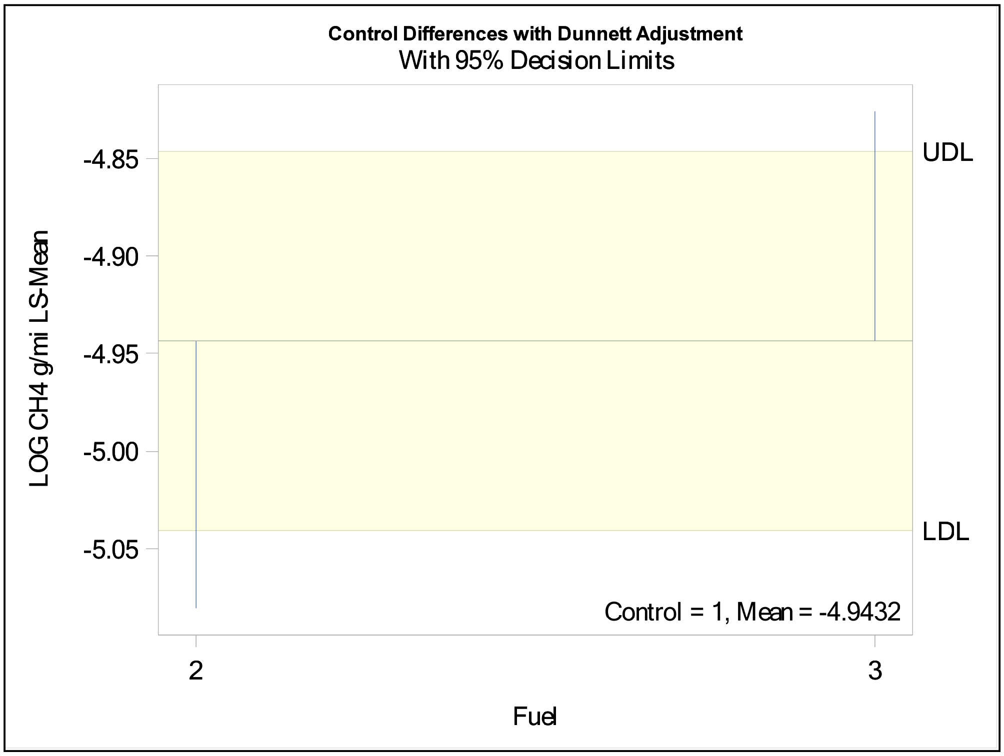

FIGURE 34. PLOT OF $LOG(CH_4)$ COMPOSITE LSMEAN DIFFERENCES AGAINST FUEL 1

5.5.2 CH_4 – Phase 1

The results of the ANOVA for the $LOG(CH_4)$ Phase 1 are provided in Table 50. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 35 illustrates the average Phase 1 CH_4 emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 1 CH_4 emission for each of the three fuels by vehicle.

TABLE 50. ANOVA TABLE FOR COMPARING $LOG(CH_4)$ PHASE 1 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.76671858	0.38335929	13.41	<0.0001
Vehicle	14	13.38584528	0.95613181	33.45	<0.0001

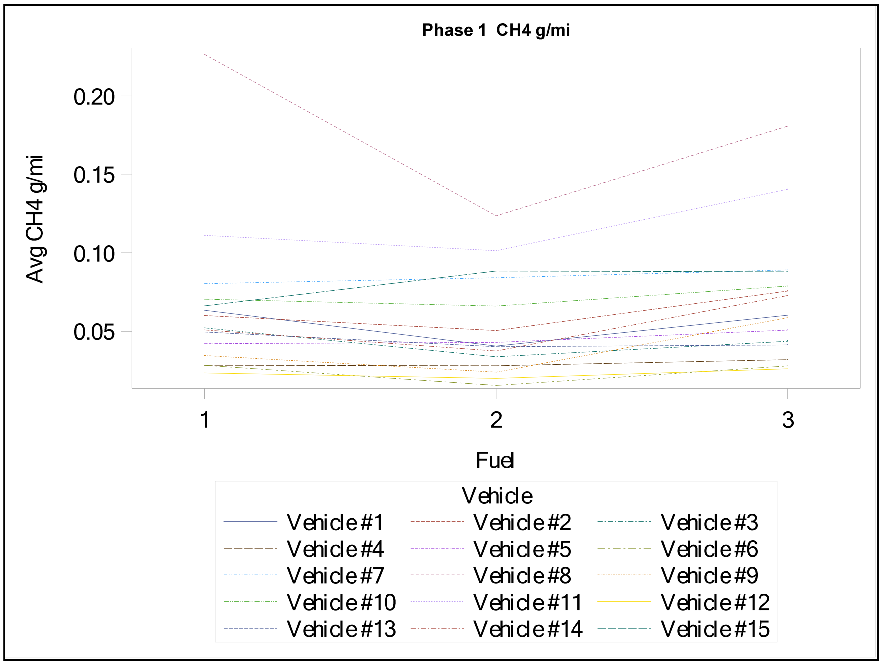

FIGURE 35. PLOT OF AVERAGE CH_4 PHASE 1 TEST RESULTS BY FUEL AND VEHICLE

The LOG(CH_4) Phase 1 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 36. As shown in Figure 36, the LSMeans for LOG(CH_4) Phase 1 are significantly different for Fuel 2 vs. Fuel 1. In the comparison of Fuel 1 vs. Fuel 2, Fuel 2 demonstrated a reduction in LOG(CH_4) Phase 1 LSMean.

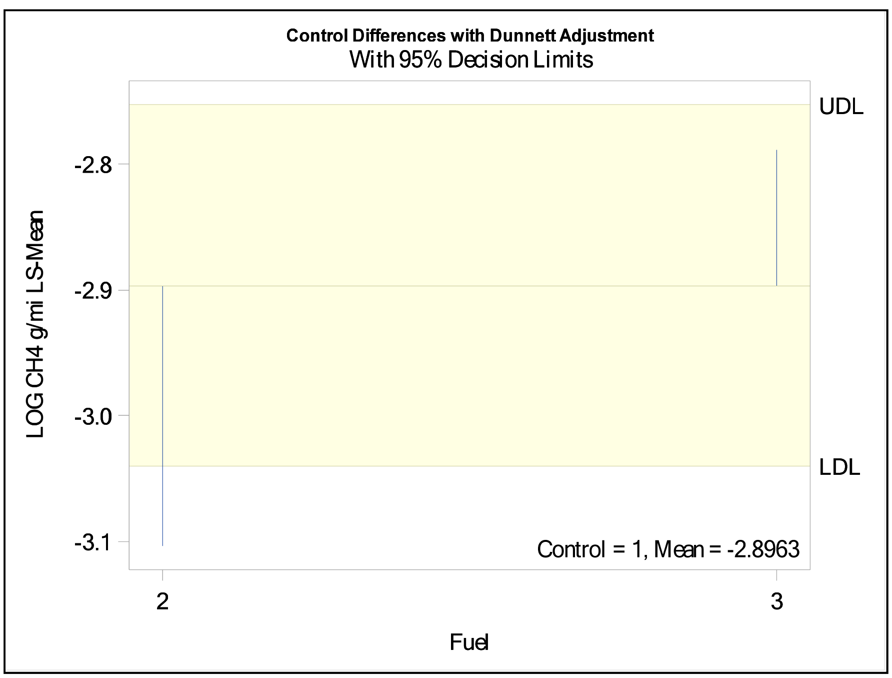

FIGURE 36. PLOT OF LOG(CH_4) PHASE 1 LSMEAN DIFFERENCES AGAINST FUEL 1

5.5.3 CH_4 - Phase 2

The results of the ANOVA for the LOG(CH_4) Phase 2 are provided in Table 51. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 37 illustrates the average Phase 2 CH_4 emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 2 CH_4 emission for each of the three fuels by vehicle.

TABLE 51. ANOVA TABLE FOR COMPARING LOG(CH_4) PHASE 2 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.31533832	0.15766916	10.46	0.0004
Vehicle	14	45.14287935	3.22520567	214.01	<.0001

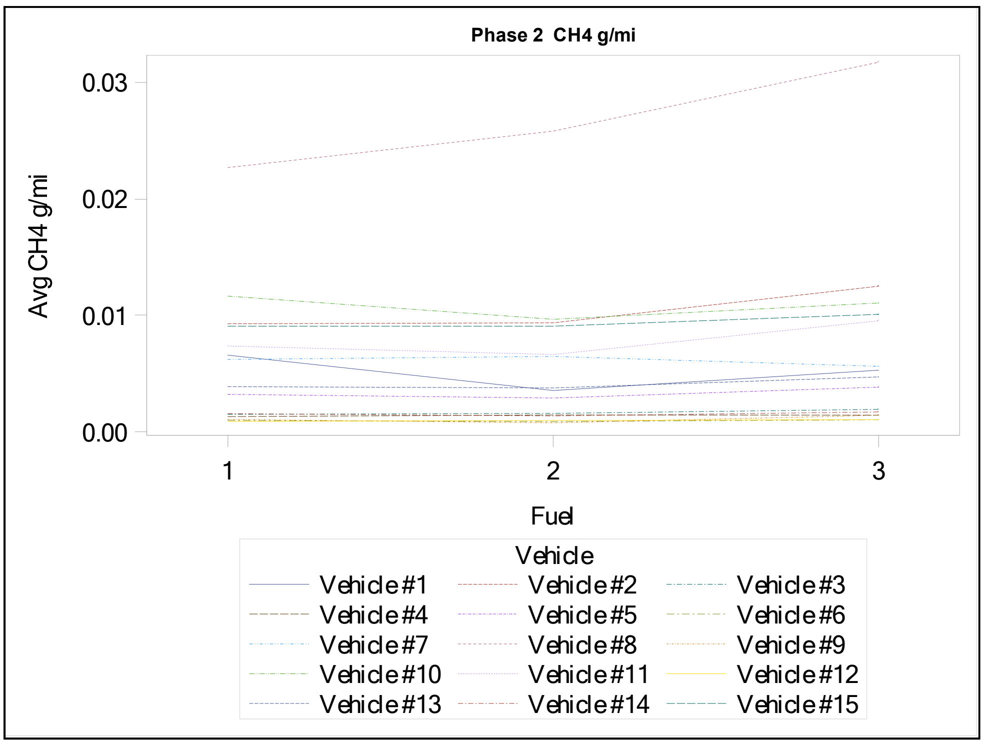

FIGURE 37. PLOT OF AVERAGE CH_4 PHASE 2 TEST RESULTS BY FUEL AND VEHICLE

The LOG(CH_4) Phase 2 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 38. As shown in Figure 38, the LSMeans for LOG(CH_4) Phase 2 are significantly different for Fuel 3 vs. Fuel 1 where Fuel 3 demonstrated an increase in LOG(CH_4) Phase 2 LSMean.

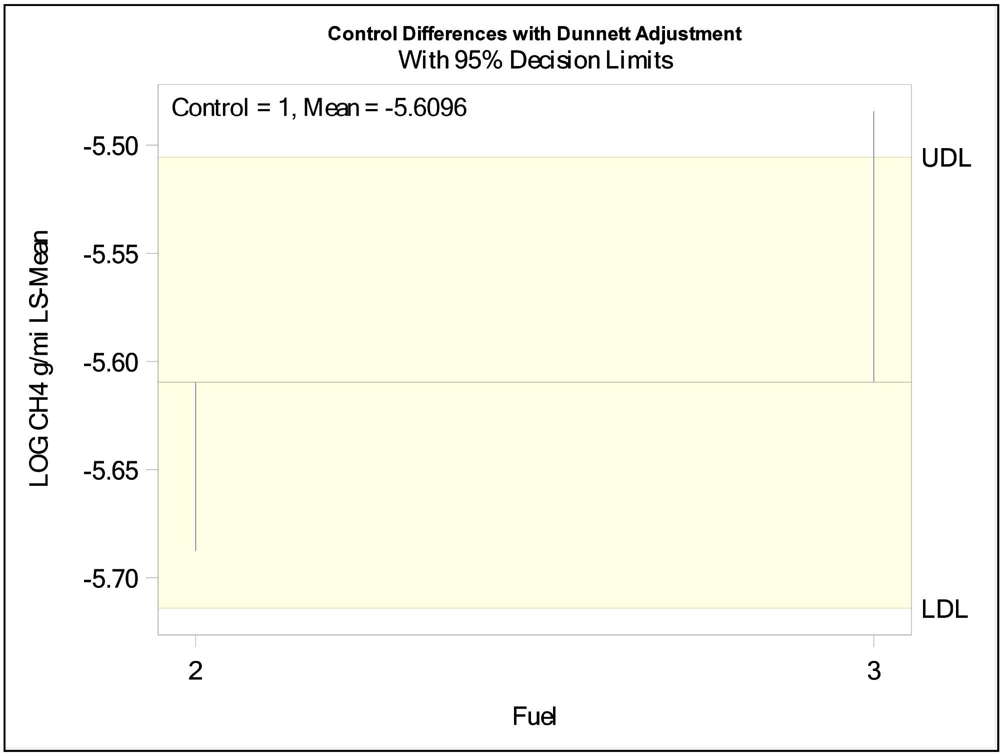

FIGURE 38. PLOT OF LOG(CH_4) PHASE 2 LSMEAN DIFFERENCES AGAINST FUEL 1

5.5.4 CH_4 – Phase 3

The results of the ANOVA for the LOG(CH_4) Phase 3 are provided in Table 52. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 39.illustrates the average Phase 3 CH_4 emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 3 CH_4 emission for each of the three fuels by vehicle.

TABLE 52. ANOVA TABLE FOR COMPARING LOG(CH_4) PHASE 3 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.19537201	0.09768600	4.93	0.0146
Vehicle	14	26.61496686	1.90106906	96.02	<0.0001

The LOG(CH_4) Phase 3 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 40. As shown in Figure 40, the LSMeans for LOG(CH_4) Phase 3 are not significantly different for Fuel 2 vs. Fuel 1 or Fuel 3 vs. Fuel 1.

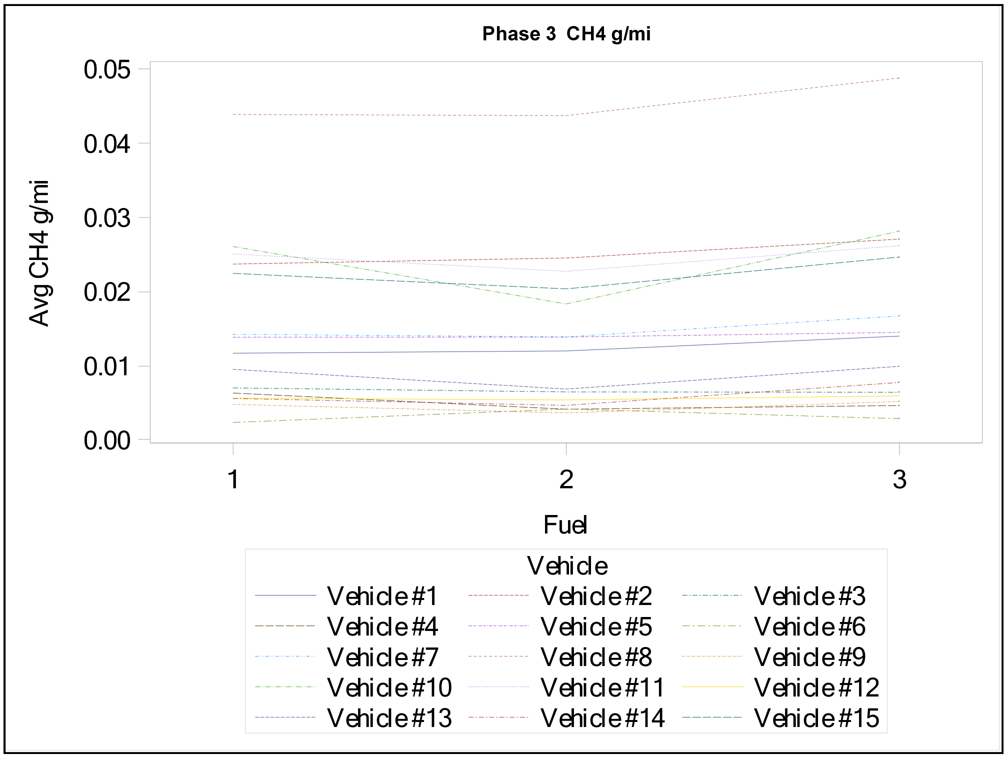

FIGURE 39. PLOT OF AVERAGE CH_4 PHASE 3 TEST RESULTS BY FUEL AND VEHICLE

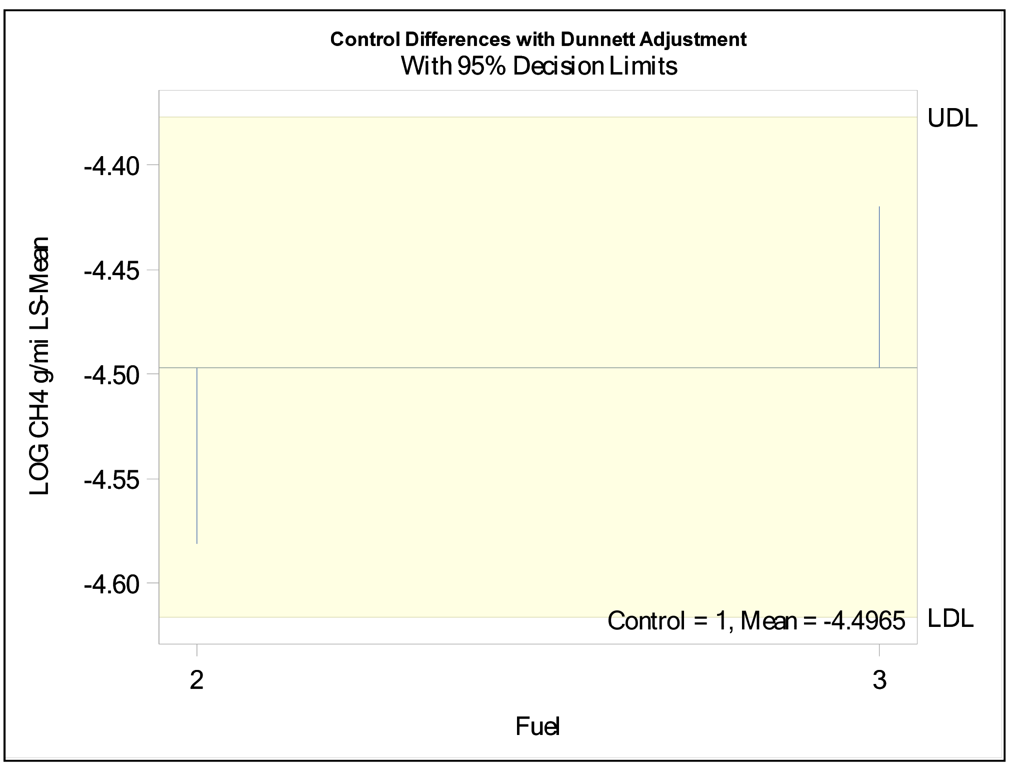

FIGURE 40. PLOT OF LOG(CH_4) PHASE 3 LSMEAN DIFFERENCES AGAINST FUEL 1

5.6 Fuel Comparisons for CO

An analysis of variance was performed to examine the changes in average LOG(CO) emissions from Fuel 1 to Fuel 2 and from Fuel 1 to Fuel 3. Also included in the ANOVA model were effects due to vehicles. The results of the ANOVA for comparing Fuels 2 and 3 to Fuel 1 are provided in Table 53. The estimated LSMeans (in LOG and original units) are listed by phase and fuel. There were statistically significant differences comparing the LOG(CO) LSMeans for Fuel 1 vs. Fuel 2 and for comparing Fuel 1 vs. Fuel 3 for the Composite, Phase 2 and Phase 3 (p-value < 0.05).

TABLE 53. ANOVA RESULTS BY PHASE COMPARING LOG(CO) LSMEANS AGAINST FUEL 1

Emission	Phase	Fuel	LOG(LSMean)	LSMean	P-Value
CO g/mi	Composite	1	-0.3004	0.740500	-
CO g/mi	Composite	2	-0.5953	0.551419	0.0016
CO g/mi	Composite	3	-0.5280	0.589795	0.0139
CO g/mi	Phase 1	1	1.5985	4.945559	-
CO g/mi	Phase 1	2	1.4988	4.476359	0.5780
CO g/mi	Phase 1	3	1.4881	4.428673	0.5153
CO g/mi	Phase 2	1	-0.9348	0.392653	-
CO g/mi	Phase 2	2	-1.3548	0.258004	0.0002
CO g/mi	Phase 2	3	-1.2662	0.281895	0.0030
CO g/mi	Phase 3	1	-0.6151	0.540587	-
CO g/mi	Phase 3	2	-1.0124	0.363335	<0.0001
CO g/mi	Phase 3	3	-0.9678	0.379918	0.0002

5.6.1 CO - Composite

The results of the ANOVA for the LOG(CO) Composite phase are provided in Table 54. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 41 illustrates the average Composite CO emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Composite CO emission for each of the three fuels by vehicle.

TABLE 54. ANOVA TABLE FOR COMPARING LOG(CO) COMPOSITE TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.71616729	0.35808365	7.70	0.0022
Vehicle	14	34.25357599	2.44668400	52.63	<0.0001

The LOG(CO) Composite results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 42. As shown in Figure 42, the LSMeans for LOG(CO) Composite are significantly different for Fuel 2 vs. Fuel 1 and Fuel 3 vs. Fuel 1. In both of these comparisons, Fuels 2 and 3 demonstrated a reduction in LOG(CO) Composite LSMeans.

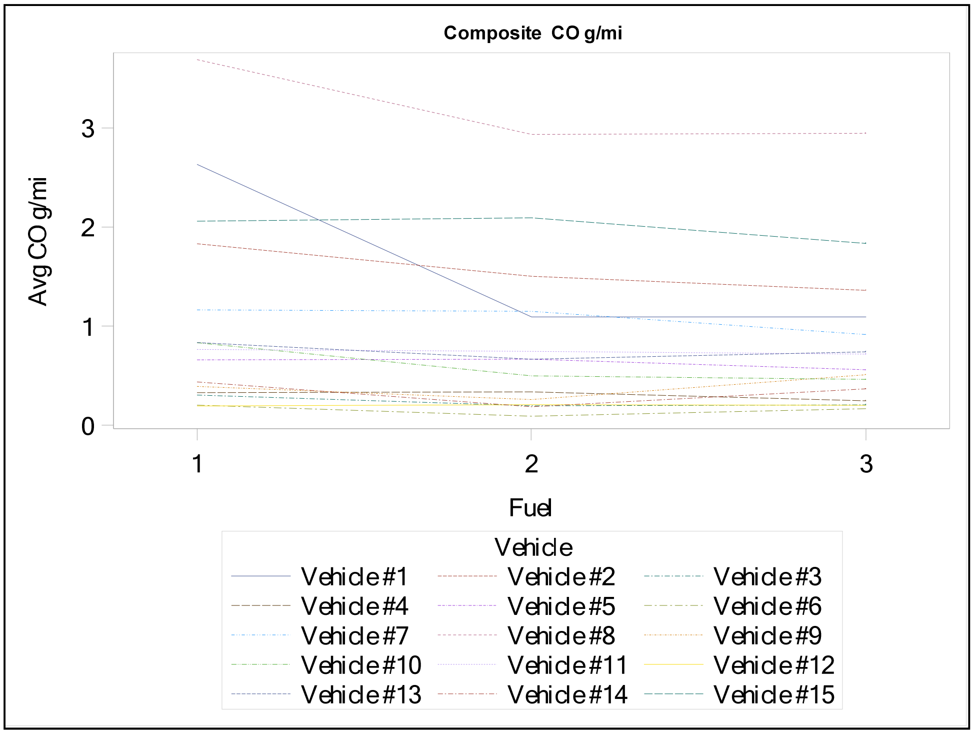

FIGURE 41. PLOT OF AVERAGE CO COMPOSITE TEST RESULTS BY FUEL AND VEHICLE

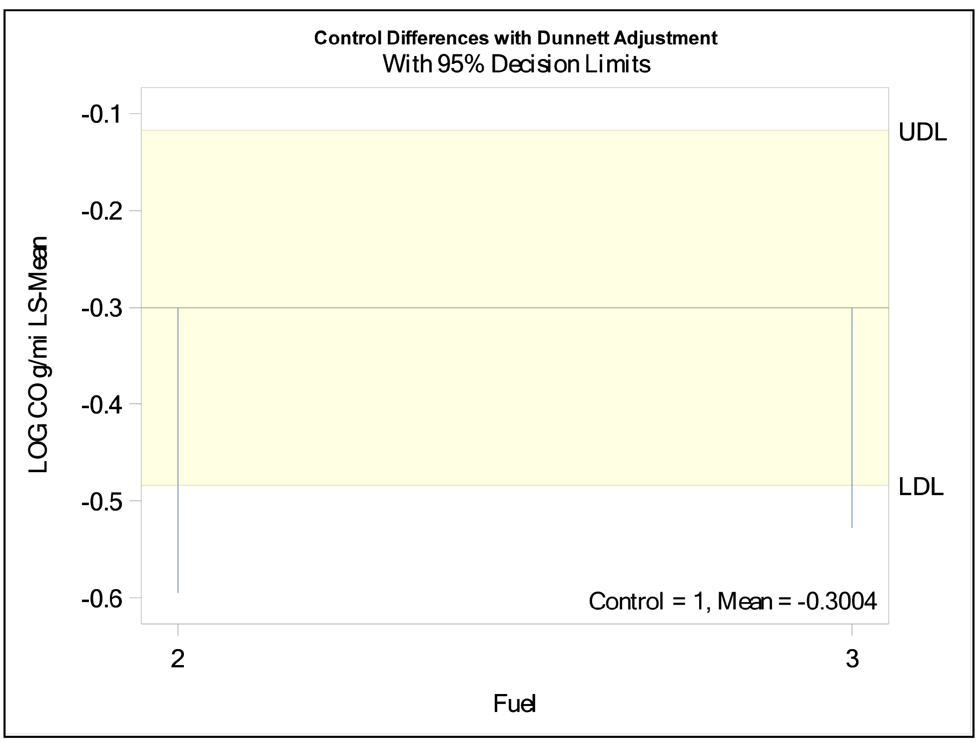

FIGURE 42. PLOT OF LOG(CO) COMPOSITE LSMEAN DIFFERENCES AGAINST FUEL 1

5.6.2 CO - Phase 1

The results of the ANOVA for the LOG(CO) Phase 1 are provided in Table 55. Note that statistically significant differences were observed across the 15 vehicles. Figure 43 illustrates the average Phase 1 CO emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 1 CO emission for each of the three fuels by vehicle.

TABLE 55. ANOVA TABLE FOR COMPARING LOG(CO) PHASE 1 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.11119013	0.05559507	0.60	0.5561
Vehicle	14	21.15042857	1.51074490	16.28	<0.0001

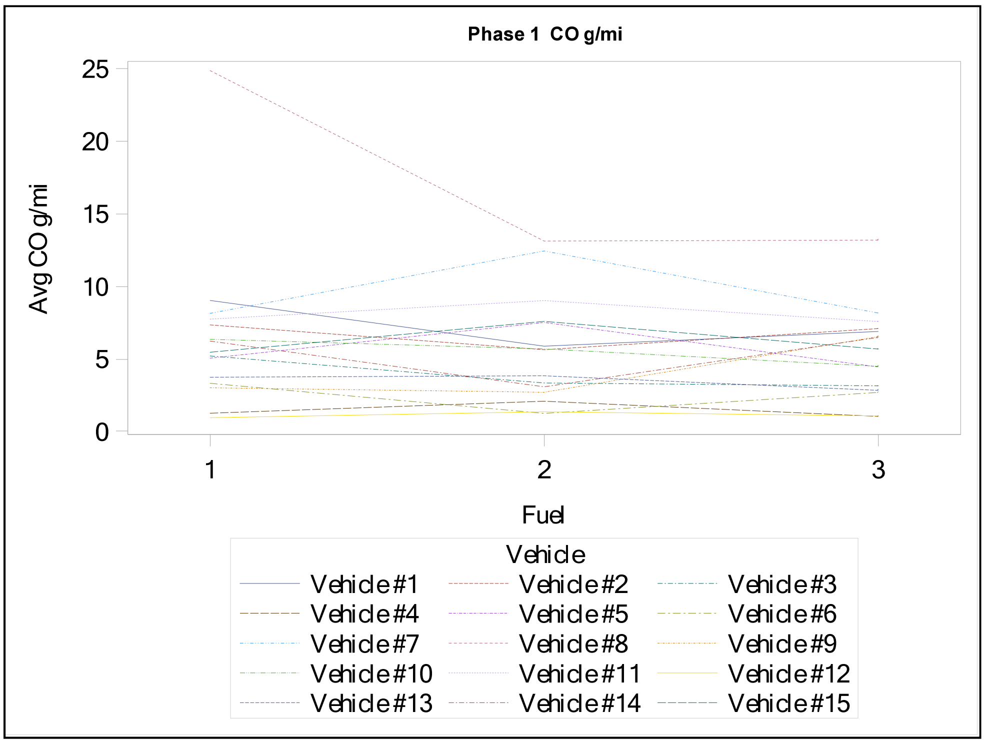

FIGURE 43. PLOT OF AVERAGE CO PHASE 1 TEST RESULTS BY FUEL AND VEHICLE

The LOG(CO) Phase 1 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 44. As shown in Figure 44, the LSMeans for LOG(CO) Phase 1 are not significantly different for Fuel 2 vs. Fuel 1 or Fuel 3 vs. Fuel 1.

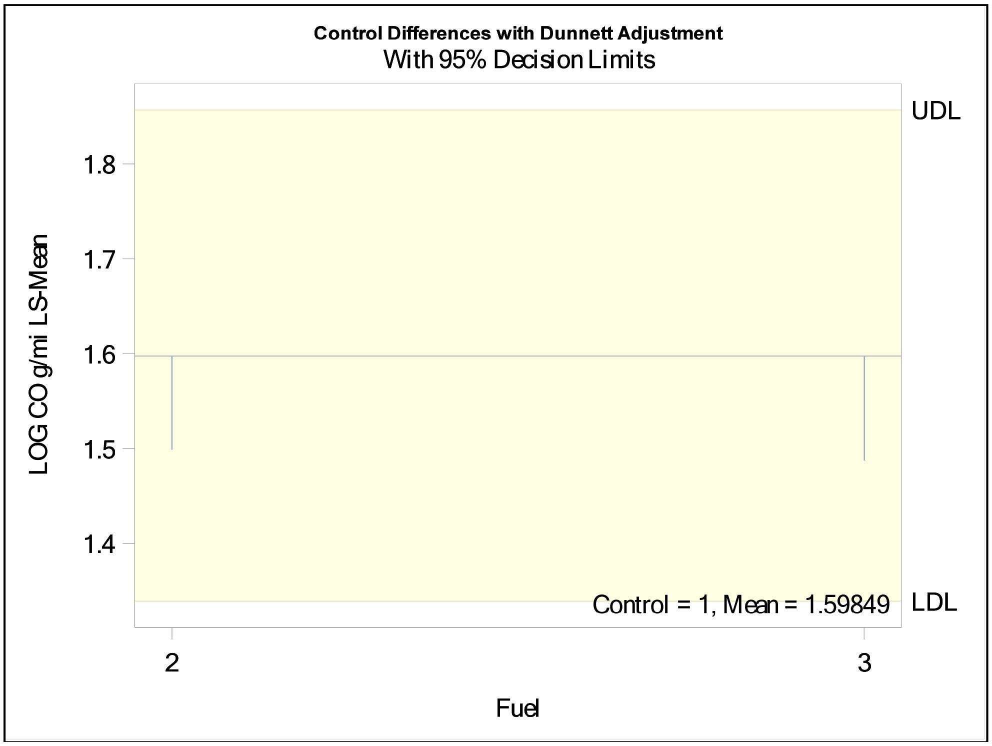

FIGURE 44. PLOT OF LOG(CO) PHASE 1 LSMEAN DIFFERENCES AGAINST FUEL 1

5.6.3 CO – Phase 2

The results of the ANOVA for the LOG(CO) Phase 2 are provided in Table 56. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 45 illustrates the average Phase 2 CO emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 2 CO emission for each of the three fuels by vehicle.

TABLE 56. ANOVA TABLE FOR COMPARING LOG(CO) PHASE 2 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	1.47006689	0.73503344	10.98	0.0003
Vehicle	14	76.09531988	5.43537999	81.016	<0.0001

The LOG(CO) Phase 2 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 46. As shown in Figure 46, the LSMeans for LOG(CO) Phase 2 are significantly different for Fuel 2 vs. Fuel 1 and Fuel 3 vs. Fuel 1. In both of these comparisons, Fuels 2 and 3 demonstrated a reduction in LOG(CO) Phase 2 LSMeans.

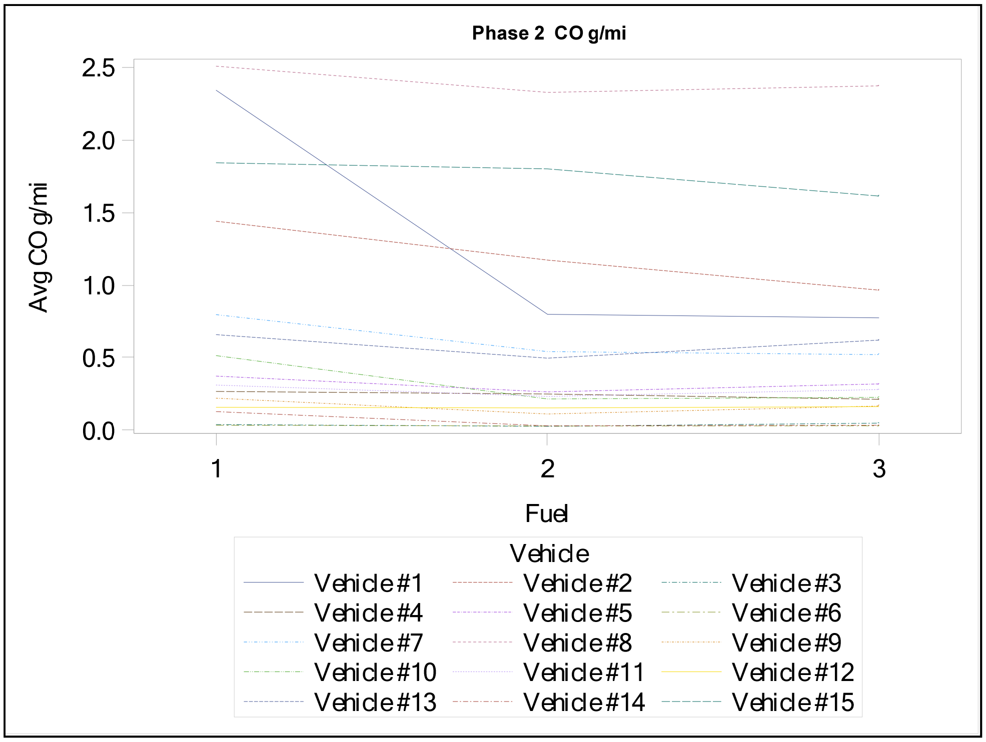

FIGURE 45. PLOT OF AVERAGE CO PHASE 2 TEST RESULTS BY FUEL AND VEHICLE

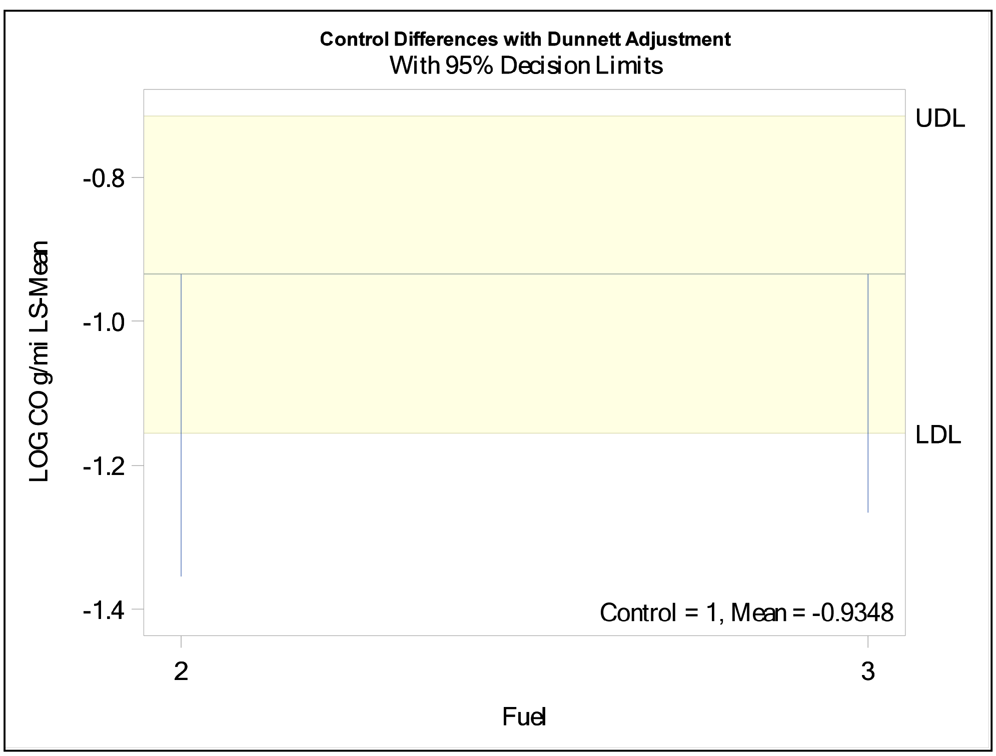

FIGURE 46. PLOT OF LOG(CO) PHASE 2 LSMEAN DIFFERENCES AGAINST FUEL 1

5.6.4 CO – Phase 3

The results of the ANOVA for the LOG(CO) Phase 3 are provided in Table 57. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 47 illustrates the average Phase 3 CO emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 3 CO emission for each of the three fuels by vehicle.

TABLE 57. ANOVA TABLE FOR COMPARING LOG(CO) PHASE 3 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	1.42132668	0.71066334	15.02	<0.0001
Vehicle	14	91.15931089	6.51137935	137.64	<0.0001

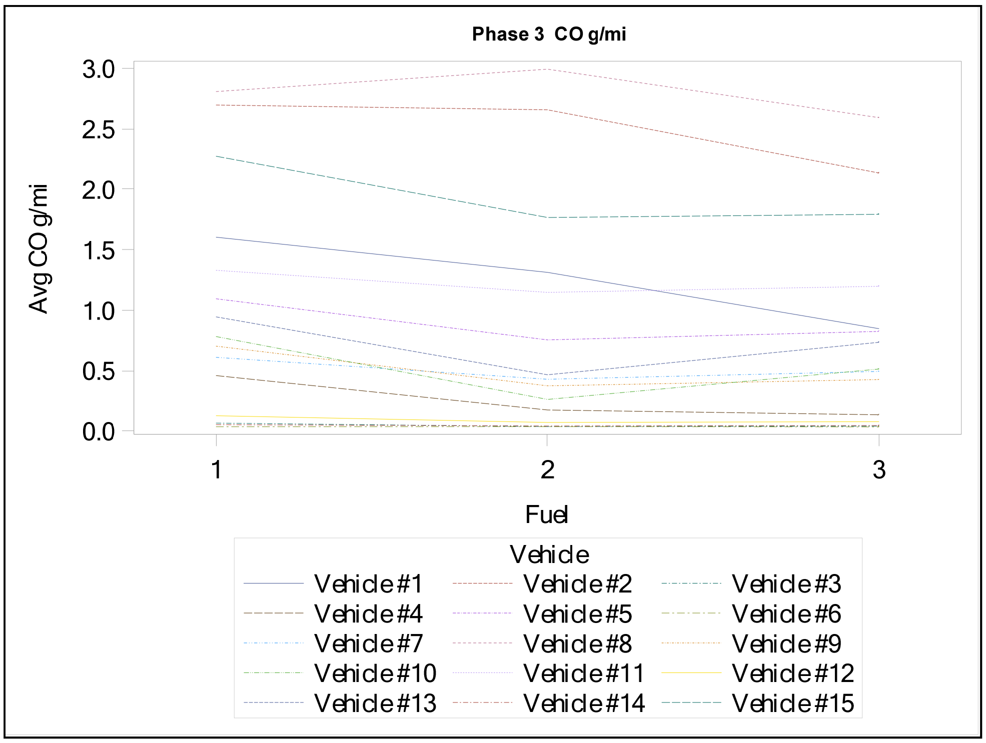

FIGURE 47. PLOT OF AVERAGE CO PHASE 3 TEST RESULTS BY FUEL AND VEHICLE

The LOG(CO) Phase 3 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 48. As shown in Figure 48, the LSMeans for LOG(CO) Phase 3 are significantly different for Fuel 2 vs. Fuel 1 and Fuel 3 vs. Fuel 1. In both of these comparisons, Fuels 2 and 3 demonstrated a reduction in LOG(CO) Phase 3 LSMeans.

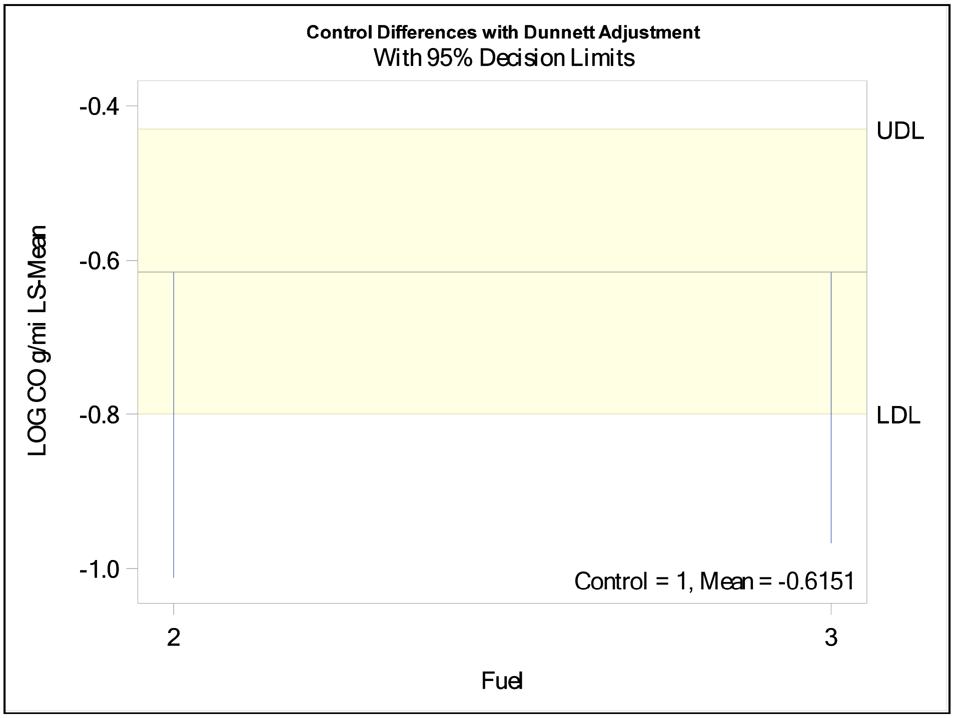

FIGURE 48. PLOT OF LOG(CO) PHASE 3 LSMEAN DIFFERENCES AGAINST FUEL 1

5.7 Fuel Comparisons for NO_X

An analysis of variance was performed to examine the changes in average LOG(NO_X) emissions from Fuel 1 to Fuel 2 and from Fuel 1 to Fuel 3. Also included in the ANOVA model were effects due to vehicles. The results of the ANOVA for comparing Fuels 2 and 3 to Fuel 1 are provided in Table 58. The estimated LSMeans (in LOG and original units) are listed by phase and fuel. There were no statistically significant differences comparing the LOG(NO_X) LSMeans for Fuel 1 vs. Fuel 2 or for Fuel 1 vs. Fuel 3 in any of the phases.

TABLE 58. ANOVA RESULTS BY PHASE COMPARING LOG(NO_X) LSMEANS AGAINST FUEL 1

Emission	Phase	Fuel	LOG(LSMean)	LSMean	P-Value
NO_X g/mi	Composite	1	-4.1343	0.016014	-
NO_X g/mi	Composite	2	-4.1907	0.015135	0.6401
NO_X g/mi	Composite	3	-4.1831	0.015251	0.7126
NO_X g/mi	Phase 1	1	-2.4341	0.087677	-
NO_X g/mi	Phase 1	2	-2.4612	0.085329	0.9529
NO_X g/mi	Phase 1	3	-2.6270	0.072293	0.1376
NO_X g/mi	Phase 2	1	-4.6053	0.009999	-
NO_X g/mi	Phase 2	2	-4.6795	0.009284	0.5789
NO_X g/mi	Phase 2	3	-4.5902	0.010151	0.9761
NO_X g/mi	Phase 3	1	-5.4896	0.004129	-
NO_X g/mi	Phase 3	2	-5.3674	0.004666	0.9035
NO_X g/mi	Phase 3	3	-5.4886	0.004134	1.0000

5.7.1 NO_X – Composite

The results of the ANOVA for the LOG(NO_X) Composite phase are provided in Table 59. Note that statistically significant differences were observed across the 15 vehicles. Figure 49 illustrates the average Composite NO_X emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Composite NO_X emission for each of the three fuels by vehicle.

TABLE 59. ANOVA TABLE FOR COMPARING LOG(NO_X) COMPOSITE TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.02815979	0.01407989	0.38	0.6873
Vehicle	14	20.33329520	1.45237823	39.20	<0.0001

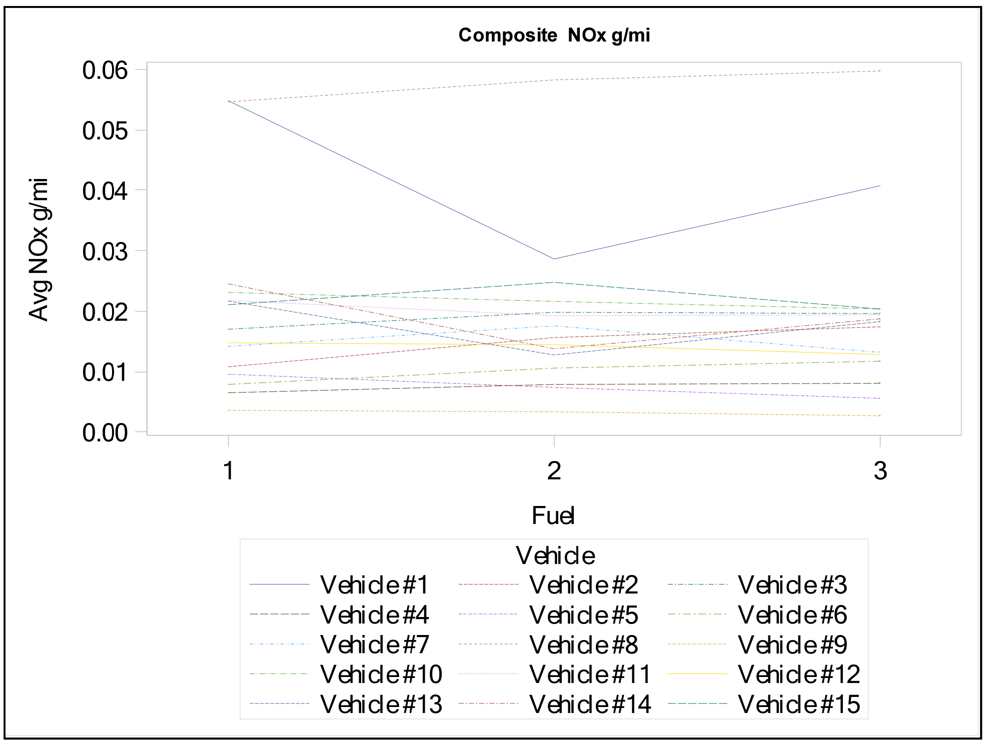

FIGURE 49. PLOT OF AVERAGE NO_X COMPOSITE TEST RESULTS BY FUEL AND VEHICLE

The LOG(NO_X) Composite results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 50. As shown in Figure 50, the LSMeans for LOG(NO_X) Composite are not significantly different for Fuel 2 vs. Fuel 1 or for Fuel 3 vs. Fuel 1.

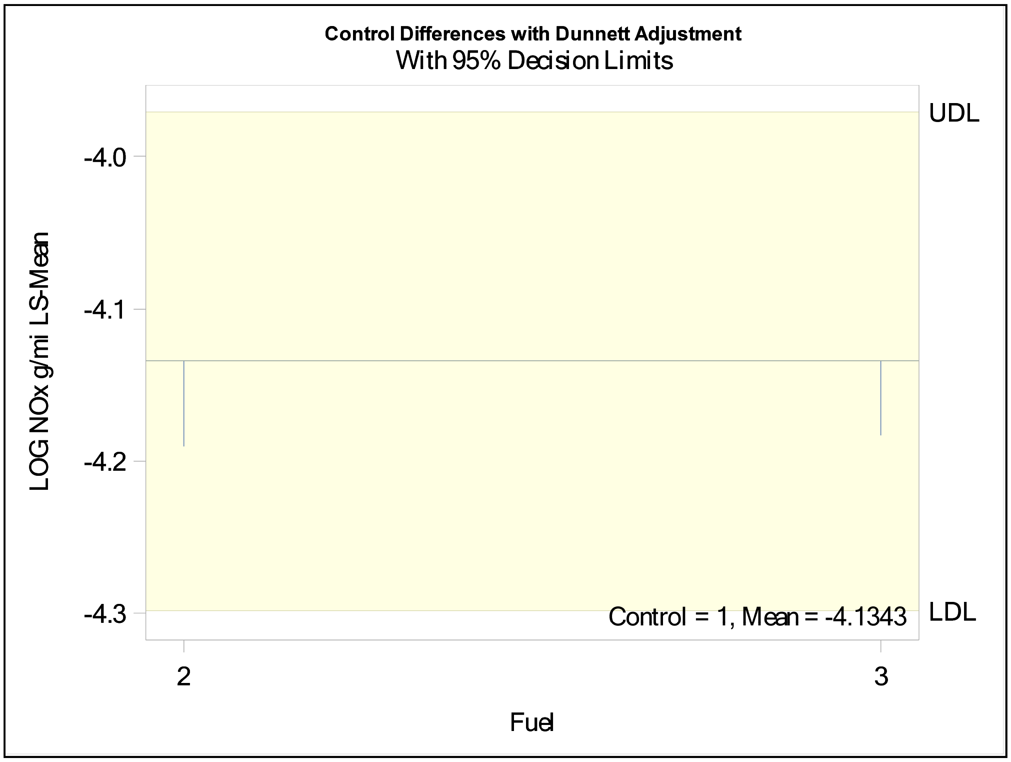

FIGURE 50. PLOT OF LOG(NO_X) COMPOSITE LSMEAN DIFFERENCES AGAINST FUEL 1

5.7.2 NO_X – Phase 1

The results of the ANOVA for the LOG(NO_X) Phase 1 are provided in Table 60. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 51 illustrates the average Phase 1 NO_X emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 1 NO_X emission for each of the three fuels by vehicle.

TABLE 60. ANOVA TABLE FOR COMPARING LOG(NO_X) PHASE 1 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.32720913	0.16360457	1.96	0.1598
Vehicle	14	20.05209763	1.43229269	17.15	<0.0001

The LOG(NO_X) Phase 1 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 52. As shown in Figure 52, the LSMeans for LOG(NO_X) Phase 1 are not significantly different for Fuel 2 vs. Fuel 1 or Fuel 3 vs. Fuel 1.

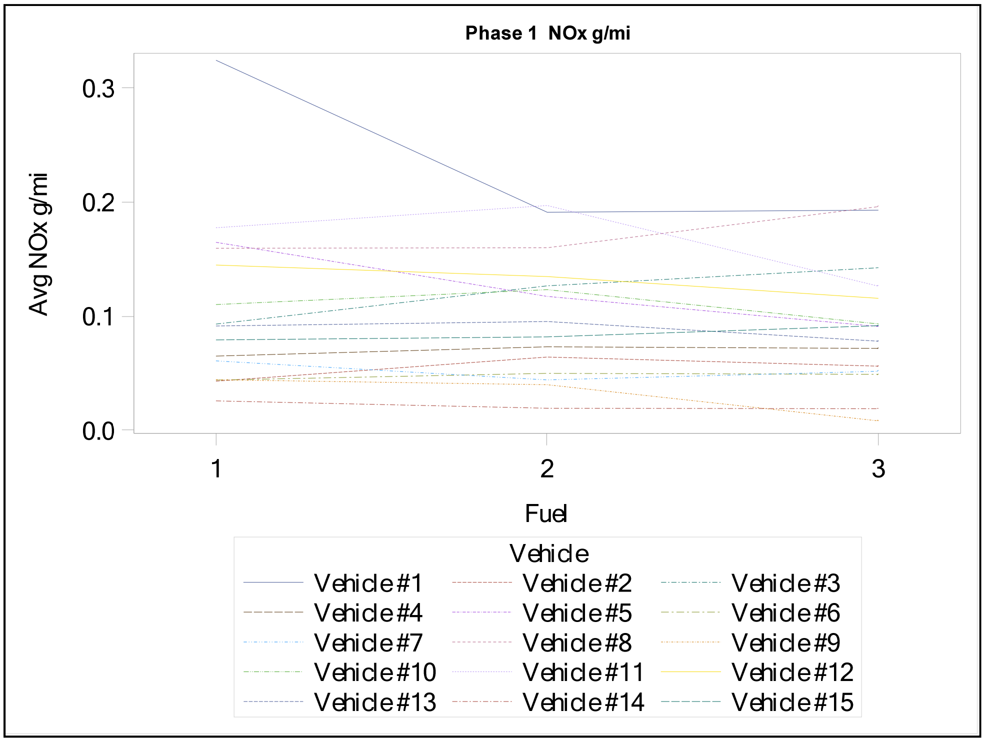

FIGURE 51. PLOT OF AVERAGE NO_X PHASE 1 TEST RESULTS BY FUEL AND VEHICLE

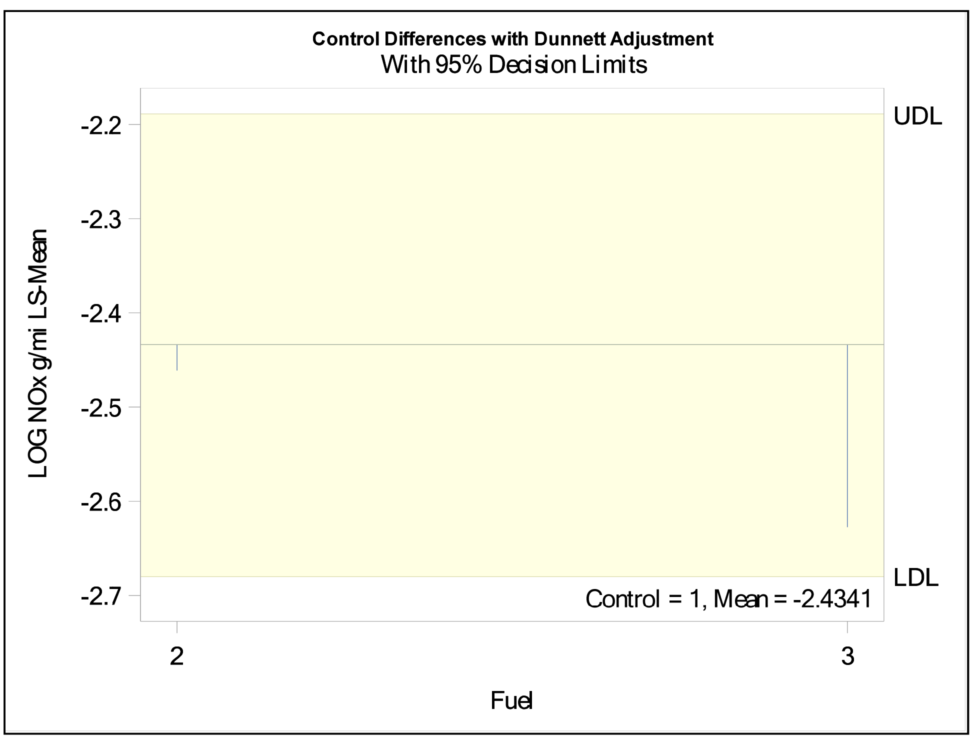

FIGURE 52. PLOT OF LOG(NO_X) PHASE 1 LSMEAN DIFFERENCES AGAINST FUEL 1

5.7.3 NO_X – Phase 2

The results of the ANOVA for the LOG(NO_X) Phase 2 are provided in Table 61. Note that statistically significant differences were observed across the 15 vehicles. Figure 53 illustrates the average Phase 2 NO_X emission test result by fuel and coded by lines styles for the 15 vehicles. Lines connect the average Phase 2 NO_X emission for each of the three fuels by vehicle.

TABLE 61. ANOVA TABLE FOR COMPARING LOG(NO_X) PHASE 2 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.06848156	0.03424078	0.66	0.5225
Vehicle	14	46.26619754	3.30472840	64.12	<0.0001

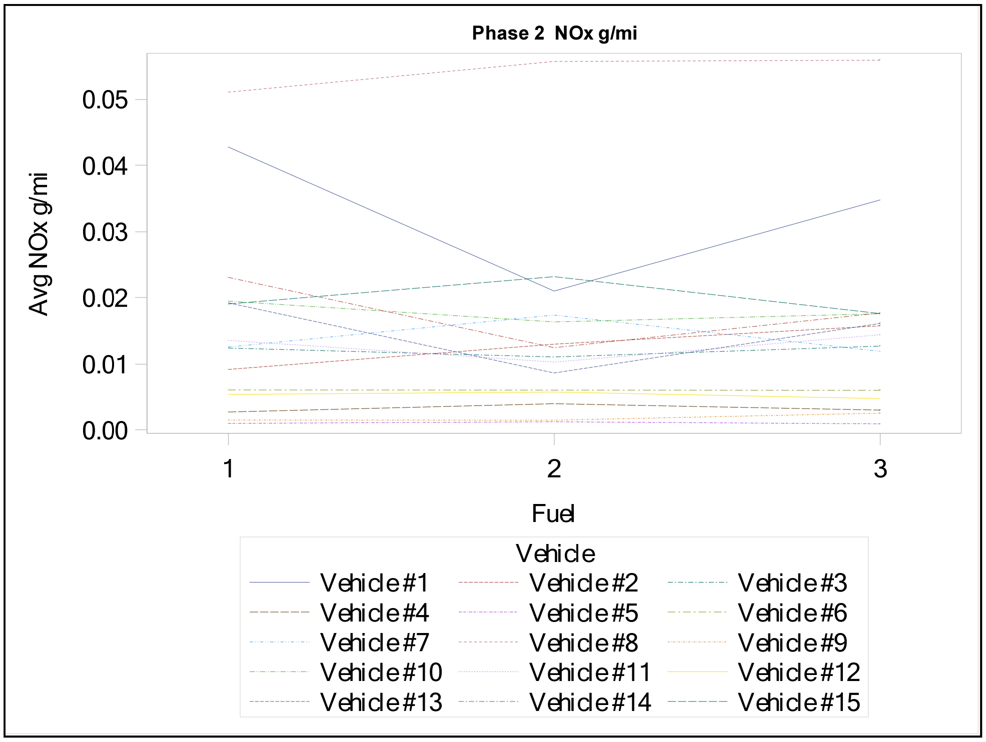

FIGURE 53. PLOT OF AVERAGE NO_X PHASE 2 TEST RESULTS BY FUEL AND VEHICLE

The LOG(NO_X) Phase 2 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 54. As shown in Figure 54, the LSMeans for LOG(NO_X) Phase 2 are not significantly different for Fuel 2 vs. Fuel 1 or for Fuel 3 vs. Fuel 1.

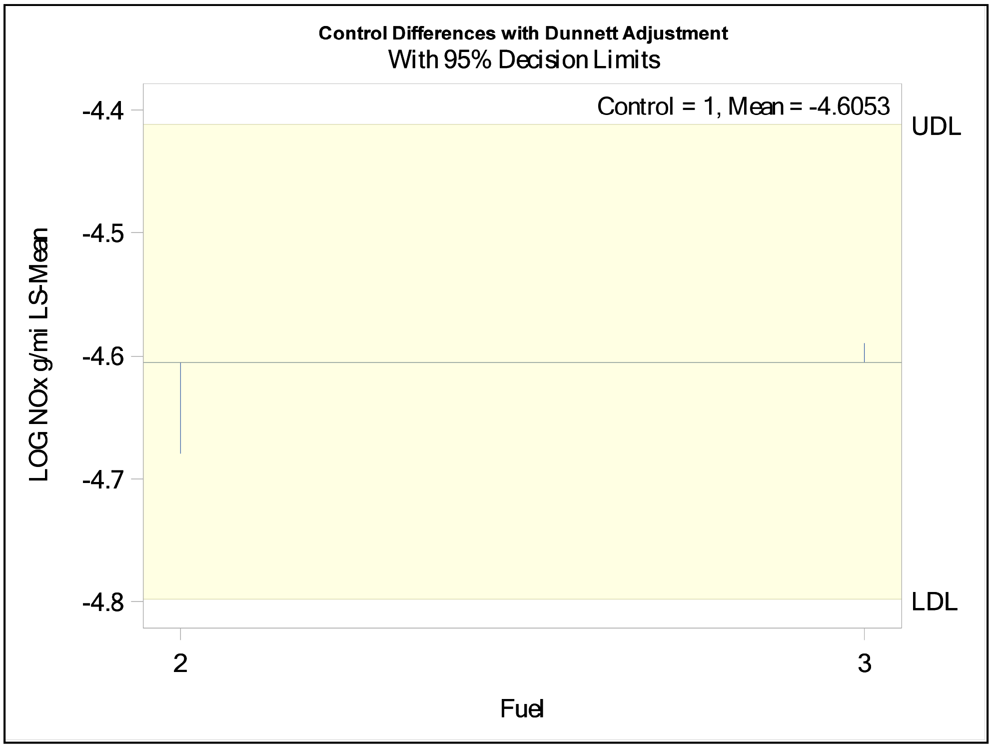

FIGURE 54. PLOT OF LOG(NO_X) PHASE 2 LSMEAN DIFFERENCES AGAINST FUEL 1

5.7.4 NO_X – Phase 3

The results of the ANOVA for the LOG(NO_X) Phase 3 are provided in Table 62. Note that statistically significant differences were observed across the 15 vehicles. Figure 55 illustrates the average Phase 3 NO_X emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 3 NO_X emission for each of the three fuels by vehicle.

TABLE 62. ANOVA TABLE FOR COMPARING LOG(NO_X) PHASE 3 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.1455986	0.0727993	0.09	0.9103
Vehicle	14	121.4392481	8.6742320	11.24	<0.0001

The LOG(NO_X) Phase 3 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 56. As shown in Figure 56, the LSMeans for LOG(NO_X) Phase 3 are not significantly different for Fuel 2 vs. Fuel 1 or for Fuel 3 vs. Fuel 1.

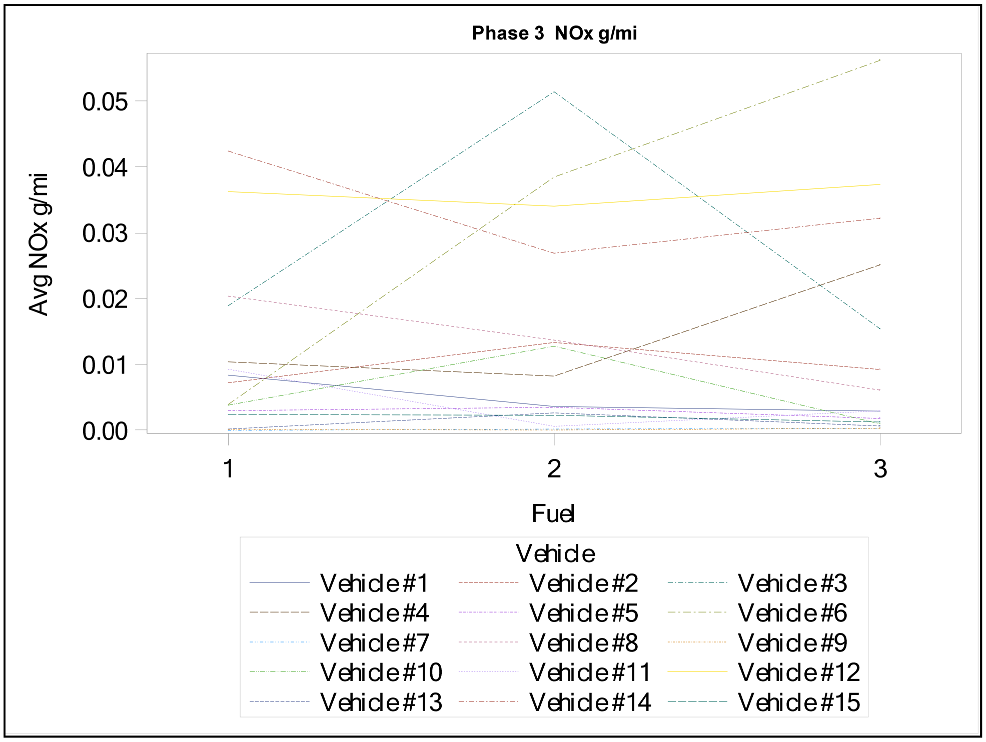

FIGURE 55. PLOT OF AVERAGE NO_X PHASE 3 TEST RESULTS BY FUEL AND VEHICLE

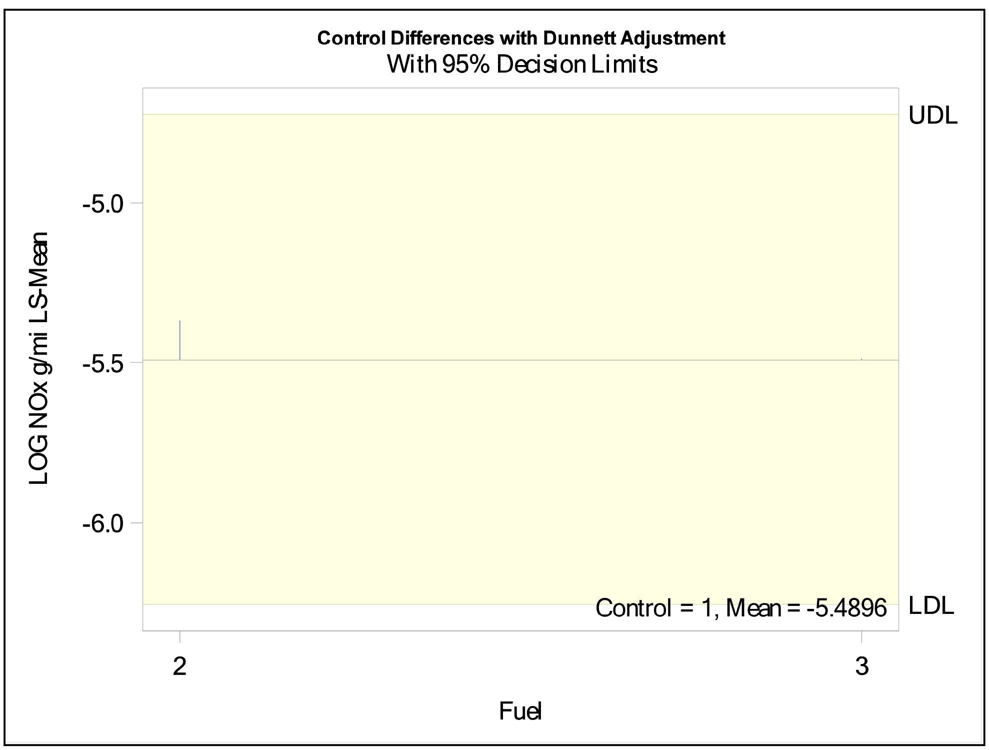

FIGURE 56. PLOT OF LOG(NO_X) PHASE 3 LSMEAN DIFFERENCES AGAINST FUEL 1

5.8 Fuel Comparisons for PM

An analysis of variance was performed to examine the changes in average LOG(PM) emissions from Fuel 1 to Fuel 2 and from Fuel 1 to Fuel 3. Also included in the ANOVA model were effects due to vehicles. The results of the ANOVA for comparing Fuels 2 and 3 to Fuel 1 are provided in Table 63. The estimated LSMeans (in LOG and original units) are listed by phase and fuel. There were statistically significant differences comparing the LOG(PM) LSMeans for Fuel 1 vs. Fuel 2 for the Composite and Phase 1(p-value < 0.05

TABLE 63. ANOVA RESULTS BY PHASE COMPARING LOG(PM) LSMEANS AGAINST FUEL 1

Emission	Phase	Fuel	LOG(LSMean)	LSMean	P-Value
PM mg/mi	Composite	1	-0.1939	0.823765	-
PM mg/mi	Composite	2	-0.5185	0.595425	0.0138
PM mg/mi	Composite	3	-0.1786	0.836432	0.9865
PM mg/mi	Phase 1	1	1.4886	4.430977	-
PM mg/mi	Phase 1	2	0.6525	1.920240	<0.0001
PM mg/mi	Phase 1	3	1.2181	3.380589	0.0612
PM mg/mi	Phase 2	1	-0.7101	0.491595	-
PM mg/mi	Phase 2	2	-0.8583	0.423903	0.2325
PM mg/mi	Phase 2	3	-0.6169	0.539642	0.5327
PM mg/mi	Phase 3	1	0.3600	1.433358	-
PM mg/mi	Phase 3	2	0.3761	1.456535	0.9977
PM mg/mi	Phase 3	3	0.5685	1.765670	0.6859

5.8.1 PM – Composite

The results of the ANOVA for the LOG(PM) Composite are provided in Table 64. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 57 illustrates the average Composite PM emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Composite PM emission for each of the three fuels by vehicle.

TABLE 64. ANOVA TABLE FOR COMPARING LOG(PM) COMPOSITE TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	1.10559854	0.55279927	5.85	0.0075
Vehicle	14	14.75712363	1.05408026	11.16	<0.0001

The LOG(PM) Composite results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 58. As shown in Figure 58, the LSMeans for LOG(PM) Composite are significantly different for Fuel 2 vs. Fuel 1 where Fuel 2 demonstrated a decrease in LOG(PM) Composite LSMean.

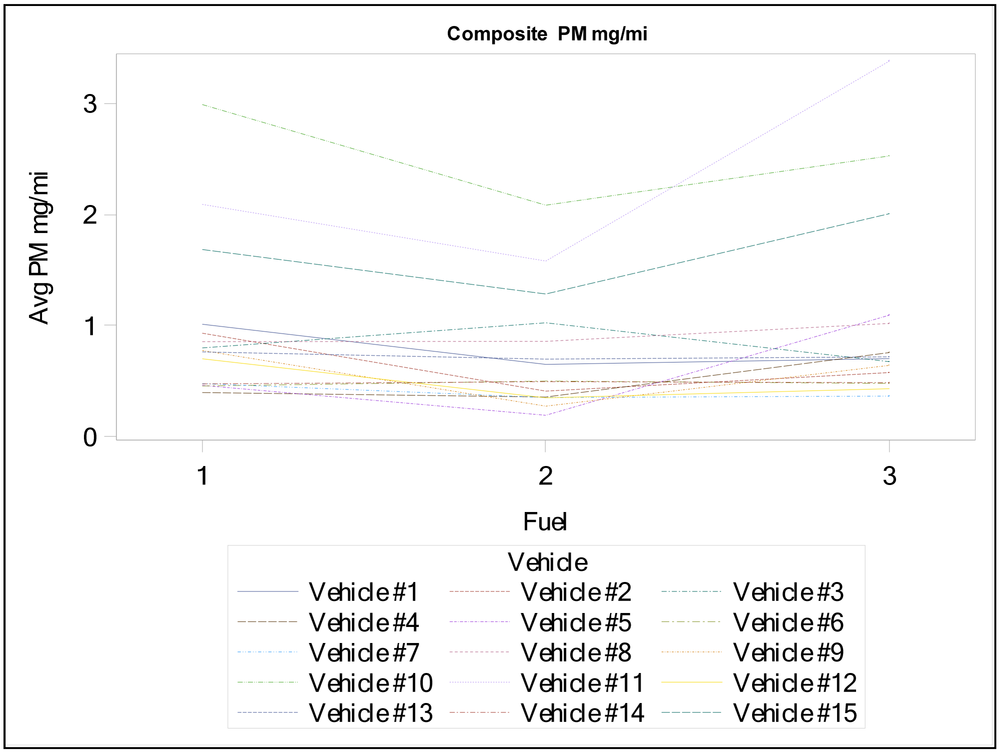

FIGURE 57. PLOT OF AVERAGE PM COMPOSITE TEST RESULTS BY FUEL AND VEHICLE

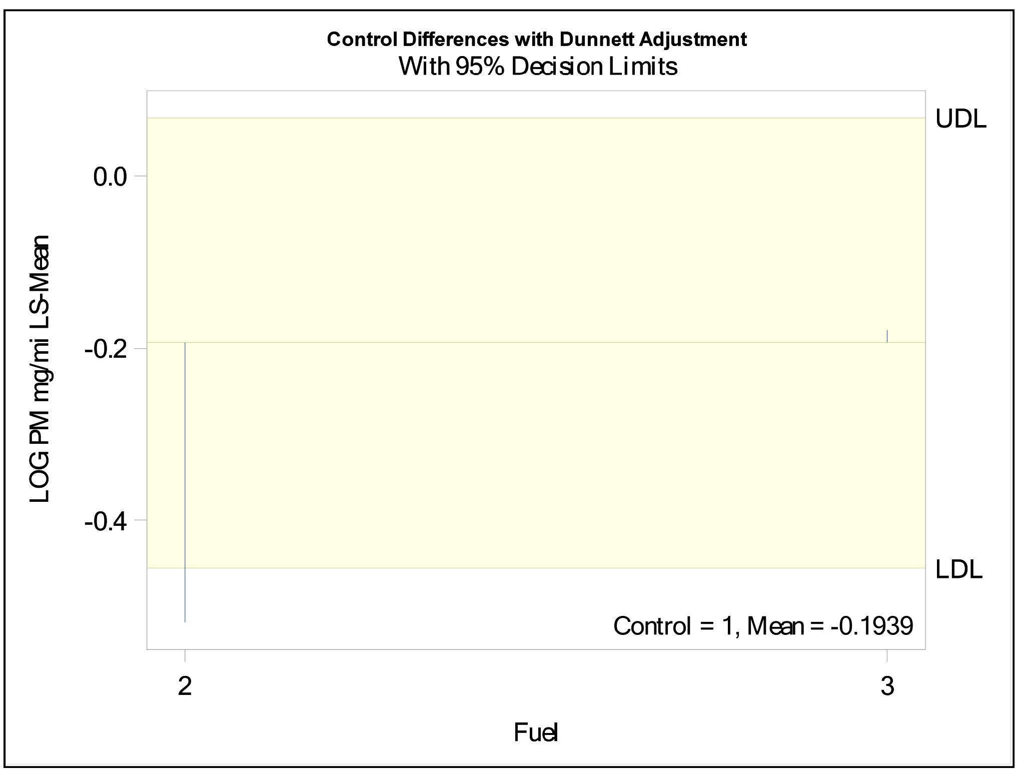

FIGURE 58. PLOT OF LOG(PM) COMPOSITE LSMEAN DIFFERENCES AGAINST FUEL 1

5.8.2 PM – Phase 1

The results of the ANOVA for the LOG(PM) Phase 1 are provided in Table 65. Note that statistically significant differences were observed between the fuels and across the 15 vehicles. Figure 59 illustrates the average Phase 1 PM emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 1 PM emission for each of the three fuels by vehicle.

TABLE 65. ANOVA TABLE FOR COMPARING LOG(PM) PHASE 1 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	5.46153651	2.73076826	24.82	<0.0001
Vehicle	14	15.10369295	1.07883521	9.81	<0.0001

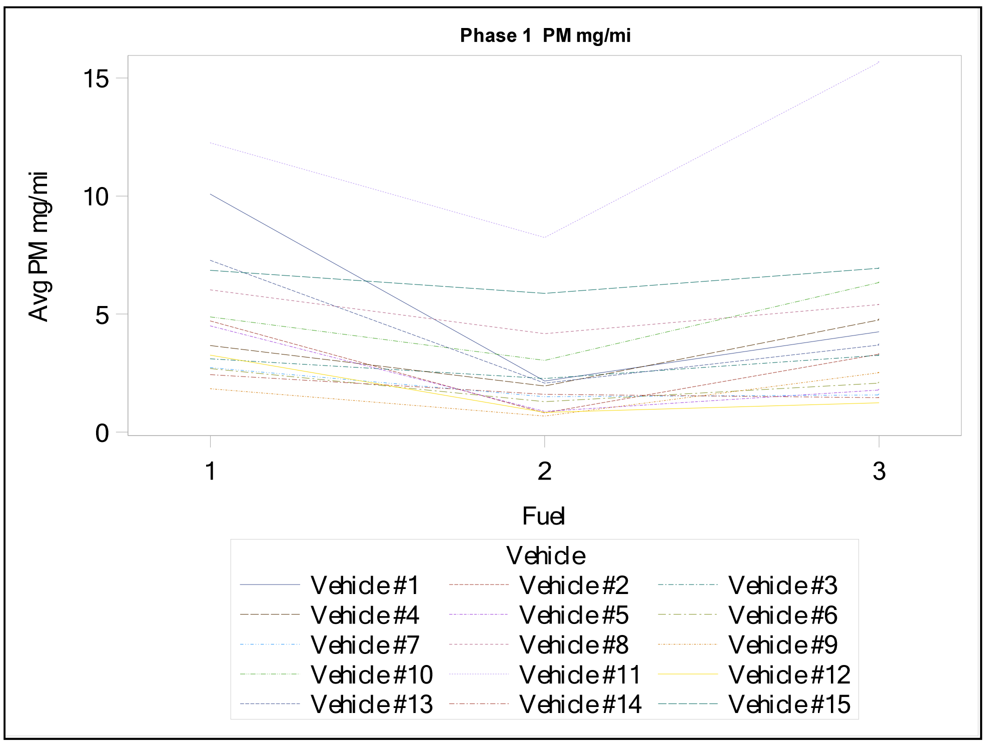

FIGURE 59. PLOT OF AVERAGE PM PHASE 1 TEST RESULTS BY FUEL AND VEHICLE

The LOG(PM) Phase 1 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 60. As shown in Figure 60, the LSMeans for LOG(PM) Phase 1 are significantly different for Fuel 2 vs. Fuel 1. In this comparison, Fuel 2 demonstrated a reduction in LOG(PM) Phase 1 LSMeans.

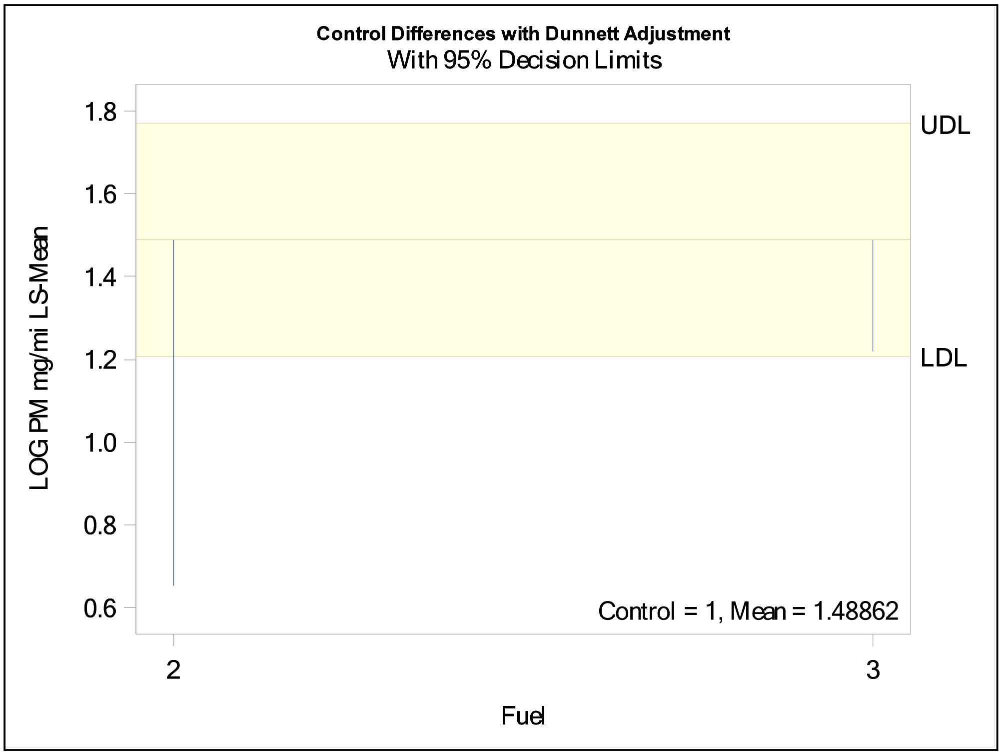

FIGURE 60. PLOT OF LOG(PM) PHASE 1 LSMEAN DIFFERENCES AGAINST FUEL 1

5.8.3 PM – Phase 2

The results of the ANOVA for the LOG(PM) Phase 2 are provided in Table 66. Note that statistically significant differences were observed across the 15 vehicles. Figure 61 illustrates the average Phase 2 PM emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 2 PM emission for each of the three fuels by vehicle.

TABLE 66. ANOVA TABLE FOR COMPARING LOG(PM) PHASE 2 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.44460916	0.22230458	3.18	0.0571
Vehicle	14	21.60167427	1.54297673	22.05	<0.0001

The LOG(PM) Phase 2 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 62. As shown in Figure 62, the LSMeans for PM Phase 2 are not significantly different for Fuel 2 vs. Fuel 1 or for Fuel 3 vs. Fuel 1.

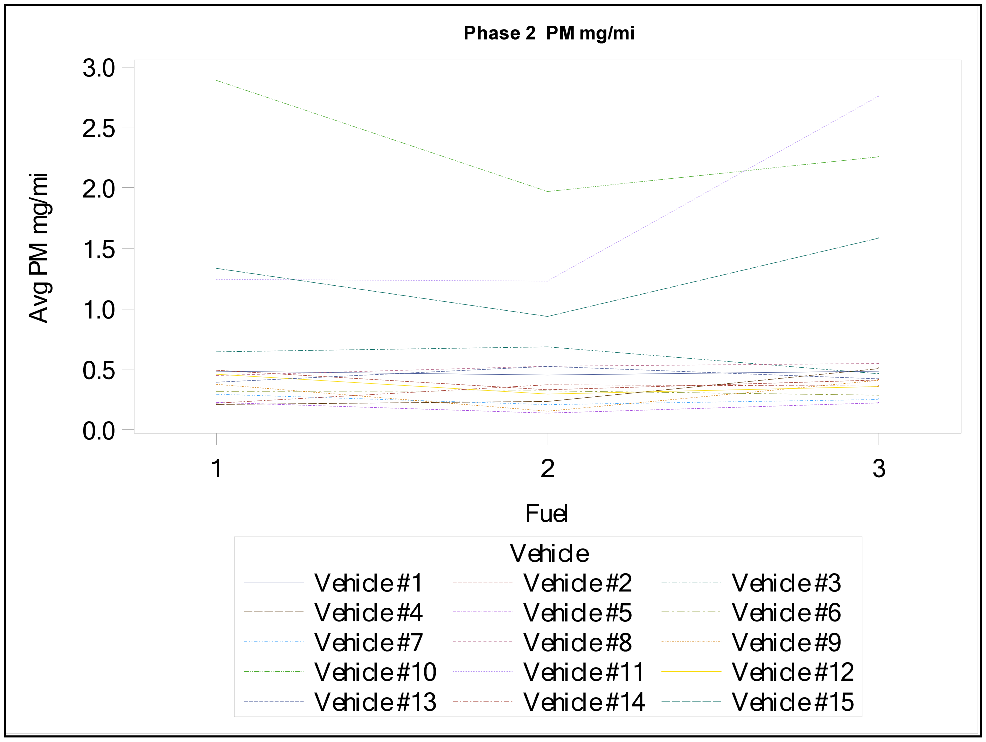

FIGURE 61. PLOT OF AVERAGE PM PHASE 2 TEST RESULTS BY FUEL AND VEHICLE

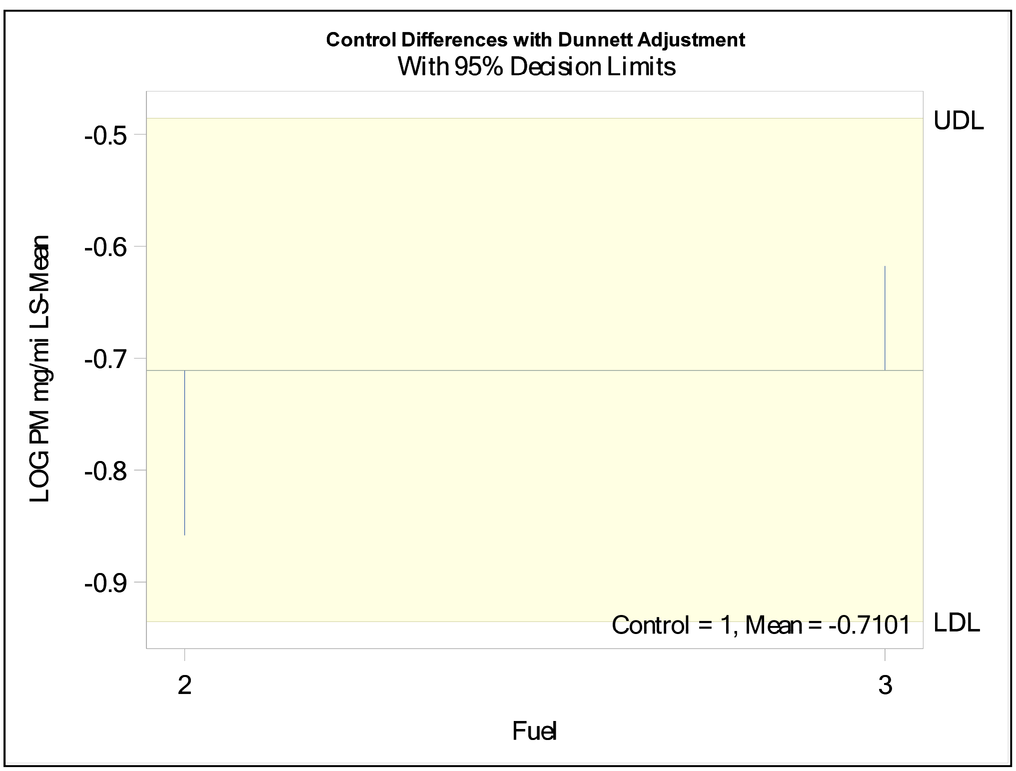

FIGURE 62. PLOT OF LOG(PM) PHASE 2 LSMEAN DIFFERENCES AGAINST FUEL 1

5.8.4 PM – Phase 3

The results of the ANOVA for the LOG(PM) Phase 3 are provided in Table 67. Note that no statistically significant differences were observed across the fuels or the 15 vehicles. Figure 63 illustrates the average Phase 3 PM emission test result by fuel and coded by line styles for the 15 vehicles. Lines connect the average Phase 3 PM emission for each of the three fuels by vehicle.

TABLE 67. ANOVA TABLE FOR COMPARING LOG(PM) PHASE 3 TEST RESULTS ACROSS FUELS

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Fuel	2	0.40387474	0.20193737	0.33	0.7183
Vehicle	14	8.64860264	0.61775733	1.02	0.4591

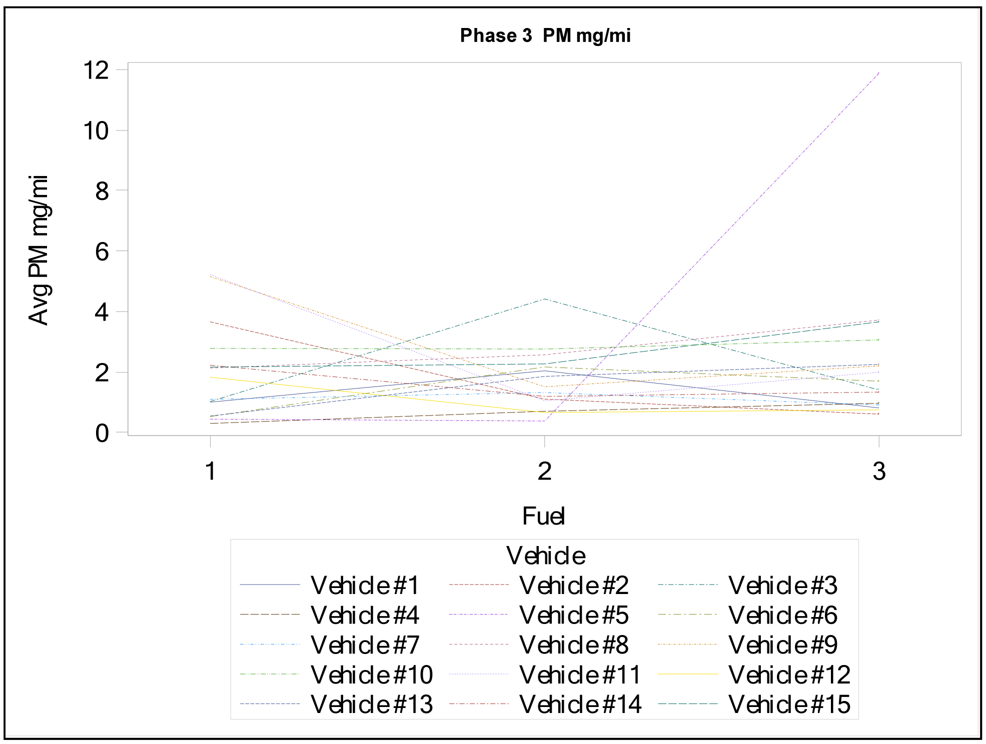

FIGURE 63. PLOT OF AVERAGE PM PHASE 3 TEST RESULTS BY FUEL AND VEHICLE

The LOG(PM) Phase 3 results of Dunnett's comparison test for Fuel 1 to Fuels 2 and 3 are graphically displayed in Figure 64. As shown in Figure 64, the LSMeans for LOG(PM) Phase 3 are not significantly different for Fuel 2 vs. Fuel 1 or for Fuel 3 vs. Fuel 1.

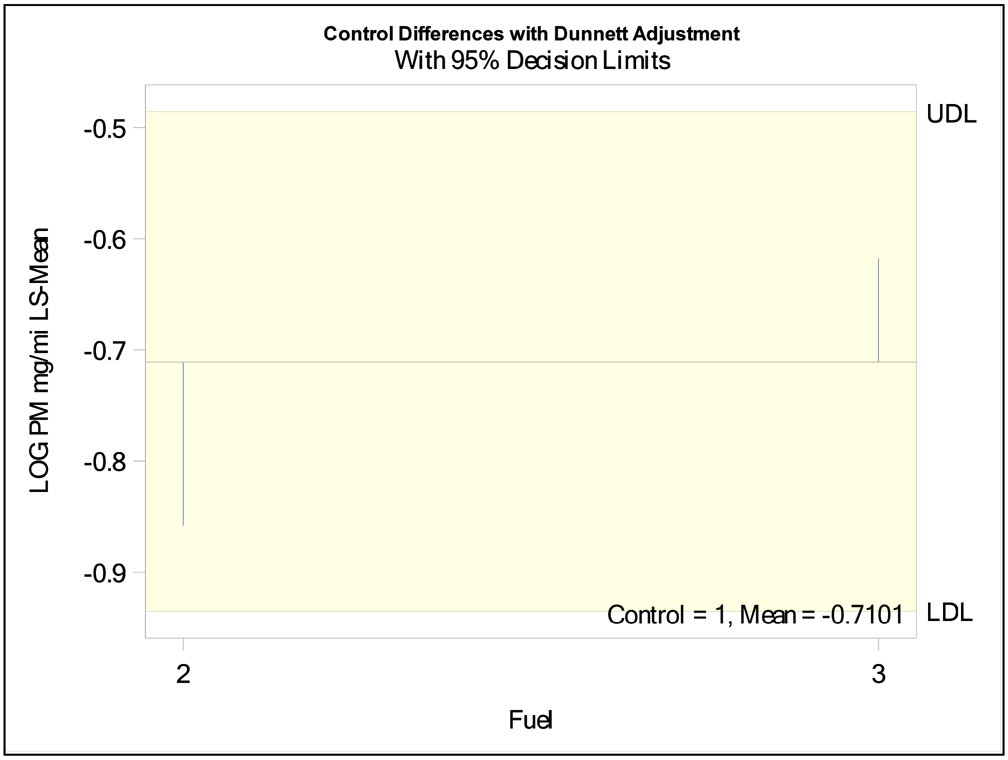

FIGURE 64. PLOT OF LOG(PM) PHASE 3 LSMEAN DIFFERENCES AGAINST FUEL 1

5.9 Percent Change in Emissions LSMEANS

As a graphical summary of the comparisons of the LSMeans emissions estimated from the ANOVA models presented in the preceding sections, the following figures plot the percent change in LSMeans from Fuel 1 to Fuel 2 and from Fuel 1 to Fuel 3 for all six emissions at a given test phase. The percent change was computed using the following equations:

For Change from Fuel 1 to Fuel 2:

$$\%\, Change\ from\ Fuel\ 1 = 100 * (e^{LSMean_{Fuel\,2}} - e^{LSMean_{Fuel\,1}})/e^{LSMean_{Fuel\,1}}$$

For Change from Fuel 1 to Fuel 3:

$$\%\, Change\ from\ Fuel\ 1 = 100 * (e^{LSMean_{Fuel\,3}} - e^{LSMean_{Fuel\,1}})/e^{LSMean_{Fuel\,1}}$$

The percent change in LSMean emissions for the Composite, Phase 1, Phase 2 and Phase 3 tests are depicted in Figures 65 through 68, respectively.

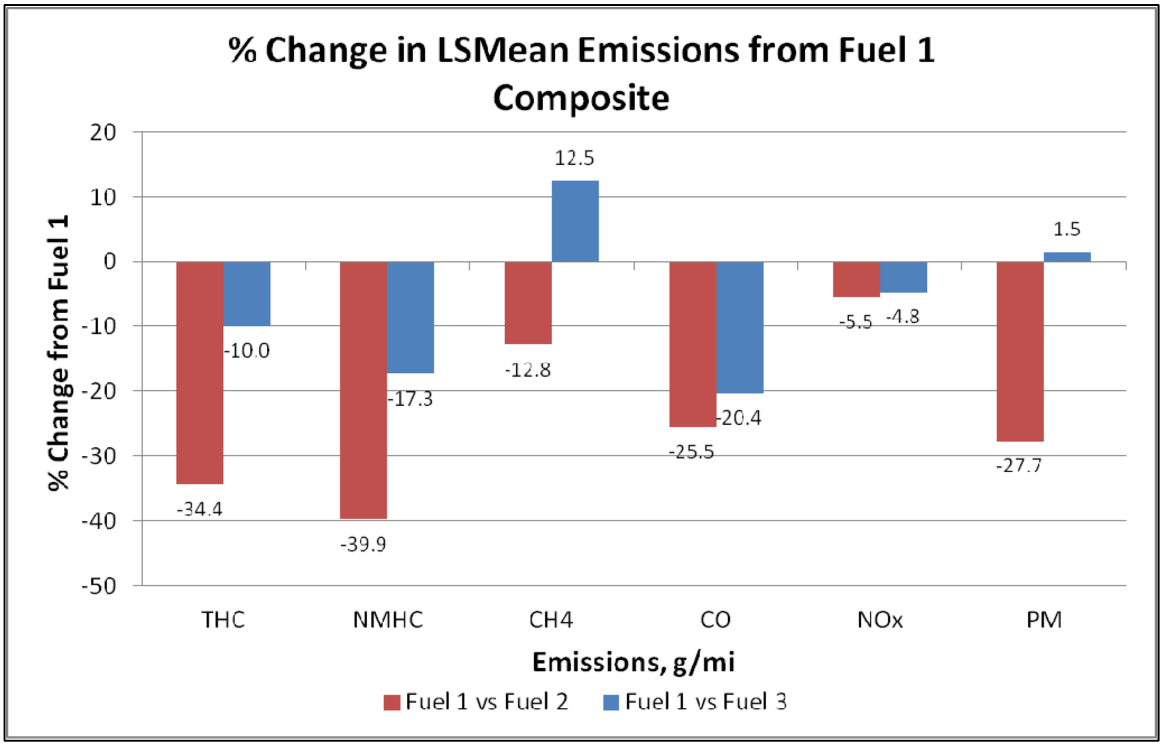

FIGURE 65. LSMEAN EMISSIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3 FOR COMPOSITE PHASE

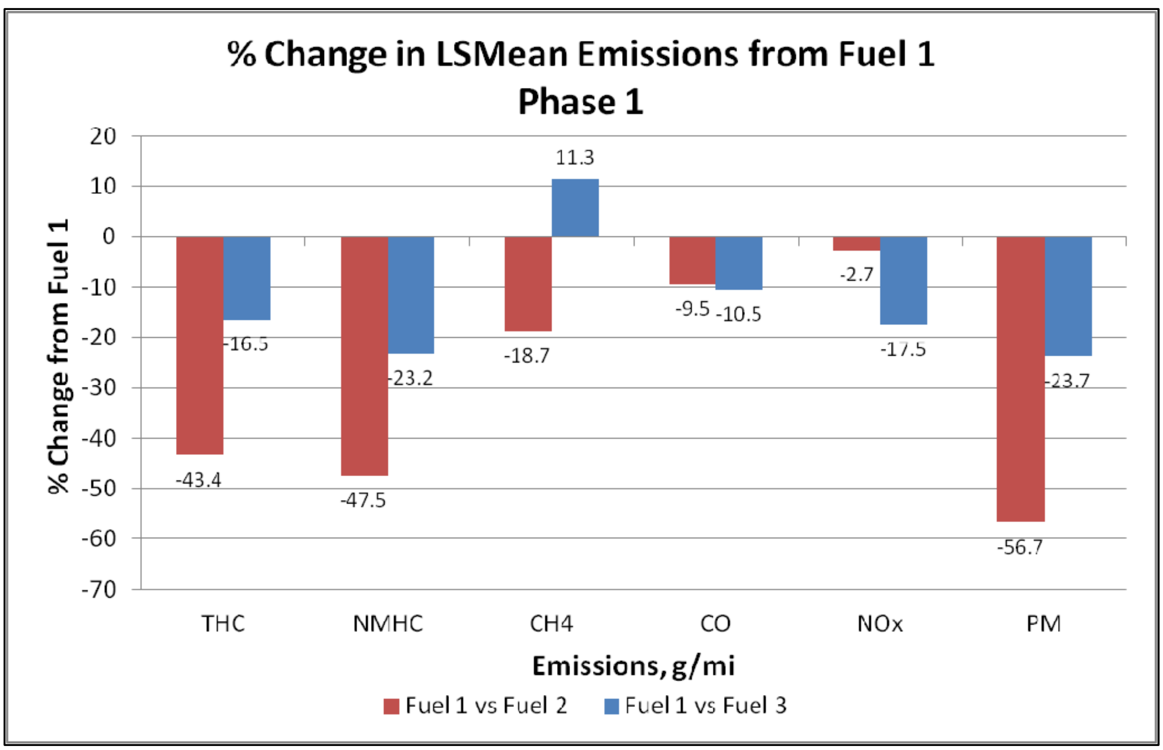

FIGURE 66. LSMEAN EMISSIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3 FOR PHASE 1

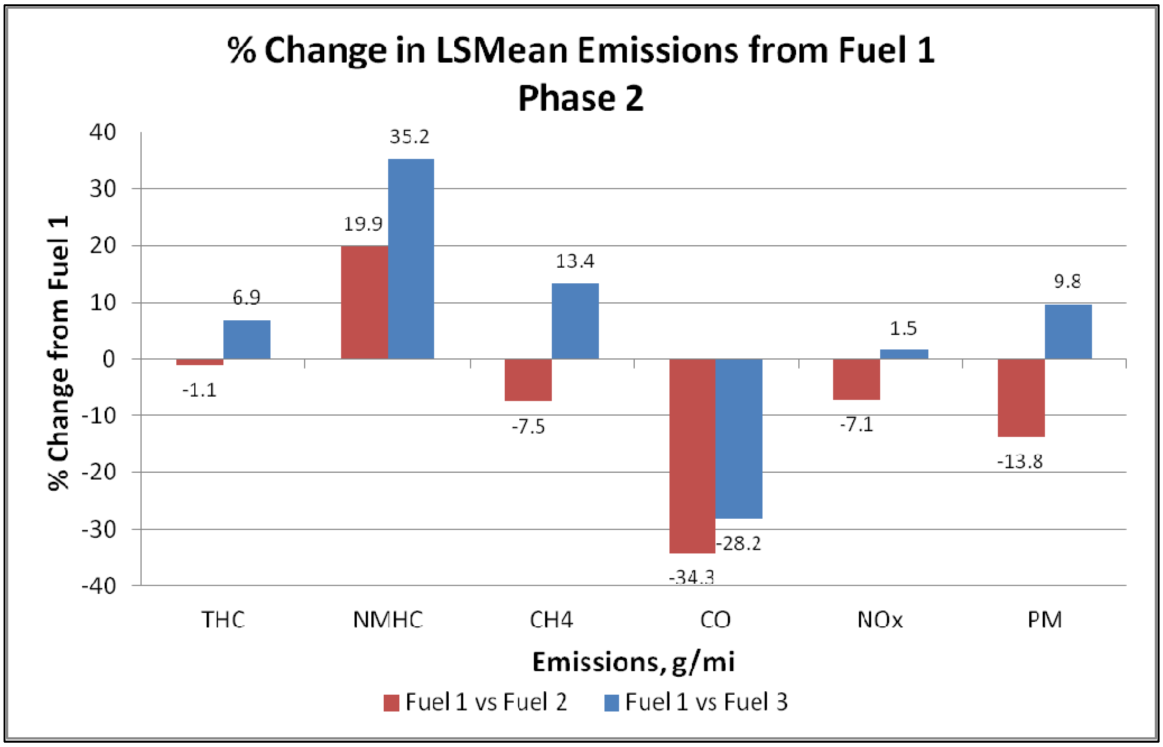

FIGURE 67. LSMEAN EMISSIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3 FOR PHASE 2

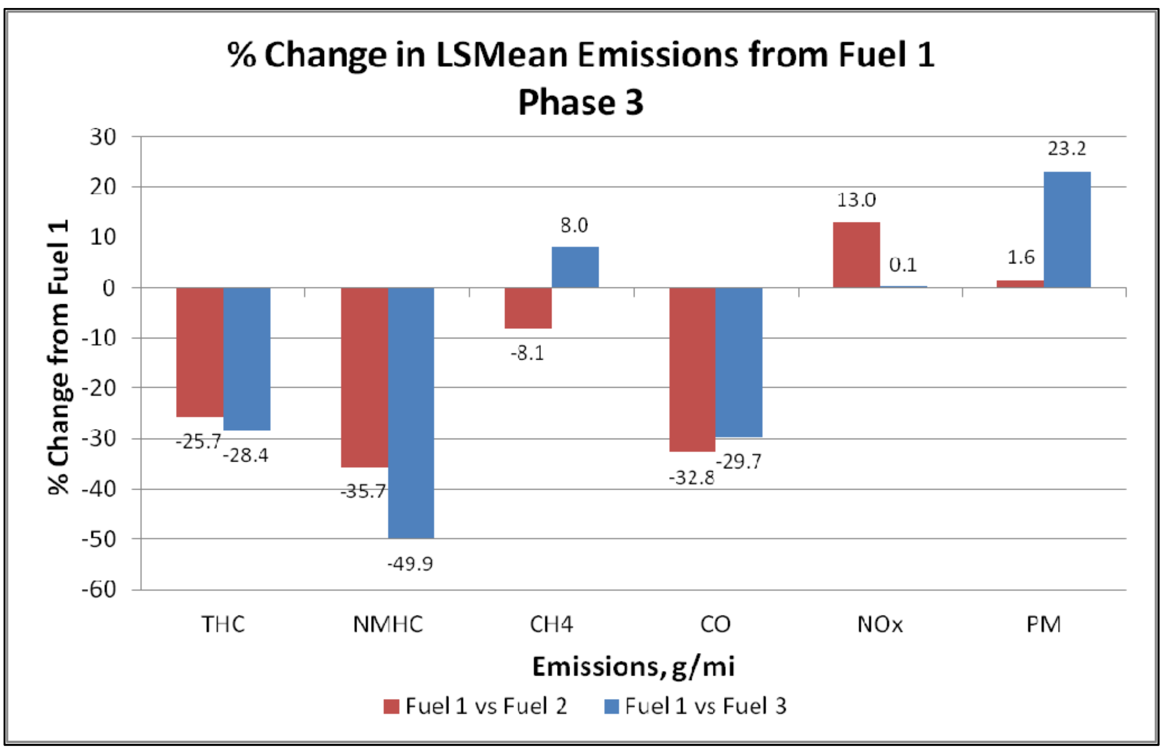

FIGURE 68. LSMEAN EMISSIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3 FOR PHASE 3

5.10 Prediction Model Comparisons Across Three E-98 Test Fuels

Several emissions predictive models have been developed in order to assess the fuel effects on exhaust emissions from light-duty vehicles certified to Tier-2 standards[1,2]. These models were based on the emissions tests from the EPAct/V2/E-89 fleet of 15 model year 2008 vehicles using 27 fuels with varying levels of five fuel properties: ethanol, T_{50}, T_{90}, RVP and aromatics. Emissions model predictions compared in this study include THC, NMHC, CH_4, CO, NO_X and PM for the Composite, Phase 1, Phase 2 and Phase 3 tests. Table 68 lists the models and phases used in comparing the 3 test fuels in the E-98 study.

TABLE 68. EMISSIONS PREDICTIVE MODEL RESULTS COMPARED IN THIS STUDY

Model	Reference	Phases	Comments
1: Gunst 17-term	Appendix III[2]	Composite, Phase 1, Phase 2, Phase 3	
2: Gunst 16-term	Appendix IV[2]	Composite, Phase 1, Phase 2, Phase 3	
3: Gunst Reduced	Appendix V[2]	Composite, Phase 1, Phase 2, Phase 3	
4: EPA 11-term	Pages 167-173 Tables 56, 60, 62, 64, 66, 68[1]	Phase 1, Phase 2, Phase 3	
5: EPA 16-term	Pages 167-173 Tables 57, 61, 63, 65, 67, 69[1]	Composite, Phase 1, Phase 2, Phase 3	• For the Composite model, used Gunst's reduced models without the T_{90}^2 term (Appendix VI[2]) • Note corrections to etOH interaction model term labels in Tables 57, 61, 63, 65, 67, 69. • Table 69 PM Phase 3 coefficients were replaced with correct coefficients from Appendix J.6[1]

The coefficients used in the predictive models are standardized coefficients. These types of coefficients represent the change in the natural logarithm of the predicted emissions when a fuel property changes by one standard deviation. The standardization of the fuel properties prior to the model development were carried out using a 'two-stage standardization' as described in Ref 1, pp. 28-30. The means and standard deviations for the fuel properties used in the two-stage standardization are provided in Table 69.

TABLE 69. MEANS AND STANDARD DEVIATIONS FOR FUEL PROPERTIES USED IN MODEL TWO-STAGE STANDARDIZATION

Model Term	Mean	Standard Deviation
T50 (°F)	190.611111	28.579112
T90 (°F)	320.533333	19.480128
EtOH (%)	10.313704	7.879557
RVP (psi)	8.517778	1.611374
ARO (%)	25.629630	10.015366
T502	0.962963	0.739766
EtOH2	0.962963	0.802769
T50*T90	-0.036304	0.960011
T50*EtOH	-0.541342	0.769153
T50*ARO	-0.068030	0.991737
T90*EtOH	0.016328	0.972825
T90*RVP	0.126761	0.972729*
T90*ARO	-0.006253	0.983536
EtOH*RVP	-0.099235	0.999615
EtOH*ARO	-0.036738	0.978461
RVP*ARO	0.043792	0.984096
* Used standard deviation from Gunst report [2]		

Predictive emissions were estimated for each of the five models listed in Table 68 using the three test fuels' property data provided in Table 1. The goals of the analyses were to (1) compare the predicted emissions for the E-98 Fuel 1 to the predicted emissions for the E-98 Fuel 2, and (2) compare the predicted emissions for the E-98 Fuel 1 to the predicted emissions for the E-98 Fuel 3. This was done using a relative change in predicted emissions as follows:

For Predicted Change from Fuel 1 to Fuel 2:

$$\%\, Change\ from\ Fuel\ 1 = 100 * \frac{(e^{Predicted\ Model\ Emission\ for\ Fuel\ 2} - e^{Predicted\ Model\ Emission\ for\ Fuel\ 1})}{e^{Predicted\ Model\ Emission\ for\ Fuel\ 1}}$$

For Predicted Change from Fuel 1 to Fuel 3:

$$\%\, Change\ from\ Fuel\ 1 = 100 * \frac{(e^{Predicted\ Model\ Emission\ for\ Fuel\ 3} - e^{Predicted\ Model\ Emission\ for\ Fuel\ 1})}{e^{Predicted\ Model\ Emission\ for\ Fuel\ 1}}$$

For each emission and phase, the relative % change from Fuel 1 is plotted for each of the five predictive models in addition to a relative % change using the GLM Model LSMeans estimated from the analysis of variance results provided in Sections 5.3-5.8.

5.10.1 *Model Prediction Comparison for THC*

Relative percent change in predicted THC emissions for the five models and the ANOVA LSMeans are illustrated in Figures 69 through 72 for the Composite, Phase 1, Phase 2, and Phase 3, respectively. Note that there was no Composite phase for the EPA 11-term predictive model for THC.

A negative percent change indicates that the predicted THC using Fuel 1 was higher than the predicted THC using Fuel 2 or Fuel 3. In each of the Composite, Phase 1, Phase 2 and Phase 3 tests the THC Fuel 2 predictions were lower than the THC Fuel 1 predictions (ranging from -37.6% to -17.8%). Similar results were shown in the comparisons of the LS Means where the THC Fuel 2 averages were lower than the THC Fuel 1 averages (-43.4% to -1.1%). For THC comparisons between Fuel 1 and Fuel 3, the results were mixed. In the Composite phase, all but the Gunst 17-term model predicted higher THC for Fuel 3 than Fuel 1, although the percentages were very small (+1.7% to -0.8%). However, the THC LS Mean for Fuel 3 was lower than the LS Mean for Fuel 1 by 10.0%. During Phase 1, the Gunst 17-term and Reduced models predicted lower THC emissions for Fuel 3 than Fuel 1 (-7.4% to -4.7%). The LS Mean for Fuel 3 was also lower than Fuel 1, but by a larger percentage (-16.5%). For Phase 2, all models predicted higher Fuel 3 THC emissions than Fuel 1 (+0.1% to 4.6%). Similarly, the THC LS Mean for Fuel 3 was higher than Fuel 1 (+6.9%). Lastly, for Phase 3 all models predicted lower Fuel 3 THC emissions than Fuel 1 (-7.0% to -2.6%). Likewise, the THC LS Mean for Fuel 3 was lower than Fuel 1, but by a larger percentage (-28.4%).

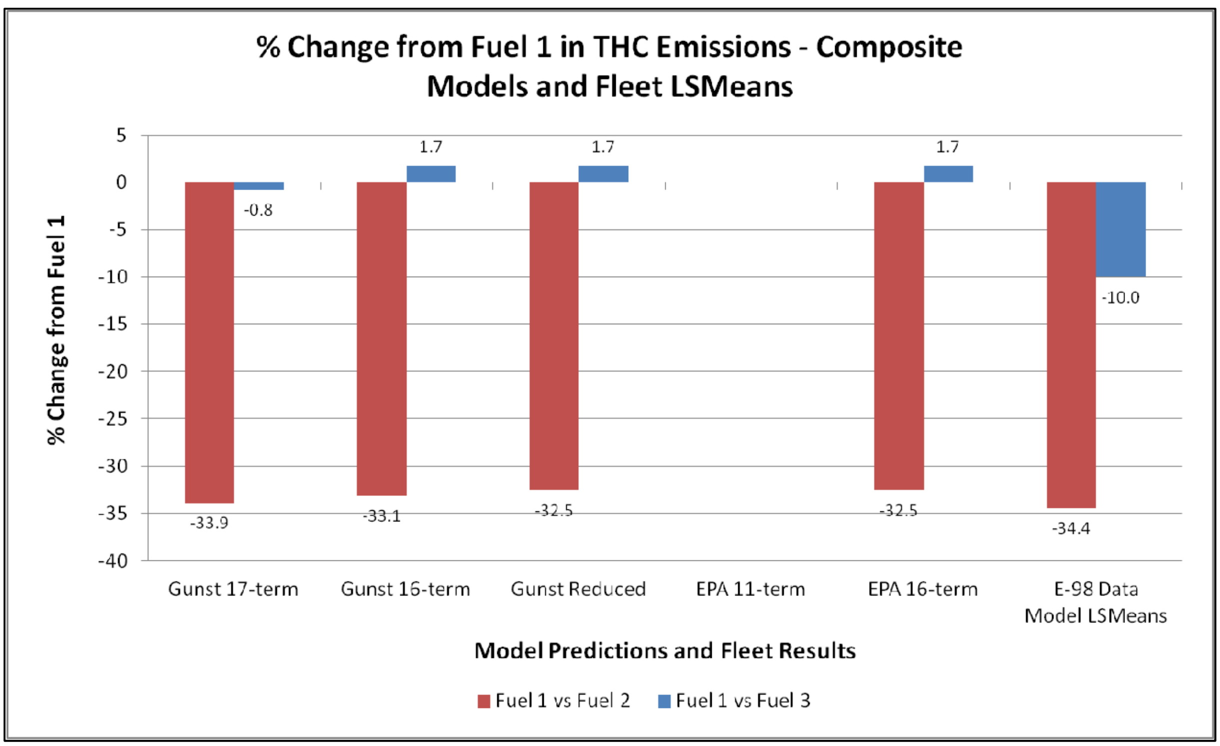

FIGURE 69. THC COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

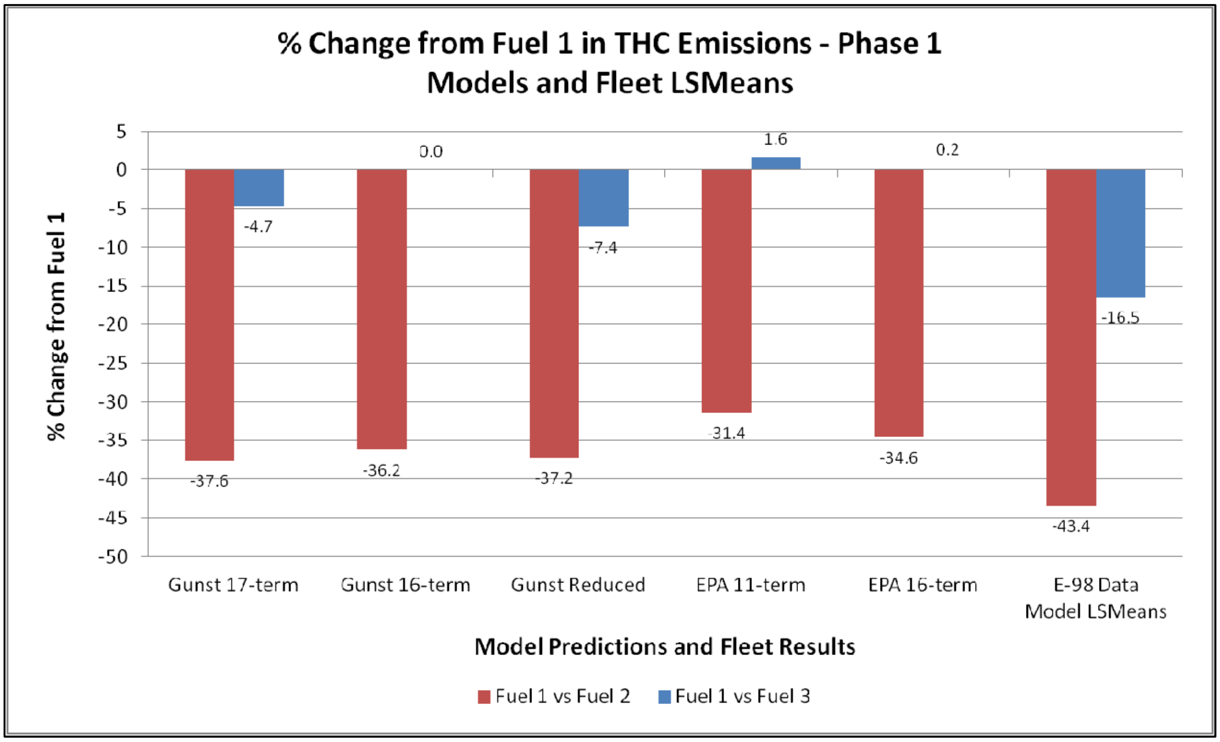

FIGURE 70. THC PHASE 1 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

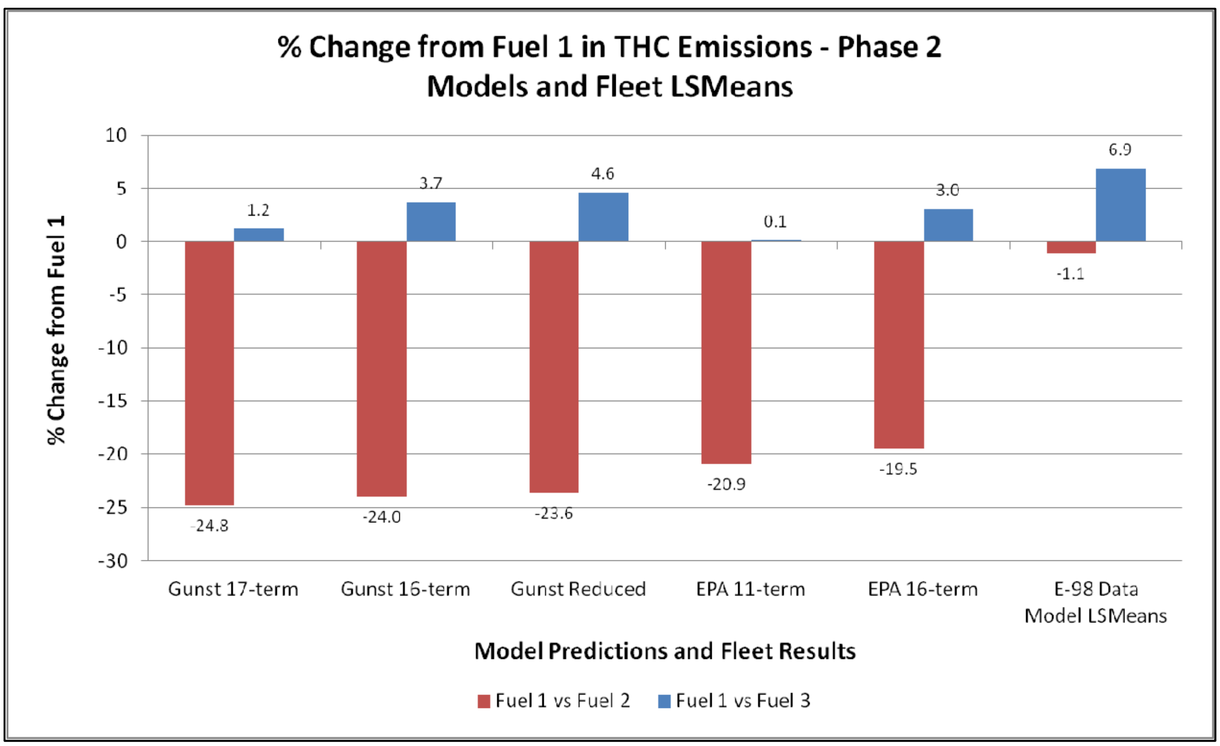

FIGURE 71. THC PHASE 2 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

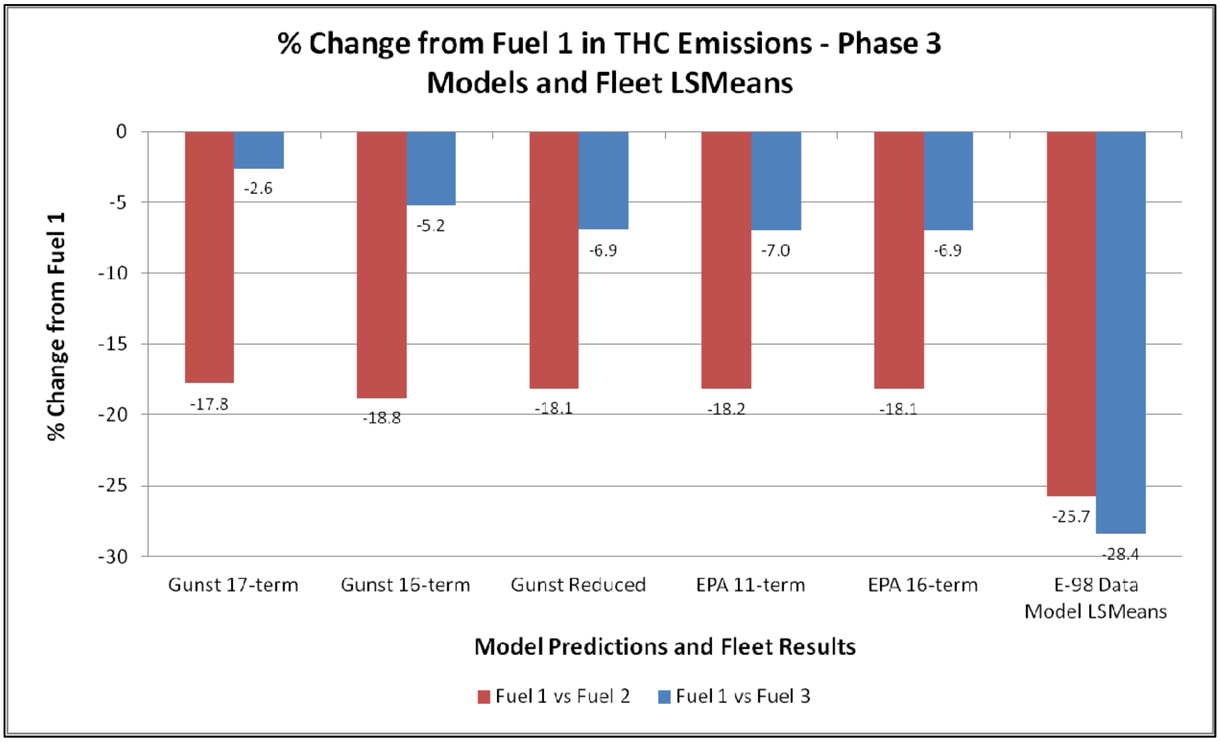

FIGURE 72. THC PHASE 3 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

5.10.2 Model Prediction Comparison for NMHC

Relative percent change in predicted NMHC emissions for the five models and the ANOVA LSMeans are illustrated in Figures 73 through 76 for the Composite, Phase 1, Phase 2, and Phase 3, respectively. Note that there was no Composite phase for the EPA 11-term predictive model for NMHC.

A negative percent change indicates that the predicted NMHC using Fuel 1 was higher than the predicted NMHC using Fuel 2 or Fuel 3. In each of the Composite, Phase 1, Phase 2 and Phase 3 tests the NMHC Fuel 1 predictions were higher than the NMHC Fuel 2 predictions (ranging from -51.9% to -30.2%). Similar results were shown in the comparisons of the LS Means where the NMHC Fuel 2 averages were lower than the NMHC Fuel 1 averages for all but Phase 2(-47.5% to -35.7%). For NMHC comparisons between Fuel 1 and Fuel 3, the predictions for Fuel 1 were also higher than Fuel 3 for the Composite, Phase 1 and Phase 3 tests (ranging from -40.8% to -5.4%). The NMHC LS Mean for Fuel 3 was also lower than Fuel 1 for the Composite, Phase 1 and Phase 3 tests, but by larger percentages (-49.9% to -23.2%). In the Phase 2, all but the Gunst 16-term model predicted lower NMHC for Fuel 3 than Fuel 1, although the percentages were very small (-14.9% to -0.1%). However, the Gunst 16-term model predicted higher NMHC emissions for Fuel 3 than Fuel 1, although it was a very small difference (+1.7%). For Phase 2, the NMHC LS Mean for Fuel 3 was also higher than the LS Mean for Fuel 1 (+35.2%).

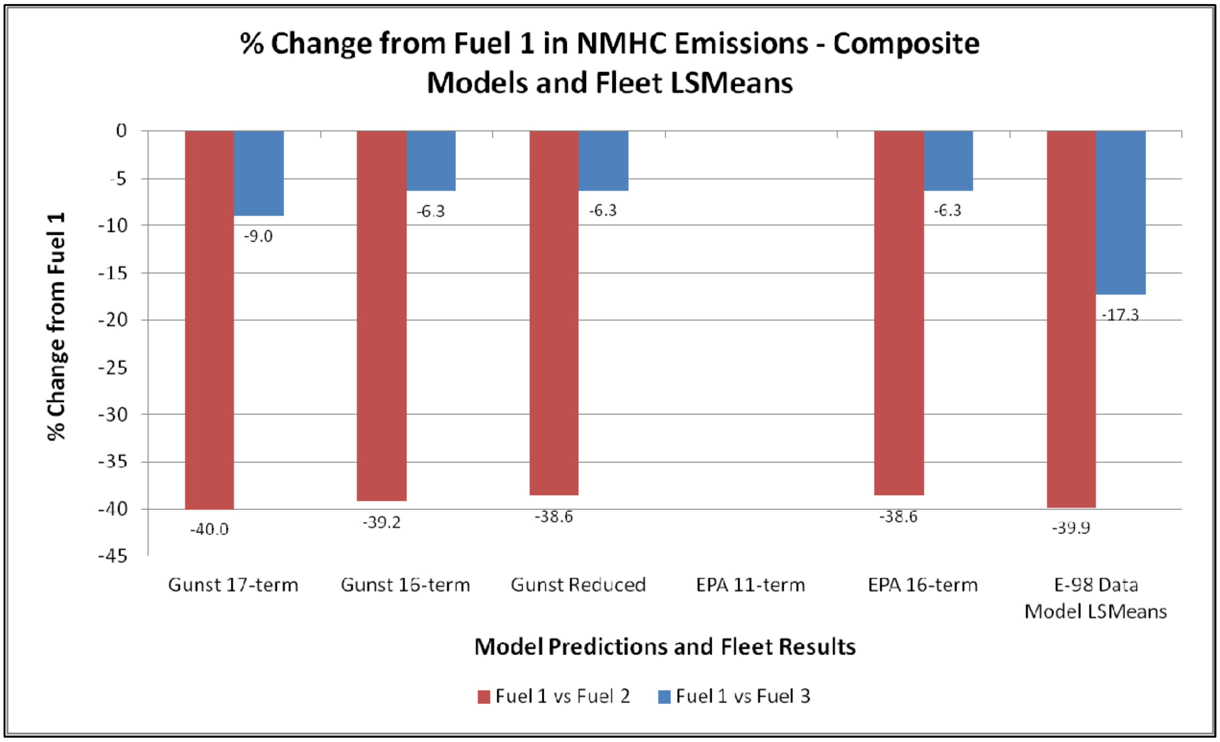

FIGURE 73. NMHC COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

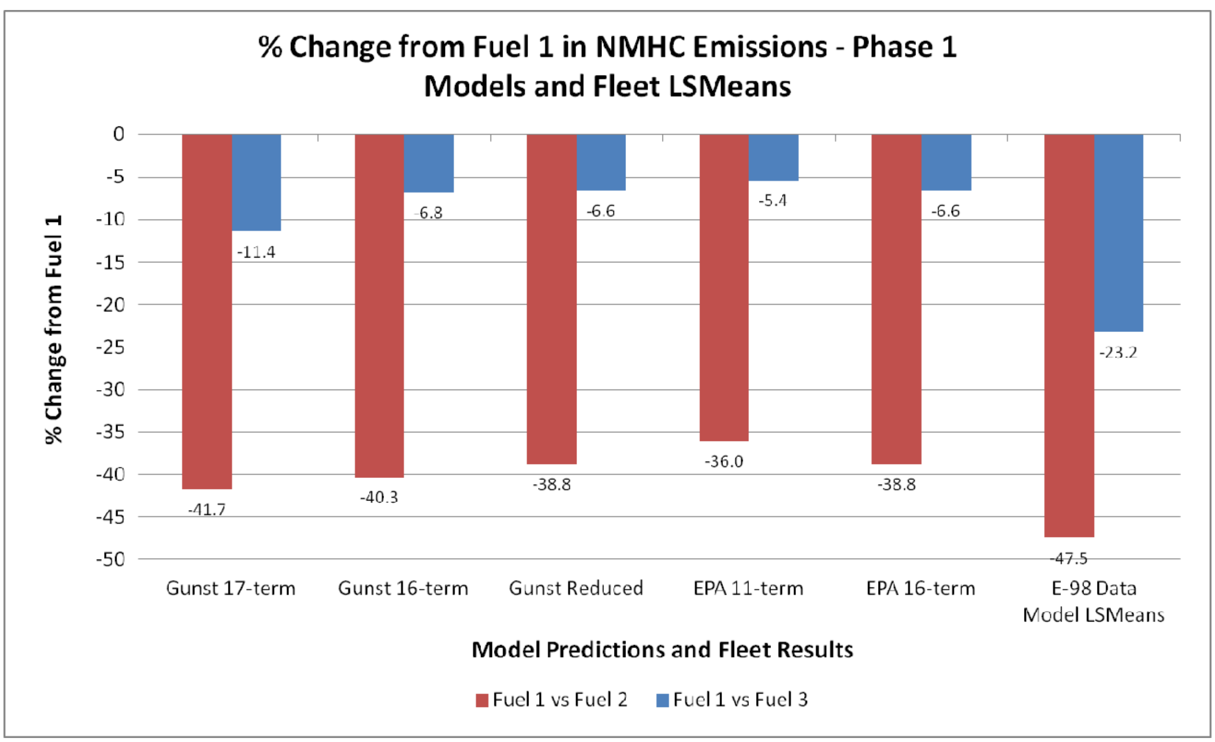

FIGURE 74. NMHC PHASE 1 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

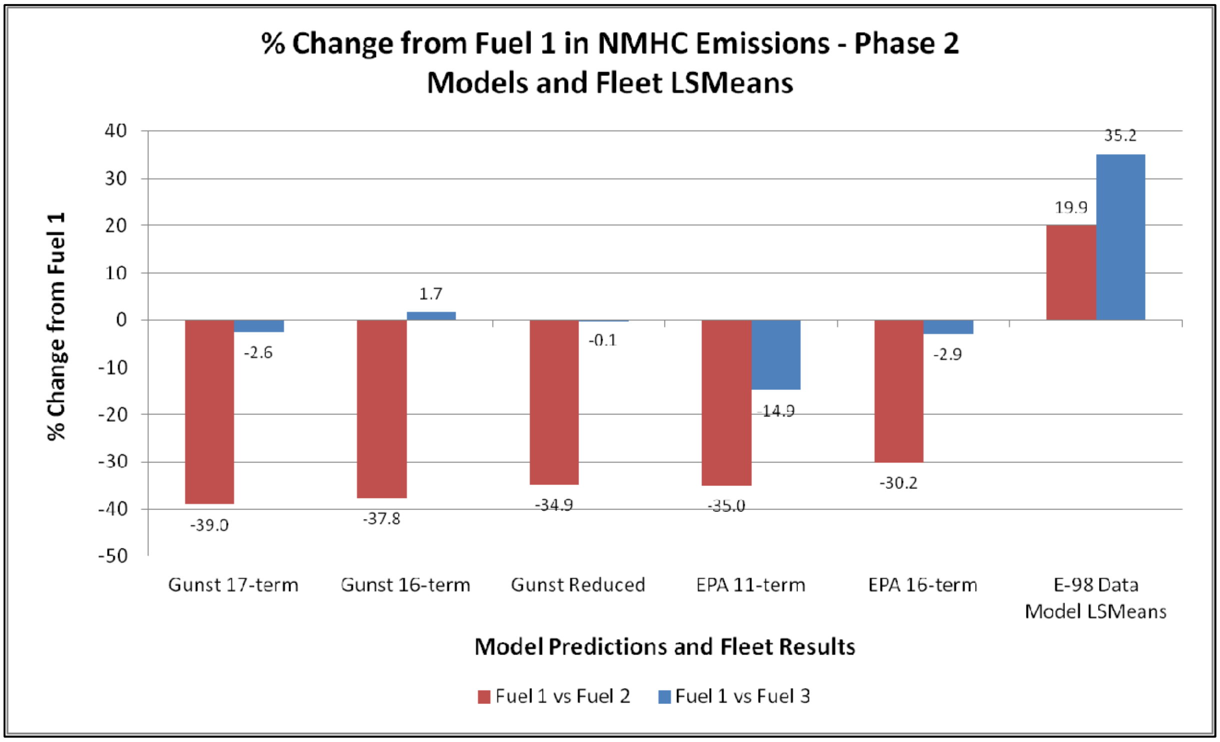

FIGURE 75. NMHC PHASE 2 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

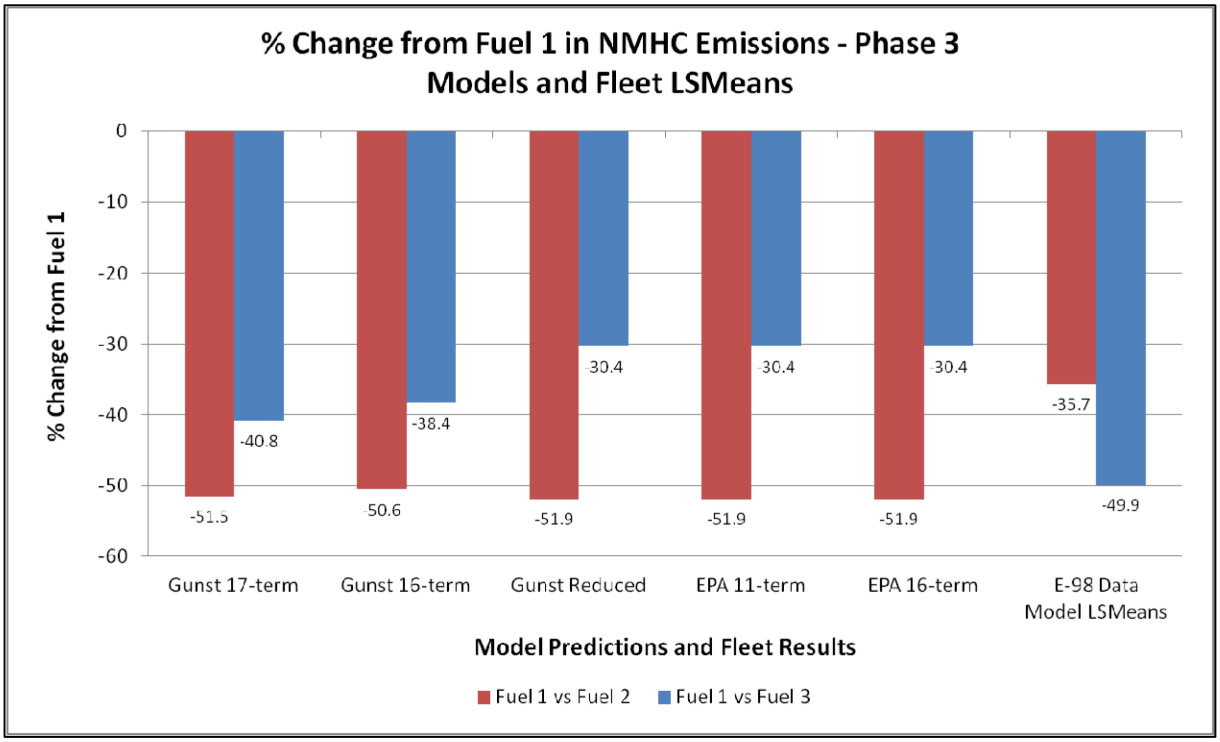

FIGURE 76. NMHC PHASE 3 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

5.10.3 Model Prediction Comparison for CH_4

Relative percent change in predicted CH_4 emissions for the five models and the ANOVA LSMeans are illustrated in Figures 77 through 80 for the Composite, Phase 1, Phase 2, and Phase 3, respectively. Note that there was no Composite phase for the EPA 11-term predictive model for CH4.

A negative percent change indicates that the predicted CH_4 using Fuel 1 was higher than the predicted CH_4 using Fuel 2 or Fuel 3. In each of the Composite, Phase 1, and Phase 2 tests the CH_4 Fuel 1 predictions were higher than the CH_4 Fuel 2 predictions (ranging from -12.9% to -1.0%). Similar results were shown in the comparisons of the LS Means where the CH_4 Fuel 1 averages were higher than the CH_4 Fuel 2 averages (-18.7% to -7.5%). Conversely, during the Phase 3 tests, the CH_4 Fuel 1 predictions were lower than the CH_4 Fuel 2 predictions (ranging from +0.5% to +3.7%). This was not seen in the CH_4 LS Means where Fuel 1 had a higher LS Mean than fuel 2 (-8.1%). For CH_4 comparisons between Fuel 1 and Fuel 3, the predictions for Fuel 1 were lower than Fuel 3 for the Composite, Phase 1, Phase 2 and Phase 3 tests (ranging from +10.4% to +27.7%). Similarly, the CH_4 LS Means for Fuel 1 were also lower than Fuel 3 for the Composite, Phase 1, Phase 2 and Phase 3 tests (+8.0% to +13.4%).

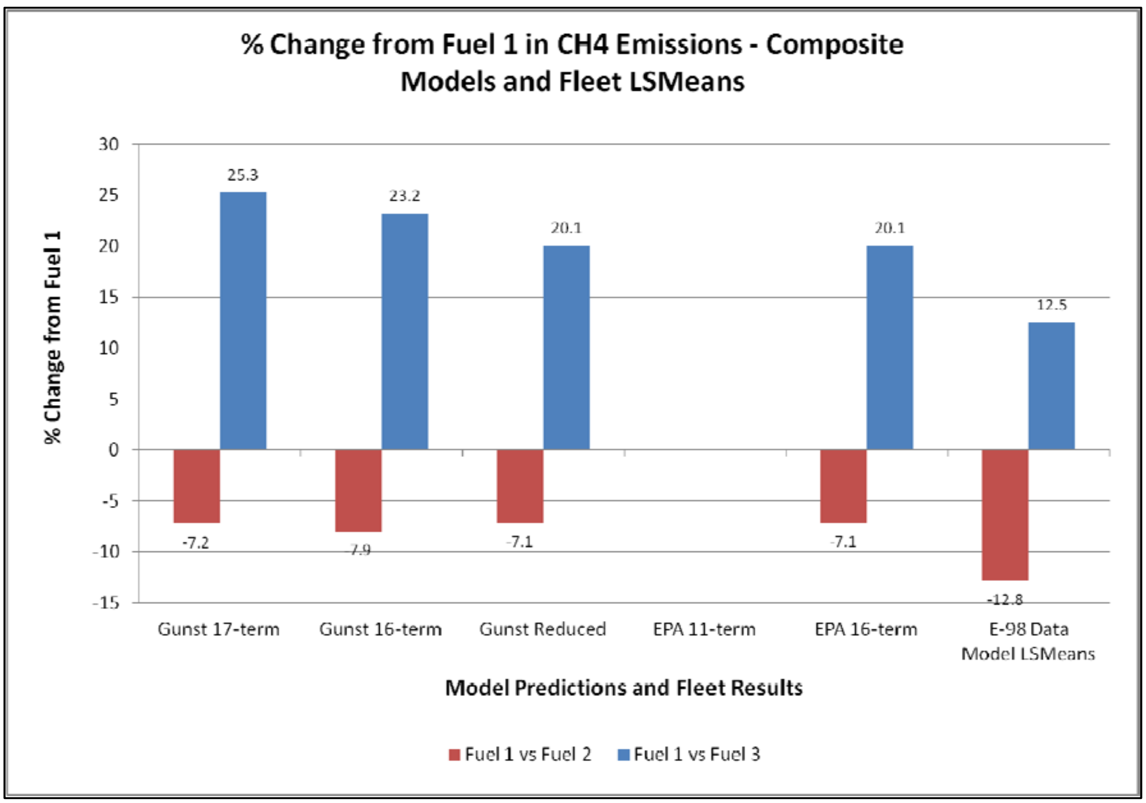

FIGURE 77. CH_4 COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

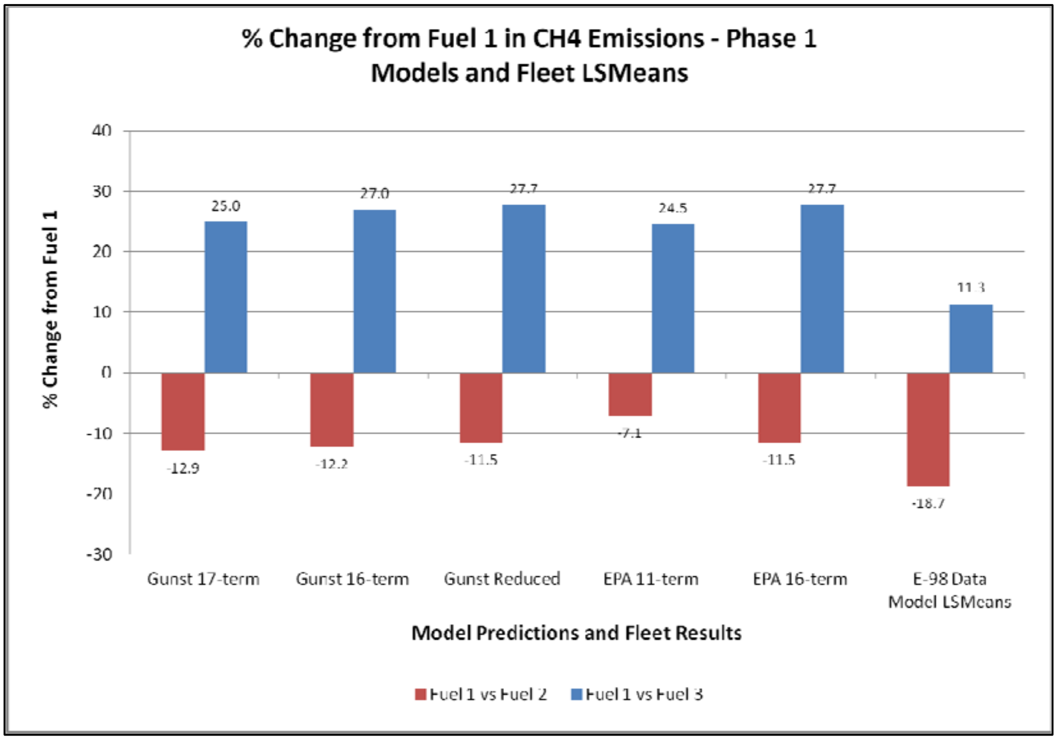

FIGURE 78. CH_4 PHASE 1 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

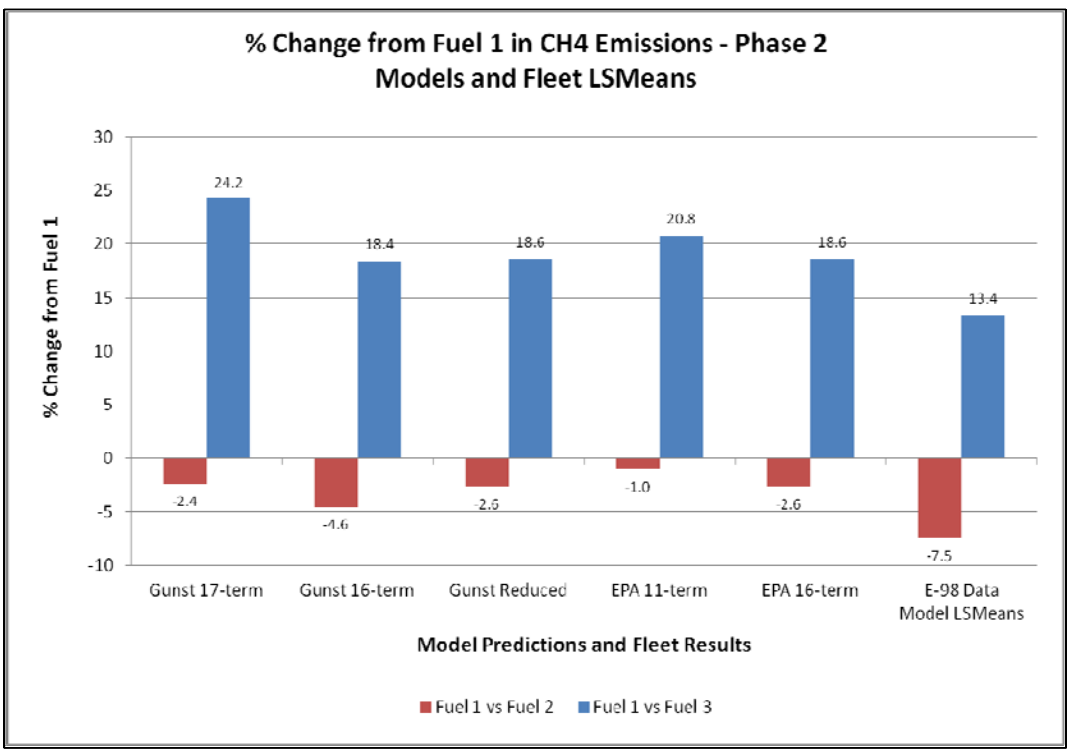

FIGURE 79. CH_4 PHASE 2 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

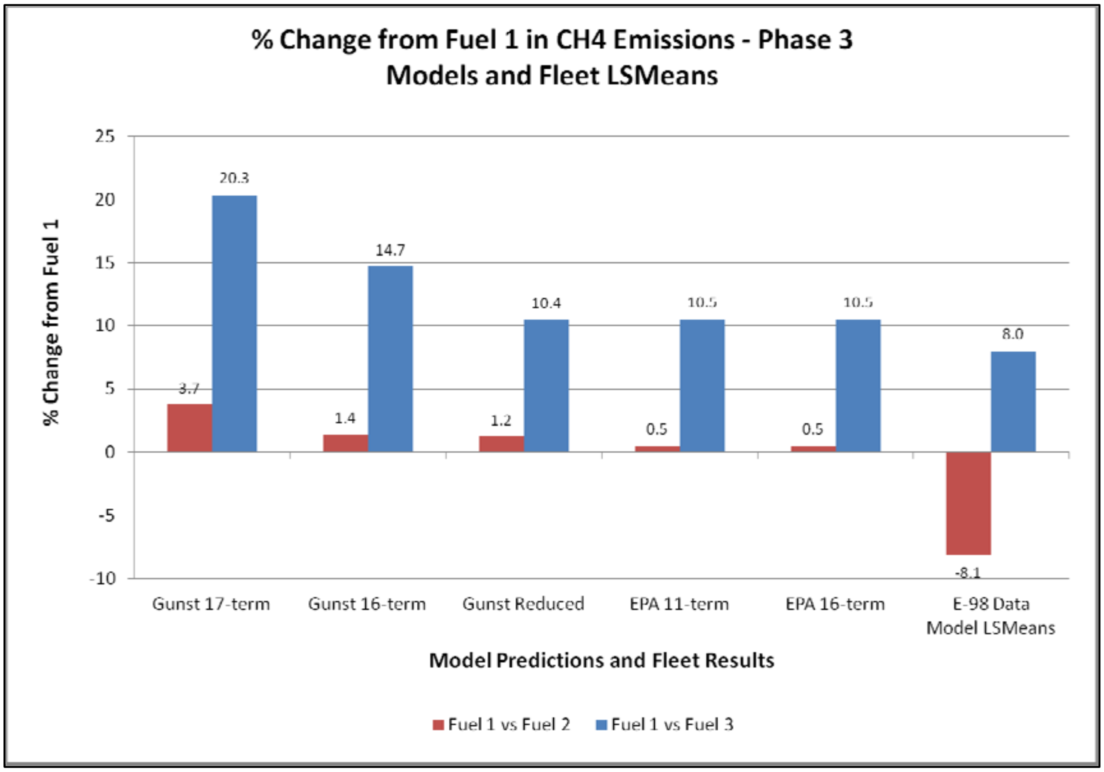

FIGURE 80. CH_4 PHASE 3 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

5.10.4 Model Prediction Comparison for CO

Relative percent change in predicted CO emissions for the five models and the ANOVA LSMeans are illustrated in Figures 81 through 84 for the Composite, Phase 1, Phase 2, and Phase 3, respectively. Note that there was no Composite phase for the EPA 11-term predictive model for CO.

A negative percent change indicates that the predicted CO using Fuel 1 was higher than the predicted CO using Fuel 2 or Fuel 3. In each of the Composite, Phase 2, and Phase 3 tests the CO Fuel 1 predictions were higher than the CO Fuel 2 predictions (ranging from -23.0% to -6.7%). Similar results were shown in the comparisons of the LS Means where the CO Fuel 1 averages were higher than the CO Fuel 2 averages (-34.3% to -25.5%). Conversely, during the Phase 1 tests, the CO Fuel 1 predictions were lower than the CO Fuel 2 predictions (ranging from +11.0% to +22.6%). This was contrary to what was seen in the LS Means for Phase 1 where the CO LS Mean for Fuel 1 was higher than the CO Fuel 2 LS Mean (-9.5%). For CO comparisons between Fuel 1 and Fuel 3, similar results were found. In the Composite, Phase 2 and Phase 3 tests the CO Fuel 1 predictions were higher than the CO Fuel 3 predictions (ranging from -23.7% to -3.0%). Similar results were shown in the comparisons of the LS Means where the CO Fuel 1 averages were higher than the CO Fuel 3 averages (-29.7% to -20.4%). Also, during the Phase 1 tests, the CO Fuel 1 predictions were lower than the CO Fuel 3 predictions (ranging from +0.6% to +6.3%). Again, this was contrary to what was seen in the LS Means for Phase 1 where the CO LS Mean for Fuel 1 was higher than the CO Fuel 3 LS Mean (-10.5%).

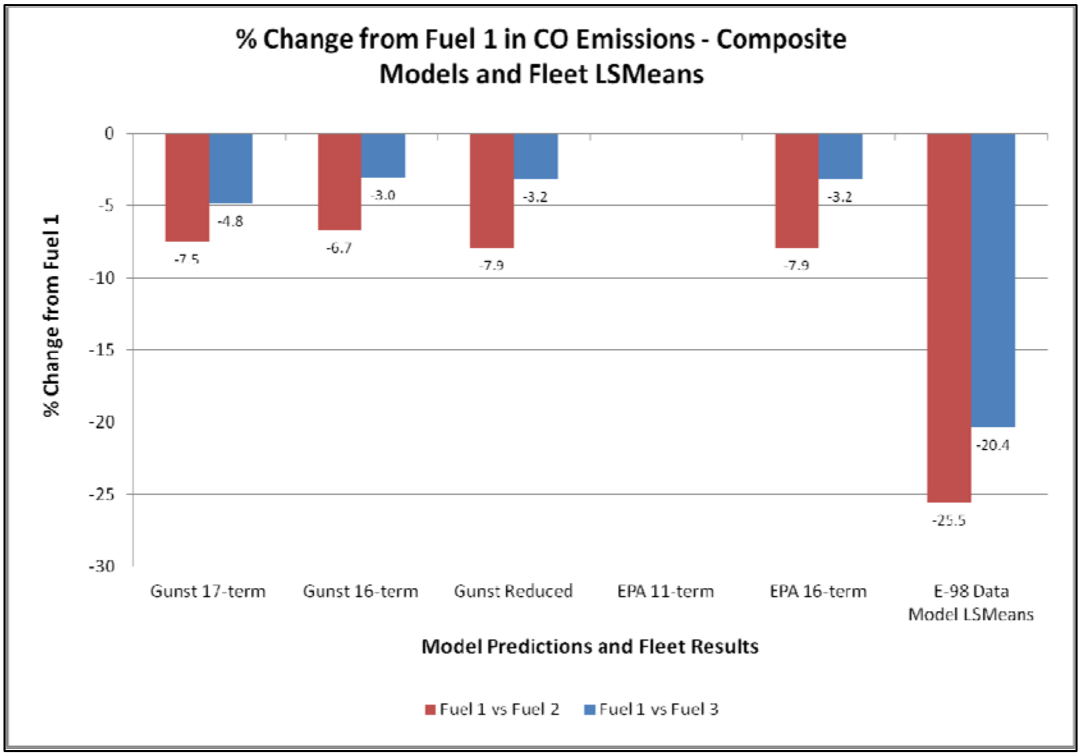

FIGURE 81. CO COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

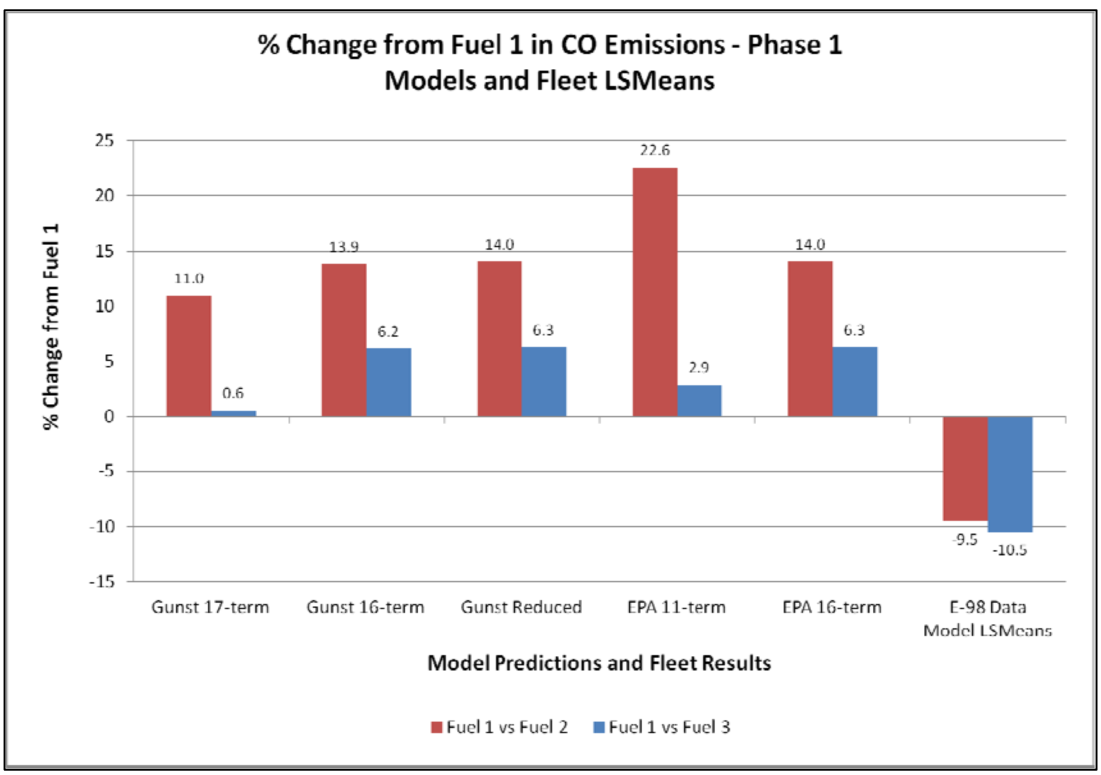

FIGURE 82. CO PHASE 1 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

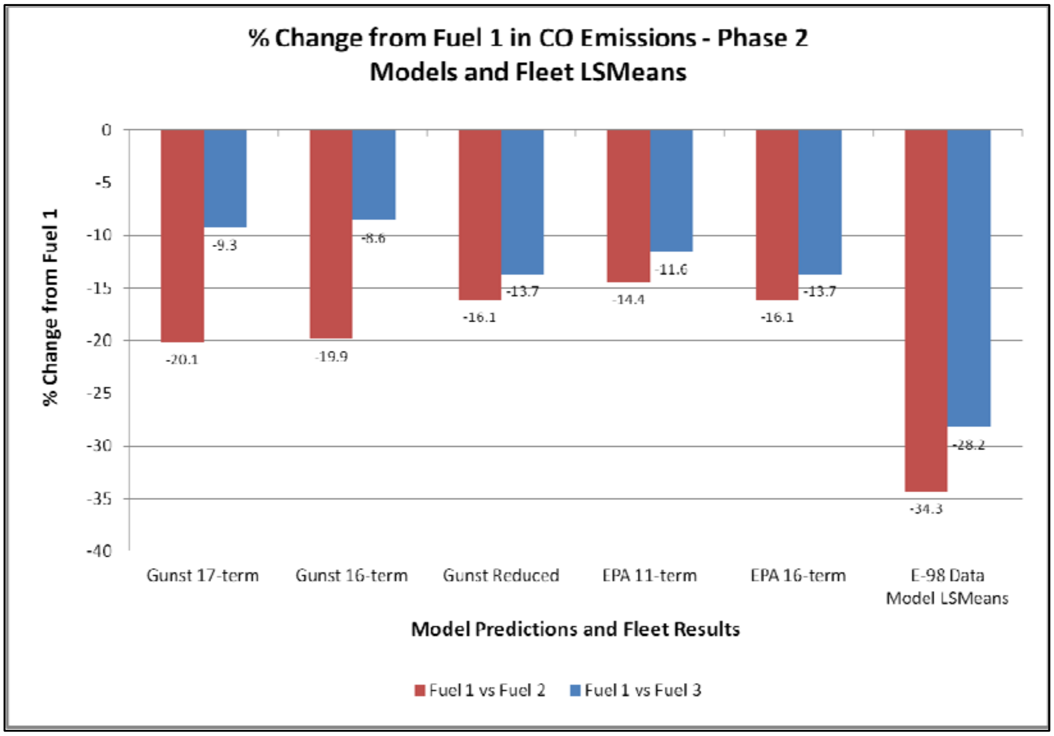

FIGURE 83. CO PHASE 2 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

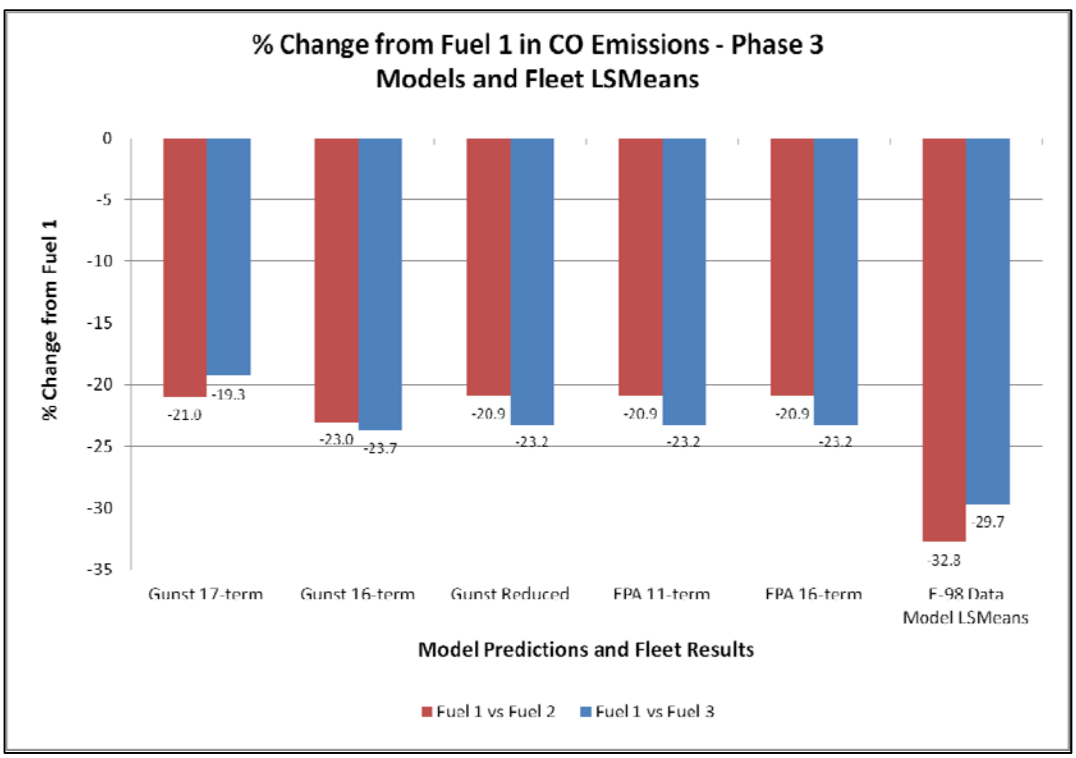

FIGURE 84. CO PHASE 3 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

5.10.5 Model Prediction Comparison for NO_X

Relative percent change in predicted NO_X emissions for the five models and the ANOVA LSMeans are illustrated in Figures 85 through 88 for the Composite, Phase 1, Phase 2, and Phase 3, respectively. Note that there was no Composite phase for the EPA 11-term predictive model for NO_X.

A negative percent change indicates that the predicted NO_X using Fuel 1 was higher than the predicted NO_X using Fuel 2 or Fuel 3. There was no consistent direction in % change from Fuel 1 to Fuels 2 or 3 among the different test phases. In the Composite phase, the Gunst 17-term and 16-terms models predicted higher NO_X emissions for Fuel 2 than Fuel 1 (+2.0% to +2.8%) while the Gunst Reduced and EPA16-term models predicted lower NO_X emissions for Fuel 2 than Fuel 1, although it was a very small reduction (-0.5%). Similar results were shown in the comparisons of the LS Means where the NO_x Fuel 2 average was lower than the NO_x Fuel 1 average (-5.5%). All models predicted higher NO_X emissions for Fuel 3 compared to Fuel 1 (+0.9% to +9.0%). However, this was not the case when comparing the LS Means. The NO_x LS Mean for Fuel 3 was lower than the LS Mean for Fuel 1 (-4.8%).

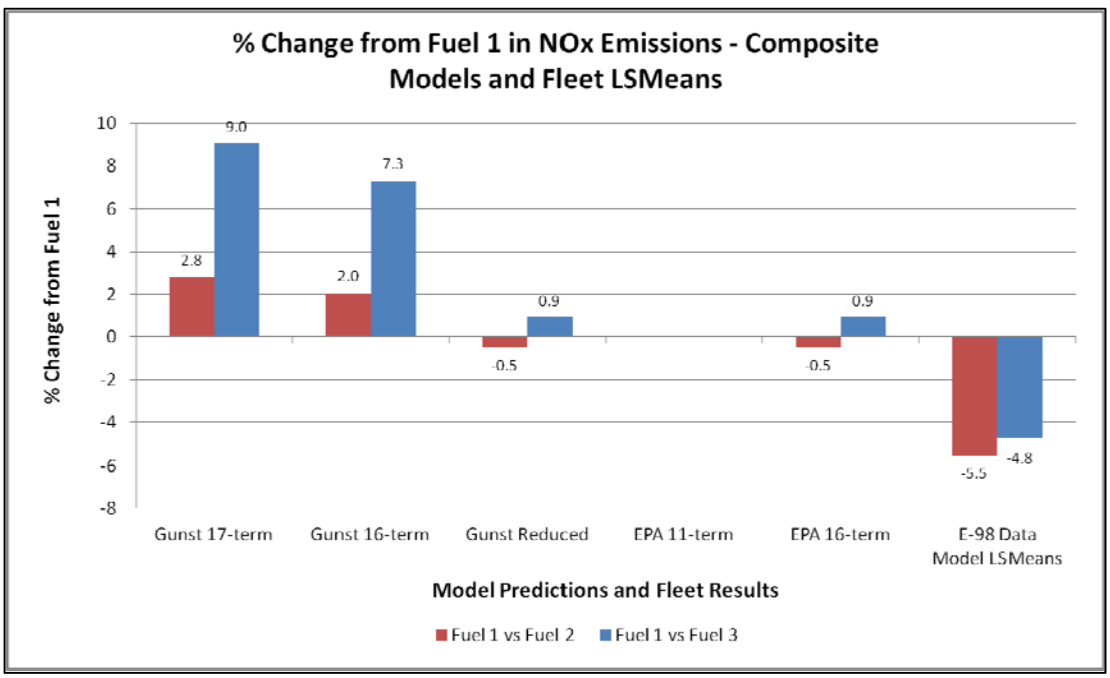

FIGURE 85. NO_X COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

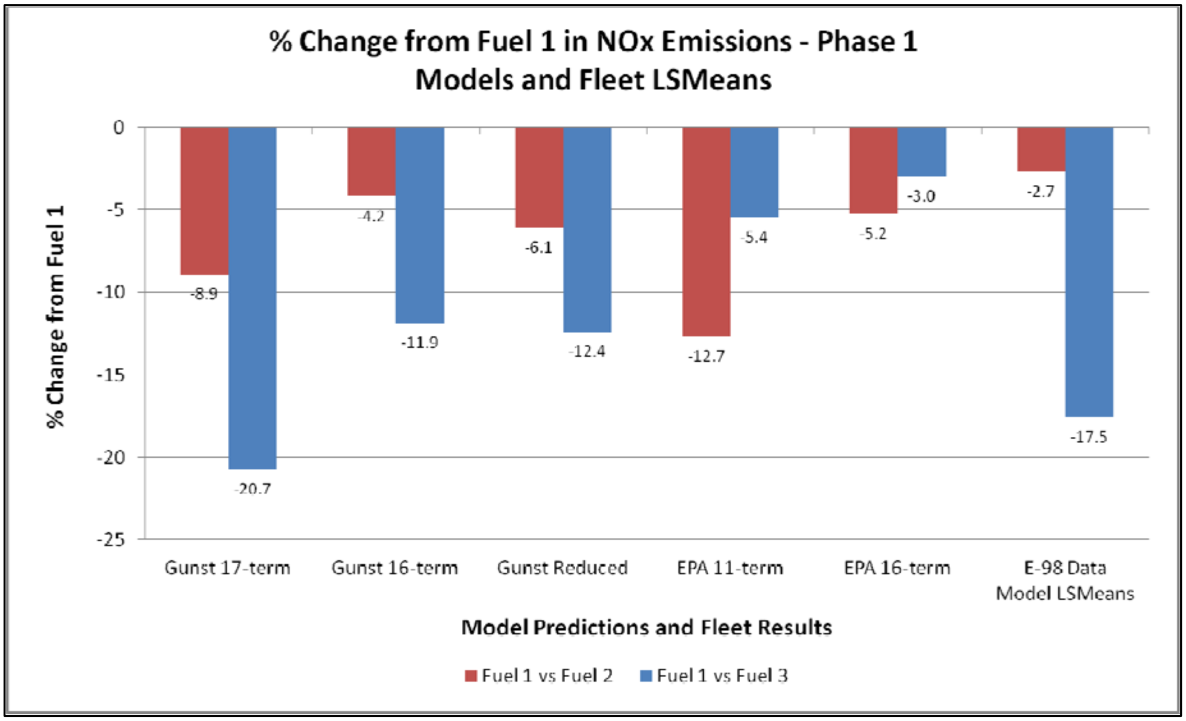

FIGURE 86. NO_X PHASE 1 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

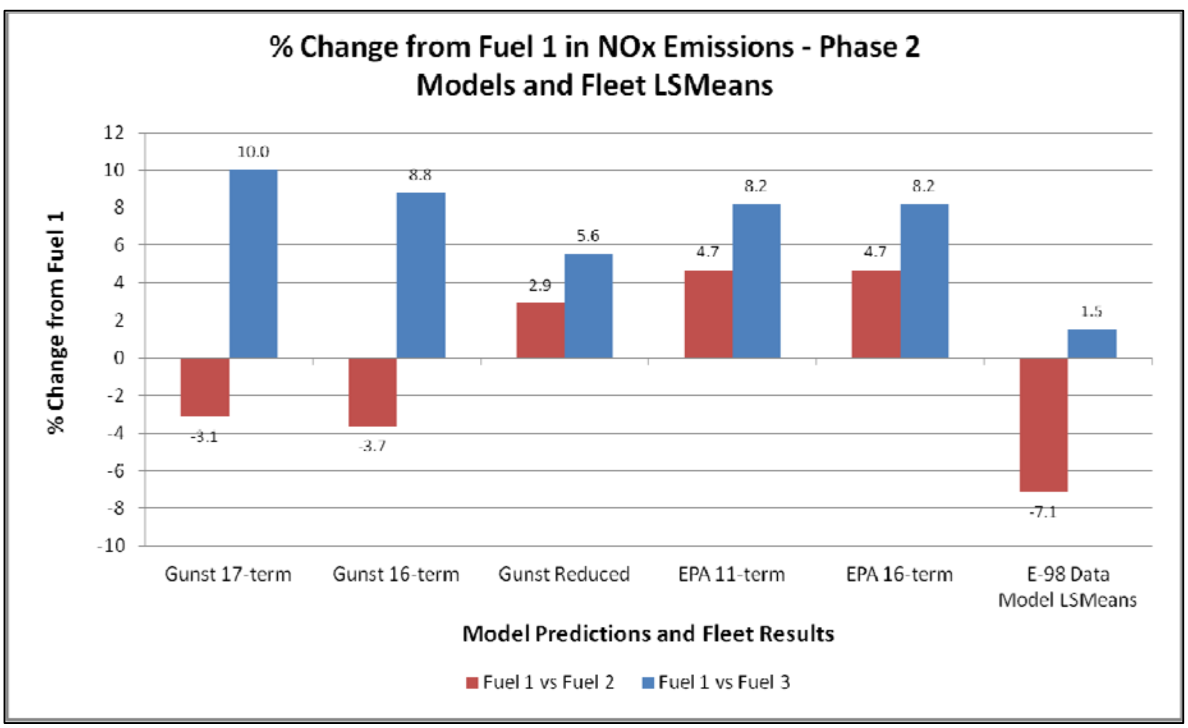

FIGURE 87. NO_X PHASE 2 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

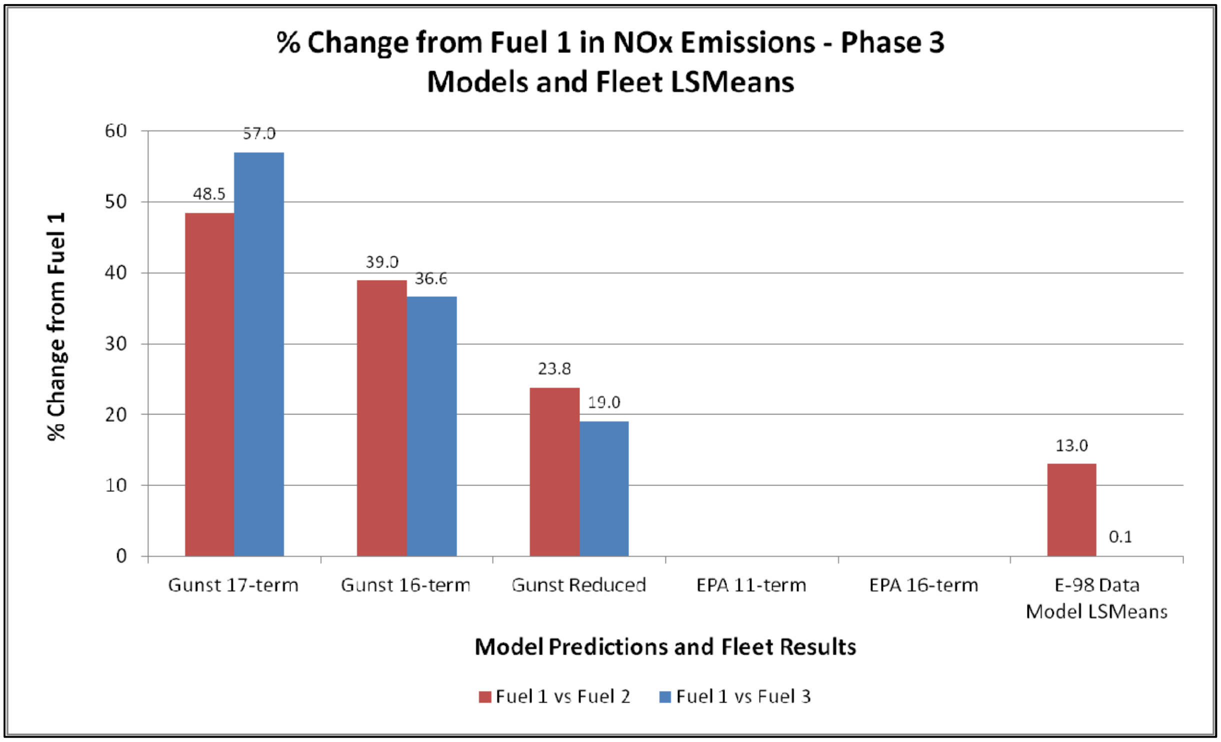

FIGURE 88. NO_X PHASE 3 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

In the Phase 1 tests, the NO_X Fuel 2 predictions were lower than the NO_X Fuel 1 predictions (ranging from -12.7% to -4.2%) for all five models. Similar results were shown in the comparison of the LS Means where the NO_x Fuel 2 average was lower than the NO_x Fuel 1 average (-2.7%). For Phase 1 NO_X comparisons between Fuel 1 and Fuel 3, the NO_X Fuel 3 predictions were also lower than the NO_X Fuel 1 predictions (-20.7% to -3.0%) for all five models. Again, similar results were found in the comparison of the LS Means where the NO_x Fuel 3 average was lower than the NO_x Fuel 1 average (-17.5%).

In Phase 2, all but the Gunst 17-term and 16-term models predicted higher NO_X for Fuel 2 than Fuel 1 (+2.9% to +4.7%). The Gunst 17-term and 16-term models predicted lower NO_X for Fuel 2 than Fuel 1 (-3.7% to -3.1%). Similar results were shown in the comparison of the LS Means where the NO_x Fuel 2 average was lower than the NO_x Fuel 1 average (-7.1%). The model predictions for Fuel 3 were consistently higher than the Fuel 1 predictions (+5.6% to +10.0%). This was similar when comparing the LS Means. The NO_x LS Mean for Fuel 3 was higher than the LS Mean for Fuel 1 (+1.5%).

Phase 3 NO_X Fuel 2 predictions were higher than the NO_X Fuel 1 predictions for the Gunst 17-term, 16-term and reduced models (ranging from +23.8% to +48.5%). There were no EPA models for NO_X in Phase 3. Similar results were shown in the comparison of the LS Means where the NO_x Fuel 2 average was higher than the NO_x Fuel 1 average (+13.0%). Lastly, during the Phase 3 tests, the NO_X Fuel 3 predictions were higher than the NO_X Fuel 1 predictions (ranging from +19.0% to +57.0%). Again, this trend was also seen in the comparison of the LS Mean where the NO_x Fuel 3 LS Mean was higher than the NO_x Fuel 1 LS Mean (+0.1%).

5.10.6 Model Prediction Comparison for PM

Relative percent change in predicted PM emissions for the five models and the ANOVA LSMeans are illustrated in Figures 89 through 92 for the Composite, Phase 1, Phase 2, and Phase 3, respectively. Note that there was no Composite phase for the EPA 11-term predictive model for PM.

A negative percent change indicates that the predicted PM using Fuel 1 was higher than the predicted PM using Fuel 2 or Fuel 3. In each of the Composite, Phase 1, Phase 2 and Phase 3 tests the PM Fuel 1 predictions were higher than the PM Fuel 2 predictions (ranging from -67.0% to -17.2%) . Similar results were shown in the comparisons of the LS Means in each of the Composite, Phase 1, and Phase 2 tests where the PM Fuel 1 averages were higher than the PM Fuel 2 averages (-56.7% to -13.8%). However, for Phase 3 the PM Fuel 1 average was lower than the PM Fuel 2 average (+1.6%).

Similar results were obtained when comparing the PM model predictions for Fuels 1 and 3. In each of the Composite, Phase 1, Phase 2 and Phase 3 tests the PM Fuel 1 predictions were higher than the PM Fuel 3 predictions (ranging from -48.8% to -0.6%). Similar results were shown in the comparisons of the LS Means in Phase 1 tests where the PM Fuel 1 averages were higher than the PM Fuel 3 averages (-23.7%). However, this trend was reversed when examining the results for the Composite, Phase 2 and Phase 3 tests. In these three cases, the PM LS Means for Fuel 3 was higher than the PM LS Means for Fuel 1 (+1.5% to +23.2%).

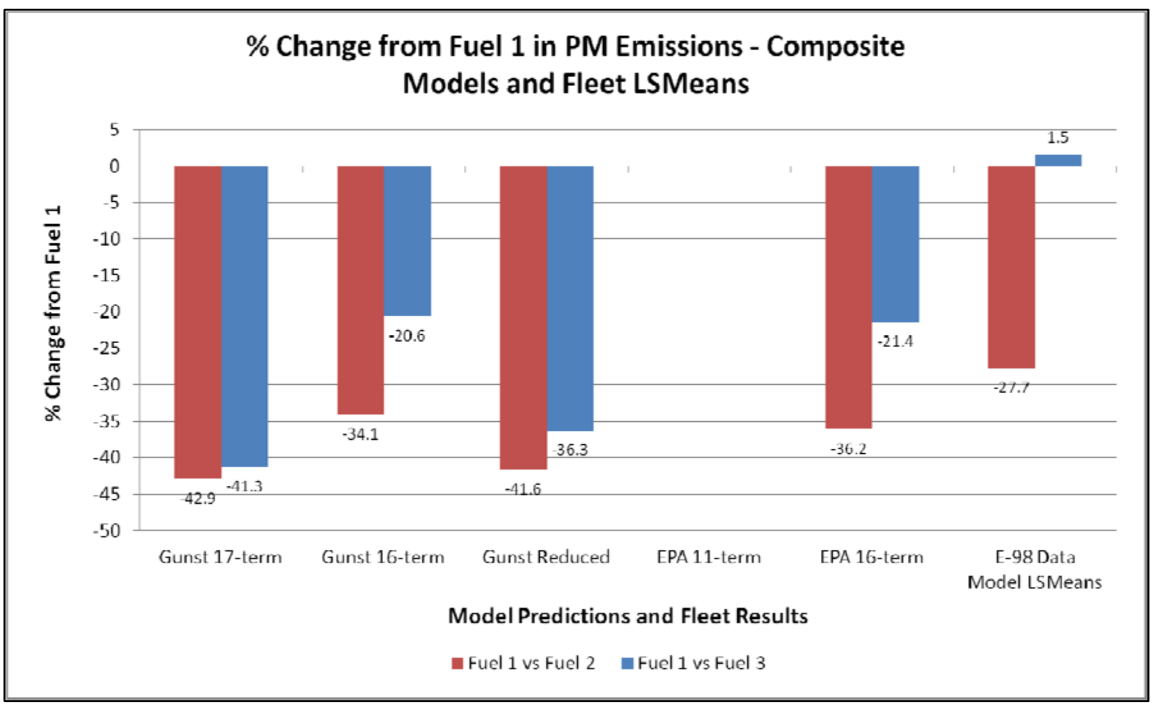

FIGURE 89. PM COMPOSITE EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

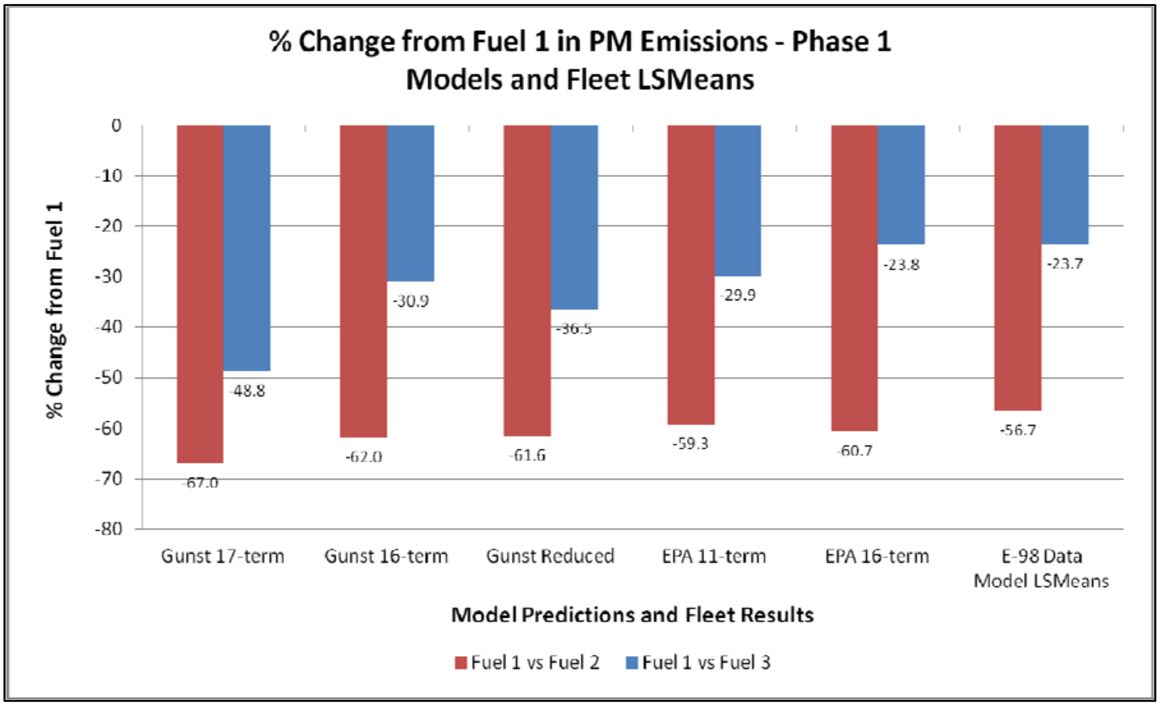

FIGURE 90. PM PHASE 1 MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

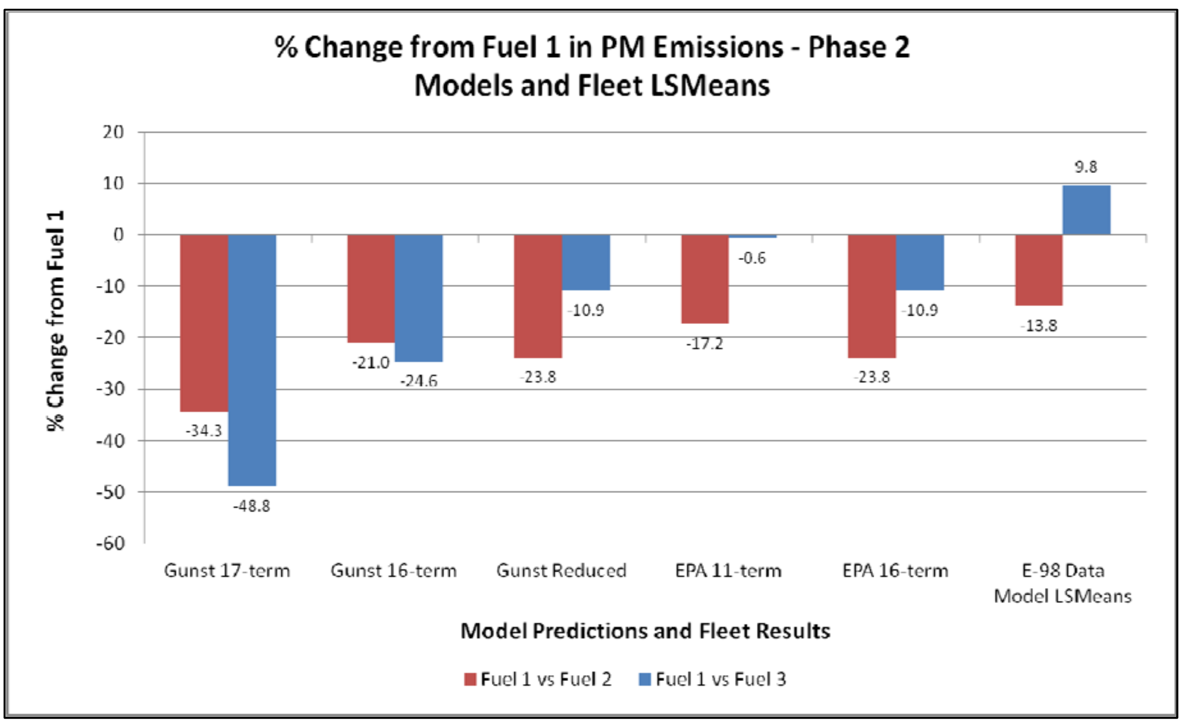

FIGURE 91. PM PHASE 2 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

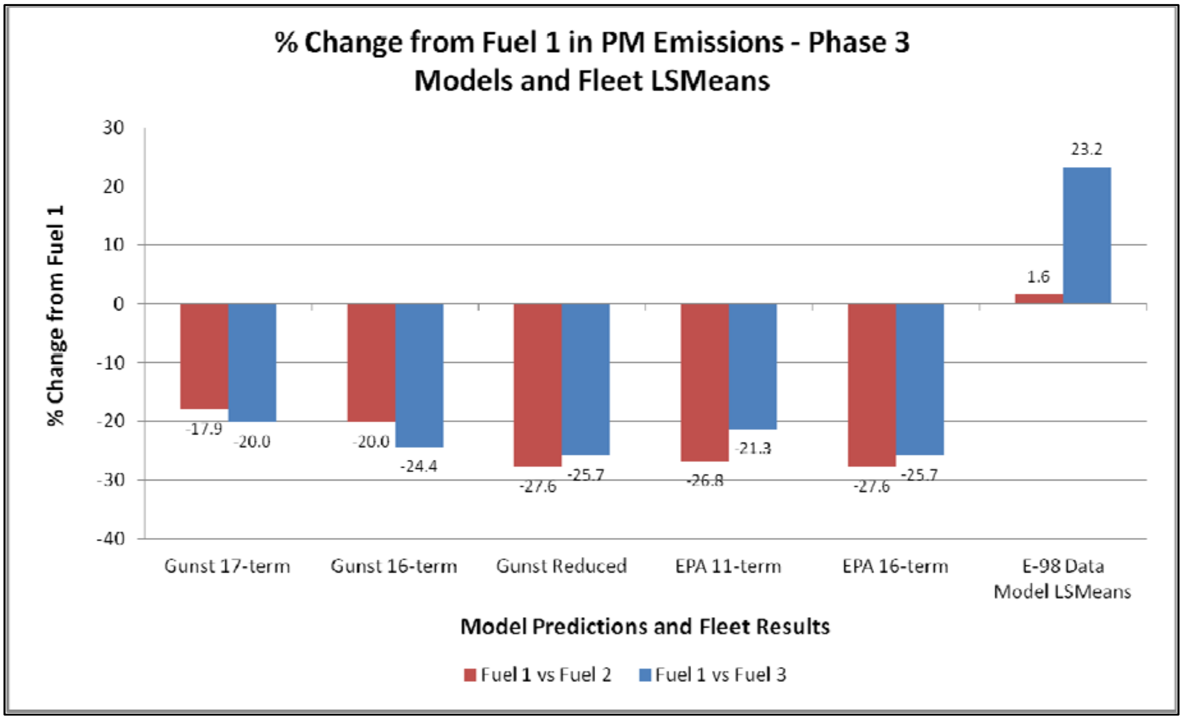

FIGURE 92. PM PHASE 3 EMISSION MODEL PREDICTIONS PERCENT CHANGE FROM FUEL 1 TO FUELS 2 AND 3

APPENDIX A

FUEL CHANGE, CONDITIONING, AND TEST PROCEDURE

FUEL CHANGE, CONDITIONING, AND TEST PROCEDURE

1. Drain vehicle fuel completely via fuel rail whenever possible.
2. Turn vehicle ignition to RUN position for 30 seconds to allow controls to allow fuel level reading to stabilize. Confirm the return of fuel gauge reading to zero.
3. Turn ignition off. Fill fuel tank to 30% with the next test fuel in sequence. Fill-up fuel temperature must be less than 50°F.
4. Start vehicle and execute catalyst sulfur removal procedure described in Appendix C. Apply side fan cooling to the fuel tank to alleviate the heating effect of the exhaust system. Engine oil temperature in the sump will be measured and recorded during the sulfur removal cycle.
5. Perform four vehicle coast downs from 70 to 30 mph, with the last two measured. The vehicle will be checked for any obvious and gross source of change in the vehicle's mechanical friction if the individual run fails to meet the following repeatability criteria: 1) maximum difference of 0.5 seconds between back-to-back coastdown runs from 70 to 30 mph; and 2) maximum ±7 percent difference in average 70 to 30 mph coastdown time from the running average for a given vehicle.
6. Drain fuel and refill to 30% with test fuel. Fill-up fuel must be less than 50°F.
7. Drain fuel again and refill to 40% with test fuel. Fill-up fuel must be less than 50°F.
8. Take a fuel sample from the vehicle's fuel rail to be tested for ethanol content and octane number.
9. Check vehicle for diagnostic trouble codes (DTC). If new codes are detected the CRC Program Manager will be contacted.
10. Soak vehicle for at least 12 hours to allow fuel temperature to stabilize to the test temperature.
11. Move vehicle to test area without starting engine.
12. Start vehicle and perform 2-phase (bags 1 and 2) LA92 cycle. During these prep cycles, apply side fan cooling to the fuel tank to alleviate the heating effect of the exhaust system.
13. Allow vehicle to idle in park for two minutes, then shut-down the engine for 2-5 minutes.
14. Start vehicle and perform the second 2-phase (bags 1 and 2) LA92 cycle. During these prep cycles, apply side fan cooling to the fuel tank to alleviate the heating effect of the exhaust system.
15. Allow vehicle to idle in park for two minutes, then shut-down the engine for 2-5 minutes.
16. Start vehicle and perform 2-phase (bags 1 and 2) LA92 cycles. During these prep cycles, apply side fan cooling to the fuel tank to alleviate the heating effect of the exhaust system.
17. Allow the vehicle to idle for two minutes, then shut down the engine in preparation for the soak.
18. Move vehicle to soak area without starting the engine.
19. Park vehicle in soak area at proper temperature (75 °F) for at least 8 hours and no more than 24 hours. During the soak period, maintain the nominal charge of the vehicle's battery using an appropriate charging device.
20. Move vehicle to test area without starting engine.
21. Perform LA92 cycle emissions test.
22. Move vehicle to soak area without starting the engine.

23. Park vehicle in soak area of proper temperature for 8-24 hours. During the soak period, maintain the nominal charge of the vehicle's battery using an appropriate charging device.
24. Move vehicle to test area without starting the engine.
25. Perform LA92 emissions test.
26. Move vehicle to soak area without starting the engine.
27. Determine whether third replicate is necessary, based on repeatability criteria (to be provided by CRC prior to start of test program).
28. If a third replicate is required, repeat steps23 – 25.If third replicate is not required, return to step 1 and proceed with next fuel in test sequence.

APPENDIX B

CATALYST SULFUR PURGE CYCLE

CATALYST SULFUR PURGE CYCLE

This procedure is designed to cause the vehicle to transiently run rich at high catalyst temperature, to remove accumulated sulfur from the catalyst, via hydrogen sulfide formation. The catalyst inlet temperature and the exhaust A/F ratio will be monitored during this procedure. It is required to demonstrate that the catalyst inlet temperature must exceed 700°C during the WOT accelerations and that rich fuel/air mixtures are achieved during WOT. If these parameters are not achieved, increased loading on the dynamometer could be added for this protocol (but not during the emissions test). Increased loading is not included in this proposal.

1. Drive the vehicle from idle to 55 mph and hold speed for 5 minutes (to bring catalyst to full working temperature).
2. Reduce vehicle speed to 30 mph and hold speed for one minute.
3. Accelerate at WOT (wide-open throttle) for a minimum of 5 seconds, to achieve a speed in excess of 70 mph. Continue WOT above 70 mph, if necessary to achieve 5-second acceleration duration. Hold the peak speed for 15 seconds and then decelerate to 30 mph.
4. Maintain 30 mph for one minute.
5. Repeat steps 3 and 4 to achieve 5 WOT excursions.
6. One sulfur removal cycle has been completed.
7. Repeat steps 1 to 5 for the second sulfur removal cycle.
8. The protocol is complete if the necessary parameters have been achieved.

APPENDIX C

INCIDENT REPORTS FOR THE DODGE CALIBER AND SATURN OUTLOOK

Incident Report

CRC E98 Project
Vehicle: Dodge Caliber "DCAL"

Date of First Occurrence: 1/29/2013
Approximate Odometer:

Incident Description: A MIL illuminated during an emissions test. The DTC was P0455, evaporative emission system leak detected (gross leak/no flow)

Action Taken:
The code had occurred one time and was not pending or active.

Performed a leak check with a Smoke Pro® Total-Tech™ device of the complete system. The smoke was injected from the evap hose at the engine and into the fuel tank. No leaks were detected.

An evap system test was also performed with the Snap-On scanner. This is a 20-minute test and no faults occurred.

The fuel cap was replaced with a new unit and the code was cleared.

Resolution:

The vehicle was driven back to Light Duty Vehicle Emissions.

Learning:

Incident Report

CRC E98 Program
Vehicle: EPASOUT, 2008 Saturn Outlook

SwRI Project Number: 17592
Date of First Occurrence: 11-01-2012
Approximate Odometer: 10,600
Test miles: 0 mi.
Test Interval: Check-out Test

Incident Description:

The Saturn Outlook arrived at SwRI with DTCs present and MIL illumination.

Action Taken:

Upon arrival at SwRI, the Saturn Outlook was inspected and scanned for diagnostic trouble codes (DTCs). Several DTCs were present and the vehicle was inoperable due to these DTCs. The DTCs present in the Saturn Outlook are listed below.

P0481 – Cooling Fan Relay 2 and 3 Control Circuit
P0480 – Cooling Fan Relay 1 Control Circuit
P0449 – Evap Vent Solenoid Control Circuit
P0300 – Engine Misfire Detected
P0201 – Injector #1 Control Circuit
P0203 – Injector #3 Control Circuit
P0205 – Injector #5 Control Circuit

Resolution:

Additional troubleshooting time is needed to accurately determine the cause of the DTCs. During the initial inspection, it was noticed that the Emissions 1 fuse was missing. The fuse was replaced and several other DTCs not listed above were corrected.

Currently, the next plan of action would be to further inspect the fuse box. There is discontinuity between connector 103 and the fuse box. This connector is responsible for supplying power to the engine harness. There are also loose relays in the fuse box that may be contributing to these issues. A replacement fuse box may be needed to correct the loose connections.

Did this incident result in a change in the Delivery Plan?

APPENDIX D

EPAct NMOG CALCULATION PROTOCOL

EPACT NMOG CALCULATION PROTOCOL

19-Feb-2009

The series of calculations shown here (Equations (1) through (6)) must be performed separately for each test phase (bag). The NMOG mass results can then be weighed in the usual way to form a test cycle composite emission rate.

First we calculate corrected NMHC concentration for dilute exhaust (subscript e) and dilution air (subscript d) as follows:

$$NMHC_e = FIDHC_e - r_{CH4} \cdot CH4_e - r_{MeOH} \cdot MeOH_e - r_{EtOH} \cdot EtOH_e - r_{PrOH} \cdot PrOH_e - r_{AcetHO} \cdot AcetHO_e \quad (1)$$

$$NMHC_d = FIDHC_d - r_{CH4} \cdot CH4_d - r_{MeOH} \cdot MeOH_d - r_{EtOH} \cdot EtOH_d - r_{PrOH} \cdot PrOH_d - r_{AcetHO} \cdot AcetHO_d \quad (2)$$

Note that these values are all as ppmC (so speciation results for EtOH, PrOH, and AcetHO reported in ppm of the particular chemical compound will need to be multiplied by 2 or 3 depending on the number of C atoms in the compound).

The following constant values shall be used for FID response factors:

r_{CH4} = 1.15 ppmC/ppmC (this program)
r_{MeOH} = 0.63 ppmC/ppmC (this program)
r_{EtOH} = 0.74 ppmC/ppmC (this program)
r_{PrOH} = 0.85 ppmC/ppmC (CARB)
r_{FormHO} = 0.00 ppmC/ppmC (various sources)
r_{AcetHO} = 0.51 ppmC/ppmC (this program)

Next, we must calculate the dilution factor to be used in generating the net NMHC concentration:

$$DF = \frac{100 \cdot \left[\dfrac{x}{x + 0.5y + 3.76 \cdot (x + 0.25y - 0.5z)}\right]}{CO2_e + (NMHC_e + CH4_e + MeOH_e + PrOH_e + EtOH_e + FormHO_e + AcetHO_e + CO_e) \cdot 10^{-4}} \quad (3)$$

The parameters x, y and z in Eq. (3) are coefficients taken from the chemical formula $C_xH_yO_z$ of a test fuel. The procedure to calculate their values is provided in Appendix 2.

Once the DF is determined, we calculate the net NMHC concentration as follows:

$$NMHC_{conc} = NMHC_e - NMHC_d \cdot \left(1 - \frac{1}{DF}\right) \quad (4)$$

Then we compute $NMHC_{mass}$:

$$NMHC_{mass} = V_{mix} \cdot Density_{NMHC} \cdot NMHC_{conc} \cdot 10^{-6} \quad (5)$$

Equations (4) and (5) must be repeated for each emission being considered. V_{mix} is the volume of dilute exhaust collected during a given phase of the test cycle, measured in standard cubic feet. Density is the calculated gas phase density of a particular species treated as a $C_1H_yO_z$ ideal gas.

The following values of gas phase density shall be used:

$Density_{NMHC} = 16.334\ g/ft^3$
$Density_{MeOH} = 37.718\ g/ft^3$
$Density_{EtOH} = 27.115\ g/ft^3$
$Density_{PrOH} = 23.581\ g/ft^3$
$Density_{FormHO} = 35.345\ g/ft^3$
$Density_{AcetHO} = 25.929\ g/ft^3$

To generate the NMOG figure, we need methanol, ethanol, 2-propanol, formaldehyde and acetaldehyde mass emissions as computed using Eq. (4) and (5) based on measured concentration values form the speciation results (as in Eq. (1) and (2)).

Finally, then, NMOG mass emissions can be computed as follows:

$$NMOG_{mass} = NMHC_{mass} + MeOH_{mass} + EtOH_{mass} + PrOH_{mass} + FormHO_{mass} + AcetHO_{mass} \qquad (6)$$

Once $NMOG_{mass}$ calculations have been completed for all three phases (cold transient (ct), stabilized (s) and hot transient (ht)) of the LA92 test cycle they, calculate the total weighted NMOG emissions using the following formula:

$$NMOG_{wm} = 0.43 \cdot \left(\frac{NMOG_{mass.ct} + NMOG_{mass.s}}{D_{ct} + D_s} \right) + 0.57 \cdot \left(\frac{NMOG_{mass.ht} + NMOG_{mass.s}}{D_{ht} + D_s} \right) \qquad (7)$$

For tests where there is no bag 2 or 3 speciation data, NMOG shall be computed assuming emission levels for oxygenated species in bags 2 and 3 are zero.

APPENDIX E

EMISSIONS RESULTS OF THIRD TESTS FOR VEHICLE FUEL COMBINATIONS

TABLE E-1. THIRD TEST FUEL 2 COMPOSITE RESULTS FOR VEHICLE #3

Test Number Formatted	Fuel Name	Odometer mi.	Weighted LA-92 THC, g/mile	CO, g/mile	NO_X, g/mi	CO_2, g/mi	CH_4, g/mi	NMHC, g/mi	PM mg/mi	Fuel Economy, mi/gal
E98-Veh#3-2-T1	E-98 Fuel 2	12239	0.027	0.212	0.018	357.5	0.004	0.022	1.3	24.08
E98-Veh#3-2-T2	E-98 Fuel 2	12250	0.023	0.207	0.023	356.1	0.004	0.019	0.9	24.18
E98-Veh#3-2-T3	E-98 Fuel 2	12310	0.026	0.182	0.019	360.4	0.003	0.022	0.9	23.89

TABLE E-2. THIRD TEST FUEL 3 COMPOSITE RESULTS FOR VEHICLE #6

Test Number Formatted	Fuel Name	Odometer mi	Weighted LA-92 THC, g/mile	CO, g/mile	NO_X, g/mi	CO_2, g/mi	CH_4, g/mi	NMHC, g/mi	PM mg/mi	Fuel Economy, mi/gal
E98-Veh#6-3-T1	E-98 Fuel 3	13210	0.023	0.171	0.017	303.2	0.003	0.020	0.6	28.00
E98-Veh#6-3-T2	E-98 Fuel 3	13221	0.034	0.173	0.010	306.2	0.003	0.031	0.5	27.72
E98-Veh#6-3-T3	E-98 Fuel 3	13232	0.030	0.168	0.009	310.4	0.003	0.026	0.3	27.35

TABLE E-3. THIRD TEST FUEL 2 COMPOSITE RESULTS FOR VEHICLE #6

Test Number Formatted	Fuel Name	Odometer mi.	Weighted LA-92 THC, g/mile	CO, g/mile	NO_X, g/mi	CO_2, g/mi	CH_4, g/mi	NMHC, g/mi	PM mg/mi	Fuel Economy, mi/gal
E98-Veh#6-2-T1	E-98 Fuel 2	13005	0.015	0.101	0.014	301.7	0.002	0.011	0.5	28.55
E98-Veh#6-2-T2	E-98 Fuel 2	13016	0.022	0.087	0.008	305.8	0.002	0.020	0.7	28.17
E98-Veh#6-2-T3	E-98 Fuel 2	13057	0.023	0.094	0.010	309.4	0.002	0.021	0.3	27.84

TABLE E-4. THIRD TEST FUEL 3 COMPOSITE RESULTS FOR VEHICLE #7

Test Number Formatted	Fuel Name	Odometer mi.	Weighted LA-92 THC, g/mile	CO, g/mile	NO_X, g/mi	CO_2, g/mi	CH_4, g/mi	NMHC, g/mi	PM mg/mi	Fuel Economy, mi/gal
E98-Veh#7-3-T1	E-98 Fuel 3	14989.3	0.043	0.880	0.007	575.6	0.010	0.031	0.4	14.73
E98-Veh#7-3-T2	E-98 Fuel 3	15000.4	0.051	0.983	0.013	581.3	0.011	0.038	0.4	14.58
E98-Veh#7-3-T3	E-98 Fuel 3	15021.3	0.050	0.892	0.019	573.0	0.011	0.037	0.4	14.79

TABLE E-5. THIRD TEST FUEL 1 COMPOSITE RESULTS FOR VEHICLE #8

Test Number Formatted	Fuel Name	Odometer mi.	Weighted LA-92							
			THC, g/mile	CO, g/mile	NO_X, g/mi	CO_2, g/mi	CH_4, g/mi	NMHC, g/mi	PM mg/mi	Fuel Economy, mi/gal
E98-Veh#8-1-T1	E-98 Fuel 1	15353.1	0.172	3.465	0.040	592.4	0.033	0.138	0.7	15.29
E98-Veh#8-1-T2	E-98 Fuel 1	15374	0.155	4.160	0.064	597.4	0.036	0.119	1.0	15.14
E98-Veh#8-1-T3	E-98 Fuel 1	15395.9	0.140	3.443	0.060	598.3	0.035	0.105	0.8	15.15

TABLE E-6. THIRD TEST FUEL 1 COMPOSITE RESULTS FOR VEHICLE #13

Test Number Formatted	Fuel Name	Odometer mi.	Weighted LA-92							
			THC, g/mile	CO, g/mile	NO_X, g/mi	CO_2, g/mi	CH_4, g/mi	NMHC, g/mi	PM mg/mi	Fuel Economy, mi/gal
E98-Veh#13-1-T1	E-98 Fuel 1	13193	0.105	0.780	0.014	540.4	0.007	0.099	0.9	16.88
E98-Veh#13-1-T2	E-98 Fuel 1	13204	0.092	0.898	0.023	532.9	0.007	0.085	0.7	17.12
E98-Veh#13-1-T3	E-98 Fuel 1	13225	0.103	0.835	0.028	536.3	0.006	0.097	0.6	17.01

TABLE E-7. THIRD TEST FUEL 3 COMPOSITE RESULTS FOR VEHICLE #15

Test Number Formatted	Fuel Name	Odometer mi.	Weighted LA92							
			THC, g/mile	CO, g/mile	NO_X, g/mi	CO_2, g/mi	CH_4, g/mi	NMHC, g/mi	PM mg/mi	Fuel Economy, mi/gal
E98-Veh#15-3-T1	E-98 Fuel 3	14579	0.056	1.962	0.022	586.5	0.015	0.040	1.8	14.41
E98-Veh#15-3-T2	E-98 Fuel 3	14590	0.060	1.686	0.015	586.8	0.015	0.043	2.0	14.41
E98-Veh#1 5-3-T3	E-98 Fuel 3	14612	0.057	1.861	0.024	585.7	0.015	0.041	2.3	14.44

APPENDIX F

COMPOSITE RESULTS OF 1,3-BUTADIENE, BENZENE, FORMALDEHYDE, ACETALDEHYDE, METHANOL, AND ETHANOL

TABLE F-1. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #1

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#1-1-T1	GA-8409_FUEL1	13823	7.44	43.17	4.0	3.6	4.2	-99.0
E98-Veh#1-1-T2	GA-8409_FUEL1	13834	8.26	39.16	3.5	2.6	9.1	-99.0
E98-Veh#1-2-T1	GA-8410_FUEL2	14029	2.36	19.16	2.4	7.6	3.6	15.4
E98-Veh#1-2-T2	GA-8410_FUEL2	14040	2.42	18.97	2.5	8.2	2.2	16.5
E98-Veh#1-3-T1	GA-8411_FUEL3	13924	3.76	27.02	3.0	11.5	-99.0	53.8
E98-Veh#1-3-T2	GA-8411_FUEL3	13935	4.07	25.67	2.0	2.4	2.2	38.4

TABLE F-2. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #2

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#2-1-T1	GA-8409_FUEL1	12308	3.47	31.02	3.0	1.8	2.8	0.1
E98-Veh#2-1-T2	GA-8409_FUEL1	12319	3.09	36.22	2.6	0.9	1.9	-99.0
E98-Veh#2-2-T1A	GA-8410_FUEL2	12469	1.67	24.44	2.4	5.8	1.2	20.0
E98-Veh#2-2-T2A	GA-8410_FUEL2	12480	1.66	20.18	2.1	5.2	2.6	18.9
E98-Veh#2-3-T1	GA-8411_FUEL3	12549	2.22	23.24	2.5	9.1	1.9	50.5
E98-Veh#2-3-T2	GA-8411_FUEL3	12560	2.74	26.89	3.1	9.2	2.4	67.1

TABLE F-3. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #3

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#3-1-T1	GA-8409_FUEL1	12391	3.79	23.86	2.8	2.3	4.8	-99.0
E98-Veh#3-1-T1	GA-8409_FUEL1	12391	3.79	23.86	2.8	2.3	4.8	-99.0
E98-Veh#3-1-T2	GA-8409_FUEL1	12402	2.92	20.83	2.6	1.7	2.2	0.4
E98-Veh#3-2-T1	GA-8410_FUEL2	12239	1.74	10.48	2.1	6.1	2.6	19.2
E98-Veh#3-2-T2	GA-8410_FUEL2	12250	1.61	9.62	1.8	4.3	0.8	16.7
E98-Veh#3-2-T3	GA-8410_FUEL2	12310	1.90	9.55	2.3	7.1	4.3	20.0
E98-Veh#3-3-T1	GA-8411_FUEL3	12481	2.23	12.61	3.0	10.6	0.7	60.6
E98-Veh#3-3-T2	GA-8411_FUEL3	12492	1.83	10.01	3.4	10.0	2.1	60.4

TABLE F-4. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #4

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#4-1-T1	GA-8409_FUEL1	13543	2.50	15.91	1.7	1.0	1.4	-99.0
E98-Veh#4-1-T2	GA-8409_FUEL1	13554	2.53	17.00	2.1	1.1	1.2	-99.0
E98-Veh#4-2-T1	GA-8410_FUEL2	13441	2.03	12.50	1.5	3.5	1.5	12.8
E98-Veh#4-2-T2	GA-8410_FUEL2	13452	2.02	13.76	1.5	3.2	1.8	13.0
E98-Veh#4-3-T1	GA-8411_FUEL3	13647	2.53	11.16	2.8	6.0	1.6	35.0
E98-Veh#4-3-T2	GA-8411_FUEL3	13657	1.69	8.51	2.3	5.4	1.0	28.9

TABLE F-5. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #5

Test Number Formated	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#5-1-T1	GA-8409_FUEL1	12743	2.08	23.22	1.5	1.3	2.5	-99.0
E98-Veh#5-1-T2	GA-8409_FUEL1	12755	1.82	25.05	1.8	1.4	2.4	-99.0
E98-Veh#5-2-T1	GA-8410_FUEL2	12847	0.95	13.76	0.6	4.4	1.1	20.7
E98-Veh#5-2-T2	GA-8410_FUEL2	12858	1.09	16.21	0.7	4.7	1.2	23.5
E98-Veh#5-3-T1	GA-8411_FUEL3	12951	1.44	14.21	2.0	7.0	2.5	45.9
E98-Veh#5-3-T2	GA-8411_FUEL3	12962	1.13	15.56	1.2	5.8	1.9	42.9

TABLE F-6. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #6

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#6-1-T1	GA-8409_FUEL1	13130	1.90	20.88	1.2	1.4	1.3	0.9
E98-Veh#6-1-T2	GA-8409_FUEL1	13141	1.19	15.36	1.2	1.3	1.5	0.5
E98-Veh#6-2-T2	GA-8410_FUEL2	13016	0.77	5.66	1.0	4.2	1.3	9.5
E98-Veh#6-2-T3	GA-8410_FUEL2	13057	0.86	7.21	1.0	5.4	-99.0	11.5
E98-Veh#6-3-T1	GA-8411_FUEL3	13210	0.97	10.58	1.8	9.1	0.2	47.3
E98-Veh#6-3-T2	GA-8411_FUEL3	13221	1.04	9.52	1.9	7.9	1.0	45.3
E98-Veh#6-3-T3	GA-8411_FUEL3	13232	1.19	8.83	1.7	7.7	0.8	42.7

TABLE F-7. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #7

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#7-1-T1	GA-8409_FUEL1	15186.3	3.23	35.63	2.4	1.4	-99.0	-99.0
E98-Veh#7-1-T2	GA-8409_FUEL1	15197.4	3.54	33.36	1.8	1.5	2.4	-99.0
E98-Veh#7-2-T1	GA-8410_FUEL2	15093.3	2.02	22.06	1.8	7.2	1.9	39.9
E98-Veh#7-2-T2	GA-8410_FUEL2	15114.3	2.12	17.21	2.5	7.8	-99.0	45.5
E98-Veh#7-3-T1	GA-8411_FUEL3	14989.3	2.02	20.75	2.8	10.4	2.0	44.8
E98-Veh#7-3-T2	GA-8411_FUEL3	15000.4	2.25	23.23	2.8	10.7	2.2	61.1
E98-Veh#7-3-T3	GA-8411_FUEL3	15021.3	2.05	19.43	2.9	8.4	2.5	45.1

TABLE F-8. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #8

Test Number Formated	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#8-1-T1	GA-8409_FUEL1	15353.1	11.37	144.94	3.9	3.2	4.2	-99.0
E98-Veh#8-1-T2	GA-8409_FUEL1	15374	10.27	134.12	3.9	3.2	4.2	-99.0
E98-Veh#8-1-T3	GA-8409_FUEL1	15395.9	8.74	125.76	5.1	3.5	2.6	-99.0
E98-Veh#8-2-T1	GA-8410_FUEL2	15273.3	3.18	54.71	2.1	7.8	3.4	29.9
E98-Veh#8-2-T2	GA-8410_FUEL2	15284.3	2.97	48.71	2.7	7.3	4.1	23.9
E98-Veh#8-3-T1	GA-8411_FUEL3	15464.5	5.09	65.10	4.2	11.3	5.9	46.5
E98-Veh#8-3-T2	GA-8411_FUEL3	15475.6	5.71	83.98	6.2	13.8	4.3	40.1

TABLE F-9. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #9

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#9-1-T1	GA-8409_FUEL1	12457.5	0.98	30.65	0.8	0.6	0.7	-99.0
E98-Veh#9-1-T2	GA-8409_FUEL1	12468.3	0.85	33.27	0.5	0.5	1.1	-99.0
E98-Veh#9-2-T1	GA-8410_FUEL2	12377.5	0.32	12.50	0.2	1.8	0.4	8.4
E98-Veh#9-2-T2	GA-8410_FUEL2	12388.5	0.41	13.16	0.2	1.9	-99.0	8.9
E98-Veh#9-3-T1	GA-8411_FUEL3	12537.6	0.65	32.73	0.7	4.6	1.7	28.2
E98-Veh#9-3-T2	GA-8411_FUEL3	12548.6	0.81	31.36	0.6	4.7	1.7	30.2

TABLE F-10. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #10

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#10-1-T1	GA-8409_FUEL1	12356	2.15	35.33	3.5	1.9	3.8	-99.0
E98-Veh#10-1-T2	GA-8409_FUEL1	12664	2.14	26.47	3.9	2.3	1.8	-99.0
E98-Veh#10-2-T1	GA-8410_FUEL2	12735	1.73	19.47	3.0	7.1	2.3	18.3
E98-Veh#10-2-T2	GA-8410_FUEL2	12746	2.06	22.36	3.9	8.3	2.5	24.9
E98-Veh#10-3-T1	GA-8411_FUEL3	12819	1.36	19.17	3.8	9.7	1.5	31.1
E98-Veh#10-3-T2	GA-8411_FUEL3	12830	1.54	14.33	4.4	9.4	3.3	26.8

TABLE F-11. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #11

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#11-1-T1	GA-8410_FUEL2	12480	8.78	48.10	4.9	3.2	3.5	-99.0
E98-Veh#11-1-T2	GA-8409_FUEL1	12491	9.01	48.55	4.5	2.5	2.8	-99.0
E98-Veh#11-2-T1	GA-8410_FUEL2	12644	6.32	28.70	4.1	7.6	2.1	25.9
E98-Veh#11-2-T2	GA-8410_FUEL2	12655	4.80	23.06	3.5	7.5	2.5	27.6
E98-Veh#11-3-T1	GA-8411_FUEL3	12562	8.22	27.36	4.9	10.3	3.2	61.2
E98-Veh#11-3-T2	GA-8411_FUEL3	12573	9.40	31.93	5.8	12.8	2.9	73.4

TABLE F-12. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #12

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#12-1-T1	GA-8409_FUEL1	12641	2.54	5.62	2.3	1.8	-99.0	0.5
E98-Veh#12-1-T2	GA-8409_FUEL1	12652	2.20	5.78	2.0	1.3	1.0	0.1
E98-Veh#12-2-T1	GA-8410_FUEL2	12868	1.23	4.72	1.1	3.1	1.1	5.8
E98-Veh#12-2-T2	GA-8410_FUEL2	12879	1.37	5.42	1.7	3.1	1.2	4.2
E98-Veh#12-3-T1	GA-8411_FUEL3	12743	2.12	4.68	3.1	8.4	-99.0	26.0
E98-Veh#12-3-T4	GA-8411_FUEL3	12776	1.87	5.23	2.9	8.0	1.4	20.5

TABLE F-13. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #13

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#13-1-T1	GA-8409_FUEL1	13193	4.35	32.50	10.3	4.4	-99.0	-99.0
E98-Veh#13-1-T2	GA-8409_FUEL1	13204	4.35	28.95	9.1	4.5	2.4	-99.0
E98-Veh#13-1-T3	GA-8409_FUEL1	13225	4.00	33.29	9.3	4.3	-99.0	-99.0
E98-Veh#13-2-T1	GA-8410_FUEL2	13002	1.86	10.05	2.2	3.8	1.1	11.6
E98-Veh#13-2-T2	GA-8410_FUEL2	13035	1.36	10.39	1.4	2.9	1.1	10.4
E98-Veh#13-3-T1	GA-8411_FUEL3	13108	2.76	10.26	9.4	12.5	-99.0	31.3
E98-Veh#13-3-T1	GA-8411_FUEL3	13108	2.76	10.26	9.4	12.5	-99.0	31.3
E98-Veh#13-3-T2	GA-8411_FUEL3	13119	3.36	12.64	6.2	8.8	-99.0	31.9

TABLE F-14. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #14

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#14-1-T1	GA-8409_FUEL1	13440	1.67	34.78	1.1	1.4	2.4	-99.0
E98-Veh#14-1-T2	GA-8409_FUEL1	13451	1.52	30.42	0.9	1.2	1.6	-99.0
E98-Veh#14-2-T2	GA-8410_FUEL2	13151	0.85	16.53	1.0	4.9	3.4	22.8
E98-Veh#14-2-T3	GA-8410_FUEL2	13192	1.43	17.11	1.0	4.4	1.8	20.5
E98-Veh#14-3-T1	GA-8411_FUEL3	13343	1.71	27.84	1.7	9.2	1.4	66.9
E98-Veh#14-3-T3	GA-8411_FUEL3	13377	1.40	27.60	1.5	8.7	-99.0	56.1
E98-Veh#14-3-T3	GA-8411_FUEL3	13377	1.40	27.60	1.5	8.7	-99.0	56.1

TABLE F-15. SIX COMPOUND COMPOSITE RESULTS FOR VEHICLE #15

Test Number Formatted	Fuel Name	Odometer mi.	1,3-Butadiene mg/mi	Benzene mg/mi	Formaldehyde mg/mi	Acetaldehyde mg/mi	Methanol mg/mi	Ethanol mg/mi
E98-Veh#15-1-T1	GA-8409_FUEL1	14683	3.17	19.01	4.5	2.2	2.2	-99.0
E98-Veh#15-1-T2	GA-8409_FUEL1	14694	3.85	17.11	4.5	2.2	2.2	-99.0
E98-Veh#15-2-T1	GA-8410_FUEL2	14889	2.87	22.15	3.9	7.9	-99.0	21.0
E98-Veh#15-2-T2	GA-8410_FUEL2	14900	2.94	16.38	3.8	7.7	2.0	16.1
E98-Veh#15-3-T1	GA-8411_FUEL3	14579	2.01	15.88	3.8	9.8	5.4	40.3
E98-Veh#15-3-T2	GA-8411_FUEL3	14590	2.88	16.71	5.6	12.8	3.5	57.2
E98-Veh#15-3-T3	GA-8411_FUEL3	14612	1.66	11.48	4.9	10.9	2.9	32.5

APPENDIX G

E-98 TEST EMISSIONS DESCRIPTIVE STATISTICS BY EMISSIONS, PHASE, FUEL AND VEHICLE

TABLE G-1. THC EMISSIONS DESCRIPTIVE STATISTICS BY PHASE, FUEL AND VEHICLE

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
Composite	1	Vehicle #1	2	0.0780149	0.0010487	0.0772733	0.0787564
		Vehicle #2	2	0.0553395	0.0021863	0.0537935	0.0568854
		Vehicle #3	2	0.0477334	0.0068769	0.0428707	0.0525961
		Vehicle #4	2	0.0191328	0.000181579	0.0190044	0.0192612
		Vehicle #5	2	0.0371906	8.4272986E-6	0.0371847	0.0371966
		Vehicle #6	2	0.0361733	0.000376850	0.0359068	0.0364398
		Vehicle #7	2	0.0553744	0.0030426	0.0532229	0.0575258
		Vehicle #8	3	0.1557592	0.0157733	0.1402806	0.1718115
		Vehicle #9	2	0.0165307	0.0013596	0.0155693	0.0174921
		Vehicle #10	2	0.0579333	0.0074419	0.0526711	0.0631956
		Vehicle #11	2	0.0617817	0.000072313	0.0617306	0.0618328
		Vehicle #12	2	0.0187144	0.0011252	0.0179187	0.0195100
		Vehicle #13	3	0.1002020	0.0072082	0.0919766	0.1054173
		Vehicle #14	2	0.0399878	0.0031958	0.0377280	0.0422476
		Vehicle #15	2	0.0557578	0.0020492	0.0543088	0.0572069
	2	Vehicle #1	2	0.0370168	0.0018935	0.0356779	0.0383556
		Vehicle #2	2	0.0460039	0.0013938	0.0450183	0.0469895
		Vehicle #3	3	0.0251481	0.0016872	0.0232737	0.0265454
		Vehicle #4	2	0.0168475	0.000043433	0.0168168	0.0168782
		Vehicle #5	2	0.0275554	0.0035546	0.0250419	0.0300688
		Vehicle #6	3	0.0199462	0.0043273	0.0150204	0.0231359
		Vehicle #7	2	0.0541763	0.000906202	0.0535355	0.0548171
		Vehicle #8	2	0.0886385	0.0092918	0.0820682	0.0952088
		Vehicle #9	2	0.0103595	0.0016629	0.0091836	0.0115354
		Vehicle #10	2	0.0397039	0.0037273	0.0370683	0.0423395
		Vehicle #11	2	0.0447185	0.000944268	0.0440508	0.0453862
		Vehicle #12	2	0.0160229	0.000081621	0.0159652	0.0160807
		Vehicle #13	2	0.0268854	0.0012080	0.0260312	0.0277395
		Vehicle #14	2	0.0217709	0.0019920	0.0203624	0.0231794
		Vehicle #15	2	0.0614553	0.0044209	0.0583292	0.0645813
	3	Vehicle #1	2	0.0635406	0.0043017	0.0604988	0.0665824
		Vehicle #2	2	0.0622356	0.0058601	0.0580919	0.0663793
		Vehicle #3	2	0.0345931	0.0032875	0.0322685	0.0369177
		Vehicle #4	2	0.0166760	0.000704037	0.0161782	0.0171738
		Vehicle #5	2	0.0330070	0.000074552	0.0329543	0.0330598
		Vehicle #6	3	0.0293426	0.0055607	0.0234211	0.0344536
		Vehicle #7	3	0.0475967	0.0042913	0.0426772	0.0505705
		Vehicle #8	2	0.1313947	0.0236723	0.1146559	0.1481336
		Vehicle #9	2	0.0283892	0.000686949	0.0279035	0.0288750
		Vehicle #10	2	0.0435146	0.000671412	0.0430398	0.0439893
		Vehicle #11	2	0.0620345	0.0069997	0.0570849	0.0669840
		Vehicle #12	2	0.0191808	0.000119017	0.0190966	0.0192649
		Vehicle #13	2	0.0512212	0.0035266	0.0487275	0.0537148
		Vehicle #14	2	0.0389158	0.0025070	0.0371431	0.0406885
		Vehicle #15	3	0.0577472	0.0017146	0.0563475	0.0596596
Phase 1	1	Vehicle #1	2	1.1859985	0.0314493	1.1637605	1.2082365
		Vehicle #2	2	0.6627701	0.0122605	0.6541006	0.6714396
		Vehicle #3	2	0.7938068	0.1495993	0.6880242	0.8995895
		Vehicle #4	2	0.3313818	0.0160915	0.3200034	0.3427603
		Vehicle #5	2	0.5484322	0.0016142	0.5472907	0.5495736
		Vehicle #6	2	0.5321432	0.1114535	0.4533337	0.6109527
		Vehicle #7	2	0.7202611	0.0494756	0.6852766	0.7552457

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #8	3	2.0621542	0.3565666	1.6994734	2.4122748
		Vehicle #9	2	0.2898932	0.0142940	0.2797858	0.3000006
		Vehicle #10	2	0.5222339	0.0925021	0.4568251	0.5876428
		Vehicle #11	2	0.8823024	0.0103620	0.8749754	0.8896295
		Vehicle #12	2	0.2576431	0.0203340	0.2432649	0.2720214
		Vehicle #13	3	1.3538143	0.1382320	1.1951582	1.4482844
		Vehicle #14	2	0.5627589	0.0445792	0.5312366	0.5942811
		Vehicle #15	2	0.4377736	0.0476583	0.4040741	0.4714731
	2	Vehicle #1	2	0.4617435	0.0149167	0.4511958	0.4722911
		Vehicle #2	2	0.4378204	0.0549939	0.3989339	0.4767069
		Vehicle #3	3	0.3793246	0.0498751	0.3220779	0.4133915
		Vehicle #4	2	0.2521407	0.0102038	0.2449255	0.2593558
		Vehicle #5	2	0.4160423	0.0421387	0.3862457	0.4458389
		Vehicle #6	3	0.1871005	0.0307743	0.1572974	0.2187617
		Vehicle #7	2	0.6488633	0.0089840	0.6425106	0.6552160
		Vehicle #8	2	0.7570456	0.0159453	0.7457705	0.7683206
		Vehicle #9	2	0.1566754	0.0102228	0.1494468	0.1639040
		Vehicle #10	2	0.4504842	0.0597171	0.4082579	0.4927106
		Vehicle #11	2	0.6342821	0.0131672	0.6249715	0.6435927
		Vehicle #12	2	0.1609004	0.0075004	0.1555968	0.1662039
		Vehicle #13	2	0.2282965	0.0036588	0.2257093	0.2308837
		Vehicle #14	2	0.3272514	0.0350792	0.3024466	0.3520561
		Vehicle #15	2	0.5045876	0.0371422	0.4783241	0.5308511
	3	Vehicle #1	2	0.8252332	0.0049958	0.8217006	0.8287657
		Vehicle #2	2	0.6352003	0.0416881	0.6057223	0.6646782
		Vehicle #3	2	0.5547034	0.0743188	0.5021521	0.6072548
		Vehicle #4	2	0.3063978	0.0326308	0.2833244	0.3294713
		Vehicle #5	2	0.4713225	0.0158182	0.4601373	0.4825076
		Vehicle #6	3	0.4013228	0.0278685	0.3694068	0.4208415
		Vehicle #7	3	0.6342965	0.0765550	0.5668490	0.7175056
		Vehicle #8	2	1.1447611	0.2125542	0.9944626	1.2950596
		Vehicle #9	2	0.4575724	0.0015336	0.4564879	0.4586568
		Vehicle #10	2	0.4137056	0.0617313	0.3700549	0.4573562
		Vehicle #11	2	0.8668838	0.0705093	0.8170262	0.9167414
		Vehicle #12	2	0.2705565	0.0030963	0.2683671	0.2727459
		Vehicle #13	2	0.4166917	0.0733620	0.3648170	0.4685665
		Vehicle #14	2	0.6293011	0.0767757	0.5750125	0.6835898
		Vehicle #15	3	0.4851728	0.0607945	0.4302168	0.5504773
Phase 2	1	Vehicle #1	2	0.0176872	0.000192162	0.0175513	0.0178231
		Vehicle #2	2	0.0195423	0.0022405	0.0179581	0.0211266
		Vehicle #3	2	0.0065965	0.000834387	0.0060065	0.0071865
		Vehicle #4	2	0.000818278	0.000879407	0.000196443	0.0014401
		Vehicle #5	2	0.0087832	0.000452019	0.0084636	0.0091028
		Vehicle #6	2	0.0094480	0.0062441	0.0050328	0.0138633
		Vehicle #7	2	0.0172462	0.000632739	0.0167988	0.0176937
		Vehicle #8	3	0.0452748	0.0032913	0.0422486	0.0487790
		Vehicle #9	2	0.0012508	0.000886624	0.000623881	0.0018778
		Vehicle #10	2	0.0305372	0.0033530	0.0281662	0.0329081
		Vehicle #11	2	0.0133318	0.000085213	0.0132715	0.0133920
		Vehicle #12	2	0.0054808	0.000381495	0.0052110	0.0057505
		Vehicle #13	3	0.0322139	0.0017233	0.0307219	0.0341002
		Vehicle #14	2	0.0120626	0.0010794	0.0112993	0.0128259
		Vehicle #15	2	0.0328411	0.0064284	0.0282956	0.0373867
	2	Vehicle #1	2	0.0134806	0.0014350	0.0124659	0.0144953
		Vehicle #2	2	0.0226401	0.000568264	0.0222383	0.0230419
		Vehicle #3	3	0.0052866	0.000934592	0.0046055	0.0063521

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #4	2	0.0040729	0.000451303	0.0037538	0.0043920
		Vehicle #5	2	0.0055182	0.0012919	0.0046047	0.0064318
		Vehicle #6	3	0.0104235	0.0063274	0.0031741	0.0148357
		Vehicle #7	2	0.0222278	0.0011399	0.0214217	0.0230338
		Vehicle #8	2	0.0500150	0.0126549	0.0410667	0.0589634
		Vehicle #9	2	0.0020253	0.0028643	0	0.0040507
		Vehicle #10	2	0.0163913	0.0014074	0.0153961	0.0173865
		Vehicle #11	2	0.0109957	0.0018555	0.0096837	0.0123078
		Vehicle #12	2	0.0081306	0.000081225	0.0080732	0.0081880
		Vehicle #13	2	0.0160923	0.0015127	0.0150226	0.0171620
		Vehicle #14	2	0.0048854	0.000164515	0.0047691	0.0050018
		Vehicle #15	2	0.0372313	0.0029676	0.0351329	0.0393297
	3	Vehicle #1	2	0.0229514	0.0052831	0.0192157	0.0266871
		Vehicle #2	2	0.0290969	0.0039324	0.0263163	0.0318776
		Vehicle #3	2	0.0061149	0.000386462	0.0058416	0.0063881
		Vehicle #4	2	0.000462669	0.000654313	0	0.000925338
		Vehicle #5	2	0.0085890	0.000847862	0.0079895	0.0091886
		Vehicle #6	3	0.0090878	0.0068481	0.0012182	0.0136922
		Vehicle #7	3	0.0143385	0.0055299	0.0102483	0.0206301
		Vehicle #8	2	0.0752318	0.0168132	0.0633431	0.0871205
		Vehicle #9	2	0.0052241	0.000860310	0.0046158	0.0058324
		Vehicle #10	2	0.0221474	0.0030489	0.0199915	0.0243033
		Vehicle #11	2	0.0165174	0.0040063	0.0136846	0.0193503
		Vehicle #12	2	0.0054031	0.000109009	0.0053260	0.0054802
		Vehicle #13	2	0.0320654	0.000512816	0.0317028	0.0324280
		Vehicle #14	2	0.0065463	0.0023791	0.0048640	0.0082285
		Vehicle #15	3	0.0337580	0.0024469	0.0322521	0.0365813
Phase 3	1	Vehicle #1	2	0.0272388	0.0022762	0.0256293	0.0288483
		Vehicle #2	2	0.0544256	0.0145601	0.0441301	0.0647212
		Vehicle #3	2	0.0128738	0.000695971	0.0123817	0.0133660
		Vehicle #4	2	0.0154591	0.0017401	0.0142287	0.0166895
		Vehicle #5	2	0.0184538	0.0075755	0.0130971	0.0238105
		Vehicle #6	2	0.0031568	0.0015853	0.0020358	0.0042778
		Vehicle #7	2	0.0390116	0.000468154	0.0386805	0.0393426
		Vehicle #8	3	0.1288534	0.0058168	0.1250893	0.1355530
		Vehicle #9	2	0.0093213	0.000487037	0.0089769	0.0096657
		Vehicle #10	2	0.0576959	0.0095823	0.0509201	0.0644716
		Vehicle #11	2	0.0618291	0.0123325	0.0531087	0.0705495
		Vehicle #12	2	0.0071019	0.0032838	0.0047799	0.0094239
		Vehicle #13	3	0.0234640	0.0033866	0.0196878	0.0262318
		Vehicle #14	2	0.0014897	0.000526360	0.0011175	0.0018619
		Vehicle #15	2	0.0577628	0.0133477	0.0483245	0.0672010
	2	Vehicle #1	2	0.0187713	0.0045346	0.0155649	0.0219777
		Vehicle #2	2	0.0508504	0.0104754	0.0434432	0.0582576
		Vehicle #3	3	0.0113595	0.0013285	0.0098302	0.0122284
		Vehicle #4	2	0.0011521	0.0016293	0	0.0023042
		Vehicle #5	2	0.0191049	0.0050832	0.0155105	0.0226992
		Vehicle #6	3	0.0139815	0.0200009	0	0.0368916
		Vehicle #7	2	0.0133087	0.0188213	0	0.0266174
		Vehicle #8	2	0.0744623	0.0174298	0.0621376	0.0867871
		Vehicle #9	2	0.0079630	0.0048628	0.0045245	0.0114015
		Vehicle #10	2	0.0285221	0.0068902	0.0236500	0.0333943
		Vehicle #11	2	0.0343174	0.0014334	0.0333039	0.0353310
		Vehicle #12	2	0.0065802	0.0031269	0.0043691	0.0087913

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #13	2	0.0117866	0.0017051	0.0105810	0.0129923
		Vehicle #14	2	0.0059207	0.0018386	0.0046206	0.0072208
		Vehicle #15	2	0.0400993	0.0041671	0.0371527	0.0430459
	3	Vehicle #1	2	0.0103661	0.0010077	0.0096536	0.0110786
		Vehicle #2	2	0.0527498	0.0050855	0.0491539	0.0563458
		Vehicle #3	2	0.0060525	0.0010939	0.0052790	0.0068260
		Vehicle #4	2	0.0061843	0.0016518	0.0050163	0.0073523
		Vehicle #5	2	0.0215412	0.0017871	0.0202775	0.0228049
		Vehicle #6	3	0.0033481	0.0025392	0.0012744	0.0061800
		Vehicle #7	3	0.0260428	0.0086552	0.0181292	0.0352858
		Vehicle #8	2	0.0863031	0.0301386	0.0649919	0.1076143
		Vehicle #9	2	0.0033785	0.000741312	0.0028543	0.0039027
		Vehicle #10	2	0.0391183	0.0039939	0.0362942	0.0419424
		Vehicle #11	2	0.0384328	0.000384902	0.0381606	0.0387050
		Vehicle #12	2	0.0037689	0.0053300	0	0.0075378
		Vehicle #13	2	0.0195854	0.0027695	0.0176271	0.0215437
		Vehicle #14	2	0.0053579	0.0075772	0	0.0107158
		Vehicle #15	3	0.0412400	0.0053997	0.0351772	0.0455317

TABLE G-2. NMHC EMISSIONS DESCRIPTIVE STATISTICS BY PHASE, FUEL AND VEHICLE

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
Composite	1	Vehicle #1	2	0.0679552	0.0013108	0.0670284	0.0688821
		Vehicle #2	2	0.0423504	0.0011504	0.0415370	0.0431639
		Vehicle #3	2	0.0430492	0.0068654	0.0381946	0.0479037
		Vehicle #4	2	0.0164883	0.000589407	0.0160715	0.0169051
		Vehicle #5	2	0.0311763	0.000135593	0.0310804	0.0312722
		Vehicle #6	2	0.0335587	0.000157150	0.0334475	0.0336698
		Vehicle #7	2	0.0447413	0.0028491	0.0427266	0.0467559
		Vehicle #8	3	0.1210844	0.0165396	0.1054255	0.1383826
		Vehicle #9	2	0.0136029	0.0010122	0.0128871	0.0143186
		Vehicle #10	2	0.0422345	0.0065158	0.0376272	0.0468419
		Vehicle #11	2	0.0477557	0.000092618	0.0476902	0.0478212
		Vehicle #12	2	0.0162678	0.0013003	0.0153484	0.0171873
		Vehicle #13	3	0.0934708	0.0075676	0.0847995	0.0987418
		Vehicle #14	2	0.0357987	0.0027537	0.0338516	0.0377458
		Vehicle #15	2	0.0427275	0.0010274	0.0420010	0.0434540
	2	Vehicle #1	2	0.0303033	0.0015674	0.0291950	0.0314116
		Vehicle #2	2	0.0329115	0.0025143	0.0311336	0.0346893
		Vehicle #3	3	0.0208851	0.0016671	0.0189947	0.0221448
		Vehicle #4	2	0.0135811	0.000173289	0.0134585	0.0137036
		Vehicle #5	2	0.0211824	0.0030647	0.0190153	0.0233494
		Vehicle #6	3	0.0172981	0.0052543	0.0112672	0.0208874
		Vehicle #7	2	0.0422488	0.000454409	0.0419275	0.0425702
		Vehicle #8	2	0.0558225	0.0073341	0.0506364	0.0610085
		Vehicle #9	2	0.0082106	0.0010987	0.0074337	0.0089875
		Vehicle #10	2	0.0258551	0.0037418	0.0232092	0.0285009
		Vehicle #11	2	0.0313122	0.000240662	0.0311420	0.0314823
		Vehicle #12	2	0.0135037	0.000130122	0.0134117	0.0135957
		Vehicle #13	2	0.0206512	0.0014255	0.0196432	0.0216592
		Vehicle #14	2	0.0179202	0.0013507	0.0169652	0.0188753
		Vehicle #15	2	0.0443862	0.000747183	0.0438578	0.0449145
	3	Vehicle #1	2	0.0537580	0.0030779	0.0515816	0.0559344
		Vehicle #2	2	0.0438068	0.0037928	0.0411249	0.0464888
		Vehicle #3	2	0.0284573	0.0030121	0.0263275	0.0305872
		Vehicle #4	2	0.0134048	0.0010336	0.0126739	0.0141356
		Vehicle #5	2	0.0248319	0.000097808	0.0247627	0.0249010
		Vehicle #6	3	0.0254728	0.0055514	0.0195230	0.0305134
		Vehicle #7	3	0.0354019	0.0038646	0.0309570	0.0379672
		Vehicle #8	2	0.0895152	0.0193338	0.0758441	0.1031862
		Vehicle #9	2	0.0230070	0.000760314	0.0224694	0.0235446
		Vehicle #10	2	0.0268235	0.0012909	0.0259107	0.0277363
		Vehicle #11	2	0.0426544	0.0055398	0.0387371	0.0465716
		Vehicle #12	2	0.0159263	0.000216449	0.0157733	0.0160794
		Vehicle #13	2	0.0432604	0.0036119	0.0407064	0.0458143
		Vehicle #14	2	0.0316115	0.0018956	0.0302711	0.0329520
		Vehicle #15	3	0.0413122	0.0012787	0.0402283	0.0427224
Phase 1	1	Vehicle #1	2	1.1195550	0.0276041	1.1000359	1.1390741
		Vehicle #2	2	0.6016546	0.0123723	0.5929060	0.6104031
		Vehicle #3	2	0.7398406	0.1453546	0.6370594	0.8426218
		Vehicle #4	2	0.3023083	0.0165222	0.2906253	0.3139912
		Vehicle #5	2	0.5051999	0.000248169	0.5050244	0.5053754
		Vehicle #6	2	0.5025204	0.1071823	0.4267311	0.5783098
		Vehicle #7	2	0.6392901	0.0451912	0.6073352	0.6712451

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #8	3	1.8343689	0.3275182	1.5019143	2.1567168
		Vehicle #9	2	0.2548401	0.0134535	0.2453271	0.2643532
		Vehicle #10	2	0.4505615	0.0795982	0.3942770	0.5068459
		Vehicle #11	2	0.7696612	0.0081901	0.7638699	0.7754524
		Vehicle #12	2	0.2333804	0.0197732	0.2193987	0.2473622
		Vehicle #13	3	1.3026679	0.1411868	1.1410600	1.4020702
		Vehicle #14	2	0.5111397	0.0432376	0.4805661	0.5417133
		Vehicle #15	2	0.3703734	0.0423163	0.3404512	0.4002955
	2	Vehicle #1	2	0.4097881	0.0166564	0.3980102	0.4215659
		Vehicle #2	2	0.3755392	0.0542613	0.3371706	0.4139077
		Vehicle #3	3	0.3337861	0.0465890	0.2801763	0.3644671
		Vehicle #4	2	0.2162341	0.0091886	0.2097368	0.2227315
		Vehicle #5	2	0.3604617	0.0390195	0.3328707	0.3880527
		Vehicle #6	3	0.1564617	0.0317935	0.1373588	0.1931634
		Vehicle #7	2	0.5417959	0.0155333	0.5308122	0.5527796
		Vehicle #8	2	0.6177273	0.0101789	0.6105298	0.6249248
		Vehicle #9	2	0.1276752	0.0098951	0.1206783	0.1346722
		Vehicle #10	2	0.3708232	0.0535190	0.3329796	0.4086669
		Vehicle #11	2	0.5171177	0.0153347	0.5062744	0.5279610
		Vehicle #12	2	0.1370964	0.0078680	0.1315329	0.1426599
		Vehicle #13	2	0.1814448	0.000148060	0.1813402	0.1815495
		Vehicle #14	2	0.2834958	0.0244182	0.2662295	0.3007621
		Vehicle #15	2	0.4046198	0.0302725	0.3832139	0.4260257
	3	Vehicle #1	2	0.7399954	0.0130242	0.7307860	0.7492049
		Vehicle #2	2	0.5274352	0.0347881	0.5028364	0.5520341
		Vehicle #3	2	0.4780720	0.0664397	0.4310921	0.5250520
		Vehicle #4	2	0.2572100	0.0272269	0.2379576	0.2764624
		Vehicle #5	2	0.3970085	0.0132578	0.3876338	0.4063832
		Vehicle #6	3	0.3490068	0.0251073	0.3204698	0.3677034
		Vehicle #7	3	0.5176450	0.0662998	0.4605827	0.5903756
		Vehicle #8	2	0.9384597	0.1898588	0.8042092	1.0727101
		Vehicle #9	2	0.3824364	0.0013165	0.3815055	0.3833673
		Vehicle #10	2	0.3173241	0.0514853	0.2809185	0.3537297
		Vehicle #11	2	0.6898983	0.0577145	0.6490880	0.7307086
		Vehicle #12	2	0.2304201	0.0022869	0.2288031	0.2320372
		Vehicle #13	2	0.3566686	0.0734347	0.3047425	0.4085948
		Vehicle #14	2	0.5239372	0.0715970	0.4733105	0.5745640
		Vehicle #15	3	0.3722512	0.0502315	0.3274363	0.4265479
Phase 2	1	Vehicle #1	2	0.0110517	0.000257511	0.0108697	0.0112338
		Vehicle #2	2	0.0102228	0.0011757	0.0093915	0.0110542
		Vehicle #3	2	0.0050596	0.000644379	0.0046039	0.0055152
		Vehicle #4	2	0.000034334	0.000048555	0	0.000068667
		Vehicle #5	2	0.0055479	0.000473998	0.0052127	0.0058831
		Vehicle #6	2	0.0084147	0.0062012	0.0040298	0.0127997
		Vehicle #7	2	0.0110614	0.000510153	0.0107007	0.0114222
		Vehicle #8	3	0.0226918	0.0014966	0.0212249	0.0242165
		Vehicle #9	2	0.000325795	0.000460743	0	0.000651589
		Vehicle #10	2	0.0189409	0.0028676	0.0169132	0.0209687
		Vehicle #11	2	0.0059851	0.000253251	0.0058060	0.0061641
		Vehicle #12	2	0.0045415	0.000561846	0.0041442	0.0049388
		Vehicle #13	3	0.0283193	0.0018581	0.0267874	0.0303862
		Vehicle #14	2	0.0104693	0.000610843	0.0100374	0.0109013
		Vehicle #15	2	0.0237748	0.0046199	0.0205081	0.0270416
	2	Vehicle #1	2	0.0098678	0.000992865	0.0091657	0.0105698
		Vehicle #2	2	0.0133199	0.000406854	0.0130323	0.0136076
		Vehicle #3	3	0.0036756	0.000778965	0.0030713	0.0045547

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #4	2	0.0025835	0.000542738	0.0021997	0.0029673
		Vehicle #5	2	0.0026033	0.0010423	0.0018663	0.0033403
		Vehicle #6	3	0.0094918	0.0063387	0.0022440	0.0140002
		Vehicle #7	2	0.0155629	0.0012011	0.0147136	0.0164122
		Vehicle #8	2	0.0243686	0.0100541	0.0172593	0.0314780
		Vehicle #9	2	0.0015586	0.0022042	0	0.0031172
		Vehicle #10	2	0.0067674	0.0013388	0.0058207	0.0077140
		Vehicle #11	2	0.0043745	0.0011377	0.0035700	0.0051790
		Vehicle #12	2	0.0070928	0.000146269	0.0069894	0.0071963
		Vehicle #13	2	0.0123160	0.0014499	0.0112908	0.0133412
		Vehicle #14	2	0.0034760	0.000086040	0.0034152	0.0035369
		Vehicle #15	2	0.0252585	0.000858117	0.0246518	0.0258653
	3	Vehicle #1	2	0.0176453	0.0042819	0.0146176	0.0206730
		Vehicle #2	2	0.0166301	0.0020299	0.0151948	0.0180655
		Vehicle #3	2	0.0041367	0.000341835	0.0038950	0.0043785
		Vehicle #4	2	0	0	0	0
		Vehicle #5	2	0.0047219	0.000633668	0.0042738	0.0051700
		Vehicle #6	3	0.0080271	0.0066106	0.000444656	0.0125795
		Vehicle #7	3	0.0087091	0.0048720	0.0050716	0.0142444
		Vehicle #8	2	0.0436142	0.0127624	0.0345898	0.0526386
		Vehicle #9	2	0.0037667	0.000885211	0.0031407	0.0043926
		Vehicle #10	2	0.0110087	0.0015237	0.0099312	0.0120861
		Vehicle #11	2	0.0069525	0.0029218	0.0048865	0.0090186
		Vehicle #12	2	0.0043350	0.000194069	0.0041977	0.0044722
		Vehicle #13	2	0.0273343	0.000323952	0.0271053	0.0275634
		Vehicle #14	2	0.0048203	0.0022752	0.0032115	0.0064292
		Vehicle #15	3	0.0236740	0.0019274	0.0224314	0.0258943
Phase 3	1	Vehicle #1	2	0.0151618	0.0015319	0.0140786	0.0162450
		Vehicle #2	2	0.0308332	0.0129314	0.0216893	0.0399771
		Vehicle #3	2	0.0050207	0.000185606	0.0048895	0.0051520
		Vehicle #4	2	0.0091717	0.0016279	0.0080206	0.0103228
		Vehicle #5	2	0.0046891	0.0065637	0.000047903	0.0093303
		Vehicle #6	2	0.000725982	0.0010267	0	0.0014520
		Vehicle #7	2	0.0248333	0.0014020	0.0238419	0.0258247
		Vehicle #8	3	0.0852463	0.0070288	0.0803857	0.0933056
		Vehicle #9	2	0.0045581	0.000363057	0.0043014	0.0048148
		Vehicle #10	2	0.0317181	0.0062930	0.0272683	0.0361679
		Vehicle #11	2	0.0368030	0.0100628	0.0296875	0.0439184
		Vehicle #12	2	0.0018885	0.0026707	0	0.0037770
		Vehicle #13	3	0.0140079	0.0043477	0.0104876	0.0188677
		Vehicle #14	2	0	0	0	0
		Vehicle #15	2	0.0353639	0.0096703	0.0285260	0.0422019
	2	Vehicle #1	2	0.0063298	0.0046767	0.0030229	0.0096367
		Vehicle #2	2	0.0264149	0.0066422	0.0217182	0.0311117
		Vehicle #3	3	0.0043851	0.000431152	0.0040323	0.0048657
		Vehicle #4	2	0	0	0	0
		Vehicle #5	2	0.0052523	0.0032911	0.0029251	0.0075794
		Vehicle #6	3	0.0107648	0.0162722	0	0.0294842
		Vehicle #7	2	0.0059449	0.0084074	0	0.0118898
		Vehicle #8	2	0.0308570	0.0165604	0.0191470	0.0425670
		Vehicle #9	2	0.0042872	0.0048576	0.000852323	0.0077221
		Vehicle #10	2	0.0101787	0.0014436	0.0091579	0.0111995
		Vehicle #11	2	0.0117009	0.000582528	0.0112890	0.0121128
		Vehicle #12	2	0.0013506	0.0019101	0	0.0027013

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #13	2	0.0049950	0.0026393	0.0031287	0.0068612
		Vehicle #14	2	0.0011239	0.0013826	0.000146193	0.0021015
		Vehicle #15	2	0.0197494	0.0030134	0.0176186	0.0218801
	3	Vehicle #1	2	0	0	0	0
		Vehicle #2	2	0.0256641	0.0043722	0.0225725	0.0287557
		Vehicle #3	2	0	0	0	0
		Vehicle #4	2	0.0015004	0.0018320	0.000205024	0.0027958
		Vehicle #5	2	0.0069995	0.0010018	0.0062911	0.0077079
		Vehicle #6	3	0.000673493	0.000877627	0	0.0016660
		Vehicle #7	3	0.0094306	0.0070264	0.0025877	0.0166272
		Vehicle #8	2	0.0370129	0.0244172	0.0197473	0.0542785
		Vehicle #9	2	0	0	0	0
		Vehicle #10	2	0.0110918	0.000864831	0.0104802	0.0117033
		Vehicle #11	2	0.0120930	0.0014962	0.0110350	0.0131510
		Vehicle #12	2	0.000668214	0.000944997	0	0.0013364
		Vehicle #13	2	0.0097322	0.0014251	0.0087245	0.0107398
		Vehicle #14	2	0.0010260	0.0014509	0	0.0020519
		Vehicle #15	3	0.0162885	0.0050118	0.0106040	0.0200705

TABLE G-3. CH_4 EMISSIONS DESCRIPTIVE STATISTICS BY PHASE, FUEL AND VEHICLE

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
Composite	1	Vehicle #1	2	0.0098517	0.000108693	0.0097749	0.0099286
		Vehicle #2	2	0.0129163	0.000958963	0.0122382	0.0135944
		Vehicle #3	2	0.0045403	4.2475904E-6	0.0045373	0.0045433
		Vehicle #4	2	0.0031026	0.000080908	0.0030454	0.0031598
		Vehicle #5	2	0.0059766	0.000142728	0.0058757	0.0060776
		Vehicle #6	2	0.0025265	0.000141769	0.0024263	0.0026268
		Vehicle #7	2	0.0106499	0.000223000	0.0104922	0.0108076
		Vehicle #8	3	0.0347056	0.0011667	0.0334539	0.0357628
		Vehicle #9	2	0.0030619	0.000150611	0.0029554	0.0031684
		Vehicle #10	2	0.0156967	0.000913266	0.0150509	0.0163424
		Vehicle #11	2	0.0139856	0.000184673	0.0138551	0.0141162
		Vehicle #12	2	0.0024328	0.000178991	0.0023062	0.0025593
		Vehicle #13	3	0.0066616	0.000412104	0.0062708	0.0070921
		Vehicle #14	2	0.0044318	0.000476330	0.0040949	0.0047686
		Vehicle #15	2	0.0129925	0.0010288	0.0122650	0.0137200
	2	Vehicle #1	2	0.0060668	0.000341203	0.0058255	0.0063080
		Vehicle #2	2	0.0125307	0.0011556	0.0117136	0.0133479
		Vehicle #3	3	0.0036270	0.000182841	0.0034163	0.0037440
		Vehicle #4	2	0.0030552	0.000132845	0.0029613	0.0031491
		Vehicle #5	2	0.0057381	0.000417906	0.0054426	0.0060336
		Vehicle #6	3	0.0019095	0.000268156	0.0016002	0.0020778
		Vehicle #7	2	0.0110421	0.000343978	0.0107989	0.0112854
		Vehicle #8	2	0.0321265	0.0020589	0.0306706	0.0335824
		Vehicle #9	2	0.0021975	5.8117106E-6	0.0021934	0.0022016
		Vehicle #10	2	0.0131854	0.000149865	0.0130794	0.0132913
		Vehicle #11	2	0.0126258	0.000668057	0.0121535	0.0130982
		Vehicle #12	2	0.0023171	0.000015184	0.0023064	0.0023278
		Vehicle #13	2	0.0059063	0.000244615	0.0057334	0.0060793
		Vehicle #14	2	0.0034977	0.000271883	0.0033055	0.0036900
		Vehicle #15	2	0.0139341	0.000045127	0.0139022	0.0139660
	3	Vehicle #1	2	0.0087531	0.0010264	0.0080273	0.0094789
		Vehicle #2	2	0.0168016	0.0017953	0.0155321	0.0180711
		Vehicle #3	2	0.0044416	0.000322919	0.0042132	0.0046699
		Vehicle #4	2	0.0032563	0.000184700	0.0031257	0.0033869
		Vehicle #5	2	0.0069724	0.000076689	0.0069182	0.0070266
		Vehicle #6	3	0.0026033	0.000062331	0.0025497	0.0026717
		Vehicle #7	3	0.0107832	0.000297248	0.0104439	0.0109977
		Vehicle #8	2	0.0405947	0.0043332	0.0375307	0.0436587
		Vehicle #9	2	0.0046570	0.000180584	0.0045293	0.0047847
		Vehicle #10	2	0.0157351	0.000549649	0.0153464	0.0161238
		Vehicle #11	2	0.0174670	0.0012459	0.0165861	0.0183480
		Vehicle #12	2	0.0027269	0.000156008	0.0026166	0.0028372
		Vehicle #13	2	0.0069986	0.000059555	0.0069565	0.0070407
		Vehicle #14	2	0.0058577	0.000075383	0.0058044	0.0059110
		Vehicle #15	3	0.0151312	0.000248203	0.0148465	0.0153020
Phase 1	1	Vehicle #1	2	0.0635753	0.0046033	0.0603203	0.0668303
		Vehicle #2	2	0.0601981	0.000542647	0.0598144	0.0605818
		Vehicle #3	2	0.0523907	0.0037250	0.0497567	0.0550247
		Vehicle #4	2	0.0284639	0.000472395	0.0281298	0.0287979
		Vehicle #5	2	0.0422679	0.0013493	0.0413138	0.0432220
		Vehicle #6	2	0.0285200	0.0042171	0.0255381	0.0315019
		Vehicle #7	2	0.0805101	0.0048272	0.0770967	0.0839234

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #8	3	0.2266327	0.0290103	0.1965449	0.2544297
		Vehicle #9	2	0.0347515	0.000775070	0.0342034	0.0352995
		Vehicle #10	2	0.0705527	0.0125740	0.0616615	0.0794438
		Vehicle #11	2	0.1112844	0.0025188	0.1095033	0.1130654
		Vehicle #12	2	0.0235609	0.000500921	0.0232067	0.0239151
		Vehicle #13	3	0.0496559	0.0040751	0.0449524	0.0521262
		Vehicle #14	2	0.0509821	0.0013716	0.0500122	0.0519520
		Vehicle #15	2	0.0663453	0.0053991	0.0625276	0.0701631
	2	Vehicle #1	2	0.0407339	0.0019383	0.0393633	0.0421045
		Vehicle #2	2	0.0505700	0.000320110	0.0503436	0.0507963
		Vehicle #3	3	0.0339174	0.0025775	0.0323296	0.0368913
		Vehicle #4	2	0.0282009	0.000746090	0.0276734	0.0287285
		Vehicle #5	2	0.0431206	0.0020676	0.0416586	0.0445826
		Vehicle #6	3	0.0156162	0.0023678	0.0136269	0.0182352
		Vehicle #7	2	0.0842259	0.0046426	0.0809431	0.0875087
		Vehicle #8	2	0.1237153	0.0036109	0.1211620	0.1262686
		Vehicle #9	2	0.0241536	0.000265920	0.0239656	0.0243416
		Vehicle #10	2	0.0662073	0.0035629	0.0636879	0.0687267
		Vehicle #11	2	0.1014519	0.0015873	0.1003295	0.1025743
		Vehicle #12	2	0.0201421	0.000142634	0.0200412	0.0202430
		Vehicle #13	2	0.0403523	0.0044578	0.0372001	0.0435045
		Vehicle #14	2	0.0375574	0.0028413	0.0355483	0.0395665
		Vehicle #15	2	0.0885541	0.0056403	0.0845658	0.0925424
	3	Vehicle #1	2	0.0603555	0.000956402	0.0596792	0.0610317
		Vehicle #2	2	0.0758204	0.000856423	0.0752148	0.0764260
		Vehicle #3	2	0.0438197	0.0076708	0.0383957	0.0492438
		Vehicle #4	2	0.0320572	0.0036440	0.0294805	0.0346339
		Vehicle #5	2	0.0509117	0.0019685	0.0495198	0.0523037
		Vehicle #6	3	0.0280411	0.0021979	0.0255242	0.0295817
		Vehicle #7	3	0.0892703	0.0065348	0.0818677	0.0942383
		Vehicle #8	2	0.1809057	0.0245234	0.1635650	0.1982463
		Vehicle #9	2	0.0589155	0.0010073	0.0582033	0.0596278
		Vehicle #10	2	0.0789666	0.0090459	0.0725702	0.0853630
		Vehicle #11	2	0.1406683	0.0081016	0.1349397	0.1463970
		Vehicle #12	2	0.0262858	0.000763225	0.0257461	0.0268254
		Vehicle #13	2	0.0414019	0.000612161	0.0409690	0.0418347
		Vehicle #14	2	0.0729691	0.0014502	0.0719437	0.0739946
		Vehicle #15	3	0.0880769	0.0046811	0.0829769	0.0921777
Phase 2	1	Vehicle #1	2	0.0065968	0.000365994	0.0063380	0.0068556
		Vehicle #2	2	0.0092834	0.000953212	0.0086094	0.0099574
		Vehicle #3	2	0.0015333	0.000207901	0.0013863	0.0016803
		Vehicle #4	2	0.0013406	0.000044323	0.0013093	0.0013720
		Vehicle #5	2	0.0032433	0.000019918	0.0032292	0.0032574
		Vehicle #6	2	0.0010058	0.000082387	0.000947535	0.0010640
		Vehicle #7	2	0.0062285	0.000121940	0.0061423	0.0063147
		Vehicle #8	3	0.0226673	0.0026270	0.0196895	0.0246570
		Vehicle #9	2	0.0010935	0.000205255	0.000948380	0.0012387
		Vehicle #10	2	0.0116540	0.000486130	0.0113103	0.0119978
		Vehicle #11	2	0.0073791	0.000179981	0.0072518	0.0075064
		Vehicle #12	2	0.000933379	0.000219010	0.000778515	0.0010882
		Vehicle #13	3	0.0039008	0.000164571	0.0037238	0.0040492
		Vehicle #14	2	0.0015874	0.000500255	0.0012336	0.0019411
		Vehicle #15	2	0.0090830	0.0018204	0.0077958	0.0103702
	2	Vehicle #1	2	0.0035739	0.000512459	0.0032116	0.0039363
		Vehicle #2	2	0.0093633	0.000992567	0.0086615	0.0100652
		Vehicle #3	3	0.0016154	0.000159893	0.0015158	0.0017999

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #4	2	0.0014754	0.000104177	0.0014017	0.0015490
		Vehicle #5	2	0.0029212	0.000227365	0.0027604	0.0030820
		Vehicle #6	3	0.000913892	0.000090999	0.000826300	0.0010080
		Vehicle #7	2	0.0064966	0.000238815	0.0063277	0.0066655
		Vehicle #8	2	0.0257824	0.0026073	0.0239388	0.0276260
		Vehicle #9	2	0.000806918	9.8648467E-6	0.000799942	0.000813893
		Vehicle #10	2	0.0096639	0.000055093	0.0096249	0.0097028
		Vehicle #11	2	0.0066486	0.000715459	0.0061427	0.0071545
		Vehicle #12	2	0.0010134	0.000048230	0.000979308	0.0010475
		Vehicle #13	2	0.0037856	0.000071033	0.0037353	0.0038358
		Vehicle #14	2	0.0013862	0.000095272	0.0013189	0.0014536
		Vehicle #15	2	0.0090795	0.000339168	0.0088397	0.0093193
	3	Vehicle #1	2	0.0053160	0.000984774	0.0046196	0.0060123
		Vehicle #2	2	0.0125071	0.0019271	0.0111444	0.0138697
		Vehicle #3	2	0.0019607	0.000049138	0.0019259	0.0019954
		Vehicle #4	2	0.0014564	0.000017217	0.0014443	0.0014686
		Vehicle #5	2	0.0038586	0.000235339	0.0036922	0.0040250
		Vehicle #6	3	0.0010583	0.000267748	0.000763464	0.0012863
		Vehicle #7	3	0.0056480	0.000654998	0.0052014	0.0064000
		Vehicle #8	2	0.0316946	0.0039769	0.0288825	0.0345067
		Vehicle #9	2	0.0014433	0.000032463	0.0014203	0.0014662
		Vehicle #10	2	0.0110660	0.0013843	0.0100871	0.0120448
		Vehicle #11	2	0.0095407	0.0011168	0.0087510	0.0103304
		Vehicle #12	2	0.0010717	0.000096177	0.0010037	0.0011397
		Vehicle #13	2	0.0047354	0.000203500	0.0045915	0.0048793
		Vehicle #14	2	0.0017356	0.000117989	0.0016521	0.0018190
		Vehicle #15	3	0.0100971	0.000636623	0.0094929	0.0107618
Phase 3	1	Vehicle #1	2	0.0116758	0.000148786	0.0115706	0.0117810
		Vehicle #2	2	0.0236904	0.0016105	0.0225515	0.0248292
		Vehicle #3	2	0.0069959	0.000124251	0.0069080	0.0070838
		Vehicle #4	2	0.0062977	0.000101445	0.0062260	0.0063694
		Vehicle #5	2	0.0138355	0.0010269	0.0131094	0.0145617
		Vehicle #6	2	0.0023318	0.000031019	0.0023099	0.0023537
		Vehicle #7	2	0.0142137	0.0018442	0.0129097	0.0155177
		Vehicle #8	3	0.0438492	0.0017112	0.0425091	0.0457767
		Vehicle #9	2	0.0047771	0.000839236	0.0041836	0.0053705
		Vehicle #10	2	0.0260531	0.0032257	0.0237722	0.0283340
		Vehicle #11	2	0.0250484	0.0023877	0.0233601	0.0267368
		Vehicle #12	2	0.0056197	0.000132097	0.0055263	0.0057131
		Vehicle #13	3	0.0094907	0.0022778	0.0073513	0.0118854
		Vehicle #14	2	0.0055793	0.000448179	0.0052624	0.0058962
		Vehicle #15	2	0.0224380	0.0036909	0.0198281	0.0250479
	2	Vehicle #1	2	0.0119673	0.000331795	0.0117327	0.0122019
		Vehicle #2	2	0.0245065	0.0038969	0.0217510	0.0272620
		Vehicle #3	3	0.0064533	0.000784061	0.0055517	0.0069750
		Vehicle #4	2	0.0041256	0.000368608	0.0038649	0.0043862
		Vehicle #5	2	0.0138541	0.0017739	0.0125998	0.0151085
		Vehicle #6	3	0.0041494	0.0026681	0.0022305	0.0071962
		Vehicle #7	2	0.0138754	0.0013494	0.0129212	0.0148296
		Vehicle #8	2	0.0436934	0.0010567	0.0429462	0.0444406
		Vehicle #9	2	0.0036404	0.000015232	0.0036297	0.0036512
		Vehicle #10	2	0.0183152	0.0053145	0.0145573	0.0220732
		Vehicle #11	2	0.0227017	0.000873033	0.0220844	0.0233190
		Vehicle #12	2	0.0053882	0.000476272	0.0050514	0.0057249

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #13	2	0.0068429	0.000958834	0.0061649	0.0075209
		Vehicle #14	2	0.0046451	0.000771113	0.0040998	0.0051903
		Vehicle #15	2	0.0203325	0.000931760	0.0196737	0.0209914
	3	Vehicle #1	2	0.0139778	0.0016536	0.0128086	0.0151471
		Vehicle #2	2	0.0270497	0.000917634	0.0264009	0.0276986
		Vehicle #3	2	0.0064151	0.000332056	0.0061803	0.0066499
		Vehicle #4	2	0.0046340	0.000139517	0.0045354	0.0047327
		Vehicle #5	2	0.0144716	0.000640704	0.0140185	0.0149246
		Vehicle #6	3	0.0028667	0.0014427	0.0019020	0.0045252
		Vehicle #7	3	0.0166921	0.0018051	0.0156174	0.0187761
		Vehicle #8	2	0.0487555	0.0062531	0.0443339	0.0531771
		Vehicle #9	2	0.0051730	0.0015950	0.0040452	0.0063009
		Vehicle #10	2	0.0281298	0.0031726	0.0258864	0.0303732
		Vehicle #11	2	0.0261635	0.0019676	0.0247722	0.0275547
		Vehicle #12	2	0.0059207	0.000461751	0.0055942	0.0062472
		Vehicle #13	2	0.0098997	0.0013610	0.0089373	0.0108620
		Vehicle #14	2	0.0077370	0.0013762	0.0067639	0.0087101
		Vehicle #15	3	0.0246205	0.0022226	0.0230090	0.0271561

TABLE G-4. CO EMISSIONS DESCRIPTIVE STATISTICS BY PHASE, FUEL AND VEHICLE

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
Composite	1	Vehicle #1	2	2.6333411	0.5583771	2.2385089	3.0281733
		Vehicle #2	2	1.8324111	0.0278921	1.8126884	1.8521338
		Vehicle #3	2	0.3080980	0.0149190	0.2975487	0.3186473
		Vehicle #4	2	0.3326319	0.0103151	0.3253380	0.3399257
		Vehicle #5	2	0.6625924	0.0293414	0.6418450	0.6833399
		Vehicle #6	2	0.2055528	0.0280761	0.1857000	0.2254057
		Vehicle #7	2	1.1660332	0.1210222	1.0804576	1.2516088
		Vehicle #8	3	3.6889426	0.4076681	3.4425401	4.1595020
		Vehicle #9	2	0.3956426	0.0016796	0.3944550	0.3968303
		Vehicle #10	2	0.8352008	0.1728488	0.7129783	0.9574234
		Vehicle #11	2	0.7671074	0.0362159	0.7414988	0.7927159
		Vehicle #12	2	0.1974415	0.0124906	0.1886093	0.2062736
		Vehicle #13	3	0.8378237	0.0594344	0.7796521	0.8984451
		Vehicle #14	2	0.4408033	0.1541605	0.3317954	0.5498113
		Vehicle #15	2	2.0612879	0.1746684	1.9377788	2.1847971
	2	Vehicle #1	2	1.0952626	0.3691609	0.8342265	1.3562988
		Vehicle #2	2	1.5046729	0.0134661	1.4951510	1.5141948
		Vehicle #3	3	0.2001680	0.0156185	0.1823585	0.2115331
		Vehicle #4	2	0.3401749	0.0477716	0.3063953	0.3739546
		Vehicle #5	2	0.6697065	0.1890974	0.5359945	0.8034185
		Vehicle #6	3	0.0939971	0.0073363	0.0868364	0.1014972
		Vehicle #7	2	1.1520252	0.0081401	1.1462693	1.1577811
		Vehicle #8	2	2.9352386	0.3387781	2.6956864	3.1747909
		Vehicle #9	2	0.2625765	0.0044743	0.2594127	0.2657403
		Vehicle #10	2	0.5018463	0.0487540	0.4673721	0.5363206
		Vehicle #11	2	0.7481456	0.0217130	0.7327922	0.7634990
		Vehicle #12	2	0.2110402	0.0108461	0.2033708	0.2187095
		Vehicle #13	2	0.6695671	0.0181407	0.6567397	0.6823945
		Vehicle #14	2	0.1900823	0.0070177	0.1851200	0.1950446
		Vehicle #15	2	2.0948471	0.0323171	2.0719955	2.1176988
	3	Vehicle #1	2	1.0952269	0.5727360	0.6902414	1.5002124
		Vehicle #2	2	1.3632890	0.1155445	1.2815867	1.4449913
		Vehicle #3	2	0.2090250	0.0106348	0.2015051	0.2165449
		Vehicle #4	2	0.2503476	0.0140898	0.2403846	0.2603106
		Vehicle #5	2	0.5628683	0.0791705	0.5068863	0.6188503
		Vehicle #6	3	0.1707043	0.0023583	0.1681900	0.1728671
		Vehicle #7	3	0.9183042	0.0560705	0.8801715	0.9826842
		Vehicle #8	2	2.9469198	0.3762030	2.6809041	3.2129355
		Vehicle #9	2	0.5132670	0.0183695	0.5002778	0.5262562
		Vehicle #10	2	0.4664480	0.0941733	0.3998573	0.5330386
		Vehicle #11	2	0.7209171	0.0436567	0.6900471	0.7517870
		Vehicle #12	2	0.2044425	0.0063463	0.1999549	0.2089300
		Vehicle #13	2	0.7436675	0.0665999	0.6965742	0.7907608
		Vehicle #14	2	0.3713553	0.0242983	0.3541738	0.3885368
		Vehicle #15	3	1.8361063	0.1393791	1.6860503	1.9615220
Phase 1	1	Vehicle #1	2	9.0260126	1.8236585	7.7364913	10.3155339
		Vehicle #2	2	7.3406918	0.2380099	7.1723934	7.5089902
		Vehicle #3	2	5.1952912	0.4425092	4.8823899	5.5081924
		Vehicle #4	2	1.2576275	0.0015105	1.2565594	1.2586956
		Vehicle #5	2	5.0496518	1.1200037	4.2576895	5.8416140
		Vehicle #6	2	3.3180561	0.5872466	2.9028100	3.7333022
		Vehicle #7	2	8.1319498	0.6322336	7.6848931	8.5790064

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #8	3	24.8628544	4.8471372	19.6237119	29.1877932
		Vehicle #9	2	3.0044069	0.0571493	2.9639962	3.0448176
		Vehicle #10	2	6.3417196	2.1399744	4.8285292	7.8549101
		Vehicle #11	2	7.7308375	0.3452311	7.4867223	7.9749528
		Vehicle #12	2	0.9466073	0.0042149	0.9436269	0.9495877
		Vehicle #13	3	3.7300035	0.4345319	3.2415456	4.0736038
		Vehicle #14	2	6.2236774	0.6066314	5.7947242	6.6526306
		Vehicle #15	2	5.4557759	0.6244020	5.0142570	5.8972948
	2	Vehicle #1	2	5.8732774	0.5432668	5.4891298	6.2574251
		Vehicle #2	2	5.6336506	0.6319553	5.1867907	6.0805105
		Vehicle #3	3	3.3327432	0.2676876	3.0346196	3.5525042
		Vehicle #4	2	2.0782155	0.0028798	2.0761792	2.0802518
		Vehicle #5	2	7.4994963	1.0404713	6.7637720	8.2352205
		Vehicle #6	3	1.2443576	0.0404360	1.1980538	1.2727090
		Vehicle #7	2	12.4335898	0.0072583	12.4284574	12.4387222
		Vehicle #8	2	13.1094275	0.3199051	12.8832205	13.3356346
		Vehicle #9	2	2.6931565	0.1024566	2.6207087	2.7656042
		Vehicle #10	2	5.6815540	0.8398057	5.0877217	6.2753863
		Vehicle #11	2	9.0107337	0.4211036	8.7129684	9.3084989
		Vehicle #12	2	1.3512744	0.0855147	1.2908063	1.4117424
		Vehicle #13	2	3.8370128	0.9040274	3.1977689	4.4762567
		Vehicle #14	2	3.0754765	0.1232371	2.9883347	3.1626183
		Vehicle #15	2	7.5759602	0.4947415	7.2261252	7.9257953
	3	Vehicle #1	2	6.8828795	0.1506764	6.7763352	6.9894238
		Vehicle #2	2	7.0832421	0.1975199	6.9435745	7.2229098
		Vehicle #3	2	3.1428478	0.0352065	3.1179531	3.1677425
		Vehicle #4	2	1.0280927	0.0654161	0.9818365	1.0743489
		Vehicle #5	2	4.4410149	0.0840730	4.3815663	4.5004635
		Vehicle #6	3	2.6896270	0.0978999	2.5774846	2.7580453
		Vehicle #7	3	8.1513352	0.4877276	7.6212104	8.5810307
		Vehicle #8	2	13.1825223	3.8797249	10.4391426	15.9259021
		Vehicle #9	2	6.5352183	0.1218209	6.4490780	6.6213587
		Vehicle #10	2	4.4876351	1.5691081	3.3781081	5.5971621
		Vehicle #11	2	7.5645151	0.2635234	7.3781759	7.7508543
		Vehicle #12	2	1.0602402	0.0663541	1.0133207	1.1071596
		Vehicle #13	2	2.8263679	0.1579090	2.7147094	2.9380265
		Vehicle #14	2	6.4823919	0.5417430	6.0993218	6.8654620
		Vehicle #15	3	5.6743893	0.6238194	5.1749321	6.3736261
Phase 2	1	Vehicle #1	2	2.3422719	0.7021579	1.8457712	2.8387725
		Vehicle #2	2	1.4396593	0.0433190	1.4090281	1.4702905
		Vehicle #3	2	0.0396013	0.0107163	0.0320237	0.0471789
		Vehicle #4	2	0.2675597	0.0119328	0.2591219	0.2759975
		Vehicle #5	2	0.3727914	0.1125928	0.2931763	0.4524065
		Vehicle #6	2	0.0348344	0.0025610	0.0330235	0.0366453
		Vehicle #7	2	0.7967844	0.1645901	0.6804016	0.9131672
		Vehicle #8	3	2.5070214	0.4603015	2.0353102	2.9549945
		Vehicle #9	2	0.2207626	0.0016895	0.2195679	0.2219573
		Vehicle #10	2	0.5137905	0.0668282	0.4665358	0.5610451
		Vehicle #11	2	0.3120687	0.0205983	0.2975035	0.3266339
		Vehicle #12	2	0.1585059	0.0138238	0.1487310	0.1682808
		Vehicle #13	3	0.6586160	0.0477566	0.6038559	0.6916258
		Vehicle #14	2	0.1288588	0.1400893	0.0298008	0.2279169
		Vehicle #15	2	1.8422810	0.2688781	1.6521555	2.0324065
	2	Vehicle #1	2	0.7979552	0.4534364	0.4773272	1.1185831
		Vehicle #2	2	1.1724804	0.0101038	1.1653359	1.1796248
		Vehicle #3	3	0.0275182	0.0019394	0.0253596	0.0291139

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #4	2	0.2496584	0.0522065	0.2127429	0.2865740
		Vehicle #5	2	0.2640450	0.1430241	0.1629116	0.3651783
		Vehicle #6	3	0.0296432	0.0063868	0.0240183	0.0365862
		Vehicle #7	2	0.5417548	0.0144395	0.5315446	0.5519651
		Vehicle #8	2	2.3260493	0.3570753	2.0735589	2.5785396
		Vehicle #9	2	0.1122479	0.0128021	0.1031954	0.1213003
		Vehicle #10	2	0.2155564	0.0028496	0.2135415	0.2175714
		Vehicle #11	2	0.2335116	0.0108817	0.2258171	0.2412061
		Vehicle #12	2	0.1539484	0.0057682	0.1498696	0.1580271
		Vehicle #13	2	0.4970857	0.0664300	0.4501126	0.5440588
		Vehicle #14	2	0.0302808	0.0018546	0.0289695	0.0315922
		Vehicle #15	2	1.8001627	0.0092515	1.7936209	1.8067045
	3	Vehicle #1	2	0.7745578	0.6553889	0.3111278	1.2379877
		Vehicle #2	2	0.9644582	0.1118705	0.8853538	1.0435626
		Vehicle #3	2	0.0488193	0.0086866	0.0426770	0.0549617
		Vehicle #4	2	0.2135118	0.0139633	0.2036383	0.2233854
		Vehicle #5	2	0.3187845	0.0915201	0.2540700	0.3834990
		Vehicle #6	3	0.0304015	0.0054230	0.0254463	0.0361948
		Vehicle #7	3	0.5205748	0.0355247	0.4834967	0.5543097
		Vehicle #8	2	2.3718957	0.2489550	2.1958580	2.5479335
		Vehicle #9	2	0.1677047	0.0194990	0.1539168	0.1814926
		Vehicle #10	2	0.2270566	0.0047021	0.2237317	0.2303815
		Vehicle #11	2	0.2810089	0.0176763	0.2685099	0.2935079
		Vehicle #12	2	0.1632557	0.0038753	0.1605155	0.1659960
		Vehicle #13	2	0.6211664	0.0470878	0.5878703	0.6544625
		Vehicle #14	2	0.0345931	0.0041589	0.0316523	0.0375338
		Vehicle #15	3	1.6126633	0.1677009	1.4242792	1.7456778
Phase 3	1	Vehicle #1	2	1.6038816	0.4647786	1.2752335	1.9325297
		Vehicle #2	2	2.6965531	0.0585713	2.6551369	2.7379693
		Vehicle #3	2	0.0670102	0.0284828	0.0468698	0.0871506
		Vehicle #4	2	0.4594782	0.0040709	0.4565997	0.4623568
		Vehicle #5	2	1.0949844	0.2022306	0.9519858	1.2379830
		Vehicle #6	2	0.0365077	0.000650402	0.0360478	0.0369676
		Vehicle #7	2	0.6101058	0.1282332	0.5194313	0.7007804
		Vehicle #8	3	2.8070665	0.5120097	2.3046453	3.3281542
		Vehicle #9	2	0.7029894	0.0256794	0.6848314	0.7211475
		Vehicle #10	2	0.7819286	0.0153823	0.7710516	0.7928056
		Vehicle #11	2	1.3295163	0.0576985	1.2887173	1.3703153
		Vehicle #12	2	0.1281793	0.000319863	0.1279531	0.1284055
		Vehicle #13	3	0.9448225	0.3092278	0.6743262	1.2819261
		Vehicle #14	2	0.0536488	0.0024071	0.0519467	0.0553508
		Vehicle #15	2	2.2731426	0.3996861	1.9905219	2.5557634
	2	Vehicle #1	2	1.3127325	0.0540678	1.2745008	1.3509642
		Vehicle #2	2	2.6570897	0.3607419	2.4020066	2.9121727
		Vehicle #3	3	0.0383558	0.0027209	0.0361727	0.0414041
		Vehicle #4	2	0.1748699	0.0077295	0.1694044	0.1803355
		Vehicle #5	2	0.7553803	0.1673008	0.6370808	0.8736798
		Vehicle #6	3	0.0376246	0.0028929	0.0353808	0.0408896
		Vehicle #7	2	0.4295515	0.0311813	0.4075030	0.4516001
		Vehicle #8	2	2.9928628	0.5636511	2.5943013	3.3914243
		Vehicle #9	2	0.3756593	0.0225239	0.3597325	0.3915862
		Vehicle #10	2	0.2627773	0.0641651	0.2174058	0.3081489
		Vehicle #11	2	1.1477414	0.1608611	1.0339954	1.2614874
		Vehicle #12	2	0.0727351	0.0218123	0.0573115	0.0881587

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #13	2	0.4658882	0.1126689	0.3862192	0.5455571
		Vehicle #14	2	0.0437802	0.000062866	0.0437357	0.0438247
		Vehicle #15	2	1.7668968	0.0520809	1.7300700	1.8037236
	3	Vehicle #1	2	0.8478510	0.0593674	0.8058719	0.8898301
		Vehicle #2	2	2.1349465	0.1112420	2.0562865	2.2136064
		Vehicle #3	2	0.0415546	0.0040483	0.0386921	0.0444172
		Vehicle #4	2	0.1359844	0.0110458	0.1281739	0.1437950
		Vehicle #5	2	0.8255044	0.0999707	0.7548144	0.8961943
		Vehicle #6	3	0.0354774	0.0012599	0.0346173	0.0369236
		Vehicle #7	3	0.4939298	0.1814607	0.3267735	0.6869248
		Vehicle #8	2	2.5918422	0.6292622	2.1468866	3.0367977
		Vehicle #9	2	0.4268771	0.1230531	0.3398654	0.5138888
		Vehicle #10	2	0.5141872	0.2698758	0.3233562	0.7050182
		Vehicle #11	2	1.1984940	0.2283124	1.0370528	1.3599353
		Vehicle #12	2	0.0790038	0.0085130	0.0729843	0.0850234
		Vehicle #13	2	0.7343111	0.2508340	0.5569447	0.9116775
		Vehicle #14	2	0.0472501	0.0082690	0.0414030	0.0530972
		Vehicle #15	3	1.7930346	0.2915753	1.4758961	2.0494993

TABLE G-5. NO_X EMISSIONS DESCRIPTIVE STATISTICS BY PHASE, FUEL AND VEHICLE

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
Composite	1	Vehicle #1	2	0.0548207	0.0012090	0.0539659	0.0556756
		Vehicle #2	2	0.0108048	0.0015672	0.0096967	0.0119130
		Vehicle #3	2	0.0170347	0.0017796	0.0157764	0.0182931
		Vehicle #4	2	0.0065239	0.000723774	0.0060121	0.0070357
		Vehicle #5	2	0.0095809	0.0011269	0.0087841	0.0103777
		Vehicle #6	2	0.0079102	0.0018272	0.0066182	0.0092023
		Vehicle #7	2	0.0141974	0.000647204	0.0137398	0.0146551
		Vehicle #8	3	0.0546073	0.0130384	0.0397328	0.0640599
		Vehicle #9	2	0.0036237	0.000175007	0.0035000	0.0037475
		Vehicle #10	2	0.0231146	0.000290214	0.0229094	0.0233198
		Vehicle #11	2	0.0217753	0.0020489	0.0203265	0.0232241
		Vehicle #12	2	0.0147803	0.0030055	0.0126551	0.0169055
		Vehicle #13	3	0.0216770	0.0068280	0.0142422	0.0276670
		Vehicle #14	2	0.0245421	0.0037291	0.0219052	0.0271790
		Vehicle #15	2	0.0210614	0.0018576	0.0197479	0.0223749
	2	Vehicle #1	2	0.0286300	0.0043466	0.0255565	0.0317035
		Vehicle #2	2	0.0156408	0.0027069	0.0137267	0.0175548
		Vehicle #3	3	0.0198341	0.0029019	0.0175728	0.0231062
		Vehicle #4	2	0.0079106	0.000894804	0.0072779	0.0085433
		Vehicle #5	2	0.0073950	0.000704981	0.0068965	0.0078935
		Vehicle #6	3	0.0106031	0.0033057	0.0078832	0.0142824
		Vehicle #7	2	0.0175849	0.0018387	0.0162847	0.0188851
		Vehicle #8	2	0.0582423	0.0126039	0.0493300	0.0671546
		Vehicle #9	2	0.0033724	0.000998310	0.0026665	0.0040784
		Vehicle #10	2	0.0216329	0.000440408	0.0213215	0.0219443
		Vehicle #11	2	0.0192623	0.0036822	0.0166586	0.0218660
		Vehicle #12	2	0.0144711	0.000380561	0.0142020	0.0147402
		Vehicle #13	2	0.0127575	0.0014002	0.0117674	0.0137476
		Vehicle #14	2	0.0138124	0.000627414	0.0133687	0.0142560
		Vehicle #15	2	0.0247756	0.0018876	0.0234408	0.0261104
	3	Vehicle #1	2	0.0407610	0.0049747	0.0372433	0.0442787
		Vehicle #2	2	0.0174219	0.0026534	0.0155457	0.0192982
		Vehicle #3	2	0.0196253	0.0034597	0.0171789	0.0220717
		Vehicle #4	2	0.0080917	0.000808818	0.0075198	0.0086636
		Vehicle #5	2	0.0055865	0.0013293	0.0046465	0.0065264
		Vehicle #6	3	0.0117347	0.0042448	0.0089029	0.0166152
		Vehicle #7	3	0.0132005	0.0062169	0.0069986	0.0194324
		Vehicle #8	2	0.0597150	0.0098474	0.0527518	0.0666781
		Vehicle #9	2	0.0027179	0.000066790	0.0026707	0.0027652
		Vehicle #10	2	0.0203581	0.000955203	0.0196827	0.0210336
		Vehicle #11	2	0.0194141	0.000423799	0.0191144	0.0197138
		Vehicle #12	2	0.0128433	0.000259280	0.0126600	0.0130267
		Vehicle #13	2	0.0182873	0.0014826	0.0172389	0.0193357
		Vehicle #14	2	0.0187499	0.000425169	0.0184493	0.0190506
		Vehicle #15	3	0.0203641	0.0045119	0.0152342	0.0237166
Phase 1	1	Vehicle #1	2	0.3244831	0.0036725	0.3218863	0.3270799
		Vehicle #2	2	0.0429937	0.0067224	0.0382403	0.0477471
		Vehicle #3	2	0.0930954	0.0340685	0.0690054	0.1171855
		Vehicle #4	2	0.0650521	0.0129473	0.0558970	0.0742072
		Vehicle #5	2	0.1647543	0.0137068	0.1550621	0.1744465
		Vehicle #6	2	0.0439916	0.0135857	0.0343850	0.0535981
		Vehicle #7	2	0.0608531	0.0105646	0.0533828	0.0683235

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #8	3	0.1595713	0.0244013	0.1314574	0.1752506
		Vehicle #9	2	0.0442412	0.0036765	0.0416415	0.0468409
		Vehicle #10	2	0.1102953	0.0058118	0.1061857	0.1144049
		Vehicle #11	2	0.1775414	0.0257793	0.1593127	0.1957701
		Vehicle #12	2	0.1448685	0.0145880	0.1345532	0.1551838
		Vehicle #13	3	0.0914028	0.0204064	0.0782576	0.1149113
		Vehicle #14	2	0.0257501	0.000564252	0.0253511	0.0261491
		Vehicle #15	2	0.0791796	0.0015605	0.0780762	0.0802830
	2	Vehicle #1	2	0.1911523	0.0206484	0.1765517	0.2057529
		Vehicle #2	2	0.0641636	0.0189689	0.0507505	0.0775767
		Vehicle #3	3	0.1267116	0.0300602	0.0924803	0.1488052
		Vehicle #4	2	0.0731385	0.0046255	0.0698677	0.0764092
		Vehicle #5	2	0.1173835	0.0249185	0.0997634	0.1350035
		Vehicle #6	3	0.0498539	0.0076992	0.0413700	0.0563969
		Vehicle #7	2	0.0441210	0.0157843	0.0329598	0.0552821
		Vehicle #8	2	0.1600193	0.0169461	0.1480366	0.1720020
		Vehicle #9	2	0.0399040	0.000493065	0.0395554	0.0402527
		Vehicle #10	2	0.1232388	0.0540241	0.0850380	0.1614395
		Vehicle #11	2	0.1970271	0.0221174	0.1813877	0.2126664
		Vehicle #12	2	0.1348465	0.0014077	0.1338511	0.1358419
		Vehicle #13	2	0.0953380	0.0255294	0.0772860	0.1133900
		Vehicle #14	2	0.0193141	0.0059947	0.0150752	0.0235529
		Vehicle #15	2	0.0819326	0.0086187	0.0758383	0.0880269
	3	Vehicle #1	2	0.1930924	0.0151673	0.1823674	0.2038173
		Vehicle #2	2	0.0562246	0.0020786	0.0547549	0.0576944
		Vehicle #3	2	0.1424763	0.0124793	0.1336521	0.1513005
		Vehicle #4	2	0.0718169	0.0197321	0.0578641	0.0857696
		Vehicle #5	2	0.0910169	0.0082078	0.0852131	0.0968207
		Vehicle #6	3	0.0490099	0.0032548	0.0454021	0.0517258
		Vehicle #7	3	0.0517641	0.0080262	0.0465878	0.0610099
		Vehicle #8	2	0.1961063	0.0667960	0.1488744	0.2433382
		Vehicle #9	2	0.0082935	0.0052930	0.0045508	0.0120362
		Vehicle #10	2	0.0932158	0.0152333	0.0824443	0.1039873
		Vehicle #11	2	0.1263840	0.0142902	0.1162793	0.1364887
		Vehicle #12	2	0.1157731	0.0019457	0.1143973	0.1171489
		Vehicle #13	2	0.0780942	0.0108929	0.0703918	0.0857967
		Vehicle #14	2	0.0188883	0.0025961	0.0170526	0.0207240
		Vehicle #15	3	0.0917345	0.0495072	0.0569468	0.1484135
Phase 2	1	Vehicle #1	2	0.0427630	0.0024323	0.0410431	0.0444829
		Vehicle #2	2	0.0091809	0.0025579	0.0073722	0.0109896
		Vehicle #3	2	0.0124160	0.0039954	0.0095909	0.0152412
		Vehicle #4	2	0.0027363	0.000744984	0.0022095	0.0032631
		Vehicle #5	2	0.0010318	0.000506427	0.000673714	0.0013899
		Vehicle #6	2	0.0060897	0.0013739	0.0051183	0.0070612
		Vehicle #7	2	0.0125473	0.0013642	0.0115827	0.0135119
		Vehicle #8	3	0.0510347	0.0139191	0.0351432	0.0610631
		Vehicle #9	2	0.0015418	0.000019383	0.0015281	0.0015555
		Vehicle #10	2	0.0194761	0.000949471	0.0188048	0.0201475
		Vehicle #11	2	0.0135592	0.0032159	0.0112853	0.0158332
		Vehicle #12	2	0.0054051	0.0047048	0.0020783	0.0087319
		Vehicle #13	3	0.0192440	0.0069988	0.0113626	0.0247323
		Vehicle #14	2	0.0230714	0.0047451	0.0197161	0.0264266
		Vehicle #15	2	0.0190406	0.0022267	0.0174661	0.0206151
	2	Vehicle #1	2	0.0210170	0.0062295	0.0166121	0.0254219
		Vehicle #2	2	0.0129836	0.0045315	0.0097794	0.0161879
		Vehicle #3	3	0.0110463	0.0014107	0.0096519	0.0124728

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #4	2	0.0040093	0.0021088	0.0025181	0.0055004
		Vehicle #5	2	0.0012746	0.000903523	0.000635734	0.0019135
		Vehicle #6	3	0.0060644	0.0013421	0.0049715	0.0075624
		Vehicle #7	2	0.0173790	0.0011938	0.0165349	0.0182232
		Vehicle #8	2	0.0556609	0.0139848	0.0457722	0.0655496
		Vehicle #9	2	0.0015034	0.0011567	0.000685504	0.0023213
		Vehicle #10	2	0.0163459	0.0014831	0.0152971	0.0173946
		Vehicle #11	2	0.0102883	0.0028851	0.0082482	0.0123284
		Vehicle #12	2	0.0057590	0.000112626	0.0056794	0.0058386
		Vehicle #13	2	0.0086354	0.000344954	0.0083915	0.0088793
		Vehicle #14	2	0.0124601	0.000741544	0.0119358	0.0129845
		Vehicle #15	2	0.0231814	0.0026260	0.0213245	0.0250382
	3	Vehicle #1	2	0.0347647	0.0065682	0.0301203	0.0394091
		Vehicle #2	2	0.0157687	0.0025601	0.0139584	0.0175790
		Vehicle #3	2	0.0126978	0.0028588	0.0106764	0.0147193
		Vehicle #4	2	0.0030272	0.000041733	0.0029977	0.0030567
		Vehicle #5	2	0.000945937	0.000850704	0.000344398	0.0015475
		Vehicle #6	3	0.0060194	0.0022760	0.0034328	0.0077158
		Vehicle #7	3	0.0119107	0.0066267	0.0051789	0.0184271
		Vehicle #8	2	0.0558638	0.0153340	0.0450211	0.0667066
		Vehicle #9	2	0.0025785	0.000200161	0.0024370	0.0027201
		Vehicle #10	2	0.0175844	0.0020313	0.0161481	0.0190207
		Vehicle #11	2	0.0143999	0.000334849	0.0141632	0.0146367
		Vehicle #12	2	0.0047837	0.000624541	0.0043421	0.0052253
		Vehicle #13	2	0.0161278	0.0022612	0.0145289	0.0177267
		Vehicle #14	2	0.0176930	0.0014388	0.0166757	0.0187104
		Vehicle #15	3	0.0175949	0.0052994	0.0131544	0.0234614
Phase 3	1	Vehicle #1	2	0.0083715	0.0101505	0.0011940	0.0155489
		Vehicle #2	2	0.0072137	0.0047722	0.0038392	0.0105881
		Vehicle #3	2	0.0189102	0.000289747	0.0187053	0.0191151
		Vehicle #4	2	0.0103988	0.0104899	0.0029813	0.0178162
		Vehicle #5	2	0.0029877	0.000528326	0.0026141	0.0033613
		Vehicle #6	2	0.0039103	0.0012477	0.0030281	0.0047925
		Vehicle #7	2	0	0	0	0
		Vehicle #8	3	0.0203859	0.0078695	0.0137739	0.0290901
		Vehicle #9	2	0.000117063	0.000165551	0	0.000234125
		Vehicle #10	2	0.0038180	0.0041733	0.000867067	0.0067689
		Vehicle #11	2	0.0092762	0.0069911	0.0043327	0.0142197
		Vehicle #12	2	0.0362486	0.0057248	0.0322006	0.0402966
		Vehicle #13	3	0.000178298	0.000178227	0	0.000356454
		Vehicle #14	2	0.0424309	0.0068256	0.0376044	0.0472573
		Vehicle #15	2	0.0023948	0.000159953	0.0022817	0.0025079
	2	Vehicle #1	2	0.0036143	0.000034324	0.0035900	0.0036386
		Vehicle #2	2	0.0133276	0.0047514	0.0099678	0.0166873
		Vehicle #3	3	0.0514022	0.0474244	0.0205465	0.1060093
		Vehicle #4	2	0.0082251	0.0113102	0.000227589	0.0162226
		Vehicle #5	2	0.0035047	0.0035902	0.000966074	0.0060434
		Vehicle #6	3	0.0384576	0.0572534	0.000546576	0.1043174
		Vehicle #7	2	0.000178157	0.000251951	0	0.000356313
		Vehicle #8	2	0.0137040	0.0088096	0.0074746	0.0199333
		Vehicle #9	2	0.000038430	0.000054349	0	0.000076861
		Vehicle #10	2	0.0127677	0.0149534	0.0021940	0.0233413
		Vehicle #11	2	0.000595160	0.000326843	0.000364047	0.000826273
		Vehicle #12	2	0.0340446	0.0049682	0.0305316	0.0375576

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #13	2	0.0026430	0.0037377	0	0.0052859
		Vehicle #14	2	0.0268826	0.0049858	0.0233572	0.0304081
		Vehicle #15	2	0.0022880	0.000735704	0.0017678	0.0028083
	3	Vehicle #1	2	0.0029005	0.000291689	0.0026942	0.0031067
		Vehicle #2	2	0.0092202	0.0075741	0.0038646	0.0145759
		Vehicle #3	2	0.0153837	0.0038080	0.0126910	0.0180763
		Vehicle #4	2	0.0251421	0.0017164	0.0239284	0.0263558
		Vehicle #5	2	0.0017904	0.0020950	0.000308995	0.0032717
		Vehicle #6	3	0.0561965	0.0921934	0.0020100	0.1626465
		Vehicle #7	3	0.000320900	0.000349780	0	0.000693750
		Vehicle #8	2	0.0060889	0.0023904	0.0043986	0.0077792
		Vehicle #9	2	0.000306358	0.000433255	0	0.000612715
		Vehicle #10	2	0.000967926	0.000306689	0.000751064	0.0011848
		Vehicle #11	2	0.0029530	0.000624054	0.0025117	0.0033943
		Vehicle #12	2	0.0373463	0.0026608	0.0354648	0.0392278
		Vehicle #13	2	0.000649379	0.000918360	0	0.0012988
		Vehicle #14	2	0.0322224	0.0142423	0.0221516	0.0422933
		Vehicle #15	3	0.0012643	0.000978516	0.000136227	0.0018840

TABLE G-6. PM EMISSIONS DESCRIPTIVE STATISTICS BY PHASE, FUEL AND VEHICLE

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
Composite	1	Vehicle #1	2	1.0118091	0.1759226	0.8874130	1.1362052
		Vehicle #2	2	0.9321272	0.2645174	0.7450851	1.1191692
		Vehicle #3	2	0.8002623	0.1292375	0.7088776	0.8916471
		Vehicle #4	2	0.3984808	0.5635370	0	0.7969617
		Vehicle #5	2	0.4635292	0.000252234	0.4633508	0.4637075
		Vehicle #6	2	0.4579302	0.0123549	0.4491939	0.4666664
		Vehicle #7	2	0.4796955	0.2321763	0.3155221	0.6438690
		Vehicle #8	3	0.8560756	0.1675905	0.7117523	1.0398824
		Vehicle #9	2	0.7774369	0.5502930	0.3883210	1.1665528
		Vehicle #10	2	2.9864612	0.1489452	2.8811411	3.0917814
		Vehicle #11	2	2.0894244	0.4647473	1.7607984	2.4180504
		Vehicle #12	2	0.7014716	0.1471789	0.5974004	0.8055428
		Vehicle #13	3	0.7639259	0.1690527	0.6074937	0.9432635
		Vehicle #14	2	0.4757220	0.0500181	0.4403539	0.5110902
		Vehicle #15	2	1.6834763	0.2245309	1.5247090	1.8422436
	2	Vehicle #1	2	0.6517178	0.0804135	0.5948568	0.7085788
		Vehicle #2	2	0.4114736	0.1164161	0.3291549	0.4937922
		Vehicle #3	3	1.0257685	0.2296108	0.8680941	1.2892004
		Vehicle #4	2	0.3590634	0.0495074	0.3240564	0.3940705
		Vehicle #5	2	0.1951774	0.2760225	0	0.3903548
		Vehicle #6	3	0.5025228	0.2202283	0.2675528	0.7042239
		Vehicle #7	2	0.3534013	0.0222054	0.3376997	0.3691028
		Vehicle #8	2	0.8583031	0.2029625	0.7147870	1.0018193
		Vehicle #9	2	0.2766016	0.3911738	0	0.5532033
		Vehicle #10	2	2.0820789	0.0028072	2.0800939	2.0840639
		Vehicle #11	2	1.5804894	0.2529838	1.4016028	1.7593760
		Vehicle #12	2	0.3517963	0.0643109	0.3063216	0.3972710
		Vehicle #13	2	0.6991772	0.0241561	0.6820963	0.7162581
		Vehicle #14	2	0.4958810	0.2993471	0.2842106	0.7075513
		Vehicle #15	2	1.2848869	0.1763910	1.1601596	1.4096142
	3	Vehicle #1	2	0.7038232	0.0230439	0.6875287	0.7201177
		Vehicle #2	2	0.5779403	0.0967238	0.5095462	0.6463343
		Vehicle #3	2	0.6762192	0.1399249	0.5772773	0.7751610
		Vehicle #4	2	0.7585253	0.0666128	0.7114229	0.8056277
		Vehicle #5	2	0.4321510	0.1777214	0.3064829	0.5578190
		Vehicle #6	3	0.4798967	0.1515377	0.3397644	0.6407146
		Vehicle #7	3	0.3673989	0.0125095	0.3531680	0.3766589
		Vehicle #8	2	1.0189774	0.1152685	0.9374703	1.1004846
		Vehicle #9	2	0.6432892	0.2214540	0.4866975	0.7998808
		Vehicle #10	2	2.5242954	0.3451181	2.2802601	2.7683307
		Vehicle #11	2	3.3769562	0.4089722	3.0877692	3.6661432
		Vehicle #12	2	0.4337961	0.0681658	0.3855956	0.4819967
		Vehicle #13	2	0.7191135	0.0438167	0.6881304	0.7500966
		Vehicle #14	2	0.4875903	0.1544196	0.3783991	0.5967814
		Vehicle #15	3	2.0055232	0.2675345	1.7512440	2.2845880
Phase 1	1	Vehicle #1	2	10.0933628	0.1783054	9.9672819	10.2194438
		Vehicle #2	2	4.7231403	1.1859429	3.8845520	5.5617285
		Vehicle #3	2	3.1223493	1.3884029	2.1406002	4.1040984
		Vehicle #4	2	3.6835245	5.2092904	0	7.3670491
		Vehicle #5	2	4.5179949	0.3247803	4.2883405	4.7476493
		Vehicle #6	2	2.7078780	0.8195264	2.1283854	3.2873707
		Vehicle #7	2	2.7504678	0.1442644	2.6484574	2.8524781

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #8	3	6.0421364	0.4456810	5.5281949	6.3221214
		Vehicle #9	2	1.8529601	0.3137122	1.6311321	2.0747881
		Vehicle #10	2	4.8968307	0.6555880	4.4332600	5.3604014
		Vehicle #11	2	12.2648434	1.4441549	11.2436717	13.2860151
		Vehicle #12	2	3.2756678	1.0134226	2.5590698	3.9922658
		Vehicle #13	3	7.2889712	0.6316613	6.7438686	7.9812168
		Vehicle #14	2	2.4500540	0.6601757	1.9832393	2.9168688
		Vehicle #15	2	6.8665573	2.2568885	5.2706961	8.4624184
	2	Vehicle #1	2	2.1767234	0.0059321	2.1725288	2.1809180
		Vehicle #2	2	0.8331292	0.2838760	0.6323986	1.0338599
		Vehicle #3	3	2.2860830	0.6578490	1.9039560	3.0456969
		Vehicle #4	2	1.9685204	0.2662863	1.7802275	2.1568132
		Vehicle #5	2	0.8937763	1.2639905	0	1.7875525
		Vehicle #6	3	1.3019637	0.5190328	0.7085340	1.6713139
		Vehicle #7	2	1.5141453	0.3643861	1.2564854	1.7718052
		Vehicle #8	2	4.1846496	0.3850056	3.9124096	4.4568897
		Vehicle #9	2	0.6963552	0.9847949	0	1.3927104
		Vehicle #10	2	3.0523193	0.8680288	2.4385303	3.6661084
		Vehicle #11	2	8.2552088	0.9038807	7.6160686	8.8943489
		Vehicle #12	2	0.8488832	0.2003025	0.7072479	0.9905184
		Vehicle #13	2	2.0876965	0.4350647	1.7800593	2.3953337
		Vehicle #14	2	1.6142863	0.9699467	0.9284304	2.3001422
		Vehicle #15	2	5.8913737	3.9230292	3.1173732	8.6653742
	3	Vehicle #1	2	4.2677406	0.3013696	4.0546402	4.4808411
		Vehicle #2	2	3.3136565	1.8690784	1.9920185	4.6352945
		Vehicle #3	2	3.2699672	0.6680972	2.7975511	3.7423832
		Vehicle #4	2	4.7667259	1.7900527	3.5009675	6.0324844
		Vehicle #5	2	1.8007717	0.1211225	1.7151252	1.8864182
		Vehicle #6	3	2.0910761	0.1461386	2.0042949	2.2597993
		Vehicle #7	3	1.5916969	0.6827355	0.8370107	2.1664340
		Vehicle #8	2	5.4154960	0.6497289	4.9560683	5.8749237
		Vehicle #9	2	2.5286111	0.8869688	1.9014294	3.1557927
		Vehicle #10	2	6.3514109	1.8260162	5.0602225	7.6425993
		Vehicle #11	2	15.6646265	1.8713824	14.3413593	16.9878937
		Vehicle #12	2	1.2592176	0.1806608	1.1314712	1.3869641
		Vehicle #13	2	3.7049749	0.5774669	3.2966441	4.1133056
		Vehicle #14	2	1.4738517	1.4007774	0.4833525	2.4643509
		Vehicle #15	3	6.9543222	0.8589076	6.1188310	7.8348723
Phase 2	1	Vehicle #1	2	0.4859850	0.0908002	0.4217795	0.5501905
		Vehicle #2	2	0.4942314	0.4765486	0.1572606	0.8312021
		Vehicle #3	2	0.6459255	0.0709052	0.5957879	0.6960631
		Vehicle #4	2	0.2115600	0.2991911	0	0.4231201
		Vehicle #5	2	0.2281371	0.0284973	0.2079865	0.2482878
		Vehicle #6	2	0.3197217	0.0371337	0.2934642	0.3459792
		Vehicle #7	2	0.2966261	0.1679410	0.1778739	0.4153783
		Vehicle #8	3	0.4509636	0.0898601	0.3645486	0.5439122
		Vehicle #9	2	0.3785500	0.1004467	0.3075234	0.4495765
		Vehicle #10	2	2.8909055	0.3119911	2.6702945	3.1115166
		Vehicle #11	2	1.2461246	0.0058454	1.2419913	1.2502579
		Vehicle #12	2	0.4610211	0.0737432	0.4088768	0.5131654
		Vehicle #13	3	0.3957593	0.1659628	0.2460498	0.5742188
		Vehicle #14	2	0.2221624	0.0032272	0.2198804	0.2244443
		Vehicle #15	2	1.3369494	0.0337526	1.3130828	1.3608161
	2	Vehicle #1	2	0.4546253	0.1314347	0.3616869	0.5475637
		Vehicle #2	2	0.3332263	0.0516980	0.2966702	0.3697823
		Vehicle #3	3	0.6873530	0.1177293	0.5591506	0.7906114

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #4	2	0.2362085	0.0811411	0.1788331	0.2935840
		Vehicle #5	2	0.1399025	0.1978521	0	0.2798051
		Vehicle #6	3	0.3232077	0.0692023	0.2574441	0.3954000
		Vehicle #7	2	0.2094242	0.0230955	0.1930932	0.2257552
		Vehicle #8	2	0.5273351	0.1005125	0.4562621	0.5984082
		Vehicle #9	2	0.1561205	0.2207877	0	0.3122410
		Vehicle #10	2	1.9721969	0.0315153	1.9499122	1.9944816
		Vehicle #11	2	1.2306474	0.3626574	0.9742099	1.4870849
		Vehicle #12	2	0.2978360	0.1551159	0.1881525	0.4075196
		Vehicle #13	2	0.5264024	0.0128991	0.5172813	0.5355234
		Vehicle #14	2	0.3743444	0.1567720	0.2634898	0.4851989
		Vehicle #15	2	0.9388325	0.0546275	0.9002050	0.9774600
	3	Vehicle #1	2	0.4859926	0.0755307	0.4325844	0.5394009
		Vehicle #2	2	0.4134132	0.0341686	0.3892523	0.4375741
		Vehicle #3	2	0.4658858	0.1038130	0.3924789	0.5392927
		Vehicle #4	2	0.5075360	0.0321751	0.4847848	0.5302872
		Vehicle #5	2	0.2245131	0.1988822	0.0838822	0.3651441
		Vehicle #6	3	0.2884334	0.1657120	0.1424378	0.4685499
		Vehicle #7	3	0.2521406	0.0756894	0.1668763	0.3113975
		Vehicle #8	2	0.5492890	0.2247976	0.3903331	0.7082448
		Vehicle #9	2	0.4116056	0.1519255	0.3041780	0.5190331
		Vehicle #10	2	2.2585484	0.2839332	2.0577773	2.4593195
		Vehicle #11	2	2.7619086	0.2306675	2.5988020	2.9250152
		Vehicle #12	2	0.3598615	0.0060213	0.3556038	0.3641192
		Vehicle #13	2	0.4227075	0.0735393	0.3707073	0.4747076
		Vehicle #14	2	0.3630609	0.0282691	0.3430717	0.3830502
		Vehicle #15	3	1.5864710	0.1906266	1.3851939	1.7642727
Phase 3	1	Vehicle #1	2	1.0020886	1.3072959	0.0776909	1.9264864
		Vehicle #2	2	3.6609716	3.1116914	1.4606736	5.8612697
		Vehicle #3	2	1.0255527	0.0751220	0.9724334	1.0786720
		Vehicle #4	2	0.3001417	0.4244644	0	0.6002834
		Vehicle #5	2	0.4437616	0.6275737	0	0.8875232
		Vehicle #6	2	0.5258669	0.0396371	0.4978393	0.5538946
		Vehicle #7	2	1.0998932	1.3414244	0.1513629	2.0484235
		Vehicle #8	3	2.1312154	2.3641891	0.1369815	4.7428488
		Vehicle #9	2	5.1539693	6.5717894	0.5070124	9.8009262
		Vehicle #10	2	2.7834721	1.3563749	1.8243701	3.7425740
		Vehicle #11	2	5.2258755	5.8684182	1.0762772	9.3754738
		Vehicle #12	2	1.8285581	0.4259150	1.5273907	2.1297255
		Vehicle #13	3	0.5440231	0.6312612	0.0305598	1.2488142
		Vehicle #14	2	2.2246026	0.2622811	2.0391419	2.4100634
		Vehicle #15	2	2.1610599	1.0805129	1.3970219	2.9250979
	2	Vehicle #1	2	2.0397328	0.5059938	1.6819411	2.3975244
		Vehicle #2	2	1.1027527	1.2594831	0.2121636	1.9933417
		Vehicle #3	3	4.4139372	1.8090234	2.8211479	6.3807301
		Vehicle #4	2	0.7033729	0.0918998	0.6383899	0.7683558
		Vehicle #5	2	0.3785731	0.5353833	0	0.7571463
		Vehicle #6	3	2.1667019	1.9758069	0.0598346	3.9781895
		Vehicle #7	2	1.3186307	0.3461044	1.0738979	1.5633635
		Vehicle #8	2	2.5693189	1.9839012	1.1664889	3.9721489
		Vehicle #9	2	1.5105980	2.1363081	0	3.0211959
		Vehicle #10	2	2.7601943	1.0138353	2.0433044	3.4770841
		Vehicle #11	2	1.0496011	0.3048757	0.8340214	1.2651808
		Vehicle #12	2	0.6598383	0.8904455	0.0301982	1.2894783

Phase	Fuel	Vehicle	N	Mean	Std Dev	Minimum	Maximum
		Vehicle #13	2	1.8572378	0.1921741	1.7213502	1.9931254
		Vehicle #14	2	1.1933699	1.5992409	0.0625358	2.3242041
		Vehicle #15	2	2.2680734	0.3132745	2.0465548	2.4895919
	3	Vehicle #1	2	0.8122618	1.0768722	0.0507981	1.5737254
		Vehicle #2	2	0.6083582	0.4494233	0.2905679	0.9261484
		Vehicle #3	2	1.4079545	1.2025782	0.5576033	2.2583057
		Vehicle #4	2	0.9678728	0.7363366	0.4472042	1.4885414
		Vehicle #5	2	2.1014797	0.1389722	2.0032116	2.1997479
		Vehicle #6	3	1.6946681	0.0883787	1.6069642	1.7837065
		Vehicle #7	3	0.9065401	0.6737072	0.5143495	1.6844612
		Vehicle #8	2	3.7190350	0.7085691	3.2180010	4.2200690
		Vehicle #9	2	2.2058277	0.6031996	1.7793012	2.6323543
		Vehicle #10	2	3.0598744	0.0274738	3.0404475	3.0793013
		Vehicle #11	2	1.9907438	1.6282262	0.8394140	3.1420736
		Vehicle #12	2	0.7472981	0.9273913	0.0915334	1.4030628
		Vehicle #13	2	2.2531509	1.1577536	1.4344954	3.0718063
		Vehicle #14	2	1.3354431	0.8240726	0.7527358	1.9181505
		Vehicle #15	3	3.6586435	1.6822810	2.2905825	5.5369840

APPENDIX H

E-98 TEST EMISSIONS DESCRIPTIVE STATISTICS BY EMISSIONS, PHASE AND FUEL

TABLE H-1. THC EMISSIONS DESCRIPTIVE STATISTICS BY PHASE AND FUEL

Phase	Fuel	N	Mean	Std Dev	Minimum	Maximum
Composite	1	32	0.0602254	0.0392206	0.0155693	0.1718115
	2	32	0.0349248	0.0202571	0.0091836	0.0952088
	3	33	0.0476808	0.0266596	0.0161782	0.1481336
Phase 1	1	32	0.8032095	0.5313666	0.2432649	2.4122748
	2	32	0.3928607	0.1820217	0.1494468	0.7683206
	3	33	0.5620314	0.2273462	0.2683671	1.2950596
Phase 2	1	32	0.0182412	0.0137731	0.000196443	0.0487790
	2	32	0.0148295	0.0131692	0	0.0589634
	3	33	0.0191592	0.0183432	0	0.0871205
Phase 3	1	32	0.0371435	0.0365158	0.0011175	0.1355530
	2	32	0.0219282	0.0205769	0	0.0867871
	3	33	0.0241688	0.0235932	0	0.1076143

TABLE H-2. NMHC EMISSIONS DESCRIPTIVE STATISTICS BY PHASE AND FUEL

Phase	Fuel	N	Mean	Std Dev	Minimum	Maximum
Composite	1	32	0.0499712	0.0319154	0.0128871	0.1383826
	2	32	0.0259477	0.0128491	0.0074337	0.0610085
	3	33	0.0357780	0.0180086	0.0126739	0.1031862
Phase 1	1	32	0.7316175	0.4861183	0.2193987	2.1567168
	2	32	0.3299494	0.1498236	0.1206783	0.6249248
	3	33	0.4664982	0.1896516	0.2288031	1.0727101
Phase 2	1	32	0.0119967	0.0090886	0	0.0303862
	2	32	0.0093063	0.0076712	0	0.0314780
	3	33	0.0124595	0.0116315	0	0.0526386
Phase 3	1	32	0.0218531	0.0246481	0	0.0933056
	2	32	0.0094318	0.0104999	0	0.0425670
	3	33	0.0088107	0.0114171	0	0.0542785

TABLE H-3. CH_4 EMISSIONS DESCRIPTIVE STATISTICS BY PHASE AND FUEL

Phase	Fuel	N	Mean	Std Dev	Minimum	Maximum
Composite	1	32	0.0102635	0.0091100	0.0023062	0.0357628
	2	32	0.0082830	0.0076443	0.0016002	0.0335824
	3	33	0.0107296	0.0093276	0.0025497	0.0436587
Phase 1	1	32	0.0704897	0.0560328	0.0232067	0.2544297
	2	32	0.0514554	0.0317417	0.0136269	0.1262686
	3	33	0.0709794	0.0410854	0.0255242	0.1982463
Phase 2	1	32	0.0063009	0.0063717	0.000778515	0.0246570
	2	32	0.0053619	0.0062510	0.000799942	0.0276260
	3	33	0.0067631	0.0075531	0.000763464	0.0345067
Phase 3	1	32	0.0155354	0.0120881	0.0023099	0.0457767
	2	32	0.0131120	0.0107796	0.0022305	0.0444406
	3	33	0.0160361	0.0122735	0.0019020	0.0531771

TABLE H-4. CO EMISSIONS DESCRIPTIVE STATISTICS BY PHASE AND FUEL

Phase	Fuel	N	Mean	Std Dev	Minimum	Maximum
Composite	1	32	1.1642683	1.0900610	0.1857000	4.1595020
	2	32	0.8010271	0.7920069	0.0868364	3.1747909
	3	33	0.8385119	0.7474485	0.1681900	3.2129355
Phase 1	1	32	6.9944745	6.4233487	0.9436269	29.1877932
	2	32	5.4199048	3.6663620	1.1980538	13.3356346
	3	33	5.4236361	3.1252495	0.9818365	15.9259021
Phase 2	1	32	0.8261391	0.8777290	0.0298008	2.9549945
	2	32	0.5300299	0.6797385	0.0240183	2.5785396
	3	33	0.5716529	0.6653055	0.0254463	2.5479335
Phase 3	1	32	1.0916100	0.9626224	0.0360478	3.3281542
	2	32	0.7857460	0.9431950	0.0353808	3.3914243
	3	33	0.7916042	0.8065423	0.0346173	3.0367977

TABLE H-5. NO_X EMISSIONS DESCRIPTIVE STATISTICS BY PHASE AND FUEL

Phase	Fuel	N	Mean	Std Dev	Minimum	Maximum
Composite	1	32	0.0215123	0.0162804	0.0035000	0.0640599
	2	32	0.0181965	0.0126891	0.0026665	0.0671546
	3	33	0.0188801	0.0137414	0.0026707	0.0666781
Phase 1	1	32	0.1095975	0.0750624	0.0253511	0.3270799
	2	32	0.1004017	0.0555622	0.0150752	0.2126664
	3	33	0.0897058	0.0560017	0.0045508	0.2433382
Phase 2	1	32	0.0171423	0.0156782	0.000673714	0.0610631
	2	32	0.0135103	0.0131146	0.000635734	0.0655496
	3	33	0.0151226	0.0138216	0.000344398	0.0667066
Phase 3	1	32	0.0110578	0.0133284	0	0.0472573
	2	32	0.0160377	0.0258702	0	0.1060093
	3	33	0.0134329	0.0294288	0	0.1626465

TABLE H-6. PM EMISSIONS DESCRIPTIVE STATISTICS BY PHASE AND FUEL

Phase	Fuel	N	Mean	Std Dev	Minimum	Maximum
Composite	1	32	0.9804893	0.7179727	0	3.0917814
	2	32	0.7432803	0.5389277	0	2.0840639
	3	33	1.0481289	0.8876709	0.3064829	3.6661432
Phase 1	1	32	5.2001433	3.0812282	0	13.2860151
	2	32	2.4624461	2.1980145	0	8.8943489
	3	33	4.2286481	3.5590891	0.4833525	16.9878937
Phase 2	1	32	0.6554990	0.6827545	0	3.1115166
	2	32	0.5570589	0.4822312	0	1.9944816
	3	33	0.7524176	0.7677995	0.0838822	2.9250152
Phase 3	1	32	1.9655420	2.4173436	0	9.8009262
	2	32	1.8301408	1.4666961	0	6.3807301
	3	33	2.4473105	3.6841547	0.0507981	21.7628394